SOIL SURVEY OF WOODBURY COUNTY, IOWA.

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DESCRIPTION OF THE AREA.

Woodbury County is located in the western part of Iowa. The Missouri and Big Sioux Rivers form the western boundary and separate the county from Nebraska and South Dakota. The bordering counties in Iowa are Plymouth and Cherokee on the north, Ida on the east, and Monona on the south. The area of the county is 877 square miles, or 561,280 acres.

Situated in the western part of the Upper Mississippi Plains region of the United States, the county, physiographically, is part of a high plain which has been greatly modified by stream erosion. The Missouri River has excavated a deep, broad valley, and owing to the elevation of the region, tributary streams have actively eroded and changed to a hilly country what probably was originally a smooth or nearly level constructional surface formed by the deposition of a sheet of silt during the Pleistocene period.

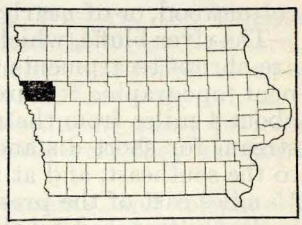

FIG. 22.—Sketch map showing location of the Woodbury County area, Iowa.

There are three prominent topographic divisions in the county: (1) The upland plain, (2) the alluvial plain of the Missouri River, (3) the Missouri River bluffs.

The upland plain has a general elevation of 1,300 to 1,400 feet above sea level and an elevation of about 300 feet above the Missouri River. Throughout the upland the larger streams, which have developed innumerable branches, have excavated deep valleys, so that the country has a hilly or strongly rolling surface. So complete has been the dissection by streams that few level stretches remain. The hilltops or ridges, however, are rounded, the slopes are generally smooth, and the topographic features in general present a softened outline, owing to the uniformity and the soft, unconsolidated nature of the loessial material through which the streams have cut their courses.

The alluvial plain or lowland traversed by the Missouri River lies about 300 feet below the upland and has a general elevation of about 1,100 feet above sea level. The plain has been formed from material

[1] The soils on the uplands were mapped by Angell, Warner, and Gray, during the summer of 1919, Angell being in charge. The bottomlands were mapped by Veatch and Orrben in the autumn of 1920, Veatch being in charge. The report was written by Veatch and revised by the inspector of the soil survey and by Mr. O'Neal, of the Iowa Station.

carried and deposited by the Missouri River. The surface now lies about 20 feet above the low-water stage of the river and is above overflow. The plain is so recent and has such a low elevation with reference to the river that its surface has undergone scarcely any modification. The topography is smooth, or even monotonously level in part, and on the whole is in striking contrast to the dissected upland. The only surface irregularities are crescent-shaped or long, narrow depressions, bordered in places by low swells of sand, representing the location of abandoned channels of the river. By a process of lateral cutting and deposition, the Missouri River is forming at present a lower plain within the older and higher alluvial plain. On the outer or convex side of the bends, where the high banks overlook the river, the strong current rapidly undermines the banks, and large sections fall away into the water. By a continuation of this action over a long period of time the river has formed a channel plain from 1 mile to 2½ miles in width. Over this plain the river is constantly shifting its course. The part of it not occupied by present channels lies only 3 to 8 feet above normal low-water stages, and is usually covered with water during high floods. The land consists either of flats of silty mud and hummocky stretches of sand which are covered with a dense growth of willow and scattered cottonwood, or of nearly barren wind-swept sand bars.

The river bluffs, which separate the alluvial plain from the upland, are abrupt escarpments 200 to 300 feet high and constitute a prominent topographic feature. At the northern county line the bluffs are about 4 miles from the river, while near Sioux City they border the stream for short distances. South of the city the bluff line swings to the southeast, and at the southern border of the county it is about 15 miles east of the present channel of the river. The bluff country is deeply trenched by the larger streams emerging from the upland and has been carved into deep ravines and sharp ridges by the erosive action of storm waters. Viewed from the alluvial plain, the abruptness of the rise in elevation, the succession of sharp ridges, the serrate crest, the treeless condition, and the atmospheric conditions combine to produce an illusion of magnitude and the appearance of a desert mountain range.

The entire drainage of the county flows into the Missouri River. The general slope of the upland plain is southward and the main streams flow in this general direction. Stream branches or natural drainage courses extend into every part of the upland and provide thorough drainage. In fact, in a part of the county the run-off is exceedingly rapid and causes much washing of the top soil. The bottomland plain is nearly level or flat and is traversed by only a few sluggish, winding streams or sloughs. Much of this plain, particularly that part which is underlain by heavy impervious clay, is so poorly drained naturally that drainage ditches and tiling are necessary before crops can be grown successfully.

The population of Woodbury County, according to the census of 1920, is 92,171, of which 22.7 per cent is classed as rural. The urban population is centered at Sioux City. The farming population consists predominantly of native Americans. The foreigners and those of foreign parentage among the farming population are mainly Scandinavians and Germans.

The first settlement in this part of Iowa is reported to have begun about 1850, and a county was organized in 1853. The agricultural development in subsequent years was fairly rapid, and by 1890 practically all of the upland and all of the better drained part of the bottomland had been taken up for farming. During the last 30 years the increase in the rural population has been slight.

Sioux City, located in the extreme northwest corner of the area, is the county seat and largest town, with a population in 1920 of 71,227. Correctionville, with a population of 1,016, Moville with 878, Smithland with 321, Anthon with 783, Sloan with 608, Hornick with 296, Salix with 396, and Sergeant Bluff with 548 are other towns of importance. Bronson, Lawton, Pierson, Cushing, Oto, and Danbury are still smaller towns enjoying railroad facilities. There are a few small villages scattered throughout the county away from the railroads.

Agriculture is practically the only industry in the county, except in Sioux City, where stockyards, packing plants, grain elevators, and various manufacturing industries have been established. Sioux City is also a railroad center of importance.

The county has excellent railway transportation facilities, being traversed or entered at Sioux City by lines of the Chicago, Milwaukee & St. Paul, the Chicago & North Western, the Illinois Central, the Chicago, Burlington & Quincy, and the Great Northern. Public highways traverse all parts of the county and follow section lines where the topography permits. They are, however, ordinary earth roads, which become difficultly passable during rainy periods and during the spring months. The rest of the year they are kept in good repair by dragging.

Rural mail routes serve all parts of the county, and telephones are in general use. Schools and churches are conveniently located throughout the area.

Most of the farm products are marketed in Sioux City and in the other towns of the county.

CLIMATE.

The climate of Woodbury County is characterized by a low or moderate rainfall, by cold winters and short summers, and by mild temperature and clement weather in the late spring and in the autumn. The average humidity is not high. The area is situated on the eastern edge of the transitional or subhumid belt of country lying between the semiarid Great Plains and the humid central part of the Mississippi Valley region.

According to records of the Weather Bureau station at Sioux City, the mean annual precipitation is about 26 inches. Approximately 65 per cent of this falls during the months of May to September, inclusive, and the precipitation is mainly in the form of slow rains or showers and is rarely violent or torrential. Snowfall always occurs during the winters, but is not excessive, the annual mean being only about 30 inches.

The mean annual temperature is 47.1° F. For the winter months the mean is 19.3° F., but zero temperatures are common, and a minimum of −35° F. has been recorded. The average frostless period is from April 28 to October 2, but frosts have been recorded as late as May 21 and as early as September 13.

The frost-free season is sufficient for maturing the staple grain and forage crops, and, because the greater part of the rainfall is evenly distributed through the growing season, failures from drought are rare. The severity of the winter makes protection for stock necessary; it also limits the kinds of fruit that can be grown and reduces the yields.

The following table, compiled from the records of the Weather Bureau station at Sioux City, shows the normal monthly, seasonal, and annual temperature and precipitation in detail, by months:

Normal monthly, seasonal, and annual temperature and precipitation, at Sioux City.

[Elevation, 1,135 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1903).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	22.6	68	−28	0.74	0.32	0.21	5.4
January	15.6	63	−35	.55	.69	.06	6.2
February	19.8	75	−31	.55	.22	.66	7.9
Winter	19.3	75	−35	1.84	1.23	.93	19.5
March	32.6	88	−17	1.26	.03	1.85	5.4
April	48.5	98	13	2.77	.82	2.39	1.9
May	60.8	97	23	4.37	1.99	11.78	.1
Spring	47.3	98	−17	8.40	2.84	16.02	7.4
June	69.4	101	39	3.88	1.41	5.65	.0
July	74.2	107	41	3.61	3.69	5.57	.0
August	72.6	102	40	3.00	2.76	5.67	.0
Summer	72.1	107	39	10.49	7.86	16.89	.0
September	64.1	103	25	2.47	3.93	3.06	.0
October	51.1	92	10	1.79	.84	3.24	.3
November	34.3	77	−9	.97	.15	.96	2.9
Fall	49.8	103	−9	5.23	4.92	7.26	3.2
Year	47.1	107	−35	25.96	16.85	41.10	30.1

AGRICULTURE.

The agriculture of Woodbury County consists of the growing of staple grain and forage crops, combined with the raising and the feeding of live stock. The major crops are corn, oats, timothy and clover hay, alfalfa, and wheat. The first four crops are largely consumed on the farms where they are grown, principally as feed for hogs and beef cattle. However, a variable proportion of these crops is always sold directly, the amount being determined by the prices of grain and forage and the condition of the live-stock market. Wheat is a source of cash income, as is also the oat crop in part, red clover seed, and potatoes. Barley and potatoes are the more important of the minor crops, while small fields of sweet clover, millet, saccharine sorghum, rape, and popcorn constitute some of the other minor crops.

The principal changes in the crops grown and in the systems of farming since the years from 1860 to 1880 have been variations in the acreage of wheat and an increase in the production of corn and the feeding of hogs and beef cattle. Alfalfa has greatly increased in acreage during the last 10 years and has become one of the more important crops of the county. Flax was a crop of some importance during the earlier period, but is not grown at all at present. Cattle ranches were operated during the earlier period of settlement, but soon gave way to farming.

Corn is the principal crop, both in acreage and in value. According to the census corn was grown on 163,278 acres in 1919, with a production of 6,104,089 bushels. The average yield on the upland, where the soil and topographic conditions are more nearly uniform, is about 40 bushels per acre. On the bottom lands, where there is greater variation in soils, the yields show a wider range, from 20 to 30 bushels on certain clay soils, or even less during the wettest seasons, to as much as 50 to 60 bushels on the better drained and naturally more productive land. Dent corn is grown almost exclusively. Reid Yellow Dent, including strains of this, is the principal variety, but white corn is also planted, apparently more on the bottom land than on the upland.

The greater proportion of the crop is fed to hogs and beef cattle on the farms. The common practice is to husk the ears from the standing stalks and then to turn the cattle and hogs into the fields to consume the fodder and the waste grain. Hogging down is also practiced.

Oats are grown on a majority of the farms; the grain is needed for the work stock, and the crop fits in well in a rotation including timothy and clover hay. It also serves as a nurse crop for alfalfa. The average yield on the more extensive soils is about 35 to 40 bushels per acre. On most farms there is commonly a surplus of grain for sale.

Until recently a mixture of timothy and red clover constituted the principal hay crop, but of late years this has been displaced to some extent by alfalfa and by red clover alone. Stands of red clover are usually obtained without special difficulty, except on the poorly drained land. A considerable acreage of wild hay is still cut from poorly drained clay land in the bottoms of the Missouri River. This consists of a coarse grass, a species of Spartina, and sedges, and is much inferior in feeding value to the tame hay.

Alfalfa is one of the more important crops. In 1919 it was grown on 24,602 acres, more than half the total acreage occupied by tame grasses, and yielded 62,052 tons of hay. Stands are obtained without difficulty when proper precautions are taken, and good yields are harvested on practically all the upland soils. It is also successful on the bottom lands, where they are well drained, and frequently replaces timothy and red clover there. Average yields of 3 to 4 tons per acre are obtained from 3 cuttings per season. The duration of stands is commonly about 5 years. In addition to its use for hay, alfalfa furnishes valuable pasturage for hogs. The crop is largely used on the farms where grown as feed for cattle, sheep, and work stock, but it is also a source of cash income, especially in years when it commands a high price.

Sweet clover, millet, and sorghum are forage crops of minor importance, grown only in small patches on a comparatively small number of farms.

Wheat, according to the census, occupied 21,375 acres in 1909 and 35,898 acres in 1919. The varieties grown at present are largely winter wheat, because spring wheat has failed lately owing to fungous diseases and other causes. Both the silt loams of the upland and the clays and clay loams of the bottomland are adapted to wheat. The yields reported during the last few years average about 20 bushels per acre.

Barley was grown on 14,238 acres in 1909, but occupied only 1,341 acres in 1919. Practically all the grain is consumed on the farms as feed for hogs and cattle.

Potatoes are grown on a large percentage of the farms for home use and the supply of local markets, but nowhere do they constitute a major cash crop. The potatoes produced on the silt loam of the upland and on the better drained sand and silt soils of the bottom land are of excellent quality. The yields average about 80 bushels per acre, but could doubtless be greatly increased if special attention were given to culture.

The orchard fruit grown consists mainly of apples, but plums and cherries are also grown with a fair degree of success. The varieties of fruit grown and the yields obtained are limited by the severity of the winter climate. Only a few commercial orchards have been planted.

Common garden vegetables are grown for home use, and the local markets are partly supplied. There has, however, been no development of truck growing as a specialized industry.

The raising and feeding of hogs is the most important live-stock industry. On practically all of the farms hogs are depended upon for a part of the cash income and on some farms they are the chief source of income. Corn is used for fattening, while alfalfa, and, to a less extent, rape and clover, furnish pasturage. The leading breeds are Poland-China, Duroc-Jersey, and Hampshire.

Cattle feeding is carried on by a majority of the farmers. A large proportion of the cattle fed are purchased during the fall months from the ranges farther west and from the local stockyards at Sioux City. Corn, corn silage, and alfalfa hay are the principal feeds. A small number of farmers raise sheep or ship them in for feeding.

Dairying is carried on only to the extent of supplying the local demand for milk, and consequently the number of beef cattle greatly exceeds the number of cattle kept for milk.

The system of farming is essentially the same throughout the county, and the raising and the feeding of live stock is the principal industry. There are some variations, however, in the system of farming and in the crops grown, which bear a relation to the soil and topographic conditions. On the uplands or hills, where the soil and topography are uniform over 90 per cent or more of the area, the methods followed and crops grown are practically the same on all the farms. In the bottoms, where there is a wider range in the texture of the soils, from clay loams and clays or "gumbo" to sands and silts, a larger proportion of the clay and silt soils on individual

farms is devoted to wheat, alfalfa, and red clover (without timothy), than on the silt loam of the uplands, and on many of the bottom-land farms corn and alfalfa are practically the only crops grown. Scarcely any wheat is grown on the sandy soils. It is realized that potatoes give the best quality and yields on the fine sandy soils and less compact silt loams and that orchards may be expected to produce the best results on the silt loam uplands. Corn is commonly planted in check rows on the upland, while on the bottom land it is more generally listed or drilled in. On the bottom-land farms crop rotations are not as consistently practiced, and in many instances corn has been grown several years in succession on the same land. This has been possible without serious reduction in yields because of the great depth and high fertility of the alluvial soils.

Most of the farms are provided with substantial dwellings and large painted barns, and the premises are generally well kept, especially on the farms operated by owners. Improved farm implements are used, and a good grade of work stock is kept on most farms.

Some crop rotation is generally followed, the principal exception being where corn is grown continuously on the same piece of alluvial land for several years. A common rotation consists of two years of corn, followed by oats, with which timothy and red clover or red clover alone are seeded. Corn, wheat, and alfalfa are also grown in rotation, the stand of alfalfa often remaining about five years. Oats usually serve as a nurse crop for alfalfa. Wheat is frequently drilled in between the rows of corn before the corn is harvested.

According to the census of 1920, there are 2,969 farms in the county, with an average size of 166 acres. The census reports 93.4 per cent of the total area of the county in farms, of which 89.1 per cent is classed as improved land. Owners operate 47.9 per cent of the farms, tenants 50 per cent, and managers 2.1 per cent. A system of cash rent, in which the rent fluctuates with the price of farm products and with land values, has been more common during the last few years than the share system.

The selling price of farms for the last four years has ranged from $100 to $150 an acre for the less desirable land, including the more hilly or broken sections of the upland, certain poorly drained clay land in the bottoms, and the more sandy land along the Missouri River, up to $300 to $400 an acre for the better lands. It is probable that in many instances the prices have been inflated beyond the actual productive value of the land, but the upland soils are generally highly productive and hence are held at rather high prices.

SOILS.

Woodbury County is located in the prairie region of the United States. In its original constructional form, the surface was smoothly rolling, a condition that existed for a considerable period before it was carved into its present form. This prairie condition, coupled with an adequate moisture supply, encouraged a luxuriant growth of grasses and weeds and the soils have been formed under the influence of this vegetation. The soils of the area, therefore, were originally high in organic matter, which gave them a dark-brown to almost black color. This condition still exists in the al-

luvial plain, where the erosional action of water has not been active, the dark-brown to black color extending to considerable depths. On the other hand, the uplands show the effect of leaching, and the surface covering is not so dark.

The soils of the area may, therefore, be grouped broadly into two main classes: First, those developed under conditions of good soil and subsoil drainage; and second, those developed under poor drainage conditions.

The soils of the first group embrace those types which predominantly have a profile consisting of a brown to dark-brown surface soil underlain by a lighter brown to yellowish-brown subsoil. This condition has been brought about by better aeration and a more thorough oxidation of the lower stratum. This group includes the Marshall silt loam, the most extensive type on the uplands, and various members of the Knox, Carrington, Waukesha, and O'Neill series. The Marshall silt loam and the Knox silt loam are loose and friable, the difference between surface and subsoil being only slight. The Knox soils show leaching to a less degree than the Marshall, since both surface soil and subsoil are calcareous. The degree of weathering and the effect of leaching become more pronounced as the distance from the Missouri River increases. The surface soil of the Marshall shows no effervescence when treated with acid, the carbonates having been carried down to lower depths. Lime concretions are quite generally found in varying quantities in the lower part of the 3-foot section. The Carrington soils show a still more advanced stage of leaching, as the carbonates have been removed to still greater depths except in a few local areas. The Waukesha and O'Neill soils belong to this latter subdivision, and their darker color is due to the fact that they were formed from alluvial deposits of dark-colored material which have been washed down from the darker-colored soils farther upstream.

The second group embraces the Wabash, Lamoure, Cass, and Sarpy series. Poor drainage has not favored leaching, aeration, and oxidation, and dark-colored soils have been formed, overlying dark-colored subsoils. The Wabash soils represent wash from the less calcareous soils of the uplands, while the Lamoure, Cass, and Sarpy soils come from the more calcareous soils bordering the bottoms. Even in the broad bottoms of the Missouri River the effect of leaching is observed in ditches, where there are concentrations of lime concretions at depths of 4 to 7 feet, the amount of calcareous material increasing with depth. The Sarpy soils represent more recent alluvium that has not accumulated as much organic matter as the adjoining types, and hence has a lighter color.

In making detailed soil maps the soils are classified on the basis of characteristics which are directly or indirectly of significance in the growth of plants and practical agriculture. The soil type is the unit of mapping. A soil series consists of soil types which are similar in origin, color, topography, structure. The types within the series differ from each other in the texture of the surface soil.

The dominant soil type on the upland is a dark-brown silt loam, underlain by a yellowish-brown calcareous heavy silt loam to silty clay loam. This soil, which is classified as the Marshall silt loam, nearly coincides in its distribution with the Missouri River loess.

The loess here is a formation of Pleistocene age, and was originally composed of grayish or pale-buff calcareous silt, mineralogically complex, porous, but retentive of moisture, and showing little or no stratification. Where exposed in bluffs and cuts it stands in vertical walls. This deposit forms a mantle 4 or 5 to more than 100 feet in thickness, overspreading a sheet of glacial drift. The Marshall silt loam represents the soil derived from this formation through weathering and other soil-forming agencies. However, the substratum, or that part lying beneath the soil proper, undoubtedly exerts some influence on the moisture content of the soil and therefore can not be entirely left out of consideration.

On many of the steeper slopes, where erosion is active, the soil is lighter brown and the unweathered loess is encountered at comparatively shallow depths. Land of this character has been mapped as the Knox silt loam.

The dark-brown soils, having a yellowish sandy clay loam to clay subsoil, and containing glacial bowlders, are classified in the Carrington series. These types have been influenced directly by the glacial drift which underlies the loess, and this drift is exposed in places at the bases of slopes inclosing the deeper valleys. The Carrington silt loam and a steep phase of the Carrington loam are mapped in this county.

The dark-brown or nearly black bottom-land soils, which become heavier in texture and more retentive of moisture at the lower depths, and contain a high percentage of organic matter, are classified as the Wabash silt loam and silty clay loam. These types consist mainly of material washed from areas of Marshall silt loam.

The soil mapped as Waukesha silt loam differs from the Marshall silt loam in the slightly more compact and retentive nature of the subsurface layer and from the Wabash silt loam in its yellow or yellowish-brown color at depths of 3 feet or less, indicating somewhat better drainage and aeration. This soil is developed on the terraces or second bottoms. Where gravel and sand are encountered at shallow depths the soil, which is otherwise similar to the Waukesha silt loam, has been classified as the O'Neill loam.

The dark-brown to black soils of the bottom-land plain traversed by the Missouri River are classed in the Lamoure and Cass series. In the Lamoure types the material is generally uniform or becomes heavier in texture and more retentive of moisture at the lower depths, but in places pervious sand and loose silt are encountered at depths of 3 or 4 feet. The Lamoure clay loam and clay are mapped. In the Cass types the texture becomes lighter and the structure more pervious at such shallow depths that the drainage, moisture content of the surface layer, and other soil qualities are influenced thereby. The Cass series is represented by the loam, fine sandy loam, and silty clay loam.

The lighter-colored soils of the bottoms (light brown, gray, or buff), which are generally underlain by layers lighter in texture and more pervious than the surface soil, are classed in the Sarpy series, represented in this county by the fine sand, very fine sandy loam, silt loam, and silty clay loam.

The larger part of the alluvium of the Missouri River bottom is moderately to highly calcareous, while the valleys of the upland

drainage ways are covered with older material which is less calcareous. The minute variations characteristic of alluvial formations, such as discontinuous layers, the alternation of thin layers of sand, silt, and clay, and abrupt changes in texture both horizontally and vertically, can not all be taken into consideration in the soil classification without going into impracticable and valueless detail. Therefore more or less generalization has been necessary, such as the recognition of only the dominant texture in an area, and the combination into one type of similar but somewhat variable textures.

The soils of the county as a whole are fairly well supplied with organic matter and are quite fertile. Probably less than 5 per cent of the county is unsuitable for cultivation because of steepness of slopes, or from other causes. Fine textures, silts and clays, predominate; and stony and gravelly soils and loose sands combined comprise not more than 1 to 2 per cent of the total area.

In the following table the actual and relative extent of the various soil types mapped in Woodbury County are given:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	328,064	58.4	Sarpy very fine sandy loam	4,480	0.8
Lamoure clay	52,928	9.4	Sarpy silt loam	3,392	.6
Wabash silt loam	34,112	7.3	Sarpy silty clay loam	3,072	.6
Colluvial phase	6,592		Cass silty clay loam	1,600	.3
Lamoure clay loam	32,704	5.8	O'Neill loam	1,600	.3
Carrington silt loam	28,544	5.1	Sarpy fine sand	768	.1
Waukesha silt loam	21,504	3.8	Wabash silty clay loam	640	.1
Knox silt loam	14,528	2.6	Cass fine sandy loam	128	.1
Carrington loam, steep phase	11,712	2.1			
Alluvial soils, undifferentiated	8,576	1.5	Total	561,280	
Cass loam	6,336	1.1			

MARSHALL SILT LOAM.

The surface soil of the Marshall silt loam is a brown to dark-brown mellow silt loam, 7 to 12 inches deep. This rests upon a brown, slightly more compact silt loam, which at 16 to 20 inches grades into a yellowish-brown to pale-yellowish, heavy, compact silt loam. The surface soil does not effervesce with acid, but the lower part of the 3-foot section is generally highly calcareous, lime concretions occurring in many places in the lower part of the soil profile. Except for local differences due to topographic position, the type is remarkably uniform in color, texture, and average depth of both soil and subsoil. The subsoil when dry often exhibits a columnar structure where exposed in road cuts.

The surface layer of brown to dark-brown soil varies in thickness according to the particular topographic situation, as much of the county is hilly or strongly rolling. A very dark-brown to almost black mellow loam is generally found at the base of slopes, attaining a thickness of as much as 20 to 30 inches, while on the steepest slopes or ridge tops most subject to erosion the dark covering is very thin or nearly absent, as is strikingly revealed by the light-brownish or yellow spots in freshly cultivated fields. Throughout the greater part of Union, Rutland, Arlington, and Banner Townships the relief is less pronounced than in other parts of the upland, and the surface

soil is deeper and has a darker color, varying from dark brown to very dark brown. In other interstream areas of the eastern third of the county this darker colored, deeper surface soil predominates, owing to the presence of more organic matter.

The Marshall silt loam is the most extensive soil type in the county. It occupies nearly 90 per cent of the upland and constitutes about 58 per cent of the total area of the county. The topography as a whole is strongly rolling or hilly, but with an absence of ruggedness. In the western part the main streams have excavated deep, broad valleys, and the slopes are furrowed by innumerable deep drainage swales. In the eastern part, except for narrow strips along the Little Sioux River, the country is less deeply dissected, so that undulating or gently rolling tracts are found. The natural drainage is everywhere thorough. Owing to the porous nature of the silty soil and substratum, permitting a ready absorption of rainfall, the run-off causes serious erosion or gullying only on some of the steepest slopes. The subsoil is retentive of moisture, and crops seldom suffer from excess moisture or drought.

Practically all the type has been placed under cultivation. Corn, oats, timothy and red clover hay, alfalfa, and wheat are the principal crops. The average yield of corn is 35 to 40 bushels; oats, 30 to 40 bushels; timothy and clover hay, 1½ tons; alfalfa, 3 tons; and wheat, 16 to 18 bushels per acre. The yields generally vary slightly on individual farms, being highest where the dark-brown surface soil reaches its maximum thickness at the base of slopes, and least on the steepest parts of slopes and on the tops of narrow ridges.

Considerable corn, oats, and hay is fed on the farms to the work stock and milk cows, and the remainder is generally utilized as feed for beef cattle and hogs. Only a small part of these crops is ever sold and shipped to outside markets, and then only during years when few cattle are fed and when feed prices are high. Wheat is the principal cash crop, and practically all except that needed for home use is shipped through elevators to outside points.

Crops of smaller acreage are rye, barley, sweet clover, sorghum, and potatoes. Gardens are maintained on every farm and help supply the demands of the home. Orchard fruits do better on this type than on the bottom soils.

A system of live-stock farming is carried on, and the staple crops are largely consumed on the farm as feed for hogs and beef cattle. A considerable number of farmers bring in cattle for feeding. The general practice is to buy these feeders at Sioux City late each fall, feed them a few months, and then resell to the stockyards at Sioux City. A large number of hogs are raised and fed each year. The breeds best liked are the Poland China and Duroc-Jersey. Dairying is practiced mostly to supply the home demands, except in the vicinity of Sioux City, where the demand makes it a profitable industry.

The soil has a mellow, loamy structure, so that plowing is not difficult and a good tilth is easily maintained. Water is absorbed rapidly, so that tillage is not long delayed by rains, yet the soil is retentive of moisture, owing to its fine silty composition, and crops rarely suffer severely during dry weather. The strongly rolling or hilly topography increases the labor and expense of cultivation and

harvesting, as compared with level land, but this is perhaps the only objectionable feature, since the soil is productive and adapted to practically all the crops that can be grown under the climatic conditions.

The average selling price of land at present (1920) is about $250 an acre, with prices ranging higher or lower according to location and improvements.

Crop rotations are practiced only in a general way. Corn is grown from two to four years, followed by oats or winter wheat for one year. After the small grain has been harvested the land is generally seeded to timothy and clover. A growing practice, however, is to sow alfalfa with the small grain, which serves as a nurse crop, and where this is done the land is left from four to six years in alfalfa before returning it to corn.

The steepness of many of the slopes causes them to wash and gully badly. Contour plowing, and, in extreme cases, terracing would prove a great help, not only in preventing excessive erosion but in preserving the fertility. Deeper plowing and better preparation of the seed bed is also very necessary for best results. The use of more definite crop rotations in which legumes, such as red clover and alfalfa, are grown as partial green-manuring crops, is strongly recommended.

KNOX SILT LOAM.

The surface soil of the Knox silt loam, to a depth of 8 to 12 inches, is a light-brown to brown, mellow, friable silt loam. It varies somewhat in color in proportion to the content of organic matter, being lighter on the steep eroded slopes and darker and deeper on the more nearly flat areas and on the lower parts of slopes. The subsoil is a yellowish-brown or pale-buff, loose, friable silt loam, practically equivalent to the parent loess. The subsoil is always sufficiently calcareous to effervesce with acid, and in many places the surface soil is also highly calcareous.

The Knox silt loam is developed mainly on the bluffs bordering the bottoms of the Missouri River and includes deeply furrowed slopes. As the areas follow slopes, winding valleys, and eroded ravines, they are rather irregular in shape. Most of the areas mapped are narrow, but in several places they are wider and cover several square miles. One of the largest areas occurs in the extreme northwest corner of the county, another lies northeast of Sergeant Bluff, and a third in the southern boundary of the county between Hornick and Smithland. Several small areas are mapped in the northeast corner of the county in Rock Township.

The greater part of the land is too broken and steep for successful cultivation and is used only for pasture, but there are some areas of smooth land of sufficient size for farms. The greater proportion of the tillable land occurs in the broad areas, where the slope from the lowlands is more gradual than on the narrow bluffs.

Corn, oats, and wheat are the principal crops grown. Crops of smaller acreage are potatoes, alfalfa, vegetables, and small fruits. Yields are usually lower than on the Marshall silt loam. The type is adapted to a wide range of truck and fruit crops, and part of the type might be used to advantage for vineyards and orchards.

The greatest difficulty in managing this soil is the prevention of erosion, since gullies started along the bluff extend with great rapidity into the smooth land. The best means of checking erosion is to stop the gullies as soon as they begin to form. If the land is cultivated, contour plowing should be practiced wherever possible. Terracing would be of great help in preventing wash and conserving the fertility of the land. The steeper slopes should be left in pasture, but even in pasture they slide and gully badly

CARRINGTON LOAM, STEEP PHASE.

The Carrington loam, steep phase, consists of a dark-brown mellow loam changing at a depth of 7 to 10 inches into a lighter brown loam, which grades into a yellowish mixture of sand, gravel, and clay at depths of 2 to 4 feet. The substratum is glacial drift, consisting of sand, gravel, bowlders, and stiff sandy clay. Gravel and bowlders are occasionally scattered over the surface.

The soil is fairly well supplied with organic matter, except in gullied areas and on the steepest slopes. In places the lower subsoil has a moderate supply of lime, and a number of tests with acid showed effervescence. This characteristic, however, was not common enough to justify changing the type to Clarion loam or to warrant the separation of areas of this type.

The steep phase of the Carrington loam occurs on the lower parts of slopes bordering the deeper stream valleys, where streams have cut deep enough to reach the glacial drift which lies beneath the loess. The upper part of the soil profile, therefore, consists of a mixture of loessial and glacial material.

This land is prevailingly strongly rolling, rough, and broken. The slopes are generally rough and steep. Drainage is good and in places excessive, the rapid run-off generally causing destructive erosion.

The principal areas occur along the Little Sioux River in the eastern part of the county. Where not too steep or gullied, generally along the lower slopes, the land has been placed under cultivation. A few areas are in forest, consisting mostly of oak, elm, ash, basswood, and maple. The more gentle slopes are utilized for the production of corn, oats, and timothy and clover. These crops are all fed on the farms. As the larger part of this type is rough and not suitable for cultivation, it is devoted to pasture, and in most places affords excellent grazing for a considerable period each year. Small fruits and apples are grown and give better results than in some of the smoother lands.

The Carrington loam, steep phase, is handled in practically the same way as the Marshall silt loam, but owing to its rougher topography cultivation is more difficult and the use of improved farm machinery is not so practicable. This soil is not as valuable as the Marshall silt loam, with which it is closely associated, and the yields are correspondingly lower. Blue grass grows well and the steeper slopes should always be left in sod. The improvements recommended for the Marshall silt loam will apply equally well to this type.

CARRINGTON SILT LOAM.

The surface soil of the Carrington silt loam is a dark-brown silt loam 6 to 10 inches deep, similar in all apparent characteristics to the surface soil of the Marshall silt loam. The soil passes gradually into a brown heavy silt loam, then at from 14 to 16 inches into a brown or yellowish-brown silty clay loam containing some gravel and a few glacial bowlders. The entire soil section is well leached and oxidized, and practically all the lime has been removed. In some places glacial drift, consisting of a yellow mixture of gravel, sand, and clay, is encountered at depths below 2 feet, and the substratum below 3 feet continues a sandy and gravelly drift of variable composition. Some of the borings showed the presence of lime in the lower part of the 3-foot section, but such areas were local and not characteristic of the type as a whole. The dark-colored surface layer varies greatly in thickness even within short distances. The rolling topography has favored such active erosion that the dark-colored surface soil filled with organic matter has either not developed to any great depth or it has been removed almost as rapidly as it was formed. The dark-brown soil usually ranges from 6 to 10 inches in depth, but in eroded areas it may be thinner or entirely absent.

The Carrington silt loam occurs on the slopes of the deeper stream valleys in the eastern and central parts of the county, the greater part of it being found along the slopes of the Little Sioux River and its larger tributaries. The type is developed where the loess has been wholly or partly removed, so that glacial drift is included within the 3-foot section. As the known drift in this region contains much coarse material, it is believed that the silty surface soil is derived from loess or, in places, from silty material washed down from higher land and deposited over the slopes. The substratum is glacial till very little altered in texture or structure.

The Carrington silt loam is prevailingly moderately rolling to rolling. The slopes are as a rule smooth and less steep than on the Carrington loam, steep phase. Drainage is good and sufficient for all needs and in the rougher areas is inclined to be excessive. The subsoil is retentive of moisture, and crops seldom suffer from drought.

The larger part of the type is devoted to agriculture, the only tree growth consisting of a few groves of oak, maple, elm, and ash, and the windbreaks of maple, cottonwood, elm, and evergreens which have been set out to the north and west of farm buildings.

Land of this type is used principally in the production of corn, oats, wheat, timothy and clover, and alfalfa, with the largest acreage in corn. All the corn, oats, and hay is used on the farms as feed. Wheat constitutes the principal cash crop, and practically all of it is sold to the elevators and shipped to outside markets. The live-stock industry consists of the raising and feeding of a few head of hogs and cattle each year. A few milk cows are kept on each farm to supply the home demands. Small gardens are planted by all the farmers, and excellent yields of all the vegetables adapted to this climate are obtained. The few orchards observed were in excellent condition.

In general the type is not as productive as the adjoining Marshall silt loam. Corn yields 25 to 35 bushels per acre; oats, 27 to 35 bushels; wheat, 12 to 15 bushels; and hay, 1 to 1½ tons.

The methods of handling this soil type are practically identical with those employed on the Marshall silt loam. The only difference is that the rougher land is left in pasture, as it erodes too badly when put under cultivation. In such areas blue grass affords excellent pasturage.

Deeper plowing at right angles to the slopes should be practiced to retard erosion, and on the rougher areas terracing would no doubt prove very beneficial. A more definite system of crop rotation is recommended, and when possible green-manure crops should be turned under to conserve and add to the supply of organic matter.

Land of this type is valued at $175 to $200 an acre, according to location and improvements.

WAUKESHA SILT LOAM.

The Waukesha silt loam consists of a dark-brown moderately compact silt loam, grading through lighter brown heavy silt loam to clay loam into yellowish, compact, stiff or plastic silty clay loam. The dark-brown color extends from the surface to depths of 12 to 24 inches, and the lighter brown clay loam extends to depths of 24 to 36 inches. The principal physical difference in profile between this type and the Marshall silt loam of the uplands is a more compact or plastic structure at a depth of 2 or 3 feet.

This type occurs in the valley of the Little Sioux River on nearly level or gently sloping alluvial terraces lying 20 to 50 feet above the river. In other places it is derived from alluvium or valley-filling material essentially the same as that of the Wabash silt loam, but the land has a little stronger slope or lies a little higher above the streams and hence has somewhat better natural drainage than that mapped as Wabash. In still other places, notably near Moville and Climbing Hill, it does not appear to be anything more than a topographic phase of the Marshall silt loam. In the vicinity of Moville it is a high eroded terrace, and in several road cuts and borings small lime concretions were observed in the lower part of the 3-foot section.

Practically all the type is under cultivation. All the general farm crops common to the county are grown, and the yields apparently are about the same as on the Marshall silt loam. Corn occupies the largest acreage and is the most important crop. Oats and wheat come next, in the order named. Hay occupies a considerable acreage and consists mostly of clover and timothy grown separately or together, and of alfalfa. Barley and rye are minor crops. All the grain except the wheat is fed to stock. A few hogs and beef cattle are raised and fed on most of the farms each year. Dairying provides only for the production of enough milk and butter for home consumption, except in a few instances, where the surplus is sold to creameries.

The methods of handling the soil are similar to those employed on the Marshall silt loam. The more level topography makes the use of farm machinery much easier. The same general rotation of

crops is in use, except that wheat takes the place of oats, as it seems to be a more profitable crop on the terraces than on the uplands. Alfalfa is generally cultivated once a year with a spring-tooth harrow to destroy weeds and grass.

Commercial fertilizers are not used. Manure is applied whenever it is available and is usually scattered over the grassland just before plowing in the fall.

The methods used for improvement of the Marshall silt loam can be applied equally well to this type. In a few places tiling would improve the condition of the soil. The price of land of this type ranges from $200 to $250 an acre.

O'NEILL LOAM.

The O'Neill loam consists of 10 to 15 inches of brown to dark-brown fine silty loam, underlain by a yellowish clay loam or friable sandy clay, which is more compact and retentive than the surface soil. A pervious substratum of unconsolidated sand and gravel is reached at depths of 2 to 2½ feet, and this constitutes the principal physical difference in the profile from that of the Waukesha silt loam. In places some soil is included which contains more sand and approaches a fine sandy loam.

Except in a few small local areas this soil is not calcareous, and on the whole does not contain as much organic matter as the associated Wabash silt loam, Marshall silt loam, and Waukesha silt loam.

The O'Neill loam is relatively inextensive and is confined to the terraces of the Little Sioux River, the largest area being found about 2 miles south of Correctionville. The surface is level to gently sloping and occupies a position high enough above the general level of the first bottoms to insure sufficient drainage. During dry years the type is inclined to be droughty.

A large part of this type is in cultivation. The principal crops are corn, alfalfa, and red clover, with the largest acreage in corn. Small grains are also grown, but because of frequent poor yields they occupy only a small acreage. Millet, sorghum, pop corn, and potatoes are grown on a small scale. A few hogs and cattle are kept.

Crop yields are variable, owing to the droughtiness of the soil. During wet seasons, however, the yields compare favorably with the best yields on the uplands, corn averaging 35 to 40 bushels per acre and oats 35 to 40 bushels.

The O'Neill loam is handled in practically the same way as the Marshall silt loam, except that the land is generally broken in the fall. Stable manure is used when available.

The price of land of this type is not as high as that of the adjoining Waukesha silt loam, averaging $150 to $200 an acre, according to improvements and location.

Deeper plowing and the incorporation of more organic matter in the soil is essential for better crop yields. The use of crop rotations in which legumes are used would also prove beneficial.

WABASH SILT LOAM.

The Wabash silt loam consists of a dark-brown to nearly black mellow silt loam, which grades at 10 to 16 inches into a more clayey

and less pervious material, generally a slightly plastic silty clay loam. The distinguishing characteristic of the soil is the depth to which the dark color, indicating a high content of humus, extends. The silt loam texture extends to depths ranging from 10 inches to as much as 3 feet, and the dark color derived from organic matter extends to 3 feet or more. Beginning at depths of 2 to 4 feet there is a gradation through a dark slaty gray to the peculiar mottled gray caused by an excess of water and lack of aeration.

This soil comprises alluvium deposited in valleys within the upland plain. Much of it represents material similar to the alluvium of the higher bottom land along the Missouri River, and into this deposit the streams have cut narrow ditchlike channels 10 to 20 feet deep. The areas appear on the map as long narrow strips conforming to the courses of the streams. The topography of the land is nearly flat, or is very gently sloping from the outer edges toward the center or toward the stream occupying the valley. Some of the land is subject to overflow, but the greater part lies 10 to 15 feet above the streams and is seldom or never inundated. Most of it can be farmed without artificial drainage, but generally tiling or ditching would be beneficial.

The Wabash silt loam is an important agricultural type, and practically all of it, except a few of the more poorly drained spots, is under cultivation or in pasture. Only a few wooded areas were observed, the tree growth consisting mostly of willow, cottonwood, box elder, and ash.

Corn occupies the largest acreage, and the yields are often much greater than on the adjoining terrace and upland soils. The crop can be grown on the same land for years without any decrease in yield. A small proportion of the corn is ground for meal, part is used to feed the work stock and milk cows, but the bulk of the crop is used for fattening hogs and beef cattle for market. During years when prices are high and the number of feeders is small, considerable quantities of corn are shipped out. Alfalfa is a profitable crop when drainage conditions are good. Small grains are used very little in the general rotation, as they lodge badly. Native grasses grow rank on this type and furnish excellent pasturage. The main live-stock industries are the raising of hogs and the feeding of beef cattle and a few sheep. The feeders are usually bought late in the fall at Sioux City. Dairying is of minor importance except in the vicinity of Sioux City. In other parts of the area only a few milk cows are kept to supply the local demand. Gardens are maintained on most farms and help supply the home demands.

Corn on this soil yields from 40 to 60 bushels per acre, although much larger yields have been recorded where the land has been carefully cultivated. Alfalfa yields from 3 to 3½ tons per acre.

The Wabash silt loam must be handled under proper moisture conditions for best results. When too wet, the plow turns up large clods which bake and are difficult to pulverize, and when the soil is very dry it breaks into hard clods. Practically all of the land is plowed in the spring. The soil is generally broken from 4 to 6 inches deep with gang plows, and then disked.

Improved drainage is necessary for best results. Many of the drainage ways, runs, and creeks should be dredged out and straight-

ened. Deeper plowing and a more thorough preparation of the seed bed is recommended. The use of lime would no doubt prove beneficial.

The selling price of land of this type depends largely on its location, its physical condition, and the improvements, and averages from $75 to $150 an acre.

Wabash silt loam, colluvial phase.—The colluvial phase of the Wabash silt loam is a dark-brown silt which has accumulated, from creep or colluvial wash, at the base of the bluffs facing the lowland plain traversed by the Missouri River. It occurs in very narrow strips, a few hundred feet to one-fourth mile in width. The wash, which consists mainly of soil from the Marshall silt loam areas, is thickest next to the bluffs, then spreads out as a thin mantle over the older alluvium deposited by the river. Narrow strips not shown separately on the map also occur at the bases of valley slopes along practically all of the streams traversing the upland.

The soil is generally a brown to very dark brown mellow silt loam, 1 to 3 feet deep, underlain by a heavier silty clay loam, which in many places is black or at least darker than the surface soil. It does not give a basic reaction in field tests except at depths of 3 or 4 feet or where there is a surface covering of recent wash consisting of a buff-colored loess.

The phase apparently does not differ in any important respect from the typical Wabash silt loam. The natural drainage may be on the whole a little better, and none of the land is subject to overflow. The soil is fertile and produces excellent yields of both corn and alfalfa.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam consists of 16 to 20 inches of dark-brown to black silty clay loam containing a high percentage of organic matter. This rests upon a black heavy silty clay loam to silty clay, which at 24 to 30 inches grades into a heavy dark-gray to drab clay slightly mottled with rusty brown, the mottling increasing with depth. In a number of borings the black color extends to 3 or 4 feet without change, the only difference between surface soil and subsoil being that the lower part of the 3-foot section becomes heavier and more plastic.

The Wabash silty clay loam is confined to the bottoms of the Little Sioux River, the largest area being found just south of Anthon. The surface is flat or slopes very gently toward the streams, and drainage is inadequate. The type is subject to overflow.

The greater part of this type is devoted to pasture and supports an excellent growth of wild grasses. The only cultivated areas consist of a few of the better drained bodies that are farmed in association with adjoining types. Corn is the principal crop, and during years when drainage conditions are favorable the yields compare favorably with those on the Waukesha silt loam.

The Wabash silty clay loam is rich in plant-food elements, but the type is of little value until drainage is improved. The straightening and deepening of creeks and the tiling of fields are necessary for best results. Land values on this type are lower than the Wabash silt loam.

LAMOURE CLAY LOAM.

The surface soil of the Lamoure clay loam is a black to very dark brown silty clay loam, 12 to 18 inches deep. The subsoil is a drab to slate-gray, plastic, impervious clay. Small lime concretions are scattered throughout the soil section, the number generally increasing with depth, and the entire soil mass effervesces with dilute acid.

This type closely resembles the Lamoure clay, but is slightly lighter in texture and not quite so stiff and intractable under cultivation. In places the alluvial deposit consists of alternating layers of clay loam or clay and grayish or yellowish friable silt. A silt layer may be encountered at depths of 10 to 20 inches, and may vary in thickness from a few inches to a foot. Such areas, however, are of local occurrence and too small to separate on the map.

The Lamoure clay loam grades almost imperceptibly into the asociated types, so that in many places the distinction between this and the soils mapped as Lamoure clay, Sarpy silty clay loam, and Cass silty clay loam is arbitrary. Included with this type are areas of clay too small to separate.

The Lamoure clay loam is the second most extensive type in the Missouri River bottoms, and most of it occurs in fairly large areas. It has a nearly level surface and occupies a position about 30 to 35 feet above the normal water level of the Missouri River. Natural drainage is inadequate, except along the ditches and creeks.

Practically all the type is under cultivation. Corn occupies the largest acreage, with winter wheat, alfalfa, and oats coming next in the order named. Corn yields 35 to 40 bushels, wheat 18 to 22 bushels, alfalfa 3 to 4 tons, and oats 20 to 40 bushels per acre. A large part of the corn and practically all of the wheat is sold and shipped to outside markets. As most of the land is farmed by tenants, very few hogs are raised and the feeding of cattle is unimportant. A considerable part of the alfalfa is sold to the stockyards at Sioux City. Some farmers raise poultry and have a considerable income from the sale of chickens and eggs.

The tillage of this type is difficult, and care must be taken to plow it under proper moisture conditions. Wet weather often hinders cultivation, especially in the early spring. The land is plowed from 4 to 6 inches deep in the fall, and by freezing during the winter the clods are pulverized to such an extent that in the spring the surface is broken down to a practically smooth, well-prepared seed bed. When the clods have not disintegrated a disk harrow is used. The general rotation consists of corn and wheat. In most cases the corn succeeds itself for a greater number of years than on the uplands without showing a decrease in yield.

The Lamoure clay loam is naturally fertile, and its productiveness depends largely upon providing good drainage and following methods of tillage adapted to heavy soils. Ditches have been dug in a number of places, but more are needed. The tiling of fields is also recommended.

LAMOURE CLAY.

The Lamoure clay is a black stiff clay grading at depths averaging from 6 to 10 inches into dark-grayish or drab, highly plastic, imper-

vious clay. The very dark slaty gray color in general extends to depths of 18 to 24 inches, below which the color is grayish with splotches of the peculiar brownish iron oxide developed under conditions of poor drainage and aeration. The surface soil is not everywhere highly calcareous, but at shallow depths the clay effervesces freely when tested with acid, and large whitish nodules of calcium carbonate occur. This soil is strongly cohesive or gummy when wet and is locally known as "gumbo."

The thickness of the layer of alluvial clay is more than 3 feet and in many places is known to exceed 15 feet. Locally it contains thin layers, from 12 to 15 inches thick, of a grayish or yellowish friable silt. This peculiar structure is most conspicuous in the vicinity of Luton, but the areas were too small and variable to justify separate mapping.

A mucky variation of the Lamoure clay is found in two places, 2½ miles south of Bronson along the Dennison Highway and 2½ miles east of Hornick. Here the soil contains a much higher percentage of organic matter mixed with the clay, or even a layer of 2 or 3 inches of black muck on the surface, so that the soil is not quite so gummy and intractable. This soil occupies marshy depressions or depressions that were formerly marshy. Whitish shells of fresh-water gasterpods are abundant on the surface and mixed through the soil. After a year's cultivation these areas approach closely the Lamoure clay in appearance and value.

Another variation occupies the sites of recently-drained lakes or sloughs and recently-abandoned channels of the Missouri River. The soil in these areas has the same structure and calcareous nature as the typical Lamoure clay, but differs from it in having less humus and a lighter color. The difference appears to be due in part to development in permanently wet situations, and also to the fact that, in some places, the clay has been deposited so recently that a sufficient length of time has not elapsed for the accumulation of organic matter.

The type occupies broad flats and low-lying depressions in the lowland plain traversed by the Missouri River, and is the most extensive first-bottom type. It lies 20 to 30 feet above the present channel of the river and is free from overflow. Backwater, however, often prevents proper run-off. Drainage is naturally poor, owing to the flatness of the topography and the impervious nature of the clay. Main drainage ditches have been dug to make the land cultivable, but even with these the drainage is not thorough enough for the most profitable use unless supplemented by lateral ditches and tile drains.

Corn, winter wheat, and alfalfa are the principal crops grown. Corn yields on the average about 30 bushels, winter wheat 15 to 20 bushels, and alfalfa 2 to 3 tons per acre. Corn planting is frequently greatly delayed in the spring because of wet weather, with a resultant loss in yields.

All of the wheat and most of the corn and alfalfa are sold. The wheat is handled by the elevators and shipped to outside markets, while the corn and alfalfa are sold to the stockyards at Sioux City. On the few farms operated by owners considerable corn and alfalfa is fed to beef cattle.

It is estimated that 10 to 15 per cent of the type, including the more poorly drained land, still remains in a virgin condition. This

land produces good yields of wild hay consisting of coarse grasses and a species of sedge. The hay is baled and sold in the local markets.

Plowing and cultivation are nearly impossible directly after rains, and even under the most favorable moisture conditions heavy teams and powerful tractors are necessary for the proper turning of the soil. If plowed when too wet, the soil clods and becomes extremely hard, and a good tilth can not be produced. The addition of organic matter would doubtless improve the tilth, but thorough drainage is the step most essential in improving the soil.

The selling price of land of this type at present is about $125 to $200 an acre, depending upon drainage conditions and improvements.

CASS FINE SANDY LOAM.

The surface soil of the Cass fine sandy loam consists of dark-brown to very dark brown fine to very fine sandy loam 12 to 15 inches deep. The content of organic matter is high, as indicated by the dark color. The upper subsoil is lighter brown to yellowish brown, and the lower subsoil below 22 to 28 inches is a loose, pervious layer of fine sand or silt having a grayish-brown to pale-yellowish color.

The type is developed in the bottoms of the Missouri River. Only two small areas were mapped, the larger being found 3 miles northwest of Salix on the east side of the Chicago & North Western Railway. The topography is nearly level; the surface is a few feet higher than the adjoining areas of Lamoure clay, which insures sufficient drainage for ordinary purposes. The type is never overflowed.

The Cass fine sandy loam is devoted to the growing of corn, alfalfa, and wheat, and in ordinary years the yields compare favorably with those of the Lamoure clay loam. The loose, porous, calcareous substratum makes it a very desirable soil for growing alfalfa.

The type is handled in practically the same way as the Lamoure clay loam and the treatments recommended for the improvement of that soil will apply equally well to this type, except that drainage is not necessary in this case. Owing to its open porous structure the soil is well adapted to the growing of vegetables and all kinds of truck crops.

CASS LOAM.

The Cass loam consists of a dark-brown mellow loam, 12 to 16 inches deep, underlain by a lighter brown to yellowish-brown loam to silt loam, which in turn grades at from 20 to 24 inches through a grayish to pale-yellowish, loose loam into a layer of loose pervious fine sand and silt. The lower part of the 3-foot section in places consists of alternating layers of fine sand and silt. The surface soil is moderately rich in organic matter and not generally calcareous, while the lower part of the subsoil is highly calcareous, showing strong effervescence when treated with acid.

Included with this type are small areas of Cass fine sandy loam and silt loam too small to separate on the map.

The surface is smooth or nearly level, the type occupying low swells or ridges slightly higher than the associated clay loam and clay soils. In origin and topographic position it is similar to the Sarpy very fine sandy loam.

The Cass loam has a total area of about 10 square miles. The principal developments are near Salix in Liberty and Lakeport Townships. Salix is located on this type.

Practically all the land is under cultivation. It is a highly desirable soil for general farming because of the good natural drainage, high fertility, and ease of tillage. Corn and alfalfa are the principal crops, smaller acreages being devoted to oats and wheat. The yields obtained are equal to or somewhat above the average for the county.

The Cass loam is easily tilled and does not clod if plowed when wet. Corn is grown on the same land for a number of years, then wheat, after which corn again, or alfalfa. Very little manure is applied. The type is handled in about the same way as the Lamoure clay loam and the Wabash silt loam, and the methods suggested for the improvement of these types would no doubt prove beneficial for this soil.

Land of this type sells at from $100 to $150 an acre, according to the improvements and its location.

CASS SILTY CLAY LOAM.

The Cass silty clay loam is a dark-brown compact loam at the surface, grading into a silt loam at 10 to 20 inches and into looser and more pervious silt or very fine sand at depths of 30 to 40 inches. The layer of dark-colored material at the surface extends to depths of 6 to 10 inches, the color gradually changing with increasing depth to pale buff or gray. There is very little or no difference in topography or surface appearance between this type and the more widely distributed Lamoure clay loam. The presence of a layer of considerable thickness of silt or fine sand at depths of 3 feet or less, through its influence on subsurface drainage, may cause some differences not readily apparent in a field examination.

The type is developed in the first bottoms of the Missouri River, the largest connected areas being between Sergeant Bluff and Salix. The surface is level to very gently sloping. The drainage is much better than on the associated Lamoure clay loam and generally is sufficient except during very wet years.

The type includes a very few small areas of Cass silt loam and fine sandy loam too small to show on the map.

All the land is under cultivation. Corn, alfalfa, wheat, and oats are the principal crops. The corn, alfalfa, and oats are used for feeding work stock, milk cows, and the few hogs and beef cattle, and the surplus is sold. Wheat is the principal cash crop.

The Cass silty clay loam is handled in about the same way as the associated Lamoure clay loam.

SARPY FINE SAND.

The Sarpy fine sand comprises hummocks and low, narrow ridges of incoherent fine and medium sand in the bottoms along the Missouri River. Most of this is of recent deposition and is but slightly darkened at the surface by organic matter. The loose sand extends to depths of 2 to 10 feet or more.

This type is of small extent and comparatively unimportant. The largest areas lie at Brewers Lake and at Browns Lake; other small

areas are mapped near the river in the western parts of Liberty and Woodbury Townships.

Some of the land has been planted to corn and alfalfa. It is less productive than the finer-textured soils, owing probably to an inadequate supply of moisture during dry periods.

SARPY VERY FINE SANDY LOAM.

The Sarpy very fine sandy loam is alluvium composed principally of very fine sand and silt, loosely coherent and pervious, extending to depths of 3 feet or more. In places the soil is a little lighter in texture or contains a higher percentage of coarser particles, beginning at a depth of a few inches, but, on the whole, there is very little change in physical character within a depth of 3 or 4 feet. The colors are buff and grayish, which represent the colors of the alluvium as deposited. Some light-brown soil is included, this being found where the deposit is older and the surface has not been recently disturbed by flood waters or the shifting of the river channels, so that a thin layer of organic matter has accumulated. The soil is everywhere calcareous at shallow depths and in most places at the surface.

In the vicinity of Browns Lake the surface soil is a gray very fine sandy loam 20 to 24 inches deep, underlain by a gray to yellowish-gray fine silt.

This type occurs as low ridges and natural levees adjacent to the present and recently abandoned channels of the Missouri River. In places the surface is billowy or hummocky, just as it is on recently formed sand bars. The natural drainage is good, owing to the pervious nature of the soil and the free subsurface drainage, so that tillage is not greatly hindered by wet periods.

Wherever this land is accessible and in large enough areas, it has been placed under cultivation. Corn and alfalfa are the principal crops. In the lower lying bottoms the fields are irregular in shape because of sloughs and the constant cutting by the river, and in places the uneven hummocky surface detracts somewhat from the value of the land for agriculture. With the addition of organic matter, the soil should be highly productive. The soil is not subject to shifting by the wind to any serious extent, and is easy to plow and put in good tilth.

SARPY SILT LOAM.

The surface soil of the Sarpy silt loam consists of a layer of buff or grayish silt loam 6 to 8 inches deep, underlain by alternating layers of variable thickness of fine sand and silty clay. Generally a layer lighter in texture or more pervious in structure than the surface is encountered at shallow depths. This would be expected to decrease the supply of moisture in the surface soil, as it permits free internal drainage. However, the silt is retentive, and the low situation of much of the land results in some subsurface irrigation, so that crops apparently do not suffer severely during dry weather. Very little organic matter has accumulated at the surface. The soil is highly calcareous.

The Sarpy silt loam is of comparatively small extent and is confined to the first bottoms of the Missouri River, the largest body lying just west of Sergeant Bluff. It generally occurs as elongated areas parallel to the channel of the river. The surface of the type consists of a succession of small hummocks and ridges.

The greater part of the Sarpy silt loam is under cultivation, corn and alfalfa being the principal crops. Corn yields 30 to 35 bushels per acre, and alfalfa 3 to 3½ tons, in several cuttings. The crops are used almost entirely for feed on the farms.

This soil is in need of organic matter, and crop rotations in which green-manuring crops are included would prove beneficial. The type is handled in practically the same way as the Lamoure clay loam and the Wabash silt loam.

SARPY SILTY CLAY LOAM.

The Sarpy silty clay loam consists of a gray, buff, or very light brown silty clay loam, 4 to 10 inches deep, underlain to 3 feet or more by a grayish to light-brown fine sand or loosely coherent silt. It contains very little organic matter.

This type occurs in the lower lying channel plain, and to a less extent on the higher bottoms, but at no place does it extend back very far from the Missouri River. It occupies mainly low depressions which represent the sites of recently abandoned channels and the beds of former lakes or sloughs. These depressions are generally bordered or inclosed by narrow ridges or low hummocks of fine sand, so that in crossing the low bottoms transversely to the direction of the flow of the river there are encountered alternating narrow swales or basins of silt and clay and ridges of sand, and in places the different textures are so closely associated in small bodies that their separate mapping on the scale adopted is impracticable. Here the soil is an alluvial formation practically unchanged, the deposition being so recent that there has been no leaching out of the carbonate of lime at the surface and no considerable accumulation of organic matter.

The land in places is poorly drained and is subject to flooding during high stages of the river. Throughout the larger part, however, drainage is sufficient for all needs. Some of the type is so situated that it may again be occupied by the river, and is likely to be swept away by the action of the river in undermining its banks.

Corn and alfalfa are the principal crops on the land in cultivation, and fair yields are obtained. Wheat does better on this type than on the lighter textured soils.

Owing to the higher content of clay, more power is required in plowing and cultivation is hindered for a longer time after rains than on the silt loams and very fine sandy loams of the bottoms.

ALLUVIAL SOILS, UNDIFFERENTIATED.

A large aggregate area of waste land has resulted from the constant shifting of the channel of the Missouri River. This land consists of barren wind-swept sand bars which are covered with water during flood stages of the river, and also areas in the flood-plain

bottoms that have been very recently occupied by channels. Here the upper part of the original alluvial deposit has been swept away, leaving flats of gray silt and clay, over which sand has been blown or unevenly deposited by water currents. Much of this land is from 3 to 8 feet above the mean low-water stage in the river, and where accessible small bodies could be cultivated, but it is traversed by sloughs and is likely to be overflowed by the river with every flood. Most of it is covered with a dense growth of willows.

The alluvium is practically equivalent to soil, since it is capable of producing fair yields of the staple cultivated crops. The dominant textures are silt and fine sand, with smaller bodies of silty clay. The detailed separation of these on a map is a difficult task and at best would probably have only temporary value, as the river is constantly engaged in cutting away its banks and changing its course, and an uneven deposit of fine sand or silt is left after every flood.

SUMMARY.

Woodbury County is situated in the western part of Iowa. It comprises an area of 877 square miles.

There are three principal topographic divisions in the county: (1) An upland plain having a general elevation above sea level of 1,300 to 1,400 feet and characterized by a hilly or strongly rolling topography; (2) a broad, level alluvial plain or lowland traversed by the Missouri River, which lies about 300 feet lower than the upland plain; (3) the Missouri River bluffs, which form an abrupt escarpment 200 to 300 feet high separating the upland and lowland and constituting a narrow strip of rough broken land.

The upland plain is everywhere well drained naturally but is not subject to serious soil erosion, except on the steepest slopes, such eroded land constituting only a very small percentage of the total. The bottom land is level, and the greater part of the heavy soils requires artificial drainage.

The population of the county, according to the 1920 census, is 92,171, of which 22.7 per cent is classed as rural.

The mean annual precipitation is about 26 inches, of which about 65 per cent falls as rain from May to September. The average period between killing frosts in the spring and in the fall is 157 days. The winters are marked by extremely cold weather.

The agriculture consists of general farming combined with the raising and feeding of live stock. Corn, oats, wheat, timothy and red clover hay, and alfalfa are the principal crops, but a number of other grain and forage crops, minor in acreage, are also grown. The corn and forage crops are largely consumed on the farms where grown as feed for hogs and beef cattle, and to a less extent for sheep and dairy cattle. Wheat is a cash crop of some importance, especially on the clay and clay loam soils of the bottomland.

Modern methods of farming are practiced, and the condition of farms is generally good.

The soils of the county as a whole are productive. Mineral fertilizers are not needed for the production of profitable yields. Fine textures, silt and clay, predominate; stony, gravelly, and loose sand soils comprise not more than 1 per cent of the total area. Probably

less than 5 per cent of the total acreage of the county is unsuitable for cultivation because of steepness of slope and for other reasons.

The Marshall silt loam is the dominant soil type of the upland, constituting roughly 90 per cent of this division and about 58 per cent of the total area of the county. This is a dark-brown silt loam grading with depth into a yellowish-brown silt containing lime concretions. This is underlain by a deep deposit of calcareous silt. It is derived from loess. The soil is fertile, easily cultivated, and adapted to practically all staple crops which can be grown under the prevailing climate.

Soil types of the upland of less importance than the Marshall silt loam are the Knox silt loam, the Carrington loam, steep phase, and the Carrington silt loam. The Knox silt loam, which is developed mainly on the bluffs, is a light-brown soil derived from loess. The Carrington loam, steep phase, is a dark-brown soil containing more sand than the Marshall silt loam and characterized by yellowish sandy clay and layers of sand, gravel, and bowlders in the subsoil and substratum. Its textural and structural characteristics have been influenced by glacial drift. It is less productive than the Marshall silt loam, and the steepness of the slopes over much of the area detracts from the values of the land for farming.

The bottom-land soils along streams in the upland division of the county are the Waukesha silt loam and O'Neill silt loam on the terraces and the Wabash silt loam and silty clay loam in the first bottoms. The Waukesha silt loam differs from the Marshall silt loam in the slightly more compact and retentive structure of the upper subsoil. It is derived largely from alluvium washed from the loess soils. The O'Neill loam is similar to the Waukesha, but differs in that gravel and sand are encountered at shallow depths. The Wabash silt loam is a soil of alluvial origin, which in this county is largely confined to the bottoms in the upland division. It is very productive. The Wabash silty clay loam resembles the silt loam, but is slightly heavier.

The soils of the Missouri River bottoms are classified in the Lamoure, Cass, and Sarpy series. The Lamoure clay and clay loam together constitute by far the largest acreage. These are dark-brown to black, calcareous, and fertile soils. They are difficult to handle on account of their stiff, gummy nature when wet. Artificial drainage is required for their highest productiveness. The Cass loam is a dark-brown fine loam, underlain at shallow depths by fine sand or loosely coherent silt. The soil is productive, easily tilled, naturally well drained, and therefore a highly desirable soil for general farming. The Sarpy types comprise the lighter-colored soils, which are underlain by layers lighter in texture and more pervious than the surface soil. The fine sand, very fine sandy loam, silt loam, and silty clay loam types are mapped. The bottom soils are all productive. Corn, alfalfa, and winter wheat are the principal crops grown on these soils.