SOIL SURVEY OF EMMET COUNTY, IOWA.

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DESCRIPTION OF THE AREA.

Emmet County is situated in the north-central part of Iowa, bordering the State of Minnesota, and is separated from the western boundary of the State by three counties. Its western boundary is about 10 miles east of Spirit and Okoboji Lakes, in Iowa's well-known resort country. The county is rectangular in shape, contains 12 townships, and measures 24 miles east and west and 17 miles north and south. The land area of the county is 393 square miles, or 251,520 acres.

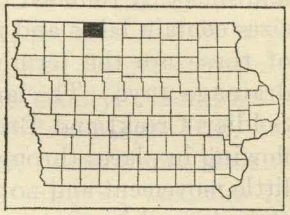

FIG. 13.—Sketch map showing location of the Emmet County area, Iowa.

Physiographically Emmet County consists of an originally more or less undulating drift-covered plain, which has been modified by erosion. The topography varies from practically level on the high uplands to gently rolling or broken in the vicinity of the larger streams. Small morainic hills or knolls occur over the county, but they are isolated and of small size; a true morainic topography, such as is found in Dickinson County on the west, is not developed in Emmet County.

In general the streams run in a southerly and southeasterly direction. The largest stream is the West Fork Des Moines River. It enters the county at its northwest corner and flows in a general southeasterly direction. Its tributaries are numerous but not of great length. Brown Creek, the largest of these, empties into the West Fork a short distance south of Estherville. In general the land bordering the river is strongly rolling to broken, the land of this character being most extensive west of the river.

The upland lying east of the West Fork Des Moines River is an undulating to rolling plain, nearly level in the central part but more rolling in the southern and eastern parts, bordering the larger stream courses and lakes. The upland west of the river generally has a rougher topography and lies from 100 to 150 feet higher.

The elevation above sea level ranges from 1,200 to 1,400 feet. Estherville is located on a high terrace at an elevation of 1,298 feet, and Armstrong is 1,237 feet above sea level.

drained land in this county. On some farms where drainage was insufficient this variety did not mature in 1920. While the other varieties are probably a little earlier maturing, they are not grown by as many farmers as is the Silver King.

Oats hold an important place in the agriculture of the county. They are grown largely as feed for the farm stock, although appreciable amounts are sold to elevators and shipped to outside markets. Varieties most in use are the Green Russian, Richland (Iowa No. 105), Albion (Iowa No. 103), and Schoolma'am. Iowar, a variety recently developed by the Iowa Agricultural Experiment Station, gave excellent results in the season of 1920. A yield of 80 bushels per acre was obtained in some fields.

Barley is grown on a number of farms each year. Most of the crop is utilized as hog feed, and the rest is sold to local elevators.

Flax is not grown as extensively as it was 20 or 30 years ago. In 1919 it was grown on 629 acres and produced 6,290 bushels. The seed is shipped from the county. Flax is generally sown on sod ground, broken for the first time.

Wheat at the present time is a relatively unimportant crop. In 1919 only 78 acres were devoted to winter wheat, producing 858 bushels, or an average yield of 11 bushels per acre. Spring wheat was grown in the same year on 1,122 acres, producing 8,976 bushels.

Rye is a crop of minor importance. In 1919 a seeding of 344 acres produced 5,010 bushels.

Timothy is the leading cultivated hay crop and is sown alone or with clover. It is often sown in combination with red clover, in which case it comprises the larger part of the yield after the second year. When sown this way, oats are used as a nurse crop. According to the census there were 17,377 acres devoted to tame grasses in 1919, which produced a total yield of 21,260 tons, and prairie hay was cut on 7,218 acres, yielding 7,741 tons. The crop is used largely for feeding work stock and cattle, there being but little shipped from the county. In 1919 there were 219 acres of timothy cut for seed, which produced a total of 384 bushels.

The decrease in the production of hay is largely offset by the production of forage crops. Silage crops on 2,899 acres in 1919 produced 23,795 tons of ensilage, and 3,260 acres of corn and 336 acres of sorghum produced 13,212 tons of forage.

Red clover is seldom sown without timothy or alsike. In practicing a rotation the better farmers plow under the second growth of the hay crop containing clover, in the fall of the year after it is seeded with oats. This is a good practice that should be followed more than it is. In a clover-timothy mixture the ground is too often left in timothy a year or two after the clover has disappeared, and

on Muck and Peat, as are sugar beets. The Sioux and O'Neill soils are known to lose their moisture readily and as a result give low yields unless there is a plentiful supply of moisture.

Ground to be planted to corn is usually plowed in the fall if other work is not pressing, and the following spring it is thoroughly disked and harrowed. The depth of plowing is usually about 4 inches, but may vary from 3 to 6 inches. When corn succeeds corn the stalk ground is often pastured through the winter, and in the spring the stalks are dragged before plowing. Ground is sometimes planted to corn without plowing, after disking thoroughly. This is a poor practice and should not be followed. The crop is either checked or drilled in rows 3½ feet apart and cultivated three to five times. Most of the crop is harvested by husking in the field, some of it is cut with a binder, and there are a few power pickers in use. Drilled corn is usually cut green for ensilage.

Oats generally follow corn. They are generally seeded broadcast and disked into the ground. Sometimes oats are used as a nurse crop for clover, in which case the oats are drilled in ground that has been thoroughly disked and harrowed.

In general, the farm dwellings of Emmet County are of an ordinary type, although there are some very fine farm houses. The census report on modern homes for 1919 gives the number with their improvements as follows: Heat, 30; light, 39; bath, 15. The well-built barns on some farms are in strong contrast to the mediocre dwellings. The fences are largely of barbed wire or hog-tight woven wire. The latter is rapidly coming into more common use. The work stock consists of medium and heavy type draft horses and some mules. The 1920 census reports 9,345 horses and 295 mules. There were 123 tractors in the county in 1919, 27 auto trucks, and 903 pleasure cars on farms. Other farm machinery includes 14-inch and 16-inch plows, harrows, riding cultivators, disks, mowing machines, hay rakes, hay stackers, hay loaders, corn and small-grain binders, manure spreaders, and planters. Gang plows drawn by 4 to 6 horses are in common use. Several threshing outfits are owned in the county.

Desirable crop rotations, although not used by all farmers, are in somewhat common use; probably one-fifth of the farmers use a strictly corn-corn-oats-clover rotation. Some follow a similar rotation, but substitute for the clover either timothy or timothy and clover and make the mistake of leaving the timothy in too long after the clover is exhausted. Where timothy alone comprises the original seeding it is not desirable to wait a number of years before returning the land to corn. The better farmers employ the four-year rotation of corn two years, oats one year, and clover one year. The succession is often employed with the land in corn for more

than two years, however. Probably the principal reason such rotations have not been followed more generally in Emmet County is that this region is hardly what could be termed a live-stock center. The county has been under drainage for a shorter period of time than the surrounding counties, and improvements are not so well advanced for that reason. The good prices for grain up to the fall of 1920 are responsible to a large extent for the large area seeded to grain and the small area seeded to clover. The majority of farmers during the war period grew all the grain possible.

Commercial fertilizer is used very little; 11 farms reported an expenditure of $2,194 for fertilizer in 1919. The better farmers apply to the land all the manure produced and some crop residues. A few carloads of limestone have been used in the county in the last two years. Rock phosphate has been used to a small extent with good results.

During the season of 1920 there was not an ample supply of laborers for farm work. Attractive wages were offered in Estherville during that year on paving and railroad work. Wages for farm help by the month were from $60 to $75, with board and washing. Day laborers received from $3 to $5 per day, depending on the man and the type of work performed. Married men are given also the use of a house and piece of ground. Labor for harvesting corn was particularly scarce in the early fall. Farm bureau members attempted to fix the price at 7 cents per bushel, or 6 cents with an elevator. Eight cents, however, was the more common rate paid for this work. By December, however, there was an oversupply of labor for corn picking. Local sources do not supply sufficient labor, and labor agencies at Sioux City, Minneapolis, and Des Moines supply outside laborers who are often unsatisfactory.

According to the 1920 census, there are 1,193 farms in Emmet County ranging in size from 80 to 360 acres, with the average size 194.5 acres. These include 92.3 per cent of the area of the county. Of the land in farms, 86.5 per cent is improved.

Of the total number of farms in 1920, 46 per cent were operated by owners, 53.1 per cent by tenants, and 0.9 per cent by managers. There has been a steady increase in the percentage of tenant-operated farms during the last 60 years. Leases usually run for one to three years, although some are longer. Under the share-rent plan, which is the most common, the owner receives two-thirds of the grain crop and about $5 an acre for hay and pasture land. Cash rentals run from $8 to $14 an acre.

Values vary greatly according to location, drainage, topography, and condition of improvements. In 1920, when the field work of this survey was in progress, poorly drained river bottom land was selling for $60 to $125 an acre; on well-drained upland farms values

ranged from $125 to $260 an acre; and well-improved farms close to the larger towns sold for $285 to as much as $325 an acre.[1]

SOILS.

Emmet County, Iowa, lies in the prairie region of the United States, where the topography and the rather high moisture supply has favored a heavy grass vegetation over the greater part of the land. It is not necessary to discuss here the agencies which brought about the prairie condition; it is sufficient to state that at the time of the first settlement by white men hardly an acre of forest had established itself upon the upland of the area. The upland soils, therefore, without exception have characteristics which indicate their development under prairie conditions.

The most striking characteristic of the surface soils of this region, and one common to soils developed under a grass vegetation with proper conditions of moisture, is a dark color. This color is imparted by finely divided carbonaceous material, derived from the decay of grass roots and intimately mixed with the mineral constituents of the soil. The percentage of this organic matter, and the depth to which it has affected the color and other physical properties of the soil, is determined very largely by average drainage conditions. On flats and sloughs the black organic matter extends to depths of 14 to 24 inches, while on the better drained ridges it does not affect the soil below depths of 8 to 14 inches. Muck and Peat represent extremes with respect to drainage and the accumulation of vegetable matter.

On flats and undulating areas the average moisture content was formerly high and the ground-water level was near the surface. In many areas water stood over the surface for days after heavy rains. Consequently there was a large accumulation of organic matter in the surface and upper subsoil, while the lower subsoil almost escaped leaching and oxidation resulting in a deep black soil filled with organic matter over a gray or mottled calcareous subsoil. These are the characteristic features of the soils which have been classed with the Webster series. Similar conditions in the poorly drained alluvial lands produced the Lamoure series.

Where better drainage conditions prevailed, as on some of the high terraces, a more vigorous movement of the soil water and better aeration have resulted in leaching and oxidation to depths of 3 to 4 feet. The surface soil is dark brown rather than black and not so deep as in the Webster group. In this county no upland soils

[1] In considering the statement of wages and prices given in the paragraphs above, and in other parts of this report, due allowance must be made for the fact that the prices prevailing in 1920, when the field work of this survey was done, were unusually high and undoubtedly in most cases have become considerably lower since then.

have reached this stage but the group is represented by the Waukesha and O'Neill soils on the terraces.

Where conditions were only partially favorable to leaching and oxidation a group of soils has been developed, intermediate in character between the two groups described above. The surface soils are dark brown to black but not so deep as in the Webster group. The upper subsoil has a uniform brown color, indicating thorough oxidation, and the greater part of the lime has been removed. The lower subsoil is brown or brown mottled with gray. It contains a relatively large quantity of lime carbonate and effervesces with acid. This lower subsoil, which in this area begins at depths of 24 to 30 inches, is the parent material, little changed by weathering. The most important soils of this class belong to the Clarion series. With it may be placed also the gravelly subsoil types of the Pierce and the Sioux series.

The Wabash soils are similar in general appearance to the Lamoure soils but do not contain lime.

The characteristics mentioned above have been imparted to the soil by the action of the great soil-forming processes, such as leaching, oxidation, and the accumulation of organic matter, and the composition of the parent material has been considered of minor importance. For the purpose of soil mapping the soils of each of the groups are further differentiated into soil series and soil types. The soil series include soil types that are similar in structure and minor details of the soil profile and in the source, character, and processes of accumulation of the material from which the soils have been developed. The division of the series into types is entirely upon the basis of difference in texture.

Emmet County lies within the region that was invaded by Pleistocene glaciers. The ice in its forward movement gathered and transported a heterogeneous mass of coarse and fine rock débris, and on its retreat left a mass of drift composed of clay, silt, sand, and gravel.

The most recently deposited drift, which now occupies a surface position, is known as the Wisconsin drift. In its unweathered state it was a whitish-yellow or gray, or, in places, a buff-colored pebbly clay. In Emmet County the layer of Wisconsin drift ranges in thickness from 4 or 5 to 25 or 30 feet[2] over that part of the county lying east of the West Fork Des Moines River and known as the Wisconsin Drift Plain. West of the West Fork Des Moines River the land is more or less morainic in character, the drift extends to a much greater depth, and the surface occupies a much

[2] Geology of Emmet, Palo Alto, and Pocahontas Counties, Iowa, by T. H. McBride, 1905.

higher elevation than in that part of the county lying east of the river.

On the basis of difference in the mode of accumulation of the soil materials, the soils of Emmet County may be grouped as follows: Glacial upland soils; terrace or old-alluvial soils; first-bottom or recent-alluvial soils; and cumulose soils, composed chiefly of plant remains in various stages of decomposition.

The upland soils of Emmet County are derived from the weathering of the Wisconsin drift. The lower subsoils over a large part of the area are composed of unaltered drift, and are highly calcareous, effervescing freely with acid. Lime is present as limestone flour, limestone pebbles, or bits of limestone rocks. Granite and some quartzite and gneiss rock formations are quite generally distributed over the area. Surface bowlders occur commonly on virgin areas, but have been removed from cultivated fields. The bowlders vary greatly in size, the larger ones being 1 to 2 feet in diameter. The upland soils are included in the Clarion, Webster, and Pierce series.

The surface soils of types of the Clarion series are dark brown to black. The upper subsoil is lighter brown in color and heavier in texture than the surface soil, and is usually a heavy silt loam to silty clay loam. The lower subsoil generally is a yellow to yellowish-brown silty clay, but in places it contains gray and approaches the color of the parent drift material. This is sufficiently calcareous to effervesce with acid, and streaks of lime and lime particles are of common occurence. The Clarion silt loam and the loam with a rolling phase are mapped.

The Webster series includes types with dark-brown to black surface soils, underlain by a gray or mottled gray, brown, and yellow heavy subsoil. This series differs from the Clarion series in having a more nearly level topography, ranging from nearly flat to undulating, and in being less well drained. These conditions are responsible for the gray color of the subsoil, which is characteristic of the series. The subsoil is calcareous, effervescing when exposed to acid. The types mapped in this series are the loam, silt loam, and silty clay loam.

The Pierce series is represented in this county by the fine sandy loam, which is a shallow soil underlain by a subsoil of sand and gravel, and high in lime, and effervescing with acid. The underlying material is composed chiefly of gravel.

The older alluvial deposits, which now form the terraces, were laid down at a time when the present river valleys and stream courses served as outlets for the tremendous volume of water released by the melting glacier. These rapidly moving waters transported and deposited great quantities of coarse materials. As the waters receded and reached present levels, they cut new and narrower chan-

nels, leaving the old flood plains well above the present level of high water. These terrace soils are classed with the Sioux, O'Neill, and Waukesha series.

The types included in the Sioux series have dark-brown, in places nearly black, surface soils. The upper subsoil is lighter in color and texture and rests on a substratum of stratified sand and gravel, which is high in lime. The soils are formed by the weathering of terrace material or deposits of glacial-outwash plains. The topography is undulating to sloping, except in a few small areas of high elevation, which have been severely eroded. Two types occur in the county, the loam and fine sandy loam.

The soils of the O'Neill series are essentially the same as those of the Sioux series, except that lime is not present in large quantities in the subsoil. The types mapped are the loamy fine sand, fine sandy loam, and loam.

The types of the Waukesha series are dark grayish brown or dark brown to nearly black in the surface soil. The upper subsoil is brown in color and heavier in texture than the surface soil, and the lower subsoil is yellowish brown in color and heavier in texture than the surface or upper subsoil. Gravel layers do not occur within the 3-foot section, and lime is not present in sufficient quantities to effervesce with acid. The Waukesha loam is the only member of the series mapped.

The recent-alluvial or first-bottom soils are formed of material carried from the surrounding glacial uplands, reworked, and deposited by the stream waters during periods of overflow. This group includes also many small depressions and old pond beds in the uplands, in which drainage is entirely lacking or is but poorly established except by artificial means. The first-bottom soils comprise those mapped in the Lamoure and Wabash series.

The surface soils of types of the Lamoure series are black or dark brown, and the subsoil is dark drab, grayish brown, or mottled gray and brown. The series represents material washed from upland soils high in lime, and the resulting soils are highly calcareous in the subsoil and, locally, in the surface soil. The series is developed along streams and in depressed areas and is subject to inundation at times of heavy rainfall and high water. The Lamoure silty clay loam is mapped in Emmet County.

The types of the Wabash series have black or very dark brown surface soils, over a drab or grayish-brown, heavy subsoil. These soils differ from those of the Lamoure series in the absence of lime. The silty clay loam is the only type mapped.

There are many depressed areas throughout the entire county containing a soil composed chiefly or entirely of organic matter. These areas were formerly sloughs, lakes, and ponds and supported a lux-

uriant growth of water-loving plants. The present soil material represents the remains of these plants, with a slight admixture of mineral material. The result is a mass of what may be called soil material, and ranges from raw, brown, fibrous Peat, still showing some of the original plant structure, to the same material in an advanced stage of decay and a more homogeneous mass, known as Muck.

Seventeen types of soil, including Peat and Muck, are mapped in Emmet County. These are described in detail, and their relation to agriculture is brought out in the following pages of this report. Their distribution in the county is shown on the accompanying soil map. The actual and relative extent of the various types are given in the table below:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarion loam	159,424	69.8	O'Neill fine sandy loam	1,024	0.4
Rolling phase	16,192		Meadow	960	.4
Webster silt loam	24,192	9.6	O'Neill loam	768	.3
Webster loam	17,216	6.8	Wabash silty clay loam	640	.2
Muck	8,960	3.6	Waukesha loam	512	.2
Lamoure silty clay loam	5,952	2.4	Pierce fine sandy loam	192	.1
Webster silty clay loam	5,696	2.3	Gravel pits	128	.1
Peat	3,200	1.3	O'Neill loamy fine sand	64	.1
Sioux loam	3,136	1.2	Total	251,520	.....
Sioux fine sandy loam	2,112	.8			
Clarion silt loam	1,152	.4			

CLARION LOAM.

The surface soil of the Clarion loam is a brown to dark-brown, friable and mellow loam to a depth of 12 to 15 inches. The content of silt, sand, and fine sand is sufficient to render the soil friable and free from stickiness, even when fairly wet. The subsoil is a brown to yellowish-brown, heavy silt loam to silty clay loam, with a characteristic whitish cast due to the presence of lime. Locally the subsoil contains fine gravel and occasionally some sand, but not in sufficient quantities to modify the texture. The subsoil effervesces freely with acid, and limestone pebbles and fragments are of common occurrence.

Locally the lower subsoil contains faint gray mottlings, or has the solid gray color of the parent till. This occurrence of gray in the lower subsoil is characteristic of the type in areas that have a more gently rolling to undulating topography. Here also the surface soil is a darker brown and extends to a depth of 18 to 20 inches. In all places where the gray subsoil occurs in areas mapped as

Clarion loam, the upper subsoil is a pure brown or yellowish brown. This is the basis of separation between the Clarion and Webster soils where they come in contact, as in the latter both the upper and lower subsoils contain the gray color. True and incipient iron concretions are more numerous in the Clarion loam subsoil where it contains this gray coloration.

Where the topography is rolling the surface soil of the Clarion loam varies in color. On points and ridges it is a brown to light-brown loam, 8 to 10 inches deep, and is underlain by a brown to yellow, heavy loam to silty clay loam, which is calcareous; on the lower slopes it is deeper and has a darker color, owing to some admixture of colluvial material from the higher soils.

The Clarion loam is the most extensive type in Emmet County and is typically developed in all parts. Where it joins with soils of the Webster series, as in Jack Creek, High Lake, Center, and Ellsworth Townships, it occurs in small isolated areas and in long tortuous strips. This type and its rolling phase comprise about 90 per cent of the uplands west of the West Fork Des Moines River, and east of the river the type occupies three-fourths or more of the upland, with the exception of the townships named above, which contain large areas of the Webster soils.

The topography ranges from undulating in one area to strongly rolling in another; but typically it is gently rolling, with smoothly rounded knolls, gently sloping swales, and small valleys. The rougher land is confined largely to the vicinity of the West Fork Des Moines River. All land of this type is well drained.

In one small area bordering High Lake on the north and northwest, and extending back from the shore about one-half mile, the lower subsoil does not contain sufficient lime within the 3-foot section to effervesce in the presence of acid. The small extent of the area did not warrant its being mapped as a separate type. The soil here is identical with the typical Clarion loam in the soil profile and topography, and differs only in the absence of lime in the subsoil and the consequent absence of the whitish or floury cast so characteristic of the Clarion loam subsoil. Excavations to below 36 inches within this noncalcareous area show the presence of calcareous material at lower depths.

A few small areas mapped with the Clarion loam in Twelve Mile Lake Township are of a morainic character. The surface soil is a brown fine sandy loam, underlain by a loamy fine sand to pure sand for a depth of at least 3 feet. These areas contain one-half to 1 acre each and are not numerous.

The Clarion loam is agriculturally the most important soil of the county, as well as the most extensive. Nearly all of it is under cul-

tivation or in pasture, there being but little in forest. It is typically a prairie soil, and the forested areas are confined to a narrow margin of hills along the larger streams. The trees are mainly maple, willow, cottonwood, walnut, ash, and oak. Many farmers have planted trees in a small area about the farmstead to serve as a windbreak.

Corn, oats, and hay are the chief crops raised on this soil. Corn is the most important, occupies the largest acreage, and is the principal cash crop, although a part is retained as feed for work stock, hogs, and cattle on the farm. Oats and hay rank second and third, respectively, in acreage. These two crops are used mainly as feed for stock, and any surplus not fed on the farm is sold. Some rape and soy beans were noted during the progress of the survey. The rape is sown between the rows of corn at the time of the last cultivation, and the field is used as a hog pasture after the corn has been husked, or else the rape merely supplements the grain and stover when the entire corn crop is hogged down. Soy beans also are planted with corn. This combination is used to provide pasturage for hogs in the fall, or where a well-balanced silage is desired. Barley, spring wheat, and some rye, millet, winter wheat, sorghum, apples, potatoes, and all kinds of garden vegetables are grown by most farmers for home use and for sale in the local markets. Barley is used somewhat as a hog feed, but a good deal of it, as in the case of wheat and rye, is shipped out of the county. Some of the alfalfa grown in the county in 1919 was seeded on the Clarion loam, and the results would indicate that the acreage in this crop could be extended profitably. There are no special crops on the type.

Yields on this type vary somewhat with position and topography, but are generally about as follows:[3] Corn, 40 to 60 bushels per acre; oats, 35 to 60 bushels per acre; wheat, 12 to 20 bushels; barley, 20 to 35 bushels; and hay, 1 to 2 tons per acre. Yields of 80 to 85 bushels of corn per acre have been obtained on this type, showing its possibilities.

The main live-stock industries are the raising of hogs, the feeding of beef cattle and a few sheep, and some dairying. Although most of the hogs are grades and are fed and shipped, there are a number of good herds of purebred hogs. There are only a few purebred beef herds. The beef-cattle industry consists of production by a few breeders, and the feeding of a few animals for market by most farmers. Dairying is developed on this type in the vicinity of Ringsted and throughout Denmark Township. There is also some finishing of feeder lambs shipped in from the West.

The soil is easy to cultivate and maintain in good tilth owing to its high content of fine sand and silt. It is naturally rich in organic

[3] Yields are based on information obtained from farmers and others.

matter and by the use of systematic crop rotations and proper methods of cultivation and management, it can easily be maintained in a high state of productiveness. A rather broad and general system of crop rotation is used by many farmers. It consists of corn for several years, followed by oats with which is seeded timothy or a mixture of timothy and clover. The land is left in grass for several years and returned to corn again. Clover, however, is not always used in the rotation, and the hay crop too often consists of timothy without a legume. The more progressive farmers use a rotation of corn, corn, oats, clover. Clover is seeded with the oats as a nurse crop the third year of the rotation, and the clover is allowed to remain in for the fourth year. Very little commercial fertilizer has been used. One carload of rock phosphate was used in the vicinity of Armstrong with good results. Stable manure is generally saved and returned to the land, and where heavily manured this soil produces exceptionally fine yields of grain and hay.

Farms on the Clarion loam range in price from $200 to $300 an acre, depending very largely on location with respect to towns and on improvements.

The Clarion loam is naturally a fertile soil and can be made to produce more than it does at the present time. The yields on many farms have been depressed by too continuous cropping with corn, oats, and timothy and the failure to maintain the supply of organic matter through the use of farm manure and more extensive growth of legumes. In some cases years will be required to restore the soil to its natural state of high productiveness. In addition to the incorporation of organic matter, the soil needs a more thorough seedbed preparation and a gradual increase of the plow depth to 8 or 10 inches. While this soil does not suffer from destructive erosion or gullying, better tilth and a greater content of organic matter will increase the water-holding capacity of the soil and reduce losses through leaching and sheet erosion.[4] Systematic crop rotations in which the clovers and other legumes play an important part should be used. A recommended four-year rotation that should give good results is corn, corn, oats, and clover.

Clarion loam, rolling phase.—The surface soil of the Clarion loam, rolling phase, is a brown loam about 8 inches deep. The subsoil is a yellowish-brown to light-yellow loam to silty clay or clay loam, containing sufficient lime to effervesce with acid. One characteristic of this phase is the presence of more or less gravel in the surface soil and upper subsoil, and here and there on the surface. The gravel is fine and composed largely of granite, quartzite, and limestone. The surface soil varies somewhat in color and depth, being lighter colored and shallower on the extremely steep areas.

[4] Circular No. 10, Iowa Agricultural Experiment Station.

The topography is rolling to strongly rolling, and drainage is good to excessive. Erosion may become very destructive if the rougher areas are not kept in permanent pasture or protected by cover crops.

The phase covers about 25 square miles in the western part of the county, on both sides of the West Fork Des Moines River. It comprises entire farms and is a soil of importance.

Contour plowing should be practiced, and the extremely steep areas should be kept in permanent pasture. The soil may be improved by the means recommended for the typical Clarion loam. This soil, however, is more depleted of organic matter and less productive than the typical Clarion loam. Green-manure crops should be grown and supplemented with crop residues and barnyard manure in order to maintain the content of organic matter and increase the water-holding capacity of the soil. Yields on this phase are lower than on the typical Clarion loam, and the land sells for less.

CLARION SILT LOAM.

The surface soil of the Clarion silt loam is a dark-brown, somewhat mellow silt loam, 12 to 16 inches deep. The subsoil is a lighter brown heavy silt loam to silty clay loam, free from mottlings, which changes at about 24 inches into heavy silty clay loam, predominantly brown or yellow in color, and mottled in places with gray. The subsoil contains enough lime carbonate to effervesce freely with acid. Sand and less commonly fine gravel occur in the lower subsoil in some localities. The surface soil of this type resembles that of the Webster silt loam, except in the area mapped in the northwestern part of section 7, Emmet Township, which has a lighter brown surface soil. The only marked difference between this soil and the Webster silt loam is the presence of an intermediate layer of brown in the upper subsoil of the Clarion which does not occur in the Webster soil. The brown layer is the result of more thorough oxidation, which has changed the gray, or mixed gray and brown, into pure brown. In a number of places this process of oxidation has not been completed, and it is difficult to determine whether the color was nearer brown or gray. In such places the soil boundaries were placed arbitrarily.

The Clarion silt loam is one of the less extensive upland soils. It is developed in small areas, mainly in High Lake and Estherville Townships. The topography is undulating to gently rolling and the drainage is usually good, though tiling is often beneficial in areas associated with the Webster soils.

This type was originally covered with prairie grasses, but is all under cultivation at present. It is considered a very productive soil,

and similar to the Webster silt loam in character and value. Because of its occurrence in small areas it comprises only small parts of farms or fields, and is farmed like the surrounding soils. Corn, oats, and hay are the leading crops. Some barley, rye, and wheat are grown. Corn yields from 45 to 60 bushels per acre, and oats, 40 to 60 bushels.

Erosion is not a problem on this type. The better farmers use a four-year rotation, apply barnyard manure, and plow under clover frequently enough to maintain a good supply of organic matter in the soil.

Land of this type is not sold separately. Its approximate value is from $200 to $250 an acre.

WEBSTER LOAM.

The surface soil of the Webster loam is a very dark brown to nearly black heavy loam 12 to 15 inches deep. The upper subsoil, to a depth of 20 to 24 inches, is a dark-brown to gray heavy silt loam. The lower subsoil is a silty clay to clay loam, predominantly gray, but mottled with brown and yellow. Stains and incipient concretions of iron are common in the lower part; fine sand or gravel occurs in places. The lime content gives a characteristic ashy appearance to the lower subsoil, which effervesces freely with acid. Included with the type are small bodies of Webster silt loam and silty clay loam not large enough to map separately.

This type occurs in areas of various sizes throughout the county, but is most extensively developed northeast of Estherville. It is not as extensive as the silt loam. A few areas are large enough to comprise entire farms, but most areas are farmed with other soils.

The topography is gently undulating to gently rolling, and in places the type occupies a position below the Clarion soils. The gentle relief has resulted in rather poor drainage conditions and a consequent accumulation of larger quantities of organic matter. Tiling has been necessary on much of this type, and has resulted in improved physical conditions and increased crop yields. The areas still in need of drainage support a growth of native grasses which are pastured or cut for hay. In places this type occurs adjoining or within areas of Muck and Peat, in which case the soil contains large quantities of organic matter but not enough to make it a true Muck.

The Webster loam is a typical prairie soil and supports no native tree growth, but trees do well on it where set out for windbreaks about farmsteads.

This soil, having a lighter texture than the Webster silt loam, is more easily worked, can be tilled when wetter, and is somewhat earlier. However, it is not equal to the Clarion loam in these re-

spects, although usually considered more desirable than the Clarion loam. When well drained and well managed it is very productive, but unless tiled the soil tends to become water-logged, owing to the heavy structure of the subsoil, where the topography is not sufficiently rolling to give free run-off.

The Webster loam is handled in practically the same way as the silt loam, and the methods of improvement suggested for the Webster silt loam and Clarion loam are applicable. Commercial fertilizer is not used. As the type generally occurs in small areas forming parts of fields containing other soils, it is farmed like the adjoining land. Crop yields average about the same as on the silt loam.

Farms on this type are generally well improved, and land values range from $225 to $300 an acre, depending on improvements, including drainage and location.

Sugar beets are grown as a special crop on this soil, mainly in the eastern tier of townships. The yields in 1920 ranged from 10 to 14 tons per acre. The crop requires a relatively large amount of labor. It is grown on contract with sugar refineries in southern Minnesota or at Mason City, Iowa.

The area of Webster loam mapped in the SE. ¼ of sec. 6, Swan Lake Township, is a variation from the typical. The surface soil to a depth of 12 to 14 inches is a dark-brown or nearly black loam with a relatively high content of fine sand. The upper subsoil to a depth of 24 inches is a dark-gray or drab fine sandy loam to loamy fine sand. The lower subsoil is an ashy-gray loamy fine sand to pure fine sand, very calcareous, and effervescing freely with acid.

WEBSTER SILT LOAM.

The surface soil of the Webster silt loam is a dark-brown to black, fairly friable and mellow silt loam 14 to 18 inches deep. The subsoil is a dark-gray silty clay loam to silty clay which grades at 20 to 24 inches into a mottled gray, brown, and yellow clay loam to silty clay. The subsoil is calcareous, effervescing with acid, and has a characteristic gray or whitish color, due to the presence of lime. The lower subsoil locally contains sand and fine gravel, mixed with the heavy clay, and many iron stains and iron concretions. Green and pink mottlings occur here and there. The surface soil contains a relatively large proportion of organic matter, but does not approach Muck in texture. In many places bowlders varying in size up to 1 or 2 feet in diameter are embedded within the soil mass or protrude above the surface.

The Webster silt loam is the second most important soil type in the county. It occupies about 38 square miles. It is most extensive

in Ellsworth, Center, High Lake, and Jack Creek Townships and the western part of Denmark Township, where it occurs in rather large areas, which include mapped areas of the Webster silty clay loam and some other soils, and also patches of the silty clay loam too small to map. In other parts of the county the type occurs generally in small disconnected bodies. The topography is nearly flat to gently sloping. Where the surface is more nearly level there is a greater accumulation of clay in the upper subsoil and the surface soil is relatively higher in organic matter. Tiling has been necessary on most of this type. The Webster silt loam is highly productive and much prized by farmers. Almost all of it has been drained and is under cultivation, and very little is devoted to pasture. It is a typical prairie soil. The only trees are those that have been planted in groves on the west and north sides of farmsteads to serve as windbreaks. These consist of maple, elm, cottonwood, ash, Lombardy poplar, and some evergreens. The small isolated areas are not generally under cultivation. They support a rich growth of native grasses which are pastured or cut for hay.

Corn, oats, and hay are the principal crops, by far the largest acreage being in corn. After supplying the farm needs, the surplus of the crop is sold. Usually the entire hay crop, which consists often of timothy and clover or one of these alone, is fed on the farm to work stock, beef cattle, and dairy cows. There are over 200 silos in Emmet County, and a considerable acreage of corn is required to fill them. The corn for ensilage is usually drilled, and sometimes soy beans are seeded with it. Small acreages of barley, wheat, and rye are grown on this type. The flax reported for Emmet County in the State census of 1919 was raised mainly on this type. It is purely a cash crop and is shipped from the county. Wheat is also a cash crop. Rye affords spring pasture, and is also threshed and the grain sold. Barley, millet, and some rape are used for feeding stock. The rape is seeded in the corn at the last cultivation and affords pasturage for hogs in the fall. Soy beans are sometimes grown for this purpose also. The principal live-stock industry is the raising and feeding of hogs and some beef cattle, and dairying. Sugar beets are occasionally grown on this type, but more commonly on the Webster loam and shallow Muck or sometimes Peat. Alfalfa yields from $1\frac{3}{4}$ to 3 tons per acre on this soil, and should be grown more extensively.

Crop yields obtained on this soil under good management are very satisfactory. Corn yields 50 to 60 bushels per acre. One farmer in Center Township reported 75 bushels per acre on this type for the year of the survey (1920). Oats yield from 45 to 60 bushels per acre; wheat, 10 to 20 bushels per acre; barley, 20 to 30 bushels per acre; and hay, 1 to 2 tons.

The Webster silt loam is a fertile soil and is very productive when drained sufficiently and managed correctly. It can not, however, be worked under as wide a range of conditions as can the lighter textured soils. If plowed when too wet the soil has a tendency to clod, but under favorable conditions it works into a very mellow and friable seed bed. It can not be worked as early in the spring as the surrounding Clarion loam, because of the heavier surface soil and subsoil, which retain moisture for a greater length of time. The drawback may be overcome in part by the incorporation of organic matter, deep plowing, and thorough tillage. Barnyard manure is generally applied, and definite crop rotations including clover are in use on the better farms.

The price of this land, which ranges from $225 to as much as $325 an acre, is determined by the location and improvements, and the extent to which the soil has been drained by tiling.

Deeper plowing, wherever practicable, is essential, as a deep well-cultivated soil can absorb more moisture without detriment to the crop than can a shallow soil in poorer physical condition. Drainage, of course, is extremely important, and this type is drained extensively by means of a system of large open ditches and tile drains. Legumes, such as clover or alfalfa, should be included in the rotation. A good plan is to remove the first crop for hay, plowing under the second growth as a green manure.

Greater care than usual should be exercised in the selection of varieties of corn and oats adapted to this type. Because the soil does not warm up quickly in the spring, crops are a little backward in starting rapid growth, and for this reason earlier maturing strains are desirable. Silver King and Minnesota No. 13 corn varieties have given good results. Wimple Yellow Dent, certain strains of Reid Yellow Dent, and other unnamed yellow strains are grown with an occasional loss from frosts. The lodging of oats is largely avoided by the use of Albion (Iowa No. 103) and Richland (Iowa No. 105), particularly the latter, which are early maturing and have short straws stiff enough to stand quite well on such a rich soil. These varieties were developed at the Iowa Agricultural Experiment Station.

WEBSTER SILTY CLAY LOAM.

The surface soil of the Webster silty clay loam is a very dark brown to black silty clay loam, 16 to 20 inches deep, containing a relatively large percentage of organic matter. The subsoil is dark gray or mixed gray and lighter gray to a depth of 28 inches, below which it is a mottled gray and brown heavy clay loam. The gray color predominates in the lower subsoil and in places there is no

brown whatever. Incipient and well-formed iron concretions, as well as some sand and gravel, are generally present in the lower subsoil. Small granite and quartzite bowlders occur very commonly in this type, both below and above the surface of the ground.

The Webster silty clay loam is found mainly in Ellsworth Township, but occurs in small bodies over the entire county. It is developed in the flatter parts of the upland or on gentle slopes bordering drainage ways and has a flat to gently sloping topography. The type is generally poorly drained, but a large part of it has been tiled and thereby made productive. The soil is naturally retentive of moisture and crops do not suffer in dry seasons.

About 75 per cent of the type is under cultivation, and the rest is in native grasses, which are either pastured or cut for hay. It supports no trees except an occasional straggling willow.

The Webster silty clay loam is productive under good management, which includes thorough underdrainage and the incorporation of organic matter. Corn, oats, and other small grains, hay, and flax are the main crops grown. Corn yields from 35 to 60 bushels and oats 40 to 60 bushels per acre. Richland (Iowa No. 105) oats do well, because the short stiff straw prevents lodging to a great extent. Flax on sod ground yields from 8 to 12 bushels per acre.

This type is farmed in conjunction with adjoining lands, usually the loam and silt loam of the same series, and the methods of plowing and seeding are the same. It is sold with the surrounding land and is considered less valuable than the other types of the Webster series.

PIERCE FINE SANDY LOAM.

The surface soil of the Pierce fine sandy loam is a brown to dark-brown or black fine sandy loam with a depth of 6 to 8 inches. The subsoil is a brown loamy fine sand to sand, which at about 12 or 14 inches grades into a gravel layer of varying composition, containing waterworn stones as large as 3 to 4 inches in diameter, as well as finer gravel and sand. The color and depth of the surface soil is not uniform. In places the layer of sand and gravel is exposed or is covered by 1 to 3 inches of a light-brown sandy loam or loamy sand. The subsoil is stratified and contains much lime.

The type occurs only in small areas, usually from 1 to 5 or 10 acres. In some cases it was necessary to exaggerate the area in order to show it on the map. It is developed on a typical kame formation and occurs on small knolls, usually within areas of the Clarion loam. In only a few instances is the topography more rough than gently rolling.

This type has little value for agriculture, and none of it was noted under cultivation. It is largely left in grass and pastured, but

it is extremely droughty and supports but a straggling growth. The substratum of gravel is frequently utilized for road surfacing, and in this way areas of the type have been a source of income.

SIOUX FINE SANDY LOAM.

The surface soil of the Sioux fine sandy loam is a dark-brown or dark grayish brown fine sandy loam, 8 to 10 inches deep. The subsoil, to a depth of 14 to 16 inches, is a light-brown or yellowish-brown fine sandy loam to loamy fine sand. Below this depth the subsoil is composed of stratified coarse sand and gravel, containing limestone pebbles and flour and effervescing freely with acid.

The Sioux fine sandy loam is one of the more important terrace soils of the county. The type lies from 10 to 30 feet above the first bottoms and is confined to the terraces of the West Fork Des Moines River. The topography is flat to sloping or undulating. The city of Estherville is located on the type, which at this point has an elevation of 1,298 feet.

Most of the Sioux fine sandy loam is under cultivation, and the rest is in wild grasses and is utilized for hay or pasture. This type, as well as the Sioux loam and the types of the O'Neill series, does not support much forest growth. Some groves have been planted about farmsteads, the trees being largely willow and poplar.

The principal crops are corn, oats, and hay, but rye, wheat, millet, and barley are also grown. This soil is handled like the Sioux loam, gives similar yields, and brings about the same price.

Owing to the relatively low content of organic matter, the surface soil should be enriched as much as possible by incorporating barnyard manure, crop residues, and green-manure crops. Deep plowing and careful preparation of the seed bed also will make the soil more retentive of moisture.

The gravel underlying types of the Sioux and O'Neill series is used extensively for highway construction and railroad ballast.

SIOUX LOAM.

The surface soil of the Sioux loam is a brown to dark-brown or nearly black, light-textured loam, grading lighter in texture and color to a depth of 8 to 12 inches. This is underlain by a light-brown to yellowish-brown, light-textured, fine sandy loam to loamy fine sand. Below 20 to 24 inches the subsoil is a mixture of medium to coarse sand and gravel, becoming coarser with increasing depth, and the substratum is largely pure gravel. Limestone pebbles and flour occur throughout the subsoil, and constitute the principal difference between the soils of the Sioux and O'Neill series. The type

as mapped includes small areas immediately bordering the upland in which the surface soil is somewhat more silty than typical.

The Sioux loam is most extensive along the West Fork Des Moines River, but occurs also in the second bottoms of the East Fork Des Moines River and the larger creeks. Its elevation above overflow ranges from 10 to 50 feet. The topography is flat to gently sloping, becoming rolling in eroded areas. The rolling areas include those bordering the East Fork Des Moines River south of Armstrong, one in sections 27 and 34 of Emmet Township and the area north of the gravel pit in section 29 of High Lake Township. In these the surface soil is lighter in color and has a higher percentage of sand, the substratum of gravel is encountered at shallower depths, and small pebbles occur commonly on the surface. The type everywhere is excessively drained, and crops suffer during dry spells.

Most of this type is under cultivation; the rest supports a growth of wild grasses, which are pastured or cut for hay. Corn is the principal crop, and oats second in importance. Some rye also is grown; it is either turned under after pasturing or is allowed to mature grain. A few cattle are pastured on some farms, but hogs constitute the principal live stock. When moisture conditions are favorable crop yields are good, but in dry seasons the yields are only fair. As a rule the yields are somewhat lower on this soil than on the adjoining upland types. Corn yields 20 to 35 bushels per acre; oats, 25 to 38 bushels; and rye, 20 to 35 bushels.

The Sioux loam is managed very much like the loam soils of the upland. Stable manure is applied to the fields, usually with a manure spreader. Definite crop rotations are in more or less common use. The rotation followed on some farms is one of corn, oats, and clover. The land is generally broken in the fall, and is plowed to a greater depth than on some other types.

The maintenance of a deep, mellow seed bed is not difficult on this type. Deeper plowing, particularly in the fall, thorough preparation of the seed bed, and a more general use of rotations which include legumes would prove beneficial. The generous use of stable manure increases the water-holding capacity of the soil. The type is well adapted to the production of early crops and vegetables, such as Irish potatoes.

Many farms on the Sioux loam are well improved, and these have a value of $125 to $175 or even $200 an acre.

O'NEILL LOAMY FINE SAND.

The surface soil of the O'Neill loamy fine sand is brown or grayish-brown loamy fine sand to a depth of 14 inches. This is underlain by brown or yellowish-brown sand.

The type occurs in patches within areas of other terrace types. The topography is nearly flat.

The type is best left in pasture, as it is very droughty. If farmed, however, it should be plowed deep and well manured.

O'NEILL FINE SANDY LOAM.

The surface soil of the O'Neill fine sandy loam is a dark-brown fine sandy loam, 12 or 15 inches deep. The subsoil is a brown sand or loamy sand, which grades at about 20 inches into a mixture of coarse and fine sand, containing gravel in places. The substratum consists of sand and gravel and is similar to the substratum of the Sioux soils, except that lime is not present in quantities sufficient to cause effervescence.

The type occupies terraces well above overflow, and has a flat or sloping surface.

The areas along the upper part of the East Fork Des Moines River vary somewhat from the typical. They are remnants of a very old terrace and occur on slopes, in places rather steep, approaching the stream or its first bottom. The surface soil is variable, ranging from a loam to a loamy fine sand, and the subsoil is a pure sand, no gravel being present. In the small area in section 12 of Lincoln Township, bordering Tuttle Lake, the surface soil is pure sand or loamy sand in places and the subsoil is a loamy sand or pure sand throughout.

This type is small in extent and unimportant. It comprises a small part of farms. The soil is droughty and does not give as large yields as the heavier upland soils, which are more retentive of moisture. Much of this type is in wild grasses, which are pastured or cut for hay.

O'NEILL LOAM.

The surface soil of the O'Neill loam is a brown or dark-brown friable loam, relatively high in content of sand and 10 to 12 inches deep. The subsoil, to a depth of 16 or 18 inches, is a yellowish-brown fine sandy loam to loamy sand, below which to the 36-inch depth it consists of a mixture of medium and coarse sand and gravel. The substratum of the greater part of the type is composed largely or entirely of sand, although in some areas it resembles the substratum of the Sioux soils in that it contains more gravel than sand. The subsoil is stratified, but does not contain lime, either as flour or pebbles, in sufficient quantities to effervesce in the presence of acid.

The type has a flat or undulating to very gently rolling topography, and occurs on terraces bordering the West Fork Des Moines River. It is one of the less important terrace types, owing to its small total area.

A part of the type is in native grasses, but most of it is cultivated. The main crops are corn, oats, and hay. Since it occurs only in small areas, it is generally farmed with the associated Sioux soils, to which it is about equal in value and producing power.

WAUKESHA LOAM.

The surface soil of the Waukesha loam is a dark-brown or dark grayish brown friable loam with a depth of 15 or 18 inches. The subsoil is a brown to yellowish-brown silt loam to heavy silt loam, becoming lighter in color and heavier in texture with increasing depth. The subsoil does not contain gravel and is not calcareous.

This type occurs on terraces above overflow and has a flat or gently undulating or sloping topography. It has an area of less than 1 square mile, and seldom if ever forms an entire farm.

The type is farmed like the upland soils and the soils that surround it. It is productive under good management, and is not droughty like the other terrace soils. It produces about the same yields as the Clarion loam, and should be handled in the same way.

LAMOURE SILTY CLAY LOAM.

The Lamoure silty clay loam is a black silty clay loam, relatively high in organic matter to a depth of 18 inches, where it grades into a dark-gray to gray, heavy silty clay loam, which becomes lighter in color with increasing depth. In places the lower subsoil is mottled brown, gray, and yellow, and iron stains occur here and there. The subsoil is invariably calcareous, effervescing with acid, and locally the surface soil contains sufficient lime to effervesce.

Included in the type are a few patches of Lamoure silt loam, which, on account of their small extent and intricate association with the silty clay loam, were not separated on the map. In the area mapped in section 27 of Swan Lake Township the texture varies toward a silt loam. In depressions or pondlike areas in the upland and in some stream bottoms where drainage is particularly poor or lacking entirely, the subsoil is especially high in organic matter, although it could not be classified as Muck, and in places the 3-foot section is black throughout or only shows a dark-gray color in the lower subsoil.

The Lamoure silty clay loam is the most extensive first-bottom soil in the county. It occurs along the East and West Fork Des Moines Rivers, along the streams and intermittent drainage ways, and in depressions and former pond areas throughout the upland. The surface is typically flat with a slight slope toward the streams along which it occurs, or in places a slight rise due to the deposition

of a natural levee at times of overflow. The type is subject to annual or frequent inundation and has poor drainage. Water stands on it for some time, and the soil dries out very slowly.

The Lamoure silty clay loam is naturally a rich and productive soil, but its utilization is seriously handicapped because of poor drainage, and it has not been reclaimed to any great extent. Heavy rains occurred in June and the early part of July in the year of the survey (1920). Water stood for a number of days in depressed areas of this type, killing corn and other crops. A large part of this type is devoted to the production of wild hay, and much of it is in permanent pasture, and a small part is used for corn and oats.

During favorable seasons corn yields are good, but oats usually lodge badly. Richland (Iowa No. 105) and Albion (Iowa No. 103) oats, which are adapted to rich soils, give good returns. Corn yields 30 to 55 bushels per acre; oats, 30 to 50 bushels; hay, 1 to 1½ tons. Flax is sometimes grown on newly reclaimed land, and some buckwheat has been grown on the type. A few hogs, beef cattle, and dairy cattle are pastured on the undrained areas. No fertilizer or stable manure is used.

The Lamoure silty clay loam is always sold with adjoining types, and prices are much less than for upland types of the Clarion and Webster series. It could probably be bought for $60 to $100 an acre.

A deposit of alkali is found in some of the depressed areas in the upland and in narrow strips along the margins of Peat or Muck areas. Such areas are easily recognized when dry by the whitish appearance of the surface. This alkali deposit interferes very seriously with the first growth of any crop.

The biggest problem connected with the reclamation of the Lamoure silty clay loam is one of adequate drainage. Underdrainage by means of tile is essential. Surface drainage should be provided where necessary. The straightening of stream courses will aid in the more rapid removal of surface water. Although the soil is high in organic matter the addition of small quantities of barnyard manure will often increase crop growth by improving the physical condition of the soil. Where the presence of alkali presents a problem, thorough drainage and the liberal use of fresh horse manure will bring about the quickest reclamation. The length of time required to remove the excess alkali depends upon the amount present originally, and the efficiency of methods employed for its removal. Several years may be required to bring the soil to a productive state.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam is a black silty clay loam, high in organic matter, extending to a depth of 18 to 20 inches. The subsoil to 36 inches is a black or drab, heavy, plastic, tenacious,

silty clay loam to silty clay. In places the subsoil below 24 inches is faintly mottled with gray, brown, and yellow. This soil resembles very closely the Lamoure silty clay loam and differs from it only in the fact that it contains no lime whatever within the 3-foot section.

Minor textural variations occur within some of the areas mapped. The area in section 7 of Emmet Township is a silt loam, but owing to its small size, it was not mapped as a separate type.

The Wabash silty clay loam occurs in numerous areas in the first bottoms along the West Fork Des Moines River, and in two small areas lying mainly in section 3 of Twelve Mile Lake Township. The surface is almost level, with a slight slope toward the stream and in the direction of its flow.

Only a very small part of this type is under cultivation, and most of it is used as pasture for hogs and cattle or for the production of wild hay. The tree growth occurring along the streams consists largely of elm, oak, willow, and ash. Hay yields up to 1½ tons per acre. Under favorable conditions the type produces good yields of corn. This land is valued at about $60 to $100 an acre.

Drainage is a very important factor in making the soil productive. The methods recommended for reclaiming the Lamoure silty clay loam apply equally well to this soil, except that there is no alkali in the Wabash silty clay loam.

PEAT.

The surface material of Peat is a brown fibrous mass of slightly decayed vegetable matter, varying widely in depth, but in most places extending to 18 or 20 inches. Generally this is underlain by a layer of black mellow muck, which at about 30 inches grades into a somewhat mucky, black, silty clay or clay loam. Many areas of Peat in the county vary somewhat from the soil profile just described. In some places the surface layer is much shallower, and in other places it has a depth of 5 feet or more. As a rule a layer of muck lies between the raw Peat and the underlying true subsoil, but in the deeper areas this may not occur within the 3-foot section. Locally the layer of muck is relatively shallow, and a yellow or grayish-yellow clay, containing some sand and gravel and very much lime, is encountered above the 3-foot depth. Sand occurs below the Peat within the 3-foot section in a few places.

Peat is developed in depressed lakelike areas throughout the upland and has a flat or slightly billowy surface. It supports a growth of wild grasses, and, where drainage has not been effected, water-loving plants. A few trees, mainly cottonwood, grow here and there.

Peat itself consists of plant remains that have accumulated under conditions not favorable to decomposition. These areas at one time

were covered with water and supported a luxuriant growth of water-loving plants, which, as they died, fell to the bottom, and because the water excluded air they did not decay. This accumulation of undecayed vegetable matter, when the water is removed, constitutes what is known as Peat. Areas that have not been drained often remain under water a large part of the year.

Peat is distributed rather generally over the entire county, but occurs most extensively in the eastern part. The largest area in the county and probably the largest in the State of Iowa occupies the south-central part of Iowa Lake Township and includes approximately 1,000 acres. The depth of the Peat over this area is variable, ranging from 14 inches to 5 feet. Old settlers recall occurrences of fire in this deposit which burned for months at a time. The underlying material here is a yellowish clay containing some sand and gravel and much lime. Other rather large areas occur in Jack Creek, Denmark, and Swan Lake Townships.

Peat is seldom if ever sold alone, as it forms only parts of farms. It has a relatively low value.

Peat is utilized mainly as pasture land, very little being devoted to cultivated crops. Sugar beets appear to grow well on shallow Peat, and other crops which may be grown include celery, potatoes, cabbage, lettuce, and onions.

Drainage is the first matter to be given attention in reclaiming Peat. This must be very thorough in order to insure the immediate removal of water during the heaviest rains. When such drainage has been established, the ground should be seeded to some good mixture of grasses, preferably alsike clover and timothy, and pastured quite heavily, as the stock will add manure and help to compact the soil. The deep-rooted clover will reach into the true subsoil below and secure from it the mineral plant food in which the surface Peat is lacking. Deep plowing, fall plowing, and deep and frequent cultivation will assist in bringing about a more rapid decomposition of the fibrous material.

MUCK.

The surface material of Muck is a layer of black, smooth-textured organic matter, containing a relatively small proportion of fine soil particles, but not enough to modify the texture, and extending to a depth of about 16 inches. The subsoil is a black silty clay to clay loam, high in organic matter. In places some gray color is present in the lower subsoil.

Some variation is found in the areas mapped as Muck. Locally the surface layer of Muck extends through the 3-foot depth. This is particularly true in areas occurring on terraces within areas of the

Sioux or O'Neill soils. These are evidently accumulations in what was formerly a bed of the river when the first bottom was at that elevation. These areas are poorly drained and swampy, and support a luxuriant growth of bunch grass and water-loving plants.

The substratum is also somewhat variable. In most places the heavy, waxy, black, or dark-drab silty clay to clay loam is encountered, but locally the underlying material is a gray calcareous sand, or a calcareous yellow clay containing some sand, gravel, and, in a few places, fresh-water shells.

The comparatively shallow areas of Muck have a greater agricultural value than the deeper ones, or Peat. Muck is merely Peat in an advanced stage of decay, and requires practically the same treatment to be made productive—that is, thorough underdrainage, deep plowing, deep and thorough tillage, and selection of suitable crops. Many drained areas support a good stand of wild grasses and are utilized for pasture or the production of hay.

Muck occurs over the entire county in pondlike or lakelike depressions in the upland, and bordering drainage ways. The topography is flat. The most extensive areas occur in former lake beds, including those of East Swan Lake in Swan Lake Township, and Ryan Lake in Center Township.

This soil does not form entire farms and is sold in connection with the surrounding types. It is difficult to state a definite price for this soil, but its value is relatively low.

MEADOW.

Meadow, as mapped in Emmet County, includes the two types of bottom land usually mapped as Riverwash and Meadow. Riverwash comprises areas of first-bottom land consisting of variable material, from a clay loam to pure sand, in which there is no uniformity of surface or subsurface. It is subject to periodic inundations and frequent changes in the material deposited. These changes may occur several times during a season. It supports little or no grass growth, but bears some full-grown trees and saplings. Usually it has a surface accumulation of sand, gravel, or flood trash, deposited upon recession of the flood water.

Meadow includes areas of first-bottom land composed of soils of many types and series, which occur in such small areas and are so interlaced and variable that they could not be separated on the map. The areas are subject to overflow, but support a growth of wild grasses and are utilized largely as pasture.

GRAVEL PITS.

Gravel pits comprise areas that have been dug over to obtain materials, mainly for road building and railroad ballast. Two

pits are mapped in the suburbs of Estherville. The largest pit is situated in sections 29 and 32 of High Lake Township. In this pit the gravel is loaded with a steam shovel and hauled out over steel rails. These areas in their virgin state were occupied mainly by the Sioux fine sandy loam.

Many other pits, too small to show on the map, occur within areas of types of the Sioux and O'Neill series on the terraces, and on knolls of the Pierce fine sandy loam in the upland. Many of the pits on private farms are a source of considerable income to the owner.

SUMMARY.

Emmet County, Iowa, is located in the northern tier of counties and the fourth from the western boundary of the State. The total area, excluding lakes, is 393 square miles, or 251,520 acres.

The topography varies from nearly flat or undulating to rolling, with some strongly rolling country along most of the West Fork Des Moines River and continuing west in Twelve Mile Lake Township. The western part of the county is somewhat more rolling and has a higher elevation than the part east of the West Fork Des Moines River. Rather extensive high-terrace lands are developed along the West Fork Des Moines River. First-bottom lands occur along this and other streams in the county.

The elevation of Emmet County ranges from 1,200 to 1,400 feet above sea level, the greater part lying between 1,240 to 1,350 feet.

The county is drained by the East and West Fork Des Moines Rivers and their tributaries. Natural drainage is good in the more strongly rolling country, but a large part of the county needs artificial drainage.

The population of Emmet County in 1920 was 12,627, all classed as rural except 4,699, the population of Estherville. The principal towns besides Estherville are Armstrong, Ringsted, Dolliver, Wallingford, Huntington, Gruver, Maple Hill, Gridley, Halfa, and Raleigh.

Railroad facilities are good, as are also the main highways, which are largely gravel. Schools and churches are sufficient to serve the needs of the county and there are several consolidated schools.

Chicago and Minneapolis are the chief outlets for farm products.

The climate of Emmet County is temperate, with cold winters and hot summers. The growing season averages 145 days. The mean annual temperature is 44.8° F. and the average annual precipitation is 31.80 inches. Rains are well distributed for crop growth.

The agriculture of Emmet County consists mainly in the growing of corn, oats, and hay for consumption on the farm and for sale, the raising of hogs and some beef cattle, and dairying.

Although many farm houses are well built, the majority of them are not in keeping with land values. Barns are usually well constructed, and there are over 220 silos in the county. Modern machinery is in general use. Horses furnish most of the motive power, although there were 125 tractors in the county in 1920.

Crop rotations are practiced by the better farmers, and manure is returned to the fields, but very little commercial fertilizer is used.

The size of farms varies from 80 to 360 acres, with an average size in 1920 of 194.5 acres.

Farm laborers have recently been scarce and wages high. Present (1920) conditions, however, indicate a decrease in wages and a more plentiful supply of help.

Farm lands sell at prices ranging from $80 to $300 an acre, the price varying with type of soil, location, drainage, and improvements.

Emmet County lies within the glaciated region, and the upland soils are developed through weathering from the underlying Wisconsin drift. The soils may be divided into upland glacial soils, terrace soils, and first-bottom soils, as well as Muck and Peat. Fourteen soil types, embraced in eight series, and Meadow, Peat, and Muck, comprise the soils of the county.

The Clarion, Webster, and Pierce soils are derived from till and are found in the upland. The terrace soils are included in the Sioux, O'Neill, and Waukesha series, and the first-bottom types in the Lamoure and Wabash series.

The Clarion loam, Webster silt loam, and Webster loam are the most important soils of the county. They are very largely under cultivation. The main crops are corn, oats, and hay. Hog raising, the feeding of a few beef cattle, and some dairying comprise the chief live-stock industries.

The terrace soils of the Sioux and O'Neill series are underlain with gravel and suffer for want of moisture in dry years. The low first-bottom soils are fertile but poorly drained.

The soils of Emmet County are relatively fertile, and their productivity can be maintained successfully by a system of soil management involving deeper plowing, more thorough cultivation, crop rotations in which leguminous crops are given their proper place, the incorporation of manure and crop residues, and thorough drainage.