U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF BLACKHAWK COUNTY, IOWA.

BY

W. E. THARP, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND HORACE J. HARPER, OF THE IOWA AGRICULTURAL EXPERIMENT STATION.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1919.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., January 10, 1919.

SIR: During the field season of 1917 a soil survey was made of Blackhawk County, Iowa. This work was done in cooperation with the State of Iowa, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this area, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1917, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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Soil map, Blackhawk County sheet, Iowa.

SOIL SURVEY OF BLACKHAWK COUNTY, IOWA.

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

DESCRIPTION OF THE AREA.

Blackhawk County is situated about midway between the center and the northeastern corner of Iowa. Waterloo, the county seat, is about 80 miles northeast of Des Moines. The county contains 565 square miles, or 361,600 acres.

In general, Blackhawk County consists of gently rolling prairie interrupted by the shallow valley of the Cedar River, which flows southeastward through the center of the county, and by the valley of the Wapsipinicon River in the extreme northeastern part. The general level of the valley floors is about 850 feet above sea level, and that of the uplands about 1,000 feet.

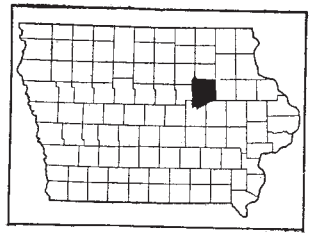

FIG. 1.—Sketch map showing location of the Blackhawk County area, Iowa.

That part of the county south and west of the Cedar Valley is gently rolling, with occasional areas on the wider divides that are little more than undulating. Throughout this entire section there is hardly an acre of upland whose surface slope is not apparent at a glance, while there is probably less than a total of 1,000 acres so sharply sloping as to be unsuited to extensive cultivation. Most of the upland east and north of the Cedar Valley consists of broad rolling ridges, with occasional tracts of a few hundred acres that are nearly level. The latter occur chiefly in the northern part of the county on the wider divides. There are about 10 square miles of gently rolling upland in this county to the east of the Wapsipinicon Valley.

The valley of the Cedar River above Cedar Falls is for the most part an uneven sandy plain, lying well above overflow. A characteristic feature is the numerous low sand ridges having a northwest-southeast trend. Below Waterloo the valley is not so wide, and the ridges of sand are absent. From Waterloo southward the western part of the valley generally consists of terraces lying 10 to 20 feet above the present flood plains of the river.

The lower courses of the West Fork of Cedar River and of Beaver Creek are within the northwestern part of the county, and their rather narrow flood plains and high, wide second bottoms form much of the level land of that section. Blackhawk Creek drains much of the

southwestern part of the county. Its valley, which is from 1 to 1½ miles wide, is generally low and flat above Hudson, but between that point and its junction with the Cedar Valley near Waterloo it consists chiefly of low terraces. Millers Creek, which drains most of the south-central part of the county, flows northeasterly into the Cedar River. Its upper valley consists chiefly of rather high terrace land, while the lower part is a wide, flat expansion opening upon the Cedar River terraces.

The valley of the Wapsipinicon River is from 1 to 3 miles wide, and much of it is subject to frequent overflow. The terraces occur chiefly on the western side, and are comparatively low. Crain Creek, the largest tributary of the Wapsipinicon within this county, has a flat valley which includes much poorly drained land. This stream receives very little drainage from the south. The heads of the northern tributaries of Cedar River are in some places within a mile or two of Crain Creek. Elk Run is the largest of these northward-reaching tributaries. The lower part of its course is through a sort of inclosed basin, embracing about 8 square miles, separated from the Cedar Valley by high, sandy hills. Similar hills, whose evenly rounded contours suggest an æolian origin, occur in many places along the eastern side of Cedar Valley.

The extreme east-central and southeastern parts of the county are drained by Spring Creek. Its rather narrow valley consists largely of terraces, and there are numerous outcrops of limestone along its lower course.

Practically all of the upland and the wider areas of recent bottomland were formerly a prairie. There is now considerable timber along the rivers and lower Blackhawk Creek, its distribution practically coinciding with the areas mapped as Meadow. Crain Creek is a typical prairie stream, and there is not much woodland along Poyner or Millers Creek, or most of Spring Creek. The valleys of all the small branches were originally treeless. Of the woods that formerly covered small areas of the high bluff lands near the larger streams a considerable part yet remain as beautiful groves of oak, hickory, elm, and ash, with some wild cherry, hard maple, and other deciduous trees. Most farm homes are sheltered by artificial groves of soft maple, box elder, and cottonwood. In many instances ash, elm, and various kinds of conifers form part of these plantings.

Blackhawk County was created in 1843 and finally organized in 1853. The first settlements were made at Cedar Falls, in 1845. Many immigrants arrived in the early fifties, and the first entries of Government land date from about that period. A considerable proportion of the present inhabitants are of German, Danish, and Norwegian descent. The population increased from 23,913 in 1880 to 44,865 in 1910 and 53,469 in 1915. In the latter year 88 per cent of the

inhabitants were native-born white persons and 11 per cent foreign-born white persons. The 1910 census reports 29.3 per cent of the entire population as rural, averaging 23.3 persons to the square mile.

Waterloo, the county seat, had a population of 26,693 in 1910. It is a distributing and manufacturing center of considerable importance and a good local market. Cedar Falls, the seat of the State Normal School, is a beautiful residential city of about 5,000 population. Laporte City in 1910 had a population of 1,233. The other towns are local trading centers.

The main line of the Chicago Great Western Railroad between Chicago and Omaha crosses the county from northeast to southwest. A line of the Chicago, Rock Island & Pacific crosses it from southeast to northwest. The Illinois Central runs through the middle of the county from east to west. All these lines center at Waterloo. A branch of the Chicago Great Western traverses the southwest corner of the county.

Except in the Cedar Valley and along a few other streams the public roads are generally located on section lines. A few of the highways have been surfaced with gravel, and all are maintained in such a condition that automobiles are in use the entire year. Almost every farm home has rural mail delivery and telephone service.

Nearly all farms operated by the owners have commodious houses, and one or more large barns, a corn crib, hog house, poultry house, and garage. Water is usually obtained from deep wells and pumped by gasoline engines or windmills. Rented farms usually are not so well improved.

CLIMATE.

The climate of this area is marked by rather wide variations in temperature, the extreme range recorded at the Weather Bureau station at Waterloo being from 32° below zero to 109° F. above. The winter mean is about 20°, and the summer mean about 71° F.

The average date of the last killing frost in the spring is May 6, and that of the first in the fall, October 6, but severe frosts have occurred as late as May 31 and as early as September 17. The average length of the growing season is about 153 days. The dark-colored soils absorb heat very readily, and after summer weather sets in all vegetation makes a rapid growth. Much of the late-maturing corn has been injured in such abnormal seasons as those from 1915 to 1917, but the early strains, or "90 day" varieties, have usually escaped injury, except on the lower lying lands or where planting has been greatly delayed. Melons, pumpkins, tomatoes, and field beans usually require early planting or otherwise favorable conditions to insure maturity before frosts.

The average climatic conditions are well suited to the growing of corn, oats, barley, and rye. The fact that wheat was formerly

grown with much success implies some other factor than climate as a contributing cause in the frequent failures of this crop during the last 20 years. Farmers, however, usually attribute the poor wheat yields to adverse seasons. The above observation seems to apply also to clover. While lack of summer rainfall or severe winter freezing is doubtless the principal cause, this does not explain the fact that some clover fields, distributed over various soil types, endure these conditions with little injury. This was particularly evident in 1917. It seems highly probable that variations in the moisture content of the soil, as influenced by previous management, increasing acidity of the soil, as well as the vitality of the seed, are all involved in this problem.

The average annual precipitation is approximately 31 inches. About 4 inches is the monthly average from May to September. On the heavier soils this seems sufficient, but it is evidently none too much. Any deficiency tends to reduce the yields on all types, while on the light soils a slight reduction or marked irregularity in occurrence greatly affects crops.

The principal climatic data as recorded at the Weather Bureau station at Waterloo are given in the following table:

Normal monthly, seasonal, and annual temperature and precipitation at Waterloo.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1902).	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	23.3	59	−28	1.27	0.47	1.94	6.4
January	16.2	61	−32	1.14	1.49	.93	7.8
February	19.5	64	−27	1.17	.50	1.47	7.4
Winter	19.7	64	−32	3.58	2.46	4.34	21.6
March	32.5	86	−13	1.63	.09	2.29	5.0
April	47.9	92	13	2.43	2.17	1.28	1.3
May	59.9	95	22	4.06	2.05	8.54	0.0
Spring	46.8	95	−13	8.12	4.31	12.11	6.3
June	68.5	98	37	3.79	1.84	6.81	0.0
July	73.9	109	44	4.23	.84	10.61	0.0
August	71.5	101	34	3.59	4.11	7.70	0.0
Summer	71.3	109	34	11.61	6.79	25.12	0.0
September	63.0	100	19	3.76	2.98	4.86	0.0
October	51.0	91	12	2.35	.37	1.50	T.
November	35.0	79	− 7	1.45	.44	1.83	2.2
Fall	49.7	100	− 7	7.56	3.79	8.19	2.2
Year	46.8	109	−32	30.87	17.35	49.76	30.1

AGRICULTURE.

Since the occupancy of this region by any considerable number of white people dates from about 1850, there is very little land that has been in cultivation more than 60 years, and a large proportion of the upland has been tilled less than a half century. Much of the area of the Clyde soils and almost all that of the Bremer soils have only been brought into tillage as artificial drainage has been introduced. Open ditches, tile drains, and road building have lowered the average level of the ground water on practically all lands except those immediately bordering the larger streams. Corn, oats, and hay have always been the leading field crops, and horses, cattle, and hogs the chief domestic animals. Wheat was formerly an important crop, but the acreage has greatly declined. Dairying has become an important industry in the last 20 years.

The acreage and production of the principal cereal crops in the last four census years is given in the following table:

Acreage and production of cereal crops in Blackhawk County, 1880 to 1910.

Census year.	Corn.		Oats.		Wheat.		Rye.		Barley.	
	Acres.	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*
1880.....	90,444	3,903,944	27,560	992,762	50,720	521,039	2,917	41,375	1,100	20,742
1890.....	81,079	2,932,699	54,647	2,371,202	441	5,019	1,918	21,662	240	7,190
1900.....	98,613	3,853,310	61,002	2,472,590	1,236	23,060	2,154	23,390	8,273	272,810
1910.....	95,572	3,498,697	54,567	1,686,616	225	4,051	2,164	26,496	5,469	113,168

There seems to be little increase in crop yields over those reported in 1880. The decline in the productiveness of the principal soil types has largely offset the effect of improved methods of tillage and the drainage of low areas. This conclusion is supported by the opinion of many farmers. The average yield of corn for the period from 1905 to 1914, inclusive, was a little more than 39 bushels per acre, and of oats, 40 bushels. The increase in the acreage of oats is due in part to the decline in wheat growing, and in part to the necessity of seeding to clover and timothy, oats being the "nurse crop" used in most instances. It is not considered by farmers a profitable crop in itself, unless the yield and price are above the average.

The marked decline in wheat production began about 30 years ago, when in several successive seasons the grain in most fields failed to fill well, owing, in the opinion of some farmers, to dry, hot weather. The chinch bug was also troublesome for several years. Spring wheat was most commonly sown, but in recent years the acreage has consisted in part of winter wheat. Results have been variable. Winter

freezing, as in 1916–17, and hot weather just before harvest often cause much injury. Three hundred acres of spring wheat and 1,500 acres of winter wheat are reported in the Iowa Yearbook for 1914, with an average yield in each case of about 22 bushels per acre.

The production of rye is confined almost entirely to the lighter soils. Barley is grown on a considerable acreage, which has remained about stationary since 1909. In 1914, 5,400 acres were devoted to barley, producing 145,000 bushels. The rather large acreage in 1917 was due largely to the failure of clover and the consequent necessity of using the ground for some grain crop. Yields of barley of 30 bushels and upward per acre are reported.

The bulk of the oat crop and practically all the wheat is sold direct. A very large proportion of the corn crop is fed to stock, not much more than 5 or 10 per cent being shipped from the county. The number of cattle fattened for market varies considerably from year to year, but feeding is almost entirely confined to a few of the larger farms. The 1915 Iowa Yearbook reports a total of 49,012 cattle in the county.

There are a number of very fine herds of Guernsey, Holstein, and Jersey cattle, and a good deal of attention is given dairying. Near Waterloo and Cedar Falls there are a number of finely equipped dairy farms, and on many stock and grain farms the sale of milk and cream is an important source of income. Creameries are in operation at a number of points. The city of Waterloo consumes most of the milk produced in its vicinity. The total income from dairying in 1909, as given by the census, is $1,381,338.

On the majority of farms, whether operated by owners or tenants, the sale of hogs constitutes the largest single item of income from live-stock sources. According to the census, about 60,000 hogs were marketed or slaughtered in 1909. On July 1, 1915, according to the Iowa Yearbook of Agriculture, the total number of hogs on farms was about 100,000, or nearly 50 head for each farm.

Considerable attention is given to the breeding of draft horses. Small herds of sheep are kept on a few farms. The total number reported in the county in 1915 was 2,516.

The production of Irish potatoes, onions, cabbage, and similar products is large, but they are produced on a commercial scale mainly by a few truckers near Waterloo and Cedar Falls. The sweet-corn canning plants at Waterloo, Cedar Falls, and Laporte City create a steady demand for corn suitable for canning, and in 1915 there was produced on 1,820 acres about 4,600 tons of corn. The local demand for melons is supplied by farmers located on the O'Neill and Carrington sandy loams.

Apples are the principal tree fruit. The most popular varieties are the Oldenburg, Greening, and Whitney. Comparatively little attention is given other fruits, and the local market demands are met by importations. In 1914 there was produced $3,170 worth of apples, $2,781 worth of cherries, and $7,054 worth of berries, according to the Iowa Yearbook.

The general methods of farming in this county are extensive rather than intensive. Labor-saving implements are in common use. The rather short active growing season usually limits the tillage of corn to three or four cultivations before hay and oats are ready for cutting. Most of the small grain is thrashed from the shock, but some farmers make a practice of stacking. There are about 500 silos in the county, and the harvesting of corn for ensilage has become an important part of the fall work. The Iowa Yearbook reports 6,084 acres devoted to the production of silage corn in 1914, producing 47,200 tons. A good deal of fall plowing is also done. The interval between corn planting and the first cultivation of the crop is often employed in hauling out the winter's accumulation of manure. Covered sheds or manure pits are not in use except on a few dairy farms. (See Pl. I, fig. 1.)

Lime has been used in an experimental way, chiefly on small plots in attempting to obtain a stand of alfalfa. The numerous limestone outcrops are a local source of lime that should meet all future requirements at a minimum cost. Potash salts have been applied to the small "mucky" areas where corn otherwise fails, but phosphorus has not been used in any form.

A systematic rotation of crops is practiced on very few farms, but corn and oats are generally cultivated with more or less frequent seeding to clover and timothy. The frequent failures of clover to make a satisfactory stand in recent years accounts for much of the irregularity in the use of this legume. On many rented farms corn and oats have been grown for years with only occasional changes to grass or other crops.

In recent years the wages of farm hands hired by the month has averaged about $30, with board and lodging. At the present time (1917) as much as $40 or $45 a month is being paid. Day wages during harvest seasons have ranged from $2 to $3. In general, efficient farm labor has been difficult to obtain, and inexperienced help is almost useless in handling the machinery and teams in common use.

The average size of the farms in this county is about 157 acres. Farms of less than 80 or 100 acres are not as economically managed as those ranging from 160 to 240 acres. This explains the steady decline in the total number of farms from 2,345 in 1880 to 2,168 in

1910. In 1915 the Iowa State census reported 2,089 farms, of 10 acres or more.

Tenancy has greatly increased in the last 30 years. In 1880 only 25 per cent of the farms were operated by tenants, but in 1910 almost 42 per cent were so operated. The customary lease is for one year, but many renters remain in the same place for several seasons. Cash rent ranges from $7 or $8 per acre for well-improved farms on desirable soil types to $5 or $6 per acre for those that are very sandy, or which include much overflow land. A few farms are operated on a partnership basis, which gives a better opportunity for stock raising and a regular rotation of crops.

The present maximum price of well-improved farms, consisting chiefly of the Tama silt loam, may be placed at $250 an acre. The sale value of the lightest phases of the O'Neill soils is seldom less than $75 or $100 an acre. Even overflowed lands suitable only for pasture and wood are not usually purchasable at less than $50 to $100 an acre. In 1914 there were 114 separate transfers of farm lands recorded, involving 13,263 acres. The average price per acre as reported was about $140.

SOILS.[1]

The greater part of Blackhawk County is covered by two classes of transported materials, drift and loess,[2] and from these deposits the principal upland soils have been derived. The underlying rocks, mainly limestones of Devonian age, are so rarely exposed the residual

[1] Blackhawk County lies immediately south of Bremer County. The latter county was surveyed in 1913, and all the terrace or second-bottom soils were mapped as Bremer regardless of the nature of their subsoils and of the character of their drainage, but experience gained since that time has shown that these soils are not all alike. Some are poorly drained, and others are very open in the subsoil, and subject to drought. In recent surveys the droughty areas have been mapped as O'Neill soils, and those that are not droughty but are well drained are identified as Waukesha soils, while the Bremer series has been restricted to poorly drained, dark-colored second-bottom soils with subsoils rather heavier than the soil.

On account of these necessary changes, due to a clearer understanding of the second-bottom soils, these soils on the Blackhawk County map do not correspond entirely to those on the Bremer County map. The O'Neill sandy loam on the Blackhawk map corresponds and joins up with the Bremer sandy loam on the Bremer map at one place and with the Cass sandy loam in another place. Neither the Bremer sandy loam nor the Cass sandy loam, as mapped in Bremer County, are true representatives of their respective series as defined in the recent surveys, but are both known to belong in the O'Neill series.

The lack of uniformity in soil mapping on opposite sides of the county lines is an expression therefore of the advance made in the recognition of soil differences since 1913. It will be noted that the Fargo soils on the Bremer map join up with the Clyde soils on the Blackhawk map. It has been found since 1913 that the Fargo soils are higher in their content of lime carbonate than those in Bremer County, so that in later maps such soils are mapped as Clyde, a series that includes dark-colored, poorly drained soils low in lime carbonate.

The Bremer loam areas mapped in the northwest corner of the county and those on the west side of the Wapsipinicon on the northern boundary of the county are both well drained and properly belong in the Waukesha series as now defined.

[2] The term "loess" is here used for a silty deposit and has no reference whatever to the source of the material or the method by which it has been accumulated.

soils from them are of rare occurrence. The loess is the younger of the superficial deposits. It covers almost all that part of the county situated south and west of Cedar River, and is the parent material of the soils over more than 32 per cent of the area. On the slopes overlooking Cedar River and Blackhawk Creek the loess ranges from 20 to 30 inches in depth, but it thickens toward the southwest, and in the southwestern corner of the county ranges from 40 to 50 inches in thickness. This loess extends south and west of Blackhawk County and is the principal soil-forming material in Grundy and Marshall Counties. From 60 to 75 per cent of the loess material consists of silt, or that grade of soil particles intermediate in size between fine sand and clay. Various changes have taken place in the loess to bring it to its present condition of a productive soil. There is a large accumulation of organic matter in the surface 10 or 15 inches, which adds greatly to the productiveness and mellowness of the soil. While there has been some translocation of clay particles from the surface to the subsurface layers, no compact or impervious clay has been developed in the subsoil, and ideal conditions of internal drainage, capillarity, and aeration prevail throughout the 3-foot section. That oxidation has been quite uniform is indicated by the uniformly brown color and the absence of mottling. If any large amount of lime ever existed in the original loess, within the 3-foot section, it has been removed to such an extent that neither soil nor subsoil effervesces with acid, and only in a few cases does enough lime remain to meet the requirements of a fertile soil. The soil is not generally deficient in mineral elements essential to fertility, but it is low in phosphorus. The loess is not, geologically considered, an old formation, and the soils derived from it have not lost their more soluble constituents in amounts sufficient to give a soil of low productiveness, though certain treatments will increase the yields of crops to a considerable extent.

Two groups of soils have been derived from the loess. The dark-colored soils grouped with the Tama series cover the southwestern part of the county. The lighter colored soils of the Clinton series occur in small areas in different parts of the county, and aggregate less than 5,000 acres. The Clinton soils occur on the high upland bordering streams, which were formerly covered with forests of oak, hickory, and other deciduous trees. The forest conditions prevented the accumulation of the organic matter which caused the black color of the prairie soils.

Underlying the loess and resting upon the bedrock are deposits of glacial drift laid down during two successive invasions of ice sheets.

The lower and older of these, the Kansan drift, is exposed only in deep stream channels, and no extensive soils have been derived from it.

The younger, or Iowan drift, is the surface covering of much of the northeastern part of the county.

The original color of the Iowan drift was bluish gray or drab gray, but oxidation has changed it near the surface to brown or yellowish brown. The material ranges in texture from a heavy clay to a sandy or gravelly clay, with occasional pockets of sand and gravel. In most places the surface material has weathered into a fine loam, which is underlain at a depth of 12 to16 inches by a clay, sandy clay, or clay loam. Glacial bowlders of various sizes are found over the surface and throughout the soil section. Gravel and rock fragments are usually more abundant in the lower subsoil than near the surface. The original till was moderately calcareous, but weathering and leaching have removed a large part of the lime, so that the material will rarely effervesce with acid within the 3-foot section. Conditions have favored the accumulation of organic matter, so that the dark-brown color extends to a depth of 10 to 18 inches. Below this, oxidation, as indicated by the brown color, has extended to depths of 5 to 10 feet, being deepest in the light-textured areas or those of greatest relief, and shallowest in the nearly level areas, where there is a heavy clay substratum.

The soils derived from glacial till are divided into two groups. Those weathered under conditions of good drainage are classed with the Carrington series, and those developed under poor drainage conditions with the Webster series.

In the sloughs and other poorly drained depressions black organic matter has colored the soil to a depth of 2 to 3 feet, and the imperfect aeration of the material immediately below is indicated by a light-gray or drab color, or gray with yellow and brown mottlings.

Based upon color, structure, origin, composition, and other characteristics, the soils are arranged in series. The series are further subdivided upon the basis of texture into types. Thus a series may contain all subdivisions from coarse sands to clays, but usually all members are not represented.

The soils of the Carrington series are dark brown to almost black, and the subsoils are yellow to brown. The topography is gently undulating to rolling.

The soils of the Tama series are dark brown or black, and the subsoils light yellow to yellowish brown. The structure is loose and friable. The topography varies from gently to sharply rolling.

The Clinton series is characterized by gray or dark-gray soils and by light-brown or yellowish-brown, compact subsoils. The topography is rolling to broken, and drainage is well established. The soils are not high in organic matter.

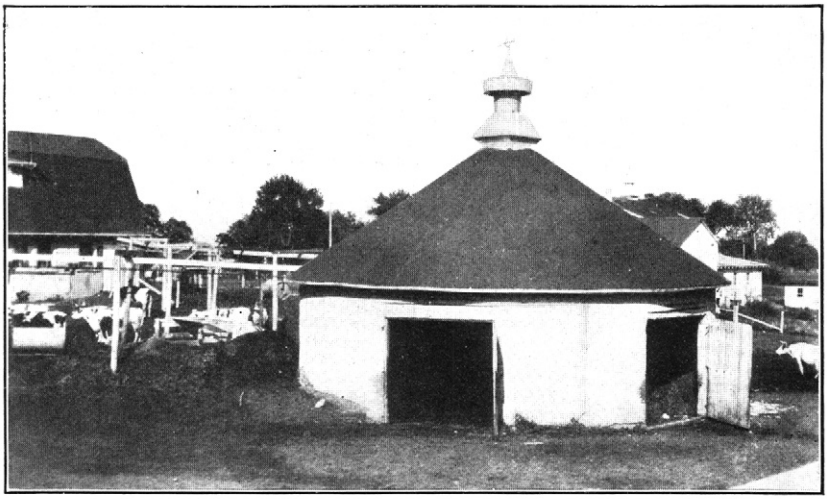

FIG. 1.—A COVERED MANURE PIT ON A LARGE DAIRY FARM 2 MILES WEST OF WATERLOO.

FIG. 2.—A CHARACTERISTIC FARM SCENE ON A SMALL AREA OF CARRINGTON SANDY LOAM 1½ MILES WEST OF HUDSON.

FIG. 1.—TYPICAL FARM IMPROVEMENTS ON THE TAMA SILT LOAM ABOUT 5 MILES WEST OF LA PORTE CITY.

FIG. 2.—AREA OF UNDRAINED AND UNIMPROVED CLYDE SILTY CLAY LOAM ABOUT 5 MILES NORTH OF LA PORTE CITY.

The occurrence of bowlders is characteristic of this variation of the type.

The soils of the Webster series are dark brown to black, and the subsoils are yellow mottled with gray. The latter are usually highly calcareous. The Webster soils occur on flat divides or in basins where drainage has not been well established.

The soils of the Thurston series are grayish brown to brown, and the subsoils are brown. The subsoils are sandy and gravelly, and usually droughty. The Thurston soils occur on knolls and ridges. In this area they are probably derived from sandy glacial deposits, but the surface soil is usually wind-blown to some extent.

Some areas of shallow, dark-colored soils, mainly of glacial origin, resting upon limestone, are classed with the Dodgeville series. These soils vary widely in texture, depth, and other characteristics.

The O'Neill series consists essentially of dark-gray to dark-brown soils, underlain by light-brown subsoils which rest upon a substratum of sand and gravel. The series occupies high terraces, and the surface ranges from nearly level to somewhat eroded. The soils of this series are derived by weathering from glacial outwash or terrace material. They are for the most part droughty.

The soils of the Bremer series are black, and the subsoils are dark gray to almost black or drab mottled with yellow. The subsoils are heavy in texture, and usually tough and compact. The series occurs on terraces where the soil was subjected during its formation to poor drainage conditions.

The Clyde series is characterized by black surface soils and gray, drab, or mottled gray and yellow subsoils. The lower subsoils are usually sandy or gravelly clays or clay loams. Neither soils nor subsoils are highly calcareous. The Clyde soils occur in stream valleys, sloughs, and depressions, and the soils have weathered under conditions of restricted drainage.

The Waukesha series consists of dark-brown to black soils with light-brown to yellow subsoils. The latter are heavier in texture than the soils, but are not compact or impervious. The Waukesha soils are only moderately calcareous, and as a rule the subsoil will not effervesce with acid. These soils occur on terraces above the present limit of overflow.

The members of the Calhoun series have gray soils and gray, drab, or mottled gray and yellow, heavy subsoils. The subsoils are characterized by a tenacious, waxy, impervious structure. These soils occupy poorly drained, flat stream terraces. They are not subject to inundation, but water stands for long periods after rains. Both soils and subsoils are deficient in lime.

The Cass series includes types having dark-brown to black soils and lighter textured subsoils which frequently pass within the 3-foot sec-

tion into sand and gravel. These soils occur on the lower stream bottoms and are subject to overflow.

The types included in the Wabash series have dark-brown to black soils, high in organic matter, and dark-drab to gray or mottled, heavy subsoils. Both soil and subsoil have a low lime content. These soils occupy first bottoms and are subject to overflow, but drainage is well established in some areas.

In the following pages of this report the different soils of Blackhawk County are described in detail and discussed in their relation to agriculture. The distribution of the soils is shown on the map accompanying this report, while the table below gives the name and the actual and relative extent of each:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Tama silt loam	110,336	31.0	Bremer silt loam	2,176	0.6
Rolling phase	1,792		O'Neill sand	2,112	.6
Carrington loam	99,840	27.6	Clinton fine sandy loam	1,792	.5
Clyde silty clay loam	28,672	7.9	Wabash silt loam	1,024	.5
Meadow	19,136	5.3	Heavy phase	640	
O'Neill coarse sandy loam	14,784	4.1	Cass loam	1,472	.4
Carrington sandy loam	12,224	3.4	O'Neill loam	1,472	.4
Waukesha loam	11,904	3.3	Waukesha sandy loam	1,344	.4
Waukesha silt loam	11,584	3.2	Webster loam	1,280	.3
Carrington sand	7,936	2.2	Thurston loamy sand	1,216	.3
O'Neill sandy loam	6,528	1.8	Waukesha fine sandy loam	960	.3
Carrington silt loam	5,440	1.5	Dodgeville silt loam, shallow phase	384	.1
Bremer loam	4,096	1.1	Muck	192	.1
Carrington fine sandy loam	3,136	.8	Calhoun silt loam	128	.1
Wabash loam	2,944	.8			
Clinton silt loam	2,880	.8			
Cass sandy loam	2,176	.6	Total	361,600	

CARRINGTON SAND.

The Carrington sand, to a depth of 10 to 15 inches, is a dark grayish brown sand, usually containing enough silt, clay and organic matter to impart a slightly loamy or even coherent character. The underlying material is a loose, brown sand. In many places there is no essential change in the material to a depth of several feet, but, as a rule, the yellowish sandy-clay till which underlies all the Carrington soils occurs at a depth of a few feet. The soil contains no stones or large gravel except where underlying till is approached, but small gravel and very coarse angular sand grains are abundant in places in the northern part of the county.

The sand apparently includes a considerable proportion of minerals other than quartz. Much hornblende, feldspathic material, and mica may be observed among the coarser weathered fragments

at the surface. There is evidently much iron present, as indicated by the uniformly brown color prevailing below the surface layer. The coarse texture of the type admits of good oxidation throughout practically the entire mass above the underlying clay.

The Carrington sand occurs on ridges and mounds along the eastern side of the Cedar Valley. In places it forms rounded dune-like ridges rising 50 feet or more above the lowlands. On the valley side the type is usually associated with the O'Neill sandy loam, while on the upland side it grades into the Carrington sandy loam.

Very little of this type north of Waterloo was originally forested, but most of the ridges bordering the Cedar River south of Gilbertville are wooded, mainly with small oak. The size of the trees as well as the number of varieties usually increases in low places or where the type approaches the Carrington sandy loam.

The agricultural value of the Carrington sand is low. Cultivation is largely confined to areas in which the sand layer is shallow and to small areas of included Carrington sandy loam. Rye, watermelons, and early garden crops are quite successful, but corn does poorly. The pasturage value of the land is low. On some of the highest ridges the surface soil drifts badly when the thin sod is broken.

CARRINGTON SANDY LOAM.

The surface soil of the Carrington sandy loam is usually a dark-brown, medium to fine sandy loam. The upper subsoil gradually changes to a somewhat lighter silt loam, but below 18 or 20 inches it gives way to a brown sand or loamy sand. At a comparatively slight depth, generally less than 30 or 40 inches, the rather stony, yellowish sandy clay till which underlies all the Carrington soils is encountered.

This type presents rather wide variations in the amount of organic matter in the surface soil, in the proportion of silt and clay in the subsoil, and in the depth at which the heavy substratum is encountered. Most of the areas near the Carrington sand are more or less rolling, the soil in the higher situations is usually light colored and sandy, while the lower slopes are considerably heavier and darker colored. Some small areas of the Carrington loam are included, usually occupying low ridges or local elevations on which the soil grades from a light-grayish silt loam on the crests to a dark-colored loam on the slopes. Many of the areas away from the larger streams have a rather dark colored silt loam surface soil with a heavy subsoil.

The Carrington sandy loam everywhere has a lower content of organic matter than the silt loam, and is distinctly acid. There is no evidence of calcareous material except in the clayey substratum, which in the more sandy areas may be 8 or 10 feet below the surface. The type is less retentive of moisture than the Carrington loam, but

very little of it is droughty. In many places the sandy substratum seems to hold moisture very well, and the capillary connection with the surface is effective.

The yields of corn and oats and the growth of clover and forage crops depend largely upon the particular variation of the type developed from place to place, and yields are also more or less affected by seasonal conditions. The natural tendency to droughtiness is offset by the possibility of earlier planting, and the liability to injury by early frosts is somewhat less than on the adjoining Carrington loam or the lower lying sandy soils.

In dry, windy weather crops on the lighter textured areas are frequently injured by drifting of the soil, which may cut the corn stalks and even destroy tender vegetation. This drifting is preventable in large measure by plowing a furrow across the field at intervals of 1 or 2 rods. Small grain is seldom injured by drifting except in the higher lying areas. Practically all the type requires methods of tillage that tend to conserve moisture. Where the surface soil is rather heavy, deep plowing may be necessary, but it is doubtful if this is required in the coarser textured areas, where the relatively loose material just below the usual depth of cultivation is already sufficiently absorptive. The essential thing is to prevent the loss of moisture by evaporation, by maintaining a soil mulch. An increase in the supply of organic matter in this soil is necessary. Much of the type is so low in organic matter as to be very light colored, and the brownish subsoil sand is not much below reach of the plow on the steeper hillsides. Lime also should be added to the soil, in order to give clover and other legumes a better opportunity, and it would be advisable to use rye instead of oats as a nurse crop for clover, as the large, late-maturing varieties of oats take so much water out of the soil that the small clover plants are handicapped unless there happens to be plentiful rainfall.

Plate I, figure 2, shows a characteristic farm scene on a small area of Carrington sandy loam.

CARRINGTON FINE SANDY LOAM.

The soil of the Carrington fine sandy loam is typically a mellow fine sandy loam, varying in color from very dark gray to black. The upper subsoil is a dull-brownish, moderately heavy but friable fine sandy loam, changing at 18 or 20 inches to a yellowish-brown sandy loam or fine sandy loam, which gradually becomes coarser with depth. Yellowish-brown stony till is always encountered at a depth of a few feet and in many places within the 3-foot soil section. Both soil and subsoil are distinctly acid and, while there are limestone outcrops on some of the steeper slopes, no calcareous material occurs within several feet of the surface.

An area of about 3 square miles of this soil is found in the northwestern corner of the county on the islandlike area of high, rolling upland which is almost surrounded by Cedar Valley and the lowlands of Beaver Creek. The northern part of this area is strongly rolling, and was originally timbered, the soil in places being rather light colored, but the southern half, which is considerably smoother, was formerly prairie except for scattered groves of bur oak, and the soil is fairly well supplied with organic matter resulting from the decay of the prairie grasses. The subsoil in this smoother, prairie region is heavier than in the timbered area, and large bowlders are numerous in many places.

A smaller area of this type occurs a few miles northeast of Laporte City, on the north side of the Cedar Valley. This consists of rolling upland in which the soil is a very friable, dark-colored silty or fine sandy loam, and the subsoil is moderately heavy.

All this latter area, and nearly all of that in the northwestern part of the county, is under tillage. On a farm near Winslow, where the soil is quite typical and has been farmed for 30 to 40 years, the following crop yields were reported: Corn, an average in recent years of 40 to 50 bushels per acre (70 to 80 bushels when the land was new); oats (crop of 1917), 60 bushels, which is above the average for the type; wheat, a maximum yield of about 30 bushels, obtained 5 years previously. In 1917 there were seen on this type a larger number of fields of clover of the previous year's seeding than on an equal area of any other soil, but this may have been due to better methods of seeding than to any difference in the soil adaptation. The structure of the type is very favorable to deep root penetration and the free movement of moisture, however, and these factors may have made clover more resistant to drought and freezing conditions.

The present selling price of this land and the usual rental value are about the same as in the case of the Carrington loam.

CARRINGTON LOAM.

The surface soil of the Carrington loam is a dark-brown to black loam, high in organic matter and friable. At a depth of 6 or 8 inches the material usually changes to a clay loam or silty clay loam, which gives way at a depth of 18 or 20 inches to a yellowish-brown clay loam containing more or less coarse sand and gravel. The substratum is generally a yellowish-brown, stony till. At a depth of 6 or 8 feet it is highly calcareous, but within the 3-foot section, according to simple field tests, it is acid.

The greater part of this type has good surface drainage, and the character of the substratum in most places permits thorough underdrainage and aeration. Oxidation, as indicated by the brown to

yellowish-brown coloration, has usually taken place to a depth of 5 or 6 feet where the surface relief is slight, and to a depth of 8 or 10 feet on the stronger slopes.

In the vicinity of the Carrington sandy loam, and on the steeper slopes near streams, the soil is sandier and lower in organic matter than elsewhere, and consequently lighter colored, while the subsoil is a compact, brownish stony clay loam. On the broad divides in the northern part of the county the soil and upper subsoil are very silty, and the material is high in organic matter to a depth of 18 or 20 inches. In nearly all the sags and local depressions the type resembles the Clyde silty clay loam, and many small areas of the latter type are included, generally at the heads of small drainage ways.

On the highest parts of the upland at the head of Poyner Creek there are included with the type some small areas, in which the soil is so thin and gravelly as to be of little agricultural value.

Southeast of Hudson and in a few places west of Cedar Falls there occur moundlike hills composed of gravelly or stony till in which the surface layer of till that forms the Tama silt loam elsewhere is so thin or contains so much coarse material that the soil is more or less stony and the interstitial soil may be a loam rather than silt loam. There is necessarily much variation in the soil and subsoil even within the space of a few square rods.

An included variation on a ridge about 3 miles northwest of Eagle Center consists of 6 or 8 inches of dark grayish brown, loose loam, containing considerable coarse sand and some small stones, underlain by a brown somewhat heavier loam, which gradually becomes heavier with depth and gives way in the lower subsoil and substratum to a yellowish-brown clay loam which resembles the substratum of the Tama silt loam. The surface soil contains less organic matter, and the subsoil is sandier than that of the latter type, but in favorable years corn on all these ridges makes about the same growth as on the adjoining heavier upland soils, except in some stony or very droughty patches.

Large bowlders occur throughout all parts of the type, but most of those of moderate size have been removed. Some of the gray granite bowlders that remain are 15 to 20 feet in diameter.

The Carrington loam is the predominating upland type throughout the northeastern part of the county. The surface in general is broadly rolling, and some areas between Mount Hope Church and the north county line and between Crain Creek and the small southward-flowing streams show very little relief. Along the lower courses of the larger creeks the surface is strongly rolling, with occasional short steep slopes, but very little of the type is unsuited to the use of modern farm machinery.

Practically all of the Carrington loam is under tillage. It is well adapted to all the field crops and the more important garden products usually grown in this section of the State. The fields generally include sloughs and low places occupied by the Clyde silty clay loam, which if artificially drained gives higher yields than the predominant Carrington soil, but if undrained lowers the yields. On the typical Carrington loam corn yields 40 to 50 bushels per acre, and much better returns are obtained in favorable seasons on well-managed farms. Oats may be safely depended upon to yield 30 to 40 bushels, and in occasional favorable years, as in 1917, the returns are nearly twice these figures. Timothy, bluegrass, and clover generally do well, but the latter crop sometimes freezes out during open winters, and a poor stand often results from dry weather in July or August.

Most crops do not make as uniform growth on this type as on the Tama silt loam. Corn, in particular, very frequently shows in its varying rate of growth the effect of slight differences in underdrainage, or variations in slope and surface conditions that influence the moisture content and the warmth of the soil. Unless very early frosts occur all the differences disappear later on, and the entire crop matures.

The present selling price of land of this type averages between $200 and $225 an acre, but there is considerable variation in prices, depending on the surface features, the location, and the improvements.

The Carrington loam has an extensive distribution in Bremer County, and the results of greenhouse experiments with this soil and analyses in which the total phosphorus, nitrogen, and carbon content is given may be found in Report No. 1, Bremer County Soils, issued by the soils department of the Iowa State Agricultural College.

CARRINGTON SILT LOAM.

The soil of the Carrington silt loam is a very dark brown to black, friable silt loam, high in organic matter, to a depth of 18 or 20 inches. The material becomes a little heavier with depth, and the lower subsoil is a yellowish-brown silty clay loam, quite plastic when moist, but crumbly when dry. At 30 or 40 inches this silty material changes abruptly to sandy clay or clay loam. The physical structure to a depth of several feet is very favorable to good drainage and aeration.

The largest area of this type occurs in the gently rolling uplands west of the Wapsipinicon River and near the north boundary of the county. Some smaller areas are included at various places in the Carrington loam, not being indicated on the map. The silt loam differs from the loam chiefly in its high silt content and the general absence of all coarse material, in which respect, as well as in physical

properties, it closely resembles the Tama silt loam. The areas on the east side of the Wapsipinicon Valley include small patches of light-colored soil whose lack of organic matter is due to a former thin stand of oak, elm, hickory, and other trees. Elsewhere the type is a true prairie soil.

All of the Carrington silt loam is in cultivation. The type is highly esteemed on account of its easy tillage and the high average yields of the staple crops.

TAMA SILT LOAM.

The surface soil of the Tama silt loam is a friable silt loam, black when wet and dark brown or dark grayish brown when dry. There is usually no material coarser than fine sand, and a moist sample has the smooth feel typical of soils consisting chiefly of silt particles. There is usually little change in color or texture to a depth of 10 or 15 inches, except that below the plow line the subsoil is a little more compact owing to the slightly higher percentage of clay. Below 18 or 20 inches the dark color changes to a pronounced brown or light brown, in which there is a suggestion of yellow, and the material at this depth is usually a silty clay loam, quite plastic when moist and crumbly when dry. At an average depth of about 35 inches there is an abrupt change to a coarse, gritty, yellowish-brown material ranging in texture from sandy loam to clay loam. The soil to a depth of 5 or 6 feet gives an acid reaction when tested with litmus paper, but below this depth it is calcareous.

The depth to the underlying coarse, stony, sandy, clay ranges from 20 to 30 inches on the more sloping areas to 40 or 50 inches on the tops of ridges and on the broadly undulating uplands in the extreme southern part of the county. Save for an occasional larger bowlder the type is free from stones, and it is remarkably uniform in composition and agricultural value.

The Tama silt loam is the predominant upland type throughout the southwestern half of the county. The topography in general is undulating or gently rolling. Some areas on the eastern side of Blackhawk Creek, as well as some of the slopes facing the Cedar Valley, have more relief, but practically all the type is admirably adapted to the use of modern farm machinery.

The moderate surface relief and friable structure insure excellent moisture conditions and relatively deep aeration. These desirable physical properties usually extend to the underlying coarse, yellowish till, as is indicated by its brownish color to a depth of several feet below its contact with the overlying loess.

All of the Tama silt loam is under cultivation. The yields of corn on well-managed fields probably average somewhat above 50 bushels per acre under favorable seasonal conditions. The crop makes a

more uniform growth and is less affected by variations in the rainfall than on either the sandy soils or the Carrington loam. This is largely due to the comparatively great depth of the zone in which equable moisture conditions and good aeration prevail. The yields of oats frequently reach 80 or 90 bushels per acre, but the average is about 50 bushels. Very little of the type is so high in organic matter as to cause an exceptionally rank growth of vegetation at the expense of grain. Where this condition does occur, it is usually in low places occupied by the Clyde silty clay loam.

The Tama silt loam is well adapted to all the staple crops. While returns vary with the tillage methods, the previous management of the land, and the seasonal conditions, a failure is practically unknown.

Good stands of clover and timothy are usually obtained very readily. The numerous failures to obtain a stand of clover in recent years are attributed by the farmers to adverse seasonal conditions. The slight acidity of the soil does not seem to affect any of the clovers, or bluegrass, which forms a dense sod along roadsides and in all pastures not overstocked. Alfalfa has not proved successful, but owing to the productiveness of the surface soil and the abundance of lime at a depth of 5 or 6 feet there seems no reason why this legume could not be grown profitably if a good stand of strong plants were once obtained.

The average value of farm improvements is doubtless higher on this soil than on any other type in the county. Plate II, figure 1, shows a typically improved farm on this soil. The present selling price of farms ranges from $200 to $250 an acre. The rental value averages about $8 an acre.

Applications of barnyard manure and the growing of clover invariably result in a marked increase in crop yields on this soil. No commercial fertilizers have been used, and lime only in an experimental way. The use of commercial fertilizers does not seem profitable under present conditions, but no positive statement can be made without the results of field tests.

Tama silt loam, rolling phase.—The Tama silt loam, rolling phase, which occurs on the upland slopes west of Blackhawk Creek in township 88, is lighter textured than the typical soil on the east side of the valley. The topography varies from strongly rolling to hilly, and occasional hills, as in sections 15 and 28, are too steep for easy tillage On the higher ground the soil is generally a dark-brown sandy loam with a yellowish-brown loam or silt loam subsoil which at 30 to 40 inches grades to a comparatively loose, brownish sand. On the lower slopes and wider ridges the soil varies from sandy loam to silt loam, and the phase as mapped is not at all uniform.

This soil is somewhat lower in agricultural value than the typical Tama silt loam. The organic-matter content is lower, and in a few places the subsoil is such a deep sand that the type is somewhat droughty.

The following table gives the average results of mechanical analyses of samples of the soil, subsurface, subsoil, and lower subsoil of the typical Tama silt loam:

Mechanical analyses of Tama silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331701, 331797	Soil	0.2	3.0	2.8	9.6	11.9	52.7	19.6
331702, 331798	Subsurface	.2	2.2	2.0	7.7	13.3	52 1	22.2
331703, 331799	Subsoil	.3	3.4	2.9	10.5	12.5	46.9	23.2
331704	Lower subsoil.	1.8	5.8	4.8	21.6	17.1	29.3	19.3

CLINTON FINE SANDY LOAM.

The areas mapped as Clinton fine sandy loam consist prevailingly of a sandy loam similar to the adjoining Carrington sandy loam and including about the same variations in texture and structure. The extreme range is from a rather light sandy loam overlying brownish sandy material, to a friable silty loam with a yellowish clay or clay loam subsoil. In all cases the organic content is low, as is indicated by the light color. In the depressions the soil is generally much darker, and in some of the "sloughs" the type resembles the Clyde silty clay loam.

Small areas of Clinton fine sandy loam are mapped on the uplands overlooking the Cedar Valley near McChane, in the extreme southeastern part of the county, and a somewhat larger development occurs on the east side of the Wapsipinicon Valley.

This soil was originally forested. The present growth consists largely of red and black oak, with open groves of bur oak on the outskirts. The greater part of the type is in cultivation, largely to corn, oats, and clover. Crops give best results in seasons of ample rainfall. Near McChane considerable sweet corn is grown on this soil and the Clinton silt loam. The yield in good seasons has averaged about 4 tons per acre, but when dry weather prevails in July and August the returns may be cut to less than 1 ton.

The present price of this land is about $100 an acre or upward. Most of the farms include some rough land, which is usually thickly covered with rather inferior timber. The rental value in 1917 for some of this land near McChane was $5 an acre.

All this type is in need of liberal fertilization with manure or green vegetation, preferably clover. It is everywhere acid, and

ground limestone should be applied regardless of the occurrence of lime rock at any slight depth.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Clinton fine sandy loam:

Mechanical analyses of Clinton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331736	Soil	1.1	6.1	7.2	29.0	17.3	31.5	7.8
331737	Subsoil	1.2	5.2	5.6	24.1	14.1	37.2	12.6
331738	Lower subsoil	1.1	7.5	6.8	23.2	14.0	24.6	22.9

CLINTON SILT LOAM.

In uncleared areas the immediate surface material of the Clinton silt loam consists chiefly of organic matter, such as decayed root fiber and dark-colored leaf mold. At a depth of 2 or 3 inches this changes abruptly to a lighter gray or grayish-brown silt loam, which contains little organic matter, but which is extremely friable when dry and almost entirely lacking in the "crumb" structure common to the dark-colored silt loams. There is usually not much change in the material to a depth of 12 or 18 inches, but below this it may contain a little more clay and occasionally may grade to a silty clay loam. The color varies from light brown or buff to slightly reddish brown. The substratum is a yellowish-brown till, like that commonly underlying the Tama soils. The depth at which it is encountered varies from less than 3 feet on the steeper slopes to several feet on the crests of the ridges.

The Clinton silt loam is confined to a few areas of high rolling upland overlooking the larger valleys. All the type is, or was originally, covered with oak, hickory, linden, wild cherry, and other trees common to this region. Under tillage the organic matter soon disappears, and the surface soil assumes a light-gray, ashy appearance. It is easily reduced to a fine state of tilth except in the areas where there is little sand in the surface soil; here the type compacts after rains and needs frequent cultivation. Adjoining the Tama silt loam and in depressions the soil has a higher content of organic matter than typical and is consequently darker colored.

Yields even in the better areas of the type are somewhat lower than on the darker silt loams, but the quality of the grain is excellent, and as a rule it matures earlier. Grain and clover do well, although the material is very acid to a depth of several feet. The type is well adapted to such varieties of apples, pears, and cherries as are suitable

to this latitude. At Cedar Heights many varieties of small fruits are very satisfactorily grown. The quality of the products is generally superior to those grown under similar conditions on the more productive soils. The soil very readily responds to fertilization.

The areas included with the Clinton silt loam in the extreme southeastern part of the county are not typical. They consist of rolling upland, in which the soil varies from a silt loam to a fine sandy loam. All these areas were formerly timbered, but in places there is considerable organic matter, and the crop adaptations are not essentially different from those of the black soils of corresponding texture and topographic position.

The following table gives the average results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Clinton silt loam:

Mechanical analyses of Clinton silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331716, 331791...	Soil.....	0.4	4.4	5.3	13.9	12.9	53.4	9.6
331717, 331792...	Subsoil.....	.3	4.6	5.9	13.6	11.6	50.9	12.9
331718, 331793...	Lower subsoil.	.1	5.1	7.9	28.5	13.9	32.3	11.9

WEBSTER LOAM.

The Webster loam occupies flat or nearly level areas on some of the wider divides in the northern part of the county. The soil is generally a fine-textured loam or rather heavy silt loam, with a silty clay subsoil. The abundant organic matter imparts a very black color to a depth of 18 to 24 inches and increases the friability of the surface layers and the granular structure of the subsurface material. The lower subsoil is usually a pale-yellowish clay or clay loam, becoming more or less mottled with gray as the depth increases. As a rule it is very calcareous at less than 30 inches from the surface.

Practically all this soil requires artificial drainage, and most of the areas have been improved with tile drains. The rest are used as pasture and hay lands. The drained areas are highly productive and good yields are obtained. Clover does well, and the occurrence of an abundance of lime at such slight depths suggests the adaptability of this soil, if well drained, to alfalfa.

THURSTON LOAMY SAND.

The surface soil of the Thurston loamy sand is a gray or slightly brownish gray loamy sand, which with increase of depth assumes a more brownish tint and may be a little coarser in texture. The percentage of silt as well as the content of organic matter varies

with the topographic position. The soil in the higher areas is generally sandier, while in the hollows and on the lower hillsides it is a silty loam. In nearly all places the soil has an ashy-gray tint when dry, and there is a noticeable lack of coherency, which distinguishes the type from the Carrington soils of similar texture. It has about the same mineralogical composition as the Carrington soils, but owing to the original forested condition the organic-matter content is low, and is confined chiefly to the first few inches.

The areas in the southeast part of the county are dunelike ridges which formerly supported a rather light growth of oak, with some wild cherry, elm, and hickory. The area on the east side of the Wapsipinicon Valley is not readily differentiated from the adjoining Carrington soils, but most of it consists of a fine sandy loam or silty loam, originally forested.

The agricultural value of the Thurston loamy sand is low. The soil in most fields ranges from a sand on the ridges to silty soil in the hollows, and the moisture conditions are not uniform. Crop returns are generally lower than on the Carrington sandy loam. The lack of organic matter and the high acidity indicate the need of adding manure and lime.

DODGEVILLE SILT LOAM, SHALLOW PHASE.

The Dodgeville silt loam, shallow phase, is similar to the Tama silt loam, except that it is underlain by limestone at a depth of a few feet. In places the surface soil is a sandy loam, but these sandier areas are too small to indicate on the map. Very little residual material is found even in the subsoil, and the latter as well as the surface soil is acid.

A few areas of Dodgeville silt loam, shallow phase, occur on the uplands west of the Cedar Valley. On the steeper slopes the underlying bedrock is exposed, but elsewhere it is generally well concealed. Symbols are used on the map to indicate the areas of outcrop. Each of the areas indicated is necessarily more or less exaggerated. Most of them include quarries which are present sources of lime for local use. The tillable areas of this soil are very similar to the Tama silt loam.

O'NEILL SAND.

The surface soil of the O'Neill sand usually consists of medium to coarse sand, ranging in color from brown or grayish brown to gray, depending on the proportion of fine earth and organic matter. At a depth of 1 or 2 feet there is encountered a well-oxidized sand which extends to a considerable depth without much change. The sand is generally quite angular, and close inspection shows it to include quite

a variety of materials other than quartz. There is little or no material larger than coarse sand.

The O'Neill sand occurs on low mounds and ridges associated with the O'Neill sandy loam, mainly between Cedar Falls and Janesville. The larger areas are narrow ridges rising 10 to 20 feet above the general surface, while the small areas in the creek valley are usually low, irregular-shaped mounds 10 to 15 feet in height.

Most of the type is in cultivation. Farmers state that the moisture conditions are generally better than would be expected, especially in the case of the ridges associated with the Waukesha soils, where the material consists of fine to medium sand. Rye does fairly well on this soil, and watermelons and cantaloupes are successfully grown in places. Some patches of Sudan grass have given fairly satisfactory results, but in general grasses soon show the effect of dry weather. Corn gives low yields.

O'NEILL COARSE SANDY LOAM.

The surface soil of the O'Neill coarse sandy loam varies from a grayish-brown coarse loamy sand to a dark-brown, moderately heavy sandy loam. In most places it is a coarse-textured, loose sandy loam, but with enough fine material to be feebly coherent when wet. There is more or less small, rounded gravel, and in many places this is very abundant. The subsurface material is usually a little heavier than the soil, slightly more compact, and much darker colored. At a somewhat variable depth, generally less than 30 inches, coarse sand and gravel occurs, and this forms the substratum to an undetermined depth.

Both soil and subsoil are decidedly acid, and there seems to be no fragments of lime rock in the 3-foot soil section or in the substratum. The stony material consists chiefly of well-worn pebbles of quartz, chert, and various other hard rocks.

Nearly all this type was originally covered with grasses, and in the areas of heavier texture there remains enough organic matter from this source to give a very dark brownish tint down to the coarse sand or gravel of the subsoil. The darker colored variations of the type, locally termed "black gravelly land," are generally confined to level or slightly depressed areas. The soil of the slight local elevations usually has very little organic matter.

The O'Neill coarse sandy loam occurs on the terraces of the Cedar Valley. In a few places it extends to the banks of the river and is reached by exceptionally high water, but elsewhere it is far above overflow. The surface is more or less uneven, there being many irregular, shallow depressions and slight elevations. The largest areas north of Cedar Falls include several distinct levels. Those near

Waterloo and that on which part of the city stands are in general a smooth plain gradually rising toward the uplands. In all these areas the surface soil is generally very coarse textured, and gravel is found at a depth of less than 20 or 30 inches. The areas south of Waterloo consist of somewhat finer materials. The underlying gravel beds here are deeper, and there is usually less gravel in the surface soil.

Nearly all the type is in cultivation. Rye is one of the principal crops, particularly on the gravelly areas above Cedar Falls. It ranges in yields from a few bushels per acre in dry seasons to 15 or 20 bushels on the heavier areas in favorable years. Much of the type is planted to corn, the yields of which in seasons of ample and well-distributed rainfall may be placed at 25 to 30 bushels per acre. Dry weather in August and July greatly reduces the average yield of the crop, and means total failure on the lightest textured areas. Considerable sweet corn is grown, yielding 1 to 4 tons per acre. Watermelons are a successful crop. In recent years a few small fields have been devoted to Sudan grass and feterita, which give promise of becoming profitable crops on this and similar types. Sorghum does well, and near Winslow from 200 to 300 acres of sorghum have annually been grown in recent years for sirup. The yield ranges from 100 to 125 gallons per acre, and the quality is excellent.

Since the structure of this type makes crops susceptible to injury by dry weather, all tillage methods should be directed toward the conservation of moisture. Frequent shallow cultivation to maintain a dust mulch at the surface would be advisable. The subsurface layer should be kept as compact as possible. There is little likelihood of getting this upper subsoil too compact, except in same swales or other places where the material is silty rather than sandy. Therefore shallow breaking or simply disking is preferable to deep plowing. The use of a roller or a subsurface packer would be advisable in many instances.

As a rule, it is difficult to get a stand of clover on the soil. It is probable that applications of ground limestone would be beneficial, although in the lightest textured areas the lack of moisture in the summer would prevent the plants from reaching maturity. Any increase in the organic content, either by means of growing a legume crop or plowing under manure, would assist in making the soil more retentive of moisture. Some farmers find it profitable to plant corn late, so that it reaches the tasseling stage about the time the late summer rains usually occur. There is some risk on account of frost, but growth is rapid on this warm coarse-textured soil.

The present selling price of this land as indicated by recent sales ranges rather widely, but the average may be placed between $75 and $100 an acre.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the O'Neill coarse sandy loam:

Mechanical analyses of O'Neill coarse sandy loa

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.*
331757, 331760...	Soil.....	4.1	27.1	22.9	31.8	2.4	6.1	5.4
331758, 331761...	Subsoil.....	1.0	17.3	22.1	38.0	3.9	9.3	8.2
331759, 331762...	Lower subsoil.	2.2	21.0	24.1	39.1	3.2	4.7	5.6

O'NEILL SANDY LOAM.

The O'Neill sandy loam is practically identical with the O'Neill coarse sandy loam except in the somewhat finer texture of the sand and in the greater depth to the underlying gravel, which lies usually below the reach of a 40-inch auger. In the lightest textured places the soil is a grayish-brown loamy sand, while in the heavier areas it consists of a moderately heavy sandy loam with a content of organic matter that imparts a dark color to a depth of 18 or 20 inches. Below this depth loose, brown, medium to coarse sand usually occurs, becoming lighter in color with depth.

This soil has a greater power to hold moisture than the coarse sandy loam. The lower subsoil material evidently affords some capillary connection between the surface soil and the underground water supply. While all the type is susceptible to dry weather, much of it is very desirable for general farming. Corn yields 25 to 30 bushels per acre in favorable seasons. In the heavier areas, which usually are low swales or areas adjoining finer textured types, clover does well, and oats give moderately heavy yields. The type is well suited to melons and most other truck crops requiring a warm, early soil.

O'NEILL LOAM.

The soil of the O'Neill loam is a moderately heavy, dark-colored loam to sandy loam. The subsoil is somewhat heavier, usually consisting of a rather light, loose loam which changes with depth to a light-brown sandy loam, underlain by brownish sand or gravel. As a rule this coarse-textured substratum is within 40 inches of the surface. Near the creek the soil is a rather coarse silt loam, and coarse yellowish sand is frequently exposed in the banks. Further from the stream the soil is generally heavier, contains more organic matter, and has better moisture-holding properties.

This type occurs on terraces lying 10 to 20 feet above the first bottoms of Spring Creek. Owing to the elevation and the sandy sub-

stratum, it is somewhat droughty. In August, 1917, all this type showed the effects of dry weather, and farmers state that it requires rather frequent rains for best results with corn, potatoes, clover, and other crops requiring a long growing season.

BREMER LOAM.

The Bremer loam as mapped in this county includes poorly drained areas of second-bottom soils varying from sandy loams to moderately heavy loams, all characterized by their dark surface and varicolored subsoils. In nearly all places there is an abundance of organic matter resulting from the decay of the native grasses and other semiaquatic vegetation under conditions of frequent or long-continued saturation. There is seldom any accumulation of Muck or Peat, as the organic matter is generally mixed with much sand, silt, and clay. The subsoil is usually a light-colored clay loam or sandy clay, with much yellowish and brownish mottling in the lower part. Frequently there are streaks of bog iron in the subsoil and slight traces in the surface soil. The substratum, occurring at depths of a few feet from the surface, consists of gravel beds.

In the Wapsipinicon Valley the Bremer loam generally occupies flat or slightly depressed areas. The surface of the lowest lying areas is usually hummocky, and supports little vegetation other than coarse grasses. Most of the wide areas, however, are comparatively smooth grass lands. The narrow areas consist of swales or ill-defined drainage ways in which the soil in its original condition is of little value, except for pasture. The areas north of Dunkerton are generally coarser textured than those farther down the valley, in which the soil is usually a loam or silt loam, with a black granular clay subsoil that changes with depth to a somewhat impervious light-colored clay.

In Elk Run Valley the type occupies low swales and flats and resembles the Clyde silty clay loam. It is productive and responds well when artificially drained.

The narrow areas of this type in the Cedar Valley below Waterloo generally occupy old channels, so nearly filled to the level of the adjoining lands that they are of more or less value for pasturage and hay. The areas near Cedar Falls also occupy old channels in which the sediment from frequent overflows and the wash from adjoining higher ground are forming a heavy soil of high productiveness. The soil at present however, is generally of little use except for pasture, as water stands in many places until late in the season.

The drainage of the Bremer loam has been improved in recent years by the construction of open ditches and the grading of public roads. These operations have lowered the average level of the

ground water in much of the type, but considerable tile drainage is still necessary to make most of this land safe for cultivated crops. The persistent wet condition seems to indicate that there is an upward pressure of water from the gravel substratum in many places, and the topographic position supports this assumption. The remedy lies in so locating drainage lines that this underflow may be cut off. Most of the present ditches have been dug through the lowest ground.

Heavy applications of ground limestone should be made after good drainage is obtained, in order to correct the highly acid condition and hasten the decay of the excess vegetable matter in the lower situations.

In many places the type shows a white efflorescence during dry weather. A laboratory examination of a sample collected on an area a few miles east of Waterloo indicates calcium sulphate as the chief constituent. It is rarely so abundant as to cause serious injury to crops.

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

Mechanical analyses of Bremer 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.*
331742	Soil	2.1	14.3	11.0	23.3	7.2	29.7	12.2
331743	Subsoil	.8	8.2	10.1	30.5	11.5	25.5	13.5
331744	Lower subsoil	2.4	12.3	11.7	28.9	8.8	21.3	14.6

BREMER SILT LOAM.

The surface soil of the Bremer silt loam is a black, mellow silt loam, high in organic matter and containing little if any sand or gravel. Below the plow line the material gradually becomes heavier, usually consisting of a crumbly silty clay loam which contains enough organic matter to have a rather open structure. The lower part of the 3-foot section is generally a light-colored clay loam containing more or less sand and small gravel, and ranging in color from dark drab to gray, mottled with various shades of yellow and brown. The mottling is due to a former high level of the ground water and is most pronounced where the underdrainage was poorest.

The Bremer silt loam occurs in second bottoms where the Waukesha loam and silt loam are the prevailing types. It is closely associated with the latter soil, and some of the areas indicated as Bremer silt loam are really a poorly drained phase of the Waukesha soil. The slow drainage is due in part to the flat or slightly depressed surface, and in part to the greater depth to the gravelly substratum which

underlies both the Bremer and Waukesha soils. Most areas have been artificially drained; in few places the natural drainage is sufficient to permit good tillage. The type is highly productive, and excellent yields are obtained under favorable conditions.

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

Mechanical analyses of Bremer silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331788	Soil	1.0	4.1	3.3	6.7	6.7	53.1	25.3
331789	Subsoil	.6	5.1	3.7	7.7	6.7	51.1	25.3
331790	Lower subsoil	1.4	10.7	8.9	21.3	8.0	29.3	20.3

CLYDE SILTY CLAY LOAM.

The surface soil of the Clyde silty clay loam is a black silt loam so high in organic matter as to be loose and mellow. At a depth of a few inches this changes to heavier and more compact material, generally a stiff black silty clay loam, which is rather sticky or waxy when wet and coarsely granular when dry. At a somewhat variable depth, generally less than 30 inches, the dark color gives place to lighter gray or drab with more or less yellowish and brownish mottling. This lower subsoil is usually a clay or clay loam containing considerable gravel and sand. In the larger areas of the type water-bearing gravel or gravelly clay is found at depths of a few feet but in the narrow areas, at the heads of drainage lines, the substratum is usually a sticky clay with a variable content of stony material. The soil is acid, and as a rule no limestone fragments or other evidence of lime occur within several feet of the surface.

There are three quite distinct regional variations of this type. Throughout the northeastern half of the county it generally occupies narrow sloughs, extending from the creek bottoms well up to the crests of the divides. Nearly all the areas that are more than 15 or 20 rods wide are indicated on the soil map, but many small strips and rather indefinite developments of the type are necessarily omitted. In all places the soil has a high content of organic material, and the drainage is usually poor. Where no open ditches have been dug or tile drains laid, the surface is usually hummocky, and in many places small areas of shallow Muck occur. In many areas bowlders are numerous. Where artificial drainage has been established, the surface becomes mellow and the subsoil assumes a more granular or crumbly structure, and excellent crops are generally obtained.

In the southwestern half of the county, where the Clyde soil is closely associated with the Tama silt loam, there is less sand in the soil, the subsoil has little stony material within 30 inches of the surface, and there is only an occasional bowlder. Wherever the soil has been well tiled it is very fertile, and generally produces higher yields of corn and clover than the adjacent uplands. There are few mucky spots, and after some years of cultivation the soil resembles the Muscatine silt loam, which probably has a similar mineralogical origin.

Along the lower course of Millers Creek the Clyde silty clay loam generally forms wide, flat areas in which the subsurface material is a heavy silty clay loam or silty clay, with the gray substratum at a depth of 30 or 40 inches from the surface. The latter is too dense to admit of very effective underdrainage, and it often contains much bog iron where it touches the underlying sand or gravel, which is usually at a depth of 6 or 7 feet below the surface. Most of this area of the type is used only for pasture.

In the Big Slough, 5 or 6 miles north of Laporte City, the soil is quite variable, but with artificial drainage this area would be very productive. (See Pl. II, fig. 2.)

In almost every area the Clyde silty clay loam is a strong productive soil, needing only adequate drainage to render it suitable for general farming. In occasional patches where the soil is very high in organic matter barnyard manure would be beneficial. In some places a faint whitish powder, probably calcium sulphate, appears on the surface after rains. This is seldom so abundant as to be injurious to crops.

WAUKESHA SANDY LOAM.

The soil of the Waukesha sandy loam is a dark-brownish or brownish-gray sandy loam moderately well supplied with organic matter in local depressions. The subsoil is a brown, medium to coarse sandy loam, fairly retentive of moisture. The lower subsoil is usually a coarser sand, with little finer material, grading at various depths, but generally within 4 or 5 feet of the surface, into gravel.

This type occurs on low terraces along the smaller streams. The drainage conditions vary considerably from place to place, but usually tile drains are necessary only in the lowest situations, which when well drained are very productive. The areas in the Elk Run Valley generally consist of low, sandy ridges alternating with the Bremer loam. The drainage here is good or even excessive, and corn in the sandier places may suffer if the rainfall is irregular.

Most of this type needs about the same methods of tillage and the same means of maintaining productiveness as are recommended for the O'Neill soils.

WAUKESHA FINE SANDY LOAM.

The soil of the Waukesha fine sandy loam is a dark-brown, friable fine sandy loam, moderately high in organic matter, and under usual field conditions mellow and free from clods. There is generally little change in color to a depth of 18 or 20 inches, below which the material is a dull-brownish, friable fine sandy loam, lower in organic matter. It usually becomes somewhat lighter colored and less silty with increase of depth, but seldom contains any gravel. The underdrainage and the aeration are excellent to a depth of several yards.

A few small areas of this type occur north of Cedar Falls, where it is associated with the Waukesha silt loam, the wider areas forming a rather gradual transition between the latter type and the coarse-textured soils to the east. The long, narrow strips consist of low ridges on which the soil is somewhat lower in organic matter than in the wider areas. The small areas south of Washburn consist of rather high ridges on which the soil varies from fine sandy loam to silt loam.

All of the Waukesha fine sandy loam is cultivated. The yields of ordinary farm crops are about the same as on the associated silt loam, but the crops on the fine sandy loam are a little more susceptible to injury by dry weather.

WAUKESHA LOAM.

The soil of the Waukesha loam is a dark-brown to black, moderately heavy loam, containing more or less coarse material, including usually a little gravel. The structure is generally friable to crumbly, but below the plow line the material becomes a little heavier and more compact. At a depth of 15 to 20 inches the color is usually a pronounced brown, and with increase of depth the texture usually changes to a light loam or sandy loam. The substratum of sand or gravel generally lies below 40 inches.

The largest area of Waukesha loam is found on the east side of Blackhawk Creek, where the terrace is 10 to 20 feet above the channel. It includes some sandy loam near the stream, but elsewhere the texture is generally a heavy loam to silty loam. The natural drainage is good and all this area is highly productive.

The areas in the Cedar Valley occur on high, well-drained terraces, where the physical conditions are generally favorable for easy tillage, owing to the absence of wet spots or sandy mounds. In some of the areas below Washburn the type is closely associated with the O'Neill soils and in places gravel occurs so close to the surface that crops do not easily endure dry weather. The areas near the river are fine-textured loams, generally heavier than those on the higher terraces. The areas near Laporte City consist of black loams to sandy loams,

with a rather heavy subsoil, and resemble the alluvial types along Cedar River. They are all well adapted to the staple crops, and usually give high average yields.

The small areas mapped in the northern part of the county represent low second bottoms along small creeks. In some instances they include swales that are not well drained, or are subject to overflow. In a few places a heavy, black silty clay subsoil occurs, and this may be within reach of the plow, forming " gumbo " spots that are rather troublesome in cultivation.

The areas along Elk Run are composed of dark-colored loam to sandy loam, slightly elevated above the adjoining Meadow and Bremer soils, and somewhat lower in organic matter than the areas of the type near the Cedar River. On this account, and owing to the more variable character of the subsoil, they are more susceptible to extremes of rainfall than the large areas in the Cedar Valley and along Blackhawk Creek, and the average crop returns are lower.

In all cases the soil and subsoil of the Waukesha loam are acid, and there is no evidence of calcareous material in the gravelly substratum. The darkest colored variations of this loam are somewhat higher in organic matter than the silt loam, and are evidently a somewhat stronger soil, a yield of 50 to 60 bushels of corn per acre being quite common in favorable seasons. Yields of other crops are about the same as on the Waukesha silt loam.

WAUKESHA SILT LOAM.

The soil of the Waukesha silt loam is a very friable silt loam, varying in color from dark grayish brown when dry to nearly black when wet. This color, which is due to a rather high content of organic matter, extends to a depth of 10 or 15 inches, then changes to light brown or yellowish brown, which continues to a depth of several feet. The subsoil consists chiefly of silt, but there is some increase in the percentage of clay with depth, so that the middle subsoil is usually a rather stiff silty clay loam. The lower subsoil is not so heavy, often consisting chiefly of silt and silty fine sand.

The areas of Waukesha silt loam along Millers Creek, as well as those near Laporte City and most of the small areas near Cedar Falls, resemble the Tama silt loam, and it is highly probable that they represent an extension of the upland silt loam over the terraces. In low places the natural drainage is rather slow and the soil has acquired a high content of organic matter.

Most of the areas along Blackhawk Creek are low terraces sloping gently toward the stream. The soil near the hills is a dark, heavy silt loam, but nearer the stream there is more or less gradation into loam, and occasional spots are so sandy as to be affected by extreme dry weather.

The Waukesha silt loam occurs on terraces of moderate elevation along the rivers and their larger tributaries. The surface is nearly level, but owing partly to the occurrence of sand or gravel at a depth of a few feet the drainage is good and the aeration is deep and effective, as is indicated by the uniformly brown coloration of the material below the zone of organic matter. The latter is derived from the former grassy vegetation; in only a few places was there any tree growth.

Practically all the small areas in the Cedar Valley are level, but well-elevated lands, admirably adapted to tillage, and the few areas in the Wapsipinicon Valley have about the same agricultural value. In these areas there occur numerous spots of a few square rods on which corn, barley, and oats do very poorly, or fail entirely. The physical structure of the soil gives no indication of the cause, which is so far unknown.

Owing to its rather high organic content and excellent physical structure, this type endures seasonal extremes well. The average yield of corn is reported as about 50 bushels per acre, with higher returns on well-managed lands. Oats, barley, clover, and other crops do well, the average yields being about the same as on the upland soils.

CALHOUN SILT LOAM.

The soil of the Calhoun silt loam is a gray silt loam, low in organic matter and almost entirely lacking the crumbly structure of the darker colored silt loams. The upper subsoil is a light-gray silt loam with some yellowish mottling, underlain by a light-yellowish or somewhat mottled gray and pale-yellow silty clay, which is so compact as to prevent good underdrainage and aeration. Small gravel occurs on the surface, and in places there are small iron concretions in the soils and subsoil.

A small area in secs. 3 and 4, T. 90, R. 11, just below the north county boundary and east of the Wapsipinicon River, forms part of a low, level second bottom which is reached by the higher flood waters. Part of it is in cultivation and fairly good yields are obtained in seasons of frequent but not excessive rainfall.

Tile drainage, heavy applications of lime, and the frequent growing of clover would be beneficial to this soil and the occasional spots in adjoining types where somewhat similar conditions are indicated by a light color of the surface soil.

CASS SANDY LOAM.

In the typical development of the Cass sandy loam the surface soil is a very dark colored, moderately coarse sandy loam. The upper subsoil is usually somewhat heavier, often a loam or silty loam, but it is never compact, although sufficiently heavy to have good moisture-holding properties. The lower subsoil and substratum consist of

loose, brownish sand. The type everywhere shows considerable variation in the surface soil and in the depth at which the brown sand appears. The slight local elevations are frequently occupied by a light silt loam, while the soil in near-by depressions may be sufficiently heavy to clod if plowed when wet. The aeration is so deep and thorough that the subsoil is seldom mottled.

Most of the areas in the Cedar Valley are level tracts slightly elevated above the adjacent meadow, but usually subject to overflow. The inundations are usually for only short periods, and are due to backwater that comes in along old channels. There is usually much deposition of fine sediment at each inundation and undoubtedly there has been some addition of nitrates in the soil of the areas below Waterloo, owing to sewage.

The local drainage of the Cass sandy loam is generally adequate and a large part of the type is cultivated, corn being the principal crop. Some very high yields have been obtained, but there have also been serious losses, owing to high water in the summer. In most places the surface soil is so sandy that the type can be safely cultivated under a wide range of moisture conditions.

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

Mechanical analyses of Cass sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331785	Soil	0.0	3.2	6.9	38.6	9.2	25.0	16.9
331786	Subsoil	.3	3.5	5.3	30.2	11.6	29.8	19.5
331787	Lower subsoil	1.1	12.6	15.4	56.8	5.1	4.5	4.6

CASS LOAM.

Aside from texture the Cass loam differs from the Cass sandy loam in the darker color of the surface soil. The former consists largely of silt and clay particles, and in places may be so clayey that it cracks and checks on drying. Over much of the type, however, the texture is a loam or sandy loam. The subsoil at quite variable depth is a brown sand or sandy loam, usually becoming much lighter with increase in depth.

All of the Cass loam is subject to overflow, but the local drainage is generally good, and at ordinary stages of the river most of the type has good moisture conditions for crops. It is better adapted to grasses than the Cass sandy loam, and aside from the menace of floods, is a highly productive soil for tilled crops.

WABASH LOAM.

The Wabash loam in the Cedar Valley lies for the most part above reach of all except the higher floods. It ranges in texture from a

silty to a sandy loam, but most of the type has a surface soil of rather heavy, black loam, crumbly or granular in structure. This structure generally prevails throughout the entire 3-foot section. The lower subsoil in many places is a dull-brownish loam or silt loam, with some mottling, usually obscure brownish stains. Capillarity and aeration are usually effective to a depth of several feet, and the local drainage conditions are good. The type may be overflowed at almost any time of the year, but the floods usually occur early in the spring. Late planting tends to reduce the average crop returns, but heavy yields of corn, clover, and oats are often obtained. The productiveness of the soil is practically inexhaustible, as each flood leaves more or less fine sediment. Sandy deposits are seldom laid down on these areas.

The type as mapped in the Crain Creek Valley above Dunkerton is not typical Wabash loam. For a few miles above the town the predominating soil is a dark-colored loam with a rather heavy subsoil, underlain at a few feet from the surface by gravel. Small parts of the type in this section are in cultivation, but most of the land is used for pasture on account of the frequent overflows.

Farther up the stream, the soil is generally a heavy loam to silt loam, with a stiff clay, silty clay, or clay loam subsoil in which the imperfect drainage is evidenced by the frequent occurrence of dull-brownish or dark-drab coloration. Gravel occurs at depths of a few feet. The surface is flat and the type subject to frequent floods. In low places it is somewhat mucky, and coarse grasses are the chief vegetation. Elsewhere the pasturage value is good. There is no forest growth except for occasional willows along the crooked channel of the creek. The type here is very fertile, but it can not be safely used for tilled crops without deepening and straightening the channel of the stream.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam is a black, friable, or mellow silt loam, high in organic matter. There is sufficient organic matter to impart a dark color to a depth of 20 inches or more, and usually this part of the 3-foot section is a blackish silty clay, more or less granular under ordinary moisture conditions but inclined to be stiff and sticky when wet. The extreme lower part of the 3-foot section contains more sand and is usually yellowish brown, with a tendency toward mottling with increase in depth.

The largest areas of Wabash silt loam occur along Blackhawk Creek below Hudson. It is a very strong, productive soil, but much of it is used only for pasture. An excellent growth of bluegrass and white clover forms most of the pasturage, with coarse grasses predominating in the low spots. The soil of the small areas west of Laporte City is derived from the adjacent silt-covered uplands.

Wabash silt loam, heavy phase.—The small areas of Wabash silt loam, heavy phase, along Blackhawk Creek consist of black silt loam or silty clay loam changing at a depth of a few inches to a stiff, heavy silty clay which continues to a depth of 3 feet or more. In the most poorly drained places the lower subsoil may be a light-drab silty clay without much tendency to the granular structure which characterizes the upper subsoil when partially dry.

The surface of this soil is flat or slightly depressed, and in conjunction with the heavy texture causes poor drainage. The phase is used chiefly for pasture.

MEADOW.

Areas of alluvial soils so variable in texture, structure, and local drainage conditions that no classification into types is practicable are indicated as Meadow.

The largest areas occur along the Cedar River, occupying the greater proportion of the first bottom. On the inner side of nearly all the sharper curves, and in all those places where the stream is threatening to establish new channels, the recent deposits consist largely of sand, while in the wider areas the soil ranges from a loose, dark-colored loam to a silty clay. Most of the Meadow along the Cedar River supports a rather open forest of oak, hickory, ash, walnut, and maple. In most places there is more or less bluegrass and white clover, so that the land has considerable value for pasture.

The Meadow along the Wapsipinicon River is mostly a sandy soil, thinly forested, and subject to frequent overflows.

Along the creeks the Meadow generally supports a scattering growth of maple, ash, and elm, with some oak.

All this type, except the sandy areas, is very productive, but owing to the liability to overflow pasture is practically the only use to which it is put. In some places where it is cultivated high yields are obtained.

MUCK.

Muck represents areas in which the soil consists of black, finely divided organic material derived through the slow decomposition of aquatic vegetation in shallow water, or under such conditions that saturation has been almost continuous. It occurs mainly in old ponds and lake beds, but not infrequently in seepy hillside areas.

Small developments of Muck occur in various parts of the county. The largest cover 15 to 20 acres. In most of the areas the organic deposit ranges in depth from a few inches at the margin to 3 or 4 feet in the center. Many small spots of shallow Muck, consisting of clay loam with an abnormally high content of vegetal residue in the first few inches, are included in the Clyde soils.

Where the moisture content can be fairly well controlled, Muck is well adapted to growing cabbage, onions, celery, mint, and a few

other truck crops. Timothy and bluegrass do well, but the former makes a coarse, woody growth. Oats in some seasons give good results, but the crop often lodges badly or fails to fill well. As much as 20 to 25 bushels of wheat, barley, or rye have been obtained on well-drained areas of shallow Muck underlain by clay, but such yields are conditional upon a favorable season.

SUMMARY.

Blackhawk County is situated in northeastern Iowa, in the basins of the Cedar and Wapsipinicon Rivers. Waterloo, a commercial and manufacturing city, with a population in 1910 of 26,693 is the county seat. The area of the county is 565 square miles.

The surface consists chiefly of rolling upland, originally prairie but now well-improved farm land. The Cedar Valley extends through the county from northwest to southeast, averaging in width about 3 miles. The Wapsipinicon River crosses the northeastern corner of the county. Its valley is narrower, and includes a smaller development of second bottoms than that of the Cedar River.

The leading crops of Blackhawk County are corn, oats, clover, and timothy. Hog raising is the most important animal industry, and the largest single source of income on most farms. Dairying is also an important industry and much attention is given to the breeding of dairy cattle. Many draft horses are raised each year.

In general, farming methods are extensive rather than intensive. Labor-saving machinery is everywhere used to the fullest extent. The average size of the 2,168 farms in the county is 156.9 acres. There has been a steady, though slight, increase in the average size since at least 1880. Tenancy is also increasing, about 42 per cent of the farms being operated by tenants at present, as compared with 25 per cent in 1880.

The present selling price of the more desirable lands averages about $200 an acre. Many farms bring higher prices, and the valuation is seldom much less, except in the case of sandy lands or areas subject to overflow.

The prevailing soil types are dark-colored loams and silt loams, of loessial or glacial origin. They are quite high in organic matter and comparatively rich in the essential mineral elements. While all the types are acid in the surface soil and few have calcareous material within the 3-foot section, good yields are obtained without the use of lime or any mineral fertilizers. The use of barnyard manure, with frequent seeding to red clover, has been the means relied on for maintaining soil productiveness.

Twenty-nine types of soil are recognized in this county. Many of them are of very small extent or are agriculturally unimportant.

The Carrington loam is the predominant type throughout the

northeastern half of the county. It has a high agricultural value. The usual yield of corn is from 40 to 50 bushels per acre, and higher yields are reported by many farms. Oats ordinarily yield 40 to 50 bushels per acre, and yields of 70 to 80 bushels are not uncommon. Clover and timothy do well. The Carrington sandy loam is a much lighter textured soil, and its average yields are less than those on the loam. The fine sandy loam is of small extent, but it ranks with the loam in agricultural value. The Carrington sand consists of ridge areas of low agricultural value.

Throughout the southwest half of the county the Tama silt loam is the predominating type. Its gently rolling surface insures good drainage, while its texture permits easy tillage and makes the soil retentive of moisture, so that it is able to resist seasonal extremes. On this account the average yields of the staple crops are somewhat higher than on the Carrington loam.

The soil in the upland "sloughs" and in strips along small drainage lines is mapped as the Clyde silty clay loam. This type is characterized by a high content of organic matter and a heavy, clayey texture of the subsoil. Much of it is artificially drained, and when reclaimed is very productive.

The Clinton fine sandy loam and silt loam are characterized by the ashy appearance of the surface soil in cultivated fields. They represent formerly timbered areas of well-drained upland.

The O'Neill soils are brownish, sandy types with coarse subsoils, and they are generally droughty.

The second-bottom types having dark-colored surface soils and rather brownish subsoils are included in the Waukesha series. The Waukesha sandy loam is not a very desirable agricultural soil, but the fine sandy loam, loam, and silt loam are productive soils well suited to general farming.

The Bremer loam and silt loam are second-bottom types having rather poor natural drainage. The silt loam gives good yields of crops under favorable conditions, but the loam is in general poorly adapted to any agricultural use at present.

The heavier, dark-colored alluvial soils are classed as the Wabash loam and silt loam. These are highly productive soils, but they are subject to injurious overflow.

The Cass series includes alluvial types having dark-colored surface soils and a brownish, sandy subsoil. The Cass soils are of small extent.

Alluvial soils of extremely variable character, which comprise the lowest lands along the streams, are classed as Meadow. These areas are generally forested, and of little agricultural value except for pasture.

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[PUBLIC RESOLUTION.—No. 9.]

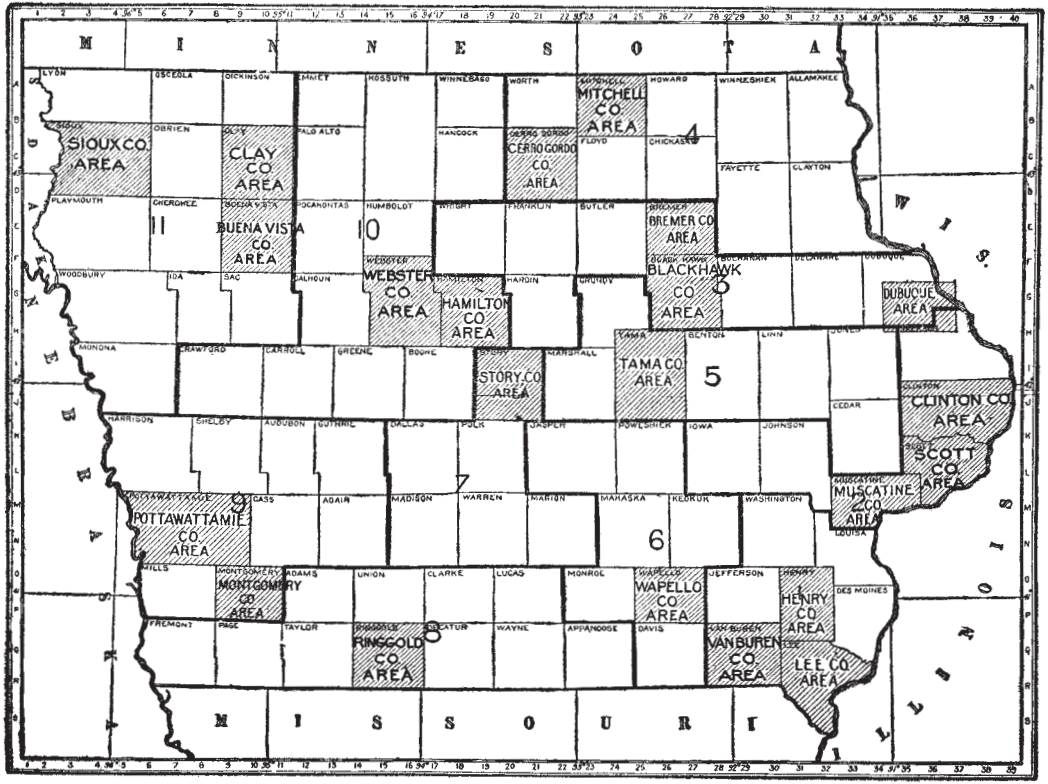
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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.]



Area surveyed in Iowa.

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