Issued June 1, 1916.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION,
C. F. CURTISS, DIRECTOR.

SOIL SURVEY OF WEBSTER COUNTY, IOWA.

BY

J. O. VEATCH, OF THE U. S. DEPARTMENT OF AGRICULTURE,
AND F. B. HOWE, OF THE IOWA AGRICULTURAL
EXPERIMENT STATION.

W. E. McLENDON, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., October 12, 1915.

SIR: During the field season of 1914 a soil survey was made of Webster County, Iowa. This work was done in cooperation with the Iowa Agricultural Experiment Station, and the selection of this area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this survey, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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SOIL SURVEY OF WEBSTER COUNTY, IOWA.

By J. O. VEATCH, of the U. S. Department of Agriculture, and F. B. HOWE, of the Iowa Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

Webster County, Iowa, is situated just northwest of the center of the State. The county comprises 20 land townships of approximately 36 square miles each. Its total area is 714 square miles, or 456,960 acres.

Webster County is included in the Upper Mississippi Plains region of the United States. In general the land surface of the county is level to very gently undulating, without marked relief. The county lies in that part of the State covered by the last great ice invasion, the Wisconsin stage of the Pleistocene period, and has the usual drift-plain topography characteristic of this part of the State. The retreat of the Wisconsin ice has been so recent geologically that the constructive topography due to the ice sheet has not been appreciably modified. Low, inconspicuous swells and low knobs in moraines are features of an otherwise uniformly level surface. Ponds, sloughs, and poorly drained tracts are numerous. There has been no considerable stream erosion or land dissection except directly along the course of the one large stream of the county, which has simply cut a narrow gorgelike valley.

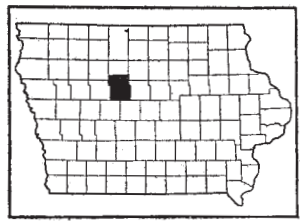

FIG. 1.—Sketch map showing location of the Webster County area, Iowa.

The general elevation of the county above sea level is 1,100 to 1,200 feet. The highest land is in the northwestern part of the county, whence there is a slight, almost imperceptible, slope southward. The prairie is nearly uniform in elevation, the extremes differing probably less than 100 feet. The Des Moines River has cut a valley 150 to 200 feet below the level of the drift plain or prairie level, but has not formed any considerable area of lowland. There are a number of narrow, discontinuous terraces along the main streams. The maximum topographic relief in the county is hardly more than 250 feet.

The county lies entirely within the drainage basin of the Des Moines River, a tributary of the Mississippi. But few tributary streams have been developed, and in this respect the Wisconsin drift sheet differs from the older drift sheets of the State, since in these older areas fairly mature systems of drainage have been formed. A large part of the county, therefore, is imperfectly drained naturally. Most of the streams have general eastward or southward courses. In their upper courses they occupy broad, shallow depressions left by the ice sheet and consequently are sluggish or tortuous.

The water supply for farm use is obtained mainly from bored wells 50 to 100 feet deep. In a few places wells on farms have been drilled to greater depths and obtain their water from the hard rocks underlying the glacial drift sheets. The well water is generally wholesome and suitable for all farm purposes. The supply of the shallow wells is fairly stable, and it is only during unusual droughts that it fails. The prairie streams are intermittent and can not be depended upon for water for stock during the summer months. There are a few springs along the bluffs of the Des Moines River and Lizard Creek, but these are small and of little or no value either for household use or for stock. Nearly all the farms are equipped with windmills or gasoline engines for pumping water for stock.

The permanent settlement of the county began about 1850, with the establishment of a military fort on the present site of the city of Fort Dodge. The native American population emigrated mainly from Illinois, Indiana, Ohio, and Missouri. About one-third of the present farming population is of foreign or mixed parentage, Swedes being the predominating nationality, followed in number by Germans, Norwegians, Irish, and Bohemians. The total population of the county is reported in the 1910 census as 34,629; Fort Dodge, with a population of 15,543, is the largest town in the county and is the county seat. No other town has a population of over 1,000, according to the census of 1910.

The interests of the county are primarily agricultural. There are, however, manufacturing industries in the vicinity of Fort Dodge and Lehigh. The brick and tile industry is important, while the mining of gypsum and the manufacture of gypsum plaster at Fort Dodge afford employment for a large number of people. Coal mining is carried on to a small extent.

The county is well provided with transportation facilities. It is traversed by the Illinois Central Railroad, the Chicago Great Western Railroad, the Chicago & North Western Railroad, the Minneapolis & St. Louis Railroad, the Chicago, Rock Island & Pacific Railway, and the Fort Dodge, Des Moines & Southern Railroad,

affording direct connection with Chicago, Omaha, Minneapolis, St. Paul, Des Moines, and Sioux City. No farm in the county is more than 6 miles from a station. Every station has one or more elevators, so that grain need be hauled but short distances to market.

The public roads follow section lines. They are commonly dirt roads, but are kept in fair condition by the use of road drags. The surface of the country being generally level, there are no steep grades, except in crossing the valleys of the Des Moines River and its larger tributaries. Extensive progress has recently been made in the improvement of the most traveled highways.

CLIMATE.

In general, the climate of Webster County is favorable for the production of the staple farm crops common to the region, particularly corn, and total crop failures are unknown.

The average annual precipitation at Iowa Falls is reported as 29.8 inches. Records[1] at Ames, Story County, 42 miles southeast of Fort Dodge, covering the period from 1876 to 1902, show a mean annual precipitation of 31.29 inches. An annual mean precipitation of 34.15 inches is recorded at Fort Dodge. About 75 per cent of the total rainfall occurs within the six months from April to September, inclusive, and is well distributed throughout the growing season. Evaporation is low, most of the soils having a favorable structure for retaining moisture during dry periods. Rains of a torrential character are infrequent, the precipitation usually occurring as light local showers or slow and moderate rains. Destructive hail storms are of rare occurrence.

Droughts of a month's duration may occur in the growing season, but the retentive character of the soils to a great extent prevents injury to the crops. There is probably greater likelihood of damage to crops from an excess of moisture than from a deficiency. The lowest annual precipitation recorded at Iowa Falls is 19.9 inches, in 1894. In that year the rainfall for the most critical crop months, May to August, inclusive, was 6.1 inches.

The winters are usually cold. The mean temperature for the winter months as shown by the records at Iowa Falls is 17° F. A minimum of 33 degrees below zero has been recorded. The prairies are often swept by cold northwest winds, so that protection must be afforded stock. The groves of maple, willow, cottonwood, and other trees which commonly appear about every farmstead were planted

[1] Iowa Weather and Crop Service, Annual Report, 1902, page 94.

mainly for protection from the wind. The only part of the county naturally protected from the severe winters is the Des Moines River belt, the course of which is fringed with a growth of timber. It was in this protected strip that the first white settlers located.

The mean summer temperature is 70° F., so that there is a range between the winter and summer means of 53 degrees. However, during the growing season the range in temperature is not great and sudden changes are infrequent, so that damage to crops from these causes is not of common occurrence. The mean annual temperature is reported at Iowa Falls as 45° F. and at Fort Dodge as 46.4° F. At Ames, Story County, a mean annual temperature of 47.5° is recorded.

The influence of temperature and rainfall on the maturing of certain plants or varieties of plants is strikingly illustrated in this locality, where varieties of corn introduced from southern climates have failed to mature, while varieties from northern regions have produced a ranker growth and less grain than in the country where they were developed.

The topography of the county is nearly uniform, and such differences as exist have but little influence on the climate. A few of the higher knolls are windswept, and winter crops are more subject to injury from freezing, while the deep, narrow stream valleys have the best natural protection from the cold.

The latest date of killing frost in the spring recorded at Iowa Falls is May 31 and at Fort Dodge May 27. The earliest date recorded in the fall at the former station is September 12 and at the latter station September 22. The average date of the last killing frost in the spring is given at Iowa Falls as May 7 and at Fort Dodge as May 5, and that of the first in the fall as September 22 at Iowa Falls and at Fort Dodge as October 4. This shows a normal growing season of 138 days at Iowa Falls and of 152 days at Fort Dodge.

The records of the Weather Bureau station at Fort Dodge are not continuous or otherwise complete, and therefore the more nearly complete observations at Iowa Falls, 35 miles east of the Webster County area, are given in the tables below, together with such means of temperature and precipitation as are available for the Fort Dodge station.

Normal monthly, seasonal, and annual temperature and precipitation at Iowa Falls and at Fort Dodge.

Month.	Iowa Falls.							Fort Dodge.	
	Temperature.			Precipitation.				Mean temperature.	Mean precipitation.
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.		
	°F.	°F.	°F.	Ins.	Inches.	Inches.	Inches.	°F.	Inches.
December	20	58	−22	1.1	0.9	2.1	8.4	22.5	0.46
January	16	57	−33	0.8	0.7	1.6	6.3	17.1	0.64
February	16	64	−28	1.0	0.2	0.8	8.4	15.3	0.71
Winter	17	.....	.....	2.9	1.8	4.5	23.1	18.3	1.81
March	31	87	−10	1.6	1.6	2.2	5.1	33.4	2.26
April	48	89	14	2.8	4.8	1.1	1.0	47.4	3.17
May	60	94	27	3.9	1.6	5.9	0.0	60.0	4.55
Spring	46	.....	.....	8.3	8.0	9.2	6.1	46.9	9.98
June	68	96	34	4.6	2.8	10.0	0.0	66.6	3.81
July	73	105	36	4.1	0.1	11.3	0.0	72.5	4.03
August	70	98	37	3.3	1.6	7.7	0.0	71.4	5.64
Summer	70	.....	.....	12.0	4.5	29.0	0.0	70.2	13.48
September	61	98	19	3.2	1.6	3.5	0.0	62.6	4.57
October	50	89	6	2.2	3.8	1.6	Trace.	52.3	3.09
November	32	73	−12	1.2	0.2	1.9	4.1	35.2	1.22
Fall	48	.....	.....	6.6	5.6	7.0	4.1	50.0	8.88
Year	45	105	−33	29.8	19.9	49.7	33.3	46.4	34.15

AGRICULTURE.

The agriculture of Webster County consists of the growing of grain and hay with the raising and feeding of live stock as coordinate industries. The county is situated in the corn belt of the United States, and corn is the principal crop. The farming methods are largely based on the production of corn, and only such other crops are grown as interfere least with its cultivation and which are believed to fit best into a rotation designed to maintain the productiveness of the corn land. It is probable at present that somewhat more than half the grain produced is sold from the farm, although this is primarily a stock-feeding country. There has been an increase lately in the amount of grain sold, owing partly to the prevailing high prices and partly to the ravages of hog cholera. Tenant farmers as a rule keep less stock and sell a greater proportion of the grain than farm owners.

Farming at present is extensive rather than intensive. Careful methods of farming are practiced, but economic conditions, chiefly the high cost of labor, render it more profitable to increase acreage to a certain limit and maintain moderate yields than to produce large yields by intensive methods on small farms. The acreage of individual farms is thus increasing instead of decreasing. The chief factor in effecting this change is the use of improved and labor-saving farm machinery.

Live stock, chiefly hogs and cattle, is kept on practically every farm, although there is very little specialization in raising pure-bred animals. The feeding of stock is regarded advantageous, because in this way the waste material and low-priced grain are most profitably utilized, the manure being greatly relied upon to maintain the productiveness of the land. Market conditions are not ordinarily so favorable that a profit can be obtained from the direct sale of the grain and hay crops.

Crop rotation is practiced to some extent, although as yet no definite system is generally followed. Practically all of the farmers recognize the need of changing crops to insure profitable yields, and therefore continuous cropping, except on a few bottom-land tracts, is not practiced. The most common rotation has been simply an alternation of the land in corn and oats, the corn land receiving all of the available manure. This has been the plan especially on farms containing wet, poorly drained land, which furnishes wild hay and pasturage.

A rotation practiced by many farmers is corn one year, followed by oats, with which timothy and clover are seeded; the land is then utilized for hay and pasturage for two or three years and again plowed for corn. Another plan followed to a small extent consists of seeding clover in oats in the spring and plowing under the growth with the stubble the same year. Such a plan, however, is regarded by many as of doubtful economy, and it does not seem likely that it will come into general use. Numerous rotations are applicable to this part of the country, but those which permit a maximum acreage in corn, since this is the most profitable crop, meet with most favor.

Barnyard and stable manure are applied to the land as a means of maintaining good tilth and fertility. The soils are naturally productive and durable, so that no need for commercial fertilizers has yet been felt. It is only on the peaty soils that fertilizers might be profitable at present, and these comprise only a small percentage of the total area.

Only moderately deep plowing is practiced—that is, to a depth of 4 to 5 inches—and breaking to a depth of 6 inches is not usual. The character of the soils permits of deeper plowing, and such practice would probably tend to increase productiveness, but the addi-

tional cost of deeper breaking, at the present price of labor and with the farm machinery now in use, is believed to be greater than any increase in crop returns which might accrue. Thorough cultivation of crops is the rule, and to this practice is due in large measure the maintenance of the high average yields.

The farm practice throughout the county is quite uniform, since there is no great dissimilarity in soils, and in addition the conditions of climate, topography, and market have no great range.

The agricultural development of the county began about 1853, with the organization of Webster County, although there were a few white settlers prior to that date. The population at that time is reported to have been 150. The rural settlement of the county was very rapid. The early settlers moved up the Des Moines River and located first in the forested areas along this stream, the timber furnishing wood for fuel and other purposes and affording protection during the severe winters, and from these areas settlement extended into the prairies. From the outset grain growing and the raising and feeding of live stock have been practiced. Corn has always been the principal crop, but much more wheat was grown in the earlier days of settlement than at present.

Gradual changes have been brought about in farming practices as the population increased, as railway facilities were improved, and as land values advanced. The increase in the area of improved land has been especially rapid during the last 10 years, or since the present system of land drainage has been established. It is probable that at the time of the first settlement as much as 20 per cent of the area was too wet or too poorly drained for successful cultivation, while data collected during the progress of the soil survey show that there is little more than 3,000 acres of permanently wet land at present. Probably more than 90 per cent of the entire county is in improved land.[1] The changes which have taken place have been gradual and have resulted from changing economic conditions.

Steady agricultural progress has accompanied the introduction of improved farm machinery and the drainage of wet lands. The land is more thoroughly prepared than formerly, though there has been a gradual increase in the size of individual farms. With drainage and resulting increased land values, the extent of native-pasture and wild-hay land has greatly decreased and the growing of tame hay, principally timothy and clover, has become a regular part of the farming operations on a majority of the farms. The rural population during the last few years has changed but little, possibly showing a slight decrease.

[1] In the U. S. Census, 1910, the percentage of improved land is given as 86.2.

According to the Federal census, 117,674 acres were devoted to corn in 1909. The estimate of the Iowa Weather and Crop Service for 1913 is 134,000 acres. The average yield per acre in 1909 was nearly 35 bushels; the average in 1913, based on the Iowa Weather and Crop Service estimate, was 42 bushels. The general average, over a series of years, is probably not far from 40 bushels. As much as 85 per cent of the land is comparatively uniform in productiveness, so that the average yield is fairly constant throughout the county.

The corn land, commonly either oat stubble or sod, is prepared by late-summer and fall plowing and by disking in the spring. Corn is planted early in May. Practically all of it is checked, and the rows commonly are about 40 inches apart; three or four stalks per hill are desired. Both single and two-row cultivators are in use and the crop is cultivated three to five times, depending upon the season and the availability of farm labor. The cultivation is completed by July. Husking of corn begins by the middle or latter part of October, but the greater part of this work is done in November. Much of the corn is cut and shocked in the fields and then either fed whole or shredded, but the greater part is husked from the standing stalks in the rows, cattle being allowed to forage in the fields afterwards. The corn binder is employed by a large number of farmers for harvesting, but has not yet come into general use. The quantity of corn grown for ensilage and the number of silos are increasing yearly. Shelling of corn for the market is done during the winter and spring. The practice of "hogging down" corn is followed to some extent and is apparently becoming more popular. Where this is practiced rape may be sown at the time of the last cultivation.

Dent corn is grown exclusively, yellow dent predominating over the white. Of the yellow varieties, Reids Yellow Dent and strains of this standard variety lead. The principal varieties of white corn apparently are Boone County White, Silver Mine, and Silver King. The names of most of the varieties grown are unknown to the farmers, the seed having been introduced by early settlers and adapted to local soil and climatic conditions by constant selection for a period of years, so that a number of local varieties or strains have been developed. Most of the seed corn brought in by the first settlers failed to mature early enough in this climate and the chief problem has been to develop by selection earliness of maturity and at the same time maintain good yields. Some damage is done to the crop by the wireworm and by the cutworm and root louse. There are also certain weed pests, among which green foxtail is the most common. The pink smartweed is detrimental to corn, especially on new Peat and Muck soils.

Oats rank next to corn in importance. This crop is reported on 91,007 acres in the census of 1910. Both climate and soil are favorable for this grain, and it has been grown since the early settlement of the county. On a large number of farms, particularly where considerable wild-hay land, unsuitable for cultivation, is available, the acreage devoted to oats about equals that in corn.

Oats fit in well with the growing of corn, both as a rotation crop and in the distribution of labor, and for this reason are preferable to some other crops that could be grown and might have a higher money value. Oat straw is preferred to wheat straw for feeding. Oats are sown broadcast on corn stubble, the land being prepared by disking. Seeding is done in April up to the 1st of May, and the oats are ready for cutting by the middle of July, or immediately after the last cultivation of the corn and after the cutting of timothy and clover hay. The crop can be removed in time for early plowing for corn. The greater part of the grain is thrashed from the field, perhaps less than one-third being stacked. The yields are a little more variable than those of corn, ranging from 25 to 60 bushels an acre, depending upon the season, the selection of seed, and the soil type. The average yields from the principal soil types are between 35 and 40 bushels per acre.

Most of the oats sown are white and medium late in maturing. A considerable acreage is devoted to early oats, which ripen early in July and are commonly called Fourth of July oats. There is some conflict in the harvesting of early oats and of the hay crop, but the opinion is expressed by farmers that the early varieties give the best results on new land because they are not so likely to grow rank and lodge. The Russian Green, Early Champion, American Banner, Silver Mine, and Swedish Select are the varieties grown.

The greater part of the grain is sold. A small part of the straw is baled and sold, but it is principally utilized for roughage on the farm.

Mixed timothy and clover constitute the chief hay crop. During the last 10 years the acreage in wild hay has rapidly decreased and the native prairie grasses have been replaced by cultivated hay and forage crops. Red clover can be grown without much difficulty on practically all of the soils and without liming. It rarely is damaged seriously during the winters. Timothy and clover are sown in the spring, usually with oats, and are becoming a fixed part of rotation plans. The average yield per acre is about 1½ tons. The census for 1910 reports 19,013 acres in mixed timothy and clover, producing 28,790 tons of hay. Most of the hay crop is consumed on the farms.

Wheat is grown to a small extent, but is not now considered an important income crop. In earlier periods much more wheat was

grown than at present. According to the 1880 census the total area in wheat was 18,169 acres in 1879, exceeding that of oats by more than 5,000 acres. This was entirely spring wheat. The growing of wheat in this, as well as in other parts of Iowa, has greatly declined, for several reasons, chiefly the decrease in yield, due to continuous cropping and the ravages of insects and blight. The wheat grown at present is chiefly for flour for home use, and the fields are comparatively small; the ordinary yield is about 15 bushels per acre. During the last few years a small quantity of winter wheat has been sowed and satisfactory yields have been obtained, 20 to 35 bushels per acre being common. There seems to be little doubt that winter wheat can be made to produce good yields, and it may replace a part of the acreage now devoted to oats, even though it does not permit of so favorable a distribution of labor as oats. Its extensive cultivation would involve a changed system of farming, which, in the opinion of most farmers, would not under present economic conditions be any more profitable than the present system. Beardless Bluestem is the most popular variety of spring wheat, and Turkey Red the principal variety of winter wheat grown.

Crops produced in small quantities or only occasionally grown are barley, flax, and buckwheat. Barley is grown principally for feed, very little of this grain suitable for malting being produced. Barley is successful in a rotation plan and perhaps has some advantage over oats in that clover can be more successfully seeded with it, but on the whole it is not regarded as likely to become a valuable money crop in this part of the State. Flax is grown more as a reclamation crop on new, low-lying land than for any other purpose. Only the seed is utilized. The crop becomes very weedy, especially on Peat soil, if grown more than one year in the same field without alternation with some other crop. Flax is believed to be valuable for "rotting," or disintegrating, virgin sod, thus preparing the land for corn and oats. About 10 bushels of seed per acre is commonly obtained. Buckwheat is sown occasionally on small, irregular tracts of new land.

Irish potatoes are a minor crop. Some of the soils are probably very suitable for potatoes, but little attention is given to their cultivation and the yields per acre consequently are low. Peat and Muck soils commonly are selected for this crop.

Millet is grown in a small way, chiefly as a supplementary crop, and to some extent as a reclamation crop, being most profitable on new Peat and Muck soil and other low-lying, newly drained land, and on alkali spots. The patches vary from one-half acre to 10 acres.

Alfalfa has been grown in an experimental way during the last few years, and on the whole the yields have been good. The soils, with the possible exception of one or two minor types, are all adapted

to this legume, and good stands have been obtained without liming or inoculation where the land is thoroughly drained and good seed has been used. Inoculation, however, probably is advisable.[1]

It is the opinion of farmers in this county that there is a need for a forage crop having a higher money value per acre than timothy and clover. Alfalfa meets this need and at the same time is an important factor in maintaining the productiveness of the soil. A rotation of corn and alfalfa should prove profitable here as well as in other parts of the corn belt.

Sweet clover grows luxuriantly along roads, railway embankments, and drainage ditches, attaining a height of 3 to 6 feet, and continues green until early in November. This plant is regarded more as a weed than as a useful forage crop, although it has a high feeding value and in some parts of the United States is cultivated. Only one farm was seen during the survey on which it is grown as a forage and seed crop.

Bluegrass does well on the alluvial or bottom lands and on the slopes of stream valleys. It also appears in timothy and clover fields used for pasturage, and after a few years, with other native grasses, crowds out these cultivated forage crops. Bluegrass furnishes excellent pasturage in the spring and also frequently in the fall, but may become dry and parched, especially on the steep slopes along streams, during summer droughts. Nonsaccharine sorghums give heavy yields, but are grown only on odd patches of ground or under special circumstances.

Fruit growing is not carried on extensively, since neither soil nor climate is very favorable. Most of the farms have small apple orchards for home and local supply, from which fair yields are obtained about once in three years. Plums can be grown, and bramble fruits do well on lands least suitable for staple crops. The climate is apparently too severe for peaches.

Live stock has generally been considered the chief source of income in this county. Hogs and cattle are kept on practically every farm, and attention is about equally divided between the two. Hogs are ordinarily more profitable than cattle, but lately the losses from cholera have discouraged many farmers. There are only a few sheep in the county.

The cattle fed are good grades of several different breeds. Little attention is given to the raising of purebred stock, purebred males being kept, however, in order to maintain good grades. Grades of the Red Poll, Shorthorn, Hereford, and Angus bloods are common. The total number of cattle is given in the 1910 census as 41,776.

[1] Information regarding alfalfa may be obtained from Farmers' Bulletin 339, U. S. Department of Agriculture, and Bulletin 137, Alfalfa Management in Iowa, published by the Iowa Agricultural Experiment Station.

The average size of the farms is reported in the 1910 census as 170.9 acres, with an average of 147.3 acres per farm improved. There are few farms of less than 80 acres, and on the other hand few of more than 320 acres. About 43 per cent of the farms are operated by tenants. The number of tenants probably is slightly increasing. The tenants as a rule, however, are good farmers and carry on farming operations much the same as farm owners. Land is rented under both the cash and share systems, and the number of tenants under the two plans is probably nearly equal, although the cash basis, at present, seems to be more favored. The cash rental value of farms with average improvements varies from $4.50 to $6 an acre. On the share basis the landowner receives one-half of the corn and two-fifths of the small grain, the tenant furnishing labor, work animals, and farm implements, and commonly paying a cash rent for pasture land.

Farm labor commands a high price and is to a large extent the factor which has determined the present type of farming. Farm hands under steady employment are paid $25 to $30 a month with board, while during the busy seasons laborers are paid $2 a day. The price paid for husking corn, an important item of expense, is commonly about 4 cents per bushel. The farm labor is entirely white and consists mainly of residents of the county. Skilled farm labor is becoming more and more in demand as the use of improved farm machinery increases and more scientific methods of farming are adopted.

Land values are high and increasing. Good farm land ranges in value from $125 to $300 an acre, depending upon improvements, character of the soil, and location with respect to railways and markets. Most of the land has a selling price of $175 to $200 an acre. In view of these values it seems that the rental price of land is relatively low. The average value of land in this county is given in the 1910 census as $80.73.

In general, farm improvements are good and denote prosperous conditions. The houses are well built and comfortable, and many recently built have the conveniences of city homes. Large, painted barns, with near-by windmills, are conspicuous features of every farmstead. There are no abandoned farms and few vacant farmhouses. Farms are generally well stocked and provided with modern farm machinery. The value of all farm property in the county, according to the census of 1910, is $44,155,470.

SOILS.

The soils of Webster County have a relatively uniform agricultural value and are highly productive. They are prevailingly dark in color. The principal soils, although differing sufficiently from

one another to warrant local separations in mapping, do not have the wide range in agricultural value and the extreme differences in physical properties and geologic origin which characterize many areas of the same size in the eastern and southern parts of the United States. Three soil types occupy 91.7 per cent of the entire area of the county.

The origin of the soil material (glacial drift) and the processes of soil formation have been such that the mineral and rock particles have been on the whole reduced to a moderately fine state so that the soils are predominantly fine textured. The sandy loams are of small extent and are confined to the first-bottom or alluvial lands along the present streams. The bodies of gravelly loam are negligible, and there are no stony soils. The loam soils greatly predominate, occupying more than 70 per cent of the county. The silt content of most of the prairie soil is high, and the loam, although friable and mellow, is generally fine grained rather than coarse. The residual soil is heterogeneous in the nature of the mineral or rock particles composing it and is analogous to the drift itself. There is a considerable area of clay loam, but the silt loam is of small extent, and there are no areas of clay large enough to be mapped.

The subsoils, except in three minor soil types, are commonly heavier and more compact than the surface material, that is, they have a higher silt and clay content and consist of clays and clay loams. The substrata, or the unmodified glacial drift, are also compact in structure, but less compact and more pervious than the subsoils.

The soils are prevailingly black. The depth to which the dark color extends varies according to local topography and drainage, but commonly ranges from 10 to 30 inches. The dark color is due to humus or decomposed organic matter resulting from the rank and luxuriant growth of grasses and other small plants of the prairie, and to the generally level topography and poor drainage, which favor the accumulation and retention of the humus in the soil. On the prairie the maximum accumulation of organic matter has been in the shallow water-covered areas, in which have been formed the Peat and Muck soils, while the minimum accumulation has been in the areas occupied by the Carrington series of soils. The most intensely black soil, the Fargo clay loam, gives evidence of being the most calcareous. Only one soil type, the Miami silt loam, occupying a comparatively small acreage, has a gray or light-colored surface soil, and for this reason is conspicuous in this region of prevailingly black soils. This light-colored soil is marked by a native forest growth on the upland bordering the streams.

There is commonly a change with depth, in both color and texture, but it is not always possible to draw any definite line between the

surface material and the subsoil or between the subsoil and substratum. The drift, which is little or not at all modified by weathering, is encountered at depths ranging from 4 to 15 feet. However, the bluish, pebbly, and gritty clay thrown from depths of 6 to 12 feet along drainage ditches supports a rank growth of sweet clover, and even the staple crops, corn and oats, make a fair growth where the embankments have been leveled and subjected to weathering for a few years.

In general the permanent productiveness of the land is believed to be more a matter of good drainage and proper tillage and crop rotation than of any treatment with mineral fertilizers. It may be stated with reasonable certainty that most of the soils are high in lime and in organic matter. It is not probable that any of the soils, the Miami silt loam possibly excepted, are of harmful acidity.[1]

There are very small areas or spots in which there has been a sufficient concentration of alkali to cause injury to plant growth, particularly corn.

The land is comparatively level and the natural subsurface drainage slow; consequently a large part of the precipitation sinks into the ground and is retained in the soil layer. The soils are generally quite moist in the spring, because of their retentive nature, and do not warm up very early.

Webster County lies within that part of the United States which was covered by continental ice sheets during the Pleistocene period. The ice in its movement transported rocks and soils, and upon its retreat left a mantle of glacial drift, consisting of deposits of heterogeneous rock débris, composed of clay, silt, and particles from sand to bowlder size. Two drift sheets are believed to be represented in Webster County, the Wisconsin and the Kansan, while a third and very ancient glacial stage, the Aftonian, may be represented.[2] These sheets have a thickness of 50 to 200 feet in this county; they cover the older rocks of the region and render the former land surface and topography obscure. The drift left by the last great ice invasion of the United States, the Wisconsin, occupies nearly the entire surface of the county and from it 95 per cent or more of the soil is derived. This portion of the country was occupied by a lobelike extension of the great ice sheet which is known as the Des Moines Lobe. The drift deposited by this lobe extends from Minnesota as far south as Des Moines, embracing parts or all of 30 counties in the central

[1] Conclusions from tests for acidity and lime requirements made by the Iowa Agricultural Experiment Station (Bul. 151, p. 183), of the Wisconsin drift soils as a whole are that few of the soils are likely to be found acid and that those found acid are not likely to be so more than 6 inches below the surface.

[2] The Geology of Webster County, Iowa, by Frank A. Wilder, 1901, and other publications of the Iowa Geological Survey are taken as authority for the age of the drift sheets and older geological formations of the county.

and north-central parts of the State and constituting one of the major soil areas of Iowa.

Stream erosion has in places revealed an older drift sheet beneath the Wisconsin, which is presumably the Kansan, but the influence of this older drift upon the character of the soils is negligible, except in the bluffs along the Des Moines River and some of its larger tributaries.

The geologic strata directly underlying the drift sheets consist of limestone, shales, and sandstones representing the St. Louis limestone and the Des Moines group, belonging respectively in the Mississippian and Pennsylvanian series (Coal Measures), while extensive beds of gypsum lying above the Des Moines group also occur.[1] The Paleozoic strata are exposed in a number of places by stream cutting, mainly in the bluffs along the Des Moines River, but also along some of the smaller streams. However, the direct influence of these strata upon the soils is very slight.

The Wisconsin drift or till in general is a bluish-drab fine silty clay or clay in which there are interbedded or intermixed a variety of coarse rock particles ranging from sand to bowlders in size. The surface color is pale yellowish, while in fresh exposures the underlying material is seen to be a dark bluish gray or bluish drab. The yellowish color is believed to be due to oxidation and represents the depth to which weathering has effected changes. In this county the depth is 6 to 15 feet. Except in a few isolated cases where small pockets of sand and gravel which show signs of stratification and water assortment occur, the drift is compact, relatively impervious, and without stratification or structural features except for a faint lamination in places, which may be due to pressure. There is a wide range in the pebbles and bowlders in the drift both in shape and size and in the variety of rock. The pebbles and bowlders are rounded and angular without a noticeable predominance of either form. The rocks are limestone, greenstone (principally diabase), various granites and gneisses, and olive-drab shale. Apparently the limestone predominates slightly over the other classes of rock, and it is fairly certain that limestone and basic igneous rocks predominate over the granitic and other acidic rocks. The pebbles of igneous rocks are generally fresh, and striations are a characteristic of the limestone. Large bowlders are not so abundant as in some other parts of the glacial-drift area of the United States, and they do not interfere with cultivation. A few bowlders as large as 6 feet in diameter were observed, but these are of rare occurrence. The large bowlders are principally granites, and but few of limestone and other rocks

[1] Geology of Webster County, Iowa, by Frank A. Wilder, Iowa Geological Survey, Vol. XII, p. 77.

more than 2 feet in diameter were observed. An important lithologic feature in relation to the soils is the large quantity of limestone and the great variety of rocks.

The drift which is correlated with the Kansan is a bluish, gritty, tough clay, not differing greatly in physical appearance from the unoxidized Wisconsin till. The upper part, however, is deep brown to nearly reddish brown in color, and shows greater oxidation than the Wisconsin. In the exposures which were examined there seems to be a smaller quantity of pebbles and bowlders and much less limestone and shale than in the later drift.

For the greater part the soils are composed of glacial drift, modified by weathering. The land surface is geologically recent and weathering processes have been in operation a comparatively short time. The drift does not show oxidation to any great depth and there is no intense coloring to indicate weathering for long periods. Physiographic features furnish further evidence of the youthfulness of the country. Both the lithologic character of the drift and the climatic and topographic conditions, however, have been especially favorable for the rapid formation of soils rich in organic matter. Much of the drift material before being caught up and transported by the ice was soil, and a still greater part doubtless represented the residue of rock disintegration. Such material was readily converted into soils, and the present soil is deeper and more fertile than in many regions of the United States where processes of soil formation have been in operation for much longer periods. There has not been the leaching out of soluble mineral constituents which has taken place in the older soil areas of the State, and but little erosion and land dissection have taken place to cause the loss of surface soil and the depletion of organic matter.

Minor differences in the soils are traceable to slight differences in the composition of the drift. Knobs in the nature of kames in the morainic belt and many of the low, isolated swells of the level prairie are gravelly and sandy, and the soils are therefore coarser in texture either at the surface or in the subsoil, more porous or open in structure, and less productive than are soils from the level ground moraine. Where there is a large quantity of limestone pebbles in the drift, the influence of this rock is reflected in the soil; also where bowlders are present in greatest quantity in the drift they are more abundant at the surface than in other localities. However, the parent rock material of the greater part of the soil is uniform, or at least not greatly variable in lithologic character from place to place, and the present soil differences are largely due to topography and drainage conditions.

The morainic section of the county has an undulating topography, and is occupied by the Carrington loam. The topography is mainly

constructional and the drainage has always been relatively good. Conditions were therefore less favorable for a luxuriant growth of vegetation and for a heavy accumulation of decomposed vegetable matter than in the case of other soils, but were more favorable for aeration and oxidation. On the other hand, in the area occupied by the Fargo loam the surface is generally level. There was a slower run-off of rainfall, a more abundant vegetation because of the poorer drainage, and consequently a greater accumulation of organic matter in the soil.

In very shallow depressions in the prairie, which are occupied by the Fargo clay loam, slightly poorer drainage conditions obtain than in areas of the Fargo loam. Conditions were equally or more favorable for a dense vegetation and the accumulation of organic matter, while a slight addition to the soil material resulted from the washing in of silt and clay from higher land.

The Peat and the Muck soils, which were formed under very similar conditions, occur in depressions which were lower than those comprising the Fargo clay loam or in other situations without natural drainage. These depressions were permanently wet, and natural conditions favored the accumulation, but not the complete decay, of organic matter. The areas occupied by the Fargo clay loam and Peat and Muck supported the most luxuriant growth of plants, and the areas occupied by the Carrington loam the least growth.

Some alluvial soils have been formed in this county, but they are comparatively unimportant in extent. This class of soils represents detritus, originally residual material from weathering, which has been washed from the land within the drainage basins of streams and redeposited in their flood plains throughout their courses. The alluvial material is derived mainly from the Wisconsin drift, with scarcely any influence from the older drift and the underlying Paleozoic strata, although some material from the latter sources is undoubtedly present. These soils are dark-colored fine sandy loams and loams which are fairly productive, but unlike the alluvial soils of most regions they are probably less productive than the residual or upland soils. The small area of alluvial soils is due to the fact that the land surface is recent and not enough time has elapsed since the retreat of the ice for the development of extensive drainage systems and of broad flood plains. The first-bottom, alluvial soils are classed with the Wabash series.

There is doubtless some wind-blown material in the soil, since conditions immediately after the retreat of the Wisconsin ice must have been favorable for the movement of the fine particles of the drift by wind. The amount of such material, however, is so slight that with one possible exception there is no soil type of

eolian origin. There is a noticeable absence of the loessial covering which appears in the eastern, western, and southern parts of the State.

The soils are separated into series on the basis of origin, color and structure, and topography and drainage. The series are divided into types on the basis of texture, or the relative quantities of different-sized particles, as sand, silt, and clay, present. Eleven soil types, including Peat and Muck, are mapped in Webster County. These represent six soil series. The following table gives the name and the actual and relative extent of each soil type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Fargo loam	213,120	46.6	Hancock loam	3,520	0.8
Carrington loam	86,784	23.0	Peat	3,456	.8
Steep phase	18,368		Wabash clay loam	1,024	.2
Fargo clay loam	101,120	22.1	Muck	256	.1
Miami silt loam	11,712	2.6	Carrington gravelly loam	192	.1
Wabash fine sandy loam	8,832	1.9			
Waukesha loam	8,576	1.8	Total	456,960	

FARGO SERIES.

The Fargo series comprises soils of black color grading into drab or grayish subsoils. These soils are calcareous and contain a high percentage of organic matter. The topography is flat to gently undulating and much of the land requires artificial drainage before it can be placed under cultivation. The series is derived both from glacial drift and from material accumulated in depressions, ponds, or lakes, and has in all cases been subjected to poor drainage conditions for a long period of time. It differs from the Carrington soil material mainly in the high content of organic matter, the unoxidized condition of the subsoil, and the higher lime content. This series occupies 68.7 per cent of the area of Webster County. It is represented by two types—the loam and clay loam.

FARGO LOAM.

The Fargo loam consists of about 10 inches of black, mellow loam underlain by a black, compact clay loam which merges at 6 to 8 inches into black clay, and this at about 24 inches passes into drab and pale-yellowish or greenish-drab, plastic clay. The surface soil contains a rather high percentage of silt and is fine in texture. Where cultivated, it has a good tilth. A high content of organic matter or humus is indicated by the intensity and depth of the black color. No important variations occur within the county.

The clay of the subsoil at 30 to 36 inches is somewhat gritty. Below this the sand particles increase in quantity and size until at a depth of 4 or 5 feet the material grades into bluish-drab and yellowish mottled, gravelly drift. The subsoil is nearly everywhere calcareous. Much of the lime present is in the form of limestone pebbles and sand and a considerable part is in the form of marl nodules. No acid conditions exist in the soil so far as could be determined by litmus-paper tests.

The physical character of this soil differs from that of the Carrington loam, with which it is associated and genetically related, chiefly in the greater thickness of black soil, and in having a somewhat more clayey and compact subsoil and a drab color in the subsoil. The soil material of both types is mainly residual and both are derived from Wisconsin drift of essentially the same lithologic character.

The Fargo loam comprises the largest acreage in the county, covering 46.6 per cent of the total area, and it is perhaps the most valuable type for general farming purposes. It is widely distributed in this county, but most of it lies in the southern half.

The land is level or only very gently undulating. Most of it is naturally sufficiently well drained for agricultural purposes, although on much of the flatter land tile drainage is needed.

The entire type is in farms, and scarcely any land remains in the original prairie condition. Owing to the level surface there is practically no waste land, and improved machinery can be used in the cultivation and harvesting of crops.

Corn, oats, and hay are grown almost exclusively. The yields of corn average about 50 bushels per acre. The average yield of oats is about 40 bushels per acre, and of timothy and clover hay about 1½ tons. The soil holds moisture well, and crops are never seriously injured by droughts. The grain is somewhat slower in reaching maturity than on the Carrington soils.

Most of this type has been in corn and oats alternately since the early history of the county, and it is only during the last few years that much of it has been seeded to clover. The soil is naturally strong and durable, and with proper crop rotation and the raising of live stock its productiveness is easily maintained without the use of commercial fertilizers. Farms on this type are valued at $200 to $225 an acre.

FARGO CLAY LOAM.

The Fargo clay loam consists of 10 to 12 inches of black silty clay loam, which grades into black, rather compact, fine-grained, plastic clay, this in turn passing at 20 to 24 inches into dark-drab, plastic clay. The lower subsoil, however, appears almost white after drying. Beginning at a depth of 24 to 36 inches the type contains con-

siderable grit or coarse sand and fine gravel and passes gradually at 4 to 6 feet into the bluish-drab and mottled drab and yellow drift clay or till. The soil section of the clay loam is similar to that of the loam type in color and in the gradational changes in texture and color with depth.

To a depth of 3 or 4 inches the soil has a somewhat loamy structure and becomes mellow with cultivation. The subsurface material and subsoil are clayey, plastic, and retentive of moisture, so that crops suffer less from droughts on this type than on associated soils.

The subsoil commonly contains a high percentage of limestone particles and white marl nodules, or lime segregations, and in general this type seems to be slightly more calcareous than the Fargo loam. The poor drainage conditions have been unfavorable for the leaching of lime and favorable for its segregation as marl nodules. Many of the greenstone pebbles of the subsoil and substratum are completely covered with a coating of calcium carbonate. Whitened shells of mollusks and small scattered pebbles of limestone are not uncommon at the surface. The organic-matter content is high. The rich, black color of the soil is probably due to the presence of a high content of organic matter and lime. The typical soil shows an alkaline reaction when tested with litmus paper, and there are a number of small spots which are sufficiently alkaline to affect the growth of corn. These alkali spots are described elsewhere in this report.

The Fargo clay loam as mapped shows slight variations, but on the whole it is very uniform in physical character. Local differences consist chiefly in the depth to which the black color extends, this varying from 18 to 36 inches. Where associated with Peat and Muck there is a narrow transitional zone which contains a large quantity of organic matter. The type also includes areas of soil locally termed "gumbo." This term is rather loosely used, but here it is applied to the more sticky or intractable areas of the black clay loam. The gumbo, however, is not sufficiently well defined for separate mapping.

Another variation from the typical soil is found in a few rather small areas in Elkhorn Township, sections 4, 5, 8, and 9. It differs from the typical soil in its occurrence in basins that were apparently occupied at one time by small lakes or which represent old filled-in valleys. The soil is essentially the typical Fargo clay loam, but either in the lower part of the subsoil or at a short distance below the 3-foot depth there is a layer of coarse sand, with some gravel, ranging from 2 to 5 feet in thickness. The occurrence of a sand layer at such a depth and in a basin where the moisture supply is large is not likely to cause the soil to be droughty, and this variation is no more subject to drought than is the typical soil.

The Fargo clay loam, although occupying a much smaller area than the loam, is one of the important soil types. It occurs throughout the county, but is most widely distributed in the southern half. It occurs in small tracts. Only in a very few places do the areas occupy more than one-half section of land. The total acreage is about equal to that of the Carrington loam.

This type occupies low-lying and poorly drained land, while the loam of this and the Carrington series occurs on the higher land. The largest bodies occupy drainage depressions which were left by the retreating ice sheet, and are mainly elongated and irregular in outline. Small, roughly circular or oval areas representing the sites of ponds are scattered throughout the county, many of them too small to be shown on the soil map. The clay loam type is flat and requires artificial drainage to be successfully cultivated. During the earlier history of the county these clay loam bodies, together with the Peat and Muck, represented the wet tracts of the prairie, were untillable, and were of value only for the wild hay and pasturage they afforded. During the last 10 years, however, the establishment of drainage has progressed so rapidly that probably 90 per cent of the clay loam has been made tillable.

The drift underlying the Fargo loam and that underlying the Fargo clay loam are similar in lithologic character. The physical and chemical differences are due primarily to topography. The clay loam depressions, although never more than 20 feet below the general upland level, have doubtless received a considerable quantity of silt and clay which has been washed from the higher land. The level topography and poor drainage have favored a greater accumulation of organic matter, and the conditions have been such that there probably has been greater chemical action on the minerals of the drift, producing a more plastic structure in the subsoil.

The clay loam is probably even more durable and productive when properly drained than the loam type, although the heavier texture of the soil and the necessity for artificial drainage offset the greater natural productiveness and about equalize the economic value of the two types. Plowing is somewhat more difficult than in the loam areas. The phase locally termed "gumbo" becomes sticky when wet and does not scour readily.

Deep cracks form during periods of drought, causing some injury to corn roots. Large glacial bowlders are more common in the clay loam depressions than elsewhere, but only in a very few places are they present in sufficient quantity to affect the value of the land.

The average yield of corn is about 50 bushels per acre with ordinary cultivation. It is of more importance to select early maturing varieties for this type than for the naturally better drained loam.

Oats produce a heavy yield of both straw and grain; the growth is frequently so rank as to cause lodging and a consequent waste in harvesting. The grain is three or four days to one week later in maturing than on the loam soils. Wheat and barley give as good results as on other types. Clover can be grown successfully, and alfalfa should do well where thorough tile drainage has been established.

In the following table the average results of mechanical analyses of samples of the soil and subsoil of the Fargo clay loam are given:

Mechanical analyses of Fargo clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330715, 330753.....	Soil.....	0.7	3.0	3.8	10.6	8.4	42.8	30.4
330716, 330754.....	Subsoil.....	1.8	3.6	3.6	9.6	9.3	44.2	28.0

CARRINGTON SERIES.

The soils of the Carrington series are black to brownish and are characterized by brownish and yellowish subsoils, generally of a lighter shade than the surface soils. These soils are derived through processes of weathering from glacial drift and are not influenced by loessial material. They are widely distributed throughout the central and western prairie regions of the glaciated northern United States. As a rule they have good drainage and are productive. The series is represented in Webster County by two types, the loam and gravelly loam.

CARRINGTON LOAM.

The Carrington loam as typically developed in Webster County consists of a black mellow loam, underlain at 12 to 15 inches by brown friable loam. At 18 to 24 inches a yellowish-brown or yellowish gritty clay loam is encountered. Yellowish glacial till little modified by weathering occurs at depths of 4 to 5 feet. Slight variations due to local topographic conditions or to minor variations in the physical or geological character of the underlying drift are found, but the type as a whole is uniform in physical character and in agricultural value.

On the higher morainic hills, subject to greater erosion and leaching, the surface soil has in many places a brownish rather than a black color. On the other hand, on the more nearly level land the black surface soil is thickest, and the subsoil in places is a heavy clay loam, or even gritty clay. In many places the yellowish-brown subsoil has a faint greenish cast. This greenish cast is so common that it may almost be considered characteristic of the type in this county.

The surface soil is generally mellow and friable. It apparently is well supplied with organic matter and generally free from coarse pebbles or bowlders. The surface soil is silty, and the quantity of coarse particles, coarse sand or gravel, increases with depth to 4 or 5 feet or until the drift is reached. Commonly the lower part of the subsoil is calcareous, but probably less so than the black loam and clay loam of the associated Fargo series.

The Carrington loam, both because of its extent and its agricultural value, is one of the most important soil types of this county. The principal areas are in the northern and north-central parts of the county, extending from Fort Dodge northward. They are confined to the morainic belts and the slightly undulating country. Smaller, detached tracts occur in the southern part of the county. The type, with its steep phase, comprises 23 per cent of the area of the county.

The Carrington loam is developed on the gently undulating prairie and on the low, smooth-sloped hills or swells of the moraines. It is naturally better drained than the associated loam and clay loam of the Fargo series. Small, isolated areas of this type occur as narrow strips on the gentle slopes to the small stream valleys of the county, these being erosional slopes, as distinguished from the constructive or ice-formed slopes of the moraines and the various isolated low hills of the prairie.

The soil is residual and is derived by weathering from glacial drift. Doubtless some wind-blown material occurs at the surface, although not in appreciable quantities. The drift belongs to the Wisconsin stage.

The entire area of the Carrington loam is well drained and easily tilled. The good drainage, favorable tillage properties, and the absence of waste land render this a highly desirable type for the kind of farming practiced in the county.

This soil is utilized almost exclusively for the staple crops, corn, oats, and hay. The farming practice is that common to the county as a whole. The greatest acreage on individual farms is devoted to corn and the next largest acreage to oats. The yields[1] of corn on this type average about 40 bushels per acre under the common methods of cultivation and where the field has been cultivated for several years. In exceptional cases, where the land is heavily manured or where particularly careful cultivation is practiced, higher yields, up to 70 bushels per acre, are obtained. Oats do well on this soil and produce average yields of 35 to 40 bushels per acre, with yields of 50 to 60 bushels in exceptional cases. The yields of timothy and clover hay are probably about 1½ tons to the acre, although it is rather difficult to obtain accurate estimates. Wheat and barley are grown, but

[1] Crop yields for the various soil types as given in this report are based on observations made in the field.

their acreage is relatively small. There are a few fields of spring wheat from which yields of about 15 bushels per acre are obtained. During the last few years winter wheat has been grown to a small extent and yields of 20 to 25 bushels are reported. Ordinarily, small grains mature 3 or 4 days earlier than on the more poorly drained black soils of the prairie, while corn is less likely to be injured by early frosts.

No commercial fertilizers are used. Stable and barnyard manure is applied perhaps to a somewhat greater extent than on the adjoining Fargo loam and clay loam types.

Improved farm land on this type has a value of $175 to $250 an acre, the difference in price being due more to the character of farm improvements and location than to differences in natural soil fertility.

Carrington loam, steep phase.—The steep phase of the Carrington loam occupies the erosional slopes and bluffs along the Des Moines River and its tributary ravines and creeks. The differentiation of this phase is based primarily upon topography.

The soil lacks the physical uniformity of the typical Carrington loam, but is not subject to wide variations in color or structure. The soil is prevailingly a black to brown friable loam, 6 to 12 inches deep, underlain by yellowish-brown, compact, gritty clay loam to clay. There are many places, especially along ravines, where the surface loam has been almost entirely removed by erosion, exposing the underlying yellowish clay loam. On the other hand, at the bases of some of the bluffs or slopes there are colluvial and taluslike accumulations where the soil is a black loam to a depth of 15 to 18 inches. In the southern part of the county on the slopes lying directly beneath the level upland occupied by the Miami silt loam the soil is in places a very light brown loam.

The widest soil variations occur on steep slopes, especially where the soil material comes from different sources, but these slopes are so narrow that the various soil phases which are found can not be mapped separately. The area as shown on the soil map really represents a topographic condition rather than a uniform soil type. The greater part of the soil on the slopes is derived from the Wisconsin drift, being directly derived from this drift on the upper slopes, while the creep or colluvial material is also largely from the Wisconsin sheet. An older till than the Wisconsin, presumably the Kansan, appears in the lower parts of the bluffs at various places along the Des Moines and its larger tributaries, and has contributed a considerable part of the soil material. Coal Measures, shales, and sandstones also are exposed on many bluffs and slopes and doubtless have contributed directly to the soil.

Practically all of the land of this phase is too steep for profitable cultivation of the staple crops of the county, since modern improved machinery can not be used in tillage and harvesting operations, and cobbles and bowlders are more abundant on the slopes than on the level upland. In many places the bluffs are quite precipitous, either because of recent erosion or because of landslides, and the land in such cases has no agricultural value. The total area of such land, however, is very small.

All of this phase is or was originally forested. The trees are mainly bur oak, red oak, white oak, basswood, and ash, with some hickory, walnut, and hard maple. A large part of the land, probably about one-third, has been cleared and is utilized for pasture. Much of it supports a luxuriant growth of bluegrass. Pastures on the cleared slopes, however, burn out during ordinary periods of summer drought.

Small patches of corn and oats are grown on the lower, smoother slopes. Should conditions be found favorable for marketing the products, some areas might be utilized successfully for the production of small fruits and berries. Raspberries, blackberries, currants, gooseberries, and strawberries probably would do well. Apples should give as good results as on any other soil of the county.

The results of mechanical analyses of samples of the soil and subsoil of the typical Carrington loam and of the steep phase are given in the following table:

Mechanical analyses of Carrington loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330721.....	Soil.....	2.0	5.7	6.0	14.0	9.6	38.5	24.1
330722.....	Subsoil.....	2.1	6.2	7.0	17.2	13.2	32.4	21.8
Steep phase:								
330729.....	Soil.....	3.0	6.2	7.2	19.7	16.0	32.1	15.7
330730.....	Subsoil.....	2.0	6.4	6.7	16.8	14.4	37.2	16.4

CARRINGTON GRAVELLY LOAM.

The Carrington gravelly loam consists predominantly of 8 to 10 inches of brown to black friable gravelly loam or sandy loam, underlain by brownish gravelly or pebbly loam. This in some places grades into yellowish-brown clay loam, while in others it passes into brownish or grayish sand and gravel at a depth of about 3 feet, or possibly less. Over most of the county the surface soil is somewhat lighter in color than the typical Carrington soils.

The type occupies small areas on the crests of the low hills or swells and kame knobs, and the few areas mapped occur in the

northern part of the county. It has a small total area and many of the bodies are too small to be shown separately. The material is residual from the more sandy or gravelly phases of the Wisconsin drift.

This type has a somewhat lower agricultural value than the Carrington loam. It does not have so high a content of organic matter, and, being more porous or open, is not so retentive of moisture, and consequently crops suffer greater injury during droughts. Most of the higher hills or knobs are wind swept in the winter and snows do not accumulate, so that winter wheat and other similar crops are more likely to freeze out than on adjoining lower lying land.

Miami Series.

The soils of the Miami series are characterized by brownish to grayish surface soils, underlain by yellowish to brownish subsoils, generally heavier in texture than the surface material. The soils are derived mainly through the weathering of glacial till. They are widely distributed through the North Central States—Ohio, Indiana, Wisconsin, Illinois, Michigan, Minnesota, and Iowa—and constitute a large proportion of the more valuable agricultural soils of this region. The Miami soils are or were originally forested. In Webster County the series is represented by one type only, of small extent—the Miami silt loam.

MIAMI SILT LOAM.

The Miami silt loam differs from the predominant prairie soils in that the surface material is grayish or light in color and the land forested. The type consists of a grayish to light-brownish, rather compact silt loam, underlain at a depth of 15 to 18 inches by brownish or dull yellowish brown, rather stiff clay. There are generally 2 or 3 inches of grayish silty clay loam between the surface material and the clay subsoil. The surface material is characteristically very light gray when dry, but darker when wet. In many places there is a very dark, almost black, surface layer 4 to 6 inches in thickness, but this is directly underlain by gray, ashy silt. In a few of the flatter areas the subsoil has a peculiar drab or drab and light-brown mottled appearance. The surface is almost entirely free from pebbles and bowlders. The subsoil commonly becomes gritty with depth and grades into yellowish, compact till or drift at $3\frac{1}{2}$ to 5 feet.

It is quite probable that this soil contains a lower percentage of organic matter and humus than the black prairie soils, and it is also probably less calcareous. Tests with litmus paper at several localities indicate acidity at the surface. This is the only soil in the county found to be acid, and it is doubtful whether the acidity is of such degree as to be very harmful to the cultivated crops.

The Miami silt loam is confined to narrow strips of level upland bordering the bluffs and steep slopes of the Des Moines River and its tributaries in the southern part of the county. The outer boundary of the type is nearly coincident with the outer edge of the timber which skirts the stream courses. The strips vary from not more than 200 or 300 feet to about three-fourths mile in width, and along the Des Moines River seem to be about equal on each side of the valley. Back from the streams this soil merges into the Fargo loam, and no sharp boundary line between the two can be drawn.

No areas of this type large enough to be mapped occur north of Fort Dodge, although there are strips of timber along the streams.

The origin of the gray soil material is rather obscure. It has been suggested[1] that such material, which also appears at other localities in Iowa, is wind blown. Facts observed during the progress of the field work in this survey indicate that the soil material is mainly residual, doubtless containing some wind-blown material, but probably no more than the prairie soils, and that the physical differences between this and the prairie soils are due to forest growth and to slightly different processes of weathering resulting from both the tree growth and the topographic situation. There is everywhere a transition in texture and color from the surface downward to the underlying drift. There is no predominance of the soil on either side of the stream valleys. The gray silt appears along such creeks as Brushy and Skillet, which have narrow, gorgelike valleys and no considerable flood plains, rather precluding the possibility of the material being blown from the valleys to the upland. The surface is mainly free from pebbles, but no more so than the prevailing black silty loam of the prairies. Analogous conditions are found in the case of soils derived from loess in other parts of Iowa. On the prairie the loess gives rise to dark-colored soils (classed with the Marshall series), while identical loess covered with timber gives rise to gray or light-colored soils (the Knox series).

The forest growth on the Miami silt loam consists principally of bur oak and white oak, with some red oak, hickory, ash, elm, clumps of aspen, and a few other hardwoods, while a growth of sumac and hazel is common. The tree growth differs from that of the bottom land and bluff slopes chiefly in the predominance of oak.

The greater part of this type has been cleared and placed under cultivation. The surface soil becomes rather compact and hard in dry weather, and a good tilth is not quite so easily maintained as on the prairie soils. However, tillage is not especially difficult. The land is nearly level, but natural drainage is adequate, except in a few local areas.

[1] Paper by S. W. Beyer, Iowa Geological Survey, Annual Report 1903, pp. 552–554.

The average yields of corn are somewhat lower than on the prairie loams, although accurate estimates could not be obtained. Corn is more subject to injury by droughts, which is perhaps the principal cause of the lower average yields. The subsoil is very retentive of moisture, but the thick surface covering of silt is not favorable for capillary action or the retention of moisture within the feeding area of the plant. In favorable seasons, however, good corn yields are obtained. Small grains—oats and wheat—seem to give as good results as on the black prairie soils, and the hay yields also are about the same.

The liberal use of manure is needed more than on other soils to maintain productiveness, favorable tilth, and good yields.

Waukesha Series.

The Waukesha soils occur on terraces bordering streams in the glaciated regions of the Central and Northwestern States. The surface soils are dark brown to black and are underlain by a subsoil or substratum of gravel and sand which is characteristically calcareous. The gravelly subsoil or substratum is not favorable for the retention of moisture, and crops frequently are seriously injured by drought. The soils are residual from fluviatile or glacio-fluvial deposits. Only the loam type is mapped in Webster County.

Waukesha loam.

The soil of the Waukesha loam is 10 to 15 inches in depth and consists of a black friable loam. This grades into dark-brown coarse, friable loam, which is underlain by brownish to grayish coarse, unconsolidated sand and gravel at depths ranging from 20 inches to 4 feet. This loam is somewhat coarser in texture or less silty than the loams of other series. The subsurface material or subsoil has a peculiar dark-brown color, nearly the shade of coffee grounds. Where forested, as along the Des Moines River in the southern part of the county, the surface soil is in many places of a lighter shade of brown than that north or west of Fort Dodge. The gravelly or coarse sandy subsoil characteristically contains a large quantity of limestone in particles ranging in size from sand to pebbles and cobbles, and commonly effervesces freely when tested with acid.

The Waukesha loam occupies narrow terraces or high benches along the Des Moines River and Lizard Creek, while smaller strips occur along Hardin and Deer Creeks.

The terrace plains are narrow, varying from 100 yards to about a mile in width, and are level or nearly level. The plain is nowhere continuous for more than 3 or 4 miles, and does not have a uniform altitude above the present stream levels. The plain along the Des Moines varies from about 90 to 125 feet above the river. It is well

defined topographically, and is easily recognized, being bordered on the side toward the stream by an abrupt escarpment or sharp descent, and generally by a fairly well defined escarpment between it and the upland level. Along Lizard Creek the terrace occupies a position above the stream ranging from 40 feet at the western line of the county to over 100 feet near the mouth of the stream at Fort Dodge.

The deposits from which this soil is derived appear to be of glacio-fluvial origin, probably in the nature of valley trains. The beds have a thickness of 5 to 20 feet and rest upon glacial drift. The material is heterogeneous in character; there is a great variety of rocks present and a great variation in the size of the stones. The pebbles are both rounded and angular. There are large quantities of limestone and shale, probably larger quantities than are present in the Wisconsin drift. Cross-bedding, stratification lines, and other evidences of water deposition may be seen in nearly every exposure. The sand and gravel beds are unconsolidated and quite porous or open in structure, permitting ready underdrainage. That the Waukesha loam has been derived, through processes of weathering, from this heterogeneous sand and gravel deposit is evidenced by the uniform gradation in color from black at the surface to brown and grayish in the subsoil and substratum, and the gradual increase in coarseness from the surface downward.

The soil is mellow and easily tilled. The land is fairly level, but has good natural drainage, and except in one or two localities it is free from stones or bowlders of such size as to interfere with farming operations. Practically the entire type is under cultivation.

Good yields of grain are obtained in favorable years, but crops are likely to be more seriously injured by droughts than on the soils of the Fargo and Carrington series, since the subsoil and substratum are not favorable for the retention of moisture. On the other hand, this soil warms up earlier in the spring and grain crops mature 3 or 4 days to 1 week earlier than on most of the other soils of the county. In favorable seasons the yields of corn and oats are about the same as on the Carrington loam.

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

Mechanical analyses of Waukesha loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330765	Soil	3.6	15.2	14.3	17.0	4.0	27.8	17.8
330766	Subsoil	14.0	37.4	21.2	14.0	0.8	3.0	9.9

Hancock Series.

The soils of the Hancock series occur on terraces above overflow. They are derived mainly from alluvial or water-laid deposits, but include some colluvial material near the base of escarpments or bluff slopes. The soil material consists of both glacial drift and loess, together with a small quantity of material derived directly from the Paleozoic sediments of the glaciated regions. The soils are black at the surface, grading into brownish or very dark gray in the subsoil or immediate substratum. The natural drainage is fair and the soils are productive. The loam type only is recognized in this survey.

Hancock loam.

The Hancock loam typically consists of a fine, friable black loam, extending to a depth of about 20 inches and underlain by loam or clay loam having a more compact structure. The black color in places extends to a depth of 30 to 36 inches, but commonly the material of the lower part of the 3-foot section or the immediate substratum has a brownish or even a very dark grayish color, depending upon local drainage conditions, though generally it is of a lighter shade than the surface material. The type as mapped is not entirely uniform in texture, but includes small patches of fine sandy loam which are not of sufficient importance to be shown separately on the map. In many places there is no appreciable lithologic difference throughout the entire thickness of the fluviatile deposit from which the soil is derived. There are no extensive gravelly or sandy layers, and, while the substratum is moderately porous, this type does not have the excessive natural underdrainage which characterizes the higher terrace soil classed as the Waukesha loam.

A phase of this type occurs in small areas just east of Kalo and near Fort Dodge. The alluvial and colluvial material from which this phase is derived rests directly on a floor of Paleozoic rocks, Coal Measures shales and sandstone, which appear at a depth of 4 to 8 feet. The rock is near enough to the surface to influence the character of the soil to some extent and this is the important difference between this phase and the typical Hancock loam. The soil for the most part consists of black or nearly black fine loam to fine sandy loam, underlain by brownish and yellowish fine sandy loam, which in places grades into yellowish compact clay loam. There is evidence in a few places that the subsoil is derived in part directly from Paleozoic strata. This phase is somewhat more droughty than the typical soil.

The Hancock loam occurs principally along the Des Moines River, where it occupies terraces or benches varying from 30 to 90

feet above the stream level. The terraces are narrow, commonly from 200 or 300 feet to one-fourth mile in width, and are nowhere continuous for any great distance. Small areas of this type occur also along Lizard Creek, lying 15 to 20 feet above the stream. The topography of the terraces, or second bottoms, is nearly level, but natural drainage is adequate for agriculture except in a few small areas.

The material from which the typical Hancock loam is derived seems to be of fluviatile origin, at least on the lower terraces. The deposits have a thickness of 4 to 20 feet or more. The sediment has been derived from the Wisconsin drift sheet and consists chiefly of glacial material. In places there are large bowlders which indicate that some of the material is ice-borne débris. Such bowlders are abundant in a small area in SW. ¼ sec. 12, T. 90, R. 29, about 9 miles north of Fort Dodge.

The soil is productive and easily tilled. Corn is the most successful crop. The average yields are perhaps nearly as large as on the prairie soils, but the land has a lower value on account of the small size and irregular shape of the fields. Oats give somewhat better results than on the lower lying first-bottom or Wabash soils. The variation developed near Kalo and Fort Dodge is moderately productive and is used to some extent for truck crops for local markets.

The results of mechanical analyses of samples of the soil and subsoil of the Hancock loam are given in the following table:

Mechanical analyses of Hancock loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330713	Soil	0.1	1.0	2.9	14.6	22.0	42.8	16.6
330714	Subsoil	.0	.2	1.4	13.8	23.4	44.4	16.9

WABASH SERIES.

The Wabash series comprises first-bottom, alluvial soils having a black to dark-brownish color and derived principally from loess and calcareous glacial drift. The surface soil generally has a high content of organic matter; the subsoils are commonly a shade lighter in color than the surface material, approaching gray or drab. The Wabash series is widely distributed through the Central Prairie States. Two types are mapped in Webster County—the fine sandy loam and the clay loam.

WABASH FINE SANDY LOAM.

Along the Des Moines River the soil of the Wabash fine sandy loam is prevailingly a black to brownish, friable fine sandy loam, 15 to 20 inches in depth. The color changes in the subsoil to faint brown or dark grayish. There is little change in texture within a depth of 3 feet, although the material becomes slightly coarser in the lower part of the section. The subsoil contains very little organic matter, but it retains moisture fairly well.

As is generally true of soils of alluvial origin, there is a lack of textural uniformity in this type. In places, especially in the southern part of the county, the soil is very fine, closely approaching a silt loam. There are also small areas of grayish, loose or incoherent fine sand or fine sandy loam, which are the result of deposition by recent overflow. The alluvial soil along the smaller streams, Lizard, Skillet, Brushy, and other creeks, is on the whole darker in color and coarser in texture, and the dark color extends to a greater depth than along the river.

The Wabash fine sandy loam embraces practically all of the alluvial soils of the first bottoms. The largest areas occur along the Des Moines River, while smaller strips border the tributary streams.

The flood plain of the Des Moines is quite narrow, varying from 100 yards to one-fourth mile in width. In places a slight exaggeration is necessary to show this type on the soil map. The plain along the river lies from 10 to 20 feet above normal water level, while the flood plains of the smaller streams lie from 5 to 10 feet above. The bottom land is hummocky or rather uneven, and on the whole less level and smooth than the terraces.

The alluvial bottoms are forested with a rather varied growth of fairly large trees. Elm, ash, box elder, hickory, walnut, butternut, and hawthorn, with some cottonwood, soft maple, and willows along the banks of the streams, constitute the principal growth.

Along the river the greater part of the land has been cleared and placed under cultivation, much of it having been utilized since the early settlement of the county. Corn is the chief crop, and in some fields it has been the only crop grown. The yields are good on the newer land, exceeding those from the prairie soils, but the land which has been cropped continuously for 25 to 40 years is beginning to show a decline in yields, and in some cases is being seeded to clover. Small grains have been grown to some extent, but the yields have been lower than on the prairie, and for this reason there has been a tendency to grow corn continuously. The bottoms are subject to overflow, but destructive floods are infrequent.

A smaller proportion of the land along the creeks has been cleared than along the river. Corn yields are perhaps slightly lower. Both

along the river and along the creeks the fields are small and irregular in shape, a condition which makes the expense of cultivation slightly greater than on the prairie.

WABASH CLAY LOAM.

The Wabash clay loam consists of a black, slightly plastic, compact clay loam, 10 to 12 inches in depth, underlain by black, plastic clay. At 3 or 4 feet the clay is sandy or gritty and dark drab or grayish in color. Along the upper courses of the streams this type merges into the Fargo clay loam, and the boundary between the two is somewhat arbitrary.

The Wabash clay loam has a small total extent. The principal area occurs along the South Branch of Lizard Creek, near Barnum. Two small strips are mapped along the East and West Branches of Buttrick Creek, near the southern boundary of the county. Only a small part of the type is under cultivation. The land is only 4 to 6 feet above stream level and is naturally too wet or too poorly drained for cultivated crops, but affords good pasturage and produces fair yields of hay. It probably would prove highly productive with thorough drainage.

MISCELLANEOUS MATERIAL.

PEAT.

The Peat soils of this county are dark brown to black in color and loose, porous, or spongy in structure. They are composed largely of partly decomposed vegetable matter of fibrous character, with only a small percentage of mineral matter. Some of the deeper Peat soil is simply a tough mat of brown semidecomposed plant roots and leaves.

The peaty material of the soil generally has a thickness of 6 to 20 inches, and it is only in two or three localities that it extends to a depth of 3 feet or more. The subsoil material is black and drab plastic clay. The few small tracts where sandy clay or sand directly underlies the Peat are not of sufficient size to warrant separate description. The unmodified glacial drift is encountered at 5 or 6 feet.

The Peat soil everywhere shows an alkaline or neutral reaction. On the darker colored, thinner Peat a white efflorescence of soluble salts is frequently seen on the surface. Small shells of mollusks are present both at the surface and in the black, mucky subsurface material, and have doubtless had some influence on the character of the soil. The drab subsoil or substratum nearly everywhere contains a sufficient amount of limestone sand and gravel or marl nodules to cause a free effervescence when tested with acid.

The Peat soils are widely distributed, occurring in all parts of the county, but the bogs are most abundant in the eastern and southern sections. The areas commonly are roughly circular in shape, corresponding to the outlines of the ponds or lakes in which the material accumulated. The greater number range from 3 to 40 acres in size; there are only a few tracts comprising as much as 80 acres, and the only very large area, approximately 720 acres, is on the site of Blairs Lake, 2½ miles north of Harcourt.

The Peat soils occupy shallow basins, having accumulated in ponds or lakes in which or around which there was a dense growth of aquatic and semiaquatic vegetation. The undrained bogs or ponds support a growth of a great variety of sedges, rushes, and other aquatic plants. Sedges and rushes have probably been the chief sources of the soil material. The Peat areas are devoid of tree growth, excepting a few clumps of willow in two or three localities. Pink smartweed and wood sage seem to be the most common and characteristic weeds on the drained soils, although there is a luxuriant growth of a great number of other species.

The basins are all very shallow, with very gentle slopes. In most cases they lie less than 10 to 20 feet below the general level of the prairie, and very little soil material has been washed in from the higher land. A considerable part of the silt and clay mixed with the vegetable matter is probably wind-blown material. The Peat is geologically recent, having been formed since the glacial period.

The Peat areas in their natural condition are permanently wet and of no value for cultivated crops. Without artificial drainage their only agricultural value is for pasturage and the production of wild hay, principally sedge. Within the last 10 years 75 per cent or more of the Peat bogs in this county have been drained and placed under cultivation. The soil, however, is much less productive than the associated black loam and clay loam of the prairie. Several years of cultivation are required before profitable yields of the staple crops can be obtained.

Corn, millet, and flax are the crops generally grown the first year, and subsequently oats and occasionally wheat are seeded. The yields of corn the first year are always small, frequently only stover or forage being obtained. The Peat soil is rather "cold," hindering early growth, while in wet seasons the plant continues to grow late in the fall and the grain fails to harden and mature properly. Corn is more subject to injury from early frost than on the adjoining soils. Tillage at first is rather difficult, on account of the soft, spongy character of the soil; also, crops for the first year or two are very weedy. On the thinner, darker colored Peat, from 6 to 12 inches in thickness,

where it is possible to reach the underlying black clay in plowing, fair crops of corn are obtained after two or three years of cultivation.

Millet is probably the most profitable crop on the newly drained land, because the growth is dense and smothers out the weeds, and yields of 1½ to 2 tons of hay per acre are obtained. The seed yield of millet is generally low. Timothy gives good results. Flax has been grown by some farmers as an initial crop, fair yields of seed being obtained. Some difficulty, however, is experienced in using a binder, on account of the soft, boggy character of the land and the uneven surface. Flax, if continued, becomes so weedy as to be scarcely worth cutting.

The yields of oats and wheat are rather low in comparison with those on adjoining soils, and the crops are late in maturing. Grain crops are weedy and do not give profitable yields until after the land has been in cultivation for several years. Rolling this land with heavy rollers is advantageous where attempts are made to raise small grain. Irish potatoes are grown on the Peat soils in a small way, mainly for home use. Smooth potatoes of medium size are obtained, but the yields are rather low, which, however, may not be due entirely to unfavorable soil.

No mineral fertilizers have been used in this county. Potash and phosphate might be of some value in hastening the maturity of grain. It is not improbable that in the case of the thick, brown Peat the potassium and phosphate content is quite low. On the thin soil deep plowing is beneficial because more clayey material of the subsoil is mixed with the surface peat and a better tilth is thereby obtained.

MUCK.

Muck is distinguished from Peat by the greater quantities of mineral or inorganic matter which it contains, while the vegetable matter is decomposed to a greater extent and the soil is generally black in color. There are no practicable means of determining any definite percentage of organic matter or any certain stage of decomposition of the organic matter, so that in some cases, in mapping, the distinction is necessarily arbitrary. In Muck decomposition or decay has proceeded to such an extent that the plant tissues forming it can not be identified.

The Muck soils in Webster County generally consist of 6 to 12 inches of intensely black loamy material, which grades, with a decrease in organic matter, into black plastic clay, this in turn passing into drab or greenish-drab plastic clay at 30 to 40 inches. The mineral matter of the surface soil consists largely of silt and clay, and the Muck soil grades imperceptibly into the surrounding areas of black silty clay loam of the Fargo series. After drainage and a few

years of cultivation the Muck, when dry, is soft, rather fluffy and incoherent, and has the feel and structure of a light, porous loam. The subsoil is not essentially different from that of the Peat. It is calcareous and has a more sticky character than the subsoil of the better drained prairie types. The surface material generally shows an alkaline reaction when tested with litmus paper, and it is not improbable that in some of the areas there is a sufficient concentration of alkali salts at the surface to cause injury to corn. Fragments of small white shells are common in the soil, as in the case of the Peat.

The Muck is widely distributed over the county in small, roughly circular areas, occupying shallow basins or depressions which are or were before drainage the sites of ponds or sloughs. The aggregate area is much less than that of the Peat. The bodies range in size from 1 or 2 acres, too small to be shown on the soil map, to about 80 acres.

The Muck was formed in ponds or water-covered areas by the gradual accumulation of plant remains. In the Muck areas, however, conditions have been less favorable for a dense growth of aquatic vegetation than in the Peat areas, or because of the intermittent character of the ponds there has not always been sufficient water covering the fallen vegetation to prevent oxidation and arrest decay. The plant growth in the undrained Muck areas is similar to that in the Peat areas, consisting mainly of sedges, rushes, and flags.

The Muck soils are much more easily tilled than the Peat, and will produce profitable crops of grain immediately after draining or after a few years of cultivation. Corn, however, as on the Peat, is subject to more or less injury from frosts, and during wet years may not mature well. Oats show a tendency to produce more straw and a somewhat lower yield of grain than on the naturally better drained soils. Millet and timothy produce good yields of hay. In one locality a good stand of alfalfa has been obtained on old, well-drained Muck soil.

In some sections of the county Muck and well-rotted Peat soils are successfully utilized for such truck crops as celery, onions, and cabbage, and they could doubtless be so used in this county, provided economic conditions were favorable for the development of the trucking industry.

ALKALI.

Small tracts of soil containing sufficient quantities of alkali salts to cause injury to plant growth occur in close association with the Fargo clay loam and the Peat and Muck soils. These so-called "alkali spots" occur in shallow depressions and occupy only very small areas on individual farms, but seriously reduce crop yields,

while the labor of preparing land of this kind for such crops as corn is frequently a total economic loss. The proper method of handling these soils continues an important problem of soil management in this county.

The alkali soil is most commonly a clay loam in texture, and in color, structure, and other features the subsoil seems to be identical with that of the productive black clay loam with which it is associated. The surface soil, however, usually has a lighter color, and is dark gray or ashy gray when quite dry. It has a peculiar soft, ashy feel or loose, loamy structure in cultivated fields. This surface material is only 1 inch to 3 or 4 inches in depth, and the underlying material is a black and drab plastic clay loam and clay. Small particles of limestone and generally fragments of shells are present. Both the surface soil and subsoil effervesce when tested with acid, and it is highly probable that the soils contain a high percentage of lime.

The following table gives the nature of the soluble salts present in samples of these soils and the degree of alkalinity:

Analyses of alkali soils, Webster County, Iowa.[1]

[Parts per 100,000 of soil.]

Soluble salt.	No. 330701, 0 to 8 in.	No. 330702, 8 to 22 in.	No. 330703, 22 to 40 in.	No. 330704, 0 to 7 in.	No. 330705, 7 to 20 in.	No. 330706, 20 to 36 in.
Ca	44	24	4	36	8	20
Mg	28	Trace.	Trace.	Trace.	Trace.	Trace.
Na	37	64	64	48	67	35
K	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
SO_4	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Cl	28	28	28	12	12	12
HCO_3	324	192	132	224	180	132
CO_3						
Total	461	308	228	320	267	199
Per cent of alkali salts	0.46	0.31	0.23	0.32	0.27	0.20

[1] Analyses by Bureau of Soils, U. S. Department of Agriculture.

Nos. 330701 to 330703 constitute one sample and Nos. 330704 to 330706 a second sample. There is doubtless a wide variation in the alkali content of various soils throughout the county, but the above samples are believed to be fairly representative.

Although the alkali spots occur only in low-lying, poorly drained land in swales and pond depressions, they do not occupy the lowest parts of the depressions, but appear on low hummocks 2 or 3 feet high. In places they almost entirely surround the margins of present or former ponds and peat bogs. The spots vary in size from one-tenth acre to 2 or 3 acres, and on an 80 or 160 acre farm there may be a half dozen or more of such spots. Their distribution is

coincident with that of the Fargo clay loam, and the spots appear in probably three-fourths of the areas of that type, but seem to be less abundant in the southeastern part of the county. Because of their small size and the difficulty of locating them in uncultivated fields, the alkali areas can not be shown satisfactorily on the soil map.

The alkali condition probably is due to the concentration of soluble salts by seepage waters in depressions without outlets and in other places having very poor drainage. As shown by the analyses, a secondary concentration of the salts takes place within the surface soil; this has been effected probably by the movement of capillary water. Even during periods of drought this soil is quite moist at a depth of 3 or 4 inches, while surrounding soils are dry to a depth of 10 to 20 inches.

Corn seems to be the plant most susceptible to injury. In many places there is no production of grain and only a very small growth of stalk. On untreated alkali spots, corn plants were observed in tassel at a height of 18 inches to 3 feet, while the growth on adjoining areas of normal soil reached a height of 8 to 10 feet. Bare spots are common in cornfields. This failure of crop growth is not always due entirely to the alkali, but during some years to the work of the wireworm, which apparently finds the alkali soil favorable material in which to propagate.

Oats on alkali soil attain a rank growth and commonly lodge. The yields of grain, however, are neither large nor proportionate to the straw produced. Millet makes a rank growth and is least susceptible to injury. Fair stands of alfalfa and clover have been obtained in a few places and sweet clover seems not to be greatly injured. On the virgin prairie these spots support a growth of grasses and weeds and are not easily located.

No special difficulties in tillage operations are encountered. However, in some places the soil does not scour well, and sometimes the plow pushes rather than turns the earth. There is everywhere a loose, loamy surface layer of 1 inch to 3 or 4 inches, and the deep cracks which occur in the normal black clay loam during the dry periods of the summer do not appear in the alkali-affected spots.

The means adopted by farmers for reducing injury to crops are draining and the application of manure or straw. Incorporating stable manure is the most efficient treatment, according to the observations of most farmers. Corncobs are spread over the land by some and may be of some benefit.

It would seem that thorough drainage is of the greatest importance in reducing the alkalinity and rendering the soil more productive. Because of the compact and retentive nature of the subsoil it is probable that effective drainage can be brought about only by

close tiling. It is not improbable that straw and manure worked into the soil are beneficial, as they break the capillary movement of the water toward the surface, and thus prevent excessive concentration at the surface where the plant roots feed. The peaty material which in many places is conveniently available might serve the same purpose. It is possible that the observed beneficial effects of manure may be due in part also to chemical action, its salts uniting with and neutralizing to some extent the alkali of the soil. No experiments have been made with mineral fertilizers.

SUMMARY.

Webster County is in the central part of Iowa. It comprises an area of 714 square miles, or 456,960 acres.

The county lies in that part of the State covered by the last great ice invasion of the Pleistocene period and has the usual drift-plain topography characteristic of this section. In general the land surface is a level to very gently undulating prairie without any marked relief. The elevation of the county above sea level is about 1,100 to 1,200 feet.

The county is drained entirely by the Des Moines River, a tributary of the Mississippi. But few small tributary streams have been developed, and a large part of the area is imperfectly drained.

The population of the county is reported by the 1910 census as 34,629. About 55 per cent is rural.

Agriculture is the chief occupation of the people, although the manufacturing and mining industries are important.

The mean annual temperature is about 45° F. and the annual precipitation about 30 inches. A normal growing season of 138 days is reported at Iowa Falls, Hardin County, and of 152 days at Fort Dodge, Webster County.

The agriculture of Webster County consists of the growing of grain and hay, with the feeding and raising of hogs and cattle as a coordinate industry.

Corn is the principal crop. It is reported on 117,674 acres in 1909. The average yield per acre is about 40 bushels. Oats are next in importance to corn, being grown on a total of 91,007 acres in 1909, according to the 1910 census. The average yield per acre is between 35 and 40 bushels. Timothy and clover constitute the principal hay crops. Crops of less importance are wheat, barley, millet, flax, alfalfa, and Irish potatoes.

Probably as much as 90 per cent of the county is improved farm land. The value of land is high, ranging from $125 to $300 an acre. Farms are generally well improved and the farmers throughout the county are prosperous.

The soils are marked by a rich, black color and high average productiveness. The larger proportion of the county is occupied by glacial soils. These are derived from drift belonging to the Wisconsin stage of the Pleistocene period. The loam class of soil predominates.

The principal soil type is classed as the Fargo loam. This is a deep, black, mellow silty loam which occupies the smoother parts of the prairie. The soil is easily tilled and is highly productive. The Fargo clay loam occupies lower lying, more poorly drained land, but where properly drained is probably a more durable and fertile soil than the loam. The soils of the Fargo series are characteristically calcareous.

The soils of the more undulating, naturally better drained prairie land are classed with the Carrington series. The loam type has the largest extent, covering about 20 per cent of the area of the county. This type is characterized by a black surface soil and yellowish or brownish subsoil. It is naturally a productive soil and is well adapted to corn and oats.

The terrace soils have been grouped into two series, one dark brown in color, the other black. They occupy a relatively small area in the county and are somewhat less valuable for corn than the better upland soils.

The alluvial soils, or first-bottom lands, occupy a comparatively small area and are of less agricultural importance than the prairie soils, although durable and productive.

A large number of small areas of Peat and Muck soils are distributed over the county. These soils require artificial drainage before they can be utilized for cultivated crops.

Small areas of soil which contain sufficient quantities of alkali to injure the growth of corn occur over much of the lower lying prairie land. It is probable that thorough drainage is the most effective means of improving these "alkali spots."

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[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

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