

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Sac County, Iowa

By

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United States Department of Agriculture



Bureau of Chemistry and Soils

In cooperation with the Iowa Agricultural Experiment Station

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SOIL SURVEY OF SAC COUNTY, IOWA

By C. L. ORRBEN, Iowa Agricultural Experiment Station, in Charge, and A. L. GRAY and W. C. BOATRIGHT, United States Department of Agriculture

COUNTY SURVEYED

Sac County is in the northwestern part of Iowa, in the fourth tier of counties south of the Minnesota State line and the third tier east of Missouri River. (Fig. 1.) The western border of the county is approximately 60 miles east of Sioux City, Iowa. The county contains 16 full townships. A 3-mile correction, to the west, prevents the county being a perfect square. The total area is 574 square miles, or 367,360 acres.

Physiographically, Sac County may be divided into two nearly equal parts. The eastern half is a level or gently undulating drift plain dissected by two large streams. The tributaries to these streams are short, and erosion is undeveloped. The western part is a loess-covered rolling plain, thoroughly dissected by streams. The divides separating the streams are comparatively narrow, the slopes gentle, and the ridges well rounded.

The eastern part of the county, as a whole, is poorly drained. Broad level areas, broken only by many small knolls and ridges, extend for miles from the major streams, giving the characteristic undulating relief of the Wisconsin drift area. Artificial drainage is necessary to remove the surplus water from the flat areas and broad swales. Raccoon River, which traverses this drift area, meanders through a comparatively wide flood plain, flanked by extensive terraces on either or both sides. Cedar Creek flows sluggishly in a southwesterly direction, emptying into Raccoon River south of Sac City. The bottoms along this creek are narrow, and no large terraces have developed. The slopes adjoining Raccoon River are steep and badly eroded for a short distance from the stream, where the relief becomes more gentle, with well-rounded ridges, finally giving way to the broad expanses of the drift plain. In few places are the broken areas more than 1 mile wide, but the level unbroken prairies extend for miles.

Wall Lake, the only lake within the county, lies almost on the western margin of the Wisconsin drift area. This body of water is about 2 miles long and has a maximum width of 1 mile. It is only 10 or 12 feet deep at the deepest point, and the waters are kept at a constant level by a dam at the outlet of the lake. The lake, which is fed by a spring at the west end and by Inlet Creek at the south side,

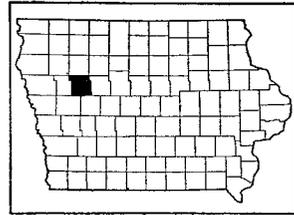


FIGURE 1.—Sketch map showing location of Sac County, Iowa

received its name from a surrounding wall of granite bowlders pushed up by ice action, but at present only a small part of the wall remains.

The relief in the western part of the county is markedly different from that in the eastern part. In the western part, the rolling loess-covered plain may be separated into three divisions. The northern part of the plain, although well drained, is not so thoroughly dissected as the southern part. The streams are numerous, and the slopes are gentle and the ridges well rounded. Narrow level divides separate the stream channels, resulting in a gently rolling relief. The southwest part is hilly, the strongest relief occurring along Boyer River, where the slopes are steep and the valleys more V-shaped. Erosion has been and is still active, the cutting process progressing at each severe rainfall.

The relief in the central-western part of the county is intermediate between that of the less dissected northern part and the hilly southern part. Here, the slopes are long and gentle, the ridges are narrow but well rounded, and the valleys are U-shaped. A narrow divide separates the drainage basins of Boyer River, Maple River, and Soldier River, the last two rivers flowing through Ida County on the west.

Boyer River meanders through a wide flood plain. The well-developed terraces lie from 15 to 25 feet above overflow. The smaller tributaries flow through narrow bottoms, flanked on either side by colluvial deposits from the upper slopes.

The eastern half of the county drains into the Des Moines River system and the western half into the Missouri River system. Boyer River was at one time part of the Des Moines River system, but a new channel cut through the loess region now drains into Missouri River. The marshy area east of the town of Wall Lake and extending to the head of Wall Lake was formerly part of the flood plain of Boyer River. The extensive gravel terraces near the town of Lake View bear evidence of the action of flood waters when the main channel traversed this area.

The prevailing slope of the county is to the south and east, as indicated by the courses of Raccoon and Boyer Rivers. Upland elevations range from 1,393 feet above sea level at Schaller, in the northwestern corner of the county, to 1,240 feet at Auburn in the southeast corner. Other elevations over the county are Odebolt, 1,361 feet; Early, 1,331 feet; Lytton, 1,220 feet; and Wall Lake, 1,233 feet above sea level. The uplands at Sac City have an elevation of 1,278 feet, and the terrace along Raccoon River is 1,196 feet above sea level.¹

Most of Sac County has always been in prairie, covered by a luxuriant growth of prairie grasses. Forest trees occur only in the well-drained areas along the master streams, in wood lots, and along fence rows. The natural tree growth along Raccoon River includes the various oaks, a few hickories, and walnut, elm, and basswood. An undercover of bluegrass grows in places where the tree growth is sparse. The trees in the bottom land are mainly elm, maple, cottonwood, willow, swamp oak, and walnut.

¹ GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bul. 274, Ed. 4, 1,072 p. 1906.

The first settlement in Sac County is reported to have been made in 1854, at a place called Big Grove, on Raccoon River in the southeastern part of the county. Previous to 1856, Sac County was attached to Greene County for political and judicial purposes. The town of Sac City was laid out in 1855, and the county was organized in 1856. Land adjacent to the streams was acquired first by the early settlers from the Eastern and Southern States, but as these areas were limited, settlement progressed westward to the better-drained virgin prairies. At present, practically all the drained areas have been reclaimed and utilized for general-farming purposes. Nearly all the population is American born, of English, German, and Scandinavian extraction. The population of the county as recorded in the 1930 Federal census² is 17,641 persons, 83.8 per cent, or 14,787, of which is classed as rural. The average density of the rural population is 25.8 persons a square mile.

Sac City, the county seat and largest town, has a population of 2,854 persons. Odebolt with 1,388 inhabitants, Lake View with 993, and Schaller with 724 are important trading centers. Wall Lake, Early, Auburn, Lytton, Nemaha, Carnarvon, Ulmer, Grant City, and Herring serve as shipping points for agricultural products.

The county is well supplied with railroads. Branches of the Chicago, Milwaukee, St. Paul & Pacific, the Chicago & North Western, and the Illinois Central systems traverse the county, affording every town an outlet to outside markets.

The public-road system is excellent. Graded, well-maintained, graveled roads connect every town and village within the county, and many township and secondary roads are graded and graveled. Two Federal highways, United States Highway No. 71 and United States Highway No. 20, and two State highways, Nos. 4 and 35, traverse the county.

Each town maintains a graded school and a high school. Country schools are located at 2-mile intervals. Consolidated schools have replaced the small schools in parts of four townships. A few country churches are scattered throughout the county.

Electric-power lines have been built in many parts of the county to serve farmsteads and small towns with light and power. Telephones and radios are found on practically all farms, thereby keeping the farmers informed on market conditions.

As Sac County lies within a rich farming belt, agriculture is the main industry. A large canning factory, a creamery, cement-products works, a silo factory, and a lightning-rod establishment furnish labor for the city dwellers. Pop-corn elevators and cleaning plants are located at Odebolt and Schaller.

CLIMATE

The climate of Sac County is typical of this part of the Mississippi Valley region. The winters are cold and the summers hot, with gradual change from one to the other during the spring and fall. The climate is healthful and favorable for the growth of all crops common to the Corn Belt.

² Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

Table 1, compiled from records of the United States Weather Bureau station at Sac City, shows the normal monthly, seasonal, and annual temperature and precipitation for Sac County.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Sac City, Iowa

[Elevation, 1,269 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1881)
December.....	°F. 22.5	°F. 60	°F. -20	Inches 1.12	Inches 0.20	Inches 0.64
January.....	17.2	58	-35	1.01	1.40	.89
February.....	21.3	60	-16	1.11	.30	2.37
Winter.....	20.3	60	-35	3.24	1.90	3.90
March.....	33.1	84	-16	1.43	(¹)	1.50
April.....	47.8	85	15	2.94	.52	2.78
May.....	58.7	95	23	4.16	2.39	6.96
Spring.....	46.5	95	-16	8.53	2.91	11.24
June.....	69.3	97	39	4.75	1.39	6.52
July.....	72.9	100	46	3.67	1.07	5.17
August.....	71.6	99	44	3.39	3.54	5.19
Summer.....	71.3	100	39	11.81	6.00	16.88
September.....	63.7	99	27	3.36	3.25	7.29
October.....	51.5	86	14	2.17	.69	5.88
November.....	35.5	76	-4	1.30	(¹)	1.36
Fall.....	50.2	99	-4	6.83	3.94	14.53
Year.....	47.1	100	-35	30.41	14.75	46.55

¹ Trace.

The mean annual temperature is 47.1° F. The mean winter temperature is 20.3°, and January is the coldest month. The actual range in temperature is from -35° in January to 100° in July. Ordinarily, the spring and fall months are mild, pleasant, and favorable for the planting and harvesting of crops. Periods of intense heat occur throughout the summer and early fall, but they are usually of short duration and broken by electrical storms and northwest winds. The extremely cold periods during the winter rarely last more than two to three weeks, when they are broken by southerly winds.

The average date of the last killing frost is May 2 and of the first is October 2, giving an average frost-free season of 153 days or a sufficient length of time to mature all the crops common to this region. The grazing season extends over a period of about 185 days. The earliest killing frost was recorded on September 12 and the latest on May 27.

Approximately 73 per cent of the mean annual precipitation of 30.41 inches falls during the growing season (April to October) in the form of showers. The precipitation during the late fall and winter is in the form of snow which often remains on the ground during the entire winter.

Crop failures owing to drought are uncommon, although dry periods lasting from two to five weeks are common during July and August. At times heavy downpours in June cause much damage to crops. The fall rains occur before corn harvest and rarely hinder the gathering of this crop.

AGRICULTURE

Agriculture has been the chief industry in Sac County ever since the first settlements were made. The early agriculture, however, consisted only in the raising of sufficient livestock, grain, and garden products to supply home needs, as lack of transportation facilities prevented the marketing of surplus crops. The first settlements were made along the larger streams where fuel and game were abundant, and hunting and trapping provided a cash income. Clearing of the land was laborious and naturally the fields were no larger than necessary to supply the home with food. Livestock required little care, as they roamed the timberlands and adjoining prairies at will. With the advent of railroads, thereby establishing outside markets, agriculture developed rapidly. New settlers entered the county, acquired the virgin prairies, and farming as an industry soon became established.

Agriculture at present consists in the production of corn, oats, hay, pop corn, barley, rye, potatoes, and minor products, and the raising and feeding of cattle, hogs, and sheep in sufficient numbers to consume the major part of the grain crops grown.

Table 2, compiled from records of the Federal census shows the acreage and production of the principal crops grown in Sac County.

TABLE 2.—*Acreage and production of principal crops grown in Sac County, Iowa, in stated years*

Year	Corn		Oats		Wheat		Barley		Hay	
	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Tons
1879.....	52, 649	1, 931, 335	9, 972	317, 602	34, 325	438, 152	1, 272	26, 076	9, 937	15, 862
1889.....	102, 875	4, 225, 046	42, 914	1, 784, 666	3, 444	54, 411	9, 024	248, 587	57, 431	76, 463
1899.....	123, 045	4, 770, 090	58, 158	2, 114, 350	17, 069	261, 250	7, 929	246, 680	44, 624	74, 810
1909.....	116, 649	4, 554, 544	69, 040	1, 831, 054	996	13, 408	8, 025	140, 517	46, 387	81, 378
1919.....	112, 446	5, 316, 414	82, 027	3, 210, 804	2, 783	36, 560	3, 597	108, 459	34, 929	55, 311
1929.....	128, 437	5, 411, 558	73, 573	3, 013, 807	359	8, 516	13, 344	457, 057	25, 154	44, 169

Agriculture has shown steady progress from 1880 to the present time. Sac County has always been primarily a grain-growing and livestock-raising community. Corn, wheat, and hay were grown by the early settlers. The wheat acreage, however, except during the period of the World War, has greatly diminished. The corn and oat acreage has remained fairly constant since 1889, the small yearly variations depending mainly on the previous year's crop and market prices.

The United States census reports show the number of farms in 1880 to be 1,330, with an average acreage of 168 acres a farm. In 1930 there were 1,874 farms averaging 184.1 acres each. In 1930, 93.9 per cent of the area of the county was in farms, a large proportion of which was classed as improved land. In 1880, 60.7 per cent of the area of the county was in farms, of which 74.8 per cent was improved land. The value of all farm property in 1880 was \$3,600

a farm, and in 1930 the value of land and buildings was \$29,241 a farm.

Farms are managed in much the same manner throughout the county. Cropping systems or rotations, which include corn, a small grain, and a legume-hay crop, are followed. Barnyard and green manures, chiefly the second-growth legume crop, are the main soil-enrichment materials. According to the 1930 census report, 67 farms reported the use of fertilizers in 1929, with a total expenditure of \$6,675, or nearly \$100 a farm. At present, the value of superphosphate (acid phosphate) as a fertilizer is being determined in a small way on many farms, and where profitable returns are obtained larger areas are fertilized by this means. Both superphosphate and potash are used on some of the reclaimed peat and muck areas, in which alkali hinders the growth of corn.

Most of the farm labor is obtained locally, and the remainder from near-by large cities. Most of the farmers employ extra help during small-grain harvest, haying, and corn-husking times. Harvest hands are paid from \$2 to \$3.50 a day with board, and corn pickers receive from 4 to 6 cents a bushel with board and team furnished. Monthly laborers receive from \$50 to \$65. It is customary to allow married men the use of a tenant house, a small garden, and other supplies from the farm. Laborers employed by the year are paid from \$35 to \$50 a month.

Farm tenancy has steadily increased since agriculture became well established in the county. According to the Iowa Yearbook, about one-fifth of the farms are rented for cash at an average rate of \$8.25 an acre and about one-fourth are rented on the crop-share basis, whereby the owner receives one-half of the corn crop and two-fifths of the small-grain crop. Table 3 shows the trend in tenure of farms during the last 50 years.

TABLE 3.—Tenure of farms in Sac County, Iowa, in census years

Year	Farms operated by—			Year	Farms operated by—		
	Owners	Tenants	Managers		Owners	Tenants	Managers
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>		<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
1880.....	73.6	26.4	-----	1910.....	53.5	45.4	1.1
1890.....	67.2	32.8	-----	1920.....	45.7	52.9	1.4
1900.....	59.6	39.3	1.1	1930.....	44.2	54.8	1.0

Modern farm equipment, including gang plows, harrows, disks, seeders, planters, mowers, binders, hay loaders, and tractors are found on a large percentage of the farms. Farm buildings are conveniently grouped to facilitate work, and many of them are surrounded by windbreaks of local hardwood or evergreen trees. The buildings are kept in good repair and include horse and cattle barns, hog and poultry houses, workshops, granaries, and machine sheds. Silos are conveniently located near cattle barns. The 1930 census reports 810 tractors in use on farms in Sac County, but horses and mules furnish most of the farm power. The lighter draft horses are universally preferred for general farm work.

Hog raising is the largest livestock industry. It is universally practiced, and the sale of hogs is regarded as the main source of the farm income and the best means of utilizing the corn crop. The 1930 census estimates the value of hogs on the farms of Sac County April 1, 1930, as \$1,621,276. These figures show the magnitude of the hog industry in the county.

Several breeds of hogs are raised, the kind depending more on the individual farmer's fancy than on the superiority of one breed over another. Duroc-Jersey, Hampshire, Chester White, Poland China, and crosses of different breeds are raised. Most of the pigs are farrowed in the spring during March and April, and fall farrowing is rapidly increasing in popularity. By raising two litters of pigs annually, fewer brood sows are required and hog feeding is extended over the year, thereby more evenly distributing the work as well as the income derived therefrom. The number of hogs kept on the individual farm depends largely on the quantity of feed available and facilities for accommodating the animals. It is sometimes necessary to purchase additional feed.

Spring-farrowed pigs are pastured on clover or alfalfa throughout the summer and, when the corn crop matures, they are placed in feed lots and hand fed or allowed to hog down small patches of the standing corn. Tankage and minerals in self-feeders furnish proteins and tonics to the fattening hogs. The finished animals are marketed at Sioux City, Omaha, or Chicago.

The beef-cattle industry in Sac County is more extensive in the southeastern and northern parts of the county. A few farmers maintain herds of Herefords, Shorthorns, and Angus for breeding, but most of the beef cattle are purchased direct from western Nebraska and a smaller number from the markets at Omaha and Sioux City. The feeder cattle are pastured through the summer months on bluegrass, sweetclover, alfalfa, or clover and timothy pastures until fall when they are placed in feed lots. They are then fed corn and commercial feeds from 160 to 200 days, and most of them are sold on the Chicago market.

Sheep raising is of minor importance in Sac County. However, it is rapidly becoming more popular. Western feeders are imported in carload lots late in the summer and pastured on stubble land or legume pastures. Early in the fall, some farmers follow the practice of turning the sheep into the cornfields. The sheep eat the weeds, grasses, and the lower leaves of the corn plants. As the supply diminishes, new acreages are opened to the sheep until the entire field is thoroughly cleared of weeds and grass. Some farmers allow the sheep to remain in the cornfields until all the grain is eaten. The number of sheep on the farms April 1, 1930, was 8,651 head. Native sheep are clipped in the spring. The total wool production in 1929 was estimated at 37,711 pounds.

The dairy industry is carried on only in sections near the various towns where the demand for market milk is greatest. A few milk cows, to supply home needs, are kept on all farms. The surplus dairy products are sold to local creameries. Holstein, Jersey, and Guernsey are the breeds preferred for milk production.

Poultry raising, once regarded as a side line on all farms, has increased so materially that it is now considered one of the main

sources of farm income. In 1929, \$350,532 were realized from the sale of hen eggs, and \$168,202 from chickens. A small number of geese, ducks, turkeys, and guinea fowls are raised. Large poultry raisers maintain their own hatcheries, and the small raisers purchase baby chicks from outside sources. Eggs are marketed in trade at the country stores or sold for cash at produce houses. A few dealers send out trucks over regular routes, buying eggs and live poultry at the farm. These products are then shipped to New York or Chicago in carload lots.

A few colts are raised annually to replace older horses that are traded or sold. The number of horses on farms April 1, 1930, was 11,301, and of mules, was 982.

SOILS AND CROPS*

Sac County lies within the center of the high corn-producing section of the United States. The soils and climate are very favorable to corn production, and if it were not necessary to rotate crops to maintain the fertility of the soils, a greater part of the land would remain in corn continuously.

The soils and the surface relief of the greater part of the county allow the production of corn on a large scale. The fields are large and regularly shaped, the soils fertile, and labor-saving machinery can be used to advantage. All these agencies tend to lower the cost of production which is so vitally important in determining the farm income, whether the grain is sold for cash or fed on the farm to produce meat and dairy products.

Three principal soils cover the greater part of the county. Marshall silt loam occupies all the western half with the exception of narrow bands along the stream valleys. Webster silty clay loam and Clarion loam are the principal soils of the eastern half. These three soils differ widely in natural drainage conditions, appearance, and composition, but not greatly in their productiveness. Although these three soils cover most of the county, there are less extensively developed soils which are not so uniformly productive as the better soils. Some of these may be cropped in one locality and not in others. A few can not be cultivated and must be used for pasture or hay only.

On the basis of the soil characteristics influencing production, with which are also associated other features such as drainage, the soils of Sac County have been placed in three groups as follows: Farming soils, farming-grazing soils, and grazing soils.

In the following pages of this report the soils of Sac County are described in detail, and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and Table 4 shows their acreage and proportionate extent in the county.

* Sac County adjoins Buena Vista County on the north, and in some places the soil maps of these counties do not appear to agree. This is owing, in most places, to changes in correlation resulting from a fuller understanding of the soils of the State. Carrington silt loam as mapped in Buena Vista County is now known to be Marshall silt loam; Wabash silt loam in places is changed to Lamoure silt loam in Sac County; and some Webster silt loam areas are changed to Clarion loam.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Sac County, Iowa*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Marshall silt loam.....	133,056	36.2	Dickinson sandy loam.....	1,024	0.3
Webster silty clay loam.....	67,776	18.4	Bremer silty clay loam.....	1,664	.4
Webster silt loam.....	3,392	.9	Fargo silty clay loam.....	1,280	.3
Webster loam.....	1,472	.4	Pierce sandy loam.....	1,280	.3
Clarion loam.....	87,104	23.7	Wabash silt loam.....	20,032	5.5
Clarion silt loam.....	7,936	2.2	Wabash silty clay loam.....	3,584	1.0
Waukesha silt loam.....	2,688	.7	Lamoure silty clay loam.....	5,696	1.5
Waukesha loam.....	768	.2	Cass fine sandy loam.....	256	.1
Judson silt loam.....	2,496	.7	Peat and muck.....	2,816	.8
Wabash silt loam, colluvial phase.....	7,296	2.0	Gravel pits.....	64	.1
Marshall silt loam, shallow phase.....	3,648	1.0			
Clarion loam, shallow phase.....	5,568	1.5	Total.....	367,360	
Lindley loam.....	256	.1			
O'Neill loam.....	6,208	1.7			

FARMING SOILS

The farming soils cover the greater part of Sac County. This group includes the smooth and, in general, well-drained areas of the soils of the Marshall, Webster, Clarion, Waukesha, and Judson series and a colluvial phase of Wabash silt loam. Of these, three soil types, Marshall silt loam, Webster silty clay loam, and Clarion loam make up the greater part of the area of the group.

The dominant crop on all soils of this group is corn which is grown as frequently as possible. Other crops are grown only to give a rotation necessary to maintain fertility or to provide special crops needed on the farm. The average yield of corn in the county for a series of years is about 25.5 bushels. The average on these soils is slightly higher.

The dominance of corn on these soils is not difficult to explain. Besides the economic factors and the exceedingly favorable climatic conditions, the soil itself is a very important factor. Corn requires for its best development fertile loams and silt loams, well drained and supplied with a large amount of humus, and these soils meet all these essential demands. In addition, these soils occupy smooth areas where machinery can be used to advantage in preparing the land and in cultivating and harvesting the crop. The farmer can cultivate a large acreage and as the yield of corn in grain and fodder is greater than for other crops, the total production for the labor employed exceeds that of other crops. As a result, where these favorable conditions of soil, climate, and topography prevail, corn will displace other crops if prices for this grain are not so low as to be prohibitive.

The distribution of the oat crop is determined in part by a set of conditions different from those which determine corn distribution, and, as a result, oats are not so uniformly distributed over the soils of this group as corn. The greater part of the oat crop is grown on Marshall silt loam, less on Clarion loam, and only a very small acreage on Webster silty clay loam. The well-drained areas of the first two soils require a crop rotation to maintain fertility, into which oats fit well. Webster silty clay loam and other less thoroughly drained soils, which are rich in humus, can withstand continuous cropping to corn with less apparent injury than other soils and crop

rotation is not so widely practiced. Oats would not be suitable for a rotation on Webster silty clay loam, as this crop makes too rank a growth and lodges badly.

Barley is a crop of growing importance, as it is supplementing oats to some extent on all these soils. It is a quick-maturing crop that can be used to fill in when the corn crop is short.

Pop corn is a crop of some importance. In 1929, 5,727 acres were planted to pop corn in Sac County. The greater part of the crop is grown on Marshall silt loam in the vicinity of Odebolt and Schaller. Pop corn can be grown on other types of soil, but the marketing facilities in the western part of the county have caused this part of the county to become the heaviest producer of the crop.

Forage and hay crops are grown on soils of this group, usually as members of rotations. These and other minor crops will be discussed in the soil type descriptions.

Marshall silt loam.—Marshall silt loam is the dominant soil of the rolling uplands in the western half of the county. The surface soil is very dark grayish-brown mellow silt. On the flat areas the dark-colored surface soil extends to a depth ranging from 10 to 15 inches. Below this the color gradually becomes lighter and the material becomes firmer, but it is still silty and friable. At a depth ranging from 18 to 24 inches is a heavy silt loam or light silty clay loam. In most places, at a depth of 3 feet, the lower part of the subsoil is mellow friable pale-yellow silt. Lime is usually abundant at this depth. On flat areas, however, the lime may be leached to a depth of more than 5 feet. No gravel or stone occurs at any depth, but in many places the soil contains a small amount of very fine sand.

On flat areas where erosion is not rapid, the surface soil is darker and the lime is leached to a depth of several feet. On the rolling areas, on which the greater part of this soil occurs, the surface soil on the crests of the knolls and upper parts of the slopes is thinner, as the result of the rapid removal of the soil, and the lime is nearer the surface. On the lower slopes, where the material has collected from the upper slopes, the dark surface soil is deep and somewhat heavier in texture.

Marshall silt loam is the only soil type of the rolling uplands in that part of the county where it occurs. The areas are broken by comparatively narrow bottom lands along the streams which thoroughly dissect the area. The steeper slopes along the larger streams are badly eroded and the gravelly clay of the underlying glacial drift is exposed, affecting the texture of both surface soil and subsoil.

Both the rolling surface soil and the porous subsoil of Marshall silt loam insure good drainage. Only where the flat areas are large is the drainage problem serious, and even here it is easily remedied by laying tile through the fields.

This soil is easily cultivated. No stones or bowlders interfere with plowing or cultivation of crops, and the silty texture and friable consistence allow the surface moisture to readily percolate to the lower depths. The fields warm up early in the spring and may be cultivated sooner after rains than the heavier soils.

The thickness of the dark-colored surface layer varies greatly. On the very gently rolling areas and on the level divides the surface soil

is darker and somewhat heavier than on the more rolling plains. The ridges and upper slopes of the hills are everywhere lighter colored and the surface soil is more shallow than elsewhere. At the base of the slope, the wash from the upper slopes has collected, producing a deep, somewhat heavier silt loam which gradually merges with the bottom land of the stream.

Marshall silt loam is an extensive soil type which covers a large area in several States along Missouri River. In Iowa it is the dominant soil type in a belt on the western side of the State bordering Missouri River. It is everywhere recognized as an ideal corn soil. In this county agriculture is centered around the production of corn, and if it were possible to keep this soil continuously in corn it would be done. As already explained, other crops are grown mainly to give a rotation with corn or to supplement corn in the feeding. This soil is favored for corn because of its high natural fertility, its ease of cultivation, and its ready response to fertilizers and green manures. The corn gets an early start in the spring in the easily prepared, uniform seed bed. The plant roots can easily penetrate to a great depth in the mellow subsoil. Corn does not fire on this soil even during periods of drought because of the power of the soil to retain moisture and deliver it to the plant as needed.

Corn grown on this soil in Sac County year after year will probably average about 40 bushels an acre. No total crop failure has ever been recorded in the county. The range in corn yields in an average year (taken from farmers' estimates) between different farms in various localities is from 25 to 90 bushels an acre. The low yields, except where due to hail, burning from hot winds, or severe storms, are on land which has been heavily cropped, where erosion is active, and where no attempt has been made to improve the land.

Small grains are grown to give a rotation of crops and to supply a nurse crop for the hay seedings which consist mainly of a mixture of timothy and clover. Wheat, oats, and barley are the principal small grains. The yields obtained vary with individual farmers and the management of the land. Wheat yields range from 10 to 30 bushels an acre with an average of 12 bushels, oats average 40 or 50 bushels, and barley yields are always higher than oats.

In the vicinity of Odebolt and Schaller, where marketing facilities are available, a large quantity of pop corn is produced on Marshall silt loam. The quality is good, yields averaging from 1,500 to 1,800 pounds an acre.

Webster silty clay loam.—Webster silty clay loam is one of the principal soil types of the eastern half of the county. It is an upland soil occupying flat or depressed areas, and it is closely associated with Clarion loam which occupies the small knolls and ridges rising above the level of the Webster silty clay loam areas. The surface soil is black heavy silty clay loam which is sticky when wet but very hard when dry. It readily forms clods if worked when too wet or too dry, but after short periods of weathering the clods soon break down. During dry periods, large deep cracks form in the soil, which in many places hinder the growth of small grains by exposing and breaking the plant roots. The loss of moisture in these cracked soils is much greater than in soils where the surface is better mulched with dust. At a depth ranging from 14 to 18 inches the black surface soil grades into lighter-colored, grayish-black or dark-gray clay loam

which is very sticky and plastic when wet. At a depth of about 25 inches, the texture of the soil material becomes more silty and the color changes to gray with a few dark streaks extending downward. The lower part of the subsoil is distinctly gray, with streaks of white lime and a few rust-brown stains throughout. Here and there the surface soil may be slightly acid in reaction, but lime is present in most places in the surface soil and throughout the subsoil below a depth of 2 feet.

Small quantities of very fine sand and a few larger pebbles occur in the surface soil and subsurface soil. The number of pebbles and the quantity of fine sand increase with depth. Sand, pebbles, and large boulders are sufficiently abundant in the lower part of the subsoil to impart a gritty texture to the soil mass. The water table lies at a depth of about 4 feet in the large areas and about 5 feet in the small, narrow areas.

There is a rather wide variation in the depth of the surface soil. Large areas having noticeably deeper surface soils have less adequate natural drainage. "Alkali spots" are present over much of this soil, and their effect on the growing corn crop is very noticeable. In such spots, about the time the corn plants reach a height of 1 to 2 feet they begin to turn yellow and many of them die. Even if the plants withstand the excess concentration of salts they become dwarfed and few of them set ears. Some alkali spots are evidenced by a white coating on the surface of the soil during dry periods. Alkali spots occur in shallow depressions, and many of them are associated with peat and muck soils. The mucky material is black partly decomposed organic matter from 1 to 2 inches deep.

As it is closely associated with Clarion loam, Webster silty clay loam in many places may include a soil which may closely resemble either the Clarion or the Webster soil. The gradation from Webster silty clay loam to Clarion loam is gradual. In the transitional area between the two soils are areas included with Webster silty clay loam which may have some yellowish-gray coloring in the subsoil and be naturally better drained than the greater part of the typical soil. The transitional areas are included with the soil type they most closely resemble.

Webster silty clay loam is naturally poorly drained. Before the land was reclaimed for agriculture, much of it was under water a greater part of the year. A large area in the northeastern part of the county has recently been reclaimed. Tiling is a very successful means of removing the surplus water from this soil, and open ditches afford outlets for the tile lines. The gritty subsoil allows free movement of water into the tile, thereby increasing the efficiency of this method of drainage.

After draining, these soils can be immediately plowed and cropped. The soil is naturally high in fertility, and as the land is usually very weedy, cultivated crops are grown continuously for several years, or until the weeds are well under control. Because of its natural high fertility, this soil can withstand continuous cropping better than any other soil in the county.

Small grains are not grown extensively because of their tendency to produce a rank growth and lodge badly. Stiff, short-strawed varieties are best adapted to this soil. Some of the newly reclaimed

land is seeded to flax or buckwheat from one to three years, but the practice is not general over the county.

Webster silty clay loam occurs in every section in the eastern part of the county. It is highly prized as a corn soil, and most of it is devoted to the production of corn. Rotations commonly used include corn for three to five years, a small grain, and a hay crop.

Legumes, mainly red clover, alfalfa, or sweetclover, are grown for hay and pasture. Corn in normal seasons yields from 40 to 45 bushels an acre. Higher yields are not uncommon and may reach 90 or 100 bushels on some farms. Small grains also yield well, but the grain often lodges badly before maturing, thereby cutting down the acre yield. The lower yields are obtained on poorly drained fields, or where alkali spots are numerous. This soil receives little or no enrichment other than the plowing under of crop residues and meadows. As the black color indicates a high state of fertility, the adjoining soils, which have been farmed for a longer time, receive the manure and the Webster soils remain untreated.

Webster silt loam.—Webster silt loam differs from the silty clay loam mainly in the texture and depth of the surface layer. The surface soil to a depth of about 6 inches is heavy silt loam, very dark brown when dry and black when wet. Beneath the silty surface layer the material changes rather abruptly to dark grayish-brown heavy plastic silty clay loam. The underlying subsoil is not materially different from that of Webster silty clay loam.

This soil occupies a position from 2 to 3 feet above the normal level of Webster silty clay loam and Clarion loam. As no farm consists entirely of this soil, cropping or farm practices do not vary from those on the surrounding soils. Corn yields as well on this soil as on the heavier soils, but small grains can be more successfully grown on this lighter-textured soil. Crop yields on Webster silty clay loam and Webster silt loam differ more according to the systems of farming followed than with differences in texture and fertility of the two soils.

Webster loam.—Webster loam is similar to both the previously described members of the Webster series, differing mainly in the texture of the surface soil which is very dark brown mellow loam to a depth of about 10 inches. Below this it is similar to the other Webster soils. This soil occupies a higher position than the other Webster soils, and therefore natural drainage is better than in the silty clay loam and silt loam types. In many places, the subsoil is slightly yellow and lime is less abundant than in the other Webster soils. There is very little difference in the productiveness of the three Webster soils.

Webster silt loam and Webster loam are better adapted to general farming than is Webster silty clay loam. Corn is not grown so often, and oats, barley, or wheat are often substituted on these better-drained soils. Because they are better drained and do not contain such a high organic-matter content as the silty clay loam, small grains do not grow so rankly and lodge. Heavy yields of oats are obtained, individual yields often reaching 90 or 95 bushels an acre. Farmers' estimates on yields in one threshing ring in 1928 placed the average yield of oats on Webster loam and Webster silt loam at 65 bushels an acre, winter wheat yields at 22 bushels, and barley mixed with oats at 58 bushels.

Clarion loam.—Clarion loam is one of the most extensive and most important soils in the eastern part of the county, where it occurs in close association with the Webster soils. It occupies the knolls and ridges or what are commonly considered the better-drained areas in this gently undulating part of the county. The surface soil is very dark grayish-brown or almost black mellow loam to a depth ranging from 8 to 12 inches. Underlying this dark surface material is brown firm heavy loam which gradually becomes lighter brown with increasing depth. Both the surface soil and subsurface soil contain little or no free lime. The lower subsoil layer is dark-yellow or grayish-yellow friable material containing larger amounts of lime which is readily identified by white streaks or splotches. Fragments of limestone, boulders, small pebbles, and sand intermixed with the silt and clay make up a gritty friable subsoil. A few stones and gravel are scattered over the surface or embedded in the upper part of the subsoil.

As it occurs on knolls and ridges, Clarion loam is more or less subject to erosion, and, therefore, the depth of the surface soil is variable. On the long gentle slopes the surface soil is darker and somewhat deeper than on steeper slopes or the crowns of hills. The lower part of the slope invariably has the deepest dark layer. In badly eroded areas, the dark surface soil has been entirely removed in many places, exposing the yellow calcareous subsoil. This condition occurs along the larger streams, and areas of sufficient size are separated as a shallow phase of Clarion loam. On account of the close association of Clarion loam with the Webster soils, a belt between the two soils is a gradation from one to the other and the areas are mapped with the predominating soil.

The percentage and fineness of the sand content in this soil are variable. Small sandy areas, too small to differentiate as a different soil type, are included with Clarion loam in mapping. In several areas, especially in the southern part of the county, lime lies below a depth of 3 feet. This variation in the depth at which lime occurs is not constant over large areas, and it was considered impractical to attempt a separation on this basis. The subsoil, containing lime in abundance, varies with the surface relief. At the crown of the hill, lime occurs closer to the surface than at or near the base of the slope, indicating that erosion is more rapid than leaching of the lime. The accumulation of the wash from the slopes near the base of the hill increases the depth to the lime zone.

Clarion loam is regarded as one of the best three soils in Sac County. It is naturally well drained except on the lower slopes, where it grades into the Webster soils. Practically all the land is under cultivation and devoted to the production of corn, small grains, and hay. This soil is more easily depleted of its natural fertility than the heavier Webster soils, and corn is not grown so often. Most farmers have adopted cropping systems which include a legume-hay crop following the small-grain crop.

The content of sand prevents clodding and baking of the soil. Consequently the ground may be plowed more easily and crops be more readily cultivated than on the Webster soils. Clarion loam warms up early in the spring, and the porous texture allows the surplus moisture to readily seep through to the lower part of the subsoil. Because of its better drainage, this is the first soil to be worked in the spring.

Clarion loam is slightly lighter colored than the surrounding Webster soils and is therefore regarded as less fertile. These naturally better-drained soils have been under cultivation considerably longer than the lower-lying wet soils. Practically all the available manure from the farms on which this soil occurs is applied to Clarion loam, and the soil responds readily to such treatment. The crests of the hills and upper slopes receive the heaviest applications. Cropping is well systematized, corn rarely being grown more than two years in succession. Because of better drainage and lower fertility, Clarion loam is used extensively for the production of oats, barley, and wheat. Small grains yield well and serve as a nurse crop for clovers and alfalfa. More of the Clarion loam than of the Webster silty clay loam is devoted to small grains and hay.

Although Clarion loam is regarded as less fertile than Webster silty clay loam, equally large yields may be obtained on it as on any other soil type in the county. To accomplish this, however, better systems of farming must be practiced, corn can not be grown so often, legumes should be plowed under, and barnyard manure must be applied regularly.

Corn yields ranging from 75 to 85 bushels an acre are commonly reported, and the average yield in a normal year is between 40 and 45 bushels. High yields are obtained on well-managed farms and low yields, except when storms, hail, or other adverse weather conditions cause heavy losses, are often the result of poor management. In general, oats yield from 30 to 40 bushels an acre, wheat from 18 to 25 bushels, and hay from 1½ to 2 tons. Alfalfa and sweetclover are well adapted to Clarion loam. Three and four cuttings of alfalfa, with a total yield ranging from 3 to 4 tons an acre, are made each season. Some sweetclover is cut for hay, but most of it is utilized as pasture for all kinds of livestock.

Clarion silt loam.—Clarion silt loam occurs only in the western part of the county, on slopes adjacent to streams where the silty surface covering is thin and rests on a calcareous dark-yellow gritty clay loam subsoil. This soil is similar to Marshall silt loam, because of its dark-brown mellow silt loam surface soil, and to Clarion loam, because of its subsoil characteristics. It is in reality a combination of the two soils. The surface soil contains a small amount of fine sand, the amount varying with the degree of slope. The depth at which the gritty subsoil occurs is also determined by the steepness of the slope. The more gentle slopes have a deeper covering of silty material, which in many places reaches a depth of 2 or 2½ feet, whereas, on steeper slopes, the subsoil may lie from 10 to 14 inches beneath the surface of the ground.

Areas of Clarion silt loam occurring on gentle slopes are farmed in conjunction with Marshall silt loam with no apparent differences in crop yields or ease in handling. The strongly rolling areas remain in pasture or are used as hay land.

Waukesha silt loam.—Waukesha silt loam is one of the principal terrace soils in the county. It occurs mainly along Boyer River in the western part. A few smaller areas are developed along the larger tributaries in this section. This is a fertile soil, very similar to Marshall silt loam, except that it occurs on high terraces. It is no doubt developed from material washed from hills covered by Marshall silt loam and deposited on the old river bottoms.

The surface soil, to an average depth of about 12 inches, is dark-brown, almost black when wet, mellow silt loam, containing some fine sand. Below this layer, the color becomes slightly lighter brown, with dark streaks extending downward through the heavy silt loam. The lower subsoil layer, at a depth of about 24 inches, is yellowish-brown or pale-yellow light silty clay loam or heavy silt loam. A few rust-brown and gray streaks occur throughout the lower subsoil layer. The entire soil profile contains little or no lime.

The texture of the surface soil is not uniform. The percentage of sand varies according to the texture of the slopes adjacent to the terrace. Where the gritty clay subsoils lie above the terraces, the wash from these slopes contains large quantities of sand which are deposited over the surface of the terrace and impart a loamy texture to the soil. Where the silty slopes adjoin the terraces the texture is uniformly silty. Where the sandy areas were of sufficient size to warrant separation they were classified as Waukesha loam. In a few small areas sand and gravel occur in the lower part of the subsoil. Where the silty covering is deep and the sandy subsoil shows no injurious effect because of its porosity, the areas are included with Waukesha silt loam.

Waukesha silt loam is farmed in conjunction with Marshall silt loam. In fact, no differentiation in farming practices is made between the two soils, as both are regarded as excellent farm land. High crop yields are obtained on Waukesha silt loam. Corn, according to farmers' estimates, averages between 40 and 45 bushels an acre. Yields vary with methods of farming, many of the better farms producing average yields between 50 and 55 bushels an acre. Oats return an average yield of 40 bushels and hay about 2 tons. Where the soil is "sweet" excellent stands of alfalfa are obtained.

Waukesha loam.—Waukesha loam is similar to Waukesha silt loam, differing only in the texture of the surface soil which is dark-brown friable loam to a depth of 12 inches. The subsurface soil and subsoil are not materially different from the corresponding layers in Waukesha silt loam. Crop yields on the loam are reported to be slightly lower than on the silt loam, but this feature is somewhat offset by the fact that the loamy texture allows earlier and greater ease in cultivation both in the spring and following rains during the growing season.

Judson silt loam.—Judson silt loam occurs only in the western part of the county. It is mapped between Marshall silt loam of the uplands and Wabash silt loam of the bottoms. The areas are narrow, few of them exceeding one-fourth mile in width. The slope is toward the stream channel. The very dark grayish-brown, or almost black, friable silt loam surface soil is very deep, in many places ranging from 20 to 24 inches in depth. Below a depth of 24 inches the material becomes lighter brown and slightly heavier in texture, though not greatly different from the surface soil. In many places the dark organic coloring reaches a depth ranging from 40 to 50 inches.

Judson silt loam is a very fertile soil. It is material washed from the slopes occupied by Marshall soil and collected at the base of the hill. Crop yields are very high, corn averaging between 50 and 55 bushels an acre. Oats and other small grains often lodge badly on this soil, thereby lowering the average yield over large acreages.

Alfalfa and sweetclover thrive on Judson silt loam if the lime content is sufficient to start the young plants. A few of the areas must be tilled to insure adequate drainage at all times, but the gently sloping surface is in most places sufficient to insure good drainage.

Wabash silt loam, colluvial phase.—Wabash silt loam, colluvial phase, is similar to Wabash silt loam except that it occurs in narrow bands along minor stream tributaries in the western part of the county and is material washed from the slopes and collected in the U-shaped valleys. In many places the dark color reaches a depth ranging from 4 to 5 feet. The main difference between the surface soil and subsoil is not in color but in texture, the subsoil being silty clay loam and the surface soil silt loam. Areas of this soil which are too wet to crop successfully are tilled and then farmed along with the other soils. Crop yields are slightly higher than those obtained on Marshall silt loam.

More than 75 per cent of this type of land is under cultivation. During wet seasons, crop yields are somewhat lowered. However, the slope and the ease of percolation through the soil allow the excess moisture to escape before crops are injured to any great extent during normal years.

FARMING-GRAZING SOILS

With the farming-grazing soils are included seven soils which have an average productivity lower than the soils of the farming group. All these soils vary widely in productivity in different parts of their areas. They cover all gradations in agricultural value from soils slightly less desirable than the soils of the farming-soil group to nontillable lands used only for pasture. The lower value of these soils is owing to characteristics of the soils themselves. In Marshall silt loam, shallow phase, Clarion loam, shallow phase, and Lindley loam, erosion has removed a large part of the dark-colored surface soil which contains the organic matter so beneficial to crops. Erosion has also caused the surface relief of areas of these soils to become sharply rolling, which further decreases their agricultural value. The value of O'Neill loam and Dickinson sandy loam is decreased by the texture of their subsoils. O'Neill loam has a dark-colored surface soil of good texture, but the subsoil below a depth of 15 inches consists of loose sand and gravel. This soil covers smooth terraces, standing from 15 to 30 feet above the present flood plain. In years of heavy rainfall, the yields of all crops are very satisfactory, but in dry seasons production, particularly of corn, is greatly decreased. Dickinson sandy loam has a moderately dark-colored surface soil which is underlain by loose porous sand and fine gravel. In seasons of ample rainfall this soil gives good yields but in dry years crops are injured. Bremer silty clay loam and Fargo silty clay loam owe their lowered productivity to excessive moisture. In years of moderate rainfall large yields of corn and other crops are obtained on the drained areas, but in wet seasons crops are injured and in many places drowned out. A large part of these soils is permanently undrained, and such areas are used only for pasture and hay land.

Marshall silt loam, shallow phase.—Marshall silt loam, shallow phase, is similar to typical Marshall silt loam, differing only in the

depth of the surface soil and the surface relief. Lime is usually more abundant in the shallow soil and is nearer the surface. The surface layer is shallow, in few places exceeding 7 inches in depth. It is lighter brown than the typical Marshall silt loam surface layer. This soil occurs on steep slopes or narrow ridges in the thoroughly stream-dissected area in the southern part of the county along Boyer River. Erosion is active and rapid. Large amounts of silty material are removed during each heavy precipitation wherever the fields are cultivated. Large areas have been eroded so badly that the entire dark surface covering has been removed and the pale-yellow calcareous subsoil is exposed. Wherever the surface relief allows, some of this land is cultivated, but most of it is allowed to remain in permanent bluegrass and prairie-grass pasture.

Clarion loam, shallow phase.—The soil mapped as Clarion loam, shallow phase, differs from the typical soil in that the surface soil is very shallow. In many places it has been entirely removed through erosion. This soil occurs mainly along the larger streams, on steep slopes, or on the crest of high knolls. Extensive areas have been mapped along Raccoon River and Indian Creek. Most of the land is too steep for cultivation and remains in permanent bluegrass pasture. Timothy and a small percentage of sweetclover from roadside plants have voluntarily seeded in the pastures.

Lindley loam.—Lindley loam is known locally as "white land" or "timber land." It is an inextensive soil in Sac County, occurring in the southeastern part north of Auburn. The surface soil is gray or brownish-gray mellow loam to a depth of about 8 inches. Below this and continuing to a depth of about 16 inches is gray, streaked with brown, compact fine sandy loam. The lower part of the subsoil is gray gritty clay. The gray color is not solid but is streaked with yellowish-brown and rust-brown stains throughout.

Lindley loam occurs on narrow ridges and steep slopes of the hills along Raccoon River. Most of the land is still in native timber. The wider ridges have been cleared, and the fields are now being cropped. Small grains and hay do well on this soil, but corn yields are low, averaging between 20 and 25 bushels an acre in good years. Oats, however, yield from 35 to 45 bushels an acre and hay, consisting of a mixture of timothy and clover, about 1½ or 2 tons. The soil responds readily to manurial treatment.

O'Neill loam.—O'Neill loam is most extensively developed along Raccoon River south of Sac City. The areas range from a few hundred feet to three-fourths mile in width. They lie from 15 to 30 feet above the present flood plain of the river. The surface relief is flat or sloping toward the stream. In most places a distinct line separates the terrace from the bottom land, giving the terrace a benchlike effect.

The surface soil of O'Neill loam is brown, dark-brown when wet, mellow loam. In many places a few pebbles are found in the upper 8 inches of surface soil. At a depth of 8 inches, and extending downward to about 15 inches, the color becomes lighter and the texture somewhat heavier, namely that of a heavy loam or sandy clay loam. Below a depth of 15 inches, the stratified, yellowish-brown sand and gravel subsoil occurs. The gravel pebbles range in size from coarse sand to pebbles 3 inches in diameter. The porous sub-

soil readily allows excess moisture to percolate downward, affording good or excessive drainage even though the areas are flat.

Practically all the O'Neill loam is under cultivation. Corn and small grains yield well during normal or moist years, but during dry seasons, crops suffer from lack of moisture because of the porous subsoil. This condition causes wide variations in yields, and average yields over a period of years may be low. During normal years corn yields average between 25 and 30 bushels, and in dry years they often drop to 15 bushels an acre. Oat yields are not so greatly affected as corn yields because the crop generally matures before extended dry periods occur. Some timothy and clover are grown on these sandy terraces, but as a rule grain crops are grown as often as possible. The fields receive treatments of manure on farms where it is available, and crop residues are plowed under each year.

Dickinson sandy loam.—Dickinson sandy loam occurs in small areas throughout the eastern half of the county. During dry seasons the areas of this soil may easily be recognized in the fields. Most of the knolls on which they occur are slightly higher than the surrounding hills, and the grass or cultivated crops fire easily during dry seasons because of the sandiness or porosity of the subsoil. Fortunately the areas are small, the largest one mapped not exceeding 40 acres in extent. The areas are most numerous in the southern part of the eastern half of the county.

The surface soil to a depth of 6 or 8 inches is dark-brown friable sandy loam or fine sandy loam. Below this and continuing to a depth of about 24 inches is lighter-brown compact sandy loam. A few gravel pebbles are present in the lower part of this layer. Below a depth of 24 inches is a yellow, gray, and brown sand and fine gravel layer which is high in lime content and porous.

Most of the areas of this soil are farmed in conjunction with the surrounding soils, but crop yields in normal years do not equal those obtained on the heavier-textured soils. Because of the openness of both surface soil and subsoil, lack of moisture is the limiting factor in crop production. During the season of the survey (1928), although it was a normal year, crops on these areas showed the need of moisture, and during harvest farmers reported decreased yields owing to lack of moisture. Corn on Dickinson sandy loam in 1928, except on fields where heavy applications of manure were made, averaged about 25 bushels an acre according to farmers' estimates. Oat and hay yields were correspondingly lowered.

Bremer silty clay loam.—Bremer silty clay loam is a very heavy black sticky soil occupying terraces which lie from 4 to 8 feet above the present flood plain of the streams or occurring in depressions within areas of better-drained terrace soils. The black surface soil ranges from 10 to 15 inches deep. It is high in organic matter and, as a rule, has a tendency to clod and bake when worked under adverse moisture conditions. The upper subsoil layer is dark-gray or dark grayish-brown sticky heavy clay loam. At a depth of about 24 inches the subsoil becomes gray and is stained with yellow and rust brown, indicating poor drainage.

This soil is naturally poorly drained. Ditching and tiling are necessary before the larger areas can be successfully cropped. Less than 50 per cent of the total area is sufficiently drained artificially to

insure good crop yields in all seasons. With good drainage, these soils produce heavy crop yields. In many areas corn is grown continuously and yields from 45 to 50 bushels an acre. The undrained areas are utilized as pasture or hay land. Wild slough grass makes a rank growth and when cut for hay is used as roughage during the winter. Small grains, because of the tendency to lodge badly, are not grown extensively on this soil.

Fargo silty clay loam.—Fargo silty clay loam is mapped on low terraces along streams, lying from 4 to 8 feet above the present flood plains of the streams. The soil profile is similar to that of Bremer silty clay loam except that Fargo silty clay loam has an abundance of lime carbonate in the subsoil layers and in much of the surface soil. The land is poorly drained and requires some artificial means to carry off the surplus moisture before successful cropping may be done. About one-third of the land has been reclaimed by means of open ditches and the laying of tile through the wettest parts of the field. On the drained areas, corn is grown almost exclusively. Small grains produce a rank straw growth and lodge badly. Yields of corn averaging 70 bushels an acre are not uncommon when the temperature and rainfall conditions are favorable. The undrained parts of Fargo silty clay loam support a rank growth of slough grass, and bluegrass thrives on the better-drained parts of the naturally wet areas. These two grasses provide good feed during the grazing season.

Fargo silty clay loam has a deep sticky heavy silty clay loam surface soil ranging from 12 to 18 inches in depth. This dark layer is very dark grayish brown when dry and almost black when wet. The subsoils are gray or slate-gray heavy compact and impervious clays. Lime is everywhere present in the subsoils and may be present in the surface layers.

GRAZING SOILS

Five soils of comparatively small extent have been placed in the group of grazing soils. These soils are largely untillable, owing to either excessive or deficient drainage. Pierce sandy loam has developed over gravelly knolls on the upland. The dark surface soil is thin and is underlain by a mass of loose gravel and bowlders. This soil is so excessively drained that no attempt is made to cultivate it. The Wabash, Cass, and Lamoure soils occur on low alluvial lands. These soils drain slowly and are subject to frequent flooding by the streams. Peat and muck are organic soils which occupy depressions and remain permanently water-logged.

Pierce sandy loam.—Pierce sandy loam is a sandy soil, low in natural fertility, droughty, and unimportant agriculturally. It occupies the higher knolls and may be readily recognized by its barren condition during dry periods. Open gravel pits on this land furnish a large proportion of the sand and gravel used in the county for building and road surfacing. The surface soil is shallow, rarely more than 3 inches in depth and nowhere exceeding 6 inches. The texture is sandy, and gravel of various sizes lie on the surface. Below the thin surface covering is calcareous sandy gravel. In some places sand and gravel are laid down in alternate layers.

This soil is of little agricultural value. Much of it is so infertile and droughty that it can not support even weed growth. It is

valuable, however, as a source of road-surfacing material. The areas are well scattered over the eastern part of the county, thereby limiting the distance of hauling and the expense of road graveling.

Wabash silt loam.—Wabash silt loam is a first-bottom soil, all of which is more or less subject to overflow. It occurs in all parts of the county, in narrow bands along practically all streams. Only the larger developments can be successfully cropped after dikes are built to control the flood waters. Artificial drainage is necessary to carry off the excess water following rains. The greatest development of Wabash silt loam is along Boyer River. This stream, however, has an extensive drainage area, and during freshets the entire flood plain is inundated, damaging or preventing the growth of crops. Some of the areas of Wabash silt loam support a growth of timber, consisting of elms, maples, oaks, locust, poplar, cottonwood, and willows. Bluegrass grows luxuriantly, affording excellent pasture throughout the grazing season. Most of the narrow bands of Wabash silt loam along small stream tributaries within Marshall silt loam areas are drained and farmed in conjunction with the upland soil.

The surface soil of Wabash silt loam is dark-brown silt loam containing some fine sand. It ranges in depth from 18 to 24 inches. Below the surface soil, the texture changes to heavy silty clay loam and the color to lighter brown. The lower part of the subsoil is gray, streaked with black, rust brown, and yellow. In many places, a dark organic color was observed at a depth ranging from 4 to 5 feet. The texture of the surface soil along the larger streams is variable, being more sandy near the banks of the streams than it is a short distance away. Within the Marshall silt loam areas, some of the narrow bands of bottom land mapped as Wabash silt loam include heavier-textured soils which were too small to separate and map.

Practically all the Wabash silt loam is utilized as pasture land. The areas sufficiently protected from overflow and properly drained are cropped continuously to corn. Yields vary with seasonal conditions and in normal years average between 50 and 60 bushels to the acre, but during wet seasons the yield is considerably less.

Wabash silty clay loam.—Wabash silty clay loam is most extensively developed along the larger streams of the county. It occupies a first-bottom position subject to frequent overflow and is naturally poorly drained. The heavy texture prevents the surplus water from percolating to the lower part of the subsoil, and the flat or depressed relief prevents run-off of excess water following rains or floods.

The surface soil is very dark brown when dry and a black compact sticky mass when wet. At a depth ranging from about 12 to 15 inches the color becomes lighter and the texture in some places is not so heavy as that of the surface soil. Below a depth of 30 inches the subsoil is dark-gray compact plastic heavy clay loam. Brown, rust-brown, and black streaks are numerous throughout the subsoil. All of this soil is utilized as pasture land. It supports a growth of wild slough grass and, in a few places, bluegrass. Wild hay is cut for winter roughage or baled and sold to stockyards at Omaha or Sioux City.

Lamoure silty clay loam.—Lamoure silty clay loam is similar to Wabash silty clay loam in color, texture, and mode of occurrence but differs from that soil in that it contains an abundance of lime

throughout the surface soil and subsoil. It is mapped along streams and is subject to frequent overflow either directly from the stream or by backwater.

Only a very small part of Lamoure silty clay loam is sufficiently protected from overflow and drained for the production of crops. The drained areas are used in the production of corn, and the undrained areas serve as pasture. Slough grass furnishes feed for livestock throughout the grazing season.

Cass fine sandy loam.—Cass fine sandy loam is brown mellow fine sandy loam to a depth of 14 or 16 inches. Below this is light-brown or grayish-brown porous fine sand. This soil is mapped along Raccoon and Boyer Rivers. It is of minor agricultural importance, as the areas are small and subject to frequent overflow. None of the land is cultivated. A forest growth, consisting of elm, maple, ash, cottonwood, willow, and haw has gained footing. The undercover consists of buckbrush, weeds, and a thin stand of bluegrass.

Peat and muck.—A few areas of peat and muck are mapped in Sac County. Peat areas include those in which the plant material has not decayed to a great extent. The layer of peat is shallow and rests on gray calcareous impervious clay. Muck areas have a thin covering of well-decomposed peat, and they occur within areas of Webster soils. Both peat and muck occur on level or depressed areas where water remains on the field throughout the year. Rings of "alkali" surround many of the peat and muck beds, causing much trouble with crops.

GRAVEL PITS

On the soil map a number of gravel pits have been indicated. They occur on knobs of gravelly glacial drift or on outwash terraces. The gravel in some of the pits has been taken out and the pits are abandoned; others still furnish a supply of gravel for local use.

RECOMMENDATIONS FOR THE UTILIZATION AND IMPROVEMENT OF SAC COUNTY SOILS

No field experiment plots are located in Sac County, but several experimental fields, conducted by the Iowa Agricultural Experiment Station in other counties and located on the same kinds of soils as occur here, definitely indicate the results which may be obtained. Experimental plots on Marshall silt loam are located in Cherokee, Montgomery, Pottawattamie, and O'Brien Counties. These are permanently laid out in $\frac{1}{16}$ -acre plots on land representative of the soil type to be studied. The experiments are planned to include tests of various fertilizer treatments under both the livestock and grain systems of farming. Under the livestock system, manure, applied at the rate of 8 tons an acre once in a 4-year rotation, is the basic treatment. Under the grain system the organic matter is supplied by crop residues (particularly cornstalks) and the plowing under of, preferably, all the clover crop but generally only the second crop. Ground limestone is applied in sufficient amounts to neutralize soil acidity. Rock phosphate, prior to 1925, was applied at the rate of 2,000 pounds an acre once in a 4-year rotation, but since that time 1,000 pounds an acre have been used. Superphosphate is applied at the rate of 150 pounds an acre for the two corn crops, for small

grain, but not for the clover. Complete fertilizer of the 2-12-2⁴ brand, applied at the rate of 200 pounds an acre a year on each grain crop is used. Muriate of potash is applied at the rate of 25 pounds an acre.

Table 5 illustrates the various treatments, crops grown, and acre yields on Marshall silt loam in Cherokee County, Iowa.

TABLE 5.—Yields per acre from Cherokee field on Marshall silt loam in Cherokee County, Iowa

Plot No.	Treatment	Corn		Oats, 1924	Clover and timothy, 1925	Corn ¹			Oats, 1929
		1922	1923			1926	1927	1928	
		<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Tons</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>
1	Check.....	59.8	51.2	49.0	1.87	34.6	47.9	43.5	88.5
2	Manure.....	64.9	56.1	54.7	2.03	32.8	52.9	45.5	91.8
3	Manure+limestone.....	66.6	59.8	55.5	2.18	35.2	53.7	49.2	99.8
4	Manure+limestone+rock phosphate.....	69.8	60.8	60.6	2.16	37.6	54.8	49.1	103.3
5	Manure+limestone+superphosphate.....	70.8	61.3	61.6	2.37	46.2	57.9	47.2	106.7
6	Manure+limestone+superphosphate+potassium.....	72.6	61.9	62.0	2.29	49.2	55.7	44.5	102.2
7	Manure+limestone+complete commercial fertilizer.....	74.2	62.8	70.3	2.38	46.0	49.7	46.8	103.3
8	Check.....	61.1	52.7	55.2	1.99	36.3	43.6	37.1	90.8
9	Crop residues.....	63.4	54.5	54.7	2.11	46.4	44.0	44.3	93.1
10	Crop residues+limestone.....	62.6	58.9	61.6	2.25	46.8	42.7	44.9	84.0
11	Crop residues+limestone+rock phosphate.....	62.6	60.3	62.7	2.19	45.8	47.7	44.4	93.1
12	Crop residues+limestone+superphosphate.....	60.4	64.7	66.7	2.32	44.8	46.4	44.5	90.8
13	Crop residues+limestone+superphosphate+potassium.....	50.8	66.7	63.2	2.47	46.6	47.9	44.4	88.5
14	Crop residues+limestone+complete commercial fertilizer.....	50.4	66.2	68.6	2.33	44.2	49.2	44.5	96.4
15	Check.....	53.9	52.3	49.7	1.92	45.6	42.7	37.4	83.2

¹ Bindweed damaged plots considerably, and yields are not representative.

Table 5 shows the results obtained with various fertilizer treatments. Manure shows its beneficial effects on all crops except corn in 1926. Limestone with manure gave further increases in all tests. The largest increases, through the use of rock phosphate with manure, were evidenced on the 1924 oat crop. Superphosphate with manure gave greater increases than rock phosphate in all but one season. Superphosphate shows its greatest effect on the timothy and clover crop in 1925 and the corn crop in 1926. Muriate of potash gave only slight crop increases, and complete commercial fertilizers gave lower yields than superphosphate alone.

In the crop-residue plots, little effect was noticeable with the residues alone. However, corn following timothy and clover showed marked increases. Additions of limestone further increased the clover and timothy yields over the check plot. Superphosphate with crop residues and lime generally gave increased yields, but rock phosphate had practically no effect. Complete fertilizers gave no better results than superphosphate.

This experiment shows that manure is the most economical enrichment to use on this soil. Where the soil is distinctly acid, liming is decidedly beneficial, especially for the clover crops and, therefore, ultimately for the following grain crops.

⁴ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

The effect of various fertilizer treatments on Marshall silt loam in other counties of Iowa can readily be seen in Tables 6 and 7.

TABLE 6.—*Acre yields from Red Oak field on Marshall silt loam in Montgomery County, Iowa*¹

Plot No.	Treatment	Winter wheat, 1918 ²	Corn		Oats, 1921 ⁴	Winter wheat, 1922 ⁵	Corn, 1923	Soy-beans, 1924	Winter wheat, 1925	Clover, 1926 ⁶	Alfalfa	
			1919 ³	1920							1927 ⁷	1928 ⁸
1	Check.....	Bush. 13.6	Bush. 52.0	Bush. 56.0	Bush. 28.2	Bush. 13.2	Bush. 54.5	Bush. 11.2	Bush. 10.4	Tons	Tons	Tons
2	Manure.....	34.1	57.2	61.6	36.9	15.5	57.8	12.4	11.6	-----	2.20	3.70
3	Manure+lime.....	31.8	59.2	66.0	37.8	18.6	64.7	14.2	11.3	-----	3.09	3.85
4	Manure+lime+rock phosphate.....	27.7	60.0	63.0	35.6	28.6	64.6	13.7	13.6	-----	3.57	4.67
5	Manure+lime+superphosphate.....	31.8	58.5	62.7	39.4	30.7	62.9	13.1	13.1	-----	3.32	4.35
6	Manure+lime+complete commercial fertilizer.....	29.5	56.2	64.2	36.4	25.4	61.3	14.6	10.6	-----	3.75	4.18
7	Check.....	54.2	54.2	56.6	31.8	17.4	50.6	10.5	9.4	-----	2.18	3.69
8	Crop residues.....	29.5	51.0	54.1	31.3	16.4	52.9	9.9	8.6	-----	2.34	3.13
9	Crop residues+lime.....	25.0	53.7	60.2	31.2	19.5	55.0	13.2	10.2	-----	2.30	4.14
10	Crop residues+lime+rock phosphate.....	18.1	57.7	59.2	35.0	23.8	55.7	12.3	13.0	-----	2.54	4.21
11	Crop residues+lime+superphosphate.....	27.2	53.7	61.6	36.9	22.3	52.7	12.1	11.6	-----	2.53	4.26
12	Crop residues+lime+complete commercial fertilizer.....	26.1	57.0	57.3	37.8	22.2	56.8	14.0	12.5	-----	1.97	3.79
13	Check.....	13.6	48.2	51.4	29.0	15.2	52.0	8.9	9.9	-----	1.53	3.78

¹ Data from State Soil Survey of Iowa.

² Clover killed and plowed up. Yield on plot 7 an error.

³ Three and one-half tons lime, applied on May 15.

⁴ Two and one-half tons lime, applied in September.

⁵ Dry weather killed out clover.

⁶ Clover stand very poor, owing to dry weather. Field was plowed and seeded to alfalfa in August.

⁷ Results of first and second cuttings combined. No results taken on third cutting.

⁸ Three cuttings.

TABLE 7.—*Acre yields from Avoca field, series 1, field 2, on Marshall silt loam in Pottawattamie County, Iowa*¹

[Superphosphate added annually since 1925]

Plot No.	Treatment	Corn, 1919 ²	Oats, 1920 ³	Clover, 1921 ⁴	Corn, 1922 ⁵	Oats, 1923	Sweet-clover, 1924 ⁶	Corn		Oats, 1927	Corn	
								1925	1926		1928	1929 ⁷
1	Check.....	Bush. 72.9	Bush. 62.2	Tons 2.0	Bush. 58.1	Bush. 48.7	Tons 0.36	Bush. 62.2	Bush. 54.6	Bush. 45.7	Bush. 64.5	Bush. 59.4
2	Manure.....	72.1	69.0	2.7	53.6	56.7	.63	63.9	63.7	56.0	67.5	70.4
3	Manure+lime.....	74.0	72.3	2.6	53.9	53.2	1.82	61.6	64.0	64.0	68.3	71.1
4	Manure+lime+rock phosphate.....	77.8	58.8	2.7	55.5	60.0	1.52	58.1	61.3	69.8	66.4	73.3
5	Manure+lime+superphosphate.....	79.3	69.0	2.5	56.5	60.0	1.68	52.3	64.8	75.0	70.9	71.5
6	Manure+lime+complete commercial fertilizer.....	77.5	61.2	2.8	57.5	66.8	1.92	51.4	65.6	79.1	65.6	70.6
7	Check.....	71.5	56.8	2.0	44.8	47.6	.85	39.8	61.0	50.0	64.3	61.3
8	Crop residues.....	78.9	63.9	2.0	44.8	49.8	.90	51.0	66.4	57.1	66.7	68.2
9	Crop residues+lime.....	80.7	68.1	2.1	50.0	56.7	1.92	58.7	64.5	66.7	66.4	59.8
10	Crop residues+lime+rock phosphate.....	78.5	68.6	2.8	54.8	59.0	1.83	56.8	69.6	66.6	62.1	66.2
11	Crop residues+lime+superphosphate.....	81.1	75.1	2.2	54.1	64.5	1.50	57.1	66.6	64.7	66.1	66.7
12	Crop residues+lime+complete commercial fertilizer.....	80.4	68.6	2.9	52.0	52.1	1.44	58.4	65.8	70.0	64.8	66.6
13	Check.....	80.0	68.6	2.2	46.3	50.9	1.12	51.8	60.8	60.6	61.6	62.2

¹ Data from State Soil Survey of Iowa.

² Field slopes toward plot 13.

³ Not limed until Oct. 1, 1920. Three tons per acre.

⁴ Field pastured until June 1.

⁵ Corn injured by hail in August and by rainy spring.

⁶ Strong winds and wireworms cut down stand considerably.

⁷ Yield on a 15 per cent moisture basis.

Two field experiments on Clarion loam, which is one of the main soil types of eastern Sac County, are located in Buena Vista County. They are known as the Truesdale fields, series 1 and 2. With various fertilizer treatments the results show that manure increased all crop yields except clover. Liming showed its most beneficial effects on the clover crop and slight increases on grain crops following clover. Clarion loam has a very calcareous or limy subsoil, but in many places the surface soil may be acid. Rock phosphate with manure and lime gave increases in clover yields but showed little effect on grain crops. Complete fertilizers were not greatly superior to superphosphate or rock phosphate.

Little or no effect on yields resulted from the plowing under of the crop residues, but there was an increase following the turning under of the clover crop. Superphosphate and rock phosphate gave good increases in corn and oats and decided increases in clover hay. Complete commercial fertilizers were no better than superphosphate alone.

From this experiment it would seem that manure is valuable on this soil type. Liming, together with manure, gives economical returns when the soil is acid. Light applications of lime start the young legume plants until the roots penetrate the acid surface soil and grow into the limy subsoil.

Table 8 shows the results obtained on Clarion loam on the Truesdale field, series 2, in Buena Vista County.

TABLE 8.—Acre yields from Truesdale field, series 2, on Clarion loam in Buena Vista County, Iowa¹

Plot No.	Treatment	Oats, 1918 ²		Corn				Oats, 1922 ⁵		Corn		Bar-ley, 1928	Alfal-fa, 1929 ⁸
		Bush.	Tons	1920	1921 ⁴	Oats, 1922 ⁵	Clo-ver, 1923	1924 ⁶	1925	Oats, 1926 ⁷	Corn, 1927		
1	Check.....	69.9	-----	47.5	32.8	18.5	1.72	38.0	40.0	29.9	50.1	31.8	2.09
2	Manure.....	94.2	-----	57.0	39.7	24.6	1.90	52.7	50.4	38.1	55.3	33.3	2.33
3	Manure+lime.....	91.2	-----	59.0	41.8	27.2	1.86	46.9	51.8	37.0	54.5	45.4	2.87
4	Manure + lime + rock phosphate.....	88.2	-----	61.2	38.1	32.4	2.26	44.4	51.7	37.3	57.3	39.3	3.03
5	Manure + lime + superphosphate.....	91.2	1.89	62.1	40.2	31.0	2.24	-----	54.8	43.3	57.7	45.4	3.28
6	Manure + lime + complete commercial fertilizer.....	88.2	2.00	64.0	44.5	31.9	2.42	45.0	58.6	43.6	58.0	46.9	3.24
7	Check.....	85.1	1.59	57.1	36.3	23.6	1.93	42.9	51.6	34.3	55.2	34.8	1.86
8	Crop residues.....	89.7	1.98	58.5	32.9	31.2	1.98	40.7	59.2	35.4	55.1	39.3	2.29
9	Crop residues+lime.....	97.3	2.07	59.2	40.1	29.8	2.03	41.8	52.2	32.7	52.9	42.4	2.51
10	Crop residues+lime+rock phosphate.....	91.2	2.19	60.0	30.6	34.4	2.39	46.0	51.1	38.7	56.3	37.9	3.14
11	Crop residues+lime + superphosphate.....	92.7	2.22	60.4	33.6	36.8	2.11	40.7	60.4	47.4	54.4	40.9	3.05
12	Crop residues+lime + complete commercial fertilizer.....	95.5	2.37	61.9	35.5	37.3	2.39	39.3	55.2	40.3	53.6	42.4	3.28
13	Check.....	85.1	1.91	60.9	34.9	28.4	2.03	39.5	49.8	29.9	50.8	31.8	1.85

¹ Data from State Soil Survey of Iowa.
² Two and one-half tons lime in March.
³ Plots 1, 2, 3, and 4 disked and seeded to oats. Clover winter killed.
⁴ Poor stand of corn.
⁵ Two tons lime in April.
⁶ Plot 5 injured by squirrels.
⁷ Dry season caused low yields.
⁸ Total of two cuttings.

Field experiments have also been conducted on Webster silty clay loam in Buena Vista County near Newell and Storm Lake. Webster silty clay loam is one of the principal soil types in Sac County. It is classed as a fertile soil and one that has not been under cultivation so long as the better-drained upland soils of the county.

On the Newell field the fertilizer treatments are the same as those on Marshall silt loam and Clarion loam. Webster silty clay loam is a heavy black soil, well supplied with organic matter, but nevertheless applications of manure gave good increases of all crops except clover. This soil type is high in lime content, but in a few places the surface soil is acid. Liming aids in obtaining good legume stands on the acid spots; the phosphate fertilizers increase the clover yield materially and the corn and oats yield to some extent. Complete fertilizers are no better than phosphates alone on this soil. Under the grain system of farming, crop residues did not give such high yields as manure treatments, but the other treatments gave about the same results as under the livestock system.

Small applications of barnyard manure are beneficial even on this dark-colored heavy soil. It would not be advisable, however, to apply manure preceding a small-grain crop, because this may result in a rank straw growth and cause the grain to lodge badly. If the surface soil is acid, light applications of limestone will aid the legume to become established until the roots reach the limy subsoil. Phosphates are more economical than complete commercial fertilizers on this soil.

The treatments and results obtained on Webster silty clay loam on the Storm Lake field in Buena Vista County are given in Table 9.

TABLE 9.—Crop yields from Storm Lake field on Webster silty clay loam in Buena Vista County, Iowa¹

Plot No.	Treatment	Corn			Oats, 1918 ²	Oats, 1921	Clover, 1922 ³	Corn		Barley, 1925	Corn, 1926	Oats, 1927	Alfalfa	
		1919	1920	1923 ⁴				1924 ⁵	1928 ⁶				1929 ⁶	
		Bush.	Bush.	Bush.	Bush.	Tons	Bush.	Bush.	Bush.	Bush.	Bush.	Tons	Tons	
1	Check.....	73.0	54.7	48.2	45.1	0.75	51.0	22.7	40.9	50.4	54.5	3.11	3.51	
2	Manure.....	73.0	54.1	57.3	42.2	1.01	60.7	27.5	47.8	50.1	50.5	3.45	4.99	
3	Manure + superphosphate + potassium.....	73.0	57.6	58.1	36.3	1.29	65.1	29.2	56.9	53.6	53.0	4.13	5.31	
4	Manure + rock phosphate.....	80.6	61.1	64.2	43.8	1.26	66.4	31.0	61.8	48.5	53.2	4.62	5.44	
5	Manure + superphosphate.....	74.5	66.4	76.5	51.8	1.42	68.5	31.8	57.6	58.4	51.7	4.12	5.37	
6	Manure + complete commercial fertilizer.....	82.0	61.1	80.0	43.8	1.43	66.8	33.9	60.7	52.8	52.5	4.56	5.78	
7	Check.....	70.0	71.5	66.6	40.9	1.10	55.8	34.0	44.5	48.5	54.5	3.88	4.08	
8	Crop residues.....	85.1	75.7	67.7	49.1	1.08	63.3	37.3	44.5	51.2	47.4	4.35	4.44	
9	Crop residues + superphosphate + potassium.....	76.0	70.1	67.2	41.1	1.25	70.7	35.7	64.4	52.8	51.2	5.08	5.54	
10	Crop residues + rock phosphate.....	79.0	70.4	76.2	41.6	1.20	63.2	27.4	52.8	50.1	54.5	4.60	4.98	
11	Crop residues + superphosphate.....	73.0	64.0	76.2	45.5	1.23	63.1	31.1	58.2	49.6	47.0	4.81	5.56	
12	Crop residues + complete commercial fertilizer.....	85.1	67.5	76.2	43.8	1.13	61.3	27.2	58.1	43.5	61.9	4.45	5.07	
13	Check.....	79.0	67.5	67.7	39.7	.86	51.9	23.1	41.6	34.9	49.5	2.52	3.13	

¹ Data from State Soil Survey of Iowa.

² Soil basic; no manure applied; oats badly lodged.

³ Superphosphate and potassium applied to plots 3 and 9 in 1922. First crop only.

⁴ Hogs in corn damaged the yield.

⁵ Early frost left corn very chaffy and light, and practically none was marketable.

⁶ Total of three cuttings.

The Iowa system of soil-management includes five main practices, which, if followed, may be expected to increase crop yields and profits per acre as well as maintain the fertility of the soil. These are as follows: (1) Drainage and cultivation, (2) manuring and green manuring, (3) liming, (4) use of phosphates and other fertilizers, and (5) rotation of crops.

Proper drainage conditions must exist in any soil before maximum crop yields can be obtained. The need of drainage is readily recognized in wet, swampy areas or on flat land where water remains on the surface several days after rains. Such areas must be drained, but there are also hundreds of acres of land now cropped that could be economically drained and should be, even though fairly good yields are now obtained. Artificial drainage converts water-logged soil into excellent crop land and makes it decidedly easier to handle. Well-drained soils warm up earlier in the spring and dry out more quickly following rains than undrained areas. Although tiling is an expensive procedure, the resultant increase in crop yields will soon offset the original cost.

In many places proper cultivation of the soil proves effective in increasing crop yields. Too often shallow plowing prevents the preparation of a uniform seed bed. Deeper plowing, followed by thorough cultivation, will increase acre returns.

Field tests, conducted by the Iowa Agricultural Experiment Station, and the experience of farmers prove conclusively the value of barnyard manure and green manures (legumes) on the succeeding crops. Light-colored soils are benefited most by manures, but even heavy black soils respond to this form of treatment. Organic matter is essential in all soils for economical crop returns. Too much emphasis can not be given the incorporation of organic matter in the form of barnyard manure, green manures (preferably legumes), and crop residues.

Wherever a soil is acid, liming is essential. All crops grow where lime is present, and some legumes refuse to grow where lime is lacking. Alfalfa and sweetclover are very sensitive to lime. Failure to recognize this is the main reason for the failure of some farmers to obtain stands of these legumes. In many places there is an abundance of lime in the subsoil but the surface soils are acid. Under this condition, if light applications of lime are made prior to seeding alfalfa or sweetclover, the plants will thrive and the roots will finally reach the limy subsoil. Soils that are acid in both surface soil and subsoil require heavier applications of limestone, the amount depending on the degree of acidity.

Analyses for total phosphorus show that most Iowa soils are comparatively low in this element. Therefore most of the soils respond to phosphatic fertilizers. Their value can best be determined on any particular soil by means of small test plots or strips through various fields on different crops. Effects can readily be noticed, and if economical returns are received larger acreages may be given this treatment. Clovers, as a rule, show marked increases following phosphate treatments. Corn and small-grain yields are increased somewhat and there is invariably a marked effect on the quality and time of maturing of the grain. The field experiments previously discussed show the effects of various fertilizers on soils similar to those occurring in Sac County.

Rotation of crops is essential in any program of soil management. Continuous cropping of land quickly reduces the fertility and lowers yields. Several good rotations may be adopted which will fit in well under any system of farming. The following 3-year rotations are suggested for Sac County: Corn, oats or wheat, sweetclover used as hay or pasture; or wheat (with clover), corn, and the third year cowpeas or soybeans. Four-year rotations may include corn (two years), oats, and clover; corn, oats, clover, and wheat; or a rotation including alfalfa. However as the alfalfa is allowed to remain on the field 5 years, this is not a 4-year rotation. A small-grain crop may be substituted for corn in the alfalfa rotation. Any cropping system which includes a legume and prevents continuous cropping should prove satisfactory. The system to be adopted will depend largely on the size and shape of the fields and the type of farming followed.⁵

SOILS AND THEIR INTERPRETATION

Sac County lies wholly within the prairie region of the United States, where temperature and moisture conditions are favorable to a luxuriant growth of prairie grasses. Seasonal changes in temperature and moisture cause the grasses to die, and they are replaced by a new growth the following season. The old grass roots, penetrating deep into the upper soil layers, decay. Year after year the supply of roots increased until the entire surface soil was filled with decayed vegetable matter which imparted to it its predominantly dark color. One of the striking features of this region, therefore, is the large amount of organic matter in the surface soil.

The soils of Sac County may be divided into two principal groups on the basis of the characteristics produced by differences in the moisture conditions under which they developed. The soils of the first group occur on the undulating or rolling uplands where both surface and subsoil drainage are well established. Here, moisture conditions were favorable for the weathering processes to proceed normally, producing a mature or nearly mature soil profile for this region. The mature or normally developed soils have surface layers of very dark grayish-brown single-grained or faintly granular material from 6 to 20 inches thick. The layer underlying this dark-colored layer grades from brown in the upper part to yellowish brown in the lower part. It is heavier in texture than the surface soil or lower subsoil layer. The upper part is very granular, but granulation rapidly decreases with depth. The third layer from the surface downward consists of the material from which the soil has been derived. In the western part of the county the parent material is loess, the texture is silty, and the color ranges from gray to grayish yellow. In the eastern part of the county, glacial drift is the parent material. The unweathered drift is dark-gray or bluish-gray clay which, on weathering, becomes brown or yellowish brown. The parent material is modified in the upper part by soil-forming processes which produce the present soils. Leaching of lime may have

⁵ Further information on field experiment projects may be obtained from Iowa Agricultural Experiment Station Bulletin 221, and soil survey reports of Iowa counties. Information on the Iowa system of soil management is fully discussed in Bulletin 213 issued by the experiment station.

occurred to a slight extent in the upper part of the parent material, but lime is nearly everywhere present within 70 inches of the surface.

In the loessial soils in the western half of the county the depth at which lime occurs varies with the surface relief. Where the ridges are wide and the surface more undulating or nearly flat, the lime has been leached, in places, to depths of 80 or 90 inches, but where erosion is more active lime may be present on the surface or within a depth of 60 inches. In the eastern part of the county, weathering and leaching have not progressed rapidly. Here, lime occurs within 40 inches of the surface on the rolling or undulating uplands.

The thickness of the dark-colored surface layer also varies with the relief. Where erosion has been comparatively rapid the surface soil is much thinner than on smooth slopes or flat divides. On the smoother areas the surface soil is deeper because the prairie grasses were well supplied with moisture during the period when soil-forming processes were most rapid and the soil formed was not removed by rapid erosion.

The most important soils in the well-drained group are those of the Marshall, Clarion, and Waukesha series. Other soils included with this group are members of the Dickinson, Pierce, O'Neill, and Lindley series. The Marshall and Waukesha series represent the normally developed soils of this region. The subsurface layer is not so heavy textured as in most mature soils. Clarion soils are comparatively young and lime has not been deeply leached, everywhere being present within a depth ranging from 30 to 40 inches. Pierce soils, which have developed over gravelly material, also contain lime in the upper subsoil layer. Dickinson soils are sandy and vary little in texture throughout the entire soil profile. O'Neill soils have gravelly subsoils and are thoroughly leached of their carbonates at all depths.

The second group of soils includes those formed under excessive moisture conditions. The areas are flat or slightly depressed, and water stood on the land after rains until it evaporated or slowly seeped to lower levels. The water table was rather close to the surface, and a few areas were permanently under water. On the low flat terraces and first bottoms, drainage was poor and overflows were frequent. Under such moisture conditions, grasses grew rankly and the excessive moisture prevented oxidation and decay of the organic material, resulting in the accumulation of larger amounts of vegetable matter and imparting to the soil mass its very dark color.

Webster soils are typical of this group. The surface soil is very dark brown or black, and the subsoils are gray or mottled. Carbonates are abundant because of lack of leaching. Fargo soils have profiles similar to those of the Webster soils, but they occur on terraces. Bremer soils are terrace soils similar to the Fargo soils except that no lime is present in the soil profile. Wabash and Lamoure soils occur on first bottoms. Lamoure soils contain carbonates in the subsoil, whereas Wabash soils have none. Cass soils have sandy subsoils and may or may not contain carbonates.

The soils of Sac County have been derived from two main parent materials, wind-laid silt, or loess, and glacial drift. The western half of the county is covered by the Peorian loess. This silty mantle, ranging from 4 to 45 feet in depth, covers practically all the underlying drift. Only where streams have cut deep ravines does the

glacial material outcrop, and in such places it occurs in narrow bands only on the steepest slopes. This loess is a fine silt containing some very fine sand and a small amount of clay. Leaching has progressed to such an extent that the carbonates have been removed to a depth of 4 feet or deeper. The dark color is owing to the accumulation of organic material, mainly grass roots. Marshall silt loam covers the greater part of the area of loess. Judson silt loam, which occupies comparatively small areas, has developed on deep colluvial silty material.

The eastern part of the county was covered by the late Wisconsin glaciation. The material left by this ice sheet differs from the so-called loess, or wind-blown material, by having a higher content of sand and clay and by the presence of bowlders of various sizes. Clarion soils represent the well-drained group developed on drift. Their subsoils contain large amounts of carbonates. Dickinson, Pierce, and Lindley soils are derived from glacial material under conditions of good drainage. The Webster soils have developed from glacial drift under conditions of restricted drainage.

The alluvial soils of Sac County have developed from alluvial material washed from both the loessial and glacial areas and deposited on the flood plains of the streams.

Waukesha soils, which occur on high, well-drained terraces, are regarded as the most mature of the alluvial soils. Their profile is similar to that of Marshall silt loam on the upland. O'Neill soils, with their gravelly subsoils, contain no carbonates and only a faint heavy development, or B horizon. The remainder of the alluvial soils are poorly drained, and their profiles are variable.

The soils of the county are grouped into series on the basis of their origin, color, surface relief, chemical composition, and the structural characteristics of their profiles. The series are subdivided into soil types on the basis of the texture of the surface soil. Minor variations in the types are called phases. Fourteen soil series, divided into 19 soil types and 3 phases, are mapped in Sac County, in addition to a miscellaneous classification, peat and muck.

Marshall silt loam, in a representative profile 4 miles south of Odebolt, shows a very dark grayish-brown friable granular silt loam surface layer extending to a depth of about 3 inches. Grass roots thoroughly fill this layer and, when a lump is shaken, the roots cling tenaciously to the small soil granules which, on crushing, change but little in color. From 3 to 14 inches the soil material is very dark brown distinctly granular friable silt loam which is darker than the material directly above it. When a mass of the soil is shaken it readily falls apart into soft granules which, on crushing, become slightly lighter in color. Between depths of 14 and 27 inches is a transitional layer, the color in the upper part of which is almost as dark as in the layer above but which becomes lighter brown with depth. The dark color occurs in spots and streaks owing to the infiltration of organic matter from the overlying layers through cleavage lines, wormholes, and insect burrows. The upper part of this layer is faintly granular, but the granulation decreases with depth. The soft granules, when crushed, change in color from brown to yellowish brown, showing that the organic material is merely a coating on the granules. The fourth layer, from the sur-

face downward to 38 inches, is brown heavy silt loam or light silty clay loam, which is structureless but breaks up into soft clods. A few dark streaks extend downward along wormholes and small animal burrows. Between 38 and 53 inches is yellowish-brown mellow structureless silt loam spotted in many places with rust-brown stains or gray spots, especially below a depth of 40 inches. There is practically no change in color or texture of the parent material to a depth of 90 inches. In this profile, no carbonates were found within a depth of 80 inches from the surface. Other profiles studied in various parts of the county show that the depth at which carbonates occur varies from a few inches from the surface on eroded slopes to 5 feet on gentle slopes and is below a depth of 80 inches on level divides.

Marshall silt loam is derived from Peorian loess, and it occurs on all the uplands in western Sac County. The surface relief ranges from narrow level divides to sharply rolling areas. Drainage is good.

Marshall silt loam, shallow phase, differs from the typical soil mainly in the depth of the dark surface layer and the depth at which carbonates are abundant. The surface soil to a depth of about 5 or 7 inches is brown friable silt loam overlying a lighter-brown transitional layer. At a depth of 12 inches and continuing downward to about 42 inches the color becomes yellow or yellowish-brown. There is no definite structure to this noncalcareous silt loam. Below a depth of 42 inches is the gray and yellow calcareous parent material. The surface relief of this soil is hilly, erosion is active, and in many areas the dark surface soil has been almost entirely removed.

A representative profile of Clarion loam was examined in section 7, T. 88 N., R. 35 W. The surface soil to a depth of 1½ inches is very dark grayish-brown loam filled with grass roots. There is no marked structure other than a faint lamination. The soil mass breaks up into small flat clods. Shaking removes most of the soil, except those particles held by the grass roots. Beneath this and extending to a depth of about 6 inches the soil mass is dark grayish-brown or almost black loam which is firm in position but breaks up into flat clods showing lamination but no granulation. Crushing produces very little change in color. Between 6 and 11 inches is a transitional layer in which the texture is loam but heavier than the loam above. The color changes with depth from dark brown to brown. The brown color is streaked with darker color, owing to the translocation of organic matter from the upper layers downward through worm and insect burrows or through cracks in the soil formed in dry seasons. Some of the worm casts are very dark and readily recognized. The material, as a whole, crushes to a brown powder. The structure is imperfectly granular but the granulation is obscured by worm casts which make up the greater part of the layer. Between depths of 11 and 19 inches is a gradational layer in which the color becomes more yellow with depth and the dark columns, although present, are much less numerous. This noncalcareous material has no definite structure but breaks up into moderately firm clods. The texture is a loam with a high percentage of silt. Between 19 and 34 inches is dark-yellow friable highly calcareous structureless very fine sandy loam containing some silt. A few brown worm casts are present in this layer,

also a few hard and soft lime concretions. Lime is also disseminated through the soil material, and in some places in this layer are beds thick with concretions. The sixth layer, which extends to a depth of 53 inches from the surface is grayish-yellow or almost yellow structureless silt loam containing much very fine sand. The mass breaks into sharp-cornered clods along cleavage planes and is more firm in position than the material above it. No concretions are present, but lime is evenly disseminated throughout the mass. Below a depth of 53 inches, auger borings show a succession of textures, sand, sandy loam, and heavy silt loam, not greatly different from the layer above, to a depth of 90 inches. A few boulders lie on the surface, but the greatest numbers are embedded throughout the lower layers of this soil.

Other Clarion loam profiles studied in other locations show variations from the one described in the depth of the dark-colored surface layer, the texture of the subsoil, and the depth at which carbonates occur. Many areas mapped in the southeastern part of the county have been classified as Clarion loam, although lime was not reached within a depth of 3 feet. However, calcareous material occurs in practically all areas of this soil at a depth of 4 feet, and, since the depth of the lime zone varies but is always present within 4 or 5 feet of the surface, the soil is mapped as Clarion loam.

Clarion loam is derived from material of the late Wisconsin glaciation. It occurs on low knolls and ridges and on the rolling areas along streams within the glaciated section.

Clarion loam, shallow phase, differs from typical Clarion loam mainly in the depth of the surface soil. In few places is the dark layer more than 4 inches thick, and in many places it is entirely absent. The entire soil profile is calcareous from the surface downward. In many places, gravel and small boulders are strewn over the surface and embedded throughout the subsoil. Gravel and sand pockets are commonly present at a depth ranging from 5 to 6 feet. This variation occurs in the hilly sections along the larger streams.

Clarion silt loam occurs only along streams in the western part of the county where a thin loessial covering overlies the glacial drift. The upper 2 inches of soil consists of brown or dark-brown mellow silt loam thoroughly filled with grass roots and partly decomposed organic matter. Between depths of 2 and 8 inches the material is dark-brown, almost black when wet, mellow faintly granular silt loam. A few grass roots penetrate this layer. The third layer extends to a depth of 24 inches and is yellowish-brown or brown heavy silt loam or light silty clay loam. The upper part of the layer is darker than the lower part because of a higher content of organic matter. No gritty material is present in this layer, but below a depth of 24 inches the mass changes abruptly to yellowish-brown granular gritty clay loam containing a few boulders. Lime streaks and concretions are abundant in the lower part of this layer. At a depth of 34 inches the color becomes more yellow and is streaked with gray. Thin layers of sand separate the silty clay loam layers. Granitic boulders and lime concretions are abundant.

The following is a description of Webster silty clay loam occurring in section 4, T. 88 N., R. 35 W. The 1-inch surface layer as observed in a pit dug along the highway is very dark grayish-brown silty clay loam containing some fine sand. Granulation is not marked, but

there is faint lamination, and the mass breaks up into flat clods. The entire layer is filled with grass roots. Below this and continuing to a depth of about 7 inches is black silty clay loam which is very sticky when wet and hard when dry. Large cracks form in the fields when the mass dries. The material in this layer is practically structureless and the clods break along what appear to be cleavage planes or former cracks. Some fine sand and a few small pebbles occur in many places. Between depths of 7 and 14 inches is black, or black with a grayish tinge, heavy clay loam or clay, which is plastic when wet but under proper moisture conditions readily falls apart in imperfect fine granules. There is very little change in the color of the material when the granules are crushed. The fourth layer from the surface downward, between 14 and 25 inches, is very dark gray, almost grayish-black, silty clay which breaks down into vague columnar blocks. These blocks readily fall apart into distinct but soft granules. From a depth of 25 to 33 inches is a transitional layer. The texture of the soil material gradually changes, becoming more silty with depth, and the color changes from dark gray to gray with dark mottlings caused by the infiltration of organic matter from above. Lime concretions and spots of soft lime occur throughout this crumbly structureless layer. At a depth of 33 inches, the unweathered glacial till is reached. This is a gray silty material, in many places splotched with white lime streaks and rust-brown iron stains. Gravel and bowlders, some granitic and some limestone, are embedded throughout this unweathered material. Borings to a depth of 8 feet show no great change in this material. All the layers of the soil profile are calcareous, the content of lime increasing with depth. However, the surface soil and subsurface soil are in many places deficient in carbonates, but the lower subsoil layer everywhere contains sufficient quantities of lime to effervesce freely with acid. The water table lies at a depth of 60 inches.

Webster silt loam has a silt loam surface soil and occupies a slightly higher position than Webster silty clay loam, but in other respects it closely resembles the heavier-textured soil.

Webster loam is similar to Webster silt loam except in the loamy texture of its surface soil. The underlying layers do not materially differ from those of the Webster soils previously described. The surface soil is dark-brown mellow loam to a depth ranging from 9 to 12 inches. Below this depth the material gradually changes to the gray calcareous subsoil. Webster loam is the highest-lying Webster soil.

Dickinson sandy loam is a minor soil type in Sac County. It occupies the high knolls or kames which rise above the level of the Webster and Clarion areas in the glaciated section of the county. The profile examined consists of the following layers: (1) From 0 to 8 inches, loose brown or dark-brown structureless sandy loam; (2) from 8 to 23 inches, light-brown, fairly compact sandy loam, containing a few small pebbles and some lime; and (3) from 23 inches downward, yellow, gray, and brown sand and very fine gravel, which are highly calcareous. In many places gravel beds are reached at a depth ranging from 7 to 8 feet.

Pierce sandy loam areas are small and well scattered over the eastern part of the county. They occupy high knolls, kames, and

eskers and most of them are of little agricultural value. They are the main source of road-surfacing material, building sand, and gravel.

The profile consists of the following layers: From 0 to 4 inches, light-brown sandy loam containing much gravel of various sizes. The material is merely an unsorted mass calcareous from the surface downward. From 4 inches downward the soil material is yellow and gray unweathered highly calcareous glacial debris. The percentage of gravel increases with depth, and gravel beds lie within a few inches of the surface in many places.

Lindley loam is the only light-colored or forested soil within Sac County. It is developed in two small areas along Raccoon River near Auburn.

The profile consists of the following layers: (1) From 0 to 1 inch, dark-gray or brownish-gray mellow structureless loam filled with grass roots; (2) from 1 to 8 inches, dark-gray or brownish-gray mellow loam which shows a partly developed platy structure and which forms soft crumbly clods, becoming lighter in color when crushed; (3) from 8 to 16 inches, gray and brown fine sandy loam which is compact in place and which is faintly discolored by iron stains, causing the crushed mass to appear light brown; (4) from 16 to 42 inches, brown, spotted with gray and heavily stained with iron, very compact fine sandy loam which forms angular compact clods when disturbed, the clods breaking down into smaller clods along lines of cleavage; and (5) from 42 inches downward, gray, with yellow and brown iron stains, compact gritty clay. The mass breaks down into large irregular-shaped clods. No carbonates are present to a depth of 6 feet.

The forest on Lindley loam consists of oaks, hickory, elm, and haw, and the undercover is hazel brush, bluegrass, and weeds.

Waukesha silt loam occurs on high terraces along the streams in the western part of the county. It is closely associated with Marshall silt loam, and the profiles of the two soils are similar. It is regarded as an almost mature terrace soil, developed under optimum moisture conditions and native-grass vegetation.

Waukesha loam is not extensively developed in Sac County. It occurs in the western part of the county on high terraces well above overflow, but receives sheet wash from the adjoining slopes. It differs from Waukesha silt loam in that the dark surface soil material is mellow loam having no definite structure. Below the surface soil the two soils do not differ materially.

O'Neill loam consists of loam overlying sandy or gravelly material and has developed under conditions of adequate or excessive drainage. It is mapped on high, well-drained areas in a topographic position between Clarion loam of the uplands and the first bottoms. The surface relief is level or slightly sloping toward the stream.

Judson silt loam occurs on terraces and colluvial slopes or at the bases of slopes between the uplands and first bottoms in the loessial part of the county. The material is of colluvial origin, but, owing to the friable texture throughout the entire profile, natural drainage is good. The parent material is silty material washed from the Marshall silt loam uplands. The areas are flat or slope toward the streams. The land receives surface wash from the slopes but is not covered by overflows from the streams.

Bremer silty clay loam occurs on low terraces from 4 to 6 feet above the present flood plain of the river or in small depressions within O'Neill loam areas. The larger areas are along Raccoon River. The surface relief is flat, and natural drainage is poor.

Fargo silty clay loam differs from Bremer silty clay loam in that it contains lime carbonates within 3 feet of the surface. Both soils occur on flat, low, poorly drained terraces.

The soils of the Wabash series are developed on recently deposited alluvium derived from the black upland soils. The appearance of the subsoils indicates poor drainage. The soil material is leached of its carbonates.

The colluvial phase of Wabash silt loam consists of dark-brown silt loam to a depth of about 16 inches, which grades into dark-brown or almost black compact silty clay loam. The color becomes more gray with depth. This phase of soil differs from Judson silt loam in having a heavy-textured subsoil and from Wabash silt loam in being better drained, not subject to overflow, and in being composed of deeper dark-colored material. This soil occurs along the smaller drainage channels in the loess-covered area. The fall of the streams is great, therefore run-off is rapid and drainage fair, allowing the areas to be cultivated with the associated soils. A few areas require artificial drainage before cropping is successful.

Wabash silty clay loam is similar to, and has the same agricultural value as, the other Wabash soils in the county.

Lamoure silty clay loam differs from Wabash silty clay loam mainly in that it contains carbonates within 3 feet of the surface.

Cass fine sandy loam is a dark-colored alluvial soil developed under poor drainage conditions from sandy and gravelly materials. This soil is mapped in first bottoms near the banks of the larger streams and is subject to frequent changes because of overflow. In its natural state it supports a growth of bluegrass and a sparse forest growth, consisting of maples, willows, cottonwood, and a few oaks.

SUMMARY

Sac County is in the west-central part of Iowa. It comprises an area of 574 square miles.

The surface features range from rolling to strongly rolling in the western half of the county, or loess-covered section, to flat or gently undulating in the glaciated eastern part. The prevailing slope of the county is to the south and east.

Western Sac County is drained by Boyer River, which belongs to the Missouri River system, and the eastern part is drained by Raccoon River and Cedar Creek, tributaries of Des Moines River.

The population of the county in 1930 was 17,641 persons, most of whom are native born. Sac City, the county seat, has a population of 2,854. Other small towns located on one of the three railroads which traverse the county serve as shipping points. Public highways are well graded. Graveled roads connect every town within the county.

The agriculture of Sac County consists in the production of corn and small grain and the raising or feeding of sufficient livestock to consume most of the crops grown. Some tenant farmers sell their grain crops for cash. Much hay is produced for feeding livestock.

Cattle feeding, although extensively practiced in past years, has decreased somewhat in recent years, and sheep feeding is rapidly becoming popular as a source of income.

Three main soil types cover the larger part of Sac County. Marshall silt loam, which occurs on all the rolling uplands in western Sac County, is naturally fertile and is highly prized as a corn soil. The mellow texture of the surface soil and subsoil render this soil easy to handle. No rocks or stones interfere with plowing or cultivation, and the soil readily responds to fertilizer treatments. Clarion loam and Webster silty clay loam are the most important soils within the glaciated section of the county. Clarion loam is better drained than Webster silty clay loam, but both are excellent corn soils. The better-drained Clarion loam is well adapted to general farming, but the Webster soils must be drained before maximum returns can be obtained. In many places on the Webster soils small grains produce a rank straw growth and lodge, because of the high content of organic matter present. Sixteen other soils of minor importance, three phases, and a miscellaneous classification, peat and muck, have been separated and mapped in the county.

Experimental data prove that any of the major soil types can be improved under definite systems of management. The use of fertilizers, especially phosphates, and manure, together with proper cropping systems and legumes, will materially and economically increase crop yields.

Practically all the land within the county is cultivable. Only a few wet areas along streams and first bottoms remain undrained. At present, 93.9 per cent of the area of the county is in farms, a large proportion of which is classed as improved land.

Few land transactions are being made, and since most of these are forced sales, land values can not be readily estimated. Prospective land buyers may profit by trips through the county, as many farms, which have been heavily cropped and are in a run-down condition, are for sale. With sufficient capital and definite plans for proper management on the part of the purchaser, these farms can be reclaimed and made to produce profitable returns.



[PUBLIC RESOLUTION—No. 9]

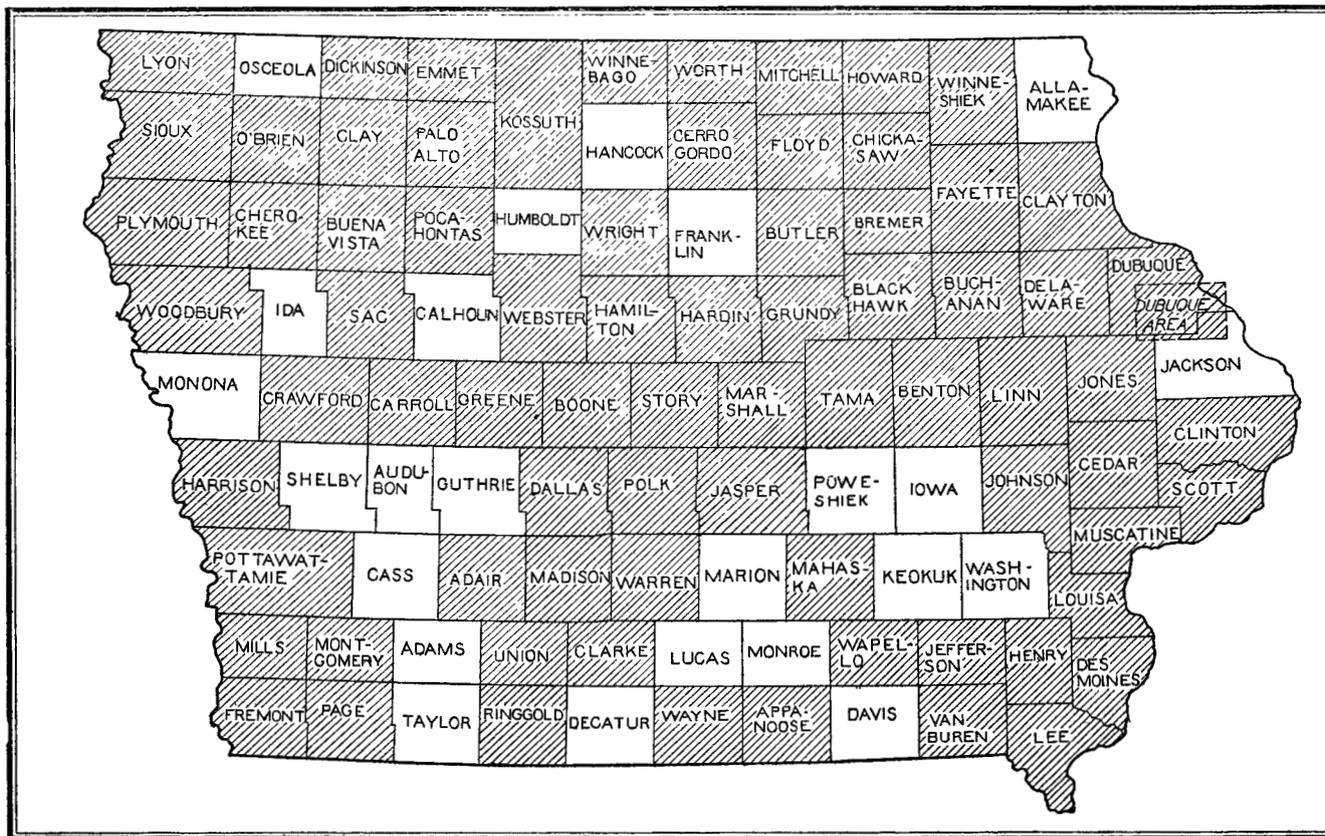
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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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