SOIL SURVEY OF JOHNSON COUNTY, IOWA.

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

DESCRIPTION OF THE AREA.

Johnson County is situated in the southeastern part of Iowa. The extreme southeastern corner is 18 miles from the Mississippi River at Muscatine, and about 60 miles north of the southern boundary of the State. It is bounded on the north by Linn County, on the east by Cedar and Muscatine Counties, on the south by Louisa and Washington Counties, and on the west by Iowa County. It includes 17 land townships, of which 16 are in the form of a square, while the remaining one forms a southern projection at the southeastern corner. The area is 610 square miles, or 390,400 acres.

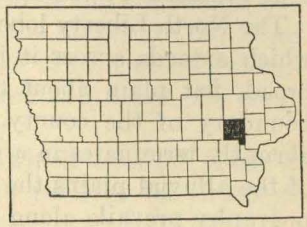

FIG. 34.—Sketch map showing location of the Johnson County area, Iowa.

The elevation of the uplands of the central, western, and northern townships ranges from about 700 to 800 feet, while that of the southeastern is generally less than 700 feet.

The original surface of Johnson County, Iowa, was part of a broad, smooth plain sloping gently toward the southeast. This plain was covered by a thick mantle of drift during the Kansan and the Iowan stages of glaciation and later the greater part was covered by a veneer of silty material commonly known as loess. The present features of the topography, except on small areas where the original constructional topography of the drift and loess still exist, have been impressed upon the plain by streams which have cut their valleys into the unconsolidated surface covering and established complete drainage over the greater part of the area. Remnants of the original constructional surface still exist in the comparatively level areas in the southern part of the county on both sides of the Iowa River where streams have not yet invaded the upland.

Many peculiar topographic forms may be seen in the county, but it is not possible to discuss them all in this report. Three lobes of Iowan drift extend into the northern part. One of these traverses Big Grove and Cedar Townships, and the town of Solon lies within its borders. This drift plain is usually called the Solon plain.

The second and largest lobe extends from the extreme northwestern corner of the county in a southeasterly direction, passing the town of North Liberty, and is usually called the North Liberty plain. Another small lobe extends a little more than a mile into the county and includes the town of Shueyville. These drift plains have common characteristic features of topography; they are comparatively smooth and gently rolling; they occupy a plain lower than the adjacent areas, covered with the silty deposits, and they are bordered by low and often indistinct terminal or interlobular ridges. The North Liberty plain is also broken in the northwest part of Madison Township by a group of sand ridges covering several square miles. They range from low swells to hills that rise 50 feet above the general level of the plains. With a few exceptions they have a northwest-southeast trend. They cover a few acres, or they may be a mile or more in length and have a width of one-quarter mile. Swan Lake, a small kettle-bowl lake, lies among these hills in sections 4 and 5 of Madison Township.

The North Liberty lobe is broken by the valley of the Iowa River, which extends across it in a west-east direction. This river has a broad, flat plain about 3 miles wide where it enters the western boundary of the county. It flows east about 10 miles and there abruptly terminates in a gorge hardly one-fourth mile wide. North of the alluvial plains the loess hills rise up abruptly, and rough topography prevails along a belt 2 or 3 miles wide, then the smooth, rolling plain of the Iowan drift reappears.

All of the county south of a line drawn east and west through the southern part of Iowa City has a characteristic topography. It has the physiographic features of the Kansan drift plain covered by a thin mantle of silty material. The Iowa River has cut a valley from north to south and has built up a broad, flat plain with a series of terraces at several different levels. Clear Creek and Old Man Creek, which flow across it from west to east and empty into the Iowa River, also carry their belts of alluvial land. The alluvial lands are flat and contrast sharply with the higher rolling upland. The region between Clear Creek and Old Man Creek is rolling, but the slopes are not so abrupt as in the loess areas north of Iowa City. Belts of rolling land border the streams south of Old Man Creek, but the broad interstream divides have a gently undulating to almost flat topography. On the broad, nearly level area that makes up the greater part of Sharon Township and the western part of Washington Township are remnants of the plain that have not yet been invaded by the drainage ways of the streams. That part of the silt-covered Kansan till plain which lies east of the Iowa River south of the latitude of Iowa City is in general smoother than the western

part. Numerous small streams traverse this plain, but they have very shallow valleys and have not yet extended their drainage ways over the whole surface. The topography is gently rolling near the streams, but the flat areas of the divides cover a considerable part of the surface.

The most varied topography in the county is exhibited by the belts of eroded silty material, one of which follows the Iowa River from the point at which it enters the county eastward and southward as far as Iowa City. Others lie west of Cedar River and on the eroded slopes occurring along Clear Creek and other streams. These silty hills stand conspicuously above the drift areas, usually rising 40 to 90 feet above the plain level. The surface has been entirely dissected and cut into an intricate system of hills and ravines. The hills are sharply rounded, and the ravines are deep and steep sided. Wherever the surface is disturbed, gullies start and cut with great rapidity into the soft silty material. These areas were all originally timbered. The smoother parts have been cleared and cultivated, but extensive wooded areas still remain along the slopes of the Iowa River north of Iowa City, and small forests are on eroded slopes within the areas that were originally timbered and which are coextensive with the areas of light-colored soils.

The largest stream is the Cedar River, which cuts off about 5 square miles of the northeastern corner and receives the drainage from less than 30 square miles on the west.

The master stream is the Iowa River, whose indirect course and widely separated sections of valley are unusual features in stream development. It enters the county about 6 miles south of the northwestern corner and, after many meanders in the flood plain of the valley previously described, escapes through a narrow gap just below Curtis. In the next few miles it makes several wide and erratic curves between the high loess-covered hills, then follows a southerly course to the southern county boundary.

Above Iowa City there are only occasional expansions of the narrow flood plain into tillable areas of bottom land. Below the city the valley again widens to 2 or 3 miles. Rather more than one-half of this consists of low timbered lands, intersected by abandoned channels, all in various stages of obliteration by deposits from the mud-laden backwaters which fill them at each overflow. The channel is very unstable and threatens new courses at many points.

The terraces are from 10 to 20 feet above the flood plain, and are generally in cultivation.

For the first 7 or 8 miles of its course in this county Old Man Creek has a valley about a mile wide. A fringe of timber borders the sinuous channel, with some woods on the hills to the south. The

greater part of the flat valley is or was a marshy prairie. Below the mouth of North Branch the first bottom is generally wooded pasture land, with cultivated terraces to the north.

The Clear Creek Valley above Tiffin is a more or less timbered alluvial flat, part of which is subject to overflow. Below Tiffin there are remnants of terraces affording some excellent farm lands.

Throughout all the areas of Clinton soils the natural drainage system is so nearly complete that there is hardly an acre of upland which has not prompt surface drainage from storm waters. Road construction and the constant extension of artificial drainage in farm lands have enormously accelerated the rate at which storm waters find their way to the main streams. The larger creeks rise rapidly and carry much fine silt and clay. The former low places in their flood plains have been very generally filled with silt, and the tendency now is for the enlarged channels to carry most of the suspended material down to the rivers. The waters of the rivers and creeks are seldom clear, even in the late summer, when erosion is at the minimum. In the area where the Tama soil predominates the waterways are less numerous but generally effective. Water power is developed at Iowa City and Coralville.

Throughout the northern half of the county a large proportion of the population is of Bohemian descent, many of the pioneers having come direct from Europe. In Washington and Sharon Townships a very large majority of the people are Mennonites. Elsewhere the rural population is chiefly American, but there are many families of Irish, German, and Swedish origin.

In all sections 90 per cent or more of the farm homes are frame houses and very many are of modern style. Throughout the areas of the Tama, Carrington, and smoother areas of the Clinton soils the conventional set of farm buildings includes, in addition to the dwelling and its associated outhouses, one or two large barns, a combined corncrib and granary, hog house, and garage, all painted red. On the rougher lands the outbuildings are not quite as large, but usually well constructed. (See Pl. XXXVIII, fig. 1.)

Small orchards, small fruit patches, vineyards, and well-kept gardens, with many old-fashioned flowers, are noticeable features of the homes of the Bohemians and Mennonites.

The water supply on the uplands is commonly obtained from wells 100 to 150 feet deep, windmills and gas engines being used for pumping.

According to the 1920 census, Iowa City, the seat of the State University, has a population of 11,267; Solon, 471; North Liberty, 171; Lone Tree, 673; Oxford, 580; Coralville, 150; Hills, 231; Tiffin, 178. The population for the entire county is given as 26,462.

The main line of the Chicago, Rock Island & Pacific Railroad between Chicago and Omaha crosses the county, and there are branch lines of this system that reach Solon and Lone Tree and the small villages in the northeastern part of the county. An electric line connects Iowa City with Cedar Rapids.

The public roads radiating from Iowa City are well graded, but not surfaced. They are traversable with automobiles at practically all seasons. This is true of most of the roads which follow the section lines, although the latter include far more steep gradients than the main roads.

There are very few farm houses without rural delivery of mail and telephone service.

CLIMATE.

The climate of this region is healthful and in the main favorable for the economical production of the crops upon which its agricultural prosperity depends.

The precipitation during July and August very largely influences the corn crops on all lands, with the possible exception of the Bremer and Wabash soils. The mean for these months, 4.5 inches, could be increased with material benefit to this crop, while a diminution of the average spring rainfall would be advantageous. Small grains and grasses almost invariably give highest yields in seasons of frequent rains and rather low temperature.

The decline in winter-wheat growing some 30 years ago can not be ascribed entirely to adverse climatic conditions, but in recent years high temperatures just before harvest have usually reduced both quality and yield. Spring wheat is especially susceptible to seasonal conditions.

The failure to obtain a stand of red clover is generally ascribed by farmers to adverse weather, but the difference in results of similar methods of seeding on the different soil types indicates that other causes are contributing factors. What these may be can be determined only by an investigation of local conditions.

The almost complete failure of orchard fruits in some seasons and fairly good returns in others is due largely to weather conditions early in the spring. Little attention is usually given to location of orchards, while garden and small-fruit patches are very commonly placed between buildings and the surrounding trees in such a manner as to accentuate the daily range in summer temperatures. Open locations and northern slopes have been found preferable to southern exposures for all except very early products.

The average date of the last killing frost in the spring is April 27 and of the first in the fall October 10, indicating an average growing season of about 166 days. Severe frosts have occurred as late as

May 23 and as early as September 18. The principal climatic data, as recorded by the Weather Bureau station at Iowa City, are given in the following table:

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

(Elevation, 683 feet.)

Month.	Temperature.			Precipitation		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1869).
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
December	24.1	65	−22	1.61	0.46	2.99
January	17.6	56	−28	1.65	1.79	1.36
February	20.5	61	−23	1.53	0.39	2.65
Winter	20.7	65	−28	4.79	2.64	7.00
March	33.2	87	−14	2.38	0.28	0.43
April	48.6	88	19	3.18	2.56	3.20
May	60.9	91	27	4.45	3.57	4.06
Spring	47.5	91	−14	10.01	6.41	7.69
June	69.8	97	37	4.45	0.98	7.42
July	74.7	104	43	4.28	2.22	7.42
August	72.2	101	37	4.24	4.98	11.43
Summer	72.2	104	37	12.97	8.18	26.27
September	63.6	100	28	3.68	3.87	3.09
October	51.0	88	15	2.72	0.57	2.07
November	34.9	79	− 1	2.26	0.69	4.48
Fall	49.8	100	− 1	8.66	5.13	9.64
Year	47.5	104	−28	36.43	22.36	50.60

AGRICULTURE.

The few settlers in this area prior to 1839 were squatters on the public lands, but in the next few years hundreds of immigrants arrived. Titles to lands were obtained in due form, and the county steadily advanced toward the highly prosperous agricultural conditions now attained.

Most of the Clinton soils required more or less grubbing of trees and destruction of brush. On the Carrington and Muscatine areas and on the second bottoms there was much ground too wet for tillage. This was true in some measure of the Tama soils, where heads of sloughs and small branch bottoms needed artificial drainage for a long time after the higher ground was cultivated. This process of

reclamation still continues to some extent but is largely confined to bottom lands.

There are very few fields that have been tilled 75 years, and a very large proportion of the uplands has been under the plow less than 50 years.

The general trend of agricultural production is indicated by the following table, compiled from census returns:

Acreage and production of cereal crops in Johnson County, 1880 to 1920, as reported by the Bureau of the Census.

Year.	Corn.		Oats.		Wheat.		Rye.		Barley.	
	Acres.	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*
1879	108,417	4,951,472	22,238	736,649	30,250	242,229	4,795	73,026	1,532	28,646
1889	87,029	4,158,355	48,760	1,925,976	3,144	34,182	4,440	70,869	893	24,990
1899	110,765	4,718,910	53,338	1,963,680	1,815	22,100	2,796	41,740	3,374	107,470
1909	100,436	4,366,297	44,726	1,327,970	3,736	76,650	1,518	22,476	3,778	83,440
1919	95,133	4,190,950	45,702	1,777,658	7,649	165,011	1,966	24,520	1,088	28,381

Corn, oats, and tame hay (clover and timothy) are the chief crops. Wheat, rye, barley, buckwheat, sorghum, Irish potatoes, and a considerable variety of fruit and vegetables are produced, but, with the exception of wheat, none have ever attained an importance comparable with the first-named products. The decline in wheat growing seems to have been due to a variety of causes, among which "blight," chinch bugs, and winterkilling may be mentioned.

The assessor's returns for 1916 indicate about 46,000 acres of tame hay in the county, or approximately one-third acre for each acre devoted to grain. The Federal census returns give nearly the same proportions for these classes of crops. About one-half of this tame-hay acreage is listed as clover or clover and timothy mixed.

In the northern and western townships not much corn is marketed; perhaps less than 10 per cent leaves the neighborhood in which it is grown. In the southeastern townships more of this crop is sold at the local elevators. In this same section a larger proportion of the oat crop is sold than in the first-mentioned section of the county.

The largest single item of income on the majority of farms is the sale of fattened hogs. The 1920 census reports the total number of swine as 131,263. According to the same authority there were in the county 51,778 head of beef cattle, 8,118 head of dairy cattle, and 12,309 sheep.

Most farmers sell more or less milk or cream at the local creameries or in Iowa City, but not many make a specialty of dairying. In the immediate vicinity of Iowa City and along the electric railway to the north, dairying has assumed considerable importance. There are fine herds of Holstein cattle in these sections, but else-

where the rather numerous herds of purebred animals are Hereford, Shorthorn, or Angus. (See Pl. XXXVIII, fig. 2.)

A considerable number of farmers make a practice of buying steers at the great central markets and finishing them here. These farmers use for feed a large part of the grain that is sold off farms where little stock is fattened.

In 1916 about 660 tons of sweet corn were sold from plantings covering 360 acres. More melons are grown in the northeastern corner of the county than elsewhere, although some are produced south of Iowa City. Most of the fruit and truck consumed in the city comes from sources outside the county. The supplies of this kind raised in the county are chiefly from small farms north of the city, very little coming from the big farms of the prairie section.

The 1,074 acres of potatoes reported for 1919 averaged about 43 bushels per acre. The same year 169 acres of alfalfa produced about 396 tons. This acreage represents many small patches, few exceeding 10 acres.

Relative to the influence of soils and topography upon farm methods the following comparisons are of interest. In Newport Township, containing about 25 square miles, nearly all of which consists of Clinton silt loam, 2,475 acres were devoted to corn in 1918, and the total yield was about 110,000 bushels, or an average of 44 bushels per acre. In Lincoln Township, which contains 24 square miles, mostly Tama silt loam with some Muscatine silt loam, there were 5,780 acres of corn, yielding about 313,000 bushels or nearly 54 bushels per acre. In Newport Township the same season there were 2,300 acres of tame hay (clover and timothy mixed) against 1,400 acres in Lincoln Township.

Union and Sharon Townships are comparable with respect to area, and most of the former consists of Clinton silt loam, while much of the latter is Tama silt loam. The acreage of corn in Union Township was 2,508, in Sharon Township it was 7,104 acres. The differences in acreage yields is not so marked as in townships previously named, because some of the fertile bottom lands of Old Man Creek are included in Union Township.

The black-soil townships also have the larger acreage of oats, but the difference in yield is in favor of the light-colored soils, so far as indicated by the figures for 1918.

The corn-growing townships in both instances have the larger number of swine and cattle. Not much attention is given the selection of varieties of corn or of oats for planting on different soil types.

The methods of preparing ground for crops and of tillage in general are very similar to those employed elsewhere in the Corn Belt. The practice of fall plowing is in general favor, but the acreage then prepared is largely a matter of convenience, or is often determined

by the autumn rainfall. The disk and common smoothing harrow are used to prepare ground for corn, which is almost always "checked" in planting and given from three to four cultivations. From May 10 to June 1 is a desirable time for planting, except that sod ground may be delayed somewhat to avoid injury by cutworms.

The latest and best types of labor and time saving machinery are in common use in caring for small grains. Oats are usually "disked" on cornstalk ground. Thrashing from the shock is the common practice. No straw is ever burned, and while some is sold to the cities, very few farmers make a regular practice of selling straw. Comparatively little hay is stacked outside of barns or hay sheds.

There are about 380 silos in the county. Gas tractors are coming into common use, and a few corn-husking machines are employed.

A succession of corn, oats, and tame grasses is observed on nearly all farms, but a systematic rotation is practiced on very few. Tenant farmers usually devote as much ground to corn as practicable. In nearly all instances the July crop of clover is harvested for hay. The fall crops may be used for pasture, or allowed to mature the seed. Both clover and timothy seed are produced in rather varied quantities.

Lime is being applied to a limited acreage by some of those farmers who are endeavoring to grow alfalfa.

Throughout the Clinton silt loam areas far less manure is produced than is needed on this type. With some exceptions considerable care is exercised in saving manure. This is particularly true of most of the Bohemian farmers, who permit little waste of manure and try to prevent soil erosion on hilly fields. The majority of Mennonite farmers are also careful in the use of straw and manure and other methods of conserving fertility. The street sweepings in Iowa City are generally dumped on vacant lots. Few farmers avail themselves of the manure that accumulates elsewhere in the city.

The usual wages of farm hands a few years ago was about $30 a month, with board and lodging, while day labor commanded from $1.50 to $2. During 1918 wages in summer were about $50 a month; in winter about $42. Most of the farm hands are young men from the cities or neighboring farms.

In 1920 there were 2,625 farms in the county. The average size of farms was 142.6 acres. Farms on the black-soil types usually contain 160 to 240 acres, while in the rougher sections of the Clinton silt loam they are smaller.

Prior to 1918 rents ranged from $6 to $8 an acre for ordinary farms to $8 or $10 for more desirable ones. Share rents were either two-fifths or one-half of grain, with cash for hay land. Since the above date there has been a marked advance.

The rapid advance in land prices during 1918–19 resulted in a few transfers at $400 an acre or even more, but these were exceptional.

The general range, however, was more than 50 per cent above former prices.

SOILS.[1]

Johnson County, Iowa, lies in the prairie region of the United States, a region dominated by a smooth, but not flat, topography on which grew for ages a grass vegetation made up of the grasses which thrive only under the influence of a rather high moisture supply. The prairies of the United States are neither semiarid nor subhumid. The normal rainfall is as high as in the timber-covered region farther eastward. A large proportion of the land is well drained in both soil and subsoil, though this condition is partly due to the development of topographic features in relatively recent times. In their original constructional form these prairies were less well drained than now and the cause of topographic change from the beginning has been along lines of increased topographic relief, thus producing surface features that favor surface and subsoil drainage. The original constructional surface, part of which still exists on the interstream uplands of the area practically unchanged, was not of such a character as to prevent surface and subsoil drainage. The prairie condition, therefore, can not be due to the poor drainage of all the soils even before existing surface relief was produced, but it is probable, if not certain, that the presence of considerable areas of poorly drained land controlled, through its control of the distribution of fires, the character of the native vegetation and prevented the spread of timber over that part of the area adapted to tree growth.

As topographic changes have developed greater relief and better drainage, bringing about the complete surface and subsoil drainage of the soil over large continuous areas, timber growth has spread over them, but has not invaded the unchanged areas. The grass vegetation of the prairies, therefore, is not the permanent native vegetation of the region. It was in course of disappearance and replacement by forest vegetation when white men invaded the region, and would finally have disappeared completely.

The native vegetation of Johnson County, under the influence of which these soils were developed, was grass on the smooth uplands

[1] Johnson County adjoins Linn County on the north, Cedar and Muscatine Counties on the east, and Louisa County on the south. In certain cases the maps of these counties do not appear to agree along the boundaries. This is due to changes in correlation resulting in part from a fuller understanding of the soils of the State. The Judson silt loam, the Carrington loam, and the Lindley types of Linn County have not been extended into this county on account of their very small area and their close resemblance to larger types in the area. For a similar reason the Bremer silty clay loam of Muscatine County has been mapped as Wabash silty clay loam in Johnson County and the Bremer clay as Bremer silty clay loam. The Muscatine silt loam of Muscatine County has been subdivided in this county into the Muscatine silt loam and the Tama silt loam, and the Memphis silt loam is now called the Clinton silt loam. The Cass sandy loam and the Cass loam as mapped in Louisa County have been combined in this county with the Cass silt loam, and the Cass sand with the Sarpy sand.

and timber in the areas of more pronounced relief. The timber-covered area was largest in the vicinity of Iowa City. It occupied an area of several square miles northeast of town, as well as a rather broad belt extending westward from town, extending from a short distance south of Old Man Creek to a short distance north of Clear Creek. Another belt stretched northwestward up Iowa River, one southward along the east side of the Iowa River drainage belt, and another along Cedar River across the northeastern part of the county.

The grass-covered and treeless area which stretched in an east-and-west belt across the northern border of the county north of the Iowa River belt of timberland as far east as the Cedar River belt of timber, thence southeastward to the county boundary east of Iowa City, southward along the county line for several miles, then spreading westward to Iowa River, covered the southeastern part of the county. Another area covered the upland in the southwestern part of the county between the Iowa River and Deer Creek, and another northwest of Iowa City on the upland between the Iowa River and Clear Creek.

The soils of the area were developed under the influence of a total precipitation, uniform for the whole area, amounting to about 22 inches, well distributed through the year. No soil differences, due to differences in precipitation, were developed. The soils of the whole county are leached of their carbonates to a depth as great as soil-making forces have extended, ranging from 3 feet, as a rule, to greater depths, depending on the texture and local topographic conditions. The subsoils are usually somewhat heavier in texture than the soils, a characteristic prevailing generally in humid region soils, this feature being more noticeably developed in the timbered soils than in the prairie soils, and in the latter somewhat better in those whose surface and subsoil drainage has long been good than in those developed under the influence of excessive moisture conditions.

A differentiation of the soils of the county on the basis of their most widely distributed and broadest characteristics is into light-colored soils and dark-colored soils.

The area of light-colored soils is coextensive with the area covered by timber when the white man first came to the area, or, to be more accurate, it includes those soils that were developed under a native vegetation consisting of trees. The soil profile consists of a surface horizon, ranging from 3 to 6 or 8 inches thick, of a grayish, very pale yellow or very light brown color and as a rule of a deflocculated, silty, or floury structure. This is underlain by a brown to yellowish-brown, heavier horizon with a coarsely granular or "nut" structure, extending to a depth ranging from 2 to 3 feet. The nut structure

gradually disappears and the deeper subsoil as a rule is not distinguished by any marked structure, or else the "nuts" become larger. The subsoil is always friable. Below 2 to 3 feet the texture is a little lighter and the material slightly less compact than above this depth.

Along the boundary of these soils, where they lie in contact with the prairie soils, they are darker in color and have a more or less well defined granular structure. In places where surface erosion is active the surface grayish horizon has been removed, leaving the yellowish-brown horizon on the surface. The soils belonging to this group, which we may designate as the Clinton group, include the various members of the Clinton, Knox, Jackson, and Chariton series, while those of the Sarpy, because of their light color, could be included, though on account of their occurrence as recently deposited alluvial material their soil profile has not yet been differentiated into horizons. The soils of the Chariton series are somewhat darker in color than the typical members of this group and their soil profile has reached a considerably more advanced stage of development than has that of the Clinton series. The subsoil is much heavier in comparison with the texture of the surface soil than is that of the types of the Clinton series.

The area of dark-colored soils is coextensive with the area of prairie on the uplands and includes also the areas of dark-colored alluvial soils, recently accumulated, whose material was derived mainly from the dark-colored upland soils. Some of the dark-colored alluvial soils, however, especially those occurring on terraces, are true prairie soils, their dark color being due to development, since their material was accumulated, under grass cover.

The dark-colored soils fall into two subclasses or groups, whose differentiation is based on the drainage condition of soil or subsoil, or both, during their development.

The soils of one of these groups, which usually is designated as the Carrington group, were developed under conditions of good soil and subsoil drainage. The typical or prevailing profile consists of a surface horizon of dark-brown to black color and granular structure, ranging from 5 to 12 inches thick. This is in most places underlain by a strong brown horizon, lighter in color than the surface, with a somewhat coarser granular structure, ranging in thickness from a mere film up to 12 inches. Below this horizon occurs the true subsoil, of a brown to yellowish-brown color and perceptibly heavier texture than the two upper horizons. It is friable and coarsely granular in structure. It extends to a depth ranging from 2 to 4 feet and is underlain by a slightly looser horizon of parent material, not greatly different from the fresh parent rock, glacial drift. The carbonates

have as a rule been removed to a depth of a few feet below the top of the horizon.

This group includes the various members of the Carrington, Shelby, Tama, Waukesha, Cass, Buckner, and some of the Wabash series. The soils of the Wabash and Cass series owe their dark color usually to the fact that they arise from recent alluvial deposition of dark-colored material washed from the other dark-colored soils.

The members of the other group of dark-colored soils mentioned above, those developed under conditions of poor drainage, usually referred to as the Muscatine or Clyde group, have a surface horizon of black color and usually fairly well defined granular structure. This is underlain by a gray or a mottled gray, yellow, and brown subsoil somewhat heavier as a rule than the surface. The details of the profiles of these soils vary considerably, depending on the depth to which good drainage and oxidation has extended. In some cases both surface and subsoil have developed under a cover of water or at least under a permanently wet condition. In other cases the soil has been rather well drained, but the subsoil permanently wet, while in still others only the deeper part of the subsoil has been subjected to conditions of excessive wetness. The details of these varying conditions will be described in the detailed description of the several soil types.

This group includes the various members of the Muscatine, Bremer, and Scott soils and certain types, usually the heavier, of the Wabash series. They are confined to the flat areas on the uplands and terraces and to low places in the alluvial plains. The Wabash soils do not as a rule have the various horizons of the profile as well developed as in the Muscatine soils.

The soils of each of the groups mentioned above are differentiated into series on the basis of differences in structure and minor details of the soil profile and on the basis of the source, character, and processes of accumulation of the material from which the soils have been developed. For example, the Tama soils are differentiated from the Carrington soils because the former are supposed to have been developed from silty material accumulated by sedimentation of dust from the air, while the latter have been developed from material accumulated by deposition from glacial ice. This difference is now considered of less importance in the determination of soil characteristics than was formerly thought to be the case. It is now thought that a Tama silt loam would not differ essentially in soil characteristics or in productive capacity from a Carrington silt loam. The matter has not yet been fully and thoroughly investigated, so that the differentiation is still continued pending further investigation.

In the following pages the soils of the county are discussed with respect to the derivation of the material from which they have been derived.

Johnson County lies within the glaciated section of Iowa. The Iowan drift sheet, which covers so much of northeastern Iowa, extends into the northern part of this county, but throughout the southern half or two-thirds of the area the immediate surface deposits are underlain by Kansan till. These deep glacial deposits rest upon Silurian and Devonian limestone, but these rocks are nowhere exposed, except along the rivers and larger creeks.

Practically all the Kansan till, except in the river valleys, is covered with loess, while much of the Iowan drift sheet is concealed by either true loess or material of such silty character that it has the properties of a loess.[2]

The loess is the parent material of nearly all the upland types and the source of most of the alluvium in the valleys. Hence the great predominance of silt loams, or that class of soils in which silt[3] particles form more than 50 per cent of the material.

For several miles on each side of the Iowa and Cedar Rivers the loessial deposits are deep, generally exceeding 10 or 15 feet of silt, then passing into yellowish sand of undetermined depth. In many instances, however, the silt deposits bordering the river valleys rest directly upon the glacial clays. This is also true of practically all the shallower phases of the loess which so generally prevail throughout the uplands of the county.

The deeper loess below the superficial weathered layers is a pale-yellow or buff porous material with no coarse sand or pebbles, except at its contact with the underlying till. It is so friable that a hand sample crushes under slight pressure, but the material will stand in nearly vertical roadside cuts, yielding rather slowly to the action of rain and freezing weather. Steep, bare hillsides, however, erode very easily.

The shallower phases of the loess coincide in a general way with the smoother areas of the Clinton silt loam and of all the Tama silt loam west of the Iowa River. The depth varies from 4 or 5 feet on the steeper slopes to 10 or more on tops of ridges and on the gentler declines.

The loess of the southwestern part of the county is somewhat shallower than that of the western and northern parts. Along the Muscatine County boundary the deeper road cuts usually reveal the

[2] The term loess is here used for a silty deposit, without regard to source of material or mode of deposition. All statements concerning geology are based on the Iowa State Geological Reports.

[3] The term silt, which is so frequently used in this report, refers technically to soil grains having an estimated measurement of from 0.05 to 0.005 mm. in diameter, or between very fine sand and clay particles. Soils composed largely of silt grains are not so loose and droughty as a sand, nor on the other hand do they retain moisture so tenaciously as clay. With respect to moisture content, and adaptability to tillage, they form the desirable mean between the sand and clay extremes. The bulk of the great staple crops of the United States is grown upon silt loams.

reddish-brown, highly oxidized Kansan till. The loess in this locality apparently averages higher in clay particles and contains less sand than that found elsewhere in the county. Very often the lower part shows some mottling, owing to poor aeration. This mottling seldom occurs in the deeper phases of the loess along the rivers. It is observable, however, in the lower layers of the silt capping broad divides and on old terraces high above the present valleys.

At a depth of from 4 to 8 feet below the surface nearly all phases of the loess contain some free lime, and occasionally lime nodules are present. Loessial deposits of no greater age than these are usually well supplied with phosphorus and potassium. Where loess is older, or thinner, or has suffered much leaching, the phosphoric-acid content may not be so high as is necessary for a fertile soil. But in this county there is no indication of a serious lack of these essential elements. There is, however, a deficiency of organic matter in all the loessial soils that were formerly timbered. Well-drained forested soils in this latitude do not accumulate much humus, compared with grass-covered soils of similar textures, particularly if the latter have a high average moisture content. At the time of the settlement of this region most of the deeper loess near the rivers and much of that of the roughest lands elsewhere was covered with a rather young but moderately dense forest. In all except poorly drained spots there was but little humus, other than a thin surface mold derived from forest débris. But further from the rivers the timber was unevenly distributed, consisting chiefly of bur oak and white oak, with patches of hazel brush. There were many open grassy areas where the prairie vegetation still persisted. The soil almost everywhere retained much of the black carbonaceous organic matter accumulated while true prairie conditions existed.

More remote from the main drainage lines there were only occasional groves and patches of hazel brush, while elsewhere grasses and herbaceous vegetation prevailed. The latter were heaviest and most persistent in locations where the average moisture content of the soil was high. This also favored the preservation of the black organic residue previously mentioned. This is old and rather inert humus compared with barnyard manure, but of high value as an element of soil fertility.

The conditions just outlined are represented by the three dominant soil types. The Clinton silt loam generally coincides with the forested or partially forested areas, where the character of the vegetation and the vigorous drainage induced by strong surface relief tended to prevent the accumulation of organic matter. The Tama silt loam represents conditions more favorable to accumulation of organic residue, although in places on this type the forest had encroached upon the prairie. The Muscatine silt loam as mapped in

this area was developed only where a high average moisture content, due to lack of surface inclination as well as retentive nature of the material itself, induced heavy growth of grasses and caused slow decomposition of their subsurface parts.

The Carrington soils occur on those areas of the Iowan drift sheet which have only a thin covering of silty material. In most instances this has a depth of at least 20 or 30 inches, and therefore determines the textural character of the soil, but the till influences the drainage to a large extent and contributes directly to the store of plant food available to crops.

The Iowan till, as exposed in road cuts, is generally a light-yellow silty clay to sandy clay, containing but little stony material. In most places it is quite calcareous at or just below its contact with the overlying silty material. The silt has little or no free lime. On steep slopes the till is leached and oxidized to a depth of several feet, and usually has a reddish-brown color.

The brown or reddish-brown tint of the upper part of the Kansan till indicates a high degree of oxidation and much leaching of the more soluble constituents. This till is commonly a rather stiff sandy clay with considerable small gravel and stones, all of the hardest and most resistant kinds of rock. Such shale, sandstone, or limestone fragments as may have been originally present have disappeared. Most of the granites have disintegrated, and large bowlders of any kind are comparatively rare.

On the high second bottoms in the river valley there is a wider range in the character of the surface materials than on the uplands. While the greater part of these old water-laid deposits is composed of silts and silty clays there are many places where they are more or less sandy. There is also a considerable development of sandy soils that owe their origin to wind action upon sand deposited by the river at a much later period than that represented by the high terraces. These wind-laid sands have been distributed upon the older deposits of the terraces in a most erratic manner, forming low mounds that occasionally approach the character of dunes. With a very few exceptions they occur only on the south and east sides of the present river flood plains. Minor developments are also found along Clear Creek and a few other streams.

The greater part of the terraces was originally covered with grasses. The same process in soil development may be discerned as upon the uplands. Drainage was largely determined (1) by texture of the surface layers and (2) by depth of the underlying sandy stratum.

On the basis of color, origin of material, topography, and structural characteristics the soils are grouped into soil series, of which 15 are recognized in Johnson County. The series are divided into

soil types on the basis of texture. Twenty-seven types, including miscellaneous materials represented by Muck, Meadow, and Riverwash are mapped.

The Clinton series is characterized by gray or dark-gray surface soils and a light-brown or yellowish-brown, compact subsoil. The topography is rolling to broken, and drainage is well established. The series is derived by weathering from loess. One type, the silt loam, is mapped in Johnson County.

The surface soils of types in the Tama series are dark brown to black, and the subsoil is light yellow to yellowish brown. The structure is loose and friable. The topography varies from gently to sharply rolling. The series is derived from loess where a large part of the lime has been leached from the upper 3 feet. The Tama silt loam is mapped in this county.

The types of the Muscatine series have dark-brown to black surface soils, and brownish-gray, grayish-brown to yellowish-brown and gray, mottled subsoils. The upper subsoil is friable, but the lower subsoil gradually becomes more compact, and with the increase in compactness the mottling begins to appear, though the mottling is strong only in rare cases. The subsoil is neutral to acid. Only the Muscatine silt loam is mapped.

The Knox series consists of light-colored calcareous soils derived by weathering from loess or other wind-blown deposits. The surface soils of this series are brown and the subsoil is light brown to yellow. The subsoil is silty and friable, consisting of loess in only a slightly weathered condition. The topography ranges from gently to sharply rolling, and the surface is generally well drained. The Knox sand, the only type of the series mapped in the present survey, conforms to the general description except in one particular—it is not calcareous, and therefore not typical of the Knox as developed in the western part of the State.

The surface soils of types in the Carrington series are dark brown, and the subsoil is yellow to light brown. These soils are derived through the weathering of glacial till, but the silty members are modified to some extent by loess. The topography is gently undulating to rolling. Neither surface nor subsoil is highly calcareous. Two types, the fine sandy loam and the silt loam, are shown on the map.

The surface soils of types in the Shelby series are dark brown to almost black, and are usually quite shallow. The subsoil is composed of yellow, reddish-brown, or brown sticky, sandy clay, often containing coarse sand and gravel. As a rule the subsoil becomes more clayey and compact with depth. The topography is usually gently rolling to sharply rolling, as the series occurs on slopes where the sandy drift is exposed. The Shelby loam and silt loam are found in Johnson County.

The soils of the Waukesha series represent areas on terraces above overflow in which the soil texture and structure induce very desirable moisture conditions, and there has been a sufficient accumulation of organic matter to give a dark-brown or black surface soil, while the subsoil is brown, owing to a rather high degree of oxidation. The subsoil is heavier than the surface soil, but not compact and impervious. The sandy loam, loam, and silt loam are mapped.

Deep, heavy deposits of a silty nature on the lower lying terraces gave rise generally to the Bremer soils, characterized by a black color and a high content of organic residue. The subsoil is usually heavier than the surface soils, and in the heavier types it is tough and plastic. The drainage is fair to poor. This series is represented by the loam, silt loam, and silty clay loam.

The Buckner series consists of terrace soils with dark-brown surface soils and lighter colored subsoil. The materials are well oxidized to a considerable depth, and the organic-matter content is low. The subsoil does not differ greatly from the surface soil in texture. The surface is level, but the drainage is good. The loamy sand, fine sandy loam, and silt loam are mapped in this county.

The Chariton soils range in color from dark gray to dark brown or black. The upper subsoil is usually an ashy-gray silt loam or silty clay loam. The lower subsoil is a mottled brown and drab, compact silty clay loam or clay. These types occur on old terraces and the surface drainage is good. Only the silt loam is mapped in this area.

The soils of types in the Jackson series are light brown in color and are underlain by a light-brown mottled subsoil. They occur on terraces and are usually not subject to overflow. The silt loam of this series is mapped.

The types of the Scott series have dark-brown to almost black surface soils. The subsoil is an ashy-gray silt loam, often loose and floury, underlain by a heavy, compact, drab clay loam or clay. The series is developed in shallow basins and depressions and the drainage is usually restricted. One type, the silt loam, is mapped.

The types of the Wabash series have dark-brown to black surface soils with high organic-matter content, and a dark-drab to gray heavy subsoil. The Wabash soils represent the latest alluvial deposits of any considerable extent or agricultural importance. The areas on the smaller streams have derived much silty material from the uplands since the latter have been brought under the plow. The areas near the rivers are in most instances in process of aggradation, receiving more or less sediment at each inundation. The Wabash silt loam and silty clay loam are mapped in Johnson County.

The Cass series includes types with dark-brown to black surface soils with subsoils of lighter texture, which frequently pass within the 3-foot section into loose sand and gravel. Both soil and subsoil

are calcareous. This series occupies first bottoms. The major parts of the Cass soils are not in receipt of much sedimentation, because they lie too high to be deeply inundated. The waters that cover them are generally shallow and move rapidly, and deposition is confined to the depressions in which backwater stands for some time after such floods. The silt loam of this series is mapped.

The Sarpy series is similar to the Cass series, differing from it only in the lighter color of the surface soils. It is represented in this county by the Sarpy sand.

The following pages of this report contain detailed descriptions of the soil types found in Johnson County, with a discussion of their relation to agriculture. The table below gives the name and actual and relative extent of each soil type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clinton silt loam	179,456	45.9	Waukesha loam	2,688	0.7
Tama silt loam	73,984	18.9	Shelby loam	1,920	.5
Carrington silt loam	28,864	7.4	Shelby silt loam	1,216	.3
Wabash silt loam	20,288	5.6	Waukesha sandy loam	1,024	.3
Colluvial phase	1,664		Bremer loam	960	.2
Muscatine silt loam	21,568	5.5	Sarpy sand	768	.2
Cass silt loam	9,344	2.4	Buckner silt loam	448	.1
Waukesha silt loam	9,024	2.3	Meadow	448	.1
Bremer silt loam	7,232	1.9	Scott silt loam	448	.1
Wabash silty clay loam	6,336	1.6	Muck	384	.1
Bremer silty clay loam	5,824	1.5	Chariton silt loam	384	.1
Knox sand	5,696	1.5	Riverwash	256	.1
Buckner loamy sand	4,352	1.1	Buckner fine sandy loam	64	.1
Jackson silt loam	2,944	.8	Total	390,400	.....
Carrington fine sandy loam	2,816	.7			

CLINTON SILT LOAM.

The surface soil of the Clinton silt loam is a light grayish brown or brown very friable silt loam, which at a depth of a few inches assumes a light yellowish tint that becomes more pronounced at a depth of 8 to 10 inches. The middle subsoil is a yellowish-brown heavy silt loam to silty clay loam, friable to crumbly, the crumbly structure being quite apparent when the material is dry. The lower part of the 3-foot section is a light yellowish brown or pale-yellowish silt loam, usually so friable that it is quite easily penetrated with a soil auger, while a hand sample crumbles under slight pressure.

These characteristics mark the yellowish-brown silty substratum to its contact with the underlying glacial material, the depth to which is seldom less than 4 or 5 feet and in many instances two or three times that much.

The soil and subsoil are invariably acid to litmus paper, but the substratum at from 6 to 8 feet from the surface is generally alkaline, and at slightly greater depths may be highly calcareous.

The organic-matter content is low and usually confined to the first few inches. On this account the dry soil has an ashy appearance in cultivated fields that are fairly level. Where slope-wash has removed much of the surface, as is the case on most hillsides that have been cultivated some years, the surface color is yellow to yellowish brown, and the soil is far less friable than in areas of uncleared land. Wherever the moisture content is much above the average there has been a greater accumulation of humus than elsewhere, but these variations are not of frequent or extensive occurrence. Near the rivers there are occasional high points capped with sandy material. These areas resemble the Knox sand. In Jefferson and Big Grove Townships the areas near the Iowa River have in many places a sandy substratum. This is exposed in deep gullies, while on hillsides the silt loam is more or less sandy. The areas east of Cedar River include many such textural and structural variations, due to admixture of wind-blown sand.

The greater part of the Clinton silt loam mapped in this area has a smoother topography than the average of the type found in other areas in the State, but none of it is flat; all of it is rolling to a greater or less degree.

The smoother variation of the Clinton silt loam has an extensive occurrence throughout the western half of the county. It also forms much of the tillable lands in the north-central and northeastern townships. Practically all is included in well-improved farms, and the major part has been brought under the plow. The surface configuration of most of this extensive variation is strongly rolling, with a local difference in elevation ranging from 75 to 100 feet. The main interstream ridges are rather evenly rounded, and slopes of moderate gradient often prevail, especially on the north side of the streams. On the south side the relief is generally stronger, but there is not much land anywhere that is too rough to prevent the use of farm machinery.

The smoother variation has in general a higher content of organic matter than the more rolling areas. On the former much of the original forest growth was light, consisting of bur-oak groves and hazel-bush patches, with only an occasional tract of mixed timber so dense as to have effectually supplanted the former prairie vegetation. A considerable part of this variation in the southern and western parts of the county was prairie at the time of its settlement.

The rather broad transitional belt between the Tama and Clinton silt loams has been included with the Clinton. Some of this has a distinctly dark colored soil to a depth of several inches.

The topography of the more eroded areas ranges from strongly rolling to rough, with a local difference in elevation of about 100 feet near the river, and somewhat less along the smaller streams. The heads of the local drainage lines are in many instances deep ravines with narrow intervening ridges. High, rounded ridges with deeply cut flanks characterize much of the topography north of Iowa City along the river. Nearly all the variation is too rough to admit of easy tillage. (See Pl. XXXIX, fig. 1.)

Practically all this rough land was forested. The woods within a few miles of the river included all the deciduous varieties common to this section of Iowa. White oaks generally predominated, with a decided increase of bur oak as the open lands were approached. On the south side of Old Man and Clear Creeks the timber was comparatively heavy and has distinctly influenced the soil.

At a rough estimate, about one-half of the more rolling land has been cleared, but only a small percentage of this is regularly cultivated. The land is used chiefly for pasture. Blue grass makes a most vigorous growth on all unforested ground, and there is more or less white clover in most pastures. The average yield of corn on the better areas of the Clinton silt loam can not be safely placed above 40 bushels per acre. This does not include the "sloughs" or narrow areas of Wabash silt loam which intersect almost every large field. On sod ground and fields that have been well manured a yield of from 60 to 70 bushels per acre is frequently obtained. Such ground endures dry weather exceptionally well. All the type, however, has a good reserve of moisture in the deep porous subsoil. Exceptions must be made where the soil has been largely washed off and the stiff brown silty clay exposed. On such spots corn requires light and frequent rains. The summer of 1919 was dry and warm, and corn on this type matured much earlier than on the heavier soils.

Oats are extensively grown, and yields of from 25 to 75 bushels are reported. As a rule the straw is not heavy, but tends to fill well unless very dry weather prevails. The soil seems better adapted to the large late-growing varieties than to the early oats.

A rather limited acreage of fall-sown wheat yielded in 1919 from 20 to 30 bushels per acre. Spring wheat made good yields. Little rye or barley is grown.

All of this type seems well adapted to clover. Oats are commonly used as a nurse crop, and in seasons of ordinary rainfall the clover makes strong growth. Even in dry summers less difficulty is experienced in securing a satisfactory stand than on the darker colored types.

Alfalfa has been grown in a small way on nearly all variations of this type. If a stand is obtained, it usually does well for about two

years, then becomes so thin that weeds and blue grass soon occupy most of the ground.

Bluegrass establishes itself quickly on all ground cleared of forest growth and in fields where cultivation is discontinued.

The foregoing statements apply chiefly to the larger acreages of the smoother areas of the type, but very similar returns are secured from the smaller fields on the rougher lands. The latter so often include very recently cleared ground still rich in humus, level tops of ridges with an ashy-gray surface soil, and steep slopes where the stiff brown subsoil is exposed, that uniformity in crop yields is not to be expected.

Compared with the best corn soils, the Clinton silt loam is decidedly deficient in humus. Experience indicates that in just such measure as this is supplied the yields of corn increase, cultural and seasonal conditions being favorable. As previously indicated, the structure and texture to a depth of several feet is very favorable to good moisture conditions. Crop returns do not indicate that the soil material is notably deficient in lime and phosphorus. Applications of lime would doubtless benefit clover. The heavier crop of clover, if returned to the soil, would increase subsequent grain crops and thus render the liming profitable.

It is not probable that application of raw rock phosphate would prove profitable on a type so lacking in organic matter. The use of the more immediately available acid phosphate can not be advised until after tests under actual field conditions have shown beneficial results.

A rotation in which clover occupies the ground two years in each period of five is the most practicable means of maintaining the productiveness of this type. The rougher lands should be maintained as permanent pastures or with only an occasional crop of corn. A great loss of humus can not be avoided while these steep slopes are devoted to tilled crops. The loss of organic matter and the physical injury to lands by erosion warrant paying much more attention to this problem than is given it, especially by large landowners on the less rolling areas of the type. The proprietors of the smaller farms in the hilly sections are generally more careful.[4]

On the tops of the wider divides there are occasional flat areas of a few acres where the surface soil may be quite dark to a depth of a few inches, but is underlain by a gray or somewhat ashy silt loam, which at 18 or 20 inches changes to a stiff silty clay, more or less mottled with gray and pale-yellowish streaks. These flat spots require tile drains, which should be placed rather close together on account of the tight, semi-impervious structure of the lower subsoil.

[4] Bulletin No. 183, Iowa State College, is a valuable contribution on this subject and very applicable to such a type as the Clinton silt loam.

Heavy liming and an occasional crop of some deep-rooted legume would doubtless prove highly beneficial.

TAMA SILT LOAM.

The surface soil of the Tama silt loam is a dark-brown to black silt loam, usually very loose and mellow in well-tilled fields. At a somewhat variable depth, but generally about 18 inches, this dark silt loam changes to a lighter brown heavy silt loam. The lower subsoil is a light yellowish brown silt loam or silty clay loam. The substratum is a comparatively unweathered silty loess, which in turn changes to a stiff yellowish-brown till at from 6 to 10 feet below the surface.

Where the surface is rolling or considerably inclined, as along the main drainage ways, the dark surface soil may be but 8 to 10 inches deep. On broad divides and wherever the surface is but slightly undulating the content of humus is greatest and imparts a dark color to a depth of 18 or 20 inches. In such locations the subsoil is heavier, and the slightly mottled coloration indicates a slower subsoil water movement than in the areas where stronger surface relief prevails. Soil and subsoil are acid, according to simple field tests.

The topography of most of this type is undulating to gently rolling. Near the areas of Clinton silt loam it is rather strongly rolling, but nowhere hilly or broken.

The Tama silt loam is the predominant type between Iowa City and Lone Tree. There is an extensive development of this type on the gently rolling uplands of Washington and Sharon Townships. Considerable areas are found in Cedar and Graham Townships. Some of the dark-colored silty soils on the high terraces west of the Cedar River are included with this type.

The soil yields very easily to tillage and may be kept in good condition with a minimum of labor. While there are many sloughs and a few flat spots that need artificial drainage, no great requirement for such improvement exists. Only limited areas have such pronounced surface slopes that erosion is a serious problem. These favorable conditions and the inherent suitability of the soil for corn cause much of it to be annually devoted to that crop.

The average yield of corn may be placed at considerably more than 50 bushels, with very frequent returns of 75 to 80 bushels. It is well adapted to oats and barley and most tame grasses and legumes. More difficulty is experienced in securing a good stand of clover than on the Clinton soils. The cause is not clear, but the more rank growth of oats, with which clover is usually seeded, as well as the more vigorous competition with weeds after the grain is removed, may be contributing causes.

All of this type is included in farms which as a rule are well toward the maximum limit in size for this county, and average high in value of improvements. While corn is the principal crop, oats, timothy, and clover are important products. Only a small acreage is devoted to blue grass.

The price of this type advanced very rapidly during 1918 and 1919, and a few well-improved upland farms sold for as high as $350 an acre. Previous prices ranged from $150 to $200, while the present average value may be placed at about $250.

MUSCATINE SILT LOAM.

The Muscatine silt loam has a dark-brown to almost black surface soil. The dark color is due to the high content of organic matter in the first 18 or 20 inches of the 3-foot section. The texture is a friable silt loam gradually changing with increase in depth to a somewhat heavier and slightly more compact silt loam. Below the range of influence of the organic matter the color is brown, which in the extreme lower subsoil changes to more or less mottled gray and yellowish-brown tints indicative of rather poor aeration. In some instances there is considerable soft ferruginous material in the lower subsoil. Where the natural drainage is especially slow the black organic matter extends to a depth of about 30 inches, while the underlying material is a gray or drab, sticky, heavy silty clay loam.

The type occurs on flat divides where the slight local differences in elevation cause a slow run-off of the rainfall and permit much of it to be absorbed. The consequent high average moisture content favored a rank growth of prairie vegetation. This is the origin of the black organic material which is more abundant here than in any other upland type of this area.

The surface soil and middle subsoil give an acid reaction to litmus paper, but the lower subsoil is only slightly acid or may be neutral. The underlying material is loessial, and there are indications that its average lime content at 4 or 5 feet from the surface is higher than that found at corresponding depths below the Tama and Clinton soils.

Isolated areas occur south and east of Iowa City to the Louisa County line. Somewhat larger tracts are embraced in the fine farming lands of Washington and Sharon Townships. A few small areas which are hardly typical occur on the divide between Clear Creek and Old Man Creek. These are associated with the Clinton soils, and include some poorly drained areas of the latter.

The type is held in high esteem for general farming. All is cultivated, and in much of it considerable tile drainage has been installed.

All the farm crops usually grown here are very successfully raised on this type. There may be a question as to the quality of crops, since a rank woody growth may be induced in forage crops, while grains do not always mature as well as on a type not so rich in nitrogen. This difference is recognized to some extent also in potatoes, sorghum, and some garden crops.

The soil is preeminently adapted to corn, and yields of 75 bushels or more per acre are often secured. It endures successive cropping to this cereal, and erosion is practically negligible.

The present (1919) price of most of this type ranges from $250 to $300 an acre. It also commands a high rental.

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

Mechanical analyses of Muscatine 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.*
333408	Soil	0.3	1.6	0.5	1.6	9.4	63.5	22.9
333409	Subsurface	.2	1.2	.5	1.8	8.6	64.6	23.1
333410	Subsoil	.2	.7	.4	4.8	14.0	62.2	17.6

KNOX SAND.

The Knox sand as mapped in this county consists chiefly of mounds and ridges of sandy material. The contours of these elevations, as well as their topographic positions, suggest wind action as the chief agency in their formation. The individual areas vary from a few acres to several hundred, and the elevation from a few feet to as much as 50 or 75 feet above the adjoining uplands. (See Pl. XXXIX, fig. 2.)

The material is chiefly sand of the fine and medium grades, but often there is considerable coarse sand. Its depth is extremely variable, even in the smallest areas. As a rule, the deepest and least coherent sand is found on the highest points, while on the flanks there is a more or less gradation into a shallow, silty, sandy loam, with a stiff, silty clay subsoil. In some places, however, there is a very sharp boundary between this sand and the adjoining silt loams.

The lighter of these sandy ridges consist of a loose, gray to grayish-brown sand, containing a meager amount of organic matter and a small proportion of silt. The silt increases somewhat with depth, so that the subsoil may be slightly coherent. The lower part of the 3-foot section is generally a loose brown sand which continues to a depth of several yards. The underlying material is commonly the loessial silt, which forms the Clinton and Carrington soils.

The sand includes quite a variety of minerals other than quartz and is so well oxidized that brown and yellow tints uniformly prevail, except in the weathered surface layer.

The Knox sand ridges are numerous in the northwestern part of Madison Township. Most of them have a northwest-to-southeast trend, and the larger ones are upwards of a mile in length but seldom exceed one-fourth mile in width. They rise from 20 to 50 feet above the surrounding uplands. Many of these are simply low, sandy swells occupying but a few acres. An irregular occurrence of these dunelike mounds prevails on the high upland near Oxford and thence southeast to a point a few miles north of Tiffin. Limited areas are found south of Clear Creek. The latter, as well as those near Oxford, are thinly wooded in places, but most of these hills are treeless pastures, where bluegrass generally displaces the original prairie vegetation. On seepy spots and around the occasional small ponds coarse water-loving grasses and weeds form most of the vegetation. The roadside growth includes much horsemint, goldenrod, and other native plants and grasses common to dry upland soils. Sand bur is abundant in most places.

There are occasional "blow-outs," or spots, where the vegetation has been destroyed by excessive grazing or by cultivation. Here the loose, gray sand drifts badly during dry, windy weather.

Very little of this type is cultivated. The exceptions are usually small patches included in the Clinton silt loam, and these are generally darker colored and more loamy than the sand of the high ridges. Corn usually makes a light crop, especially if the rainfall is not abundant. This is also true of small grains and tame grasses. No truck crops are now grown, but very favorable spots could be selected for early truck, melons, and such forage crops as Sudan grass, sorghum, and feterita.

In the area east of the Cedar River the sand hills rise from 50 to 75 feet above the valley. They are irregularly dispersed mounds rather than ridges, but the smooth outlines suggest a dunelike origin. The sand is of extremely variable depth, and in places is entirely absent, the underlying brown silt being exposed. Formerly the lightest sand supported a rather open forest in which black oak predominated. Elsewhere the woods were dense, and included various kinds of oaks, with more or less hickory, walnut, elm, ash, and wild cherry. Groups of poplar (quaking asp) marked the rather numerous seepy spots, while cottonwood, willow, and sycamore surrounded miniature lakes, whose occurrence indicated the slight depth to a semiimpervious substratum. In these sheltered locations there was a great variety of forest undergrowth, while at the margin of the groves on the higher ground there were many weeds and grasses common to the prairies farther to the east.

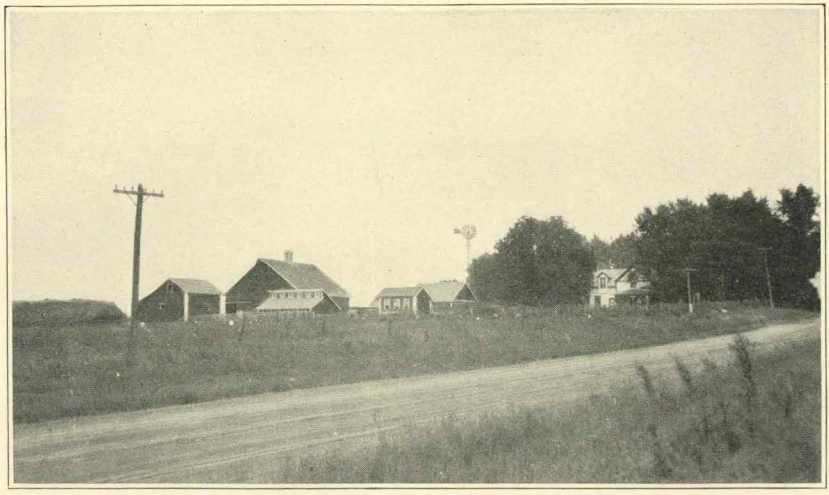

FIG. 1.—TYPICAL FARM BUILDINGS ON THE CARRINGTON SILT LOAM.

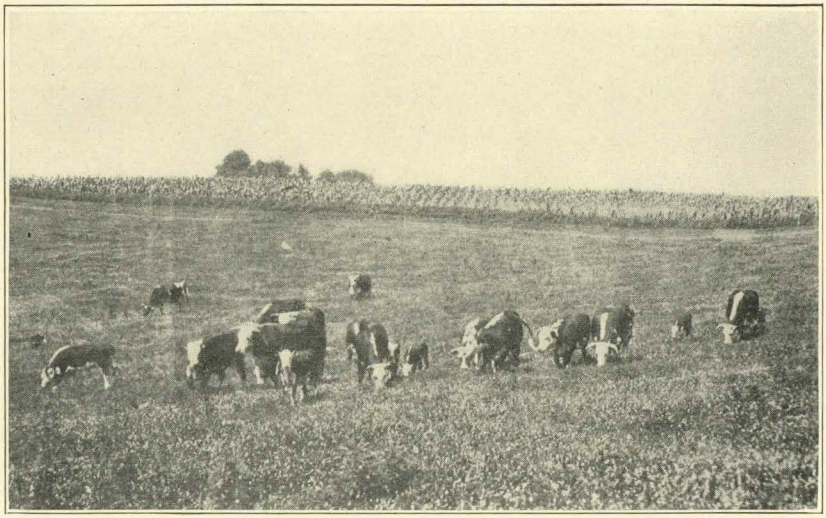

FIG. 2.—HERD OF BEEF CATTLE AND FIELD OF CORN ON THE CLINTON SILT LOAM.

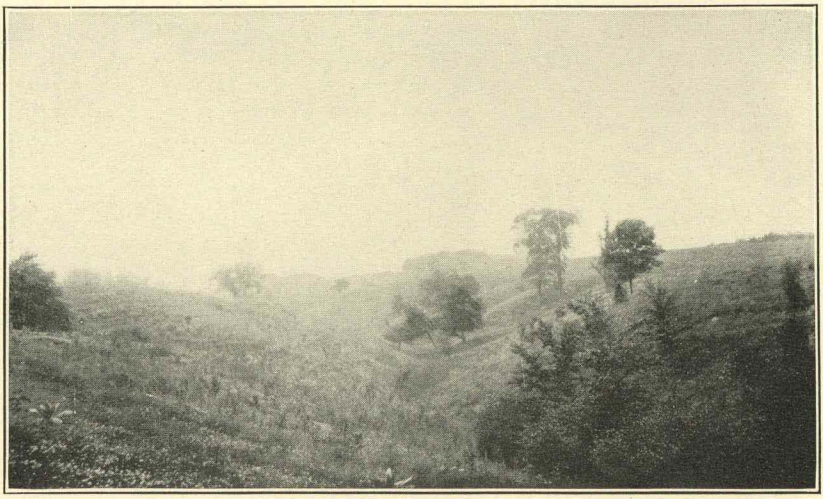

FIG. 1.—CONTOURS OF THE MORE ROLLING AREAS OF THE CLINTON SILT LOAM.

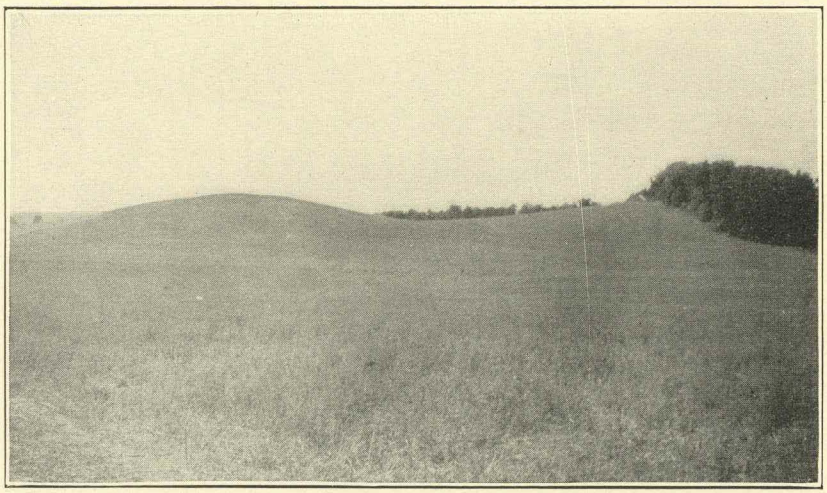

FIG. 2.—TYPICAL CONTOURS OF THE KNOX SAND.

Much of this area is not in cultivation. Some of the ridges are too light to give profitable returns of corn, oats, or clover, except in very favorable seasons. The scanty humus supply is wasting rapidly, due to excessive drainage and high surface temperature in the summer. On the lower slopes and depressions the soil is of variable character, but in general produces fair crops. Occasional spots are very productive, and nearly all is a warm, early type that quickly responds to fertilization. Melons and early truck are very successfully grown, and fruit trees do well on the shallower areas of the type.

The small areas south of River Junction are low, narrow ridges, on which the loose brown sand usually occurs on the highest points, while the flanks are of much heavier texture. The larger ridges are blue-grass pastures with scattering bur oak trees. The tillable areas are generally low swells with light, sandy loam in the central parts. These produce fair crops of corn, small grains, and clover.

A variation of the Knox sand occurs on those peculiar topographic features of the northern part of the county, which have been termed "pahas" or "paha ridges" by the earlier geologists. These elevations are associated with the Carrington silt loam, and, while predominantly sandy, are in many instances a silt loam quite similar to that of the surrounding country. Along the tops of most of these ridges, and in places along the entire elevation, sand of considerable depth prevails. A representative boring usually reveals a dark-gray or brownish-gray, medium to fine sand, in which is considerable humus similar to that of prairie soil. The subsurface is brown sand, which gradually becomes less loamy and lighter colored with change of depth. Loose sand of undetermined depth forms the substratum.

CARRINGTON FINE SANDY LOAM.

The Carrington fine sandy loam is not a distinct type with respect to the texture. It occurs where the Carrington silt loam in the vicinity of sand ridges has been covered or modified by sandy material.

In most of the areas indicated on the map the soil is a dark-brown silty loam, containing enough medium and fine sand to render it distinctly looser than the soil of the Carrington silt loam. There is generally less humus than in the silt loam, and it affects the color to a lesser depth. The subsoil in most instances is a dark-brown silty clay loam, crumbly or friable, and possessing good moisture-holding properties.

In nearly every field, however, there are innumerable gradations toward the Knox sand. There are many small spots, usually mounds of slight elevation, which are a light-brown loamy sand, or sandy loam, more or less droughty and otherwise distinctly inferior in agricultural value to the surrounding land.

The areas east of the Cedar River are mostly black loams or sandy loams between sandy ridges. These small tracts merge into the Carrington silt loam to the east. Nearly all of this is in cultivation and produces good crops of corn, oats, and hay. There are many spots in need of tile drainage.

CARRINGTON SILT LOAM.

The Carrington silt loam to a depth of about 20 inches is a dark-brown to dark grayish brown silt loam, overlying brown or dull yellowish brown silty clay loam. At a depth of 30 to 40 inches coarse sand grains, gravel, or occasionally small stones, occur, and with slight increase of depth there is much of this coarse material mixed with the stiff yellowish-brown silty clay.

In some places the substratum, which is the Iowan till, is quite sandy, and the overlying subsoil is a light-brown, well-oxidized silty clay loam. Occasionally the till is a stiff, heavy clay, which does not admit of as free underdrainage as the typical soil.

In nearly all the type the surface soil consists chiefly of silt particles and the organic-matter content is high. This insures a porous, friable structure conducive to ease of tillage and the maintenance of good moisture conditions. The moisture-holding quality is also favored by the crumbly or granular structure of the subsoil.

The surface soil is acid, but not to such a marked degree as that of the lighter-colored upland soil. In places calcareous till is found slightly below the 3-foot soil section. There is considerable local variation in this respect, the sandy variations of the substratum having lost more of their original calcareous constituents than the stiff clayey phases. It is very doubtful if the lime content anywhere exerts any influence upon the soil and upper subsoil. Deep-rooted crops, however, may reach the calcareous till.

The area west of North Liberty is undulating to slightly rolling. Most of the natural drainage lines are rather wide sloughs or sags at their heads, but become better defined where several coalesce to form small branches. Considerable tile drainage has been installed and more is needed. The deep silty soil is so free from stony material that an occasional gray granite bowlder is about the only surface indication of its being a glacial type.

An area of 8 or 10 square miles of the Carrington silt loam lies north and northwest of Solon. The surface for the most part is gently rolling, with rather marked inequalities in the average elevation in different sections. The silty flanks of the "paha" ridges are included with the types, and these, as well as some of the interstream divides, lie well above the general level of the surrounding country. The drainage in general is good, but there are a few sloughs or seepy spots where tiles are absolutely necessary.

There are some sandy variations in these areas, usually occurring as slight elevations. In some places the crests of the smaller "paha" ridges are a complex of sandy and silty soils with less humus than in the heavier occurrences. This area was originally treeless except for occasional bur-oak groves.

The Carrington silt loam west of Swisher and along the Linn-Johnson County boundary consists of rather deep silt over a brown or yellowish-brown heavy till. As a rule, the till forms only the lower subsoil, so that sandy or gravelly material occurs only to a limited extent in the surface soil. The level to undulating areas have a deep, black, mellow silt loam soil, while in the more rolling lands the type resembles the Tama soils.

Nearly all of this type is devoted to the production of corn, oats, clover, and timothy. The rather limited exceptions are sloughs not yet provided with tile drains and occasional sandy knolls. The heavier variations along the heads of drainage lines do not come into condition for tillage as early in the spring as the more rolling areas, but crops thereon grow very rapidly later in the season.

The yields of corn commonly range from 50 to 75 bushels per acre, with higher returns not at all uncommon.

Oats tend toward a rank growth, especially in wet seasons. The seasonal factor is as important in this as in any other type, so that a statement of the average yield is not easily made. Returns of from 40 to 80 bushels per acre are reported. Clover and timothy do well, and bluegrass finds this a most congenial soil.

The price of farms on the North Liberty area are influenced to some extent by proximity to the electric railroad. Recent prices (1919) are in the neighborhood of $300 an acre, compared with a previous average of about $150 to $200. The land near Solon is also held at similar high prices.

As previously mentioned, tile drainage is needed in many of the sloughs and on occasional sloping hillsides where the underlying till is too compact to admit of the usual underdrainage.

A five-year rotation of corn, oats, and clover should maintain the productivity of the soil for a long period, particularly if most of these products are fed to live stock and the manure applied to the land, as is the present general practice.

SHELBY LOAM.

The Shelby loam as mapped in this area includes the tops of ridges on which the silty layer is so thin that the underlying till forms a considerable part of the 3-foot soil section. The surface soil varies from a brown loam with some stones to a very dark colored silty sandy loam free from other coarse material to a depth of 18 or 20

inches. The subsoil is usually a stiff, coarse-textured loam or clayey loam, often grading with depth to a reddish-brown sandy loam. It is usually less retentive of moisture than the subsoil of the Carrington silt loam. Most of the small areas along the northern county boundary are of this character.

The ordinary farm crops are grown, but the yields are quite dependent upon the seasonal conditions. Clover usually does well, but timothy makes a good growth only on the more silty areas.

The areas in the extreme northwestern part of the county are rolling to hilly. The soil conditions are so varied that the loam prevails only on the higher and steeper slopes, while on the tops of these ridges as well as on the lower slopes there is found a dark-colored silty soil little inferior to the Carrington silt loam.

This type produces fairly good crops of corn, oats, and clover. The highest and lightest colored knolls, usually somewhat stony, are more susceptible to dry weather than the silty occurrences. Clover, if once well established, does well on these areas and offers the most practicable means of utilizing them, as well as improving the soil. All the type requires rather careful handling to prevent further loss of the scanty humus supply by erosion. Frequent changes to grass crops are necessary.

SHELBY SILT LOAM.

The small areas of Shelby silt loam, as mapped in the western part of the county, are rather steep slopes and narrow crests of ridges where the brown silty soil is of quite variable depth, but usually less than 10 or 15 inches. The subsoil is a stiff clay loam or sandy clay of reddish-brown color. In most places there is a considerable quantity of gravel and small stones in the subsoil. There is not much stony material on the surface, except on the steepest inclines or on the ends of narrow ridges that rise abruptly from the intervening drainage ways.

These variable soils are closely associated with the Clinton silt loam, and no sharp distinction can be made between them and the rougher areas of the latter. While the Clinton consists entirely of loessial material, the Shelby includes much of the underlying till. Since the till is generally less porous than loess, the Shelby soil has not such good moisture relations. The shallow areas are somewhat droughty and are also inclined to erode badly if brought into tillage.

Most of the areas mapped are used only for pasture.

WAUKESHA SANDY LOAM.

The Waukesha sandy loam varies in color from a brown to a dark brown and from a coarse to a fine sandy loam. The color over small areas is often a rather light shade of brown owing to the

meager content of humus. No very distinct line can be drawn between soil and subsoil, for in many instances the latter is quite similar to the surface soil, except that it is of lighter color.

Small strips of this type occur along the riverside on the high terraces south of Iowa City. The crest of the slope is a loose, light-colored sandy loam or sand, which merges at a few rods back into the heavier and darker colored soils. Many areas of this type are too small to show on the map. In a few places the sandy loam prevails over a considerable part of the terrace. Here the type resembles the Buckner loamy sand, but has a heavier soil and subsoil and contains more humus, making it more resistant to drought.

The areas shown are generally in cultivation, and give quite satisfactory returns of corn and small grain.

WAUKESHA LOAM.

The Waukesha loam as mapped in this county includes those well-drained second-bottom lands which have a moderately heavy surface soil with some coarse material. The soil to a depth of 20 to 30 inches is a dark-brown loam, the coarser constituents consisting largely of coarse sand of somewhat variable mineralogical composition. The occasional small pebbles are mostly quartz. The organic matter content is highest in the more silty occurrences and least in the sandy developments of the type. This humus consists chiefly of black organic residue common to the upland prairie type. Most of these lands were originally prairie or but sparsely timbered. The lower part of the 3-foot soil section is usually a brown, well-oxidized loam or sandy loam, with little or no organic matter. At a slightly greater depth it usually becomes more sandy and loose.

The largest areas lie to the north and northwest of Swan Lake. The slightly uneven surface includes low mounds of sandy soil that are somewhat droughty and wider depressions in which a stiff black silty loam prevails. Most of the type, however, is friable, easily tilled, and a dependable soil for general farm crops.

The small areas south of Iowa City and east of the river have a somewhat uneven surface of rather variable soil texture, but are well adapted to corn and clover. The areas on the west side of the river are low terraces, and include some ground liable to overflow. The soil is generally a rather light brown and produces good crops of corn, oats, and clover.

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam is a dark grayish brown to black friable silt loam. Below the plow line the material is usually somewhat heavier and darker colored than the surface soil, but otherwise quite similar to it. At a depth of 25 or 30 inches the subsoil gradually changes to a pronounced brown silt loam or silty

clay loam. The latter has that uniform brown color indicative of deep and effective aeration.

The soil and middle subsoil have a high content of organic matter, consisting chiefly of the black carbonaceous material characteristic of the types that were formerly covered with prairie vegetation.

In nearly all instances the natural drainage is good, while the average moisture content is rather high, owing to the excellent physical character of the entire 3-foot section.

This type is well developed on the higher terraces south of the Iowa River in Oxford and Madison Townships. In a few places it extends across the lower terraces quite to the river banks. These areas are not quite typical and include some low swales and an occasional low sandy mound. Elsewhere the surface is nearly level and admirably adapted to the use of farm machinery. Soil and subsoil are acid to litmus paper, but not to a marked degree.

The areas of Waukesha silt loam south of Iowa City occur at various levels above the first bottoms. The material is not in all places as silty as that of the areas just described. It often contains sandy spots on slight elevations, and the margins of terraces may be a loam or sandy loam. In general the structure of the 3-foot section is less compact than that of the silty variation of the higher and older terraces. Aeration and underdrainage are effective, while the material retains a very desirable moisture content. In some of the areas north of River Junction small patches of Bremer soils are necessarily included.

Practically all this type is in cultivation and is adapted to all the farm crops usually grown in this section. The crop adaptation and average returns are nearly the same as on the Tama and Muscatine types.

BREMER LOAM.

The Bremer loam resembles the Bremer silt loam in general character of material and natural drainage conditions, but the texture is coarser. There is enough sand in most instances to render the surface soil a loam or occasionally a rather coarse sandy loam. In some places the subsoil is decidedly sandy, but as a rule it is heavier than the surface soil though not compact. Where the former high level of the ground water has been lowered prompt drainage and rather deep aeration result.

Well-drained land has about the same crop adaptations as the silt loam. Limited areas are still too wet for tillage and are used only for pasture or the making of wild hay.

BREMER SILT LOAM.

The Bremer silt loam includes those black, silty, poorly drained soils which are of common occurrence on the second bottoms of the

Iowa River and its larger tributaries. They have a high content of organic matter in the soil and subsoil, while the substratum is usually a light-colored silty clay not easily permeable to water. Some of these lands are now comparatively dry during ordinary seasons, but the early settlers knew them as marshy prairies.

The areas on the north side of the Iowa River in Monroe Township are but slightly higher than the adjoining Cass soils, but generally above overflow. They include some low swells where the soil conditions are much like the Waukesha silt loam, but in most places the surface is a heavy humus-laden silt loam with a light-colored or mottled heavy subsoil. The areas farther east are low terraces and include some ground reached by backwater during high floods. All are tillable and produce heavy crops of corn, clover, and timothy.

On the south side of this section of the Iowa River Valley the Bremer soil occurs as flat tracts lying a trifle lower than the adjoining Waukesha and Buckner soils. The surface is usually a black, friable silt or silty sandy loam, in which there is much organic matter to a depth of 20 or 30 inches. In places the surface is mucky, and small ponds in which shallow muck occurs are quite common. The subsoil is heavy and in part responsible for the slow drainage. Much of this land is used only for pasture or the production of wild hay. Some parts have been drained and prove well adapted to corn, clover, and timothy.

The area in section 12, in the northeastern part of Oxford Township, is a drainage basin whose outlet has been much obliterated by wind-blown sand on the north. The soil is quite variable, but most of it is a black silt loam, very productive where local drainage conditions admit of tillage. Elsewhere bluegrass, redtop, and some native grasses afford good pasturage.

The Bremer silt loam of the lower Old Man Creek Valley consists chiefly of low, somewhat uneven terraces, not sharply separated from the alluvium in all instances. Much artificial drainage has been installed, and these lands are becoming very productive and are far less influenced by adverse seasons than formerly. Corn may mature later than on adjoining types, but usually escapes frost. The areas on the east side of the valley near Morfordsville are lower terraces and include some ponds and marshes.

All this type has a very high degree of fertility. Its availability is, of course, dependent upon artificial drainage. With a few exceptions, adequate outlets for tile drains are not difficult or expensive to secure. The soil structure admits of a relatively easy water movement toward any drain or outlet. It is possible that in some instances small spots of this type could be drained by sinking a well to the underlying sand.

Owing to the silty texture and abundance of organic matter, these lands can be cultivated under a wider range of moisture conditions than the Bremer silty clay loam. The soil is less inclined to pack or become cloddy, and where underdrainage is good the surface dries quite rapidly after heavy rains.

This is a strong productive soil capable of retaining its fertility under long cropping to corn and other grains.

BREMER SILTY CLAY LOAM.

The Bremer silty clay loam is a black, heavy silt loam to silty clay loam, which at a depth of a few inches grades into a stiff silty clay, or in many instances to a waxy clay not very easily penetrated with a soil auger. There is usually not much change in color or texture to a depth of 25 or 30 inches, but below this level a dark bluish gray, tenacious silty clay occurs, which at 40 inches may be quite light colored and contain yellow iron stains.

The exceptionally dark color is due to the high content of black organic material derived from the former luxuriant prairie vegetation. This organic matter increases the tendency of the silty clay to assume a distinctly granular structure on drying. This is usually apparent in recently plowed ground, which has a harsh, crumbly surface compared with the soft, friable silt loams.

This type is characteristically developed in the wide, flat basins and drainage lines south and southwest of Lone Tree. The opening of many natural lines of drainage and the construction of roads provided fairly good surface drainage many years ago, but the more recent installation of tile drains was needed to render these fertile lands safely tillable. Practically all the larger areas are cultivated. Numerous small depressions are either marshy ponds or pasture ground on which bluegrass has largely supplemented the native vegetation. The type includes some black friable silty soils with black waxy subsoils. There are also included with the larger areas small spots of the Scott silt loam.

Small areas of this soil occur a few miles southeast of Iowa City and thence southward to near Lone Tree. These are mostly flats and slight depressions having very poor natural surface drainage. Limited developments occur along the small drainage lines, and in such instances are not very distinct from Wabash silty clay loam. Undrained areas include shallow ponds, filled with cat-tails and other rushes.

The soil is easily made cloddy, if plowed or cultivated when wet. Much of it is hard to plow when dry, but at a moderately high moisture content works easily. The so-called "gumbo spots" are places where the stiff waxy clay occurs close to the surface. Fall

plowing usually results in a very crumbly surface the following spring.

The type where well drained is admirably adapted to corn. Large yields are usually secured, although there are places where inadequate drainage or overflows from ditches occasion more or less injury.

Oats make a heavy growth, but the large, late varieties often lodge badly. Barley and wheat are not grown to any extent, but the type is adapted to these crops.

This is a strong soil, capable of continuous cropping for many years without appreciable decrease of yields.

BUCKNER LOAMY SAND.

The surface soil of the Buckner loamy sand is a dark-brown, medium to fine sand, containing enough silt and clay to give it a loamy appearance and render it slightly coherent. Usually there is not much change in the material to a depth of 20 or 30 inches, except that the slight content of humus does not affect the color below the immediate surface layer. The lower subsoil is generally a yellowish-brown loose sand, and in most instances this forms the substratum to a depth of several feet. Heavier material may underlie this sand at rather slight depths, particularly where the surface is nearly level. The humus content is low, except in occasional depressions where poor drainage prevails. Soil and subsoil are distinctly acid, according to litmus-paper tests.

Many small areas of Buckner loamy sand are found in northern Oxford and Madison Townships. They are low mounds, ill-defined ridges, and larger tracts where the undulating surface lies from 2 to 10 feet above the adjoining types. In many places no sharp line of separation exists, while elsewhere a low rim of brown sand may mark the limits of the Buckner soil. Where the roads follow these limits, or cross the higher points, the loose yielding sand is not at all suggestive of the crop-producing properties this light type possesses.

The average yield of corn is about 30 bushels per acre. On the more sandy points it is less than one-half this amount, but these droughty spots form perhaps less than 10 per cent of the total area. There was a very light rainfall during most of August, 1919, but the crop generally exceeded 25 bushels per acre, except on the lightest knolls.

Rye is a favorite crop and usually yields from 15 to 20 bushels per acre. Oats and wheat are seldom grown on the larger areas, but on included spots of rather low ground fair returns are often obtained.

While most of this type is devoted to cultivated crops, some is pastured. Bluegrass forms a rather thin sod and affords little grazing

after the weather gets hot. Clover is generaly limited to heavier variations where humus may have accumulated. The roadside growth includes horsemint, goldenrod, wild sunflowers, and drought-resistant native grasses. Sand burs are abundant almost everywhere.

The areas of Buckner loamy sand south of Iowa City are generally darker colored and somewhat heavier in texture than those just described. In slight depressions, and where the type merges into the adjoining Waukesha or Bremer soils, it is a sandy loam. The sandy spots are of very limited extent.

The yields of corn on these lands often exceeds 30 or 35 bushels per acre, particularly if the land has been well manured. Rye does well, and other small grains are often grown and fair returns obtained. Watermelons, Irish potatoes, and most garden crops find this a congenial type.

As a very general estimate the present price and the rental value of this type may be placed at about two-thirds that of the adjoining heavier soils.

The available moisture content of this sandy soil is higher than would be suspected on casual inspection. The loose structure admits of very easy tillage, as well as deep root penetration. Since in such light soils the greater part of the moisture is readily yielded to the plants, their favorable growth in ordinary seasons is explainable. This soil is also deeply and thoroughly aerated and well drained, thus rendering such plant food as it contains quickly available. In some instances where heavy applications of manure were made, and fairly abundant rainfall was received, excellent yields of corn have been secured.

The above observations suggest tillage methods that will compact the soil rather than loosen it. Shallow plowing and surface cultivation tend toward this result. The addition of all possible quantities of organic matter is also recommended. Clover is easily grown if summer rains are numerous. It is probable that applications of lime would prove more profitable if the clover or other crop residues were plowed under preparatory to the use of the land for corn. Sorghum, Sudan grass, and feterita would do well on most of this type. Suitable locations for melons, sweet potatoes, and early truck are easily found.

Small areas of a coarse sandy development of this type are found on the terraces of the Cedar River, south of Sutliff. The soil consists chiefly of medium and coarse angular sand grains, with which there is enough fine material to give it a loamy character. There is usually not much difference between the surface and subsoil material, except that the latter has a pronounced brown color while the former is a rather dark brownish gray to light gray, depending upon the amount

of organic matter present. There is generally some waterworn gravel, but no stones.

Most of this type maintains a fairly good moisture content in the lower part of the 3-foot section, but the surface dries rapidly after rains and in most instances has a droughty, infertile appearance.

The areas of this soil are largely devoted to melons, sweet potatoes, and some other truck. The soil is well adapted to these products, which are marketed at Cedar Rapids, Iowa City, and other towns.

Limited areas are found on the Iowa River. They are coarse sandy soils of inferior agricultural value.

BUCKNER FINE SANDY LOAM.

The Buckner fine sandy loam comprises dark-brown, well-drained terrace soils. They have a range in texture from very sandy loams to loams, but the average and most extensive texture is a fine sandy loam. The subsoils below 12 inches are somewhat lighter in color, usually changing gradually from a dark brown downward into a brown. In texture they do not differ greatly from the surface soils.

The type occurs in several small areas in the southeastern corner of the county, near and bordering the Louisa County line.

The Buckner fine sandy loam occupies a position on the Iowa River terrace above the present limit of overflow. It covers low ridges and divides slightly higher than the heavier types. The soil is well drained but not droughty.

On account of its small area this type has no special agricultural interest. While not so productive as the silt loams, it is used for the general farm crops of the area. It is well adapted to the growing of truck crops, but this industry has not been developed.

BUCKNER SILT LOAM.

The Buckner silt loam is not so well developed in Johnson County as in the counties to the east. In this area the type passes into the Waukesha and Jackson silt loam. In the small areas near the Cedar River the soil has less organic matter than commonly found in the Waukesha silt loam, while the subsoil seldom has the compaction occurring in the typical Jackson silt loam. The small areas are well drained, easily tillable, and yield good crops.

The areas in the extreme southern part of the county are generally dark silt loam with rather open yellowish-brown subsoils similar to the subsoils of the Tama silt loam. In places tile drainage is needed, but otherwise the type is well adapted to general farming.

CHARITON SILT LOAM.

In its typical development in this county the Chariton silt loam consists of about 8 inches of moderately dark gray silt loam, which

WABASH SILT LOAM.

The Wabash silt loam in the river valleys is generally a black silt loam to silty clay loam, extending without much change in character of material to a depth of 20 to 30 inches. The lower subsoil is quite variable, but usually is a silty clay somewhat lighter colored than the surface soil. There is much organic matter in the soil and upper subsoil, rendering them friable to crumbly and greatly enhancing their fertility.

The areas near the channels are generally low, subject to frequent overflow, and not cultivated, except in a few instances. Those farther back from the streams lie somewhat higher and are safely tillable. The soil is lighter colored than that just described, but hardly less fertile. Very heavy yields of corn are often secured. Although most of these areas are liable to overflow, water does not remain long except in the lower depressions.

Most of the alluvium on Clear Creek above Tiffin is a dark-gray to nearly black silt loam from 12 to 24 inches in depth. The subsoil is usually a pale-yellow or mottled yellow and gray, plastic silty clay loam, with some iron stains in the extreme lower part. Except in occasional depressions where the soil may be a stiff silty clay loam, the surface is crumbly to very friable, while the subsoil is porous and easily permeable to air and water. Sandy spots are of very rare occurrence, and there are not many sloughs or ponds.

Most of this land is subject to overflow, but the floods are of short duration. They are liable to occur, however, at any season. The local drainage is good, for the rather deep channel affords a good means of escape for surface water.

Much of this part of the valley is regularly cultivated, and good crops of corn, oats, clover, and timothy are grown. A fringe of timber skirts the channel, and this forested land and some low places farther back are usually well set to blue grass.

The Wabash silt loam on Old Man Creek, above its junction with North Branch, is generally confined to the immediate vicinity of the channel. It is a black, friable, humus-laden silt loam 2 or 3 feet in depth, but so frequently overflowed that most of it is used only for pasture. The structure to a depth of several feet seems sufficiently open to give good local drainage. A little farther back from the stream the material is generally heavier and merges into the silty clay loam.

Below the confluence with North Branch the alluvium indicated as Wabash silt loam is a heavy black silt loam to silty clay loam. It all possesses good physical properties, yielding rather easily to tillage, and maintaining a uniform moisture content wherever the creek is at normal stages. Most of it is now used for pasture. In all this type there has been much addition of silty material since the uplands were brought under the plow.

The innumerable narrow strips of Wabash silt loam on the small drainage lines in the Clinton silt loam are usually a very dark brown to black, friable silty soil, consisting in large part of recent wash from the surrounding uplands. They are a mixture of alluvial and colluvial types.

As a rule the lower subsoil is a dark-colored silty clay loam a little more compact than the surface soil, but rarely impervious or like "gumbo." In the wider areas some black heavy soil may be found in which tile drains are necessary, but most of these areas are regularly cultivated. In nearly all instances, however, tile drains would render the ground tillable much earlier in the spring than is now the case.

The type on the small branches is very generally used for pasture; that in the sloughs or heads of drainage lines is commonly tilled in the same manner as the higher ground on each side, but the yields of corn exceed those of the uplands. Clover usually does well, and this is true of oats and other grains.

The Wabash silt loam in the areas of Tama and Muscatine soils is generally richer in humus than the alluvium from the Clinton silt loams. They also include many spots of silty clay loam with a stiff, black, waxy subsoil. Many of them are rather broad "sloughs," with a good gradient toward their confluence with the main drainage line, but flat with respect to higher ground on each side. Most of these places require tile drains to render them conveniently tillable. All are very productive and will long endure continued cropping to corn.

On much of this type in the Clinton silt loam areas some method of intercepting the fine earth washed from the adjoining uplands is highly desirable. A large proportion of this wash consists of dark-colored, humus-laden surface material of highest value in soil composition. Most of it now goes into the ditches, and thence to the creeks and rivers. Less of it is caught in depressions of the valleys than formerly, because the floods are discharged so rapidly by the numerous artificial ditches. In many instances earth dams of rather simple construction would intercept much of this sediment. On some farms more expensive construction involving concrete dams and tile drains would be justified.[5]

Wabash silt loam, colluvial phase.—The colluvial phase of the Wabash silt loam occurs on small areas of gently sloping ground at the foot of the uplands. The phase owes its origin to the creep and wash of silty material from the higher slopes, which forms narrow strips or occasional fan-shaped areas that seldom exceed 20 acres.

The soil is a dark-brown to black, rather loose silty loam to a depth of 20 or 30 inches, underlain by yellowish-brown silty loam, more friable and less compact than the corresponding zone on the up-

[5] See Soil Erosion, in Bul. No. 183, Iowa Agr. Expt. Sta.

land soils. The high content of humus and the porous structure insure excellent moisture conditions, while the elevation gives good surface drainage. These areas are very productive, and large yields of corn, clover, and timothy are commonly secured.

There are many small areas along the north side of Old Man Creek in the vicinity of Windham, and a few larger ones bordering on Clear Creek near Tiffin. Innumerable patches occur on many of the other streams, but they have been included with the alluvial soils.

WABASH SILTY CLAY LOAM.

The Wabash silty clay loam includes the black, heavy alluvial soils 3 feet or more in depth. There is considerable variation in drainage conditions, also in the character of the lower subsoil, but the materials usually consist of silt and clay particles deposited by comparatively quiet waters. Subsequent conditions have favored the accumulation of much organic matter, with a minimum loss through drainage, leaching, or other agencies that tend to reduce the more soluble constituents.

The type as developed on the upper course of Old Man Creek is a black crumbly to friable silty clay loam. Below the plow line it is usually somewhat heavier, and in places may be a stiff silty clay. As a rule the black color and crumbly or granular structure prevail to a depth of 20 to 30 inches, then the material gradually changes to a dark bluish gray clay, less permeable to air and water.

The surface is level or nearly so. There are some depressions along the foot of the northern hillsides in which the black waxy subsoil is frequently found. This would more commonly appear at the surface had there not been much recent deposition of silty material from the uplands. All these former low spots still require artificial drainage to make them safely available for corn.

All this type on Old Man Creek is very fertile, and if the menace of summer overflows were removed, and some tile drainage installed, would be highly valuable for general farming. A part of it is regularly cultivated, and 70 to 80 bushels of corn per acre are frequently obtained.

The areas on the north side of the Iowa River in Monroe Township are wide, gently inclined tracts, lying above the reach of ordinary floods. Occasional slight elevations resemble the Waukesha silt loam, but most of the soil is a black silt to silty clay loam with rather heavy granular subsoil. The drainage is generally good, and heavy crops of corn, clover, and timothy are obtained. In this area no very definite line can be drawn between the Wabash and Cass soils, but the latter are subject to annual floods, while the former are not.

The type as developed on the streams draining the Tama and Muscatine silt loams is a black silt to silty clay loam, with heavy subsoil.

The latter often shows more or less mottling, due to imperfect drainage. "Gumbo spots" occur, but are not extensive. The soil material throughout is generally so granular that it responds well to tile drainage. The physical properties are highly favorable to heavy and continuous crop yields, especially of corn and tame grasses.

Wherever the surface soil is exceptionally heavy, it would be rendered somewhat lighter by deposition of the silty wash from the uplands. Such local measures as temporary obstructions in ditches and deflection of the washings from the hillsides into these depressions are recommended.

CASS SILT LOAM.

The Cass silt loam as mapped in this county includes all the low, dark-colored alluvial soils along the Iowa and Cedar Rivers in which loose sandy material forms the lower subsoil. The surface soils are quite variable, ranging from a heavy silty loam to a sandy loam. The latter occurs most frequently near the present channels, and on the low ridges and other slight elevations of the somewhat uneven flood plain. Farther back from the streams the soils are predominantly heavy. In most places a very dark brown to black, moderately heavy silt loam prevails to a depth of 8 or 10 inches, then changes to brown or grayish-brown sandy material. This usually becomes lighter textured with depth, in many instances a loose brown sandy loam or sand. In the "cut-offs" through which water flows during the high stage of the rivers, deposits of variable character are found. These areas are necessarily included with the type.

In all the Cass soils there is usually a high content of organic matter to such a depth as the heavy material extends. Below this the dull brownish colors, with but little mottling, indicate considerable oxidation. This would result from the deep aeration and prompt underdrainage induced by the sandy substratum. The drainage conditions of the low-lying areas are not so good. The level of the water table is, of course, governed by the stage of the river. Normally it is considerably below the reach of a 40-inch soil auger.

According to the litmus test the soil is acid, although less strongly acid than the upland soils of similar texture.

All this type is subject to overflow. These floods may occur at any season, but usually the highest and longest continued inundations occur in May or June. A very large proportion of these lands is under water for only a few days at a time.

The Cass silt loam in the Iowa River Valley of the northwestern part of the county is in most places rather thinly wooded. Elm, ash, soft maple, and several kinds of oak are the predominant varieties. Hickory, walnut, sycamore, and cottonwood are common but not abundant. There is little undergrowth, and much of this area

affords very good pasturage. The bluegrass on the elevations is affected by dry weather, but elsewhere compares favorably with that on the upland soils.

The Cass silt loam south of Iowa City is similar to that just described, but may be a little more heavily forested. In the old channels and other depressions there are deep accumulations of black humus-laden mud of comparatively recent deposition. These areas approach the Wabash silty clay loam in character, and some of them would have been mapped with that type if they had been of sufficient size to justify the separation.

Some of the type is quite regularly cultivated to corn, the results depending largely upon the behavior of the river. If no floods occur later than the middle of June a crop is generally assured. The warm, highly fertile soil induces a rapid growth. Liability to injury by frost menaces late plantings, while no fall-sown crops are practicable.

SARPY SAND.

The Sarpy sand consists of 10 to 15 inches of light-brown or brownish-gray, medium and fine sand. The lighter colored areas are somewhat loamy, while the darker ones contain much silty material and considerable organic matter. The subsoil is usually a light-brown sand not essentially different from the surface soil. Typically the substratum is sand or very sandy material, but there is much variation in this respect.

Limited areas are found along the Iowa River between Coufalls and Iowa City. Here the narrow flood plain precludes such widespread inundations as occur above and below this section of the river. Very frequently the waters rise rapidly and strong currents prevail outside the main channel. The type represents the coarsest sediments dropped as the waters break over the banks, while the heavier and darker colored phases include the variable combinations of finer materials deposited farthest from the channel. There are few places where backwater stands, so that clayey sediments are extremely limited. Where the adjacent upland slopes are in cultivation, there is some addition of silt from this source. These variable soils do not admit of accurate mapping, and in all the Sarpy areas heavier and darker colored phases are necessarily included.

All but the very lightest areas of this sand contain much plant food, while the heavier developments are very fertile. All are easily tilled and warm up rapidly in the spring or after each overflow. Much of it is regularly cultivated. Corn is the chief crop, and under favorable conditions excellent yields are obtained. Some sorghum is grown, and the quality is good. Fall-sown crops are not practi-

cable. Clover and bluegrass do well on the heavier soils, but there is a possibility of injury or complete loss from late overflows.

MUCK.

The small areas of Muck in Madison and Oxford Townships are sites of shallow lakes, and in rainy seasons they become marshes with small pools of open water. Ordinarily much of the surface is dry enough to admit of cattle grazing on the coarse grasses and semi-aquatic vegetation. In several of the larger areas a rim, or bank, 10 to 15 feet high occurs on one side, while the other merges very gradually into the adjoining soil types. The Muck near the high bank may be several feet deep and quite peaty, but toward the opposite side it becomes more shallow and is a true Muck, black spongy vegetable remains, overlying a black clayey mud. These shallower areas are in a process of reclamation by a general lowering of the average height of the water level, and by trampling of cattle, which mixes more or less of the clayey subsoil with the Muck.

Small spots have been tile drained with good results. Grazing is the common and most practicable method of utilizing this land. One or two open ditches usually provide sufficient surface drainage so that, if heavily pastured, bluegrass and white clover may become established. Further oxidation of the organic material and an increase of the earthy constituents will in time convert this into a nearly normal soil adapted to cultivated crops.

Swan Lake is little more than a continually saturated bed of Muck and Peat.

Some small areas of shallow Muck are associated with the Bremer soils southeast of Iowa City. The largest one, in sec. 25, T. 79 N., R. 6 W., has been artificially drained, but is still liable to overflow from a small creek. The soil in most places is a deep Muck containing much earthy material. In the lower part there are occasional streaks of bog iron.

According to the litmus-paper test the type is not very acid, but no alkali spots or excessive quantities of carbonate of lime occur. The underdrainage is often poor, owing to a tight substratum. If provided with effective drainage and protection from overflows, these Muck soils should give heavy yields of clover and timothy. Corn will be somewhat more dependent upon a season free from excessive rains or early frosts. While no indication of special need of manure or potash salts is apparent, it is possible that light applications would be beneficial to corn.[6]

On well-drained Muck in other counties of the State barley does well, and wheat sometimes gives satisfactory yields. The quality

[6] For treatment of Muck soils, see Bul. No. 157, Iowa Agr. Expt. Sta.

of the product is not as good as that grown on upland soils. If the moisture content can be controlled, Muck is well adapted to cabbage, celery, onions, and some other truck crops.

MEADOW.

Meadow, as mapped in this area, is composed of recent alluvium and consists of a heterogeneous mixture of sands, silts, and clays so intermixed that no one texture is continuous over an area of sufficient size to map separately. It differs from Riverwash in the general darker color of the material, and is a more advanced stage in soil formation. In it are included small areas of Cass and Wabash soils and Riverwash. Nearly all the type is marshy. It supports a luxuriant growth of water grasses and weeds, and clumps of willows grow along the stream banks. The type has no agricultural value except that it furnishes pasturage for a few cattle and hogs.

RIVERWASH.

Riverwash represents the areas bordering the river in which the surface material consists chiefly of sand. In many instances the sand is of comparatively recent deposition and overlies a black silty soil at depths ranging from a few inches to several feet. The wider areas usually include cut-offs and some mud deposits, the latter being overgrown with willow, birch, and cottonwood.

All these places are subject to each overflow, and liable to very great modification during exceptional floods. They have some value for pasture.

SUMMARY.

Johnson County is situated in southeastern Iowa. Iowa City is the commercial center and has a population of 11,267. The area of the county is 610 square miles, or 390,400 acres.

The uplands throughout most of the county are strongly rolling. The relief of the three southeastern townships ranges from undulating to gently rolling, and there are a few areas in the northeastern and north-central parts that have very mild relief.

The Iowa River Valley embraces almost 30 square miles in the northeastern part. Along its course in the central part of the county there is very little alluvial land, but below Iowa City there are about 30 square miles of flood plain and terrace. The Cedar River cuts off about 5 square miles of the northeastern corner of the county. Its valley is about 1 mile wide.

The leading crops are corn, oats, clover, and timothy. Hog raising is the most important animal industry and the largest single source of income on most farms. A considerable number of cattle are fattened. There are many fine herds of the leading beef breeds and a small number of dairy herds.

There are 2,625 farms. Those in the areas of black soils average about 160 acres each, while in the more rolling sections or lighter-colored soils the average size is below 140 acres. Good improvements are everywhere the rule, and labor-saving machinery is in general use. Twenty-nine and three-tenths per cent of the farms are operated by tenants.

Prior to the World War the best lands commanded about $200 an acre and the less desirable $100 to $150. The present (1919) prices are about 50 per cent higher.

The prevailing soil types are silt loams of loessial origin. The strongly rolling to hilly lands formerly had more or less timber and the soils are not high in organic matter. The less rolling lands are generally prairies and the soils are well supplied with humus. All except some sandy types of limited extent are comparatively rich in the mineral elements. Practically all types are acid, but calcareous material usually occurs at a depth of a few feet and occasionally within the 3-foot section.

Twenty-seven soil types are mapped. A considerable number are of limited extent or not important agriculturally.

The Clinton silt loam is the most extensive. The rougher areas are used chiefly for pasture, but all the smoother lands are in cultivation. Corn averages about 40 bushels per acre and oats yield 40 to 50 bushels. The type is well adapted to clover, bluegrass, and tree fruits.

The Tama silt loam resembles the Clinton, except in higher content of organic matter. It is well adapted to corn and small grains.

The Muscatine silt loam is nearly level, and the deep black soil is admirably adapted to corn.

The Knox sand is a wind-laid soil. It occurs on hills and ridges and has little value except for pasture.

The Carrington silt loam is gently rolling to undulating, and glacial material forms the subsoil. It is a highly desirable type for good farming. Limited areas of a loam or sandy loam are associated with the Carrington silt loam, but have rougher topography. The fine sandy loam is similar to the silt loam in agricultural value.

The principal second-bottom type is the Waukesha silt loam, which is a well-drained, easily tilled soil of high productivity. The loam and sandy loam are good farming types, but of limited extent.

The Bremer soils have poor natural drainage, but much of the loam and silt loam have been artificially drained and are now highly desirable for corn.

The Buckner loamy sand produces fair crops of rye, and from 20 to 25 bushels of corn per acre are often secured. The coarse variation of this type is a desirable soil for melons and early truck but poorly adapted to grain.

The Wabash silt loam of the river valleys is generally unsafe for tillage, but the narrow strips on the uplands are very productive. The silty clay loam of the Old Man Creek Valley is a heavy but exceedingly fertile type.

The Cass soils include most of the overflow lands of the river bottoms. They are sparsely timbered lands of considerable value for grazing but not safe for cultivated crops.