U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF WAPELLO COUNTY, IOWA.

BY

E. C. HALL, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND E. I. ANGELL, OF THE IOWA AGRICULTURAL EXPERIMENT STATION.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

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

WASHINGTON:
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1919.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., January 29, 1919.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of Wapello County, Iowa, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1917, as authorized by law. This work was done in cooperation with the Iowa Agricultural Experiment Station.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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MAP.

Soil map, Wapello County sheet, Iowa.

SOIL SURVEY OF WAPELLO COUNTY IOWA.

By E. C. HALL, of the U. S. Department of Agriculture, In Charge, and E. I. ANGELL, of the Iowa Agricultural Experiment Station.—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Wapello County is situated in the southeastern part of Iowa, in the second tier of counties north of the Missouri State line and in the fourth tier west of the Mississippi River. It lies about 95 miles southeast of Des Moines. The area is rectangular in shape and comprises 12 land townships, each containing 36 square miles. The total area surveyed is 428 square miles, or 273,920 acres.

The surface of Wapello County as a whole is that of a drift plain which originally was nearly level, but which is now eroded and dissected by streams. The broad valley of the Des Moines River, extending from the northwestern corner of the county to the southeastern corner, is the deepest valley in the county and has wider bordering belts of dissected hill country than any of the other valleys. The topography varies quite noticeably in different parts of the county. The degree and depth of dissection determine the relief of the country. This varies with the size of the master stream of each locality and the distance from it, so that the topography consists of rough belts along the streams and smooth belts along the upland divides. While the greater part of the original plain has been materially changed in topography, the northeastern part of the county has been eroded less than the southwestern part, and it is comparatively smoother and has shallower stream valleys. In this more gently rolling country the interstream divides are broad, representing remnants of the original plain surface. The slopes are long, gentle, and well rounded, becoming steeper near the streams. This sort of topography characterizes the greater part of Competine, Pleasant, and Highland Townships and parts of Agency, Dahlonega, Washington, Richland, Adams, and Columbia Townships. The rougher, more eroded, and thoroughly dissected portion of the county lies adjacent to the Des Moines River and to the southwest of that stream, where only narrow ridges remain to represent the original upland level. The divides are high and narrow and generally parallel the stream valleys.

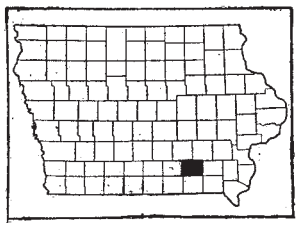

FIG. 1.—Sketch map showing location of the Wapello County area, Iowa.

The alluvial lands bordering the streams consist of terraces, which are generally above the reach of overflows, and the first-bottom lands, or the present flood plains of the streams. The most extensive alluvial areas are developed along the Des Moines River, being represented by high and low terraces and first-bottom lands, the terraces forming the greater proportion of the area. The entire alluvial area of the Des Moines River, including terraces and first-bottom lands, varies in width from three-fourths of a mile to 2 miles, the average width being about 1 mile. The flood plain is wider between Ottumwa and Eldon than between Eddyville and Ottumwa. This difference is probably due to a difference in the rock in which the valley has been carved.[1] Below Eddyville as far as Ottumwa the river has cut its channel through the soft Coal Measures shales into the harder and more resistant St. Louis limestone. Below Ottumwa the limestone lies beneath the bed of the river and the stream in forming its valley has had to erode only the easily washed shales and soft sandstones.

The highest part of the county is at Blakesburg, where the upland plain has an elevation of 912 feet above sea level. The elevation at Agency is 807 feet and at Highland Center 780 feet. The elevations of several towns situated in stream valley areas follows: Eddyville, 676; Chillicothe, 660; Ottumwa, 650; Bidwell, 720, and Dudley, 674 feet. The towns of Eddyville and Ottumwa are situated on the Des Moines River and their elevations show a fall in that stream of 26 feet in a distance of about 14 miles. The lowest point in the area is at Eldon, in the Des Moines Valley near the southeastern corner of the county. The prevailing slope of the county, as shown by the drainage, is from northwest to southeast, with the exception of the southwestern part, where the slope is almost due eastward.

The Des Moines River and its tributaries drain about two-thirds of the county, and Competine, Cedar, and Little Cedar Creeks the other third. The Des Moines River traverses the county southeastwardly, following a course of about 37 miles, in which distance the fall amounts to about 48 feet, or about 1.3 feet per mile. The course of the river from Eddyville to Ottumwa is much straighter than from Ottumwa to Eldon. Below Ottumwa the channel meanders back and forth across the flood plain, and the numerous changes in its course are attested by the presence of old channels, cut-offs, and "ox-bow" lakes. The Des Moines River has many tributaries, the largest of which are Soap, Little Soap, Village, and Bear Creeks. Practically all these streams are bordered by comparatively narrow alluvial flood plains and wide belts of eroded upland. Competine, Cedar, and Little Cedar Creeks, which drain the northeastern part of the county, have comparatively shallow valleys and narrow

[1] Geology of Wapello County, by A. G. Leonard. Iowa Geol. Survey.

flood plains. Cedar Creek, the largest stream of the three, has a flood plain which averages about one-half mile in width.

The drainage system of Wapello County is very intricate. Streams ramify over the whole area until practically every farm is connected with a drainage outlet. Only a few areas lack good surface drainage. All the streams, with the exception of those in the northeastern part of the county and a few of the smaller ones, have cut deep valleys. The Des Moines River and its larger tributaries flow in valleys that are probably 150 to 200 feet in depth, while the valleys of Competine and Cedar Creeks are about 40 to 60 feet below the surface of the upland plain. The drainage system of this region is approaching maturity, but the streams have not yet reached base level. The Des Moines River has sufficient fall to furnish water power for local uses.

The chief source of water supply for domestic use is from wells. The streams furnish an abundant supply for stock except during very dry and hot seasons.

The history of Wapello County began with the establishment of an Indian agency in 1838 at the site of the present town of Agency. The Des Moines Valley and the adjacent hills were occupied by the Sac and Fox Indians, but in 1843, under the terms of a treaty, the Indians gave up the territory and it was occupied by white men. Before this time there were very few white settlers, but as the Indians left immigration proceeded steadily. In 1844 the county was organized. The early settlers were largely from Pennsylvania, New York, Ohio, Indiana, Illinois, and Kentucky. While the greater part of the population is American born, there are many other nationalities represented, principally German, Swedish, Danish, Italian, Greek, and Mexican. In 1910 the urban population, which includes that of all towns of 2,500 inhabitants or more, exceeded the rural by 6,281. The total population in that year was 47,743, of which number 41.68 per cent was classed as rural. The farming population is rather uniformly distributed over all parts of the county, with the exception of Polk, Green, and Keokuk Townships, which are less thickly settled.

Ottumwa, the largest town and the county seat, had a population of 22,012 in 1910. It is situated almost in the center of the county and is a very important trading and manufacturing center. Eldon, with a population of 2,030, is situated in the southeastern part of the county. It is the second largest town, but its interests are largely agricultural. Eddyville, in the extreme northwestern corner of the county, is next in size, with 1,046 inhabitants. Towns of less than 1,000 population include Kirkville, Chillicothe, Highland Center, Blakesburg, Bidwell, Farson, Laddsdale, Ormanville, Munterville, Dahlonega, Dudley, and Bladensburg.

The interests of Wapello County are primarily agricultural and manufacturing. At Ottumwa there are located many important manufacturing industries, the largest of which are a packing plant, which occupies about 40 acres, and a farm-implement factory. Other industries include the manufacture of wood and clay products, wagons, iron products, and tools. Coal mining and the quarrying of building stone also are important.

The county is well provided with transportation facilities. Four railroads radiate from Ottumwa in various directions, bringing the county in direct touch with Chicago and the east, St. Paul and Minneapolis to the north, St. Louis and Kansas City to the southwest, and Omaha and Denver to the west. The county is traversed by the Chicago, Burlington & Quincy Railway. A branch line of the Wabash Railway extends from Ottumwa southward, connecting with the main line at Moberly, Mo. The main line of the Chicago, Rock Island & Pacific Railway passes through Eldon, from which place a branch extends to Des Moines, passing through Ottumwa and Eddyville. The Chicago, Milwaukee & St. Paul Railway traverses the county from northeast to southwest, passing through Farson, Ottumwa, Bear Creek, Bidwell, and Blakesburg. A branch extends northeast through Highland Center.

The wagon roads of the county are as a rule in good condition. Where the topography allows the public roads follow land lines. They are all dirt roads, but are kept in fair condition by the use of drags. Progress in the improvement of the most traveled highways is being made. Rural telephone service and mail routes reach every part of the county. Country schools and churches are numerous.

Ottumwa is the principal local market for farm products. Smaller trading points are Eddyville, Eldon, Farson, Blakesburg, Chillicothe, and Kirkville. Outside the county the principal markets to which products are shipped are Chicago, Des Moines, Omaha, Kansas City, and Minneapolis.

CLIMATE.

The climate of Wapello County in general is favorable for the production of all the staple crops common to this region, and total crop failures are almost unknown.

The average annual rainfall as recorded at Oskaloosa in Mahaska County, where the climatic conditions are practically identical with those prevailing in Wapello County, is 29.07 inches. The heaviest rainfall occurs within the six months from April to September, inclusive, and the precipitation is well distributed throughout the growing season. Heavy downpours of a damaging nature are not frequent, and destructive hailstorms are rare. Excessively dry weather, often of several weeks' duration, occurs in occasional years,

and may produce severe loss of crops. The lowest annual precipitation recorded was 16.54 inches, in 1890, and the greatest annual rainfall 44.88 inches, in 1902.

The winters are usually cold. The mean annual temperature for the winter months is 23.2° F. and a minimum of 31° below zero has been reached in February. Many farmers have planted groves of various kinds of trees and evergreens for protection from the cold winds that often sweep the prairies during the winter months. Along the stream courses the country is naturally protected by the timber growth. The mean summer temperature is 72.5° F. During the summer months short periods of excessive heat often occur, and a maximum temperature of 109° F. has been recorded.

The latest date of killing frost in the spring recorded at Oskaloosa is May 17 and the earliest date in the fall is September 18. The average date of the last killing frost in the spring is given as April 23 and that of the first in the fall as October 9. This gives a normal growing season of 169 days. The grazing season averages over 200 days in length.

The data given in the table are compiled from the records of the Weather Bureau station at Oskaloosa:

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

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1890).	Total amount for the wettest year (1902).	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	26.1	59	−17	1.15	.75	1.53	5.3
January	20.0	63	−31	.96	1.41	.28	6.0
February	23.4	66	−31	1.13	.85	.88	6.3
Winter	23.2	66	−31	3.24	3.01	2.69	17.6
March	35.7	87	−14	1.80	.89	.97	3.8
April	50.6	89	12	2.76	.60	3.31	1.1
May	61.6	95	24	3.82	1.85	3.72	T
Spring	49.3	95	−14	8.38	3.34	8.00	4.9
June	70.2	102	38	3.87	1.57	7.24	0.0
July	74.6	109	47	3.61	.37	8.79	0.0
August	72.8	104	37	3.19	2.78	7.57	0.0
Summer	72.5	109	37	10.67	4.72	23.60	0.0
September	64.7	99	23	3.05	2.61	5.12	0.0
October	52.5	88	15	2.18	1.59	3.60	T
November	36.8	78	−10	1.55	1.27	1.87	1.3
Fall	51.3	99	−10	6.78	5.47	10.59	1.3
Year	49.1	109	−31	29.07	16.54	44.88	23.8

AGRICULTURE.

The agricultural development of Wapello County began with the organization of the county, about 1844. The few white settlers in this territory prior to that date were mostly traders and trappers who bartered with the Indians. Settlement increased rapidly with the retirement westward of the Indians. The settlers coming largely from eastern States, moved up the Des Moines Valley and located in desirable places along this stream where the forests furnished wood for fuel and timber for building purposes, and afforded protection during the cold winters. Gradually settlement extended into other parts of the county and eventually the prairie lands were used. In the earliest years the agriculture consisted of grain growing and the raising of live stock, and these have continued the principal industries to the present day.

Gradual changes in farming, due to various causes, have taken place as the population has increased and as better transportation facilities and improved farm machinery have been introduced. In the early period only the most desirable tracts were farmed, but gradually other areas were taken up and improved and the size of farms has increased accordingly.

Below is a table showing acreage and production of the staple crops as taken from the census from 1880 to 1910:

Acreage and production of principal crops.

	Corn.		Oats.		Wheat.		Hay and forage.		Irish potatoes.	
	Acres.	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Tons.*	*Acres.*	*Bushels.*
1880.....	57,897	1,918,179	16,667	533,437	15,692	183,621	30,465	37,319	.....	87,318
1890.....	48,807	1,975,928	21,889	755,842	5,506	68,678	43,258	57,279	1,472	127,854
1900.....	66,016	2,328,740	19,095	533,890	535	5,510	41,464	53,822	1,622	128,386
1910.....	61,608	1,709,307	19,354	500,083	5,142	99,523	80,008	106,771	1,322	88,644

The agriculture of Wapello County at the present time consists primarily of the growing of hay and grain and the raising and feeding of live stock. In general the farming methods are based wholly upon the growing of corn, and other crops are grown that fit in well with its production. Corn is grown mainly as a feed crop, but lately, owing to the high prices, large amounts have been sold. Wheat is largely a cash crop. Hay and forage are used principally to feed the work stock and beef cattle. Special crops, such as potatoes, are grown for home use, with some surplus for sale. Many kinds of vegetables and small fruits are grown for market and there are a few large commercial apple orchards.

In 1909 there were 50,666 hogs and 24,188 head of cattle sold or slaughtered in Wapello County. The total value of animals sold or

slaughtered was $1,928,208. In addition, a large number of horses, mules, cows, hogs, and bulls are kept on the farms for work stock and for breeding purposes. Live stock is distributed over the whole county, and there are very few farms that do not have at least small herds on hand that may at almost any time be turned into cash.

Alfalfa is gradually becoming a crop of some importance. It is profitable on account of its large yields. The few areas in this crop are located on the Grundy and Clinton soils, but other types, as the Lindley and Waukesha, should prove valuable for this crop. Bluegrass is a very important pasture crop, and its growth is gradually being extended over the rougher uplands. It helps to resist erosion and supplies excellent pasturage. Millet is of very little importance. Sweet clover grows luxuriantly along the railroad embankments, roadsides, and ditches. It has a high feeding value and the seed brings good prices. The crop is seeded and cultivated in many counties of the State and is considered useful and profitable. Only one small area was seen in Wapello County where the crop had been seeded.

Fruit growing, while not carried on extensively over the county as a whole, is rather important in local areas. One of the several commercial apple orchards is located near Farson, on the Clinton silt loam. The principal varieties of apples grown are Ralls, Jonathan, Willow Twig, Grimes Golden, Ben Davis, Wealthy, Greening, and Baldwin. Cherries are a crop of local importance, sold on the local markets. Some grapes, strawberries, raspberries, and blackberries are produced.

Irish potatoes were grown in 1909 on a total of 208 acres, with a production of 360,599 bushels. The principal early varieties are Early Ohio and Early Rose. The Rural New Yorker is a popular late variety. Other crops grown to some extent by many farmers, largely for home use or for sale on the local markets, include barley, rye, peanuts, buckwheat, and sweet potatoes and other vegetables.

Dairying is relatively unimportant, but there are a few well-kept and thriving dairies, principally in the section around Ottumwa. On a large number of farms from 1 to 20 cows are kept, the milk and cream being sold to the creameries or the packing plant at Ottumwa. The latter offers an excellent market. Holstein cattle predominate in the dairy herds.

Cattle feeding is an important industry, and one of the chief sources of income on the farms of the county. Usually it is carried on in conjunction with general farming. In the grade of cattle as well as in the large number sold the county ranks high among the counties of the State. According to data gathered during the course of the survey the Angus and Hereford breeds of beef cattle predominate. There are also many Shorthorn and Red Poll cattle,

as well as grades of these breeds. Cattle for breeding are bought largely at live-stock markets. The large packing plant in Ottumwa buys a large number of the fattened animals annually.

Hog raising also is a very important industry. The main breeds of hogs raised are the Duroc-Jersey and Poland-China. Other breeds are the Berkshire, Chester White, Tamworth, and Hampshire. Hogs are sold largely on the local markets, but some are shipped to larger live stock centers.

Horses and mules are raised to a small extent by all farmers for work stock. Sheep raising, while not an important industry in the county as a whole, is gradually increasing. A few herds of goats are kept.

The systems of farming and the crops grown in different parts of the county have been influenced both by the general topography and by the character of the soils. In the level prairie country the lands are used very largely for general farming. The large and regular fields are easily laid out in these sections. In the rougher areas, as in those occupied by the Lindley loam and the Clinton silt loam, the fields are used largely for pasture and hay production, though some corn and other cultivated crops are grown. Over the county as a whole it is recognized that the Grundy silt loam and silty clay loam are best adapted to the production of general farm crops, especially corn. When drainage is well established and danger from overflow removed the Bremer and Wabash soils are also considered excellent corn soils. The Marion and Clinton silt loams, on the other hand, are believed to be the best soils for tree fruits, small fruits, grapes, and berries. The Knox fine sand is recognized as the best soil in the county for the production of watermelons, cantaloupes, and early truck crops. The Waukesha loam, Calhoun silt loam, and other terrace soils also are used to some extent for the production of small fruits and truck crops, because their natural features and climatic environment fit them for these uses.

Corn is usually grown on oat stubble or sod, and the seed bed is prepared by plowing in the fall and disking it in the spring. Corn, which is usually check-rowed, is planted in May. It is cultivated three to five times, depending upon the season, but as a rule cultivation is completed by late July. Both single and two-row riding cultivators are used. Much of the crop is husked by hand. Part of it is cut and shocked in the field, in which case it is later shredded or fed whole, and a part is cut for ensilage. There are a large number of silos in the county. The practice of "hogging down" corn is followed to some extent. This has been found a profitable way of harvesting the crop. Under this plan the soil is enriched, without added labor or expense. When corn is grown to be "hogged down,"

rape or cowpeas are often sown between the rows at the last cultivation. In recent years much care has been taken in the selection of seed corn, as the farmers realize that this is a certain method of increasing the yield. Both white and yellow corn are grown extensively. Reid's Yellow Dent is the most popular variety of yellow corn, and Boone County White, Silver Mine, and Silver King are the standard white varieties.

Oats have been produced since the days of early settlement, as the soil and climate are favorable and the crop fits in well with corn. Oats are sown on corn or small-grain stubble. In some cases the land is merely disked, but generally it is plowed. Seeding is done in April, the seed being either broadcasted or drilled, and the crop is usually ready for harvest by the middle of July. The oat crop is cut and shocked or stored in barns. It is thrashed in the field or fed in bundles. Much of the grain is sold, but a large part of the crop is used as feed and roughage for the work stock. The varieties of oats grown principally are the Swedish Select, Early Champion, Iowa 103, and Texas Red. The Iowa 103 and the Early Champion have proved to be excellent varieties for this locality.

Both winter and spring wheat are sown, the acreage of the latter being much the smaller. The land is prepared for winter wheat by plowing, disking, and harrowing, and the crop is sown about the first week in October. When seeded early much trouble is experienced from the Hessian fly and when sown too late there is a tendency to winterkill. The wheat is harvested with a binder and shocked or stacked in the field, to be thrashed later. The greater part of the wheat crop is sold, but some farmers grow only enough for home use. The Turkey Red, Beardless, Bluestem, Poole, Fultz, Fulcaster, and Mediterranean are the principal varieties grown.

The chief hay crop is timothy and clover mixed. Timothy and clover are usually sown in the spring with oats and are rapidly becoming a fixed crop in practically all rotations. Clover grown alone does not cover a very large acreage, although it is successful on most of the soils. It is sown in the spring with one of the small grains as a nurse crop. The flat, poorly drained areas are least adapted to clover production, as the freezing and thawing tends to winterkill the crops. Acid soils are unfavorable for clover, but this condition can be corrected by the application of lime. Clover is sometimes used for pasture the first year. The second year the first cutting is used for hay and the second for seed. Timothy when grown alone is seeded without a nurse crop. In addition to the hay made from these cultivated grasses, there is some produced from wild grasses.

Generally speaking, the farm improvements are good and reflect the prosperous condition of the agriculture. Most of the houses are

well constructed, and many have all the modern conveniences. The barns are generally large and well built, and silos and windmills are numerous. The farms are generally equipped with modern machinery, including manure spreaders, corn planters, drills, binders, rakes, hay loaders, hay stackers, disks, breaking plows, cultivators, mowing machines, corn binders, and gasoline engines. On all the better farms draft horses are large and well bred. Very few mules are used.

Systematic crop rotations are rapidly coming into general use. Corn is generally grown 2 to 4 years, followed by wheat or oats for 1 or 2 years, after which timothy alone, clover alone, or timothy and clover mixed occupy the land for 2 or more years. Other rotations used are: Corn, 1 year; oats, 1 year; clover or clover and timothy, 1 or 2 years; corn, 3 years; wheat or oats, in which grass is seeded, with hay and pasture, for 2 or 3 years. Numerous forms of rotation are followed, but those that permit the greatest corn production are favored. Nearly all the farmers realize the need of changing crops to insure profitable yields.

The soils of this county are as a whole strong and productive and, generally speaking, have not as yet needed the assistance of commercial fertilizers to insure good yields. However, some fertilizer is used for wheat and oats. In general, commercial fertilizers produce immediate results, but to hold the increased yields the supply of organic matter in the soil must be maintained. Practically all the soils of the county are deficient in lime, and such soils are unfavorable for the best yields of most crops, especially the legumes. Lime or ground limestone is being applied by many farmers to correct this condition.

The barnyard and stable manure produced is valued for maintaining good tilth and productiveness of the soils, and is commonly applied to grass land before it is broken for corn. Much manure is used in the production of fruit and truck crops.

Labor is scarce and commands a high price. All the laborers are white. Hands employed the entire year receive $25 to $30 a month, with board. During busy seasons the pay ranges from $2 to $3.50 a day, with board. Skilled farm labor is becoming more in demand as more scientific methods of farming are adopted and modern farm machinery comes into use.

The average size of farms in Wapello County, as reported by the 1910 census, is 94.9 acres, of which 82.8 acres is improved. The farms range in size from 40 acres to 1 square mile or more. The total number of farms in the county is 2,255.

According to the census, 68.1 per cent of all the farms are operated by owners, 30.7 per cent by tenants, and 2.2 per cent by managers. Only a small percentage of tenanted farms are rented for cash. The

prairie lands bring a cash rental of about $8 an acre, while the rougher areas in the southern part of the county bring about $3 or $4 an acre.

On the share basis the landowner generally receives one-half of the crops, the tenant furnishing the labor, work stock, and implements. Occasionally the tenant furnishes everything essential and gives the landowner one-half the corn and hay and two-fifths of the small grain, paying cash for the use of the pasture land at the rate of about 50 cents an acre.

In 1880 the average assessed value of farm land was about $25 an acre. In 1910 the assessed value averaged $76 an acre. Land values at present are high and increasing, ranging from $35 to $300 an acre. Most of the better farm land is held at $100 to $200 an acre. The average price for the county as a whole is about $125 an acre.

SOILS.

The greater part of Wapello County is covered by soils derived from three classes of transported materials, loess, glacial drift, and alluvium. A superficial covering of loess has given rise to the greater part of the upland soils. This material ranges in depth in different parts of the county from a few inches to about 15 feet. In its unweathered condition the loess is an even-grained material composed largely of silt. The color ranges from pale yellow to brown. The material is slightly coherent where undisturbed, but breaks down readily into a loose, floury powder. Under erosion the undisturbed mass has a tendency to maintain vertical banks, and often shows a columnar structure.

The loess soils have been converted into their present state by the processes of weathering and leaching and by the accumulation of organic matter. The loess in this area is an old deposit and the resulting soils differ greatly from those derived from the newer loess of the areas bordering the Mississippi River and the Missouri River. The slow accumulation of organic matter through a long period has given a dark color to the surface soil, and weathering and leaching have resulted in the removal of the greater part of the lime and other soluble salts from the soil. The finer particles of clay and silt have been washed down, and their segregation in the subsoil has in the case of the Grundy and Putnam soils given a clay or silty subsoil with a rather compact structure. In the case of the Putnam soils the surface color is lighter, and a gray silty layer intervenes between the soil and the heavy mottled lower subsoil. The Clinton soils, wherever found in Iowa, have been weathered either from a newer loess or from an old loess under good conditions of drainage. A timber growth which was unfavorable to the accumulation of organic matter covered the surface, and drainage favored

the oxidation of the subsoil. The result has been a light-colored, almost white, surface soil with a heavier, compact subsoil and a low percentage of lime in both soil and subsoil. The soils of the Marion series have developed on flat areas, where drainage was doubtless inadequate, but forest covering prevented any accumulation of organic matter. The soils of this series are nearly white, with compact, impervious subsoils.

Underlying the loess is a heterogeneous mass of drift material deposited directly by the ice. This drift is known as the Kansan drift. The materials of which it is composed are clay, sand, bowlders, and gravel, the proportions varying in different localities. There are only a very few large bowlders, and these are of fine-grained granite. Smaller bowlders of diabase and greenstone are common in the area. The drift varies widely in thickness over different parts of the county. The greatest thickness, as reported from well borings, is probably about 200 feet, but the average depth is about 100 feet. The changes due to weathering and leaching by which the drift was converted into a productive soil are similar to those which took place in the loess. In this area only one soil type; the Lindley loam, has been derived from the drift. It occurs only where the drift has been exposed by the removal of the loess in deep valleys and along steep slopes.

The older rock strata which appear at the surface in Wapello County are mainly limestones of the Lower Carboniferous.[1] Exposures of these rocks occur along the Des Moines River and some of its larger tributaries. Only small areas of soil have been derived from the weathering of these rocks, and this is classed as the Union silty clay loam.

The alluvial soils occupy the broad flood plain of the Des Moines River and the narrow bottoms of the smaller streams. They are largely composed of materials washed from the upland glacial and loessial deposits. Much of the alluvium of the Des Moines River bottoms has naturally been transported from long distances upstream. These alluvial soils represent water-deposited material laid down by currents of varying velocities, and this mode of formation partly accounts for the different textures and characteristics of the river-bottom types. The alluvial soils occupy both first bottoms and terraces. The former are as a rule subject to overflow, while the latter generally lie high enough to escape flood waters.

The soils are separated into series on the basis of origin, color, structure, and other characteristics. The upland soils covering the greater part of the prairie land are dark in color and belong to the Grundy series, while the lighter-colored prairie soil is classed with

[1] Geology of Wapello County, Iowa, Geol. Survey, Vol. XII.

the Putnam and Knox series. The Union series is partly forested and dark colored. The light-colored forested soils are classed in the Marion, Lindley, and Clinton series.

The Grundy series includes dark-colored upland loessial soils. The subsoil is a dense, plastic, mottled clay, usually dark brown with bluish-gray, drab, and yellow or yellowish-brown mottling. These soils occupy level to undulating or slightly rolling areas, and in many places need artificial drainage.

The Putnam series includes types with dark-gray soils overlying impervious, tough, dark-brown subsoils, mottled with drab. It differs materially from the Grundy series in the presence of an ashy, whitish, silty layer between the soil and subsoil. The Putnam soils occur on the level to flat upland and, owing to the hardpan or the impervious nature of the subsoil, require artificial drainage.

The types classified in the Clinton series are characterized by gray soils underlain by yellowish-brown subsoils, which are heavier than the surface material. The soils of this series are derived from the loess. They occupy undulating to rolling areas and surface drainage is good or even excessive. They differ from the Grundy and Putnam soils in that they occupy areas either forested now or in the recent past, are lighter in color, contain less organic matter, and have a more broken topography.

The Marion soils are ashy gray to almost white, with a subsurface layer of ashy-white, flourlike silt several inches in thickness. The subsoil immediately underlies this layer and is a tough clay of brown or mottled yellow and brown color. The Marion soils are known locally as "hardpan" soils. They are derived from weathered loessial deposits. They were originally forested and are light colored, but differ materially from the Clinton series in having a layer of silty material between soil and subsoil, and in having a harder, tougher, and more compact subsoil.

The types in the Lindley series have brown soils and brown, yellow, and drab, heavy plastic tenacious clay or sandy clay subsoils, always heavier and more compact than the surface soil. In some areas the color is not uniform, but mottled with various combinations of the colors mentioned. The members of this series are derived from weathered Kansas till, though the surface soil may be influenced to some extent by the admixture of loessial material.

The Knox series includes types with light-brownish to grayish-brown soils underlain by brown incoherent subsoils. The topography is undulating and dunelike in places. The origin of the soils of this series is uncertain, but they are either wind-blown or glacial.

The surface soils of the types classified in the Union series are generally brown. The subsoil is variable in color, being brown,

gray, drab, and slightly red. The subsoil contains numerous fragments of limestone, shale, and chert. The Union soils are residual in origin and occupy steep slopes along streams and ravines.

The alluvial soils comprise both first-bottom and second-bottom or terrace types. The first-bottom soils are classed in the Wabash, Genesee, and Sarpy series, while the terrace soils belong in the Calhoun, Bremer, Plainfield, Jackson, and Waukesha series.

The surface soils of the types classed in the Calhoun series range in color from dark gray to brown. The upper subsoil is an ashy-gray silt loam to silty clay loam, usually 6 to 8 inches in thickness. The lower subsoil is a compact silty clay of a mottled brown and drab color. The Calhoun soils are found on old terraces, which are as a rule above overflow.

The Bremer series comprises types with black soils and dark gray to almost black or drab subsoils, mottled with yellowish-brown and containing black iron stains. The subsoils are at least as heavy as the soils to a depth of 3 feet or more, and are tough and plastic. The series is confined to low terraces, which may or may not be above overflow, and drainage is generally poorly developed.

The surface soils of the types belonging to the Plainfield series are light brown to brown and the subsoils are lighter brown to yellowish. The subsoils are slightly lighter in texture than the surface soils. The members of this series occur on terraces above overflow.

The types in the Jackson series are characterized by light-brown to dark-brown soils and slightly lighter colored subsoils, streaked and mottled in the lower part with gray and various shades of brown.

The Waukesha series comprises types with dark-brown to black surface soils, and lighter brown to yellowish-brown subsoils. The subsoils are heavier in texture than the soils, but are not very compact. In this county the Waukesha soils are not calcareous. They occur on high terraces and are well drained. The soils differ from the Bremer in having lighter and more friable subsoils and in occupying a higher, better drained position.

The types in the Wabash series are characterized by dark-brown to black soils and black subsoils, which in the lower part become slightly gray and drab. The members of this series are closely associated with the glacial and loessial soils occurring over wide areas in southern Iowa.

The types of the Genesee series have brown surface soils, and somewhat lighter colored subsoils. They are developed along the streams draining the glacial and loessial regions of the United States. They differ from the Wabash soils in color, in having lighter textured subsoils, and in their position on terraces rather than on present flood plains.

The Sarpy series includes types with light-brown to very dark brown surface soils and brown to yellowish-brown subsoils, distinctly lighter in texture than the surface material. This series is developed in first bottoms.

In the following pages of this report the various soils of Wapello County are described in detail and discussed in their relation to agriculture. The name and the actual and relative extent of each type are shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clinton silt loam	80,192	31.0	Waukesha silt loam	2,240	0.8
Broken phase	4,608		Genesee fine sandy loam	2,176	.8
Grundy silt loam	82,624	30.1	Sarpy silt loam	2,112	.8
Lindley loam	42,624	15.6	Waukesha loam	1,600	.6
Genesee silt loam	14,208	5.2	Grundy silty clay loam	1,216	.4
Wabash silt loam	7,872	4.1	Bremer silty clay loam	960	.3
Colluvial phase	3,328		Wabash silty clay loam	768	.3
Marion silt loam	9,984	3.6	Knox fine sand	448	.2
Bremer silt loam	4,992	1.8	Riverwash	320	.1
Calhoun silt loam	3,776	1.4	Plainfield loamy fine sand	320	.1
Putnam silt loam	2,624	1.0		273,920	.....
Union silty clay loam	2,560	.9			
Jackson silt loam	2,368	.9			

GRUNDY SILT LOAM.

The surface soil of the Grundy silt loam is a dark-brown to black silt loam 8 to 14 inches deep. The subsoil is a dark-brown silty clay loam which becomes heavier and shows yellowish-brown mottlings in the deeper section. Below 24 to 30 inches and continuing throughout the 3-foot section, the subsoil is a bluish-gray, heavy, plastic clay, mottled with brown and yellow. The material underlying the 3-foot section becomes lighter and more mottled with yellow. In some small areas there is a thin grayish-white layer in the lower surface soil and upper subsoil, and where these are of sufficient size the soil is mapped as the Putnam silt loam. The grayish layer, which approaches the characteristics of the Putnam, occurs in numerous areas of the Grundy silt loam in the southwestern part of the county. The soil and subsoil of the type are acid, as shown by litmus tests in the field.

In the northeastern part of the county, on the level or undulating prairies, the Grundy silt loam has a deep, black surface soil. Along the breaks to Cedar Creek and its tributaries, where the Grundy and Clinton soils are closely associated, the surface soil is shallower than typical, and on the slopes toward the creeks the line between the Grundy and Clinton silt loams is very often arbitrarily drawn.

The Grundy silt loam is the second most extensive soil in the county, occupying a little less than one-third of its total area. It occupies level to undulating or gently rolling prairie lands and the more important ridges and other elevated areas. As the steeper slopes are approached it gives way to the Lindley loam and the Clinton silt loam. Drainage is fairly well established, but there are a few level areas where the run-off is inadequate and where the dense subsoil prevents ready downward percolation. These places remain wet during rainy seasons and the growth of crops is hindered. On many farms this condition has been remedied by tile drainage.

This is considered one of the most desirable soils in the county for general farming. It is very productive, having a high organic content, and is easily cultivated; also, there is little danger of erosion. Because of its generally smooth topography it contains a very small percentage of waste land, and practically all of the type is farmed.

The Grundy silt loam is considered one of the best corn soils in the county. Oats, wheat, rye, and grass all do well and have a definite place in the farming systems. Clover gives good yields and alfalfa has been successfully grown where the drainage is good.

Live-stock raising is second to grain farming in importance. Nearly every farmer raises a few calves and colts for sale, but the type is not so generally devoted to grazing as are some of the rougher soils. A large number of farmers keep dairy cows and produce cream for sale. Some sheep are kept, and hog raising is a very important industry.

Farmers report corn yields ranging from 30 to 100 bushels per acre, with a general average of about 43 bushels. Oats yield from 25 to 75 bushels, and wheat 18 to 40 bushels. The ordinary yield of timothy and clover hay ranges from 1 to $2\frac{1}{2}$ tons per acre.

The general method of handling this soil is to break the ground 5 to 7 inches deep. Corn is given frequent and thorough cultivation. Stable manure is used on nearly every farm, being applied with a manure spreader. Practically no commercial fertilizer is used, but some green manure is incorporated when manuring crops are grown in the rotation.

The price of land of the Grundy silt loam varies according to the location and the improvements. Values in the northeastern part of the county range from $150 to $250 an acre. In the southwestern part the value is somewhat lower. The average selling value of the type is about $175 an acre.

The general farming methods on this soil are well suited to the maintenance of its productiveness. It is probable that tile drainage would prove beneficial in some localities, as would the application of barnyard and green manures.

GRUNDY SILTY CLAY LOAM.

The Grundy silty clay loam, to a depth of 8 or 10 inches, consists of a very dark brown to black, friable silty clay loam. This grades into a heavy, compact clay of a dark-brown to brownish-drab color. With increase in depth mottlings of brown and yellow appear, becoming more numerous in the lower part of the 3-foot section. Small iron concretions are abundant in the lower subsoil in some places. Below 30 inches the subsoil, though still clay, generally becomes less compact than the overlying material. Tests with litmus paper show both the soil and subsoil to be acid.

The Grundy silty clay loam is developed in rather small areas, the largest lying along the Chicago, Milwaukee & St. Paul Railway about 3 miles northeast of Highland Center. Smaller areas occur 2 miles southeast of Dahlonega, 2½ miles east of Agency, 2 miles southeast of Kirkville, and one-half mile and 1 mile northwest of Salem Church.

The surface of this type is flat to depressed. Owing to this and to the compact nature of the subsoil, both surface and internal drainage are in general only moderately effective and in places wholly inadequate.

All the Grundy silty clay loam is under cultivation. It is considered as productive as the silt loam, and where it is improved with tile drains it gives even larger yields of corn. Small grains, grasses, and clover also do well. Corn generally yields 50 to 80 bushels per acre. Other crops yield about the same as on the silt loam.

As this type is heavier than the silt loam it requires greater draft for all cultural operations. Fall plowing is resorted to more often than in the case of the silt loam, and plowing is shallower than on the latter type. The soil requires greater care in handling, and for best results the range of moisture conditions under which it must be worked is considerably narrower.

This land is held at practically the same prices as the Grundy silt loam.

Improvement of drainage is needed in places on this type. The dense structure of the soil in places could be remedied to some extent by applying barnyard and green manures.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Grundy silty clay loam:

Mechanical analyses of Grundy silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332301	Soil	0.0	0.3	0.6	4.4	6.1	64.4	24.3
332302	Subsoil	.0	.1	.0	1.2	4.4	65.5	28.8

PUTNAM SILT LOAM.

The soil of the Putnam silt loam consists of 8 to 10 inches of light-gray to dark-gray smooth silt loam, the dark color showing more strongly in the wet material. The upper subsoil is a distinct layer of ashy-gray to white silt, about 6 inches in thickness, passing abruptly into a heavy silty clay loam to clay of a mottled gray, brown, and yellow color.

In flat, poorly drained areas, known as "glades," this type has a very light gray color. Where the soil is deep and has good drainage it is dark brown to black, owing to a high accumulation of organic matter. The subsoil also varies somewhat in color. In poorly drained areas it is almost black, with slight mottlings of drab and some yellow. The type gives an acid reaction with the litmus paper.

The largest area of Putnam silt loam occupies the crest of a drainage divide 1 mile south of Bear Creek station. Smaller areas occur in other parts of the county. The topography varies from almost flat to gently rolling, and the natural run-off is only fair or poor. The tough, plastic clay in the subsoil, while not impervious, retards underdrainage.

This is not an important type agriculturally, owing to its small extent, but practically all of it is under cultivation. Much of it formerly supported a heavy growth of prairie grasses. Probably a part was forested with oak or supported a brushy growth of trees and shrubs.

This soil is used principally for the production of the crops grown on the Clinton and Grundy soils. Dairying and cattle and hog raising are carried on to some extent. Crops give slightly better yields than on the Clinton and Marion soils, but do not yield as well as on the Grundy soils. The type is handled in the same manner as the Clinton silt loam, with which it is closely associated.

The selling price of land of this type ranges ordinarily from $50 to $100 an acre, with some highly improved areas held at a higher price.

In poorly drained areas, in which the acidity is marked, the type would be benefited by liming. It can generally be improved also by growing cowpeas or other legumes, by incorporating stable manure, and by thorough cultivation.

CLINTON SILT LOAM.

The Clinton silt loam, to a depth of about 12 to 14 inches, consists of a light-brown to buff-colored, smooth, uniform silt loam, though the immediate surface when dry may be light gray, closely resembling the Marion silt loam. The subsoil is composed of a very

compact, heavy silt loam to silty clay loam, light brown in color, and in many places mottled with gray and brown. In some areas the material in the lower part of the 3-foot section contains numerous iron concretions, giving the subsoil a dark-brown to black mottled color. According to tests with litmus paper the soil is acid.

The type is closely associated with the Grundy, Putnam, and Marion silt loam, and it is impracticable to draw exact boundaries between the several soils in some places. It is possible that small strips of the Grundy, Marion, and Putnam silt loams may be included with the Clinton soil as mapped.

The Clinton silt loam is widely distributed. In general it extends in a broad belt diagonally across the county, parallel to and on each side of the Des Moines River, separating the wide areas of prairie soils on the north and northeast from the residual, glacial, and loessial soils on the west, south, and southeast. The type is characteristically developed along the deep-cut slopes of the Des Moines Valley. It also occurs along practically every stream slope in the county and occupies slopes and ridges between almost all the small drainage ways. On many of these divides the topography varies from undulating to very rolling, the latter type surface existing where the areas merge into areas of the broken phase of the Clinton silt loam or of the Lindley silt loam. Where small streams head well out on the prairie in areas of the Grundy soils, narrow strips of Clinton silt loam occur along their slopes. As these streams become larger the areas of this type become wider, extending up all the small tributaries until the type forms a complete border around the prairie soil or Grundy silt loam.

Good drainage prevails over practically all of this type, and in some of the rougher areas the run-off is excessive. In some of the more nearly level areas, the drainage is slightly deficient, as the compact subsoil retards the downward percolation of water.

The Clinton silt loam is an important upland type, although only about one-fourth of it is in cultivation. It is fairly productive under favorable conditions. The type was originally forested, and some is still in forest, but the timber is gradually being removed and a larger acreage is put into cultivation each year. The native tree growth includes white, post, blackjack, and other oaks, elm, ash, hickory, hazel, and many other species both of trees and shrubs.

All the common farm crops are grown on this soil, the more important being corn, oats, wheat, clover, timothy, and alfalfa. Some dairying is carried on, and cattle and hog raising are well-developed industries. Truck products and fruits, berries, and grapes are also important crops in the vicinity of Ottumwa, where they are marketed in season, and these crops are grown to some extent elsewhere in the county.

Corn yields from 25 to 60 bushels per acre. The yield of wheat ranges from 10 to 30 bushels, of rye 10 to 25 bushels, and of oats 20 to 40 bushels. The ordinary yield of clover and timothy hay is 1 to 1½ tons, and of alfalfa 1½ to 3 tons per acre per season. Sweet potatoes yield 100 to 200 bushels per acre. Cherries, strawberries, apples, grapes, blackberries, and raspberries give excellent results in favorable seasons.

This soil, though friable and easy to handle, often has such a rough topography that the fields are irregular. Usually the type is well farmed. Full use is made of the stable manure available, and under the prevailing system of live-stock farming and diversified cropping the soil is generally kept in a fairly good state of productiveness. Some commercial fertilizers are used on the special crops.

Land values are somewhat higher than on the Marion silt loam, ranging from $50 to $150 an acre.

This soil washes badly unless steps are taken to prevent it. Various methods can be used to stop small washes and avoid the serious loss of soil material through destructive erosion, such as keeping plowed or cultivated fields in a cover crop during the winter months, deep plowing, and the addition of organic matter. Incipient gullies and draws should be filled with brush and eroded areas should be seeded with some thick-rooted grass. Care should be taken also to lay out corn rows with the contours of the hills and slopes. The rougher areas of the type should be kept in forest and used as pasture land. The type is naturally lacking in organic matter, and one step in maintaining productiveness should be the growing of leguminous crops in rotations and turning them under.

Clinton silt loam, broken phase.—The broken phase resembles the typical Clinton silt loam closely, except in having a rougher topography and in being less uniform in texture. Because of its rough and steep surface it has a shallower surface soil, in many places the subsoil being exposed in so-called "clay spots" and "gall spots." Some small strips of Lindley loam or of a residual type, the Union silty clay loam, are included. The texture of this phase varies from a sandy loam to a silty clay loam.

The broken phase of the Clinton silt loam occurs very closely associated with the main type, and in many places the boundary between the two is arbitrary. In general the broken phase occupies the steeper, rougher slopes along stream courses. It is well developed along the upper course of Sugar Creek, northeast of Ottumwa, along Turkey and Jim Creeks, south and southeast of Monkey Mountain, and along the main drainage way between Ashland and the Des Moines River bottom. The drainage is good to excessive.

Only a very few small patches of this soil are under cultivation, the rougher areas being unsuited for farming. About the same crops are grown as on the typical Clinton silt loam, and they give good yields in favorable seasons though yields in general are lower than on the typical soil. The phase is used largely for pasture. Most of it is forested with a growth of hickory, various oaks, and other trees and shrubs. Bluegrass does well, and cattle grazing and hog raising are important industries. The selling value of this land is low as compared with that of other upland soils. It ranges from $30 to $75 an acre.

In farming this soil it would be advisable to get a good stand of bluegrass on all the bare spots, to prevent erosion as much as possible.

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

Mechanical analyses of Clinton silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332307	Soil	0.0	0.7	0.8	3.3	7.6	72.1	15.5
332308	Subsoil	.0	.4	.3	1.2	5.4	61.3	31.4

MARION SILT LOAM.

The Marion silt loam consists of 2 to 6 inches of gray, yellowish-gray, or almost white silt loam, underlain by a white or grayish flour-like silt to silty clay loam, 6 to 14 inches thick, containing in some areas numerous small iron concretions. There is an abrupt change to the subsoil, which is composed of a yellowish-brown, stiff, tenacious clay, sometimes mottled. Below 30 inches the material is a much mottled gray and brown silty clay.

In fields that have been cultivated for some time the surface soil is almost white, while the virgin soil of forested areas is considerably darker. The type is closely associated with the Clinton and Putnam silt loams, and as it is very difficult to draw definite boundary lines between these soils, it is quite likely that small strips of the Clinton and Putnam silt loams are included with the Marion silt loam as mapped, and vice versa. Tests with litmus paper show the type to be strongly acid in both soil and subsoil.

The principal areas of Marion silt loam occupy the crests of ridges and projecting points of upland near some of the larger drainage ways, where conditions are favorable for leaching. Some of the larger areas occur in the northern and northeastern parts of the city of Ottumwa and between that city and Eldon east of the Des Moines

River. The type also is relatively extensive in the extreme southern part of the county between the Des Moines River and Hickory Flats School. Important areas lie west of Bidwell and in other parts of the county.

The type is partly glacial and partly loessial in origin. The surface soil is doubtless derived largely from the loessial material that covers most of the upland sections of the county, while the subsoil has originated, in part at least, from the weathering of a mixture of loess and till. The heavy clay subsoil has resulted from an accumulation of clay particles from the overlying soil, carried down by percolating rainwater. This subsoil is so nearly impervious that it has practically the same effect as a true cemented hardpan.

In general, the Marion silt loam has good drainage, but where it occupies wide, flat areas the run-off is slow, and the heavy subsoil retarding the downward movement of water drainage is not as thorough as it should be.

This type is not very important agriculturally. Probably not over 40 per cent of it is in cultivation, the remainder being largely used for pasture land. Most of the untilled areas support a growth of white and blackjack oak, hickory, and other trees and shrubs. The type is known locally as "white-oak land."

Small fruits, apples, peaches, pears, grapes, corn, wheat, oats, and bluegrass are the principal crops grown. Hogs and cattle are raised in considerable numbers. The hogs are allowed to range the woods for acorns and nuts. The growing of small fruits is profitable on some areas. Some tobacco is grown. In general the crop yields are somewhat lower than on the Putnam and Clinton silt loams. Corn yields from 15 to 40 bushels and wheat from 10 to 20 bushels per acre. Other small grains and hay give moderate to low yields.

When in the optimum moisture condition this soil is friable and easily cultivated. It is handled in much the same way as the Clinton and Putnam soils. Stable manure is used extensively, and commercial fertilizers are applied for tobacco, small fruits, and truck crops. Green manures are used to a small extent.

In the vicinity of Ottumwa, in the thinly settled parts of the city limits and extending out toward the country, this land has been divided largely into 5, 10, and 20 acre plots, which are held at $75 to $100 an acre. In the remoter country, where the type is forested to a great extent, the prices of farms range from $35 to $85 an acre, depending upon the acreage in cultivation and the improvements.

Owing to its relatively high clay content, this soil puddles if cultivated when too wet and bakes and cracks on drying, forming hard clods. The content of organic matter is low and the soil erodes easily, so that great care is necessary in cultivation. The content of organic matter should be increased by liberal applications of

barnyard manure and the plowing under of crop wastes and green-manure crops, using legumes for this purpose when possible. In the flat areas tile drainage would be beneficial.

LINDLEY LOAM.

The surface soil of the Lindley loam is a gray or brown loam 8 to 10 inches deep. The subsoil is usually a light-brown or yellowish-brown sandy clay loam or sandy clay, which in places is mottled with red, orange, and drab. The subsoil generally contains some lime nodules and in many places a large percentage of iron concretions, gravel, and fine and coarse sand. Field tests show the subsoil to be neutral to slightly calcareous.

While typically a loam, no other soil in the county varies so much in texture as does this type. The surface soil may range from a sandy loam, on the one hand, to a silt loam or silty clay loam, on the other, but the areas of the various textures are so small that it would be practically impossible to separate them on the map. The soil also varies in color from gray or dark gray, where it adjoins the Clinton or Marion silt loams, to yellowish brown or reddish brown on the breaks along some of the smaller streams, where erosion has exposed the subsoil. The subsoil, too, varies widely in different localities in its content of sand and gravel.

Practically all of the Lindley loam occurs in close association with the Clinton silt loam. It occupies slopes approaching stream courses and covers to a large extent the areas lying between the Clinton silt loam and the stream bottoms. Where the type comes in contact with the Clinton silt loam, at its highest elevation, the surface soil is quite silty and differs little from the Clinton. On the lower slopes the surface soil has been wholly or partly removed by erosion, so that the sandy clay subsoil is exposed or lies very near the surface. The narrow strips below these eroded areas contain considerable wash from the higher lying areas of this soil and also from the Clinton silt loam. Drainage is in general well established and in many places excessive. Underdrainage is better than in the other upland types.

Owing to its unfavorable topography, the Lindley loam is not widely cultivated, although it is a fairly productive soil. A large proportion of it is forested with hickory, pin oak, white oak, post oak, blackjack oak, hazel, sumac, elm, and other trees and shrubs. Some corn, oats, wheat, clover, bluegrass, and hay crops are grown. Much of the type is used as pasture for live stock, including cattle, sheep, horses, and hogs. Dairying is carried on in a small way.

Yields average about the same as those obtained on the Clinton silt loam. Corn is reported to yield from 20 to 40 bushels per acre. Wheat, clover, and alfalfa do better on this soil than on the Clinton,

Marion, or Putnam soils, because of its more pervious subsoil and higher lime content.

Where not badly eroded this type is easily cultivated, but it requires care in handling. It is usually farmed in much the same manner as the Clinton silt loam, as only the more nearly level areas are in cultivation.

This land varies largely in value with the location, topography, and improvements. The selling price ranges from $35 to $100 an acre.

The Lindley loam in general can best be used for pasture. It is well suited to growing bluegrass, and it occupies positions along streams where water is as a rule plentiful and where the tree growth affords shade during the hot summer days and some protection from cold winds during the winter. Where the type is cultivated, deep plowing, the furrows following the contours of the slopes, should be practiced to prevent erosion. The productiveness of the type can be greatly increased by applying manure and by the use of green manures. Alfalfa should prove a good crop on this soil, because of the favorable subsoil conditions and the lime content. Sweet clover also should do well on the type.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Lindley loam:

Mechanical analyses of Lindley 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.*
332340	Soil	2.7	9.1	7.1	27.8	16.3	26.5	10.1
332341	Subsoil	2.1	7.4	6.8	25.7	12.5	20.6	25.8

KNOX FINE SAND.

As developed in Wapello County, the Knox fine sand consists of a loose, incoherent fine to medium sand, of a gray, grayish-brown, or brown color, extending to a depth of 3 feet without much change in color or texture. The subsoil in places ranges from very light brown to orange or yellow. Well records show that this sand may have a depth of 50 feet or more.

This type occurs in one area, occupying approximately 1 square mile, in the northwestern corner of the county just east of Eddyville. A continuation of this area is said to extend parallel to the Des Moines Valley in a northwesterly direction for a distance of 7 or 8 miles. The origin of the type is uncertain. It either represents a glacial deposit or has been deposited in its present position by the action of the wind. The surface varies from undulating to dunelike, and drainage is well established.

This type is not an important one, although it is largely under cultivation. A small total area supports a sparse growth of wild plum, grass, shrubs, and scrub oak. The most important crops are corn, hay, fruits, and truck crops. The type is used for the production of watermelons and cantaloupes to supply the neighboring towns. Stock raising is not carried on extensively.

Stable manure and some commercial fertilizer are used on this type. The soil is loose and very easily plowed and cultivated. Farmers allow crab grass to grow unhindered in the late summer or else put in a winter cover crop to protect the surface from the severe winter winds, as the soil, when left unprotected, drifts badly.

Land of this type sells for $50 to $75 an acre.

This soil needs organic matter, which can be supplied by applying barnyard manure and by plowing under green manures, the legumes preferred.

UNION SILTY CLAY LOAM.

The Union silty clay loam consists of a brown silty clay loam, 6 to 8 inches deep, underlain by a silty clay loam to clay subsoil which varies in color from brown to gray or drab, in places splotched with red and reddish purple. It contains numerous fragments of limestone, chert, shale, and in some places sandstone. In many areas bedrock is reached within the 3-foot section.

This type is quite variable. In some places the surface soil is a silt loam and in others it may be almost a clay. The type is closely associated with the Clinton silt loam and the Lindley loam, and a definite boundary between it and these types can not be drawn.

The largest areas of Union silty clay loam are mapped along the sandstone bluff extending northwest and southeast of Cliffland and along the deep drainage ways and ravines north of that place. Smaller areas lie at Laddsdale, one-quarter mile south of Happy Hollow School, and about 1½ miles south of Munterville along South Avery Creek. The type occupies the steep slopes of ravines and ridges in the immediate vicinity of rock outcroppings. It has a rolling to rough and broken surface and the drainage is excessive.

This type is not important agriculturally, because of its small extent and rough, eroded condition. Practically none of it is under cultivation. It is largely forested with various kinds of oak, hickory, hazel, and other trees and shrubs. Several coal mines are located on or in the immediate vicinity of this type.

Land values on the Union silty clay loam are rather low.

CALHOUN SILT LOAM.

The Calhoun silt loam typically consists of a dark-gray to dark-brown, smooth, velvety silt loam, 8 to 10 inches deep, underlain by a layer of ashy-gray to white, flourlike silt 10 to 12 inches thick.

The lower subsoil, which begins abruptly, consists of a very heavy, tough, compact, and almost impervious clay, which is dark brown to black in general color, mottled with shades of brown, yellow, and drab.

This type varies considerably in color, but is fairly uniform as to texture. The surface color varies from almost white in a few places to dark brown or black in others. The subsurface layer of silt in some places is not distinctly developed, and in a few areas it is not present at all. The color and structure of the subsoil vary to some extent. In a few places the subsoil is not tough and plastic, but actually friable, and it is in places yellowish or brown.

The Calhoun silt loam occurs on rather old terraces lying above overflow along the Des Moines River. The larger areas occur in the outskirts of the southwestern part of the city of Ottumwa, in sections 22, 26, 5, and 6 of Center Township, at Kirkville Station, at Reed School, and 1 mile southeast of Eldon. There are several smaller areas along Middle Avery Creek and other small streams.

The topography is level to faintly undulating, and surface drainage is not well established. The heavy, almost impervious subsoil retards the downward movement of water, also impairing the drainage of the type.

The Calhoun silt loam is a rather extensive type in a few localities. The greater part of it is under cultivation, the remainder being used for pasture. Corn, oats, wheat, timothy, and clover are the principal crops. Hog raising is the most important live stock industry. Corn yields 30 to 60 bushels per acre, wheat 10 to 30 bushels, oats 20 to 40 bushels, and hay about 1 ton.

This type is handled in much the same manner as the other general-farming soils. It is easily plowed and cultivated, and a seed bed of good tilth is readily prepared. During periods of excessive rainfall the type often clods badly if cultivated when too wet. Commercial fertilizers are not extensively used, but liberal applications of barnyard manure are made where this material is obtainable.

This land sells at $75 to $150 an acre, depending upon the improvements and the nearness to shipping points. In a few localities where the type is closely associated with other good agricultural types the value may be slightly higher than that mentioned above.

The Calhoun silt loam is lacking in organic matter, and responds readily to applications of stable and green manures. The type also needs artificial drainage in many places.

BREMER SILT LOAM.

The surface soil of the Bremer silt loam is a dark-brown to black, uniform silt loam, 10 to 12 inches deep. The subsoil, into which the

soil merges gradually, is heavy tenacious clay of dark-brown to black color in the upper part, and drab mottled with yellow in the lower part. In a few local areas some sand, grit, and gravel are present in the subsoil.

Several variations from the type as above described occur. In the area 2½ miles northeast of Bladensburg a low terrace is included, on which the soil resembles the Calhoun silt loam in having the characteristic faint-gray subsurface layer. Along the south side of Cedar Creek, 1½ miles northeast of Bladensburg, a terrace soil is included which does not have the dense, heavy subsoil typical of the Bremer. Such variations were not of sufficient importance to warrant separation.

The Bremer silt loam occurs on low stream terraces, but lying to a large extent above overflow. Along the smaller streams it merges into the upland and first-bottom soils so gradually that the lines of separation are difficult to draw. The larger areas of the type are found in the valley of the Des Moines River. Important areas lie between Fudge and Brown Creeks, in the northwestern part of the county, around Ottumwa in the central part, and in the vicinity of Eldon in the southeastern part. Smaller areas are mapped along Cedar and other creeks. The topography is level or very gently sloping, and drainage is fair or poor because of the low-lying position and the dense subsoil.

This is an important soil agriculturally. Practically 75 per cent of it is in cultivation, the remainder being used as pasture land. The most important crops are corn, oats, wheat, and timothy and clover hay. Some wild hay, consisting of heavy sedge or slough grass, is harvested. Live-stock farming is not carried on extensively, but nearly every farmer has a few cattle, hogs, and cows, and occasionally some sheep. Corn yields range from about 25 to 80 bushels per acre. Oats and wheat do well, and timothy yields an average of about three-fourths to one ton of hay per acre.

Land of the Bremer silt loam sells at prices ranging from $75 to $200 an acre, depending upon the improvements, the situation as to transportation facilities, and the danger from flood waters.

This soil in most places is acid and in need of lime. Liming and artificial drainage increase the yields in a marked degree. The soil is usually very productive, but to insure returns permanently the farmer should make use of all the stable manure available, plow under occasional leguminous green manures, and if other plant-food elements are needed supply them with commercial fertilizers.

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

Mechanical analyses of Bremer silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332325	Soil	0.1	0.5	0.5	2.0	8.0	65.6	23.3
332326	Subsoil	.0	.2	.2	1.3	10.1	62.8	25.4

BREMER SILTY CLAY LOAM.

The Bremer silty clay loam consists of a black silty clay loam 6 to 8 inches deep, grading into a dark-brown to black heavy, compact, dense clay, extending to 20 inches. Below this depth the material has the same texture, but changes in color to drab, mottled with yellow or brown, which characteristics continue to the bottom of the 3-foot section.

One of the largest areas of this soil is mapped at Eddyville and another in Washington Township in sections 19 and 30. It occurs on low terraces not wholly above overflow. The topography is level and the drainage, both surface and internal, is poor.

The Bremer silty clay loam is practically all in cultivation. Corn is the principal crop. It yields 35 to 65 bushels per acre. Oats, wheat, and timothy also do well. Live-stock raising is not well developed, most farmers keeping only a small number of hogs and a few cattle.

The selling value of this land is about the same as that of the Bremer silt loam, and the suggestions made for the improvement of the silt loam apply equally well to this type.

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

Mechanical analyses of Bremer silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332333	Soil	0.0	0.3	0.6	6.0	10.0	58.4	24.7
332334	Subsoil	.0	.2	.3	3.9	9.4	59.1	27.1

PLAINFIELD LOAMY FINE SAND.

The Plainfield loamy fine sand consists of a dark-brown loamy fine sand underlain at 12 to 15 inches by a light-brown sand, which gradually becomes lighter in color and coarser in texture with in-

creased depth. In some places adjacent to the uplands, as in section 6, Keokuk Township, it includes a few small areas of silt loam.

This soil occupies high terraces lying just below the upland bluff. An area lies at Eddyville, where the adjacent upland is occupied largely by the Knox fine sand, and it would seem that much of the material is colluvial wash from that type. The largest area of the type is in the extreme southeastern part, across the river from Eldon. The surface is level or gently sloping from the upland to the more level lower terraces, and drainage is good.

The Plainfield loamy fine sand is inextensive and of little agricultural importance. A small percentage of it is under cultivation, watermelons, cantaloupes, truck products, and berries being the most important crops. These are produced largely for home use and for sale on the local markets.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Plainfield loamy fine sand:

Mechanical analyses of Plainfield loamy fine sand.

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.*
332331	Soil	0.4	8.8	20.6	42.6	9.5	14.1	3.9
332332	Subsoil	.5	15.7	34.7	46.5	.8	.9	1.1

JACKSON SILT LOAM.

The soil of the Jackson silt loam ranges from a light-brown to dark-brown, uniform, smooth silt loam, 12 to 14 inches deep. The upper subsoil is a slightly lighter brown silt loam, streaked with gray. The subsoil becomes heavier with depth and in places the lower subsoil is a brown silty clay loam or heavy silty clay loam—the former being the more typical—mottled with yellow and drab.

This type as mapped includes many small patches of soil varying considerably in texture and structure. In some places small areas of sandy material have been washed over the surface, and it is not uncommon over small areas to find layers and pockets of variably textured material through the subsoil.

The Jackson silt loam occurs as a second-bottom or terrace soil along the Des Moines River. Most of its area lies above overflow. The type is most extensive near Eldon, southeast of Cliffland bridge, at Ogg School, in section 8, Keokuk Township, in the southwestern part of Richland Township, and in Columbia Township. Smaller areas are scattered along the Des Moines River and Cedar Creek bottoms. The surface ranges from level to gently undulating and the drainage is fair to good.

Although the Jackson silt loam is of small extent it is an important agricultural soil, and the greater part of it is cultivated. Dairying and live-stock raising are not extensive industries, as the type has been developed principally as a grain and hay producing soil. Live-stock raising is carried on in conjunction with general farming, the feed being grown on this soil and the rougher uplands being used for pasture.

Corn, the principal crop, yields an average of about 40 bushels per acre. Oats, wheat, timothy, and clover also do exceedingly well, and alfalfa where tried in small patches has proved successful. Apples are grown in a few small orchards, which seem to be productive. The type is also of local importance as a market-gardening and small-fruit soil, practically all of this produce being grown for the local markets. Stable manure is used extensively on this soil and some commercial fertilizer is applied on special crops.

It is rather hard to estimate the average selling value of this type of soil, as some areas used intensively for trucking occur near the city, where the prices asked are more or less speculative. The range in price, however, is from $100 to $250 an acre.

This soil would be improved to some extent by shallow ditches to carry off rain water now collecting in small depressed areas. The soil is not rich in organic matter, and when cropped intensively is very likely to decline in productiveness, unless means are used to maintain or increase the supply. The structure and productiveness in general would be improved if leguminous green-manure crops were turned under in the fall.

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

Mechanical analyses of Jackson 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.*
332350	Soil	0.6	1.4	1.5	8.9	13.0	63.7	10.8
332351	Subsoil	.4	1.7	1.3	6.2	13.3	61.2	15.8

WAUKESHA LOAM.

The Waukesha loam consists of a dark-brown loam, 12 to 14 inches deep, underlain by a subsoil of brown loam which extends to a depth of 3 feet without any marked change, though it gradually becomes somewhat lighter in color and coarser in texture with depth.

The type is variable in texture, color, and structure. In some places the surface soil is a sandy loam or fine sandy loam, while in small depressions it may be as heavy as a silt loam. The subsoil also in places has a silt loam or silty clay loam texture.

An area of this type is situated 1½ miles northwest of Cliffland. It is most extensive in South Ottumwa and the outskirts of that city. The type occurs as a second-bottom or terrace soil along the Des Moines River, and lies above overflow. The topography is level or only gently undulating, but the surface drainage is fairly well established and the internal drainage is good.

The Waukesha loam is not an extensive soil and much of its area is occupied by city streets and buildings. Trucking is the most important agricultural industry, but small fields are used for corn, oats, wheat, and hay, and apples and small fruits and berries are grown to some extent. Watermelons and cantaloupes are also produced for local markets. Stable manure is used extensively and some commercial fertilizers are applied to certain crops.

Land values on this type are difficult to estimate, because the greater part of the type is occupied by city lots. Agriculturally, the price would apparently range from about $75 to $200 an acre.

Since this soil is rather deep and loose, and where unprotected by vegetation tends to blow and drift badly during the winter, crab grass should be allowed to grow in the fall or some winter cover crop should be seeded. The type is deficient in organic matter, which can be supplied by turning under green manures, crop residues, and stable manure. Alfalfa should do exceedingly well on this soil.

WAUKESHA SILT LOAM.

The Waukesha silt loam consists of a dark-brown to black, uniform silt loam, underlain at 10 to 15 inches by a heavy, brown silt loam to light silty clay loam. The subsoil gradually becomes lighter in color, passing from brown in the upper part to light brown, slightly mottled with gray, in the lower part. It is very friable and below 24 inches gradually becomes coarser in texture. A substratum of heavy silt loam is encountered at about 40 inches.

This type occupies parts of the high terraces of the Des Moines River, lying above overflow. It resembles in topography, and to some extent in color, the Grundy soils, into which it gradually merges in some places, in which case it is very difficult to tell where the terraces and the upland begins. The drop, however, to the lower terrace is very distinct.

The Waukesha silt loam represents very old alluvial deposits which have been cut through by deep stream channels. The largest area of the type is mapped along and north of the Ottumwa-Eddyville River road, about 2 miles southeast of Eddyville. This area is about 3 miles long and averages about three-fourths mile in width. Another rather large area is located at and south of McElroy Lake. Other areas are mapped one-half mile southwest of Eldon and 2¼ miles north of Laddsdale.

The topography of the Waukesha silt loam is generally level or undulating, but in some places where the streams have cut down through this terrace material the land immediately adjacent is rather eroded and rough. The type has good drainage.

This type has a total area somewhat less than 4 square miles, but it is an important soil agriculturally. It is not subject to overflow, is mellow and naturally productive, and practically all of it is in cultivation.

All the general farm crops are grown. Corn is the most important crop, but wheat, oats, timothy, and clover are grown extensively. Alfalfa is being tried in a few small patches. In favorable years good yields of all crops are produced. Corn averages about 40 bushels per acre. The type compares favorably in cropping value with any other in the county. It is not as strong as the Grundy silt loam, but it has some favorable characteristics, such as good internal drainage, that the latter soil lacks. The most modern methods used in general farming are followed on the Waukesha silt loam. Commercial fertilizers are not used, however, excepting on small areas of special crops.

This land sells at $75 to $175 an acre, depending upon the topography, location, improvements, and general condition.

The Waukesha silt loam is naturally a productive soil, but care should be taken to keep it in good condition by using a systematic rotation which will allow the frequent turning under of a leguminous green-manure crop. Stable manure should be applied liberally to all unproductive patches. Care should be taken in the vicinity of drainage ways to stop or prevent all washes that may in time cause serious erosion.

WABASH SILT LOAM.

The Wabash silt loam typically consists of a dark-brown to black, smooth, uniform silt loam, passing gradually at 10 to 14 inches into a silty clay loam subsoil which gradually becomes heavier with increased depth. The upper subsoil is dark brown, but the color changes with depth to dark drab, mottled with brown and yellow, at the bottom of the 3-foot section. Small iron concretions are sometimes present in varying quantities.

This type as mapped has been made to include some areas which depart in some particulars from the type as described above. A few small areas resemble the soil mapped in Ringgold County as the Wabash silt loam, gray-subsoil phase. In some places in the Des Moines River bottom, where the Wabash silt loam is closely associated with the Genesee silt loam and the Wabash silty clay loam, the line between these soils has been arbitrarily drawn because of the difficulty of distinguishing them accurately where they merge.

About 2 miles southeast of Eddyville, along the bank of the Des Moines River, there is included a small area of Wabash fine sandy loam. One mile north and 1 mile east of Ogg School there occurs an area of several acres covered with coarse sand and gravel. This area has been included with the Wabash silt loam, but is distinguished on the map by gravel symbols.

The Wabash silt loam reaches its greatest development along Cedar Creek, which flows across the northeastern part of the county. The bottom land along this stream varies in width from a hundred yards to about three-fourths mile. The type is also developed in narrow bottoms along Little Cedar, Wolf, Competine, Buckeye, Comstock, and Rock Creeks, and Honey Branch and to a small extent in the Des Moines River bottom. It has for the most part a level to slightly undulating topography. In some places there is a gradual rise toward the upland at the outer edge of the bottom, and such areas are rarely flooded, but the type as a whole is subject to overflow. Drainage in general is only fair. Some areas are well drained, but there are parts in which the soil is entirely too wet much of the time.

This is an important soil, and the greater part of it is in cultivation or used as pasture land. Most of the land used as pasture supports a growth of oak, hickory, elm, ash, maple, sycamore, and willow. The type is productive and well suited to the production of the general farm crops of the region, corn, wheat, oats, timothy, clover, and alfalfa. Corn is apparently the most important crop, with yields ranging from 25 to 80 bushels per acre. The yield of oats, also an important crop, shows a range of 25 to 50 bushels per acre. Cattle and hog raising are important industries.

This soil is valued highly, and is as a rule well farmed. Most of the poorly drained areas, unsuitable for farming in their present condition, are valuable for pasture, because of the natural productiveness of the soil. Surface ditches and some tile drains are used to assist in the draining of the lower, wetter spots. Barnyard manure and green crops are often plowed under as fertilizers on areas showing deterioration from constant cropping.

This land ranges in price from $75 to $175 an acre, depending upon the location, the forest growth, the drainage conditions, and the improvements.

A considerable proportion of the Wabash silt loam could be improved to a marked degree by drainage. Tile drains in some places and shallow ditches in others would be beneficial. It is often impossible to get access to this land during the early spring months, but delay in planting can be avoided to some extent by fall plowing. Flooding of some areas could be controlled by diking and straightening the stream channels.

Wabash silt loam, colluvial phase.—The colluvial phase of the Wabash silt loam to an average depth of about 10 inches is a dark-brown to black silt loam to silty clay loam. This grades into a dark-brown to black, silty clay loam subsoil which in the lower part is mottled with brown, yellow, and drab. Considerable loamy material and even a fine sandy loam soil are mapped with this type in some places. The subsoil often contains pockets of sand, and gravel has been found in some areas.

The colluvial phase of the Wabash silt loam occurs along most of the smaller drainage ways or draws that extend back into the black prairie areas occupied by the Grundy soils. It occupies narrow slopes and small stream bottoms. The soil is largely of colluvial origin, having been carried from the adjacent Grundy soils by sheet wash, wind action, and small land slides. Drainage ranges from fair to poor.

Practically none of this soil is in cultivation. Its total extent is very small, and it is of little importance in the agriculture of the county, although it is naturally productive. It is sold only with other soils, and is consequently valued at a higher price than it would command if sold alone.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam consists of about 6 to 8 inches of dark-brown to black silty clay loam. The subsoil is a dark-brown to black clay to a depth of about 20 inches, where it becomes more brownish in color, mottled with drab and rusty brown. Slightly to the southwest of the junction of Buckeye and Cedar Creeks a small area of Wabash clay is included, and another of similar texture about 1¼ miles southeast of Eddyville. In approximately the central part of section 15 and the north-central part of section 22, of Columbia Township, several small areas included with the silty clay loams are covered with medium to coarse sand, underlain by a dark-brown to black subsoil of a heavy, compact structure.

The largest developments of this type occur in the Des Moines River bottom southeast of Eddyville, along the north side of the river, three-fourths mile northwest of Cliffland, and three-fourths mile southeast of Eldon. The type occurs as a low-lying flat or gently undulating first-bottom soil subject to overflow and as a rule poorly drained.

Owing to its small extent this soil is not of much agricultural importance. Probably about 60 per cent of it is under cultivation, the remainder being in forested pasture. The tree growth is the same as on the Wabash silt loam. Corn is the most important crop, followed by wheat, oats, and grasses. The grazing of cattle and hog raising are well-developed industries. Yields on this soil do not average as high as those obtained on the silt loam. Since this is a

much heavier soil, it requires heavier implements and more horse power. The cropping methods are about the same as on the silt loam, and the productiveness of the silty clay loam can be improved by similar means.

GENESEE FINE SANDY LOAM.

The Genesee fine sandy loam consists of a light-brown or grayish-brown fine sandy loam grading at 10 to 12 inches into a brown, light silt loam which typically continues to the depth of 3 feet. Numerous intermingled patches of very fine sandy loam texture on the one hand and of sandy and coarse sandy loam texture on the other are included, but these are small and unimportant as compared with the area having a fine sandy loam texture. The subsoil in places contains some strata of sand, and sometimes gravel is present in small quantities. The subsoil may vary in color, being in some spots light brown mottled with gray.

The Genesee fine sandy loam occurs in the first bottoms of many of the smaller streams of the county and is subject to overflow. Some of the most extensive areas are mapped along South Avery and Fudge Creeks. A few areas are also encountered along the Des Moines River 1½ miles west of Eldon and south of the river opposite Cliffland. The type occurs along the smaller streams which flow through rough, broken country occupied largely by the Lindley loam. It has a level to slightly undulating or billowy topography, and the drainage is good except during periods of excessive rainfall, when the type is subject to overflow.

Because of its small acreage the Genesee fine sandy loam is not an important soil in Wapello County, although it is largely under cultivation. It is used in connection with surrounding soils for the production of corn, grasses, truck crops, watermelons, cantaloupes, sweet potatoes, and alfalfa. The average yields are lower than those obtained on the Genesee silt loam. Corn yields 20 to 65 bushels and wheat 10 to 25 bushels per acre. Melons and truck crops do well.

The Genesee fine sandy loam is fairly productive, but it occurs in such narrow strips that it is almost impossible to establish regular fields. The type is usually sold in conjunction with other soils, and for this reason a price can not be stated.

In the areas including patches of loose, incoherent sandy soil the type is very unproductive. The recommendations given for improving sandy areas in the Genesee silt loam can be applied here. This soil blows badly when left bare, and cover crops should be grown to protect it during the windy winter months.

GENESEE SILT LOAM.

The surface soil of the Genesee silt loam is light brown to grayish brown when dry and brown or dark brown when wet. In texture

it ranges from a light silt loam to almost a silty clay loam. The surface soil extends to a depth of 6 to 15 inches, gradually becoming heavier, and the subsoil is usually a silty clay loam, dark brown in the upper part and mottled with gray and yellow in the lower part. In some places pockets and layers of sand are encountered within the 3-foot section.

Several small areas that vary from the typical Genesee silt loam are included with it because of the difficulty of separating them in mapping. Much of the type along Middle Avery Creek is bordered by uplands composed of Lindley loam, and during rains much sand is carried out from the surrounding hills over the Genesee silt loam. Where these areas are too small to be separated as the Genesee fine sandy loam they are included with the silt loam. In many places in the Des Moines River bottom sand spots occur irregularly and so intricately associated with the type that no attempt has been made to separate them.

Large areas of the Genesee silt loam occur along the Des Moines River, and continuous strips along North Avery, Middle Avery, South Avery, Palestine, Bear, Village, Little Soap, and Brush Creeks. The type occurs in the first bottoms and is subject to frequent overflow. Not only does it vary considerably in texture, but the texture may change to some extent with each flood in areas where the currents are swift. The topography is level to fairly undulating. Where sand spots or "blows" are numerous the surface presents a hummocky appearance. The drainage is generally adequate and is better than in the Wabash silt loam areas.

This is a fairly extensive, naturally productive, and locally important soil. About 75 per cent of its area is under cultivation, and the remainder is forested and in pasture. The soil is well adapted to all the general farm crops, and it is largely devoted to general farming. It is well suited to alfalfa, but this crop is not extensively grown. Dairying is carried on in a small way, and cattle and hog raising are well-developed industries. Corn yields range from 30 to 75 bushels, wheat 12 to 25 bushels, and hay 1 to 2 tons per acre. Watermelons and cantaloupes are grown in small patches.

The Genesee silt loam is a loose, friable, soil, easily plowed and put into good condition. Because of its better drainage and more porous nature it is easier handled than the Wabash silt loam—the other important first-bottom type. No commercial fertilizers are used, but liberal applications of barnyard manure are made where this material is available.

Where this type occurs in large bodies and is in a good state of cultivation, it is classed among the high-priced lands of the county, but where it is subject to frequent overflow or is deficient in drainage

it has a considerably lower value. The selling price ranges from $65 to $150 an acre.

Areas of the type including patches of loose, incoherent, sandy soil would be greatly benefited if in plowing, the sand is mixed as much as possible with the surrounding heavier soils. The sandier areas are also deficient in organic matter, and are naturally less productive than typical, and where they occur in sufficiently large numbers or the individual areas are sufficiently extensive the yields are cut down materially.

SARPY SILT LOAM.

The Sarpy silt loam is a smooth, uniform, brown silt loam, 10 to 15 inches deep, resting on a brown subsoil, much lighter than the soil in texture. The color becomes lighter with increase in depth and the material is slightly mottled with gray and yellow in the lower part. The lighter texture of the soil is the characteristic distinguishing this type from the Genesee silt loam. The subsoil may be either fine sandy loam, very fine sand, or fine sand. Included with the type are a number of patches of heavier soil, varying from silt loam to clay, which are too small to map as separate types.

The Sarpy silt loam occurs in narrow strips in the Des Moines River bottoms, usually adjacent to the channel. Some of the larger areas lie in secs. 10, 11, 12, 13, and 14, Keokuk Township, one-half mile northwest of Chillicothe, and near Ottumwa.

The topography is level to slightly undulating, varied with occasional ridges made up of sandy soil or depressions occupied by heavier soil. The drainage is good. The type is subject to overflow. It comprises the immediate banks of the river and in many places is subject to erosion.

Owing to its small extent the Sarpy silt loam has little influence in the agriculture of the county. About half its area is under cultivation, the remainder being unsuitable for farming because of the danger of overflow. The untilled land is forested.

Corn is the principal crop on this type. Wheat, oats, timothy, clover, and alfalfa are grown to a small extent, and melons and truck crops are produced for local use. Some parts of the type are profitably used as pasture.

Land of the Sarpy silt loam sells for $60 to $125 an acre, depending on the liability to flood and the location and improvements.

A fine sandy loam variation is included with the Sarpy silt loam. The surface soil is a light brownish gray or grayish-brown fine sandy loam, averaging 10 to 15 inches deep. The subsoil is like the surface soil in color, but is more open in structure and coarser in texture. The percentage of sand increases with depth, and in many cases the lower part of the 3-foot section grades into fine or very fine sand.

This soil occurs in the first bottoms of the Des Moines River. It is usually found near the stream channel, and is subject to overflow. An area of this description is mapped at Cliffland bridge, on the north side of the river. The topography is generally level to slightly undulating. There are occasional ridges of loose sand and depressions made up of heavier material. This fine sandy loam soil is unimportant agriculturally. Corn, wheat, and oats are grown to some extent. Truck crops, such as sweet potatoes, melons, cantaloupes, and cabbage, do well. The soil is deficient in organic matter and drifts badly during the winter.

RIVERWASH.

Riverwash consists of recently deposited alluvial material. As mapped in this county it consists mainly of heaps of loose, fine sand, sand banks, or low-lying sand bars. The material is usually a grayish-brown to gray sand varying widely in texture. Some water worn gravel occurs over small areas.

Riverwash occurs along the Des Moines River, and is subject to frequent overflow. It supports a sparse growth of brush, willow, and water-loving grasses. The type is practically nonagricultural. A few attempts have been made to produce corn, with indifferent results.

SUMMARY.

Wapello County is situated in southeastern Iowa in the basin of the Des Moines River. It has an area of 428 square miles, or 273,920 acres. The uplands range from level to gently rolling. There are considerable areas of flat river flood plains or bottom lands.

The northeastern part of the county is drained by Cedar Creek and its tributaries, and the remainder by the Des Moines River and its tributaries.

The 1910 census shows a total population of 37,743. Ottumwa, the largest town in the county and the county seat, had a population of 22,012 in 1910. Eldon, Eddyville, Farson, Blakesburg, Kirkville, and Agency are towns of less importance.

The county is well equipped with railroads, which supply direct means of communication with Chicago, Kansas City, St. Louis, Omaha, Minneapolis, and Des Moines.

The climate of Wapello County is characterized by a mean annual temperature of 49° F., and an average annual rainfall of about 29 inches. The normal growing season extends over a period of 169 days.

The agriculture is based on general farming. Some farmers specialize in raising cattle and hogs, and some engage in dairying or truck growing. Corn, oats, wheat, and hay are the principal crops.

Bluegrass does well and is used extensively for seeding down rough areas. Fruit is grown commercially in a small way.

About 95 per cent of the area of the county is in farms, and about 82 per cent of all the farm land is improved. The average size of the farms in 1910 is reported as 115.2 acres.

Twenty soil types, two phases, representing 15 series, and one miscellaneous soil are correlated and mapped in this county.

The Grundy and Putnam series include the dark-colored prairie soils. These are well suited to corn. They lie on the rolling uplands back from the river valley.

The Clinton and Marion soils are light-colored types of loessial origin, frequently supporting a forest growth. They occur on the margin of the prairie soils, between them and the stream valleys. They are used for fruit and general farm crops, and for cattle and hog raising.

The Lindley loam occupies rather rough and rolling areas. It has originated from glacial material. This soil is used largely for pasture.

The Knox fine sand occupies only small acreage. It is used largely for the production of melons and truck crops.

The Union silty clay loam is of little importance agriculturally. It is composed of residual material derived from limestone and shale.

The Calhoun silt loam is a grayish soil occupying high, old terraces. It is used for general farm crops.

The Plainfield loamy fine sand occupies only a very small acreage and is agriculturally unimportant.

The Bremer soils are black in color and occupy low terraces. They are inherently very productive and where well drained make excellent farm land.

The Waukesha loam and silt loam are dark-colored soils occupying high terraces of the Des Moines River. They are strong and productive and compare favorably with the best soils of the county.

The Jackson silt loam is a brown terrace soil, used for the production of general farm crops. It occupies a rather small acreage in the valley of the Des Moines River.

The Wabash soils are dark-colored types occurring in the first bottoms along the streams. They are naturally productive and are considered good grain and hay soils where drainage is well established.

The Genesee series also include first-bottom soils, occurring along practically all the streams of the county. They are productive and are used for general farming.

The Sarpy silt loam occupies a small acreage in the first bottoms of the Des Moines River. It is naturally productive but its value is impaired by the danger of overflow.

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[PUBLIC RESOLUTION—No. 9.]

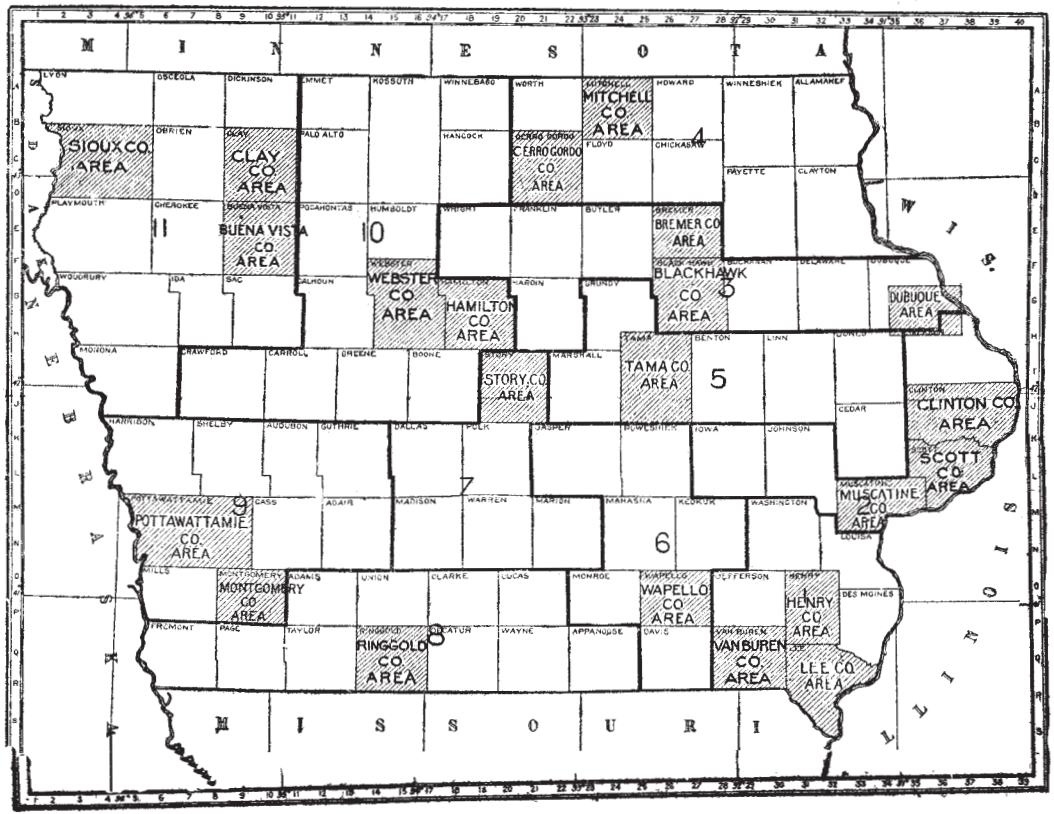
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved, March 14, 1904.

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



Areas surveyed in Iowa.

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