

**UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS**

In cooperation with the Iowa Agricultural Experiment Station

**SOIL SURVEY
HARRISON COUNTY, IOWA**

BY

**T. H. BENTON, Iowa Agricultural Experiment Station, in Charge
and N. J. RUSSELL, U. S. Department of Agriculture**



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SOIL SURVEY OF HARRISON COUNTY, IOWA

By T. H. BENTON, Iowa State Agricultural Experiment Station, in Charge, and
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COUNTY SURVEYED

Harrison County is in the southwestern part of Iowa, where the Missouri River forms its western boundary, and the southern boundary is about 25 miles north of Omaha. Monona County lies north, Pottawattamie County south, and Shelby County east of it. In one place where the river has shifted its channel after the State boundaries were established, the State of Nebraska forms about $2\frac{1}{2}$ miles of the western boundary. Here the line runs along a practically obliterated channel of the Missouri River which was occupied by that river at the time when the State boundary was established. The county is roughly rectangular, having a north-and-south width of 24 miles and averaging about 30 miles east and west, the winding of the river making the western boundary irregular. Its area is 691 square miles, or 442,240 acres.

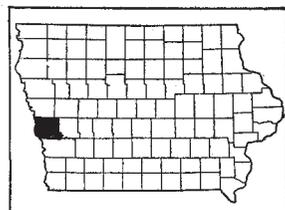


FIG. 29.—Sketch map showing location of Harrison County, Iowa

Harrison County is part of a plain, once level but now modified greatly by erosion and stream action. It may be separated topographically into two distinct areas—the upland comprising the eroded plain, and the deep broad alluvial valley of Missouri River with the narrower and shallower alluvial valleys of its many tributary streams.

The upland for the most part ranges from gently rolling to rough, and is characterized by rounded ridge tops and smooth gentle slopes, leading down to the stream channels. The more hilly and rough areas are in western Jackson, Boyer, Cass, La Grange, Raglan, Magnolia, Allen, and Lincoln Townships and in eastern Jefferson Township. There are no extensive areas too rough for cultivation, except the steep bluffs which border the valley of the Missouri River. The slipping and sliding of the loess on these bluffs has resulted in many faults or cat steps on the south and west slopes, but to the east these hills slope gradually and merge into the rolling plain.

The uplands constitute approximately 47 per cent of the county and lie at elevations ranging from 1,000 to about 1,200 feet. The alluvial plain of the Missouri River lies from 1,006 to 1,040 feet above sea level, increasing gradually in altitude from the south to the north. Other elevations are Mondamin, 1,025 feet; California, 1,011 feet; River Sioux, 1,040 feet; Missouri Valley, 1,006 feet; and Modale, 1,016 feet; all on the Missouri River bottoms. On the terraces and

uplands are Dunlap, 1,097 feet; Woodbine, 1,058 feet; Logan, 1,033 feet; Yorkshire, 1,135 feet; and Persia, 1,167 feet.

The alluvial lands are extensively developed in the Missouri River Valley and in its many tributary valleys. They are largely first-bottom land, most of which is not subject to overflow.

Terraces or second bottoms are practically restricted to Boyer, Soldier, and Willow Rivers, where they occur as prominent benches from 5 to 50 feet high, the highest being along Boyer River, where flat benches are from 30 to 50 feet above the stream channel. The few distinct benches along Missouri River skirt the base of the bluffs; most of them are low and gradually merge into the bottoms, and they vary from one-eighth to one-half mile wide and from one-fourth mile to $1\frac{1}{4}$ miles long. Practically no sand or gravel is present on or under any of the terraces in the county, as they consist almost wholly of silt and clay.

The first-bottom lands comprise about 44.5 per cent of the total area of the county. All first bottoms are above overflow except narrow strips along the smaller creeks and branches. Before deepening and straightening the channels of Boyer, Willow, and Soldier Rivers, and Mosquito, Pigeon, Allen, and Steer Creeks, thousands of acres of first bottoms along these streams were overflowed annually, causing serious crop damage. Bottom lands along streams tributary to Missouri River range from narrow ribbonlike strips from 75 to 100 feet wide to broad bottoms from 1 to 2 miles in width. Along Missouri River the bottoms are from $5\frac{1}{2}$ to 10 miles in width.

The entire county is in the Missouri River drainage basin.

An intricate network of drainage lines forming many deep valleys, and dividing and subdividing, ramify all parts of the upland. All the principal drainage channels follow a general southwesterly course to the Missouri River lowlands, through which they originally cut winding courses to the main channel. Straightened artificial channels now carry this upland drainage water and prevent flooding of the Missouri River bottoms, which was frequent and destructive before the channels were straightened.

The valley of the Missouri River is divided into two plains, one subject to frequent change by periodic flood waters and the other lies well above overflow. The first plain, directly along the channel, consists largely of mud flats, interspersed with barren patches of sand, sand ridges, hummocks, and dunes from 1 to 10 feet high, all subject to constant reworking by wind and water. Dense clumps of willow and sparse growths of cottonwood cover much of this lowland, whose areas range from one-fourth mile to nearly 2 miles wide. The outer irregular border is frequently changed by the shifting of the river channel.

The second plain lies from 5 to 15 feet higher, from 20 to 30 feet above normal low water, and well above overflow. This plain is from 5 to 9 miles wide and extends to the bluffs. Except for occasional ridges parallel to old or present stream courses, it is flat and monotonous. Sand is encountered under the heavier soils at depths ranging from $2\frac{1}{2}$ to 10 feet over a large part of this plain. Serious damage is done at times by the undermining action of the water and the carrying away of large areas of land. A few low, narrow

terraces from one-eighth to one-half mile wide and from one-fourth mile to $1\frac{1}{4}$ miles long lie at the base of the bluffs; some on distinct benches, but most of them low, and gradually merging into the first bottoms.

Forested areas occur along stream slopes, deep ravines, and gulches, and a few groves on the ridges and divides, mainly in the western part of the county. Considerable belts of forest occur on the Missouri River bottoms but are restricted to within 2 miles of the river channel. Harrison County is said to have more native forest than any other Iowa county in the Missouri River basin.

Harrison County was organized in 1853. The first exploring expedition to visit this region was that of Lewis and Clark in 1804, 44 years before the first white settlers located near the present village of Calhoun on the Missouri River bluff line. The early settlers came largely from eastern and southern Iowa, Missouri, Illinois, Ohio, and adjacent States.

The present population of the county as reported by the 1920 census is 24,488, of which 20,503 is rural. Practically all the population is native white. People of German, Danish, and Irish descent predominate. The populations of incorporated towns, as given in the 1920 census are: Missouri Valley, 3,985; Dunlap, 1,455; Woodbine, 1,463; Mondamin, 508; Little Sioux, 436; Pisgah, 421; Persia, 380; and Magnolia, 299. Logan, the county seat, located approximately 3 miles southeast of the center of the county, has 1,637 inhabitants. The rural population comprises 83.7 per cent of the total and has an average density of nearly 30 persons to the square mile. It is fairly evenly distributed but is somewhat less dense for about 2 miles east of the bluff border and in the lower Missouri River bottoms, which are subject to frequent overflow. About 56 per cent of the people live outside of incorporated towns and villages.

Agriculture is the most important industry of the county and furnishes employment to the greater part of the working population, but a considerable number of men are employed in the railway shops and roundhouses at Missouri Valley, which is a division point of the Chicago & North Western Railway. Grain elevators, creameries, and cream-buying stations are located in nearly every town.

Railway transportation facilities are adequate, few farms being more than 8 miles from a shipping point. The Chicago & North Western Railway and the Illinois Central Railroad follow the Boyer River Valley diagonally across the county from northeast to southwest, serving Dunlap, Woodbine, Logan, and Missouri Valley. Washington Township in the extreme southeastern corner of the county is crossed by the Chicago, Milwaukee & St. Paul Railway, and the Chicago Great Western Railroad cuts its extreme southeastern corner. The Chicago & North Western Railway runs north from California through the center of the Missouri River Valley bottoms to Sioux City, serving Modale, Mondamin, and River Sioux, and a branch of this railway extends from Mondamin northeastward through Soldier River Valley and serves Orson and Pisgah.

All roads are of dirt construction. The Lincoln Highway crosses the county from northeast to southwest closely following Boyer River Valley. The State road from Council Bluffs to Sioux City passes

through the western side of the county through the Missouri River Valley bottoms and follows the bluff line in the southern half of the county. Another main State road runs in a general east and west direction nearly across the center of the county and joins the Missouri Valley Bluff road east of Mondamin. County roads are usually graded and are kept in condition by dragging.

Rural mail routes and telephone lines serve all parts of the county. Excellent rural schools are located conveniently to most farms, and a number of consolidated schools in towns serve a large rural community. Many country churches are scattered in convenient locations over the county.

Omaha and Sioux City are the principal outside markets for livestock and agricultural products.

CLIMATE

The climate of Harrison County is characterized by a wide annual range of temperature. Winters are moderately cold and summers warm with short periods of excessive cold and heat common in their respective seasons, but usually not sufficiently protracted to injure crops materially. The mean temperature of the summer is 72.2° F. and for winter 23.6°. The highest recorded temperature is 110° and the lowest -35°. The yearly mean is 49.4° F.

The mean annual precipitation at Logan, about 3 miles southeast of the center of the county, is 32.23 inches. Rainfall is well distributed and usually sufficient for the production of excellent crops. The heaviest precipitation occurs in May, June, and July. Hailstorms sometimes cause considerable damage over small areas, usually moving in narrow belts about a mile wide. In the wettest year, 1881, the rainfall was 56.6 inches and in the driest year recorded, 1894, it was 16.79 inches. Snowfall averages 30.8 inches for the year. In the rougher areas drifts frequently cause temporary blocking of roads.

The date of the latest killing frost on record is May 25 and for the earliest, September 12; but the average date of the last frost in the spring is May 3 and of the first in the fall, October 4, giving an average frost-free season of 154 days. Fall plowing, however, frequently extends to December 1, and spring work starts about March 15 or 20. The grazing season normally covers about six months. The season is sufficiently long to allow maturing of all crops common to this region.

The data in the accompanying table, giving the normal monthly, seasonal, and annual temperature and precipitation for Harrison County, have been compiled from records of the Weather Bureau station at Logan, situated at an elevation of 1,035 feet.

Normal monthly, seasonal, and annual temperature and precipitation at Logan

[Elevation, 1,035 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1881)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	25.4	66	-27	1.13	1.14	1.90	6.0
January.....	20.3	63	-35	1.00	.74	3.10	7.0
February.....	25.0	74	-34	1.19	.70	5.30	8.3
Winter.....	23.6	74	-35	3.32	2.58	10.30	21.3
March.....	37.2	89	-13	1.66	.40	2.40	5.0
April.....	50.8	95	14	2.79	1.88	5.40	1.5
May.....	61.3	100	21	4.24	.55	9.30	Trace
Spring.....	49.8	100	-13	8.69	2.83	17.10	6.5
June.....	69.8	102	36	5.18	3.75	5.10	.0
July.....	74.2	110	35	4.41	4.41	9.50	.0
August.....	72.7	108	37	3.69	1.99	1.20	.0
Summer.....	72.2	110	35	13.28	6.15	15.80	.0
September.....	65.7	100	19	3.16	2.22	5.30	.0
October.....	52.2	92	8	2.38	3.01	6.60	.7
November.....	37.3	80	-10	1.40	.00	1.50	2.3
Fall.....	52.1	100	-10	6.94	5.23	13.40	3.0
Year.....	49.4	110	-35	32.23	16.79	56.60	30.8

AGRICULTURE

The first permanent settlers in the county arrived in 1848 and located on the more rolling lands and slopes adjacent to the larger streams. The first settlements were near the bluffs where these stream valleys opened on the wide lowlands of the Missouri River Valley. Building materials and fuel were obtained from the heavily forested hill slopes and ravines. Gradually the settlers moved up these streams and out on the prairie uplands, which were covered with prairie grasses. Agriculture has progressed steadily during the last 75 years, with only slight changes in character. The growing of staple field crops, together with the raising of livestock, has always been of major importance.

The greatest development in farming took place during the decade between 1880 and 1890 when the proportion of the county in farms increased from 57 to 88 per cent; and although the increase since that period has been slower, it has been steady. The census of 1920 reports 93.2 per cent of the county in farms. The trend of agriculture is shown in the following table of acreages and yields of the various crops since 1879, as reported by the census:

Acres and production of principal crops in 1879, 1889, 1899, 1909, and 1919

Crop	1879		1889		1899		1909		1919	
	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels
Corn.....	93,377	4,363,991	139,600	5,998,247	146,903	5,752,130	151,114	5,757,312	143,515	5,041,567
Oats.....	4,941	156,725	21,002	665,145	20,936	711,860	23,987	562,133	29,183	855,384
Wheat.....	18,879	240,093	7,391	107,757	54,384	768,030	27,457	396,019	53,543	648,406
Rye.....	525	8,271	493	8,560	478	7,640	298	4,395	389	4,578
Barley.....	227	3,910	2,727	70,859	1,211	33,450	3,391	66,058	2,146	49,856
Potatoes.....		63,472	1,665	169,752	2,017	239,333	1,746	166,442	1,156	58,371
Hay and forage.....	20,304	43,933	40,491	77,577			41,958	77,626	41,011	91,524
Timothy.....							4,853	7,683	2,118	3,111
Timothy and clover.....							15,376	22,602	4,045	5,770
Clover.....					2,620	4,318		2,826	1,917	2,718
Alfalfa.....					148	411	5,025	14,573	19,197	47,288
Other tame grasses.....					11,242	23,301	1,288	2,788	897	1,869
Wild or prairie grasses.....					21,790	41,501	12,519	24,464	6,449	11,561
Grains cut green.....					384	867	465	664	3,218	6,421
Legumes for hay.....									408	545
Silage crops.....									1,002	8,106
Coarse forage.....					216	554	574	2,026	1,760	4,135
Apples.....			Trees 47,085	Bushels 70,525	Trees 151,673	Bushels 47,320	Trees 126,295	Bushels 230,898	Trees 49,942	Bushels 55,400
Grapes.....					Vines 12,763	Pounds 17,300	Vines 21,491	Pounds 184,388	Vines 18,663	Pounds 141,418
Berries.....					Acres 68	Quarts 73,430	Acres 92	Quarts 144,481	Acres 72	Quarts 35,306

The present system of farming in the county consists of the production of grain and hay combined with the raising of livestock. Dairying is carried on to some extent.

Corn has been the leading crop from the time of the earliest agriculture in the county. The annual average yield per acre for the five census years from 1879 to 1919 has shown a steady decline, as follows: 1879, 46.7 bushels; 1889, 43 bushels; 1899, 39.2 bushels; 1909, 38.1 bushels; and 1919, 35.1 bushels. The State census gives the average acre yield for 1921 as 43 bushels; for 1922, 46 bushels; for 1923, 43 bushels; and for 1924, 26 bushels. When corn is grown after sweet clover and alfalfa, the yields range from 50 to 55 bushels per acre. Reid Yellow Dent is the most popular variety, and Iowa Silvermine ranks second. Seed is largely grown and improved locally. Prior to the last five years practically all the corn was fed on both upland and lowland farms, but at present a considerable quantity is shipped out, especially from the bottom lands, and corn is marketed largely in Omaha and Council Bluffs. Eighty per cent of the marketed corn is shelled. Some sweet corn and pop corn are grown for home consumption and local markets.

Oats are grown on a majority of farms chiefly as a nurse crop for alfalfa and sweet clover. Iowa 103, Iowar, Iowa 105, Kherson, and Green Russian are the favored varieties in order of their importance. The State census for 1922 gives only 26 bushels per acre as the average yield, but normally the acre yield will average between 30 and 35 bushels. This crop is practically all fed to horses and hogs. Damage is caused occasionally by smut and rust in some sections.

Wheat is grown as a cash crop on the heavier soils on the Missouri River bottoms and in the southeastern corner of the county. Winter wheat is largely grown, and not much winterkilling has been experi-

enced. Turkey, Kanred, and Kharkof are the principal varieties of winter wheat. Spring wheat is practically all Marquis. According to the State census of 1922, the average yields are 22 bushels per acre for winter wheat and 14 bushels for spring wheat. Most of the wheat is shipped to Omaha and Council Bluffs. On the bottom lands much of the wheat and oat straw is burned, but on the uplands it is used for bedding livestock, and a small quantity is baled and sold.

Barley is grown in small acreages and fed to hogs and chickens. The State census reports 2,012 acres in 1922, and the 1925 Federal farm census reports 1,464 acres, yielding 32,760 bushels in 1924. Rye, emmer, and buckwheat are grown to a small extent. Hay and forage crops are very important. According to the 1925 Federal farm census 71,527 tons of hay were cut from 30,491 acres in 1924. Of this hay, alfalfa was cut from 18,759 acres; sweet, crimson, and Japan clover from 2,641 acres; other clovers from 652 acres, timothy and clover mixed from 1,985 acres, timothy alone from 588 acres, wild grasses from 3,962 acres. Wild hay is cut mainly from the low, poorly drained bottom lands and a little from the prairies. It is practically all fed on the farms. In the spring some prairie or wild hay is shipped in from Nebraska, as alfalfa is not considered a good feed for horses on heavy work.

Alfalfa is grown extensively over the entire county on both alluvial and upland soils. Most of the seed is shipped in from North Dakota and South Dakota, and a little comes from Nebraska. Most of the locally grown seed is of the Grimm and Turkestan varieties. Fall and spring seeding is practiced, with and without a nurse crop, which when used is largely oats, and from 15 to 20 pounds of seed is used per acre. Sometimes a little sweet clover is sown with the alfalfa. Good stands are nearly always obtained without inoculation, and the stand is retained for from three to five years. Three or four cuttings are made during the season with a total yield of from 2½ to 4 tons per acre, most of the alfalfa is fed to cattle, sheep, and horses, or it is pastured. About 50 carloads are baled and shipped annually, largely to neighboring counties and to the East. Acidity and poor drainage are limiting factors in the production of alfalfa and sweet clover.

The sweet clover grown is mostly of biennial varieties. Most of the seed comes from Nebraska and the Dakotas, and only a small acreage is cut locally for seed, as the seeds ripen unevenly, on the lower branches first, requiring a specially equipped binder to save the shattering seed. Considerable yellow sweet clover is grown, and more of this than of the white is cut for seed because it ripens more evenly, is smaller, and easier to handle. The white has the greater value for green manure, as the plant and root development of the yellow is smaller and finer. Most of the sweet clover is used for pasture and green manure. The first year it is cut for hay in the latter part of July; it is cured for two days and stacked. It is all fed on the farm, as it is too stemmy to be marketable. As the pasture is poor the second year the clover should be plowed under in September of the first year before the second-year buds are formed, or after growth starts in the spring of the second year. Where well plowed under and followed with thorough cultivation it will be practically eliminated and cause no trouble. Only a little

red clover is grown, because alfalfa and sweet clover have greater fertilizing and feeding values.

Dalea, a comparatively new legume with a purple flower originally discovered in Harrison and Pottawattamie Counties, grows wild along the river bottoms. It is an annual with a shallow root system, and usually very heavily supplied with nodules. It is not a pasture or hay crop but is valuable as a green manure. It decays as readily as sweet clover and has the advantage of not outgrowing and spoiling the crop of small grain with which it may be grown, and it will thrive on a slightly acid soil. It is grown on only a few farms.

Soy beans are grown mainly for hogging down and for silage, and are usually planted with corn by means of a special attachment on the corn planter. Manchu is the variety most grown for hogging down, and some Midwest is grown for silage. Black Eyebrow and Ito San are other popular varieties. Most of the seed is grown locally. Sudan grass is grown on a small acreage. It makes a heavy leafy growth, furnishes a good hay for work animals, and affords good summer pasturage. Sorghum is grown on a small acreage for feed and in Raglan and Boyer Townships is grown for sirup for local markets. Cultivated pastures are largely sweet clover or a combination of clover and alfalfa. There are very few bluegrass pastures. According to the State census, 99,972 acres were in pasture in 1922. Shepherd's-purse is the most common weed in pastures.

Potatoes are raised for local consumption. Early Ohio predominates, but some Rural New Yorker and a few Irish Cobbler are grown. The average yield is about 125 bushels per acre, although in favorable seasons yields may be as high as 200 bushels on the lighter soils along the Missouri and Soldier Rivers. From 15 to 20 carloads are shipped in some seasons, largely to commission houses at Omaha. Very little commercial fertilizer is used on potatoes, legumes are plowed under instead.

Onions are raised commercially in the section south of Modale in Clay and Cincinnati Townships, and are marketed in Omaha. Melons are grown for the local markets and some are shipped out of the county. They are raised principally on the sandier bottom lands, along the outer edge of the Missouri bottoms. Other truck crops and vegetables are grown for local markets. About one-half mile south of Mondamin an extensive truck farm is operated by a colony of Japanese.

Fruit growing is extensive in some localities and is probably best developed in Raglan Township, and to a considerable extent in St. John and Boyer Townships. Apples are the predominating fruit, but cherries, plums, and a few peaches and apricots are grown. A few fruit trees are found on nearly every farm, and commercial orchards vary in size from 5 to 40 acres or even more. Most orchards are on rolling upland light-colored soils, which are especially adapted to tree fruits. Jonathan is the variety of apple most commonly raised, and Grimes Golden, Winesap, Delicious, York Imperial, Gano, Ben Davis, Northwestern Greening, Wealthy, and Willow-twig are other common varieties, practically all of which are adapted to this section. From 50 to 70 carloads of apples are shipped out in normal seasons.

Grapes, mostly Concord, are raised for the local markets. Raspberries, blackberries, and strawberries are grown commercially for

local markets. Some raspberries are shipped from the Raglan district to Sioux City, Carroll, and to neighboring counties.

The principal weeds are cocklebur and foxtail, and dock and smartweed grow on acid soils. The most common troublesome plant diseases are corn root louse and rootworm, caused largely from lack of rotation. Dry-rot does some damage in certain seasons. Oat smut gives some trouble but can easily be controlled by the formalin treatment. Black stem rust and scab are sometimes troublesome wheat diseases.

Beef cattle, dairy cattle, sheep, and horses, are important sources of income on most farms. Hog raising is carried on extensively over the entire county. Although most of the hogs are grades, many purebred herds of Duroc-Jersey, Hampshire, Poland-China, Chester White, and Spotted Poland-China are in the county, and many purebred boars are used. Hogs, varying in weight from 100 to 150 pounds are shipped in annually from Kansas City and Omaha and fattened on alfalfa and corn which are the principal feeds, and in addition some oats and considerable tankage and oil meal are fed. For hogging down, corn planted by itself is used mostly; but a few farmers grow soy beans with corn. The large shipments of hogs are made in October, November, and December; most of them go to the Omaha markets, some to Chicago, and a few from the northwestern corner of the county to Sioux City. They are marketed through cooperative shipping associations and local buyers, but many of the larger feeders ship direct to the packing houses.

Beef cattle are next in importance to hogs. Shorthorn grades predominate and Hereford and Angus rank second. Some purebred herds are found in different parts of the county, principally Hereford and Shorthorn, and a few purebred sires are used. About 250 carloads of western feeders, weighing from 600 to 900 pounds, are shipped in through Omaha annually, usually in October, and mostly to the upland farms. Most of these animals are fed for about 90 days, and then marketed, but a few are carried through the winter on roughage and finished later in the spring on concentrates. Corn, alfalfa, and sweet clover pasturage are the principal feeds, and some oil meal and alfalfa meal are added during the finishing period. About 60 per cent of the finished cattle are marketed in Omaha, the remainder largely in Chicago. The average farmer feeds and raises about 25 head.

Dairying is carried on principally in conjunction with livestock raising. Holstein, Guernsey, and milking Shorthorn are the favored dairy breeds, and a few Jersey and Brown Swiss are raised. The average farm herd comprises 4 or 5 cows. Commercial dairy herds are located near towns; a few farmers have as many as 40 head. Alfalfa, ground corn, and some oats, silage, and oil meal are the principal feeds. The 1922 State census reports 11,097 cows and heifers. A campaign is now in progress to make the county tuberculosis free. Cream is the principal dairy product marketed, and it is sold at the cream-buying stations in the nearest town from which it is shipped to Denison, Council Bluffs, and Omaha.

Sheep raising is of minor importance. According to the State census, 2,769 sheep, predominantly Shropshire, were raised in 1922, mostly in the more hilly sections, and in small flocks. Several car-

loads of western feeders, mostly lambs weighing from 60 to 65 pounds, are shipped in about October and fattened on corn and alfalfa. "Sheeping down" standing corn is a common practice. The Omaha market gets practically the entire output. From 15,000 to 20,000 pounds of wool are clipped annually and 75 per cent of this is marketed through the Iowa Wool Growers Association. A few Angora goats are kept in the rougher parts of the county and used for clearing brush land. Small feeders in the southern and western parts of the county sell many hogs, sheep, and a few cattle on the Omaha market.

Horses on all farms, according to the State census of 1922, totaled 13,775; stallions, 19; mules, 2,237; and jacks, 19. About 8 horses are kept on the average farm, mostly light drafters and farm chunks. Percheron is the predominating breed, but some Belgian and a few Clydesdale are raised. Enough colts are raised to maintain the supply of work animals.

Poultry raising is an important source of revenue on most farms. The flocks average about 125 fowls. Rhode Island Red, Wyandotte, Leghorn, and Barred and White Plymouth Rock are the predominating breeds. Many flocks are composed of purebred fowls, but most of them are mixed. Through the activity of the local farm bureau many flocks over the county have been culled with excellent results. Geese, ducks, turkeys, and guinea fowls are raised in small numbers. Most of the poultry is shipped alive. The 1922 State census reported 344,510 fowls on the farms of the county.

Adaptation of crops to certain soils is recognized, but general farm crops are raised on nearly all kinds of soils. The heavy, black Wabash and Lamoure soils, where well drained, are the strongest corn and wheat soils; and the Marshall soils are particularly well adapted to corn and general farming and in the hilly sections are considered especially suited to tree and bush fruits. Potatoes, melons, and truck crops do better on the sandier bottom lands.

The upland soils are usually slightly acid or neutral at the surface and calcareous at depths ranging from 18 to 45 inches. On the steeper hill slopes the soil is very thin and the dark layer immediately at the surface may be missing over a considerable area, so that the calcareous material is encountered at a depth varying from 4 to 8 inches and in many places at the surface. The Missouri River bottom-land soils are predominantly calcareous, whereas those in the tributary valleys are generally neutral or slightly acid. Limestone should never be applied to these soils until a test for acidity has been made. Organic matter can be easily incorporated because of the ease of growing alfalfa and sweet clover.

Crop rotation in some form is practiced on most farms. A common rotation on the upland farms is corn, corn, small grain, and sweet clover. Where alfalfa is grown in the rotation, it is usually left from three to five years. The nurse crop is pastured in a few localities. On the heavier bottom-land soils, a four-year rotation of corn, corn, oats or wheat, and sweet clover is practiced.

Farming operations center more or less around the production of corn. The heavier bottom lands are plowed in the fall, and much of the upland is plowed in the spring. Corn is planted between May 1 and 15 and three or four cultivations are given. Nearly one-half of

the corn on the upland is listed, because this method helps to control the weeds. Some soy beans are grown with corn. Ninety per cent of the bean crop is hogged down, and the remainder is put into silos. Corn matures the latter part of September, and most of it is picked and cribbed; but probably 10 per cent is left standing in the field, into which the cattle, sheep, and hogs are turned. Oats follow corn generally and are used as a nurse crop for sweet clover and alfalfa. In preparing the seed bed for oats, some farmers use stalk cutters and others use a drag to break down the cornstalks. Forty per cent of the land is double-disked, and the seed is broadcast the last of March and the first of April. In wet years oats are cut for hay with sweet clover, as in such years the clover tends to outgrow the oats. Sweet clover is sown with wheat on the heavy gumbo soils of the river bottoms southwest of Missouri Valley. After the wheat is cut the clover is pastured and the following spring after the green growth starts it is plowed under in preparation for corn. Wheat is usually threshed from the shock and hauled immediately to the elevator.

Very little commercial fertilizer is used except in an experimental way, but has proved profitable on some wheat and truck farms. Barnyard manure is applied for corn.

The number of tractors on farms in the county is reported as 338, most of which are used on the level bottom-land farms. Light trucks are used on many farms, and 125 trucks and 2,049 automobiles are reported. In the southern and western parts of the county, agricultural products and livestock in great quantities are trucked to Omaha and Council Bluffs.

Over 64 per cent of the farms employed hired labor, usually for about eight months. Laborers hired by the year are paid from \$40 to \$50 a month, and in addition are provided with a house, garden, chickens, and a cow. During harvest extra labor is paid from \$3.50 to \$4 a day. Corn pickers get from 4½ to 7 cents a bushel. Day labor is paid an average of \$2 and board. The average amount spent for labor per year on the farms reporting was \$485.08.

Owners operate 56.9 per cent, tenants 42.5 per cent, and managers 0.6 per cent of the farms in Harrison County, according to the 1920 census report. Much of the land is rented on the grain-share basis, the owner receiving one-half the grain and from \$4 to \$8 an acre for pasture and hay land. On some farms the tenant and owner each bear half the expenses and divide the profits equally. A little land is rented for cash; the rent varies from \$6 to \$10 an acre.

Land values are influenced by many factors, location, roads, soils, general condition of fields and buildings, extent of improvements, schools, and community. The bottom-land soils currently range in price from \$25 to \$200 an acre, depending largely on the character of the soil. The rougher upland farms sell for \$30 to \$50 an acre, and the general upland farms range in price from \$85 to \$200 an acre. Especially well improved farms located close to towns bring a higher figure.

SOILS

The characteristics of the soils of any region are primarily the result of the character, intensity, and the depth to which the weathering forces have been effective. To a less extent soil characteristics

are the characteristics of the geologic materials from which the soils have developed. In rare cases only does the character of the geologic material have a preponderating influence in determining many of the characteristics of a soil. The soil-forming processes, which have been controlled to a large extent by climatic conditions, are believed to have been of much greater influence in determining the character of the soils of Harrison County than the composition of the parent material. An evidence of this fact is that the parent materials in this county are similar, but the soils differ widely. The differences which can be studied readily in the field are differences in the content of lime carbonate and organic matter, and in the texture and structure of the soils. These differences are due to differences in the intensity of the soil-forming processes which have acted upon these soils and the length of time to which the soil materials have been exposed to these forces.

The most mature soils of the county, or those which have been left undisturbed and subjected to weathering for the longest time, are found on the smooth well-drained uplands and terraces. These soils have developed a very dark grayish brown surface layer, as a result of the accumulation of a large quantity of black well-decomposed organic material composed mainly of partly decayed grass roots and intimately combined with the mineral part of the soil.

The surface layer has a single-grained or finely granular structure, being almost everywhere silt loam in texture. On the more nearly level or rolling areas this surface layer has an average depth of about 12 inches. The heavier-textured layer below is dark brown in color, but grades downward into brown. The dark color is imparted by organic matter which has been carried downward from the layer above, following shrinkage cracks, root holes, and worm and insect burrows. In position the material of this transitional layer is slightly more firm and compact than the topsoil, but is very granular when broken up, and reaches a depth varying from 18 to 24 inches. The next lower layer may be brown or yellowish brown in color and heavy silt loam or silty clay loam in texture. It is rather compact but is easily broken up and pulverized. Granulation is very indistinct, and in many places this layer is not present. At depths ranging from 45 to 60 inches this layer merges into the parent material which has been little altered by weathering, is yellowish brown or grayish yellow in color, and, in the loess areas, usually has a heavy silt loam texture. In texture and structure it does not differ greatly from the layer above.

The lime carbonate has been removed from the upper layers of the soil but is normally present in this originally calcareous parent material. On the smooth, well-drained upland, where the surface has not been lowered by erosion, leaching of the carbonates has proceeded usually to a depth of about 60 inches. Below this depth the loess contains sufficient lime carbonate to effervesce when treated with acid. On the slopes below the flat divide lime carbonate is present near the surface, the thickness of the overlying leached layers depending upon the rapidity and degree of erosion. On eroded slopes and tops of hills the leached material is thin and the light-colored calcareous loess is exposed at the surface in small areas.

The principal characteristics considered above are those imparted to soil by the soil-forming processes. In the differentiation of soils into series consideration has also been given to the source, process of accumulation, and composition of the material from which the soils have developed. The soil series, therefore, includes soils that are similar in color, origin, and structural characteristics. The soils in a series differ from each other mainly in the texture or the coarseness and fineness of the surface soil. The soil type is the unit of soil mapping.

The general characteristics which have been described are best shown in this county by the Marshall soils which have developed on the upland over the silty parent material known as loess. Two or more loess sheets have been identified in Harrison County, but only the youngest, known as the yellow loess, has been important as a soil-forming material. This loess is the surface covering of the entire upland, except in small areas where it has been removed by erosion. The original loess sheet was evidently of such thickness that deep erosion might take place before the underlying rock is exposed. The maximum thickness of the deposit is along the bluffs of the Missouri River, where a thickness of 90 feet has been observed.¹

A less perfect soil development is found in small areas where the underlying drift is exposed. The Kansan drift, which consists of beds of light-gray or blue clay interspersed with beds of sandy clay, presumably underlies the uplands, but it is buried so deeply by the loess that only small areas along the steeper stream slopes have been exposed to weathering. At a depth of several feet large amounts of lime remain in the drift material and indicate the calcareous nature of the original deposit, but in this county the upper weathered layers of the soil are thoroughly leached and lime rarely, if anywhere, occurs within 3 feet of the surface. Other drift sheets underlie the Kansan drift and contribute materials which modify the soils in small areas, but the exposures are in no place of sufficient size to produce any considerable areas of distinctive soils. In Harrison County only one type of soil, Carrington loam, has developed over the Kansan drift. It has very dark grayish-brown loam surface soil, a transitional layer of dark-brown silty clay, and a subsoil of yellowish-brown silty clay loam material. The parent material at a depth varying from 24 to 30 inches is brown sandy or gravelly clay.

The Judson and Hancock soils, developed over deep colluvial or slope deposits, also belong to this group of soils which have dark surface layers and well-drained and well-oxidized lower layers. These are young soils and owe their dark color to organic matter brought down in sediments from other dark-colored upland soils. The soils of these two series differ principally in their lime content, the Hancock soils being highly calcareous and the Judson soils comparatively poor in lime carbonate.

The parent material of the alluvial soils of the county consists of sediments brought down from the uplands and deposited on the flood plains. The greater part of the Missouri River alluvium is composed of reworked drift and loess materials similar to the soil

¹ COLVIN, SAMUEL. IOWA GEOLOGICAL SURVEY. Vol. XX. Annual Rept. of the State Geologist. 1909.

materials of the upland areas, and the alluvial deposits along the shorter streams which have their sources within the area consist of sediments derived entirely from local materials. The older alluvial deposits left as terraces by the lowering of the stream beds have undergone the same processes of weathering as the upland soils and have developed similar characteristics. Thus, Waukesha silt loam, which has developed under conditions of good drainage, has reached the same stage of development as the Marshall silt loam of the uplands.

A second important group of soils has developed in the north-western part of the county on the eroded slopes along Missouri River and its principal tributaries. In these areas erosion has prevented the accumulation of large quantities of organic matter in the surface soil. A forest growth covered the eroded slopes, so that soils characteristic of forested areas have resulted.

The soils in these forested areas are thinner and lighter in color than the soils of the smooth upland. The usual color of the surface layer is light grayish brown, the texture is silt loam, and the structure is single grained. The depth to which the surface soil has accumulated depends on the rapidity of erosion and varies from a very thin covering on the steep slopes and tops of knolls to about 8 inches on the more level areas. The topsoil is underlain by a slightly more compact, heavier, brown or yellowish-brown layer, which in most places reaches a depth not greater than 18 inches and in many places is very thin and not distinctly developed, and the surface soil apparently rests on the parent material. Where this layer is thick, the structure may be granular, but in many other places this structure is not distinctly developed. The next lower horizon is the parent material, which, in the Knox silt loam, the only representative of this group in the county, is loess. The material of this horizon is a yellowish-brown silt similar to that of the lower horizon of Marshall silt loam. It shows no granulation but is soft and structureless. Lime is present in abundance and in eroded areas occurs very near the surface.

The soils of a third group which were developed under conditions of poor surface or subsoil drainage in this county are confined to the lower alluvial lands. The surface soils are black and have a fine granular structure, and the gray or mottled gray and yellow subsoils are heavier in texture than the surface soils. The profiles of these soils vary widely, depending on the character of the alluvium from which they have developed and the depth to which oxidation has penetrated. The soils which constitute the lower bottom lands vary widely in texture, as the parent materials consist of alternating beds of gravel, sand, silt, and clay. In most places sufficient time has not elapsed for the development of soil layers and in places the streams are constantly changing the character of the soils by deposits of new sediment. The Wabash and the Lamoure soils of the first bottoms belong to this group of poorly drained soils. Where lime has been removed to a depth of several feet, the soils have been classed in the Wabash series; where lime is present, in the Lamoure series. The Cass series includes low-lying alluvial soils which have sandy or gravelly subsoils. The Sarpy soils have similar textural profiles, but the surface soils are light colored.

In the following pages of this report the soils of the county are described in detail; their distribution is shown on the accompanying soil map; and the following table shows their acreage and proportionate extent:

Acreage and proportionate extent of the soils of Harrison County

Type of soil	Aces	Per cent	Type of soil	Aces	Per cent
Marshall silt loam	202,432	45.8	Sarpy silt loam	5,120	} 1.6
Waukesha silt loam.....	7,104	1.6	Deep phase.....	1,920	
Lamoure silt loam.....	11,008	2.5	Sarpy silty clay loam, deep phase.....	384	.1
Lamoure silty clay loam.....	11,392	2.6	Sarpy silty clay.....	4,992	1.1
Lamoure silty clay.....	28,544	6.5	Sarpy very fine sandy loam.....	2,816	.6
Wabash silt loam.....	41,280	} 15.0	Sarpy fine sand.....	832	.2
Colluvial phase.....	27,328		Carrington loam.....	1,280	.3
Wabash silty clay loam.....	9,408	2.1	Judson silt loam.....	5,312	1.2
Wabash silty clay.....	14,272	3.2	Ray silt loam.....	512	.1
Knox silt loam.....	29,632	6.7	Hancock fine sandy loam.....	64	.1
Cass silt loam.....	10,752	2.4	Riverwash.....	4,672	1.0
Cass silty clay loam.....	11,584	2.6			
Cass silty clay.....	8,000	1.8	Total.....	442,240	
Cass very fine sandy loam.....	1,600	0.4			

MARSHALL SILT LOAM

The surface soil of Marshall silt loam, to a depth of about 5 inches, is very dark grayish-brown, friable silt loam, which appears almost black when wet. The structure is granular (the granules are very small), and the interstitial material is loose silt. The subsurface layer is uniformly dark like the surface layer and consists of a very slightly heavier silt loam. This material is firmer when in position than the surface soil but can be easily broken, when it falls apart into granules slightly larger than those of the surface soil. The average thickness of this layer on the smooth upland is about 7 inches. The combined thickness of the two dark-colored layers varies according to position, as the rapidity of erosion determines the accumulation of the black organic matter; but the combined depth of the two layers on the smooth almost level interstream divides is about 12 inches. The topsoil is thin on the slopes, and over small areas on steep slopes and on the tops of sharp knolls and ridges it may be entirely lacking and the brown subsoil exposed.

The upper part of the subsoil has a dark grayish-brown color which changes gradually with depth to a lighter shade. A close examination shows that the dark color which occurs in indistinct tongues and streaks, that decrease in size downward, consists of a coating of black organic matter over the granules or on breakage plane surfaces, which has penetrated downward from the surface soil, following cracks, root holes, and worm and insect burrows. In the lower part of this layer the granules are larger, more distinct and well formed than above. This transitional layer continues to depths ranging from 18 to 25 inches where it grades into grayish-brown, heavy silt loam material which continues to a depth varying from 25 to 35 inches. The granulation decreases in distinctness with increasing depth and ends with this layer. At a depth of about 35 inches a marked change occurs. The color is grayish yellow or yellowish brown, and the material is soft, friable, and structureless, and breaks into irregular lumps or

clods. Some leaching is presumed to have taken place, as the material is lacking in carbonates. This is underlain by the unweathered, unleached, parent material, which consists of loose, structureless, grayish-yellow or yellowish-brown silty material, or loess. It contains sufficient lime carbonate to effervesce freely when treated with acid, and small lime concretions are found in the upper part of the layer.

This soil is found over all of the upland of the county except where a lighter-colored loessial soil, Knox silt loam, occurs as a narrow strip from one-fourth to 2½ miles wide on the bluffs which skirt the Missouri Valley. It is the most extensive soil in the county, constituting almost 46 per cent of its total area. Areas of Marshall silt loam were formerly prairie, and was once a level plain; but it is now deeply cut by an intricate network of drainage ways, and the surface features vary from undulating to hilly. A few of the divides in the eastern part of the county have flat tops with poor natural drainage, but these cover only from 3 to 15 acres. The more hilly and rough areas are found in eastern Jefferson Township and in the western part of Cass, La Grange, Magnolia, Allen, and Lincoln Townships; and some very hilly areas from 50 to 100 feet in elevation, occur in western Boyer and Jackson Townships. The surface soil on some of the steeper slopes is very thin and in places has been entirely carried away, exposing the lighter-colored subsoil. Some of these areas are of fair size and others occur as narrow continuous strips on the hillsides. The soil of these areas resembles the Knox soils. Drainage over practically all this soil is thorough, and even excessive on the steeper slopes, where gullies are formed if proper care is not taken. One heavy rain may cause the formation of gullies from 2 to 5 feet deep.

Marshall silt loam is fertile and has good moisture-holding capacity, and only on the thinly covered hill slopes and eroded spots does drought seem to affect crops seriously.

The stream slopes and rougher ridges were once heavily forested, but much of the timber has been removed and most of that remaining is restricted to patches on the steep stream slopes. All of this soil, except the forested slopes and adjacent upland bluffs, is under cultivation and produces the staple crops or pasture grasses.

Corn, oats, alfalfa, and sweet clover are the principal crops. Reid Yellow Dent and Silvermine are the principal varieties of corn. The average yield is about 43 bushels per acre normally, but yields of about 50 bushels are obtained where it follows sweet clover and alfalfa. This soil is particularly well adapted to sweet clover and alfalfa because of the excellent natural drainage and calcareous subsoil, and good stands are easily obtained over most of the county without liming or inoculation. Oat yields average about 30 bushels per acre. The acreage of oats is comparatively small, about 1 acre to every 4 of corn. The oat crop is used largely as a nurse crop for sweet clover and alfalfa, and is frequently cut for hay where sown with sweet clover. Cultivated pastures are largely sweet clover or a combination of alfalfa and sweet clover. Very little wheat is grown on this soil (most of it in the southwest corner of the county), and yields of about 22 bushels an acre are obtained. Very few soy beans are grown because of the abundance of clover and alfalfa.

Sorgo (sweet sorghum) is grown mainly for home use, and some sirup is made for local markets in Raglan and Boyer Townships.

Small truck gardens around towns and many farm gardens supply the local demand for vegetables. Orchardng is carried on extensively, small plantings being found on many farms. Commercial apple orchards range in size from 5 to 40 acres; the largest is in Raglan Township and other large commercial orchards are located near Missouri Valley, Logan, Woodbine, and in all parts of the county. Small forests and tree fruits thrive on this land. Small fruits are grown for the local markets, and some are shipped to the larger markets from Raglan Township.

Cattle and hog raising and feeding are the most important livestock industries. Some sheep are raised chiefly in the rougher sections. Dairying is carried on to some extent. The larger herds are found near towns, whose dairy products supply the local demand. A considerable quantity of alfalfa is shipped to the neighboring counties and to Omaha.

Practically no commercial fertilizers are used on this soil, but barnyard manure is applied on corn ground in the spring and on pasture sod. Sweet clover and alfalfa are used extensively as green manures.

Marshall silt loam is mellow, easy to plow, and can be cultivated under a wide range of moisture conditions. It is naturally fertile, but most of it is below its maximum productivity because of leaching, erosion, and poor crop rotations, poor because they do not include sufficient legumes to maintain the organic matter. Neither droughts nor wet periods of normal duration seriously affect the crops, owing to the compact, friable, and naturally well-drained subsoil.

Some system of cropping is practiced on all farms. The most common is corn for 2 or 3 years, followed by oats, then alfalfa or sweet clover. Alfalfa is usually left from 2 to 4 years, but sweet clover is ordinarily left only 1 year. The white biennial sweet clover is used in preference to the yellow because of its greater value for green manure. Very little red clover is grown because of the natural adaptability of sweet clover and alfalfa to this soil.

The current value of Marshall silt loam is from \$100 to \$200 an acre, depending on location, improvements, and general condition of the farm. Well-improved farms adjoining towns sell for a much higher figure.

Greater care should be used in selecting a rotation on many farms where the steeper slopes are subject to washing. Deeper plowing, better preparation of the seed bed, the cropping of alfalfa over long periods, together with contour plowing on these steeper slopes, tend to check erosion and help maintain fertility.

WAUKESHA SILT LOAM

Waukesha silt loam has very dark grayish-brown surface soil about 18 inches thick, the upper 5-inch layer of which contains more loose silt among the fine granules than does the lower part, which is made up almost entirely of granules. This surface layer is underlain by a layer of very granular silt loam, or in places heavy silt loam material. The color changes downward from very dark grayish brown to brown. At a depth varying from 24 to 36 inches is a layer

yellowish brown in color and silty clay loam in texture about 12 inches thick and which may be underlain by sandier material or stratified beds of material of various textures. Beds of sand and gravel are found in a few small areas.

Waukesha silt loam occurs on well-drained terraces and, where typically developed, it is similar to the Marshall silt loam of the uplands.

Because of the small total acreage, a few patches of lighter-colored soils have been included in mapped areas of Waukesha silt loam. The soils in these patches are all calcareous and occur where the original darker surface materials have been removed by erosion. The town of Calhoun is located on the only area of this soil, along the Missouri River Valley bottoms. The total acreage of this light-colored soil is less than 100 acres. Another inclusion with Waukesha silt loam is a calcareous soil in which both topsoil and subsoil are calcareous. It has developed in narrow continuous strips from 50 to 200 feet wide on the edge of the terraces and slopes which adjoin the first-bottom lands. The surface soil resembles that of the Waukesha silt loam, but on the whole is thinner, and the subsoil is exposed in many places on the steeper slopes adjacent to the stream bottom. Considerable coarse sand and gravel, deposited by flood waters, also occur along these slopes.

Waukesha silt loam is the most widely developed terrace soil in the county, comprising probably 85 per cent of all terrace soils. The most extensive areas are found along Boyer River, from its entrance into the county to the Missouri River Valley plain, into which this stream cuts. It occurs on distinct benches from 5 to 30 feet above overflow. Smaller areas are found along Willow River, usually from 5 to 10 feet above overflow, and along Soldier River northeast from Orson to the county line. The benches along Soldier River lie from 15 to 30 feet above the first bottoms, and the color of the surface soil is lighter than typical.

Waukesha silt loam occurs on flat alluvial terraces, which usually have a very gentle slope toward the stream channel. The areas vary in width from a few hundred feet to three-quarters of a mile, and are in continuous bodies or strips from one-fourth of a mile to 3 miles long. Streams issuing from the adjoining uplands dissect these flat benches in places.

The natural drainage is good, except in a few sags and small depressions where the drainage is slow. Some trees formerly grew on some of these areas, but all have now been cleared, and the land has all been brought under cultivation.

The crops, yields, and general methods of cultivation are the same as those on Marshall silt loam, but are slightly higher on some of the better-improved and deeper soil. This soil has excellent physical properties, is naturally fertile, and is little affected by seasonal extremes as regards moisture.

The selling value varies with improvements, location with respect to markets, and condition of the soil. Farms located wholly on this soil are currently valued at from \$100 to \$175 an acre, but a few farms especially well located and improved bring \$200 or \$250 an acre.

Incorporation of more organic matter through the growing of alfalfa or sweet clover is needed on some of the areas of shallower and lighter-colored soils which are included in mapped areas of this type. Barnyard manure is applied, but not enough is available to maintain fertility on most farms. Inoculation is occasionally necessary on this soil for the successful growing of legumes.

LAMOURE SILT LOAM

The topsoil of Lamoure silt loam varies from very dark grayish-brown to black heavy silt loam with a finely granular structure. The subsoil is granular grayish-brown silty clay loam material which, below 24 inches, is more variable, the color varying from grayish brown to dark gray mottled with yellowish brown and rust brown. The material below a depth of 24 inches is clay loam or clay. In a few places thin beds or pockets of sand or silt are found at depths below 24 inches. In nearly all areas the soil is calcareous from the surface down.

Lamoure silt loam is rather extensively developed, the largest areas occurring along Willow and Soldier Rivers. Along both rivers, particularly Willow River, the surface soils when dry are slightly lighter in color than the typical dark-colored Lamoure soils. A number of widely scattered areas occur on the Missouri River bottoms. In many places the subsoil is only slightly heavier than the topsoil. The soil in a large area southwest of Calhoun varies greatly in texture, as here a considerable quantity of alluvium from Willow River was deposited before its channel was straightened.

The land is nearly flat with a slight incline toward the stream channel. Because the stream channel along both Willow and Soldier Rivers has been deepened and straightened and rough and uneven strips border both the old and new channels, surface drainage and underdrainage are efficient, except in a few shallow basins. This improvement of the drainage has prevented the periodic overflows, except in small areas toward the stream heads which are flooded only partially and at rare intervals.

This soil is practically all under cultivation, except for an occasional narrow strip along the stream channel, which bears a scant forest growth. These areas are used for pasture.

Corn is the principal crop and is often grown for several years in succession. Much of it is sold, but most of the crop is used for feed. Some oats, alfalfa, and sweet clover are grown. Corn produces from 30 to 65 bushels per acre, and hay from 2 to 3 tons. Some truck gardening is done, principally along Soldier River.

This soil is mellow, easy to cultivate, and withstands drought reasonably well. No definite rotation is practiced. Barnyard manure is applied on corn ground, but no commercial fertilizers are used.

Land values are variable, being governed by location and improvements. Usually some hilly land or terrace land is included with the farms. The selling price in 1922 ranged from \$75 to \$160 an acre.

The organic matter should be increased by growing and plowing under legumes, as available barnyard manure is not sufficient. In some fields the crops in shallow, depressed areas suffer some damage

from standing water after heavy rains. These areas should be drained.

LAMOURE SILTY CLAY LOAM

Lamoure silty clay loam to an average depth of 10 inches is dark grayish-brown or black heavy plastic silty clay loam, underlain to a depth of 24 inches by dark-brown or black plastic silty clay or clay loam. This is underlain by light grayish-brown or yellowish-brown clay loam material or silty clay. The intermediate layer is usually only faintly calcareous, but the lower part of the subsoil is highly so, because many lime nodules are present between depths of 24 and 36 inches. The surface soil effervesces with hydrochloric acid in only a few places.

This soil occurs in fairly large areas in the Missouri River bottoms from Little Sioux southward to the Pottawattamie County line. A few areas are found along Soldier River from the Monona County line to its entrance into the Missouri River Valley, and a few small areas have been mapped along Willow and Boyer Rivers. Along Boyer River many small areas which could not be shown on a map of this scale were included in mapped areas of Wabash silt loam. Colluvial silt from the upland hill slopes is found along the edges of areas along the smaller streams.

This soil usually occurs on the outer edge of the bottoms nearest the upland slopes. In some of the undrained flat or depressed areas water stands for some time after heavy rains. Drainage is poor, and tiling is necessary in many places before the soil can be cultivated. Wild hay is cut from a few undrained areas. Staple farm crops give excellent yields, where the soil is properly drained and cultivated. Corn is the principal crop, and wheat, alfalfa, sweet clover, and oats rank in importance in the order named. Corn yields from 35 to 70 bushels to the acre; wheat from 17 to 35 bushels, and alfalfa from 2½ to 4 tons of hay. Oats are used as a nurse crop for legumes and are often cut with sweet clover for hay. They yield from 20 to 45 bushels an acre, depending on the season. On many farms corn is grown on the same field for several successive years. Some of the smaller areas along the tributary drainage ways are used for pasture.

This soil is fertile when it is well drained and tilled. Care must be taken to plow and cultivate this land under proper moisture conditions, otherwise clodding or baking of the soil may result. Fall plowing is commonly practiced, as the consequent weathering breaks the soil into fine granules, and thus makes a better seed bed. The disk harrow is ordinarily used on the seed bed before planting. Manure is applied but is available only in small quantities. Very little commercial fertilizer is used.

A few small areas, consisting of narrow strips at the edge of formerly ponded areas, are affected by alkali. Plowing under liberal applications of barnyard manure and tiling would aid in correcting this condition. Special crops could be grown on these alkali spots but because of their small extent such crops would be unprofitable.

The current value of farm lands comprising Lamoure silty clay loam varies from \$100 to \$200 an acre. The value is governed by

general improvements, location, and drainage, the latter being an important factor.

The primary factor in obtaining maximum yields on this soil is thorough drainage. Deeper plowing and the incorporation of green manures, crop residues, and barnyard manure will improve the physical condition of the soil, as well as stimulate crop production.²

LAMOURE SILTY CLAY

Lamoure silty clay consists of very heavy, plastic, black silty clay, which is underlain at a depth of 16 or 18 inches by grayish-brown or drab impervious clay. Mottlings of brown and reddish brown (iron stains) occur in many places in the lower part of the subsoil. The surface soil is characteristically free from grit and not highly calcareous, giving a lime reaction in only a few places. In places lime nodules are found near the surface and concretions abound in the lower part of the subsoil. Local variations occur usually as layers of silt 3 or 4 inches in thickness. Sand is encountered in areas on the Missouri River bottoms at depths ranging from 3½ to 40 feet. Where the sand is nearer the drab clay subsoil, less gray and more brown mottling is found.

This first-bottom soil is restricted to the Missouri River Valley plain. The largest area is at the bluff base along Allen Ditch in Taylor Township, which extends over an area more than 6 miles long and about 2 miles wide. Other extensive areas are found in the vicinity of California, north and northwest of Little Sioux, and smaller areas are widely scattered over the bottoms. The area near Little Sioux is flat and has an underlying base of sand at a depth varying from 3½ to 8 feet.

Lamoure silty clay occurs in large depressed flats which are almost level but have an almost imperceptible slope from all sides toward the center. Owing to the heavy texture of the surface and sub-surface material, and to the position, natural drainage is poor. Many of the areas near the bluffs are now inadequately drained. In a few places, during seasons of heavy precipitation, water stands on the surface nearly all the time, making these areas unfit for cultivation. Swamp symbols show these shallow ponded areas. Deep drainage ditches are cut through the larger bodies of this soil forming an outlet for surface and tile drainage. Formerly waters from the upland drained into the natural depressed basin along the bluff line and formed a wide swampy area which was impossible to cultivate. Allen Ditch takes care of most of this run-off, so that there is very little inundation at present. The flood waters from Missouri River do not cover this soil, and only small areas where the removal of the surface drainage is slow are affected by backwater.

Nearly all this soil is cultivated. Corn is grown most extensively, and on many farms it is grown for a number of years in succession. Yields range from 35 to 75 bushels an acre, but 80 and 90 bushels have been reported on small areas which have been especially well drained and cultivated. Wheat is grown in large acreages around California, and yields range from 15 to 35 bushels, depending on

² STEVENSON, W. H., and BROWN, P. E. IMPROVING IOWA'S PEAT AND ALKALI SOILS. Iowa Expt. Sta., Bul. No. 157, 1915.

seasonal conditions. Rust and Hessian fly cause damage at times. Alfalfa, sweet clover, and oats are also grown. Oats tend to grow rank and lodge when weather and moisture conditions are unfavorable. Alfalfa yields average about 3 tons per acre.

Lamoure silty clay is fertile when drained, but it can be cultivated only under a narrow range of moisture conditions, as puddling and baking result if it is plowed while too wet. Fall plowing is practiced on much of this land. Cornstalks are burned on the bottom lands along Missouri River, particularly on the heavier soils. Clean cultivation is difficult in wet seasons.

All the wheat and much of the corn grown on this soil are cash crops. Hog and cattle feeding are becoming more common.

Land values are variable, depending largely on drainage, location, and improvements. The current selling price varies from \$115 to \$200 an acre. Untiled or ponded areas have a lower value.

The greatest need of this land is thorough drainage, deeper plowing, good cultivation and seed-bed preparation, and the incorporation of green manures, crop residues, and barnyard manure to add available elements of plant food.

WABASH SILT LOAM

Wabash silt loam consists of dark-brown friable silt loam to a depth of 14 inches where it grades downward into faintly mottled brown clay loam or silty clay loam, underlain at a depth of 24 inches by a black, tough, plastic silty clay or clay. This soil is characteristically noncalcareous in both topsoil and subsoil. As with all alluvial first-bottom soils, the texture varies widely. Small patches in which the soil varies from sand to clay are scattered over the bottoms, although silt predominates.

Wabash silt loam is most extensively developed along Boyer River, and is also found along all creeks and their tributaries which dissect the loessial areas which bound the Missouri River Valley eastward to the county line. Only a few bodies are found on the Missouri River bottoms, and these are a considerable distance from the river channel.

In the areas along the tributary streams in the western side of the county which cut through the lighter-colored upland soils considerable light-colored silt is mixed with the darker soils, making the surface soil here lighter in color than typical. Along the smaller creeks and tributaries the subsoil is somewhat lighter textured, and here the surface layer of silt loam is underlain at a depth of 18 or 20 inches by silty clay loam material. Many areas and pockets in which the soil has a slightly calcareous subsoil occur along the larger creeks and Boyer River, particularly in the bottoms between Logan and Missouri Valley. Along Boyer River small patches of lighter-colored silt loam and black silty clay loam too small to separate have been included in mapped areas of Wabash silt loam.

Areas of this soil are nearly flat, with a slight slope toward the channel. Previous to the time when the channel of Boyer River and some of the larger creeks were straightened and deepened, flood waters did much damage; but flood waters are now carried away rapidly, so that little damage results from high water. Only small, narrow strips of bottom land along the smaller streams which have

natural channels are subject to overflow. Here pastures are maintained. Tiling and ditching are not necessary on most of this land. A few native trees are found near the stream banks. Most of this land is under cultivation, as it is mellow, easily tilled, and highly productive. A few of the small poorly drained areas are in permanent pasture.

Corn is the principal crop, and yields range from 30 to 60 bushels an acre, although larger yields are obtained on the better farms in especially favorable seasons. Some hay, principally alfalfa, and some wheat and oats are grown on this land. Alfalfa yields from 3 to 3½ tons per acre. Wheat and oats give fair yields but are apt to lodge in wet seasons. Native grasses furnish excellent pasturage on uncultivated areas. Truck crops are grown for home use and local markets. Very little manure and practically no commercial fertilizers are used. The natural fertility of the soil has made it possible in the past to grow corn many successive years without appreciable decrease in yield. The practice of rotating crops is on the increase.

Many farms, especially along the narrower stream bottoms, have as much or more upland soil than Wabash silt loam. The current value of Wabash silt loam varies from \$85 to \$190 an acre, depending on drainage, location, and improvements.

Wabash silt loam, colluvial phase.—Wabash silt loam, colluvial phase, is a dark-brown friable silt loam to an average depth of 18 inches, underlain by a slightly lighter colored and heavier textured friable subsoil of heavy silt loam or silty clay loam material. The depth of the topsoil varies from 8 to 40 inches. The soil material consists of dark-colored silt washed from the hill slopes and deposited along and at the heads of the smaller shallow drainage channels. This soil is found throughout the entire loessial area near the sources of the smaller streams.

The surface of this land is nearly flat. Drainage is good, owing to the looseness of the loessial material. In a few small basinlike areas at the heads of tributary streams, water may stand for a short time after rains; but such areas can be easily drained by tile, small open ditches, and in places by furrows.

This soil is all under cultivation or in pasture. All the staple crops are grown, and the yields of corn exceed those on the adjacent upland Marshall silt loam. Small grains are apt to lodge, so that they are grown very little. Alfalfa does well.

Wabash silt loam, colluvial phase, is mellow, easy to manage, holds moisture well, and is very fertile. It is usually neutral or slightly acid.

It is farmed and sold with the closely associated Marshall silt loam, and usually comprises only a small part of a farm.

WABASH SILTY CLAY LOAM

The surface soil of Wabash silty clay loam is dark-brown or black silty clay loam to a depth of 8 inches. This is underlain by a dark brown, plastic clay loam subsoil material which, at a depth of 24 inches, is very dark brown or black silty clay. In many places, a layer of lighter silty clay loam or silt loam material, from 4 to 6 inches thick, occurs at a depth varying from 8 to 24 inches. The deeper part of

the subsoil in the poorly drained or swampy spots is drab or dull-gray silty clay mottled with dull brown and gray. This soil differs from Lamoure silty clay loam in being poor in lime in both surface and subsurface layers. Areas of Lamoure silty clay loam, too small to map separately, are included in mapped areas of Wabash silty clay loam.

On the Missouri River bottoms Wabash silty clay loam is restricted to Taylor and St. John Townships, and the northeastern corner of Cincinnati Township, the most extensive area being in St. John Township. Other small areas are south of Yorkshire on Mosquito Creek, and a large depressed area is along Boyer River. On the latter area water used to stand for a considerable period after an overflow, before the channel was deepened and straightened. Many of these areas are wet and swampy for some time after prolonged rainy periods. The surface is flat or depressed, so that natural drainage is poor. Tiling is necessary to obtain effective drainage.

This soil is fertile, but must be cultivated under favorable moisture conditions to prevent cracking, puddling, and baking. About 85 per cent is under cultivation and the remainder is largely in pasture. It is managed in the same way as the Lamoure silty clay loam, and the crop yields are the same. This soil is cropped mostly to corn and some wheat, alfalfa, and oats. A little wild hay is cut from the more poorly drained areas, which yields from 1½ to 2 tons per acre.

Some barnyard manure but practically no commercial fertilizers are used. Growing and turning under more legumes would improve the tilth and fertility of this soil.

Wabash silty clay loam has about the same value as Lamoure silty clay loam. Where poorly drained depressions or ponded areas occur and are unreclaimed, the average value of the land is lowered.

WABASH SILTY CLAY

Wabash silty clay consists of an 18-inch layer of black, plastic and impervious silty clay, underlain by a subsoil of black clay which is slightly lighter in color than the material above. In places the lower part of the subsoil is dull gray or drab. In places thin layers of silt, silty clay loam, or sand occur in the soil profile. Both topsoil and subsoil are noncalcareous, differing from the Lamoure silty clay in not being calcareous in the lower part of the subsoil. Both the Wabash and Lamoure silty clay soils have black tenacious topsoils and waxy, impervious subsoils; and they are locally called gumbo.

This soil is found principally on the Missouri River bottoms, in the western part of St. John Township, in the eastern part of Cincinnati Township, and the southern part of Taylor Township. One area is located in Boyer Township along Boyer River and two small areas are located in Raglan Township. Nearly all of this soil is found in the southern half of the Missouri River Valley plain, where it occurs on a wide, depressed flat bottom, which was formerly ponded.

The natural drainage is poor, owing to the heavy impervious topsoil and subsoil, and to the flat depressed surface which prevents run-off and allows ponding. Large open ditches now carry off the excess surface water and furnish outlets for lines of tile, which are necessary

for efficient farming. Practically none of the soil at present is subject to overflow.

Corn and wheat are the predominating crops. Ordinarily corn yields from 40 to 75 bushels and wheat from 18 to 38 bushels an acre. Wheat must be grown on areas which have been well tilled. Alfalfa does well on thoroughly drained fields, and yields from 2½ to 4 tons per acre. The poorly drained areas furnish excellent pasturage, and from 1 to 1½ tons of wild hay to the acre may be cut from some of them.

Care is necessary in managing this heavy and intractable soil. Fall plowing is practiced when the season is favorable. Recommendations for improving the Lamoure silty clay apply to this soil.

The current value of this land varies from \$125 to \$225 an acre in most of these areas, but the more poorly drained and untilled areas have a lower value.

KNOX SILT LOAM

The topsoil of Knox silt loam is light-brown or brown, loose, friable silt loam which contains a small quantity of organic matter. On steep slopes or other places where the surface material is being constantly removed by erosion, the soil is thin; and on very steep slopes and tops of sharp knolls and ridges, the darker surface layer may be entirely lacking. On comparatively smooth areas it may reach a depth of 8 or more inches, but the usual depth is about 5 inches. Below the topsoil is a transitional layer in which the brown color changes downward to yellowish brown, and in which the texture is very slightly heavier than that of the surface soil. In position this material is firm but not hard or compact. Where this layer is well developed it is continuous to a depth varying from 12 to 18 inches, and the material breaks up into distinct particles or granules. In most places, however, this layer is entirely lacking, and the darker surface soil rests on the parent loess of yellowish-brown silt loam. This material is soft and structureless, and breaks readily in blocks that fall apart into soft clods which are irregular in size and shape.

The upper two layers, where this soil is best developed, are leached of their carbonates; but the lower parent material is everywhere highly calcareous, and lime concretions are abundant. In many places the lime carbonate occurs in streaks at any depth in the loess. In areas in which erosion is active and the soils are thin, the lime carbonate is near the surface.

A variation of this soil occurs in a small area on a low terrace above overflow on the Monona-Harrison County line 2 miles north of Pisgah. Here the surface material is silt loam which is similar to that of typical Lamoure silt loam. The surface layer is underlain by a black silty clay loam, mottled with gray and brown.

There is some variation in color of the topsoil. The color is lighter on the rougher slopes and ridges where erosion has been active than on the gently rolling or nearly flat areas where some organic matter has accumulated in the soil. In no place, however is the color of the topsoil so dark as that of Marshall silt loam. Faint gray mottlings may occur in the deeper subsoil and iron stains are present in places. Pockets of very fine sand or sand occur in a few places

in the subsoil, usually at the base of the higher bluffs adjoining wide areas of bottom land.

Knox silt loam has developed most extensively along the upland bluffs which border the Missouri River Valley plain. The largest area, $2\frac{1}{2}$ miles wide and $6\frac{1}{2}$ miles long, extends northward from Orson into Monona County. Strips from one-fourth mile to $2\frac{1}{2}$ miles wide are found along the Missouri River Valley bluffs and extend for some distance along the upland bluffs along Soldier River, Steer, Allen, and Stowe Creeks and their tributaries. Other small areas occur on the upland ridges adjacent to the deeper drainage ways.

Most of this land is rolling, with many gradual slopes and a few narrow undulating ridge tops, from 50 to 200 feet wide, all of which are cultivable. Along the valley of the Missouri River the bluffs on which Knox silt loam occurs rise from 125 to 160 feet above the bottoms, and the steeper slopes support only a scant growth of grass and a few patches of scrub trees. Faulting of the loessial silt on these bluffs has caused steplike formations called cat steps. These bluffs are for the most part too steep for cultivation, but special crops such as grapes are very successfully grown on steep areas of this soil in Pottawattamie County.

Drainage is good, owing to the friable nature of the loessial material. On many slopes, particularly the steeper ones, erosion has been serious and damaging. Run-off is so rapid on much of this land that drought affects crops more than on Marshall silt loam, although the soil has a high moisture-holding capacity. Originally much of it was forested, but it is now largely cleared.

Probably 50 per cent of this soil is under cultivation. Corn is the principal crop and yields from 20 to 50 bushels an acre, according to the content of organic matter and depth of soil. Alfalfa and sweet clover grow well and yield from 2 to 3 tons an acre. Inoculation has been found necessary in places to obtain good stands. Wheat and oats are grown in small acreages. Oat yields range from 20 to 35 bushels an acre. Potatoes and vegetables are grown in small patches and yield well. Yields of other crops are somewhat lower than on Marshall silt loam. Grapes and bush and tree fruits, which are grown to a small extent, are well adapted to this soil.

No definite crop rotation is practiced. Corn is grown one or two years and is followed by small grain in which alfalfa or sweet clover is sometimes seeded. Commercial fertilizers are used on very few farms. Barnyard manure is applied but is not available in sufficient quantities to build up the soil so that a maximum crop can be obtained.

The current value of this land varies from \$30 to \$115 an acre, depending on improvements, location, and proportion of plowland. Orchard lands and better-improved farms near towns bring higher prices.

In most places this land is subject to erosion. Contour plowing of the hills and seeding down the steeper slopes permanently or for long periods would help check erosion. More alfalfa or sweet clover should be grown and turned under to supply organic matter, since the organic matter is deficient, as indicated by the light color.

Increased plantings of vineyards and orchards should prove profitable.

CASS SILT LOAM

The surface layer of Cass silt loam, to a depth of 8 inches, consists of dark-brown friable silt loam which contains considerable fine sand. Below this layer the material is dark-brown in color and very fine sandy loam in texture to a depth of 30 inches. Below this depth is a layer of yellowish-brown sand several feet thick. In places the upper layers are slightly calcareous and the underlying sand is strongly calcareous. Small patches of fine sand and sand occur in the silt loam areas, usually on slightly raised ridges or near old and new stream channels. Thin stratified layers of yellowish-brown or yellow sand occur in places in the surface soils.

The largest area about $3\frac{1}{2}$ miles long and 1 mile wide is north of Modale, and small irregular bodies occur throughout the Missouri River lowlands. An area $2\frac{1}{2}$ miles southeast of River Sioux has a slightly lighter-colored surface soil than typical.

This land for the most part is flat. Drainage is good, as the mellow open subsoil readily carries away excess water, but it has good moisture-holding power. Practically none of this soil is subject to overflow, and the low places near the river channel are leveed to prevent inundation by backwater.

Cass silt loam is practically all under cultivation. A few thinly forested areas are used for pasture. This soil is mellow, easy to work, and productive. Corn, alfalfa, and wheat are the principal crops, and some oats, sweet clover, potatoes, onions, and truck crops are grown. Corn yields from 30 to 60 bushels an acre; wheat, from 16 to 30 bushels; and hay, from 2 to 3 tons. The crops are largely fed on the farms to hogs. Barnyard manure and a little commercial fertilizer are used for truck crops, but the fertility is below normal on some of this land. More alfalfa and sweet clover should be grown in the rotation.

The current value of this land varies from \$75 to \$160 depending on the location, improvements, and condition of the soil.

CASS SILTY CLAY LOAM

Cass silty clay loam is dark-brown heavy plastic silty clay loam, underlain at a depth of 14 inches by brown or grayish-brown friable silty clay loam, and this, in turn at a depth of 30 inches, by yellowish-brown sand or fine sandy loam material. The soil to a depth of 20 inches is not usually calcareous, but below this point it effervesces with hydrochloric acid and the sandy subsoil is highly calcareous.

This soil is widely scattered over the Missouri River bottoms. Large areas occur north and south of Mondamin. It is closely associated with other Cass soils of silt loam and silty clay loam texture, with a gradual textural gradation between them, so that the boundaries between areas of these soils have been drawn rather arbitrarily.

The land is flat and has fair drainage which is generally sufficient in normal years, but the greater part of this soil is subject to inundation in periods of flood. The soil is used for general farming and

is nearly all under cultivation. Although considerable timber once grew over this land, there are now only scattered trees near the drainage ways.

This soil is largely planted to corn, and some wheat, alfalfa, and oats grown in an irregular and indefinite rotation. Yields are slightly higher than on Cass silt loam, except in extremely wet seasons.

Current land values range from \$90 to \$175 an acre.

CASS SILTY CLAY

Cass silty clay has a surface layer of dark-brown or black, tenacious silty clay underlain at a depth of 15 inches by tough clay which is somewhat mottled with yellowish brown and contains some iron stains. At a depth of 28 inches the material is yellowish-brown silty very fine sandy loam mottled faintly with yellowish brown and iron stains. The subsoil is highly calcareous and the surface soil in many places gives a slight effervescence with hydrochloric acid.

A shallower phase of this soil in the northwestern corner of the county along the Missouri River bottoms near the stream channel is subject to an annual overflow. The surface soil here is dark-brown plastic clay from 3 to 5 inches deep, underlain by mottled brown material which varies in texture from sandy clay loam to clay. At a depth of 10 or 12 inches, this layer is underlain by light-brown fine sand. A large portion of another area 800 to 900 acres about $1\frac{1}{4}$ miles southwest of Modale is under water much of the year. The clay surface soil here is black or dark brown to depths varying from 1 to 3 inches and is then brown or light brown to a depth of 18 inches where it rests on yellowish-brown sand. This area is low, depressed, and naturally poorly drained. Soldier River drains through it, and a lagoon or swamp is formed on a part of it, indicated on the map by swamp symbols.

This soil occurs as small strips or large irregular bodies which range in size from 10 to 900 acres, and is restricted to the Missouri River Valley bottoms.

The surface is level but rarely depressed, with the exception of the large area southwest of Modale, which lies from 4 to 6 feet below the adjoining bottom land. The surface and upper subsurface drainage is slow, owing to the waxy, impervious soil, but the open material of the lower part of the subsoil affords good underdrainage. Cass silty clay should be handled in much the same way as the heavier Lamoure and Wabash clay soils.

With the exception of the large area in the northwestern corner of the county which supports only a growth of coarse grasses and scattered willow clumps and the area $1\frac{1}{4}$ miles southwest of Modale on which there is a thin forest growth, this soil is mostly under cultivation. A few lightly timbered areas are used for pasture. Corn, wheat, and alfalfa are the principal crops. Wild hay is cut from a few poorly drained bodies. Crop yields are comparable to those on Cass silty clay loam.

The current selling price of this land varies from \$75 to \$150 an acre. Many farms comprising excellent soil of high productivity are old Government accreted lands to which no clear title can be obtained.

The selling value is accordingly very low, probably not exceeding \$40 or \$45 an acre and may be as low as \$10 or \$15.

CASS VERY FINE SANDY LOAM

The surface layer of Cass very fine sandy loam consists of dark-brown very fine sandy loam which contains a high percentage of silt. At a depth of 9 inches this is underlain by brown or dark-brown very fine sandy loam material which becomes gradually lighter in texture with depth, so that the deeper part of the subsoil in many places is brown very fine sand. The entire soil mass is highly calcareous.

This soil occurs in small areas in only three townships—Little Sioux, Morgan, and Clay. The largest areas are 2 and $4\frac{1}{4}$ miles northwest of Modale. Three small areas are northwest of Mondamin, one south of River Sioux, and one adjoins River Sioux on the west.

The surface is slightly higher than that of the surrounding soils, and is flat or gently undulating. The open soil allows good drainage, and in seasons of drought, crops are affected. This land is never inundated.

Cass very fine sandy loam is farmed largely with other soils and is cropped to corn, oats, potatoes, and wheat. Yields are about the same as on Cass silt loam.

It is sold mostly with associated soils, but alone its current value varies from \$70 to \$140 an acre.

SARPY SILT LOAM

Sarpy silt loam to a depth of 12 inches is light-brown or brown friable silt loam which contains considerable very fine sand. The subsurface layer varies in color from light brown to brown and in texture it may be heavy silt loam or sandy silty clay loam. It is underlain at a depth of 28 inches by lighter-brown or grayish-brown very fine sand. The surface layers are everywhere highly calcareous. A few iron stains occur below a depth of 30 inches. Thin layers, from 2 to 3 inches thick, of material which varies in texture from fine sand to silty clay loam are found near the surface.

Most of this soil occurs near the main Missouri River channel, its cut-off channels, and near Little Sioux and Soldier Rivers, from 1 to 3 miles back from their entrance into Missouri River. The areas are well scattered, irregular, and high lying, with one exception—the body one-fourth mile southeast of Blair Ferry, which is depressed—and include irregularly distributed patches of clay, very fine sand, and of stratified materials.

The largest areas are at Little Sioux and adjoining and south of River Sioux. A large area in which the surface soil is grayish brown to yellowish brown occurs $2\frac{1}{2}$ miles west of Modale; and other bodies occur in a large horseshoe bend of the Missouri River, $3\frac{1}{2}$ miles west of California near Blair Ferry. A small, depressed area of Cass silty clay loam too small to map occurs in the town of Little Sioux.

The surface is smooth with occasional hummocks and ridges, usually near old stream channels. Drainage is adequate. Owing to the low position and the high water table, the soil is retentive of moisture and little affected by moderate droughts. Only a few small areas are subject to overflow.

This soil contains little organic matter but is productive and has good tilth. Very little commercial fertilizer is used. Sarpy silt loam is nearly all under cultivation. Corn, alfalfa, oats, potatoes, and some truck crops are grown. Corn yields from 25 to 50 bushels an acre; alfalfa, from $2\frac{1}{2}$ to $3\frac{1}{2}$ tons; and other crops give good returns. Most of the potatoes and truck crops are sold, but other crops are largely fed on the farm.

This land currently ranges in value from \$70 to \$145 an acre, according to improvements and location.

Sarpy silt loam, deep phase.—The surface soil of the deep Sarpy silt loam is a friable light-brown silt loam 12 inches deep. This is underlain to a depth of about 28 inches by light-brown clay loam material, below which occurs a darker or olive-brown tenacious clay. The subsoil is highly calcareous and the topsoil is usually so. In places stratified layers of yellow calcareous sand are encountered in the soil, usually at a depth of about 24 inches. Much fine sand and very fine sand is incorporated in many areas, particularly in the Missouri River bottoms, where the subsoil is slightly heavier.

Sarpy silt loam, deep phase, occurs as irregular and widely scattered areas, mostly in the Missouri River Valley bottoms. Two small areas occur along Soldier River, $1\frac{1}{2}$ miles north of Orson; another one is one-half mile north of Pisgah; and a small area is in section 33, Boyer Township, along Boyer River. The soil in the area north of Pisgah is somewhat mixed, the subsoil in places being almost as light in texture as the surface soil, and it receives some wash from a small upland drainage channel which has formed an alluvial fan at this point.

The surface of this land is flat, and the areas lying nearest the Missouri River channel are broken here and there by a few shallow old and dry drainage channels. Only those areas along the smaller stream channels which have not been deepened or straightened are seriously affected by flood waters. A few depressed areas are not well drained, but for the most part drainage is good.

This soil is all under cultivation or in pasture. Scattered tree clumps dot the fields and narrow bottoms near the present or old stream channels. The soil is mellow and easy to plow and cultivate.

Corn is the principal crop. Some alfalfa, sweet clover, oats, a little wheat, truck crops, melons, and potatoes are grown. Corn yields from 35 to 50 bushels per acre, and hay from $1\frac{1}{2}$ to 3 tons.

This soil needs more organic matter, as the color indicates. Growing more alfalfa, sweet clover, or dalea, and the plowing under of the two latter crops as green manure would be beneficial. Experiments with acid phosphate and complete fertilizer on truck crops have given good results. Very little barnyard manure is available and other fertilizers must be used to increase and maintain productivity.

The current selling prices range from \$75 to \$150 an acre.

SARPY SILTY CLAY LOAM, DEEP PHASE

Sarpy silty clay loam, deep phase, has a heavy plastic brown silty clay loam surface soil 8 inches deep, underlain by a heavy tenacious subsoil which may vary in texture from silty clay to clay and which is highly mottled with yellowish brown and contains rust-brown iron concretions and stains. The surface soil is usually calcareous and the subsoil in places reacts with hydrochloric acid.

Practically all this soil is found in Cincinnati Township in the Missouri River lowlands and its total area is only 384 acres. The areas are small and irregular and are located about $2\frac{1}{4}$ miles northwest of California. One area is in an old drainage channel. The surface is flat and depressed and natural drainage is poor.

Sarpy silty clay loam is managed in a similar manner as Lamoure silty clay loam. It is not so rich in organic matter, however, and crop yields are less, on an average, than on the black soils. The treatment recommended for the Wabash and Lamoure silty clay loams will apply to this soil.

SARPY SILTY CLAY

Sarpy silty clay has a 6-inch surface layer of brown, tenacious silty clay, underlain by a shallow subsurface layer, from 5 to 10 inches thick, of light-brown or grayish-brown silty clay loam, and a subsoil of yellowish-brown highly calcareous medium sand which is mottled in places with a few iron stains. The surface and subsurface layers are variable in thickness; the surface layer in places is 10 or 12 inches thick and the subsurface layer in many places is light-brown plastic clay loam material to a depth of 20 inches. In some of the deeper depressions the heavier surface layer over the sand may be 30 inches deep. The principal difference between Sarpy silty clay and Cass silty clay, as mapped, is in the color of the surface layer. The Cass soil is dark brown or black, whereas the Sarpy soil is light brown or brown because it contains less organic matter.

Except for areas in sections 10 and 21, Clay Township, and section 8, Cincinnati Township, this soil is low in position and subject at times to overflow. In the areas excepted, the surface soil is heavier in texture and varies in depth from 10 to 30 inches overlying sand, are uniformly light in color, and are cultivable. Another body 2 miles west of Modale in sections 26 and 35, Clay Township, occurs in an old river channel or shallow lake basin and supports a luxuriant growth of slough grass. Other areas are along the lower bottoms along the present river channel and do not extend back very far toward the main bottoms. These are separated by river wash, narrow swales filled in with clay and silt, low hummocks and narrow ridges of sand, all of recent origin and deposition. Tall cottonwood trees and dense willow clumps and thickets cover much of this lowland. The small vegetation consists of scant coarse grasses in patches, affording only meager and poor pasturage. The old channel and lake swales are soggy and wet in places.

This soil is of little importance agriculturally because of its small acreage, and only little of it is cultivated. Where the surface covering is thin drainage is good, whereas on the deeper clay drainage is somewhat restricted.

The tillable land is managed in a similar manner as Cass silty clay. Good corn, alfalfa, and wheat can be raised on this soil, but yields are not so high as on Cass silty clay.

The uncultivated areas with thin and mixed surface soils are subject to annual overflow and are of little value. The cultivated areas, in which the soil has a clay surface layer from 12 to 30 inches deep, the current land value varies from \$50 to \$125 an acre.

SARPY VERY FINE SANDY LOAM

Sarpy very fine sandy loam soil to a depth of 14 inches is light-brown or grayish-brown very fine sandy loam, and the subsoil material is grayish-brown and slightly lighter in texture than the surface soil. In places pockets and layers of coarse sand and assorted gravel are found. The subsoil is always highly calcareous and the surface layer is usually so. It was impossible to indicate on the map the small areas of very fine sand and fine sand which occur on ridges, mounds, and hummocks. Two miles west of Mondamin is a rather large high and flat area in which the texture of the surface soil varies from silt loam to very fine sand.

The largest area of this soil is 1 mile southeast of Blair Ferry, the southern part of which is spotted by large mounds from 40 to 60 feet across and from 2 to 6 feet high. Part of an extensive area 2 miles southwest of Modale is farmed by a colony of Japanese to truck crops and melons.

The surface is flat to gently undulating, with billowy ridges along or near old channels in the lower bottoms. The porous soil allows excellent drainage; and because of its low position it usually contains a good supply of moisture. Crops will burn, however, during prolonged dry weather to a greater extent than on Sarpy silt loam. Only a small portion is subject to overflow and is only rarely inundated.

A thin and scattered forest growth is found on this soil, and there are some large original trees. Small cleared patches within this timbered area are under cultivation. Probably 70 per cent of the entire area is cropped to corn as the principal crop. Alfalfa does well, and potatoes, melons, and onions are especially adapted to this soil and give excellent yields. This soil is too light in texture for the small grains, especially wheat. Corn yields from 15 to 40 bushels per acre. High winds, frequent on the bottoms, cause some shifting of the surface soils in the bare fields, but little damage to crops.

Sarpy very fine sandy loam has a wide range in value, which is determined largely by position, surface and textural uniformity, location, and improvements. The current value varies from \$25 to \$100 an acre.

The principal need of this soil is organic matter to increase the moisture-holding capacity and productivity. The growing of alfalfa, sweet clover, and rye would be advantageous.

SARPY FINE SAND

Sarpy fine sand consists largely of mixed waste sands which vary in texture from very fine sand to medium sand, and in color from light yellowish-brown to grayish-brown. At a depth of 10 inches the material is light yellowish-brown fine sand. In places where a heavy grass growth covers the soil the surface layer is slightly darker to a depth of 4 or 6 inches; but usually there is no change in color from the surface downward. The lower part of the subsoil contains slightly more coarse sand than do the upper layers. The surface soil is in most places calcareous and the subsoil is everywhere highly so.

This soil is confined largely to two townships—Clay and Cincinnati. Areas are found $2\frac{1}{2}$ miles west of Modale and one-half mile

east of Blair Ferry. In a horseshoe bend of Missouri River northwest of River Sioux is a low area which is subject to overflow; likewise two small areas 2 miles south of Blair Ferry. The other developments are well above ordinary overflow. The area $3\frac{1}{2}$ miles northwest of River Sioux is nearly all waste land. It contains billowy surface ridges and irregular sand mounds from 2 to 10 feet high, and small, depressed areas which are covered thinly with clay or very fine sandy loam, and ponded areas from 25 to 50 feet across that are filled with a coarse reed growth. A sparse growth of trees and willow clumps are prominent here and on this kind of land near the main channel of the river in both Cincinnati and Clay Townships. Near Blair Ferry, an area of this soil has irregular hummocks and sand ridges of incoherent fine and medium sand from 5 to 8 feet high.

Only a small proportion of this soil is cropped. Corn, melons, and truck crops mainly are grown, and a little alfalfa and rye. Because of its openness, this soil is more droughty than any other soil in the county, and consequently much smaller yields of the staple crops are obtained. Melons and truck crops give good yields, but require some fertilization. This soil has a very low cash value, usually less than \$50 an acre.

CARRINGTON LOAM

The topsoil of Carrington loam to an average depth of 6 inches is a very dark grayish-brown loam. Most of the material consists of very small aggregates one-sixteenth inch or less in diameter and the remainder is single grained. The topsoil is underlain rather abruptly by a dark yellowish-brown silty clay loam material which continues to a depth of 24 or 30 inches below the surface. All of the subsoil material consists of aggregates which are distinct and well formed and larger than those of the surface soil, ranging in size from one-eighth to one-fourth inch in diameter. This may be underlain by stiff brown sandy or gravelly clay which constitutes the parent material of glacial drift, and which is structureless and breaks into hard, coarse clods.

The texture of the surface material varies greatly, from silt loam, where wash from the higher areas of Marshall silt loam has brought in considerable loessial silt, to coarse sandy loam, where the surface soil has been badly eroded. Coarse sand, gravel, and a few small boulders are found in small quantities in the surface soil and in larger quantities in the lower layer and parent material.

This soil has developed where the streams which have cut through the loess have exposed the underlying drift material to the soil-forming forces; and it is confined to narrow disconnected strips on the lower hill slopes which border the stream valleys of nearly all the rivers and creeks and their larger tributaries. Many patches are too small to show on the map, and these were included in mapped areas of Marshall silt loam.

The land is prevailingly rolling, and in a few places is so rough as to be suitable for pasture only. Drainage is naturally good.

Carrington loam is of little importance, agriculturally, because of its small total acreage. Most of it is cultivated, but a few areas support a patchy growth of scrub trees. It is farmed and cropped with Marshall silt loam, and returns similar yields, except in areas

where the soil is thin. The steeper slopes are usually left in bluegrass, which grows abundantly.

JUDSON SILT LOAM

Judson silt loam consists of a very dark grayish-brown friable silt loam to a depth of 15 inches, underlain by a slightly lighter colored and slightly heavier material which becomes lighter in color with depth and in a few places is faintly mottled with gray. In a few depressions, mottlings of gray or brown appear at a depth of 3 feet.

This soil is not extensive. The largest areas are in the northeastern corner of the county along the Boyer River bottoms south of Dunlap, where it occurs in bodies from one-eighth mile to $2\frac{1}{2}$ miles long and from one-eighth to over one-half mile wide. Small isolated areas are found at the base of the upland slopes along all the rivers and larger creeks. This soil is formed from dark-colored silt which has been carried down by small streams which issue from the upland, wash from adjacent slopes, and alluvial material deposited by the main stream.

Most of the land is nearly flat, sloping gently toward the first bottoms into which it grades almost imperceptibly. A few gently undulating areas are found on the recent deposits of tributary streams which cut through the main bottom lands. Practically all of it lies above overflow, but a few areas may be inundated for a short period during exceptionally high water.

This soil is fertile and is all under cultivation. It is very retentive of moisture and very little affected by drought, and is an especially strong corn soil. All the general crops are grown, and yields are similar to those produced on the better areas of Marshall silt loam; and corn yields are ordinarily higher. Some of this land is in permanent pasture. Soil of this type usually constitutes only a small part of the farm, and is sold with Wabash silt loam with which it is closely associated. The current value of this land varies from \$100 to \$150 an acre.

RAY SILT LOAM

The topsoil of Ray silt loam consists of a light-brown to brown silt loam, to a depth of 6 inches, underlain abruptly by a subsurface layer of black tenacious silty clay. The surface layer in places varies in texture from heavy silt loam to light silty clay loam. It consists of colluvial wash from the light-colored bluffs and hill slopes which has been carried down streams which issue from the upland and deposited along the shallow channels during overflow or spread out as alluvial fans over the black alluvial clays along the Missouri River lowlands near the bluff line.

The soil is not extensive, the total acreage being less than 1 square mile. It occurs as narrow strips along ditches or small tributary streams. Small areas occur along Boyer River 4 miles northeast of Missouri Valley, between Calhoun and Missouri Valley along Willow River, in section 11 of Taylor Township, and $2\frac{1}{2}$ miles northeast of Mondamin along an artificial drainage ditch.

Ray silt loam is mostly under cultivation. Drainage in the silt surface layer is good, but on the whole it is poor because of the impervious black silty clay subsurface layer. Crop yields are similar to those obtained on Sarpy silt loam.

HANCOCK FINE SANDY LOAM

The topsoil of Hancock fine sandy loam is dark grayish-brown fine sandy loam which is loose and friable when dry but which contains sufficient clay to cause it to break into soft clods when plowed too wet. At a depth of 18 inches it is underlain by brown or yellowish-brown loamy fine sand or sand, which is less coherent than the surface material. Both topsoil and subsoil are highly calcareous.

Only three small areas of this soil have been mapped in Harrison County, two in section 17, Jefferson Township, and one in section 1 of Jackson Township. The soil in the small area in Jackson Township is yellowish-brown fine sandy loam.

Drainage is good to excessive. In dry periods, crops suffer from a lack of moisture, owing to the low water-holding capacity of the open sandy subsoil.

All this soil is under cultivation, and crop yields average lower than on Waukesha silt loam. More organic matter is needed in this soil to increase its water-holding capacity and its supply of plant-food elements. More barnyard manure should be applied or more green manure should be turned under.

RIVERWASH

Riverwash includes waste land along the present channel of Missouri River, principally sand bars and coarse sandy alluvial areas which are inundated at flood stage. Owing to the constant shifting of the channel, much of this land is found along older cut-offs which were probably a part of the main channel. This recently deposited sediment is a heterogeneous mixture of sand, silt, and clay. Flats of grayish-brown silt and silty clay, underlain by sand at depths from 4 to 16 inches, occur in many places between these old channels.

The areas of this soil lie from 2 to 8 feet above the normal water level of the river, and are inundated frequently during the year. Uneven-layered deposits of sand, silt, and clay are left after the flood waters recede. The sandy deposits are shifted by strong winds, so that the surface relief consists of large ridges and dunes from 2 to 6 feet high.

Some of these areas, principally the higher flats, might be cultivated; but because of frequent overflow and the winding old channels and sloughs which dissect this area, it would be impracticable to estimate the agricultural value of such land. A dense growth of willows covers much of this riverwash.

SUMMARY

Harrison County is situated in the southwestern part of Iowa, and Missouri River forms its western boundary. It has an area of 691 square miles, or 442,240 acres.

The county has two topographic divisions, the hilly upland and the broad alluvial lands of the river valleys. The upland surface varies from gently to sharply rolling. The ramifications of the drainage ways have penetrated every part of the upland and provide good drainage. The alluvial lands are mostly flat; and though drainage in places is slow, only a very small acreage is permanently insufficiently drained.

The greater part of the county lies at an elevation ranging from 1,000 to 1,300 feet above sea level.

According to the 1920 census, the population was 24,488, of which 20,503 are rural.

The climate is characterized by cold winters and warm summers. The average mean temperature is 49.4° F. The mean annual precipitation is 32.23 inches, most of which falls during the growing season. The average frost-free period is 154 days.

Agriculture consists principally of hay farming combined with livestock raising.

The soils of the county are for the most part silty in texture, are easily tilled, retentive of moisture, and very productive.

Marshall silt loam is the most extensive and important soil of the smooth or moderately rolling upland. It has a very dark grayish-brown color, owing to the large quantity of organic matter it contains. It is an ideal corn soil; and on it oats, alfalfa, and sweet clover also produce good yields.

Knox silt loam is the light-colored soil that covers the eroded upland slopes. About 50 per cent of it is cultivated. Corn, alfalfa, and sweet clover are the principal crops; but yields are not so high as those obtained on Marshall silt loam.

Carrington loam is another dark-colored upland soil, but this is underlain by gravelly clay loam or clay. It constitutes only a small area in the county. Yields on this soil are about the same as on Marshall silt loam.

Waukesha silt loam is a terrace soil similar to Marshall silt loam.

Judson silt loam is a deep black soil on the slopes. It is very productive, but it totals only a small acreage.

Wabash soils, including silt loam, silty clay loam, and silty clay, occur on the first bottoms. They have black surface soils with gray or mottled subsoils. They contain no lime. These soils are very productive where good drainage is provided. Corn and alfalfa are the principal crops.

The Lamoure soils, including the silt loam, silty clay loam, and silty clay members, are first-bottom soils similar to the Wabash soils, except in their higher lime content. They occur on low first bottoms, and much of it is poorly drained. On the cultivated portions corn, alfalfa, and oats are the principal crops.

The soils of the Cass series have black topsoils from 24 to 30 inches deep, and light-textured subsoils which usually consist of loose sand and gravel. Most of this soil is flooded during periods of high water, but the water drains off rapidly. Corn, alfalfa, oats, and some wheat are grown on it.

Sarpy soils have light-colored surface soils underlain, at depths ranging from 18 to 30 inches, by sand and gravel. These are first-bottom soils that are subject to overflow during periods of high water but which are droughty in dry seasons. The average crop yields on this land are lower than those obtained on the Cass soils.

Riverwash consists mainly of river sands and gravel.

[PUBLIC RESOLUTION—No. 9]

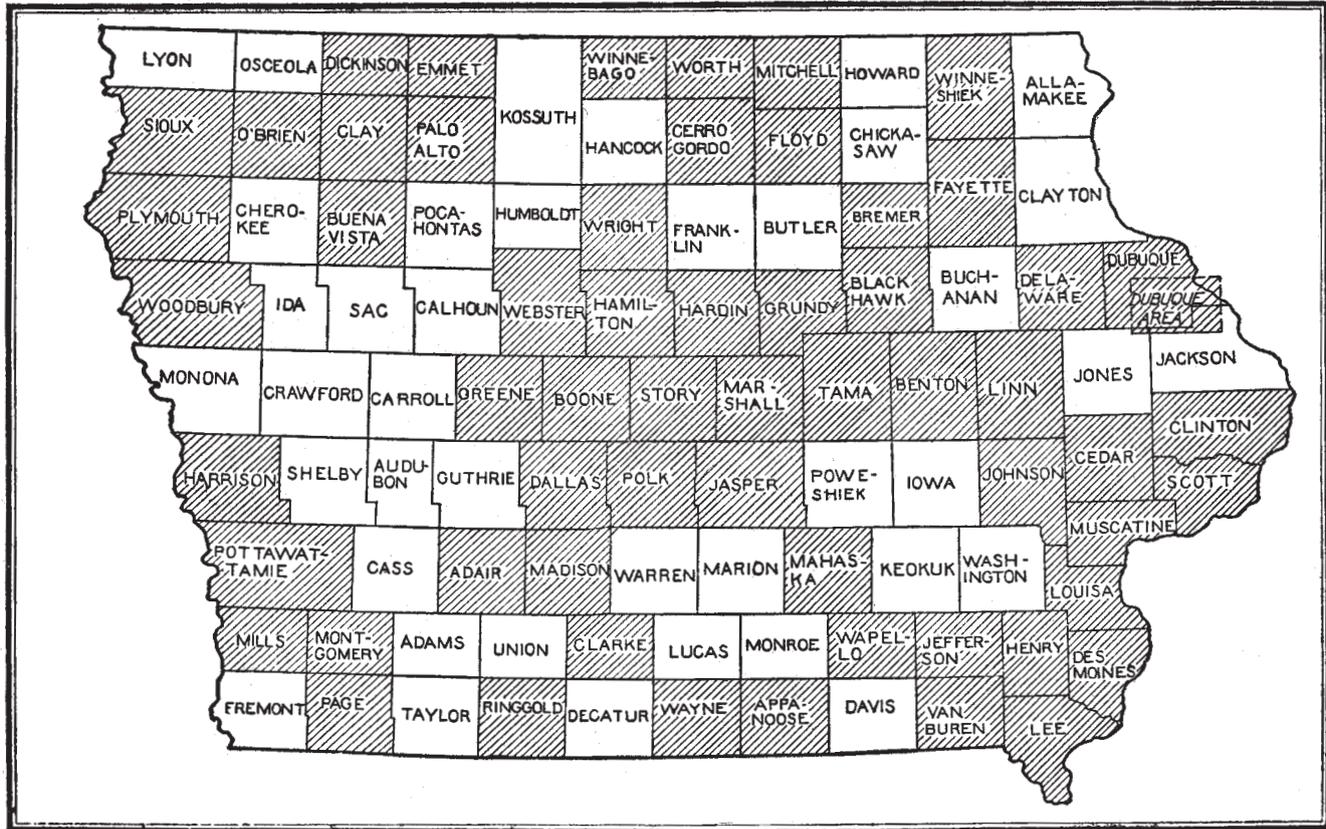
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Iowa, shown by shading

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