

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION,
C. F. CURTISS, DIRECTOR; W. H. STEVENSON, IN CHARGE SOIL
SURVEY; P. E. BROWN, ASSOCIATE IN CHARGE.

SOIL SURVEY OF WINNEBAGO COUNTY,
IOWA.

BY

W. E. THARP, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN
CHARGE, AND G. H. ARTIS, OF THE IOWA AGRICULTURAL
EXPERIMENT STATION.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1918.]



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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., February 2, 1921.

SIR: Under the cooperative agreement with the Iowa State College of Agriculture and Mechanic Arts, a soil survey of Winnebago County was carried to completion during the field season of 1918.

I have the honor to transmit herewith the manuscript and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1918, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. E. T. MEREDITH,
Secretary of Agriculture.

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MAP.

Soil map, Winnebago County sheet, Iowa.

SOIL SURVEY OF WINNEBAGO COUNTY IOWA.

By W. E. THARP, of the U. S. Department of Agriculture, In Charge, and G. H. ARTIS, of the Iowa Agricultural Experiment Station.—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Winnebago County is situated in the northern tier of counties of Iowa, about midway from east to west across the State. The county has an area of about 399 square miles, or 255,360 acres.

The western half of the county has a type of topography characteristic of the Wisconsin drift plain that covers a large area in north-central Iowa. This plain is the bed or path of a great continental ice sheet which left deposits smoothed and packed by the ice. The topography is nearly everywhere constructional—that is, the land forms are not produced by the sculpturing of the streams, but were built up by deposits from the ice so recently in geologic time that streams have not altered any considerable part of the surface. The topography varies from almost level to gently rolling. The hills and ridges are low swells in the landscape, with rounded lenticular contours. The general slope of the plain is toward the southwest, and several sluggish streams that have established drainage connections flow in that direction. These drainage ways along the greater part of their courses are not the result of erosion by the streams themselves, but are low belts between the hills and ridges of drift sought out and followed by the drainage waters. Some of the drainage courses are beginning to cut back and tap these depressions; others have as yet no outlet, except where artificial drainage has been provided. The few streams that have started find their way in most cases through the winding depressions in channels that are mere ditches. They have not deepened their own channels nor extended their ramifications sufficiently to drain the depressions through which they flow.

The drift plain type of topography passes rather abruptly into the morainic topography of the eastern part of the county. In this

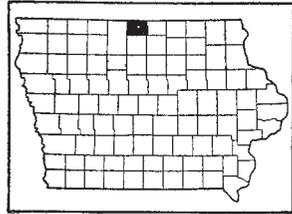


FIG. 1.—Sketch map showing location of the Winnebago County area, Iowa.

region the surface is strongly rolling to moderately hilly. East and northeast of Forest City and north of Lake Mills there are considerable areas of topography designated as "knobby drift." This type of topography is characterized by morainic hills and ridges with sharply rounded contours, produced by the dumping of glacial débris. The hills and ridges are irregular in distribution and have apparently no relation to one another. Drainage in this region is even more restricted than on the drift plain. The drainage channels are imperfect, consisting of long, irregular, winding sloughs and marshes. Only one stream, Lime Creek, cuts through the hills. In general, the drainage is so inadequate that it has been necessary to cut deep ditches before much of the land could be utilized. As land has become more valuable more of the poorly drained areas have been reclaimed. Large ditches, 10 to 15 feet in depth and width, afford channels where formerly the surface waters overflowed from one depression to another or escaped by evaporation. Many lakes and smaller ponds and muck beds have been drained by these ditches.

The valley of Lime Creek for 4 or 5 miles below the northern county boundary is an ancient lake bed from 1 to 2 miles in width. Across the eastern side of this wide depression the stream has developed a narrow, marshy flood plain only a few feet lower than the level lands to the west, which are thus left in slight relief and form a low terrace. The southeastern part of this terracelike plain is bounded by rather high "knobby" ridges, which also continue in a southeasterly direction toward the town of Lake Mills. The stream itself cuts through these hills and pursues a southerly course in a narrow valley which has no bench lands until Leland is reached. This village stands on a low terrace underlain by deep gravel beds. Somewhat similar second bottoms of limited extent occur along the western side of the valley for a few miles below the village. Here there is another low plain extending 4 or 5 miles to the west and averaging about a mile in width from north to south. Lime Creek flows across the extreme eastern end of this plain and enters the hills again just north of Forest City. Thence to the southern county boundary the flood plain is about one-fourth mile wide and bounded by uplands of moderate height.

Lower Buffalo Creek has a narrow flood plain, but practically all the other streams are without true alluvial deposits. Most of the stream channels have been canalized and are straight ditches that frequently cut through the lower slopes of ridges.

The creeks that have been mentioned, as well as the larger ditches, maintain their flow during the entire season. In all of them the waters after each rain are very dark, with sediment derived from the surface soils of adjoining fields.

Lake Harmon is under State supervision and will be preserved.

A considerable part of the extreme eastern end of the county was formerly timbered. There were many groves in which bur oak predominated and larger areas on which this oak and more or less wild plum, hazel, sumac, and other species were encroaching upon the prairie. In the vicinity of the lakes and on all the islands so many kinds of trees and shrubs had become established that forest conditions prevailed. Much of this native timber remains on the rougher lands, and there are many groves near farm buildings, but elsewhere it has very generally been removed.

According to the census of 1920, the population of the county is 13,489. A large proportion of the population is of Scandinavian origin, and there are many people of Teutonic and Irish descent.

Forest City, the county seat, has a population of 2,145; Lake Mills, 1,529; Buffalo Center, 894; and Thompson, 548.

Four lines of railway provide good transportation facilities to Des Moines, St. Paul, and Chicago.

Most of the county roads are well constructed, but only a comparatively small mileage is surfaced with gravel. The roads are generally traversable by automobiles and loaded wagons at all seasons.

CLIMATE.

The climate of this region is characterized by rather long winters, but the summers are pleasant, and exceptionally high temperatures are limited to a few days. Calm, mild days are typical of September and October, and such weather conditions, with sharp frosts, often prevail well into December. During the spring months the wind movement is generally strong, and local rainstorms are of frequent occurrence.

The climatic conditions are very favorable for vigorous growth and high quality in all grains, grasses, fruits, and vegetables produced in this region. While wheat is sometimes injured by warm, moist weather just before harvest, other grains are seldom seriously injured. The frequent failures with clover are usually attributed by farmers to drought, but it is highly probable that other factors are often involved.

Climate, rather than character of soils, is the limiting factor in corn production. The total amount of heat during the growing season is none too much for the best development of this grain. A little higher average temperature during May and June would be acceptable to the corn plant. The average length of the growing season is about 155 days, and since planting is usually not safe before May 15, the margin of safety with respect to early frosts is not very

wide. As a rule, the July and August rainfall is ample for good growth during that period, owing in part to the moisture-retaining qualities of the soils.

The average date of the last killing frost in the spring is May 1 and of the first in the fall October 2. The latest recorded frost occurred on May 31, and the earliest in the fall on September 13.

The table below, showing the normal monthly, seasonal, and annual temperature and precipitation, is compiled from records of the Weather Bureau station at Forest City.

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

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1909).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	19.6	55	-28	0.67	0.45	1.40	6.3
January.....	12.8	55	-36	.78	2.40	2.25	6.9
February.....	15.1	67	-33	.84	.30	1.05	6.5
Winter.....	15.8	67	-36	2.29	3.15	4.70	19.7
March.....	28.9	84	-19	1.44	.24	1.55	5.3
April.....	45.9	94	10	2.35	.15	3.57	.8
May.....	58.5	93	22	4.49	2.14	4.69	.2
Spring.....	44.4	94	-19	8.28	2.53	9.81	6.3
June.....	67.5	101	34	4.22	2.48	5.78	0
July.....	72.6	106	38	3.64	1.80	3.13	0
August.....	70.1	101	39	3.44	2.75	2.81	0
Summer.....	70.1	106	34	11.30	7.03	11.72	0
September.....	61.3	99	22	3.45	2.28	3.60	T.
October.....	48.3	92	11	2.41	1.28	.75	.3
November.....	31.7	75	-11	1.43	T.	7.21	2.8
Fall.....	47.1	99	-11	7.29	3.56	11.56	3.1
Year.....	44.4	106	-36	29.16	16.27	37.79	29.1

AGRICULTURE.

The earliest white settlements in Winnebago County were made about 1850 near Lake Mills. During the next 10 years a considerable number of immigrants arrived, most of them locating in the eastern part, where the drainage conditions were favorable and where there was an abundance of timber. A few of the oldest fields have been in cultivation about 70 years.

The lands throughout the middle and western sections of the county, which had good natural drainage, had been quite generally included in farms prior to 1880, although not all such land was then in cultivation. The full utilization of the area deficient in natural drainage was delayed until the completion of the big ditches afforded outlets for the innumerable ponds, sloughs, and flats. Most of these ditches have been constructed within the last 15 or 20 years.¹

The earliest settlers raised more wheat than corn, but in more recent years, with the development of the varieties of corn adapted to northern Iowa, this grain has become the leading cereal. In 1910 the acreage in corn was greater than that in all other cereal grains. A very large proportion of the corn crop is fed on the farms on which it is produced. Much that is sold finds a local market, and less than 10 per cent leaves the county.²

There are more than 100³ silos in the county. It requires approximately 10 acres of corn to fill the average silo.

The canning plant at Lake Mills in 1918 used the sweet corn raised on 1,200 acres, most of which was grown in Winnebago County. There is also a smaller canning plant at Forest City. The average yields in 1918 ranged from 4½ to 5 tons per acre, and the price received by growers was \$12 per ton for early and \$14 for late varieties. For a number of years this crop has given very satisfactory returns to the growers.

Oats now rank second to corn in acreage. The crop is important on practically every farm. It is estimated⁴ that from 40 to 50 per cent of the production reaches outside markets. As a rule, a larger proportion of this crop is sold from rented farms than from those operated by the owners.

The annual hay crop is in the neighborhood of 60,000 tons. More than half, however, consists of native grasses growing on ground deficient in drainage or otherwise unsuitable for tilled crops.

Irish potatoes of good quality and fair yield are grown on almost every soil type. The total production in 1916 was 37,456 bushels. This supplies the local demands.

Climatic conditions are not favorable for commercial apple production, but on nearly all farms there are small orchards or at least

¹In 1918 there were about 95 "drainage districts" in the county. The limits of each are defined by the local organization that petitions for such improvement. The assessment of costs of the main outlets is apportioned according to degree of benefit to holdings of individual members. The engineering and financial direction is under county management. The assessments have ranged from \$5 to \$25 per acre, and are distributed over a period varying from 7 to 15 years.

²Estimated by county agent.

³The number in 1916, according to the Iowa Agricultural Year Book, was 102, and many have been built since that year.

⁴Estimate by county agent.

a few trees, and enough summer fruit for home use is usually obtained. The Northwestern Greening, Wealthy, Dutchess, Tetofsky, and Yellow Transparent are the most successful varieties. There are several orchards, each of 10 acres or more, near Forest City, but they have not proved commercially profitable. Cherries, plums, gooseberries, currants, red raspberries, and strawberries could be produced in abundance, but not a great deal of attention is given them. On practically all rented farms and on the majority of those operated by the owners, little or no small fruit is grown, and with the exception of summer apples, a very large proportion of all fruit consumed in the county comes from outside sources.

In 1918 many farmers raised small patches of sorghum, and there was a marked revival of the old custom of making molasses. The yield was less and the quality of the sirup not so good as that produced on more sandy soils.

The following table, compiled from the United States census returns, gives the acreage and yields of the leading crops and indicates the trend of agricultural production during the past 40 years:

Acreage and production of important crops in Winnebago County, Iowa.

Year.	Corn.		Oats.		Wheat.		Rye.		Barley.		Flaxseed.	
	<i>Acres.</i>	<i>Bush.</i>	<i>Acres.</i>	Bush.	Acres.	Bush.	Acres.	Bush.	Acres.	Bush.	Acres.	<i>Bush.</i>
1919...	58,110	1,985,054	49,464	1,561,624	6,544	61,508	47	622	2,768	52,075	894	5,312
1909...	49,635	1,826,834	34,313	824,315	7,032	120,797	47	794	5,979	108,625	549	5,030
1899...	44,924	1,578,540	40,549	1,333,890	28,113	339,340	115	2,320	3,492	91,650	3,524	38,470
1880...	18,577	430,522	16,586	511,869	8,304	114,523	2	12	1,419	32,877	2,616	19,525
1879...	4,774	165,907	3,654	134,920	19,964	207,356	8	185	682	13,484	(¹)	891

Year.	Tame hay.		Wild hay.		Hay. ²		Coarse forage. ³		Potatoes.	
	<i>Acres.</i>	<i>Tons.</i>	<i>Acres.</i>	<i>Tons.</i>	<i>Acres.</i>	<i>Tons.</i>	<i>Acres.</i>	<i>Tons.</i>	<i>Acres.</i>	<i>Bush.</i>
1919.....	22,410	34,638	14,909	17,981	.....	.....	3,842	9,809	938	34,022
1909.....	22,418	35,831	21,328	28,941	.....	.....	862	2,879	1,030	124,102
1899.....	14,836	23,948	25,983	37,814	.....	.....	77	221	853	87,361
1880.....	.....	.....	.....	.....	39,733	41,690	.....	.....	645	49,613
1879.....	.....	.....	.....	.....	11,303	20,022	.....	.....	1	28,066

¹ Number of acres not reported.

² Tame and wild hay not reported separately in the earlier censuses.

³ Not reported in the earlier censuses.

The State census returns for 1915 indicate an increase in the acreage of both corn and oats, but little change in the production of the other grains. In the State census year (1914) about 45,000 bushels of spring wheat were produced, or an average of 13 bushels per acre. Only 28 acres of winter wheat were reported.

Throughout the county a comparatively simple type of agriculture has developed. It is extensive rather than intensive; the acreage per man is large, labor-saving implements are in general use, and horse-

power is utilized whenever practicable. Tractors are being introduced, and their more extensive use seems assured. Such crops as flax and buckwheat are little more than "catch" crops, and their culture is confined to recently broken sod, "mucky" land, and wet spots that dry out too late for corn. Barley finds favor chiefly with farmers who use it as feed for hogs. It is also a safe crop on Muck.

In compliance with requests from the Food Administration in 1918, many farmers sowed spring wheat, the individual acreages seldom exceeding 20 acres. Returns of from 25 to 30 bushels were very commonly obtained, and the quality may be rated as fair to good. Several varieties of rust, as well as scab and smut, were observable in many fields, but the injury usually was not serious. The most common varieties of wheat grown were Marquis and Velvet Chaff. The seasonal conditions in 1918 were favorable for small grain, but the results indicate the possibility of wheat being regularly grown with a fair degree of success.

Practically all wheat and flaxseed is sold. As yet no use has been made of the flax straw.

There are very few farms on which a regular rotation of crops is followed, but there are many farms on which corn and oats are the alternate crops, with red clover after oats at rather irregular intervals. This irregularity is due in part to the fact that in recent years clover has frequently failed to make a stand or has been winterkilled. The necessity of growing clover is not considered imperative on such soils as the Webster clay loam and heavier phases of the Clarion loam. On the rolling phase of the Clarion loam clover is more commonly grown. In many instances, particularly in the eastern townships, it is sown with oats and the stand plowed under later in the season as a fertilizer for the succeeding corn crop. Probably less than 10 per cent of the small grain acreage is sown to clover alone. While some 18,000 acres of mixed clover and timothy are reported in the 1910 census, the actual stand obtained in most years is below this. The 1920 census reports 14,197 acres in timothy and clover mixed, with a production of 23,123 tons.

There is much wastage of manure. While many barns are equipped with litter carriers, there are none that have a shed to protect the manure from leaching and loss due to exposure. Frequently the winter's accumulation lies in open lots until after harvest before being hauled to the fields. On practically all farms the annual supply is insufficient to cover more than a small fraction of the tilled land. No commercial fertilizer or lime is used.

A good deal of ground intended for corn is plowed in the fall, and is usually in condition for planting earlier than spring plowing. The disk harrow and large steel smoothing harrows are generally used in preparing the seed bed. On all these humus-laden soils this preparation is accomplished with a minimum of labor.

Corn as a rule receives three to four cultivations. Further tillage is not generally practicable, because haying and grain harvest usually begin early in July.

Most of the oat crop is sown on land used the preceding year for corn. Broadcast seeding is a common practice, with disk and smoothing harrows used afterwards to loosen the soil and cover the seed. In the seeding of other grains the drill is commonly used.

According to census returns for 1920, there were 35,723 cattle of all kinds in the county. Of these about 20,670 were dairy cattle. Practically all the dairy business is conducted in combination with other lines of farming. On the majority of farms the monthly sale of milk or cream is an item of considerable importance. There are well-equipped and ably managed cooperative creameries in each town. The total value of dairy products sold in 1919 (United States census) was \$646,354.

Pasturage is the common method of caring for cows during summer. The feed in winter consists chiefly of grain and hay produced on the farm. Very little concentrated feed is purchased, and the soiling method of feeding is not practiced.

On nearly all farms the largest single item of income is from the sale of fattened hogs. It is in this form that most of the corn crop is marketed. The total number of swine of all ages on farms on January 1, 1920, was 48,115.

During the past 40 years the average size of farms has increased from 111 to 157.5 acres. In 1880 there were 664 farms (United States census) and in 1900 about 1,512. Ten years later there were 1,425 farms, a decrease of 87. At least a part of this decrease may be attributed to consolidation of farms. According to the 1920 census Winnebago County had 1,543 farms.

During the period mentioned above there has been a most marked increase in tenancy. In 1880 only 8.8 per cent of the farms were rented, but in 1920 42.3 were operated by tenants. The number of small holdings is still decreasing, but conditions arising from the war may cause a cessation of this movement. Owing to labor shortage in 1918, small farms were in better demand for rent than large ones.

The prevailing terms of rent are two-thirds of the grain delivered at the nearest elevator, and a cash payment for hay land and pasture, ranging from \$5 to \$6 an acre in most instances. If a part of a farm consists of Muck or poorly drained ground, the rental is adjusted accordingly. Some farms rent on a cash basis entirely, \$1,000 per year often being the rental for 160 acres of well-improved land. As a rule the leases are for one year only.

Until 1918 there was no marked scarcity of labor, except occasionally at harvest time. A few years ago the rate of pay for good farm hands ranged from \$30 to \$35 a month for the summer season, with board and lodging.

According to the 1920 census returns, the total value of farm lands and the improvements was \$52,410,268. This indicates an average valuation of \$33,966 for each farm. The average assessed valuation is given as \$166.88 an acre.

SOILS.

Winnebago County lies wholly within the Wisconsin drift area. This glacial deposit forms the surface of the entire county and is the parent material of all the soils. The Wisconsin drift is of recent deposition, geologically, and the derived soils are young when compared with those coming from the older glacial deposits of the State. The Wisconsin drift has suffered comparatively little change through erosion, leaching, and oxidation, and the soils represent a less advanced stage of weathering.

Throughout this region the Wisconsin material is remarkably uniform. In the first 2 or 3 feet the original nature of the material has been more or less modified by the various agencies of weathering. Below this it is a mixture of pale-yellow or light-buff silt, clay, and sand containing varying proportions of stones. In most places the silt and clay constitute from 70 to 80 per cent of the mass, and medium and coarse sand make up most of the remainder. It is not compact, but invariably has a crumbly or somewhat granular structure, and a hand sample breaks under slight pressure. It is easily permeable by air and water and does not, even in the heaviest phases, tend to form a dense substratum or "hardpan."

All this buff material is very calcareous, and limestone fragments are in most places numerous. Bits of soft, bluish shale, which in an older drift sheet would have disappeared long ago, are in places abundant. The other stony material includes much granite, some quartzite, and many kinds of hard, metamorphic rocks. The gravel is chiefly quartz, but very many minerals are present. Chert is not an abundant constituent.

On the morainic ridges there may be more stony material in places, with an occasional pocket of gravel, but as a rule the till of all these elevations is quite similar to that found elsewhere.

Many chemical analyses have been made of the Wisconsin drift material and the soils derived therefrom. All indicate the presence of potassium in such quantities as to insure as high a percentage of this element as usually occurs in most fertile soils.⁵

With the exception already mentioned in the description of the area, all this region was originally covered with prairie grasses. The character of the vegetation, the climatic conditions, and the generally retentive nature of the soils have caused the accumulation

⁵ See Soil Survey of Iowa, Report No. 7, p. 26.

of much organic matter. This is chiefly in the form of very finely divided carbonaceous matter intimately mixed with the mineral constituents of the surface soils. The percentage of organic matter and the depth to which it has affected the color and physical structure of the soil material has been determined very largely by the drainage conditions. On flats and in sloughs the material is black to a depth of 20 to 30 inches, while on high, well-drained ridges it reaches a depth of only a few inches. This deficiency of organic matter, as indicated by color, also occurs in sandy spots where the drainage is excessive.

The development of the upland soils is determined partly by topographic position. On the flat or very slightly undulating areas the average moisture content was formerly high, and the groundwater level was within 2 or 3 feet of the surface, in many instances much nearer. Consequently there was a large accumulation of the carbonaceous material in the surface soil and middle subsoil, while the lower subsoil almost entirely escaped leaching and oxidation, resulting in a deep, black, organic-matter laden zone over a light-colored, calcareous subsoil. These are the characteristic features of the Webster clay loam. Similar conditions in the sloughs and depressions give rise to Lamoure silt loam. This, however, is not a very distinct type and often grades into Muck or Peat.

Where the topography ranges from undulating to gently rolling, the better surface drainage, the freer movement of the soil water, and deeper aeration have resulted in more or less leaching to a depth of 3 or 4 feet, and considerable oxidation to about that depth. The subsoil has little free lime, and a pronounced brown color has developed. The proportion of organic matter is moderately high, but less than in the Webster and Lamoure soils. These average conditions, a dark to black surface loam with brown to gray calcareous subsoil, are exemplified in the Clarion loam, a type of extensive occurrence.

The Waukesha and Fargo soils represent terrace or second-bottom types that have developed under good and poor drainage, respectively. The chief difference between these is the varying depth at which a coarse gravel substratum is found.

The surface soils of the Clarion series are dark brown to black. The upper subsoil grades downward from a dark brown into a brown, and its texture is heavier than that of the surface soil, being usually a silty clay loam. The lower subsoil is grayish brown to gray, approaching the color of the glacial drift from which it is derived. This is sufficiently calcareous to effervesce with acid, and streaks of lime and iron concretions are common. The series is derived from calcareous drift and occurs where the leached and weathered zone is less than 3 feet thick.

The soils of the Webster series are black and the subsoils gray or mottled gray and brown. The subsoil is heavy in texture, ranging from silty clay loam to clay. The subsoil is calcareous, usually effervescing with acid. The series has been formed by the weathering in place of till under poor conditions of drainage. The series occurs on nearly level or undulating plains where erosion has not set in, or in areas of restricted drainage where shallow lake or swamp conditions formerly prevailed. The soil profiles in this series are similar in color and texture to those of the Fargo series. This series, however, has a topographic position on the upland instead of in lake basins and is derived from till in position instead of from reworked glacial drift.

The types included in Waukesha series are characterized by dark-brown to black surface soils and a brown to yellow subsoil. The latter is heavier in texture than the soils, but not compact and impervious. This series is only moderately calcareous, and the lower subsoil will not usually effervesce with acid. These soils occur on terraces above the present limit of overflow and are well drained.

The Fargo series includes types with black soils and a dark-drab or mottled heavy subsoil. The soils occur on lake or river terraces where they have been formed by the reworking of glacial till and subsequent weathering under conditions of poor drainage. A large percentage of organic matter is present in the soil. There is also present a large percentage of lime, particularly in the subsoil. The topography is always level and natural drainage is poor.

The types included in the Lamoure series have dark-brown to black soils. The subsoil varies from yellowish brown to gray or dark drab or mottled gray and brown. It is usually much heavier in texture than the soil, though it may have about the same texture. Soils of this series are derived from the alluvium of streams that drain calcareous soils. They have usually developed where there is a moderate to low rainfall, and are themselves highly calcareous. These soils are moderately to poorly drained and are subject to flooding at varying intervals.

The following table gives the actual and relative extent of the several types of soils mapped in Winnebago County:

Areas of different soils

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarion loam.....	117,504	73.2	Peat.....	6,912	2.7
Rolling phase.....	68,928		Waukesha loam.....	4,416	1.7
Steep phase.....	576		Fargo silt loam.....	2,048	.8
Webster clay loam.....	27,200	10.7	Meadow.....	1,216	.5
Muck.....	13,312	5.2			
Lamoure silt loam.....	13,248	5.2	Total.....	255,360	.....

CLARION LOAM.

To an average depth of about 6 inches the soil of the Clarion loam is a black, friable, fine-textured loam or silt loam. Below this, to a depth of about 20 inches, occurs a layer forming the upper subsoil, consisting of a black or very dark brownish black clay loam. The organic matter content of soil and upper subsoil is high. Below 18 or 20 inches the organic matter content decreases and the material gradually changes to a brown or yellowish-brown clay loam. The underlying buff or gray material of unweathered till normally lies below the 3-foot limit, but many local exceptions occur, chiefly on the slopes of slight elevations. In such instances the lower subsoil is somewhat calcareous. The soil and middle subsoil are acid, according to the litmus-paper test.

The topography ranges from undulating to gently rolling. The surface drainage is good, except in local depressions and the sloughs necessarily included in the type. There are many slight elevations, low mounds, and ridges, where the type approaches the rolling phase. Some of the more pronounced of these may be somewhat gravelly, sandy, or encumbered with stones, but the subsoil is usually a loam, rarely a sandy or gravelly loam. If it is the latter, the area is generally limited to a few square rods. Boulders are not uncommon, but most of them have been removed from cultivated fields.

The Clarion loam is the predominating soil in the central and western townships, and areas of considerable size are found in all parts of the county. Most of it is in cultivation and highly esteemed for general farming.

Labor-saving implements can be used advantageously on all the land of this type. This is due in part to topography and in part to the ease with which the soil can be tilled. In most instances the surface has a soft or mellow structure, and there are no clods or at most only such as readily break down. The porous subsoil has excellent moisture-holding properties, and under good management the type resists drought extremely well. The structure of the subsoil and substratum favors effective underdrainage.

The average yield of corn on this soil may be placed between 40 and 50 bushels per acre, with returns of 60 to 70 under very favorable conditions. In 1917 and 1918 the yield of oats ranged from 40 to 80 bushels per acre, with an average that was not far from 60 bushels on well-managed land. As a rule oats stand up well, and the quality is good. A considerable proportion of the barley raised in the county is grown on this type. The results with wheat during 1918 indicate its adaptability to that crop.

All the minor crops usually grown in this county may be successfully raised on this type. Where only moderate returns are obtained

the cause is generally poor tillage or adverse seasons. Much of the type has been cultivated to grain crops, with few changes to clover and with little or no application of manure.

Most of the land of this type is held at prices above \$150 an acre. Well-improved farms command a higher price.

As already stated, the lowest ground is generally in need of artificial drainage. Tiles work well, and in many cases their installation has hastened maturity of corn, so that there is much less likelihood of injury by frost. All the type responds well to manure, and the corn which succeeds a crop of clover usually shows the beneficial effects of the legume.

A variation of the Clarion loam in which a forest growth has appreciably affected the soil occurs in this county, but in comparatively few places has the change from a prairie soil to a timber soil been sufficiently developed to warrant a separation on this basis. In most places the forest which the early settlers found had occupied the ground such a comparatively short period that the black organic residue derived from the preceding prairie flora was still abundant, and the surface soil was very similar to those in corresponding topographic locations on the prairies. In some places, however, arboreal vegetation had occupied the ground for a longer time and a true forest soil had begun to develop. The humus supply was decreasing, and just below the dark layer a lighter-colored zone had developed. This zone, where it is most pronounced, is a dull-gray, friable soil, with thin streaks and specks of light gray marking the joint planes and minute crevices. This material often has an ashy feel when rubbed between the fingers, and is always very friable. Below this layer, which usually occurs between the depths of 10 and 20 inches, the brown clay loam distinctive of the Clarion subsoil is found.

The areas under cultivation give good returns of all the common crops. In the estimation of some of the earlier settlers the land is well adapted to wheat. It certainly affords better sites for apple orchards than are commonly found on the prairies. Small acreages in fruit near Forest City show its adaptability to most tree and bush fruits. Potatoes and garden vegetables do well.

Clarion loam, rolling phase.—In its typical development the surface soil of the Clarion loam, rolling phase, is a very dark brown or black loam containing some coarse angular sand and a little gravel. It has a rather loose or open structure as deep as the organic matter extends, which is from 5 or 6 inches on slopes to 12 or 15 inches where the surface is more nearly level. The subsoil is a dark-brown crumbly loam or clay loam, becoming somewhat lighter colored with increase in depth. Below 20 or 24 inches from the surface it is usually a yellowish-brown clay loam, gradually changing

with increase of depth to the buff-colored calcareous till, which as a rule lies below the 3-foot soil section, though local exceptions are numerous. On the steeper slopes and on the tops of the moundlike elevations, stony material varying from gravel to small bowlders is usually found, and the soil is usually gravelly or in some places a coarse sandy loam. Most of the phase, however, is free from stones other than an occasional bowlder.

In general, the topography varies from strongly rolling to hilly, and the relief from 50 to 100 feet. This is a very general statement, for irregularity in height and degree of slope is the rule rather than the exception. Most of it, perhaps more than 90 per cent, is in cultivation. All farm machinery is used without difficulty, except on the roughest places.

Most of the areas of this phase in the central and western part of the county are ridges that rise above the general level of the surrounding country. The areas near Coon Grove and some miles to the north are quite hilly but generally tillable. The "islands" on the border of the Muck are sandy, stony ridges of low agricultural value.

The areas between Scarville and Leland are mostly high, rolling ridges of excellent farm land. This divide is more strongly rolling as the southern county boundary is approached.

The rolling phase immediately east of Lime Creek has rather mild relief, except at a point a few miles northeast of Lake Mills, where small ridges of the steep phase are shown on the map. Here, as well as near the old lake beds farther south, there is much of the "knobby drift," with its sharp slopes, narrow ridges, and many moundlike elevations. The local difference in elevation on any 100-acre tract seldom exceeds 50 to 100 feet. In general, the roughest lands lie a few miles east of Forest City, forming the northern slopes of Pilot Knob. The roughest areas are in part covered with brush and small timber and are generally used for pasture.

Near Lake Mills the phase departs somewhat from the typical description. Here is usually a dark-brown coarse-textured loam to sandy loam with moderately high content of humus. From a depth of 6 inches to about 18 or 19 inches the material is a yellowish-brown, coarse-textured loam to clay loam. The lower subsoil is usually a sandy loam, changing with increase of depth to loose sand or gravel. The areas of lightest texture occur on the local elevations, while the heavier soil, better supplied with humus, occupies the depressions with the gravelly substratum seldom within reach of a 40-inch auger. The lowest ground may require tile drains, but most of it has good natural drainage. On some of the highest points the drainage may be excessive, owing to the shallowness of the loam over loose sand or gravel. There is some development of this variation

near Turtle Lake, 5 miles south of Lake Mills, but the areas are small and not well defined.

The areas east of Forest City are mostly morainic ridges on which the soil is somewhat stony and ranges in texture from a sandy loam to loam. As a rule the subsoil here is a yellowish-brown clay loam, with the gravel occurring as pockets or spots rather than as a continuous stratum. Some of the small narrow areas near Muck beds are low ridges of sandy, gravelly till with variable surface conditions. Nearly all are tillable, and good crops are grown on those in cultivation. The rougher parts have a scattering growth of bur oak. Bluegrass and white clover have generally supplanted the native grasses.

The Clarion loam, rolling phase, is a somewhat earlier soil than the other upland types. This difference is due to better drainage rather than to the character of the soils. As already stated, the 3-foot section usually consists of as heavy material as the typical Clarion loam and has about the same capacity for holding moisture. Some differences in this respect are apparent on slopes where the brownish tint of plowed fields indicates a relatively small supply of humus. Such places, of course, are more difficult to keep in tilth and are more subject to drought than the darker colored soil. In very few instances, however, are these thin places inclined to be cloddy. All this phase has a friable structure and generally yields very easily to tillage.

In seasons of heavy rainfall the yield of corn on the rolling phase is higher than that on the lands having less relief, but in normal seasons the difference is in favor of the latter. The rolling phase has a little wider margin of safety with respect to frosts.

The large later maturing oats give more satisfactory returns on this phase than on the darker colored soils. The difference with respect to other grains seems slight. Some farmers think that wheat does better on the rolling lands than on the black soils, but this may be an impression retained from earlier experiences when the black soils were not well drained.

Timothy and clover do well, and in most roadside cuts sweet clover is well established. The shallow depth at which a highly calcareous subsoil occurs on many of the "knobs" and narrow ridges renders these spots very favorable for all the clovers. Bluegrass does well in such places, but makes the heaviest growth on lower ground.

There is not much difference in the present price of this land and that of the smoother areas of the type, except where very rough land forms a considerable proportion of the tract in question. The price is quite variable, but may be placed between \$100 and \$150 an acre.

The maintenance of fertility requires more frequent changes to clover or heavier applications of manure than are necessary on soil

better supplied with organic matter. Dairying or stock raising should be more generally followed. Continuous cropping to grain can not be practiced so well as on the Webster clay loam and the heavier areas of the Clarion loam. If rye, wheat, or rather light seeding of an early oat were used as the nurse crop with clover the chances of success with the latter would be improved. The practicability of using lime to improve the clover stand should be determined by tests extending over several seasons. The soil is not essentially lacking in lime.

While the washing or gullying of hillside fields occasions a distinct loss, especially if it is humus that is being removed, the evil is not serious. The subsoil is rich in mineral elements, more so in some instances than the upper soil layers, and has nearly as desirable structure. Clover or manure to restore the organic matter will render such places very productive. Of course, erosion should be prevented as far as practicable, and to this end frequent use of hay or pasture crops is recommended.

Clarion loam, steep phase.—The steep phase of the Clarion loam consists of morainic ridges with such steep sides that tillage is impracticable. Their relief ranges from 25 to 50 feet in most instances, but several small areas represent more prominent elevations, rising 100 feet or more above the nearest stream. The larger areas north of Lake Mills are high ridges covered in part with oaks. The narrow areas bordering streams and lake beds are steep, untillable slopes. The few small areas shown at other points are prominent local elevations, usually stony and unsuitable for cultivated crops.

The soil is generally a yellowish-brown clay loam, with a thin layer of darker soil on the crests of ridges and on the more gradual slopes. Highly calcareous till is often exposed in shallow washes. In most places the surface is more or less stony, and pockets of gravel are of common occurrence in the areas forming the higher elevations.

A few small areas are cultivated, but most of this phase is suitable only for pasture. Bluegrass and white clover have become established wherever the growth of trees or brush is not too dense.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Clarion loam:

Mechanical analyses of Clarion loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
333019.....	Soil.....	1.2	5.8	5.1	29.7	15.4	31.3	11.2
333020.....	Subsoil.....	1.0	5.2	4.9	29.2	15.3	34.0	10.2
333021.....	Lower subsoil...	2.0	6.2	4.5	24.6	18.8	32.8	11.0

WEBSTER CLAY LOAM.

In its typical development the surface soil of the Webster clay loam is a black, mellow, silty clay containing a little coarse sand and a few pebbles. At a depth of a few inches this layer changes to a slightly compact silty clay loam, or in many instances to a sticky silty clay. The black color usually prevails to a depth of 18 inches, then gives place to dull grayish black or very dark drab, which, with further increase of depth, is light drab slightly mottled with yellow iron stains. All the black material has a granular structure, very apparent when moderately dry. The light-colored lower subsoil is generally a sticky silty clay, but in many instances contains a good deal of sand, gravel, and small stones.

In all places the lower subsoil contains a high percentage of calcium carbonate. The surface soil is usually slightly alkaline or neutral. As a rule those areas having the poorest natural drainage are richest in lime. In areas of better drainage the soil is acid and only the lower subsoil is distinctly alkaline.

The largest areas of the Webster clay loam lie in the southwestern townships. Smaller areas occur throughout the northwestern and central parts of the county. In all of these the type is more variable than in the larger developments farther south. They include many small patches of Clarion loam, and necessarily there are innumerable gradations between the two types. There are also many small Muck beds, and the soil in the immediate vicinity of ponds may be a shallow Muck. There are many comparatively narrow strips of the Webster clay loam between drainage lines and large bodies of the Clarion loam. In most instances these areas are low, uneven tracts having somewhat better local relief than the Lamoure silt loam, but not so much as the Clarion loam. Variations of all the types just mentioned, as well as small Muck beds, may be found within a single area, but the general agricultural values are similar to those of the typical Webster soil.

Practically all the Webster clay loam requires artificial drainage to render it safe for cultivated crops. Owing to the high content of organic matter in the soil and upper subsoil and the granular structure of the lower subsoil, tile drains work very effectively. Any surface accumulations of water near a drain soon disappear, and the lateral movement toward well-laid tiles seems to be very broad, judging from the manner in which a single line will relieve a pond or slough several rods in width. There are, however, many instances where more laterals are needed, usually on level or slightly elevated ground that in wet seasons is slow coming into proper condition for effective tillage.

The highly desirable physical properties of the type are most apparent in lands that have been well underdrained. The surface soil assumes a very mellow condition, while the subsurface, by reason of excellent capillarity, maintains a nearly optimum moisture content under rather wide variations in rainfall. As a rule, the permanent water table is but a few feet below the surface in all flat or slightly depressed areas.

The Webster clay loam is admirably adapted to corn. In favorable seasons yields of 60 to 70 bushels per acre are commonly obtained, and higher returns have been reported. The average yield of the type as a whole is lowered by the inadequately drained places and occasional "alkali" spots. The quality of grain is good, except when injury by frost occurs. Economical production is favored by the level topography and the ease with which good tilth is maintained. A large proportion of the type is annually devoted to corn.

In 1917 and 1918 the average yields of oats on most of this type ranged from 60 to 70 bushels. Ordinarily there is some loss due to lodging if the season is wet. Short-strawed early varieties are coming into favor for this soil.

Wheat gave good returns in 1918. In general barley does well, and in favorable years excellent yields of this grain are reported. The type is an almost ideal one for red clover, but no considerable acreage is sown. More frequently mixed clover and timothy is grown, and heavy yields of hay are often obtained.

The abundance of organic matter, high lime content, and the presence of a water-bearing substratum sufficiently near the surface make nearly ideal conditions for alfalfa. Of course, thorough drainage to a depth of several feet is absolutely necessary, but this is now assured in most places. With proper methods of seeding and care after a stand has been obtained, alfalfa should prove very successful on this type.

The present price of farms on which this type predominates is generally above rather than below the average price of the other soils of the county. The land is generally held for more than \$150 an acre, with some well-improved lands as high as \$200 an acre.

WAUKESHA LOAM.

The Waukesha loam, as mapped in this county, includes all the naturally well-drained soils of the bench lands, or terraces, in the Lime Creek Valley. The thorough drainage is due to the presence of loose sand or gravel at depths usually not exceeding 5 or 6 feet. The surface is somewhat uneven. The average elevation near the stream is from 5 to 10 feet above the lowlands immediately bordering the channel; farther back it may be somewhat greater. The larger areas

have a gradual, although slight, downward slope from the foot of the uplands toward the first bottoms.

In most instances the surface soil is a dark-brown, coarse-textured loam or sandy loam. At a depth of 8 or 10 inches this changes to a pronounced brown loam, somewhat heavier than the surface material. In some of the heavier variations the soil may be a clay loam and the lower subsoil a sticky sandy gravelly clay. As a rule, however, the lower subsoil is coarse loamy sand which grades at less than 40 inches into coarse sand or irregularly stratified sand and gravel.

In the lighter variations, which usually occur as low ridges, there is some organic matter in the surface soil, but very little in the sub-surface material. The latter is well oxidized to a depth of several feet and contains only a small amount of lime. In the areas of heavier soil, which usually occupy the more level benches, there is considerable organic matter, and the lower subsoil may include many bits of limestone. The soil in all places is acid, according to the litmus paper test, while the substratum, whatever its texture or structure, is calcareous. In nearly all the areas along Lime Creek there are low moundlike elevations and very broad swells where the soil is a sandy loam, with rather coarse sand or gravel at a depth of 20 to 30 inches. These places are droughty, and in dry seasons crops suffer. On the normal areas, where the surface soil is usually black or very dark brown loam, the moisture-holding properties are better, and in average seasons good crops are obtained.

Along the base of the uplands the type is usually a loam with a heavy brown or yellowish-brown clay loam subsoil. In some places small Muck beds occur, and in depressed or flat areas the type passes into the Fargo silt loam. Variations of this character are common along the Twister Branch, 3 miles northwest of Forest City. Similar conditions prevail east of Scarville, where the Waukesha and Fargo types are closely associated.

Small developments of the Waukesha soils are found on the small streams of the western part of the county. Those north of Buffalo Center are brown loams with the underlying gravel at 4 or 5 feet. The small areas in sec. 31, T. 100 N., R. 25 W., and sec. 36, T. 100 N., R. 26 W., about 5 miles northeast of Buffalo Center, vary greatly from place to place. There are some very light and somewhat droughty areas on the highest knolls, while much of the type is a dark-colored heavy loam. The variations are due principally to irregularity in subsurface conditions.

While much of this type requires rather frequent rainfall for best results, its free underdrainage is of distinct advantage in wet or backward seasons. Some farmers state that in such years most of the type is from one to two weeks earlier than the upland soils.

In 1918 excellent crops of corn, oats, and wheat were grown on practically all this type. The yield of corn was somewhat lower on the lighter variations than elsewhere, but small grains gave good returns on all parts of the type.

Garden crops usually do well on this early soil. Irish potatoes make large yields and are of good quality. Sorghum, likewise does well and yields a good quality of sirup.

The chief problem in the management of the lighter parts of the Waukesha loam is the maintenance of the humus supply. This is highly necessary in order to increase the power of the soil to hold moisture. As the available barnyard manure is usually insufficient, turning under clover or other green crops becomes an essential step in the cropping system. It is highly probable that better success with clover would follow the use of rye or wheat instead of oats as a nurse crop. A light seeding of rye or wheat takes less of the soil moisture, and the crop comes off the ground earlier than oats. Timothy can not be recommended, except for the darkest colored and heaviest phases. Catch crops in corn, such as rape, soy beans, or vetch, should be considered, especially if the corn is "hogged off." Trampling does not injure this soil. Much of it needs compaction, and such methods of tillage as tend to produce this condition are beneficial in all except the wettest seasons.

FARGO SILT LOAM.

The Fargo silt loam includes all the poorly drained soils on the second bottoms of Lime Creek. The surface is flat, or nearly so, and usually lies a few feet lower than the average level of the Waukesha loam. The inferior drainage is caused in part by this topographic position, and in some measure by the close, retentive nature of the soil material to a depth of several feet. The substratum is sandy or gravelly material similar to that under the Waukesha soils, but it lies too deep in most instances to have much effect upon the subdrainage.

In the areas east and southeast of Scarville most of the Fargo silt loam is a heavy black silty loam abundantly supplied with organic matter. The middle subsoil is usually a black, silty clay, sometimes quite sticky, but never impervious or like a hardpan. The lower subsoil varies from light-colored, sticky silty clay to a rather loose sandy loam. The latter may be partly oxidized and not highly calcareous, but all the areas of heavier material are very poorly oxidized and more or less limy.

In general, the drainage conditions in all these areas are better than they were before roads or ditches had been constructed. In wet seasons water stands on the surface for long periods, and much of the land is used only for pasture or for the production of hay. Small tracts have been effectively drained and are producing good crops.

As the general level of all this land is several feet above Lime Creek, drainage is practicable. It is possible that drainage might be effected in some places by sinking "wells" to the underlying gravel, though this plan has not been tried.

The Fargo soils northwest of Forest City consist of a black loam to silty clay loam, the loams prevailing near the Waukesha soils and having somewhat better natural drainage than the soil of heavier texture. Most of the areas near Twister Branch are in cultivation, tile drains having been laid through the lowest places. These soils assume a mellow or friable condition under tillage and produce heavy crops of corn, oats, and barley. They are well adapted also to clover and timothy, and it is probable that alfalfa would do well. In most places the soils are alkaline or neutral, while the lower subsoil is calcareous. The matter of drainage should be carefully considered in growing alfalfa. The permanent water table is high, evidently just below the tile drains in most places, and this might affect the results with this deep-rooted crop.

Throughout this type "alkali" spots are of common occurrence. With improvements and the extension of drainage these will probably disappear or yield easily to the remedial treatment described elsewhere in this report.

LAMOURE SILT LOAM.

The Lamoure silt loam, as mapped in this county, includes those black organic matter laden soils found in sloughs and shallow basin-like depressions and along the poorly developed drainage ways that in recent years have been so commonly superseded by big ditches. It is a rather variable type with respect to depth of the surface soil and textural character of the subsoil, but invariably the former is black, while the latter is light colored. As a rule the surface soil is alkaline, or at least not distinctly acid, but the remainder of the 36-inch section effervesces with hydrochloric acid, and in many places the lower subsoil is highly calcareous.

A typical section consists of 6 or 8 inches of black, crumbly, or in many instances rather spongy, silt loam, which changes with increase of depth to a sticky silty clay a little more firm or compact than the surface soil. The lower part of the 3-foot soil section is usually a sticky silty clay with very little gravel or sand. In places it is a clay loam, or it may carry much coarse material and consist of a mixture of gravel and stones in a sticky, clayey matrix. In some places the lower subsoil is till, but no attempt has been made to separate these small areas from the typical Lamoure silt loam.

In nearly all the areas shown on the map spots of Muck are included, and where the type borders upon deposits of Muck or Peat no very well defined line of separation exists.

In a few places the subsurface is a stiff waxy clay that does not plow easily if very wet or very dry. "Alkali" spots occur but are nowhere very extensive.

The largest bodies of this type lie along the large ditches of the central and western sections of the county. They have good artificial drainage, or may be drained at small expense. As a rule the level of the water table formerly high has been permanently lowered, except in the land situated farther from the ditches. While many sections of these rich semialluvial strips of land are now used for hay or pasture, a constantly increasing proportion is being brought under the plow.

The Lamoure silt loam also comprises the soil of the higher lying parts of the flood plain of Lime Creek. The surface here is flat and has an elevation of 3 or 4 feet above the bottom of the stream. All this land is subject to overflow and therefore is used only for pasture. Bluegrass, white clover, and many kinds of field weeds have displaced the original vegetation.

The type along lower Buffalo Creek is a loam and is the recently deposited alluvium of that stream. It is a valuable pasturage soil.

The crop adaptations of the Lamoure silt loam are almost identical with those of the Webster clay loam.

MUCK.

Deposits of Muck and Peat are found in all parts of the county. They range in extent from small patches a few rods across to areas of several hundred acres. In most instances they do not exceed 3 or 4 feet in depth, but there are numerous exceptions, and in the central parts of many of the larger bodies the beds are several yards in thickness. Clay or clayey material generally forms the substratum on which this accumulation of vegetal matter rests.

In nearly all the smaller areas and in most of the larger ones Muck is the predominating material. Peat is more generally found in beds of lakes recently drained and along the larger ditches.

The Muck consists of black, finely divided, carbonaceous material derived by slow decomposition of vegetable remains under water, or at least where saturation was almost constant. There is usually but little mineral matter mixed with this material, except in the lower part at the contact with the clay. In many places carbonates are abundant, especially along the margins of artificially drained areas. Sometimes small shells are numerous near the margins of these deposits. In all instances the Muck is loose or very porous and absorbs and holds water like a sponge.

Wherever good drainage has been established for several years, the Muck becomes somewhat finer, especially if the deposit is shallow and some admixture of earthy material has occurred. After this stage

has been reached, bluegrass, white clover, and many kinds of weeds usually take possession of the land. On such areas corn can be grown if the season is long enough. As a rule the plants grow slowly in the spring and continue growing much later than on a normal soil, so that frost often injures the crop. In the so-called "alkali" spots the corn fails entirely. Oats do not fill well, and much difficulty is experienced in harvesting them, unless very dry weather prevails. Barley does well, and some yields of 25 to 30 bushels per acre have been reported. Timothy makes a strong growth and is a safe crop. Red and alsike clover will grow on the well-drained shallow deposits, but it is often difficult to get a stand. In 1918 large yields of Irish potatoes were obtained. No cabbage, onions, or celery is grown, although the Muck in many instances is well adapted to such crops.

Success with all Muck soils is chiefly a problem of moisture control. First the soil should be relieved of all excess water to a depth of several feet and then given such tillage as will insure an adequate moisture supply well up to the surface. Applications of barnyard manure are beneficial, and the addition of silt and clay from higher ground serves the twofold purpose of adding earthy constituents and introducing needful bacteria. Potash salts, if available at reasonable prices, would probably prove profitable with corn.

PEAT.

Typically Peat consists of coarse, brown, fibrous plant remains that have not reached so advanced a stage of decomposition as Muck. The material, however, is in all stages of change from partially decayed sphagnum moss to black, soft Muck and an exact separation of the two types is not feasible. Most of the areas indicated as Peat nevertheless consist chiefly of rather deep deposits of a brown fibrous or spongy material further removed from a normal soil than most of the Muck. The areas that formerly were Rice Lake and Bear Lake, and some other deep deposits, are of this character. The big drainage ditch southeast of Thompson and the outlet of Lake Harmon expose deep Peat in many places.

The areas in which swamp symbols appear are marshes filled with aquatic vegetation. In other places, as a rule, some pasturage is obtained or wild hay is secured from the drier places. Bluegrass has not yet become established, although it encroaches upon the native vegetation as fast as drainage insures a few inches of comparatively dry surface material.

The lowering of the water table tends to hasten decay, and eventually much of these Peat deposits will change to Muck. Under present conditions their agricultural value is low.

MEADOW.

Meadow includes all the alluvial soils along Lime Creek, which by reason of their low position and flat surface have very poor drainage. The surface in most instances is but 2 or 3 feet higher than the average level of the water in the shallow, crooked channel of the creek. The subsoil is almost constantly saturated, and any slight depression is marshy, while even the higher parts are wet during all but the driest periods of weather.

In the better locations the soil is practically the same as that of the Lamoure silt loam. In most of the marshy places it is a mixture of Muck and silt rather than a true Muck. The organic matter is so intimately mixed with sediments, chiefly silt and clay, that a very black spongy soil has developed. Considerable areas occur where the surface is a series of hummocks 2 or 3 feet across and separated from each other by fissures 1 to 3 feet deep and a foot or so wide. On these hummocks bluegrass is establishing itself, as well as in other places where the surface is not too wet. In the lower places, however, the vegetation consists chiefly of coarse water-loving grasses and sedges. There is no tree growth, except an occasional willow.

These black mucky deposits rest upon a bed of gravel, exposed in places in the bottom of the creek, and in some places the gravel layer is but a few feet below the surface of the soils. The value of the lands for pasturage and hay would be greatly improved, and perhaps some rendered tillable, if the stream channel were deepened; but as the areas are rather small, it can not be safely asserted that such improvement would be profitable.

"ALKALI" SPOTS.

In the Webster clay loam, Lamoure silt loam, and Fargo silt loam there are numerous small areas locally called "alkali" spots. They vary in extent from a few square rods to a fraction of an acre. They occur on the margin of depressions, particularly of Muck beds, and in sloughs. They are rarely found in the middle of these depressions on ground having fairly good natural drainage. Their location suggests an accumulation of salts due to evaporation of water from ponds having no outlet.

Where the alkaline condition is well developed the surface soil, if dry, is somewhat lighter colored than that nearby and has a distinctly loose and ashy structure. Otherwise the physical conditions are not essentially different from those of the normal soil. The subsoil also conforms to that of the type where structure and drainage conditions are comparable.

Corn does not grow well on the affected spots. The plant usually attains a height of 10 to 30 inches and then turns yellow and either dies or finally matures as a stunted, barren stalk. In the latter case the root system is poorly developed, having but a few deep branches.

Oats will mature if seasonal conditions are favorable, but the straw is weak and the crop may be lost through lodging. Other cereals, timothy, and clover are not affected. Irish potatoes sometimes fail to mature on these spots, but bad drainage or some other unfavorable conditions may be the cause.

A sample of soil from one of these spots was collected in the NE. $\frac{1}{4}$ sec. 28, T. 98 N., R. 24 W., and subjected to chemical analysis. It showed a total of but little more than 0.1 per cent of soluble material, and this consisted mainly of carbonate of lime. The percentage of soluble material, if it consisted of injurious salts, is not high enough to injure crops, and the fact that it consists of lime makes it practically certain that this is not the reason for any injury to crops that may take place. It is possible that the lack of subsoil drainage is a factor of some importance.

Indeed, drainage in most instances greatly alleviates the trouble within a few years. After good drainage has been secured applications of manure are highly beneficial. Some farmers report almost complete eradication of these spots by such means. In one instance manure from a hog lot gave better results than any other kind used on the same ground.

As the affected areas are never of great extent and invariably yield in some measure to drainage and application of manure, the condition can not be considered serious.

SUMMARY.

Winnebago County is situated in the northern tier of counties in Iowa, about midway across the State. The area, according to planimeter measurements, is 399 square miles.

All of the county was formerly a prairie, except some of the extreme eastern part which has some native timber. The topography ranges from very gently undulating to rolling, with limited areas, chiefly in the eastern townships, where morainic ridges and knobs are common features. In the central and eastern townships there is much land that originally required artificial drainage. Nearly all of this has been reclaimed.

The climate is favorable to agriculture. The mean annual temperature is 44.4° F., with an extreme range of 142 degrees—from -36° to 106° F. The average annual rainfall is 29.16 inches, more than half of which occurs during the growing season. The average date of the last killing frost is May 1; of the first, October 2.

The principal crops are corn, oats, and hay. Barley, wheat, flax, and potatoes are secondary crops. No special industries have been developed except the canning of sweet corn at Forest City and Lake Mills.

About 90 per cent of the corn and 50 per cent of the oats are consumed in the county. A large part of the corn is used in fattening hogs. Few cattle are fattened, but on nearly all farms there are a sufficient number of cows to make the sale of milk and cream an important source of income.

Corn, oats, and mixed clover and timothy form the usual succession of crops, but in many instances the grass crops are omitted. While farmers recognize the beneficial effects of clover, its use as a regular member of a rotation is not considered necessary, except on some of the lightest colored soils.

Commercial fertilizers are not used. Stable manure is used, but it loses much of its value by leaching before being put on the land.

The average size of farms is 157.5 acres. Those in the eastern townships are smaller than the prairie farms of the central and western townships. Improved machinery and heavy teams are in common use.

About 42 per cent of the farms are operated by tenants. Cash rents range from about \$5 to \$7 an acre, but in many of the leases the consideration is two-fifths of the grain crop and a definite cash payment for hay and grass land.

All the county lies in the Wisconsin drift area. Nearly everywhere this material gives rise to loams, silt loams, or clay loams, in which the surface layers are rendered crumbly or mellow by the high content of black organic matter. Calcareous material is usually found within or just below the 36-inch soil profile.

The Clarion loam is the prevailing type. It is a black soil with yellowish-brown subsoil, the extreme lower part of which may be calcareous. The type is well adapted to corn, small grain, and grasses. The rolling phase has less organic matter and usually consists of more thoroughly oxidized material than the principal type. It is a good soil. The steep phase includes some prominent ridges and slopes of little value for cultivated crops.

The Webster clay loam is the type of the flat to very gently undulating uplands. It requires artificial drainage. It contains large quantities of organic matter and has a calcareous subsoil, and when properly drained is very productive.

The Waukesha loam includes the well-drained areas of the second bottoms. This type requires rather frequent rainfall for best results, but has a distinct advantage over other soils in wet, backward seasons. The wet areas in the second bottoms have been mapped as Fargo silt loam. When drained, the land is very productive.

The Lamoure silt loam is the soil of the sloughs and ill-defined drainage ways and the higher lying first bottoms along Lime Creek. When reclaimed from its wet condition, this soil has about the same crop adaptation as the Webster clay loam.

Deposits of Muck and Peat are of very common occurrence. The innumerable small areas in the uplands are mostly Muck, while the larger are Peat. The Peat has little agricultural value except for hay or pasture, but much of the Muck produces corn, oats, and potatoes.

Meadow represents overflowed lands of little present agricultural value.



[PUBLIC RESOLUTION--No. 9.]

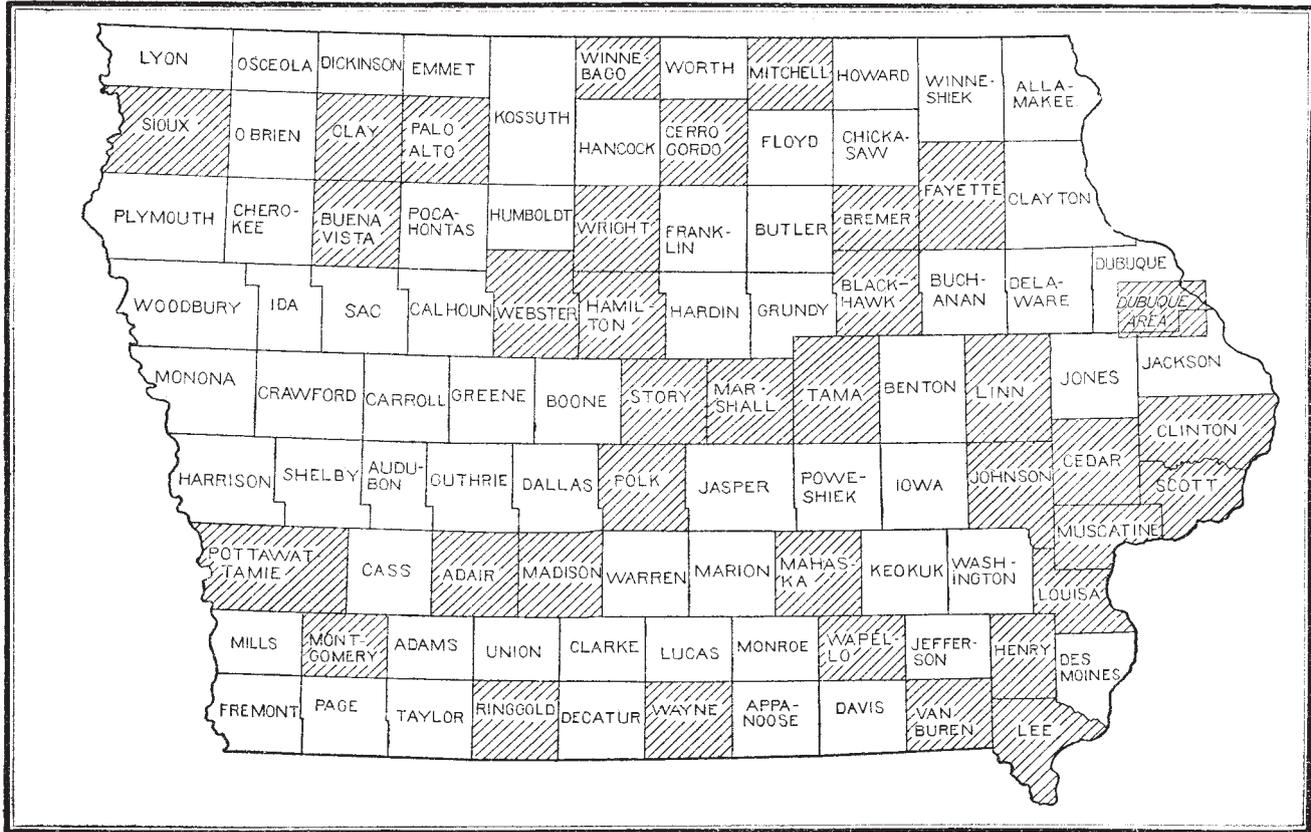
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved March 14, 1904.

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



Areas surveyed in Iowa.

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