Series 1929 Number 31

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Houston County, Minnesota

By

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and

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Bureau of Chemistry and Soils

In cooperation with the
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SOIL SURVEY

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SOIL SURVEY OF HOUSTON COUNTY, MINN.

By A. L. GRAY, in Charge, W. J. MORAN, and A. H. HASTY, United States Department of Agriculture, and SAM HILL, C. H. MATTSON, H. C. NEWMAN, and H. T. PETRABORG, University of Minnesota

COUNTY SURVEYED

Houston County is the southeasternmost county in the State of Minnesota (fig. 1). It has a total area of 565 square miles, or 361,600 acres. The eastern boundary is formed by Mississippi River which separates Minnesota from Wisconsin. Caledonia, the county seat, is 20 miles southwest of La Crosse, Wis., and approximately 150 miles south of the Twin Cities, Minneapolis and St. Paul.

FIGURE 1.—Sketch map showing location of Houston County, Minn.

The eastern half of the county is in an area, known by geologists as the driftless area, which includes the southwestern corner of Wisconsin, the northwestern corner of Illinois, the northeastern corner of Iowa, and the southeastern corner of Minnesota. The western half shows only slight evidence of glaciation, so that the physical features of the whole county are very different from those of a glaciated region.

Physiographically, the land surface of Houston County comprises parts of two old plains, the older of which survives as a low flat-topped ridge in the southwestern quarter. The younger, which forms the greater part of the county, has been eroded into an intricate pattern of deep valleys and ravines separated by narrow ridges.

The low ridge, or older land surface, has a northeast-southwest trend from a point about a mile west of Caledonia to a detached section in the southwestern corner of the county. The northern edge of this ridge is much smoother in outline than the southern edge where several deep indentations form comparatively narrow secondary ridges, one of which extends in a southerly direction from Spring Grove to the Iowa State line. The ridge rises more than 100 feet above the level of the rest of the county. The elevation of the railroad at the station at Spring Grove is 145 feet higher than at the railroad station in Caledonia.[1] This old land surface has been almost entirely removed in Houston County because the comparatively thin covering of limestone capping it is underlain by a sandstone so soft that it may easily be broken up with the hand and

[1] Elevation figures supplied by the Chicago, Milwaukee, St. Paul & Pacific R.R.

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hence has been subject to rather rapid destruction by the erosional action of water.

The very thorough dissection of the greater part of the county by long-continued and uninterrupted erosion has been made possible by the lack of modification by glaciers and by the character and arrangement of the underlying rocks which consist of alternate layers of tough magnesian limestones and friable sandstones. Valleys 500 feet deep have been formed, and every creek, tributary, and rivulet more than one-half mile long runs through a rock-walled gorge or valley.

A very good idea of the depth of some of the valleys may be formed from elevation figures obtained by Minnesota geologists from barometric measurements.[2] The bluffs at Sheldon are 420 feet above the village; at Houston the bluffs north of the town are 520 feet above the level of Root River in summer; Mount Tom, at Hokah, is 530 feet above the Root River flood plain; and the bluff at Brownsville is 486 feet above the Mississippi River flood plain.

The lowest point in the county, of which there is a reliable record, is on the railroad at Reno, 636 feet above sea level, and the highest point so far recorded is at the railroad station at Spring Grove, 1,322 feet above sea level. At the station at Caledonia the elevation is 1,177 feet.[3] As given in the first volume of the Geological and Natural History Survey of Minnesota, 1872–82, the mean elevation above sea level of Houston County is approximately 990 feet.

Most of Houston County was timbered when settlers first came into the region. The eastern and northern parts supported the heaviest forest growth, and the central and southwestern parts were either partly timbered or were open prairie. The trees in these two sections occurred in an open or savannalike growth, with many scattered large trees and a lower growth of hazel brush and grass. The steep slopes of the ravines were all timbered.

The trees are of many different varieties and species, the most numerous of which are black, bur, white, and red oaks. Largetooth aspen and cottonwood are abundant on the steep hillsides and creeks, where there are also a few white birch and white pine. The pines were never widespread, but grew in occasional clumps on the north slopes of a few of the valleys. Butternut was and is still plentiful, but hickory is rare, as this county is almost the northern limit for hickories. Maple, elm, basswood, ash, wild cherry, wild plum, crab apple, and boxelder were at one time abundant. Dwarf sumac grows on the drier parts of the hillsides, the brows, and southern-exposed slopes of the valleys. Blackberries are not so plentiful as they once were, but red raspberries and black raspberries (blackcaps) are still abundant on the hillsides and soon spring up in cleared places. Wild grapes are becoming scarce, but they were once plentiful.

The first settlement in Houston County was made in the late winter of 1848 by Job Brown, at Wild Cat Bluff, later known as Brownsville. In 1854, Col. Sam McPhail built a store on the site of Caledonia and later platted the village for which he suggested the name. Early in the year 1854 the county was set apart from Fillmore County and named for Gen. Sam Houston, and the first county election was held in April of that year. The earliest set-

[2] WINCHELL, N. H. THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA v. 2, for 1873, 219 p., illus. St. Paul. 1874.

[3] See footnote 1, p. 1.

tlers were largely Irish, who settled in the valleys in order to be near wood and water. Well digging on the ridges was a serious problem for the early settler, who was poorly supplied with tools. Later Norwegians settled in the county, largely in the western and southwestern parts. Spring Grove is the center of the Norwegian settlement. Germans settled near Eitzen and Luxemburgers around Caledonia and Freeburg. The northern part of the county has been settled largely by people of German descent.

According to the 1930 census,[4] the population of Houston County is 13,845, all of which is classed as rural, no town in the county having more than 2,500 inhabitants. Native whites comprise 92.2 percent of the population and foreign-born whites 7.6 percent. The density of the population is 24.3 persons a square mile.

Caledonia, the county seat and largest town, has a population of 1,554; Spring Grove has 867, and Houston has 794. These three towns are shipping points for the greater part of the farm produce. La Crescent, Freeburg, Hokah, Riceford, Money Creek, Brownsville, and Eitzen are important local trading centers. The generally rough surface relief and the lack of good roads in the past resulted in the establishment of a number of country stores in the more remote parts of the county, seven or eight of which still exist.

The county is served by one main line and two branch lines of the Chicago, Milwaukee, St. Paul & Pacific Railroad. United States Highway No. 16 (State Highway No. 9) passes through La Crescent, Hokah, and Houston; and State Highway No. 44 branches from United States Highway No. 16 at Hokah and passes through Caledonia and Spring Grove. In recent years local contractors have established trucking lines on these highways and are furnishing the merchants of the various towns with freight and express service to and from Winona, Minn., and La Crosse, Wis. Bus lines, in increasing competition with the railroads, provide passenger transportation over both highways.

CLIMATE

Houston County is probably as well located climatically as any county in Minnesota, as it is in that part of the State where both the mean temperature and average annual rainfall are highest. To the north the temperature is lower, and to the west the rainfall decreases. The normal summer temperature and rainfall are adequate for production of the common Corn Belt crops. Temperature changes may be rather sudden, and blizzards are frequent during the winter. A temperature range from −43° F. to 104° is recorded at La Crosse, Wis., the nearest Weather Bureau station.

Killing frosts have occurred as late as May 25 and as early as September 10, but the average frost-free period covers 162 days, from April 29 to October 9, inclusive. This is ample time in which corn can mature.

The average annual rainfall is 31.17 inches, which is enough for the growth of all crops adapted to the county. The average annual snowfall is 41.3 inches. Extremely dry or extremely wet years are

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

rare, although occasional abnormal years do occur. Rainfall is well distributed throughout the growing season over all parts of the county.

Table 1 gives climatic data from the records of the United States Weather Bureau station at La Crosse, Wis. These data are not applicable to all parts of Houston County, because of differences in elevation and surface configuration, but they are indicative of climatic conditions in general.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at La Crosse, La Crosse County, Wis.*

[Elevation, 714 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1881)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	22.3	61	−37	1.33	0.67	0.26	8.9
January	16.1	57	−43	1.08	1.33	1.51	10.5
February	19.2	65	−34	1.06	.51	1.26	9.0
Winter	19.2	65	−43	3.47	2.51	3.03	28.4
March	31.5	83	−23	1.65	.03	1.01	6.5
April	47.2	93	10	2.29	2.23	1.35	1.9
May	59.3	96	26	3.75	1.63	3.13	.2
Spring	46.0	96	−23	7.69	3.89	5.49	8.6
June	68.3	100	33	4.43	.37	2.75	0
July	72.8	104	45	4.07	1.03	8.86	0
August	70.0	101	35	3.41	4.99	5.01	0
Summer	70.4	104	33	11.91	6.39	16.62	0
September	62.2	98	24	4.12	2.95	10.87	(1)
October	50.3	88	6	2.46	.57	7.56	.3
November	35.2	75	−21	1.52	.46	1.17	4.0
Fall	49.2	98	−21	8.10	3.98	19.60	4.3
Year	46.2	104	−43	31.17	16.77	44.74	41.3

[1] Trace.

AGRICULTURE

Agriculture in Houston County has, in common with that of other farming communities of the Corn Belt, passed through several periods of expansion, curtailment or abandonment, and readjustment. First was the pioneer period, when all farming was carried on for subsistence, very little surplus products being sold. Later came improved machinery and increased demand by cities both for food and labor, which led to systems of farming being tried and abandoned when national conditions changed or when the systems were not adapted to local conditions. A period of groping occurred until the final or present-day scheme was evolved that fitted all conditions, as well as any scheme or system may fit.

In Houston County, as in adjacent sections of the State and in Iowa, Wisconsin, and Illinois, the settlers in a few years became almost exclusively wheat farmers. This was brought about by the gradual westward movement of wheat growing to the then cheaper

lands and by the Civil War, which greatly stimulated wheat production. For several years wheat was practically the only crop grown in these sections. The peak was reached when a million and a half bushels were produced in 1 year.

After the close of the Civil War great areas of the western prairies, which were cheaper wheat lands, were opened to settlement, and a slump in wheat prices resulted. Insect pests and diseases, including the chinch bug, rust, and the hessian fly began to decrease yields in this county, and by the middle seventies wheat growing was almost discontinued. During the time that wheat growing was profitable, the town of Brownsville on the Mississippi was a very important shipping center, wheat being hauled there by ox team from farms 40 and 50 miles inland. Large warehouses and granaries crowded the water front, but hardly a vestige of this enterprise remains.

After wheat ceased to be an important crop, hog raising claimed the attention of the farmers. Large numbers of hogs were killed on the farms and hauled frozen over the ice to La Crosse, Wis. Hog raising required large acreages of corn, and it was with some difficulty that corn varieties were obtained that would do well in this climate. When corn varieties became adapted it was discovered that the land was too rough to grow corn in the large quantities necessary to support a large hog-raising industry. However, this industry did not attain nearly the same proportions as had wheat growing, because at the same time cattle were being raised. The combination of cattle and hog raising did very well until dairying began to develop in the nineties.

Dairying has had a gradual development in Houston County. A large acreage of rough land was available for pasture, and during the eighties the production of feeder cattle to be shipped out to corn farmers for finishing in feed lots reached considerable proportions. This industry was hardly more than a side line, however, and with the gradual increase in the numbers of dairy cattle it soon declined. The greatest expansion in dairying has been between 1910 and the present time. Before 1910 milk and its products were merely a side line with most farmers, the surplus over home needs being sold to furnish a little ready cash. No ready market, in the form of creameries at convenient points for milk and cream existed prior to the beginning of this century, although subsequent to 1895 a small creamery in Caledonia operated for a few years. During the great increase in interest in creameries in the first decade of this century several creameries were established, the large one in Caledonia being built in 1910. In the last 20 years dairying has expanded until nine creameries are now operating in the county, and a cheese factory is located at Hokah.

An important influence in the expansion of dairying, that has been felt in Houston County as well as through the State, is a cooperative dairy organization that has enrolled most of the creameries of the State as its members and by advertising and up-to-date management has obtained a steady market in the eastern States for its butter and cheese.

Although Houston County is not a strictly dairy county, dairying has proved to fit in nicely with farming conditions, and the production of milk and cream provides the greater part of the farm

income. Hogs and cattle make up the rest. The Minnesota annual crop and livestock statistics report that the number of milk cows increased from 13,500 in 1920 to 18,200 in 1928.

From 2,130 in 1900, the number of farms has decreased to 1,910 in 1930, as reported by the Federal census. Some of the decrease in the number of farms is owing to land abandonment, the land being turned out of production and rented for pasture. This is explained by the fact that many farms in Houston County are too steep to be profitably farmed in these days of necessarily increased efficiency in farming practice.

In 1900 the average-sized farm included 156 acres; in 1925, 168.4 acres; and in 1930, 174.6 acres. This increase in the average size of farms is in keeping with the general trend all over the country.

According to the census, the value of farm property has increased materially in most respects. The value of all property on a farm was $4,669 in 1900, $13,753 in 1925, and $14,791 in 1930. Of this, in 1900, land represented 66.5 percent, buildings 16 percent, implements 3.5 percent, and animals 14 percent. In 1930, land accounted for 52.3 percent of the total value of farm property; buildings, 27.5 percent; implements, 6.4 percent; and domestic animals, 13.8 percent. The value of land has decreased 14.2 percent since 1900, the capital in buildings has had a total rise of 11.5 percent, and the capital invested in implements increased 2.9 percent.

During the summers of 1928 and 1929 there was a noticeable increase in the number of colts raised. A considerable part of the farm power must be furnished by horses, as tractors cannot furnish power so efficiently or so economically in Houston County as they do on the smooth prairie land. The proportion of level rectangular fields on farms in the greater part of the county is too small for the economical use of tractors.

According to the census, the average assessed land value was $19.94 an acre in 1900, $47.60 in 1925, and $44.34 in 1930, with a high point of $73.63 in 1920. These values do not reflect the worth or selling price of individual farms.

Expense for farm labor in 1909, 1924, and 1929 shows very little fluctuation. In 1909, 62 percent of the farms reported an average expenditure for labor of $186.43 a farm; in 1919, the peak year, the expense for labor on 71 percent of the farms averaged $380.38 each; in 1924, with 59 percent of the farms reporting, the expense was $197.94; and in 1929, 61.4 percent reported an average expenditure of $227. At present the number of farmers employing labor other than their families is not large.

In 1909, 28.5 percent of the farms reported a feed expense of $56.31 a farm; in 1919, 50 percent reported an average feed expense of $164.14 a farm; in 1924, 61 percent reported an average outlay of $152.23 a farm; and in 1929, 65.4 percent reported an average expenditure of $151.09.

Only a small number of farmers report the use of fertilizer and the quantities used. In 1909, the expenditure for fertilizer on the 15 farms reporting averaged $56.60 each; in 1919, on 17 farms the expenditure was $134.65 each; in 1924, on 53 farms the expenditure was $29.86 each; and in 1929, on 127 farms the expenditure was $51.72 each. The year 1919 seems to have been abnormal in respect to this item as well as most others.

Although there has been a gradual decrease from 1880 to 1930 in the number of owner-operated farms and a corresponding increase in tenancy, the standard of farm operation in Houston County is still very high. It is believed to be higher than most Corn Belt counties and probably much higher than the average for the country. Table 2 gives the percentages of owners, tenants, and managers on farms in the county in different census years.

TABLE 2.—*Percentage of farms operated by owners, tenants, and managers in stated years*

Year	Farms operated by—			Year	Farms operated by—		
	Owners	Tenants	Managers		Owners	Tenants	Managers
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
1880	89.2	10.8		1920	75.8	23.1	1.1
1890	83.8	16.2		1925	72.6	27.3	.1
1900	81.5	18.1	0.4	1930	69.4	29.8	.8
1910	79.2	20.4	.4				

By far the greater part of the land rented is on the half-and-half crop-share basis, the usual lease used in the Corn Belt. Cash rentals are rather high, ranging from $6 to $12 an acre.[5]

The land boom following the World War had little effect on Houston County, and no large numbers of farm mortgages were foreclosed following the collapse of the boom, such as occurred in so many other sections of the Corn Belt. As a result the general wealth of the county is high.

The principal sources of income are livestock, dairy products, and poultry. Poultry and poultry products are side lines, but they form an important part of the farm income. According to the census, dairy products sold in 1929 were valued at $1,314,349, and poultry and eggs sold were valued at $298,320. According to the same census the total value of livestock on farms, April 1, 1930, was $3,891,220, and as all forage crops grown are consumed on the farm the value of these is reflected in the livestock valuation. The total value of all farm crops produced in 1929 was $2,970,062.

Most of the farm homes are well-built houses of the widespread square or rectangular style that has become the typical Middle West American farmhouse design, although a few bungalow-style houses have been built in recent years. Very little landscaping has been done beyond establishing front lawns, and here lies a large field for extension workers and farmers to make farm surroundings more attractive, as they so readily can be made.

Barns are large, commodious, and all are painted. The slope of the land is such on many farms that basement barns have been built. The machinery in use is largely horse drawn, of modern design, and is kept in good repair. Side-delivery rakes are common, although the dump rake is still largely used, and hay loaders are used on all farms, even on the steepest fields. The draft animals are of good size but are not heavy, because many fields are too steep for heavy

[5] Figures furnished by the president of Sprague State Bank, the owner of many farms and conversant with land tenure.

horses. Very few mules are used, the 1930 census reporting only 99 on April 1 of that year.

Purebred cattle are widely distributed over the county, although it cannot be said they predominate. Several herds of pure-bred Brown Swiss are near Caledonia. Holstein-Friesians, Jerseys, Guernseys, and good grades of these breeds are the most common, and some cattle are mixtures of all breeds.

Corn is usually the most extensively grown crop in the Corn Belt counties, but in Houston County it takes second place in total crop acreage, as reported by the census for 1930. Hay crops, including alfalfa, sweetclover, and timothy and red clover mixed, rank first with 46,818 acres, or 27.8 percent of the total of 168,278 acres of improved land reported; corn was grown on 35,193 acres, or 20.9 percent; and oats were grown on 24,177 acres, or 14.3 percent. The other grains reported were barley grown on 8,586 acres, or 5.1 percent; and wheat on 1,996 acres, or 1.2 percent.

Owing to the comparatively small amount of land available for profitable corn production and to the fact that practically all farms are operated by the farmer's family, a system of farming is practiced that differs from the common Corn Belt practice. The common practice in Corn Belt farming is to market, through fat livestock and dairy products, most of the feedstuffs produced on the farm and to sell some corn and oats for cash. In Houston County this system has been modified to the extent that on most farms all crops grown are fed on the farm. Dairy products and fattened livestock are the sources of revenue in this system, the foundation of which is the production of forage crops, their best utilization being in dairying in combination with hog raising. The raising of beef cattle is secondary and is practiced to the greatest extent in the rougher sections, where the proportion of rough woods pasture is greatest. As this is not a cash-crop system, the grains are grown in combinations for feed purposes. All the corn is grown for feed, oats are grown almost entirely in combination with wheat and barley for the same purpose, and clover mixed with timothy is produced for roughage. The alfalfa acreage is small, only 2,054 acres being devoted to this crop in 1929.

The number of livestock, including hogs, dairy cattle, and beef cattle, that the average family-operated farm can manage is determined by the physical and financial resources of the individual farm. If the acreage in crops is sufficient to produce more than enough feedstuffs for the livestock kept, a small surplus is sold for cash, but livestock and crops are so near a balance, owing to the amount of land available, that for the county as a whole no surplus is grown. Only three carloads of barley were shipped out of Caledonia during 1928. No other grains were shipped out, but corn and mixed feeds were shipped in. The curtailment and practical abandonment of wheat growing following the Civil War was the conclusion of the growing of wheat as a cash crop.

With the exception of flax, the acreage of special crops is small, tobacco, raspberries, bulbs, flowers, and apples making up the list.

The census reports 920 acres of flax harvested in 1929, and tobacco was grown on 155 acres. The growing of raspberries of the large Latham variety has become important in the immediate vicinity of

La Crescent which is just across the Mississippi from La Crosse, Wis. These raspberries are grown largely for the Chicago market. A few acres of bulbs and flowers, principally gladioluses, are grown in the same neighborhood, and the only commercial apple orchards in the county are in this section. The 1930 census reports 687 acres in apple orchards in 1929, with 36,127 bearing trees.

Almost every crop grown in Houston County is fed on the farms. If a corn crop turns out soft it is not so great a loss as it is in the cash-corn sections of the Corn Belt, because the corn here is grown to be fed and not for sale. All small grains are fed to dairy cattle, hogs, a few beef cattle, and the dairy-bred males which are fattened for beef. Forage crops, hay, and fodder form a very important part of the feed used. Practically none of the hay produced is sold outside the county. Hogs are marketed throughout the year, the largest numbers being shipped during October, November, December, and January. During 1928, 263 carloads of hogs were shipped from Caledonia, about twice that number from Spring Grove, and about the same number from Houston as from Caledonia. Twenty-seven carloads of cattle were shipped from Caledonia in the same period, and shipments from Spring Grove and Houston were in about the same proportions as for hogs. No figures are available for livestock hauled by autotruck.

In many years the feed requirements are greater than the production, and feedstuffs are shipped in. In 1928, 20 carloads of dairy concentrates, 29 carloads of corn, 5 carloads of oats, and 1 carload of hay were shipped into Caledonia.

Dairy products, principally butter, are shipped out steadily the year around. Very little butter is now made on the farms and sold by the farmers in the towns as was the former way of disposing of the surplus from a few cows. Several commercial dairymen supply the towns of Caledonia, Spring Grove, and Houston with fresh milk and cream.

A large chick hatchery at Caledonia annually produces about half a million chicks, and a small hatchery hatches about one-half that number. The chicks are shipped to all parts of the country and to nearby farmers who furnish the eggs from disease-free purebred hens, under the supervision of the hatchery. The hatcheries provide added income for the few months of spring and early summer when the hatching business is at its height.

At one time in the earlier history of the county the production of cordwood was an important source of winter income. Of late years this enterprise has declined to a point where it has almost ceased, because of the increase in the cost of labor and the decreasing supply of timber, although a small quantity of wood is cut each winter. A few portable steam sawmills manufacture oak crossties, but the supply of timber suitable for crossties is fast being depleted. Many owners of wood lots will not sell their timber but are holding it for future needs.

Nearly every town and village has one or more gristmills which grind principally small grains for cattle feed. At one time during, and for some years after, the wheat-growing period, a large number of water-power mills on several of the larger creeks milled wheat for flour and sawed lumber. Most of these are now in ruins

or nonoperative, only two gristmills—one at Hokah and the other on Beaver Creek about a mile south of Sheldon—now being in operation.

The usual methods of seed-bed preparation, seeding, and cultivation are practiced. Some farmers having very steep fields plow more or less with the contour of the land, as plowing is easier that way and helps to control erosion. A few farmers sometimes cultivate corn down hill, but this practice is very likely to prove disastrous when rains occur, as each furrow formed by the cultivator becomes a ditch, and valuable topsoil disappears into the nearest drainageway. During the year of the survey two or three farmers between Caledonia and Eitzen practiced contour planting of corn, the rows following around the slope instead of across. One of these men used a rotary hoe, and another an ordinary cultivator. Both methods slowed up soil washing to some extent, although several places were noticed where run-off water had broken through a corn row and formed a small gully. Many other instances of corn cultivation were noted, where, after one plowing down the slope, in places of not more than 4 or 5 percent gradient, rain had formed at least one small gully between each two corn rows. Realizing the danger of soil washing, most farmers do not plant the steepest slopes to corn but keep them in small grains and clover. It would be a good plan to seed these steeper slopes to alfalfa, making considerable effort if necessary to do so, in order to form a cover that would almost entirely stop erosion.

The smoother tops of the ridges could be used for the usual rotation of corn, oats, or other small grain, and clover, more than is now done, with the added advantage of having a more valuable crop on the slopes than the prevalent practice of using the clover-timothy mixture. Alfalfa would last 4 or 5 years, whereas clover returns only 1 dependable hay crop and possibly 2 seasons of pasture, though often only 1. On the less rough farms on the broader ridges such a procedure would not be necessary and would be desirable on only a few small patches.

More ground limestone is being used each year. As more farmers grow alfalfa and as other farmers realize its value as a feed crop, ground limestone will become an important item in the county farm budget. At present practically all the limestone material used is produced either on the farm where used or in the immediate neighborhood. Nearly all the grinding of limestone is custom work, as very few, if any, farmers own their own machines. Hauls are, and must be, short, in order that the use of limestone may be economical. Nearly every farm has its own source of high-grade limestone or is near enough to such source that the haul is not too expensive. Detailed information on this subject may be obtained from the University of Minnesota Special Bulletin No. 107.[6]

As the figures for fertilizer expense indicate, little use is made of soil amendments other than barnyard manure and crop residues. Very little sweetclover is grown, and none is turned under as green manure. On most of the upland soils liming is necessary for sweetclover and alfalfa and has not reached proportions sufficient to insure

[6] ALWAY, F. J., and ROST, C. O. LIMING FOR ALFALFA IN SOUTHEASTERN MINNESOTA. Minn. Univ. Agr. Ext. Spec. Bul. 107, 32 p., illus. 1926.

a very large acreage of either. Experiments conducted by the State university on fields near Caledonia indicate that an appreciable increase in the yield of corn is obtained on many fields through the use of superphosphate (acid phosphate). The use of potash has brought no outstanding results. The experiments indicate that many fields on Tama silt loam and Fayette silt loam give increased yields with phosphate but not with potash.

The following varieties of farm crops for southeastern Minnesota are recommended by the University of Minnesota, Extension Division, in Extension Folder No. 12, entitled "Improved Varieties of Farm Crops Recommended for Minnesota, 1929":

Spring wheat—Marquis (Minn. Acc. no. 1239[7]), Ceres, North Dakota no. 1658 (Minn. Acc. no. 2223), Marquillo (Minn. no. 2202), and Mindum (Minn. no. 470).

Winter wheat—Minturki (Minn. no. 1507).

Oats—Gopher (Minn. no. 674), Victory (Minn. Acc. no. 514), Minota (Minn. no. 512), and Anthony (Minn. no. 686).

Barley—Velvet (Minn. no. 447) and Glabron (Minn. no. 445).

Flax—Redwing (Minn. no. 188) and Winona (Minn. no. 182).

Soybeans—Minsoy (Minn. no. 139), Chestnut (Minn. no. 110), Haboro (Minn. no. 109), Elton (Minn. no. 167), and Manchu (Minn. Acc. no. 195).

Alfalfa—Grimm.

Corn—Silver King, Murdock, Minnesota no. 13, and Rustler.

SOILS AND CROPS

Less than one-half the total area of Houston County is available for farming. With the exception of the southwestern corner, which includes about one-fifth of the area and comprises comparatively smooth land, the county has a broken terrain, with a succession of narrow ridges, deep ravines, and valleys, and a very large proportion of the land is nontillable. Of the 361,600 acres included in the county, the census classes 168,278 acres as improved land, which includes 143,293 acres of crop land and 24,985 acres of plowable pasture. Thus it may be seen 46.1 percent of the land in the county is available for crops. In order to compare Houston County with a county of much smoother surface features, Rock County may be taken. Rock County is in the southwestern corner of the State, the soils are similar to those in Houston County, and the counties are nearly the same size. In Rock County, 82.3 percent of the total area is classed as improved land.

The tillable parts of Houston County consist of more or less smooth ridge tops and valley floors, and the nontillable parts comprise the steep valley sides and the poorly drained areas of the creek and river bottoms. About one-third of the nontillable land furnishes pasture of a dependable character. During dry weather the grass on the valley sides, particularly on the southern slopes, suffers from lack of moisture and dries, the soil covering being too thin to stand much drought. Except during periods of inundation, the creek and river bottoms are more reliable for pasture.

A very good idea of the relative proportion of nontillable to tillable land may be obtained from figures 2 and 3. These figures were made from map tracings of representative areas in the rough and in the smooth sections of the county. Figure 2 represents the

[7] Accession number signifies that the variety originated elsewhere but has been tested in Minnesota and proved desirable.

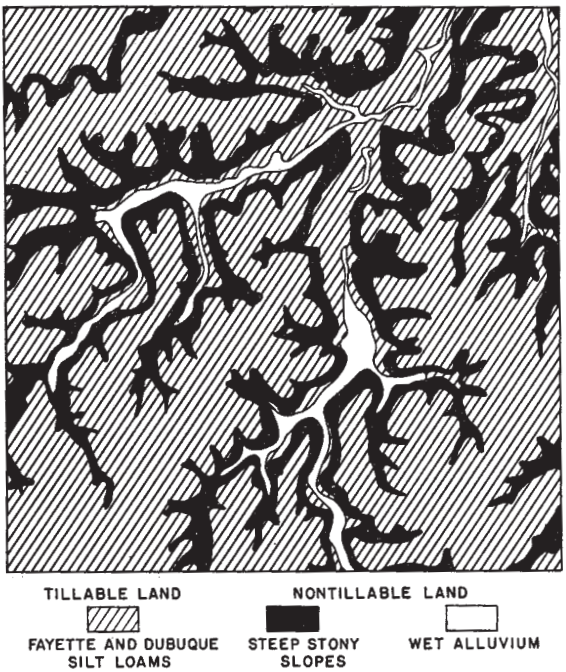

FIGURE 2.—Distribution of tillable and nontillable land in a rough section of Houston County.

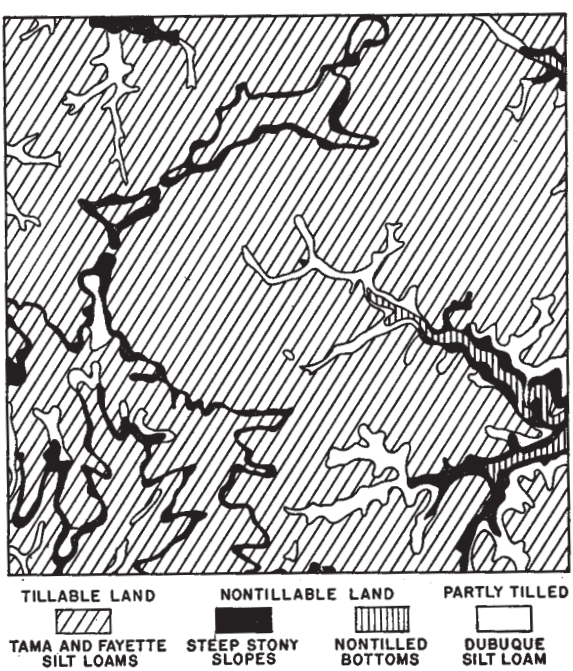

FIGURE 3.—Distribution of tillable and nontillable land in a smooth section of Houston County, in Caledonia and Wilmington Townships.

proportion of nontillable to tillable land in the rough section, and figure 3 represents these proportions in the smooth section. In the southeastern corner of the county is an area of rough land, approximately 10 square miles in extent, in which the proportion of nontillable to tillable land is even greater than that shown in figure 2. Here many of the ridge ends are a mile or more beyond the last field on the ridge.

Practically all farms include some land unsuited to tilled crops, either as nontillable land or as land that is unprofitable to till. This gives nearly every farm some land that must be put to uses other than to tilled crops, usually pasture and woodland. It is this disproportion of nontillable to tillable land, together with some uncertainty of corn as a crop, that has determined the present farming practices.

Although Houston County is near the northern edge of the Corn Belt, corn is the cheapest grain to grow. Being near the northern limit of profitable corn production, the crop, more frequently than farther south, is faced with the possibility of adverse fall weather, and a fully matured crop cannot always be expected. This climatic factor, together with the comparatively small amount of tillable land, increases the cost of growing corn and prevents its use as a cash crop. It is necessary, however, to grow grain for feed, and corn is best suited for this purpose. Over a large part of the county, continuous corn production is prevented by the surface relief. Only sufficient corn to feed livestock is produced on the ridge farms, because cultivation of this crop leaves the soil unprotected against erosion, and as this feature is too serious to ignore, corn is grown on a smaller acreage than it would be if the land were smooth. This crop, where it must be grown on slopes, is kept out of the rotation as long as possible, because of the danger of soil washing.

The system of farming in Houston County, which is a modification of the usual Corn Belt type, has been largely determined by the surface relief. This means that the most economical use of the land is to use all that is suitable for cultivation for the production of feed crops, and the less suitable, for pasture and hay land. In addition, a large acreage of land is altogether nontillable and is best utilized for forestry or rough pasture. With this usage as a basis, the soils of the county may be divided into three groups as follows: Cultivable soils, grazing soils, and forest soils. This is not a hard and fast grouping, as there is a certain amount of overlapping in actual use on individual farms. However, experience has developed a system of farming that in the main utilizes the soils on the basis of this grouping.

The cultivable soils are those which by reason of their composition, smooth surface relief, adequate drainage, and freedom from stone or gravel, are, for the most part, suitable for the production of cultivated crops. The grazing soils include those soils that cannot be cultivated as economically as soils of the first group. This has been determined by their location, either on steep slopes subject to destructive erosion or on overflow bottoms along streams where frequent inundation or poor drainage makes crop production an uncertainty. The group of forest soils comprises the steep valley sides and ravines where little or no soil material exists and where cultivation is impossible.

In the following pages of this report the soils of Houston County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Houston County, Minn.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Fayette silt loam	108,032	29.9	Wabash silt loam, poorly drained phase	384	0.1
Fayette silt loam, smooth phase	4,416	1.2	Bremer silt loam	640	.2
Tama silt loam	32,640	9.0	Sarpy silt loam	7,680	2.1
Waukesha very fine sandy loam	1,408	.4	Sarpy fine sand	1,536	.4
O'Neill sandy loam	384	.1	Ray silt loam	4,032	1.1
O'Neill fine sandy loam	320	.1	Cass sand	256	.1
O'Neill sand	832	.2	Cass stony loam	256	.1
Judson silt loam	3,968	1.1	Plainfield sand	5,248	1.5
Davenport silty clay loam	1,600	.5	Meadow	18,880	5.2
Wabash silt loam	7,296	2.0	Rough stony land	96,512	26.7
Cass silt loam	3,712	1.0			
Boone sandy loam	384	.1			
Dubuque silt loam	61,184	16.9	Total	361,600	

CULTIVABLE SOILS

The cultivable soils comprise the silty soils of the smooth uplands, the better drained terraces, and the first bottoms. However, the entire area of these soils is not at present in cultivation. Low prices of farm products tend to keep land out of cultivation, except where the productivity of the soil is high and where the land is very favorably located. Land that is somewhat inaccessible or lacks transportation facilities may be kept in pasture, although it is otherwise suitable for cultivation. In a farming system based on livestock raising or dairying, it is always necessary to keep a certain amount of land in pasture, and where the nontillable land is not sufficient for this purpose, farming land must be used.

Common characteristics of the cultivable soils are mellow surface soils of sufficient depth to allow good root development, and a texture and structure most favorable for retaining and delivering to the plant a store of water and plant food. Another characteristic of these soils is a smooth surface relief which will not allow excessive erosion under cultivation. The silty upland soils of this county are highly erosible and are easily washed down slopes, hence it is not advisable to cultivate steep slopes as in regions where the soils are more resistant to erosion. The soils of the smoother parts of the county are also rich in organic matter, as in this climatic belt any grassland soil that is undisturbed for a long period accumulates a store of organic matter in its surface layer that greatly adds to its productiveness.

The soils of this group are also free from stones and gravel, either on the surface or throughout the soil. This absence of coarse material increases the ease of cultivation and is an indication of a deep soil, as a stony soil is usually a shallow one.

The cultivable soils group includes Fayette silt loam, Fayette silt loam, smooth phase, Tama silt loam, Waukesha very fine sandy loam, O'Neill sandy loam, O'Neill fine sandy loam, O'Neill sand, Judson

silt loam, Davenport silty clay loam, Wabash silt loam, Boone sandy loam, and Cass silt loam.

The two most important agricultural soils of this group are Fayette silt loam and Tama silt loam, both occurring on the uplands. Fayette silt loam, the most extensive, is a light-colored soil with a moderately rolling surface relief. The light color is the result of the development of the soil under a forest growth that had begun to encroach on the upland before settlement of the region. Since clearing, the slow removal of the surface soil by erosion has been sufficiently rapid to prevent the accumulation of a large amount of organic matter but not so rapid as to destroy the agricultural value of the land.

Tama silt loam is the only dark-colored soil on the smooth uplands. The depth of the surface soil and the content of organic matter, combined with the smooth surface, make it the most valuable soil in the county. Other dark-colored soils occur on the terraces and first bottoms but are not so important agriculturally as Tama silt loam, because the areas of terrace and bottom land are not so large or so uniform and in some places are not so accessible. Some of these soils, such as Cass silt loam, lack adequate drainage during wet years. Others, including the O'Neill and some of the Cass areas, because of their sandy and gravelly subsoils, do not retain sufficient moisture to carry crops through dry seasons. The less valuable soils are not entirely farmed. A part, usually a small part, of a soil area less favorable for farming may be left as pasture. Other areas, where crop yields differ widely, according to the season, may be left out of cultivation following bad years.

Fayette silt loam.—In the undisturbed, or virgin soil, the 6-inch surface layer of Fayette silt loam is light grayish brown, and the material has a light silt loam texture. When crushed with the fingers it has a floury feel, owing to the absence of granulation. Below the surface layer the soil material grades into yellowish-brown silt loam which is slightly heavier in texture. This subsurface layer is heavier textured than either the surface layer or the subsoil. It is somewhat compact in place but is not so heavy nor so compact as to interfere with root penetration. It breaks into small blocks, having a maximum diameter of one-fourth inch, whose surfaces are coated with gray very fine powdery material. The soil material, below a depth of 30 inches, is yellow moderately compact light silt loam. It readily allows the upward and downward movement of soil moisture and the penetration of roots. The abundance of tiny root channels indicates that plant rootlets have no difficulty in penetrating the material of this layer.

In cultivated fields the surface layer has been so disturbed and mixed by cultivation and removed by erosion that its appearance is different from that of the virgin soil. The light grayish-brown surface soil has been mixed by plowing and has become lighter brown. The surface soil in cultivated fields averages between 6 and 8 inches in thickness. In many fields having steep slopes it may be only 3 or 4 inches thick. The material below the surface soil has not been changed by cultivation.

Fayette silt loam contains no lime carbonate within a depth reached by most crop roots, but lime carbonate usually occurs in the deeper

layers of the soil at a depth ranging from 10 to 14 feet, beyond the reach of all but a few alfalfa roots and the roots of trees. In areas where the soil is shallow, overlying broken limestone, lime carbonate may be reached by plant roots at a depth of 3 feet or less.

Fayette silt loam occurs on the tops of ridges and their upper slopes in all parts of the county. The largest and smoothest bodies are in the southwestern part, where the areas border and gradually merge with Tama silt loam areas. Other smooth bodies are developed near the central part. In these smoother areas, the forest has most recently encroached on the uneroded prairie upland and the soil still retains some of the dark color of the original prairie. The forest cover had not occupied this section of the county long enough, when settlement began, to entirely change the dark color of the prairie soil to the light color of the forest soil. The greater part of the soil, however, occurs on the rolling uplands and narrow ridge tops of the hilly and broken sections of the county.

The areas of Fayette silt loam differ considerably in depth and color, depending largely on the degree of slope and the extent to which erosion has removed the surface soil. The smoother areas supported a scantier tree growth and a heavier grass covering which, with less destructive erosion, has left a somewhat deeper and darker soil than that on the more heavily forested and rougher areas. In many steeply sloping fields, soil to a depth ranging from 6 to 14 inches has been lost through erosion.

The soil of the smoother land is friable, loose, and easy to cultivate, but the greater part of the area of this soil occurs on the steeper slopes where it is more difficult to handle, and the greatest care must be taken to prevent washing. Corn and other cultivated crops are not grown in the rotation oftener than once in 3 years, and then only on the smoother land. The moderately steep land is used for small grains, clover, timothy, and other hay crops, and the steeper slopes are, as a rule, kept in permanent pasture. About 80 percent of the total area of this soil is devoted to the production of crops, from 30 to 50 percent of the cultivated land being planted to corn which yields an average of about 35 bushels an acre, depending largely on the smoothness of the land and the depth of the surface soil. Oats are grown on a larger proportion of the soil than of Tama silt loam, and they yield from 25 to 45 bushels an acre. Barley is usually grown in combination with wheat for feed, the yields ranging from 10 to 15 bushels an acre. Clover and timothy, usually in combination, is the principal hay crop and is widely grown on this soil, yielding from 1 to 2½ tons an acre. The pasture land is used principally in connection with dairying and to some extent for fattening beef cattle and hogs.

Fayette silt loam, smooth phase.—Areas of Fayette silt loam having an unusually smooth surface relief, a thicker surface soil, and an increase of organic matter that accumulates on a smooth surface, have been mapped in the central and northwestern parts of the county as a smooth phase of this soil. In places on these smooth areas the darker surface soil may have a maximum thickness of 12 inches. The color ranges from grayish brown to rather dark grayish brown, but nowhere approaches the dark color of Tama silt loam. The subsoil layers are similar to those of typical Fayette silt loam.

Both the smooth surface relief and the depth of the surface soil make this a more desirable soil than typical Fayette silt loam. It is only slightly lower in value than Tama silt loam. Nearly all the land is under cultivation. Corn is the principal crop. Corn yields average about 5 bushels an acre higher than on typical Fayette silt loam, and hay yields on some fields may be one-half ton higher. Oats yield about as well as on Tama silt loam.

Tama silt loam.—Tama silt loam differs from Fayette silt loam in that it is dark in color. The surface soil, to an average depth of 12 inches, is very dark grayish-brown (black when wet) silt loam which is very finely granular, mellow, and easily tilled. All these are characteristics of a good corn soil. Below a depth of 12 inches the color is dark grayish brown, which becomes lighter with depth, and at a depth of about 30 inches is yellowish brown. The material below a depth of 12 inches, although silt loam, is not so mellow as the surface soil nor does it contain so much organic matter, as is indicated by its lighter color. It is not so granular, and the granules are not so soft as in the surface soil. The subsoil becomes yellower with depth and is mottled with light-gray spots. It is also more compact than the soil above but is filled with tiny root holes and insect burrows, showing that plant roots easily penetrate it. No lime carbonate is detectable in the lower soil material, which is the same as that of Fayette silt loam.

This soil, although not so extensive as Fayette silt loam, is of greater agricultural importance because of its greater natural fertility. It is a more productive soil because of its greater organic content and less tendency to wash or erode. The organic matter of Tama silt loam, which is a grassland or prairie soil, has resulted from the gradual accumulation, during a very long period, of decayed grass roots. The original heavy growth of prairie grasses provided a thick mat of roots, and the high summer temperatures promoted their rapid disintegration into humus. This humus reacted with lime brought up from the deeper part of the subsoil by live roots to form stable organic compounds that are not easily removed by percolating soil water. This organic stability, added to each year, resulted in a very fertile soil that has retained its fertility to a large extent, even under cultivation.

The lessened tendency of Tama silt loam to wash is partly attributable to the stability of its organic matter, together with a smooth surface relief. As the organic matter combined with lime to form stable compounds, the very fine soil particles were banded together to form granules which are not easily broken up by percolating rain water, so that little of the fine soil material has been leached out. Since cultivation began, surface wash, or sheet erosion, has been speeded up, owing to the destruction of the thick covering of prairie grasses, but erosion has not been so severe on Tama silt loam because the smooth surface relief does not allow such rapid run-off as does the rougher surface relief of Fayette silt loam.

Tama silt loam occurs in the southwestern corner of the county, the smoothest section and the one in which the greatest agricultural development has taken place. This section extends from Eitzen, near the southern county line, north to Caledonia and west to the Fillmore County line at a point 3 miles south of Riceford. This part of

the county is least cut by ravines and, although the general level is surmounted by the low ridge, previously mentioned, the extent and relief of this ridge is not such as to greatly interfere with farming operations, and large fields are possible. Here the percentage of tillable land is greatest, being 75 or 80 percent of the whole section.

Crop yields on Tama silt loam are higher than on any other soil in the county, with the possible exception of corn yields on some of the better drained fertile creek- and river-bottom soils. Corn yields from 30 to 50 bushels an acre, with occasionally higher yields during the most favorable seasons and on exceptionally well managed and fertilized fields. Oats average about 40 bushels an acre, and grains grown for cattle feed, barley and wheat in combination, yield from 12 to 18 bushels. Mixed timothy and clover yield from 2 to 3 tons. Other legumes, such as alfalfa, sweetclover, and soybeans, are not widely grown. Most of them are grown in small fields of a few acres each.

Waukesha very fine sandy loam.—The surface soil of Waukesha very fine sandy loam consists of a 5-inch layer of dark grayish-brown very fine sandy loam. Below this and continuing to a depth of about 20 inches is yellowish-brown very fine sandy loam which is slightly heavier in texture than the surface soil. The lower part of the subsoil is grayish-yellow gritty loam or silt loam. In a few places the lower part of the subsoil is lighter in texture, owing to a larger content of very fine sand.

This soil occurs on well-drained terraces along Mississippi River in the vicinity of La Crescent and Brownsville, near the mouth of Winnebago Creek in the southeastern part of the county, and on the north side of Root River about 2 miles northeast of Houston.

Waukesha very fine sandy loam is a productive soil and is probably more desirable for farming than any other soil in the county except Tama silt loam. The surface soil is sandy enough to cause the soil to warm up earlier in the spring than the heavy-textured soils. For this reason this soil is used at La Crescent for raspberries, truck crops, bulbs, and flowers. The early warming of the soil gives the raspberries, the most important of these crops, a good start, and they reach the market at an early date. In this respect, however, it is not so valuable a soil as O'Neill fine sandy loam which, being sandier, is the best soil in the county for early produce. Vegetables are grown to some extent at La Crescent, but the enterprise is not important. Bulbs are grown by one gardener in this neighborhood.

This is not an extensive soil, and the farming practices are the same as for the well-drained upland soils. Corn, small grains, and hay crops are grown on the larger part of it, with yields that compare favorably with those on Tama silt loam.

O'Neill sandy loam.—The surface soil of O'Neill sandy loam, to an average depth of 6 inches, consists of dark grayish-brown fine sandy loam. In places the presence of coarse sand imparts a gritty character, but as a rule, the sand is of the medium and fine grades. The upper part of the subsoil is lighter brown loam with about the same texture as the surface soil. At a depth ranging from 18 to 30 inches, the finer material is underlain by coarse sand and gravel. Variations occur locally within this soil, and their total area was so small that no separation on the soil map was attempted. In some places,

the lower part of the subsoil is composed of boulders and coarse gravel; in others, it is fine sand. In places the surface soil contains a small percentage of small gravel.

This soil occurs only on the borders of the Mississippi bottom land and does not extend up the valleys of the smaller streams. The largest areas are in the vicinity of La Crescent, and one narrow strip lies along the river road about 4 miles south of Reno.

Although this soil occupies low terraces, drainage is good. The loose porous subsoil makes the soil droughty in very dry seasons, but crops do not suffer during short droughts. Corn and hay crops are grown, and yields are good in favorable seasons, but the average yields are lower than on the silty upland soils.

The growing of raspberries at La Crescent has become well established, and practically all of O'Neill sandy loam in this vicinity is utilized for this crop. The conditions here are nearly ideal for the growing of early-maturing small fruits and berries, as the location is high and dry; three trunk-line railroads within 3 miles, at La Crosse, Wis., connect this section with Chicago, the principal market; and the soil is sandy, easily tilled, quick to dry out after a rain, and the first to warm up in the spring. These conditions make it possible to place berries on the Chicago market early enough in the summer to command a high price.

The other areas of O'Neill sandy loam and O'Neill fine sandy loam are too far away from good shipping facilities to be valuable raspberry soils, and the heavier textured upland soils in the vicinity of La Crescent do not warm up quickly enough in the spring and do not respond so quickly to fertilizer treatment. Under these conditions the O'Neill soils around La Crescent are too valuable for the common field crops. The raspberry industry is not likely to expand greatly in Houston County, owing to the scarcity of sandy soils within economical hauling distance of La Crosse, Wis., the best shipping point.

O'Neill fine sandy loam.—O'Neill fine sandy loam closely resembles O'Neill sandy loam, except in texture of the surface soil. It has the same gravelly subsoil as the sandy loam, but, owing to its finer textured surface soil, it is a somewhat better soil. It is not so variable as O'Neill sandy loam and is more consistently a fine sandy loam.

O'Neill fine sandy loam occurs adjacent to O'Neill sandy loam at La Crescent and also in several areas along the western edge of the Mississippi River bottom land, along the river road from La Crescent to New Albin, Iowa. A variation of this soil was mapped at the lower end of Crooked Creek Valley. Here the soil has a dark grayish-brown fine sandy loam surface soil, 6 or 8 inches thick, that grades into lighter colored fine sandy loam, and at a depth ranging from about 33 to 37 inches into a substratum of fine sand instead of gravel, as is usual in O'Neill sandy loam. As only a small area of this variation was mapped, it was included on the soil map with typical O'Neill fine sandy loam.

O'Neill fine sandy loam is used for the same crops as O'Neill sandy loam, and the yields are practically the same.

O'Neill sand.—The surface soil of O'Neill sand is dark grayish-brown or almost black sand or loamy sand to an average depth of 8

inches. Below this depth the texture remains the same, but the color gradually becomes lighter, and at a depth of 30 inches it is light-brown material similar in all respects to the lower subsoil layer of Plainfield sand.

O'Neill sand occurs on terraces along Root River and South Fork Root River. The surface relief is flat or gently rolling, with a few small sand ridges. The land is naturally well drained, owing to its porous subsoil, and in seasons of prolonged drought crops are seriously damaged.

The organic matter in this soil gives it a somewhat higher value than the light-colored Plainfield sand. In favorable seasons, yields are only slightly lower than those on O'Neill sandy loam. Corn produces from 20 to 30 bushels an acre, small grains about 15 bushels, and hay from 1 to 2 tons.

Judson silt loam.—The surface soil of Judson silt loam is dark grayish-brown or nearly black mellow silt loam, ranging in thickness from 20 to 30 inches. The subsoil is lighter brown material with a texture slightly heavier than that of the surface soil. This soil has developed as colluvial deposits that have accumulated in fanlike bodies on the outer edges of terraces, at the bases of slopes, and near the upper ends of shallow drainageways, in most places where two or more drainageways come together. The natural drainage of both surface soil and subsoil is good. The greater part of the land is above present overflow. The lower terrace areas and areas in swales that serve as drainageways may either be saturated or inundated for a few hours, but the surplus water soon drains away.

Judson silt loam is recognized as a good soil for all the crops commonly grown in Houston County, but its mellow condition and high content of organic matter make it especially productive of corn. On all smooth areas of sufficient size, corn is grown almost exclusively. Some small bodies on the outer edges of terraces are not cleared of brush and weeds, and they are used for pasture. Yields of corn on smooth areas of this soil are usually a little larger than those on the surrounding upland soil, ranging from 40 to 50 bushels an acre. As a rule this soil makes up only a small part of a cultivated field.

Davenport silty clay loam.—The surface soil of Davenport silty clay loam, to an average depth of 12 inches, is dark-gray or dark grayish-brown silty clay loam which is plastic when wet but granular and friable when dry. It is underlain, to a depth of about 20 inches, by grayish-brown heavy clay. Below this the material is of a pale-salmon color which gradually deepens to red, with gray mottles below a depth of 32 inches. The color is due to the composition of the parent material and not to poor drainage. The lower subsoil layer is silty clay loam but is not so heavy and tenacious as the layer above.

This soil occurs in the lower ends of the valleys of Pine Creek, Root River, Wildcat Creek, Crooked Creek, and Winnebago Creek, that merge into the Mississippi bottom.

Davenport silty clay loam is a productive soil but one that is hard to handle in extreme moisture or drought, as too much water makes it very sticky and too little causes it to bake and crack. It produces very good yields of corn, oats, and clover. Owing to the difficulty of handling it, most of the land is kept in legumes as long as pos-

sible and not cropped to corn any more than can be helped. In favorable years corn yields from 30 to 40 bushels an acre, small grains from 15 to 20 bushels, and mixed timothy and clover from 1 to 3 tons of good hay.

Wabash silt loam.—The surface soil of Wabash silt loam, to a depth ranging from 8 to 12 inches, is very dark grayish-brown or black silt loam. It is underlain by brown silty clay loam or clay, which, in turn, is underlain, at a depth of 20 inches, by grayish-brown silty clay. Like the other flood-plain soils of the county, considerable variation occurs in the color and texture of the surface soil within short distances, as a result of the different kinds of materials brought down by flood waters.

Wabash silt loam occurs in several large areas in Root River and South Fork Root River Valleys, each covering about 1 square mile, and in smaller areas in these valleys and along small streams in other parts of the county. This soil occupies the immediate flood plains rising above stream level to a height of several feet. The land is flooded at every period of high water, but it soon drains after the waters recede. The wider bottoms, which are covered only by high water, are under cultivation. Corn is the principal crop, and yields are as high as on the best upland soils, averaging about 40 bushels an acre. Occasionally a crop is damaged or destroyed by floods. Along the smaller streams, this soil is too low and too subject to flooding to be used for cultivated crops. The uncultivated areas are used for pasture land which in most places furnishes excellent grazing.

Areas of somewhat heavier texture have been included with Wabash silt loam. In these areas the surface soil is very dark grayish-brown or almost black silty clay loam, ranging from 8 to 15 inches in thickness. When wet this material is very sticky, but when dry it becomes moderately friable. The upper part of the subsoil is dark-gray silty clay loam which, with depth, becomes gradually lighter in color and heavier in texture. In most places below a depth of 24 inches, spots and streaks of rust brown occur.

This soil occurs in two small areas in Root River Valley near Hokah. It occupies about the same topographic position as Wabash silt loam and is farmed in the same way. It is a good corn soil where cleared and used for that purpose, and yields in favorable seasons are only slightly below those from Wabash silt loam. However, a large part of this soil is in woods and is used as pasture. Its heavy texture makes it difficult to handle and late to warm up in the spring.

Cass silt loam.—Cass silt loam is the most important member of the Cass series in Houston County. Like the other Cass soils, it has a dark-colored surface soil overlying coarse sand or gravel. The surface soil is a 12-inch layer of very dark grayish-brown or nearly black silt loam. It is underlain by silt loam that changes in color with depth to grayish brown. At a depth ranging from 18 to 24 inches, the finer material is abruptly underlain by light-brown loose coarse sand.

The greater part of this soil occurs in discontinuous areas along Root River extending from its mouth about 15 miles westward. Several areas lie along South Fork Root River, and small bodies occur along a few of the smaller streams. In the narrow valleys of

the smaller creeks the surface soil is lighter in texture and the underlying coarser material consists largely of limestone fragments brought down by floods from ravines where the limestone is being cut by streams.

In the broader valley of Root River, where flooding is not frequent or sudden, a large part of the land is under cultivation, and corn is the principal crop. In favorable seasons yields are as large as on any soil in the county, but the yield in many years is considerably reduced by flooding. In the narrow valleys this soil is used only for pasture.

Boone sandy loam.—Typical soils of the Boone series have light-colored surface soils, ranging from grayish brown to rather dark grayish brown, and yellow or brown friable subsoils. The material on which these soils have developed is derived from the weathering of sandstones. In Houston County an admixture of material from other soils has modified the surface soil in many places and produces a rather wide range in color and composition. The areas of typical Boone sandy loam are developed on the outcroppings of a soft sandstone at the base of a low ridge in the southwestern part of the county. The surface soil, to a depth ranging from 6 to 10 inches, is brown or grayish-brown sandy loam. The subsoil is yellowish brown or brown and is, in most places, heavier in texture than the surface soil, ranging from sandy loam to loam.

The greater part of the area of Boone sandy loam is modified by colluvial materials brought down from higher land. In places dark-colored silt from Tama silt loam areas gives a siltier texture and a darker color to the surface soil. In other places the colluvial covering is derived from Fayette silt loam areas, and the change is toward a silty texture. In such places the surface soil may reach a depth of 15 inches.

This soil occurs for the most part on slopes where the surface relief is not suitable for large fields. The bodies are small, many of them too small to indicate on the soil map. This land has no special use, and the cleared areas are, as a rule, included in fields with other soils. Where a patch of this soil is near the farmhouse it could well be used for an early garden.

GRAZING SOILS

The soils classed as grazing soils include 9 soil types and 1 miscellaneous classification (meadow). These soils, where used at all, are almost exclusively devoted to grazing, as they are, in their present condition, economically unsuited for cultivation. They are either too steep or too thin to allow profitable cropping and are too poorly drained, subject to too frequent overflow, or too sandy or stony to be good farming soils.

Dubuque silt loam, the most extensive of these soils, is topographically unsuited to cultivation. Even where the soil is sufficiently deep to support crops, the slopes are so steep that if the land were cultivated, erosion would immediately begin to remove the soil. A large part of the soil has already been eroded, until it now forms only a thin covering over the bedrock.

The soils of the Bremer, Wabash, Sarpy, Ray, and Cass series of this group are either too poorly drained or too frequently overflowed

for them to be profitably farmed. In some places these soils could be drained, but the present prices of land and farm products would not justify the expense. The Cass and Plainfield soils are underlain by sand and gravel at so slight a depth as to seriously impair their agricultural value. The material mapped as meadow is cut by numer ous sloughs and is subject to frequent overflow, making it difficult to handle and problematical as to the saving of a crop.

Dubuque silt loam.—Dubuque silt loam occurs in narrow bands on slopes in all parts of the county, in a topographic position intermediate between the crests or smooth tops of the ridges and the steeper slopes below. The large total area of this soil gives it an important place among the soils of the county. Fayette silt loam occupies the tops of the ridges and the smoother upper slopes above the areas of Dubuque silt loam. The lower, steeper, more eroded slopes are classed with rough stony land. Areas of Dubuque silt loam adjoin areas of Tama silt loam along small drainageways that penetrate into the smooth upland.

The surface soil is derived from the same material and in the same way as Fayette silt loam, but it is underlain at a slight depth by broken limestone. The silty soil material ranges in thickness from a foot to as much as 30 inches. In places where the silty layer is more than 30 inches thick the material is mapped as Fayette silt loam. In many cultivated fields in the narrow saddles of ridges, the thickness of the soil covering has been so reduced by erosion that bedrock is exposed. At the time this land was first cleared, the soil material may have been more than 2 feet thick.

Under cultivation soil washing may occur to such an extent in some fields as to materially reduce the depth of Fayette silt loam and thus produce a soil that, in mapping, must be classed as Dubuque silt loam. This has already happened in many places, on rather narrow summits of ridges where the original soil covering was probably deep enough to have been mapped as Fayette silt loam and at the beginnings of drainageways some distance from the ravine proper.

No conclusive proof exists that land now mapped as Dubuque silt loam was at the time of clearing the forest Fayette silt loam, but some evidence indicates that this might have been the fact. In woods adjacent to cleared fields, both of the same slope, the soil in many places is deep enough to be mapped Fayette silt loam, but the soil in fields is too thin to be so mapped. The soil in the woods may have a surface soil as much as 15 inches thicker than that in the fields, where as little as a 4-inch surface soil remains, in some places no surface soil at all. Fayette silt loam occurs on comparatively narrow ridges in the woods, but, as a result of erosion, the soil on a ridge of the same width in a cultivated field will very likely be Dubuque silt loam. This leads to the belief that, with the exception of the very narrowest ridges and a few sharp knobs, the forest cover with its thick carpet of leaves and leaf mold has been of the greatest protection against erosion and removal of soil, by causing rain water to be absorbed and allowing it to run off so slowly as to carry off very little soil. Under present-day cultivation this protection has been removed and Fayette silt loam in some places may rapidly be transformed into Dubuque silt loam.

Variations in surface features, the character of the soil, and the thickness of the silty covering occur within short distances over these narrow bands of soil, but it was impractical to show all these differences on the soil map. On account of the unfavorable topography very little of Dubuque silt loam has been placed under cultivation, even where the soil material was sufficiently deep to grow crops. The smoother part, which has been cleared or partly cleared of trees, makes excellent pasture, as bluegrass and other good pasture grasses soon cover the surface. Occurring as it does on the narrowest ridges, saddles, and as a margin around the edges of Fayette silt loam areas and between these areas and the steep hillsides (rough stony land), Dubuque silt loam is usually fenced off from the areas of Fayette silt loam, and it merges into the hillsides. Dubuque silt loam and rough stony land are both used for pasture, and although rough stony land is secondary to Dubuque silt loam in pasture value, the whole area thus used comprises nearly two-thirds of the county.

Wabash silt loam, poorly drained phase.—A poorly drained phase of Wabash silt loam occurs in low stream bottoms, where drainage is restricted to such a degree that the ground is saturated with water for a large part of, or all, the year. The principal areas are along the lower end of Pine Creek just west of La Crescent in the northeastern part of the county. The soil profile differs from that of typical Wabash silt loam, in that the subsoil shows more gray or mottling as a result of poor drainage and the immediate surface layer contains more organic matter, in places being nearly a muck. These areas are for the most part wet and marshy, and the vegetation consists mainly of marsh grass and other water-loving plants. This soil has no value except as low-grade pasture land.

One small area of peat, lying about 3 miles northwest of Hokah, has been included with this soil on account of its small extent. The material in this area is mainly organic, consisting of coarse water grasses and plants in a raw undecomposed condition. Only a small amount of mineral matter has been washed in. The character of the material and the undrained condition gives this area a lower value than the areas of the Wabash soil.

Bremer silt loam.—A few small areas of Bremer silt loam occur in the northwestern part of the county, north of Houston. Owing to its small total area, this soil has little influence on the agriculture. The soil as mapped is somewhat variable, but the following description is representative of the greater part. The surface layer, to a depth of 4 or 5 inches, is dark grayish-brown or black silt loam, below which the color becomes grayer and the texture heavier to a depth of 18 inches. In the next layer the texture is heavier, the material is silty clay loam or silty clay, and the color is mottled gray and yellowish brown. The principal difference between this soil and the other terrace soils of the county is the heavy texture and poorly drained condition of the subsoil. The poor drainage of this soil is owing partly to the heavy somewhat impervious subsoil and to the occurrence of the soil on low terraces. Conditions are favorable for the accumulation of organic matter.

When the land is drained and the water-logged condition is overcome, Bremer silt loam becomes a productive soil, being particularly

valued for corn which produces about 40 bushels an acre. Small grains, particularly where organic matter is abundant, have a tendency to lodge.

Most of the Bremer silt loam is in need of drainage, and under existing conditions its best utilization is as permanent pasture. It supports an excellent growth of bluegrass and white clover, making it a valuable pasture soil. The pasture value is increased because of the location of the soil adjacent to small drainageways, the other soils along which are also used as pasture. In favorable locations this condition increases the available amount of grazing in one continuous body.

Sarpy silt loam.—Sarpy silt loam is a light-colored soil of the lower bottoms. The texture of the surface soil may range from silt loam to very fine sandy loam, but the silt loam is the more extensive. The color is grayish brown in the upper 8 inches and light grayish brown or grayish brown below. Over the greater part of the area of this soil, the subsoil is heavy silt loam. In most places at a depth of about 15 inches, but in some places as deep as 40 inches, the texture becomes lighter. In many places thin stratified layers of sand, silt, and silty clay make up the lower part of the subsoil; and in other places, a sand, composed of fine and medium grades, underlies the silty layers.

This soil occurs in a number of areas along the valley of Root River in the northwestern part of the county, along South Fork Root River, and along many of the creeks. It occupies the lowest part of the flood plain and is subject to frequent overflow. The soil drains rapidly after recession of the floods, and, with the exception of a few low basinlike depressions, it is well drained. Over a part of the areas sediment is deposited by one flood and partly or wholly removed by subsequent floodings, so that the surface soil is constantly changing in character.

Owing to the frequent flooding of this land, probably less than half of it is used for cultivated crops. Where cropped, corn is grown almost exclusively. Yields are fair in good years, but the average is cut down by flood damage. The uncultivated land supports a growth of weeds and grasses, with occasional patches of brush. Some open land is mowed for hay, but the greater part is used only for summer pasture.

Sarpy fine sand.—Sarpy fine sand does not hold an important place among the agricultural soils of the county, owing to its small total area and low productivity. The surface soil of fine sand is lighter in texture than that of Sarpy silt loam. In most places the upper few inches are darkened by a small content of organic matter which soon disappears under cultivation. Below a depth of 18 inches, the subsoil is loose sand ranging from fine to moderately coarse. Like Sarpy silt loam both surface soil and subsoil vary in texture within short distances.

This soil occupies many small areas in Root River Valley. It is a first-bottom soil subject to periodic flooding. The land has low agricultural value, and very little of it is in cultivation. It is used mainly for pasture.

Ray silt loam.—A common soil along the smaller creeks is Ray silt loam. The surface soil is light-brown or grayish-brown silt loam, from 8 to 12 inches thick, and the subsoil in most places is very dark

gray or black heavy silt loam. Because of this contrast in color between the surface soil and subsoil, the assumption is that the subsoil is an older surface soil that has been covered by more recent wash from the light-colored soil of adjacent ridges. It is known that, since the ridges have been cleared and farmed, during heavy or continuous rains the run-off is very rapid, and small streams carrying heavy loads of silt quickly spread over their narrow valleys and drop their burden on material that was formerly a dark-colored soil. In some places this filling has been deep, and in others less than a foot of alluvium has been deposited. Where the deposit is less than 1 foot deep the soil is classed with Ray silt loam.

Ray silt loam does not occur in any large bodies, and it is confined largely to narrow bottoms. Almost none of the land is used for crops, but it is used, in association with the rough land, as pasture.

Cass sand.—The surface soil of Cass sand consists of a 6- or 8-inch layer of fine sand or medium sand ranging in color from dark grayish brown to almost black. Below this the color gradually becomes lighter downward and at a depth of less than 18 inches changes to brown or yellowish brown. In most places very little change occurs in the texture, but the sand of the subsoil becomes more incoherent as a result of the lack of organic matter. In a few places a coarser sand containing a few fine gravel occurs below a depth of 2 feet.

Most of this soil occurs in small areas in the valley of Root River west of Houston, and it is covered by water at every rise of the stream. Although flood water drains out of the soil rapidly, the value of the land for cultivated crops is greatly decreased. The land is almost entirely used for pasture and hay meadows.

Cass stony loam.—In some of the small narrow creek valleys, a soil occurs that was separated from the typical Cass silt loam as a stony type. Instead of the surface material being underlain by gravel, it is underlain by broken limestone fragments, ranging in diameter from a fraction of an inch to 6 inches. The surface material is very dark grayish brown and is usually a light silt loam, but in many places it has a loamy texture. The average depth is about 15 inches, the lower 4 or 5 inches of which is, in many places, sandy and may contain small pieces of limestone. The change to broken limestone fragments is rather abrupt, and the underlying material is composed entirely of this stone. In these ravines the bedrock bottom was formerly composed of limestone and has since been covered by a deposit of soil material from the ridges. This soil does not occur in extensive areas, and it is scattered over the county. It has no agricultural value and is included with woods pastures.

Plainfield sand.—Plainfield sand belongs to the group of light soils or those which have not accumulated a large store of organic matter. The upper 5 or 6 inches consist of grayish-brown medium sand. Below this is light-brown or light grayish-brown sand that continues to a depth ranging from 4 to 8 feet. The sand rests on stratified fine sand, silt, and clay.

This soil occurs in a number of areas on terraces bordering the bottoms of Root River and its branches. Although it occupies a total area of 8.2 square miles it is unimportant agriculturally. The coarse texture of the sand renders the soil so droughty that it is not dependable for crops. It is used almost exclusively as rough pasture.

Meadow.—The term meadow is used to designate lands in the Mississippi bottoms, which differ widely in texture and composition. It consists not of a definite soil type but of a number of materials that make up recently deposited alluvium. Over some parts of the area the surface soil is changed or shifted with every rise of the river. In other places the material has been stationary a sufficient time to allow the development of small areas of soils similar to those in other creek and river bottoms, hence a few more or less well-developed areas of the typical bottom soils are included. In the greater part of the area, however, the alluvial deposits do not remain undisturbed long enough to develop a true soil and are constantly being modified or replaced by other materials.

The bottoms are cut up by old channels and sloughs, with scattered areas of marshes. During overflows the water first finds its way through the old channels and sloughs, dumping the coarser sands first as it spreads out over the bottoms. Farther away in the quieter places the silt and clay are dropped, with scattered spots of sand. Old sloughs, cut-offs, and quiet backwaters have been filled with fine material, and old sand bars have been reworked and fine material mixed in, so that the areas bear little resemblance to any particular soil. In some of the lower places fairly typical Wabash silt loam has developed, in others Cass silt loam. Sarpy fine sand is present in many places but Sarpy silt loam only in spots. These soils occur all over the bottoms in small pocketlike bodies, narrow strips, and intricate meandering areas. A few areas of meadow lie along the lower ends of Crooked and Winnebago Creeks in the southeastern corner of the county. Here the valleys have been filled so recently that the soil is not uniform.

The Mississippi River bottoms in Houston County cover approximately 26 square miles, nearly all of which is classed as meadow. Very little of this land is used for cultivated crops, and wild hay is cut from most of that not in forest. A few fields of corn and one or two of oats are grown on the outer edge of the bottoms, at their juncture with the upland. In the bottoms proper, some distance from the upland, only one field of corn, including about 40 acres, was observed during the course of the survey. This was the only attempt being made to farm in the bottoms proper. Cattle are allowed to roam the bottoms, and they find very good grazing, particularly in the unforested areas. At one time large numbers of cattle were grazed, but very few are now pastured.

Until comparatively recently, attempts have been made to organize drainage districts to reclaim most of the bottoms for agriculture. These attempts have failed, owing to the uncertainty of success and to the fact that this area is included in the Federal Government's Mississippi River Fish and Game Refuge, for which large acreages have been and are to be bought by the Government. Without considering natural reasons, the expansion of these reservations will prevent most of this territory from being farmed.

FOREST SOILS

Forest soils are those which, for various reasons, have such a low agricultural value that their best use is for the growing of trees,

either for timber or for firewood. They may be and usually are used to furnish auxiliary pasture, but full dependence for grazing cannot be placed on them.

In Houston County rough stony land has been placed in the forest soils group because its steep, rough topography makes farming impossible. The soil is so thin that, except on a few ridge tops and at the bases of some of the slopes, grazing of good quality is not possible. Erosion keeps such close pace with soil-forming processes that there is no opportunity for much soil to accumulate.

Rough stony land.—The soil materials of rough stony land are of several kinds. Some of the ridge tops have a thin covering of silty material similar to that composing the Tama and Fayette soils. This material is mixed with fragments and boulders of limestone and some clay formed from the limestone. The slopes are composed of broken limestone and silty material washed down from above and mixed with outcroppings of sandy material.

The valley slopes covered by rough stony land have, in the main, been heavily timbered, the heaviest stands of timber occupying the north slopes of valleys having a general east and west trend, but where the valleys run north and south the sides were evenly timbered. The southern slopes were either thinly covered with trees or entirely bare of them. This condition has been brought about because the southern slopes have a longer period of exposure to sunlight during the day than the northern slopes. As tree seedlings need a cool moist soil in which to grow, the longer heating period on the southern slope tends to keep the thin soil dry, and trees either do not grow under such conditions or grow in sparse stands. The opposite is true of the northern slopes. Here conditions are favorable for tree growth because the hot summer sun does not dry out the thin soil covering to such a great extent. As a result of this difference in tree growth the southern valley slopes have a thinner soil covering than the northern slopes, as they have not had the protection of forest litter and leaf mold to slow up surface runoff during rains as have the timbered slopes, and consequently loose soil material has been quickly lost. The soil covering on many southern slopes is so thin that grass soon dries up during late summer.

Although rough stony land occurs on stream slopes in all parts of the county, the largest areas are in the southeastern corner, where it makes up more than one-half of the total land surface. This land extends upward away from the streams, forming a band from 300 feet to more than a mile wide, extending parallel to the streams in unbroken, winding stretches for many miles.

In some localities a narrow strip on the extreme lower slope has a deeper soil than usual, which may be cultivated. With the exception of these occasional strips, rough stony land can be used only for forestry or as secondary pasture.

In a few small areas in the valley of Crooked Creek and in one in the valley of Winnebago Creek, the soil is deep mellow sandy loam filled with stone fragments. This soil occurs on colluvial material brought down steep slopes and spread out on more gentle slopes. The slope in most places is still too steep and the stone content too high to allow cultivation of the land. The greater part of these

areas is used only for woodland and pasture, and the grasses furnish better grazing than on other parts of rough stony land.

EROSION

Erosion is rapidly reducing the fertility of the two most important agricultural soils of the county, Tama silt loam and Fayette silt loam, by removing the surface soil. With the exception of Dubuque silt loam of the group of grazing soils, erosion has had little effect on the other soils.

There are two principal kinds of erosion, gullying and sheet erosion, and both are at work in Houston County as conditions—a loose soil and a strong or moderate relief—are particularly favorable. Gullying is so obvious and immediately destructive that steps to correct it usually are taken early in its history. Few farmers neglect to fill in small gullies with brush, build brush dams, and leave unplowed strips in their fields to stop and prevent gullying.

Little or no attention, however, has been given to sheet erosion. It is the most insidious kind and is the easiest to overlook and minimize. In fact, many farmers do not realize that it is taking place to any great extent. Nevertheless, it is sheet erosion that fills the gullies, and it is sheet erosion that is gradually raising the level of the small creek valleys.

The smaller creek valleys have in many places been filled up a foot or more in the last 50 or 60 years. In the Root River bottoms near Hokah, near the mouth of a small valley, three successive fences have been built, one on top of the other. The third fence has approximately 4 feet of the posts showing. At least 6 feet of soil, rock, and sand have been washed in at this point. Nearly half of this material must have come from nearby ridge fields. At Freeburg the valley of Crooked Creek has been filled in to an average depth of nearly 15 feet. The stone foundation of an old mill was 36 feet above the creek bed 40 years ago. Now the top of the foundation is barely 4 feet above the present soil level. Soil to a depth of nearly 30 feet has been washed in to fill the creek bottom. This extreme case of valley filling has been made possible by the building of a railroad grade across the mouth of the valley. The flood waters of Crooked Creek were further slowed down by the substitution, during 1900, of culverts and short trestles for the original long trestles on the railroad in the valley. The washed-in soil came largely from the cultivated fields adjacent to the tributaries of Crooked Creek which has a watershed of approximately 30 square miles. Some sand and rock have been washed in with the soil to form a heterogeneous mixture that today has little crop value, and little of the land is farmed.

The soil erosion station at Bethany, Mo., has found that, on a soil similar to Tama silt loam and Fayette silt loam in texture and structure, as much as 20 or 25 tons of soil have been lost from an acre during a single rain. If the soils of Houston County are only half as erosible as this Missouri soil it would still mean that 10 or more wagonloads of soil an acre may be lost during one heavy rain. Multiply this several times a year and some idea may be obtained of the loss farmers are allowing on lands unprotected from

sheet erosion. This loss was reported on land with an 8 percent slope, and many fields in Houston County with an even greater slope are cropped to corn.

The Tama and Fayette soils are very susceptible to erosion, as they are composed of fine soil particles that are quickly taken into suspension by rain water and carried away. Their looseness and mellowness make them highly erosible, particularly the Fayette soil. Although the granular structure of the Tama soil does give the soil a slight tendency to resist erosion, it is not to be depended on. The smooth surface features of that part of the county covered by the Tama soil allow less erosion than the rougher surface features of the part covered by the Fayette soil, but erosion control is needed there as elsewhere. Any slope greater than 2 percent needs to be protected. This may be done by contour plowing, terracing, and use of fall-sown grains as winter cover crops, if the land must be plowed in the fall. Grain and clover stubble may be left on the land over the winter and plowed under in the spring. This will protect the soil from destructive fall and early spring rains. Greater use of bluegrass in swales and depressions and the land left unplowed will help stop and prevent gullies. Contour plowing and planting, although inconvenient, are preventives. Terracing is necessary on some of the steeper slopes and may be used to advantage on the gentler slopes by building broad-based terraces which are possible to cultivate.

Any method of erosion control will prove inconvenient and upsetting to present farming practices, but, if the valuable topsoil is to be saved and fertility maintained, concessions must be made or many fields will have to be thrown out of cultivation in the not far distant future.

SOILS AND THEIR RELATIONSHIPS

Houston County lies well within the prairie region of the United States. In this region, although precipitation was sufficient to support forests, the smooth nearly level upland was covered by a grass vegetation. The prairies were not permanent but were decreasing at a comparatively rapid rate. As the streams and drainageways cut their way back into the smooth tabular divides and destroyed them, eroded valleys were produced, over which forests gained a foothold. Houston County is on the transitional belt between the grassland and the fast-encroaching forest spreading out from the Mississippi. No doubt, a large part of the area was at one time smooth and maintained a grass cover, but at the time of settlement by white men only a comparatively small remnant had been left in prairies. The remainder of the county had been more or less eroded and covered by a growth of deciduous trees.

The influence of the two types of vegetation has been impressed on the soils. The dark-colored soils are nearly coextensive with the smooth nearly level areas and the grass cover, and the light-colored soils are confined to the forested areas that are for the most part eroded. Under the influence of these two environmental factors, topography and vegetation, two groups of soils have developed—dark-colored soils on the smooth prairies and light-colored soils on the rolling slopes. By far the greater proportion of the soils is

light colored, the dark-colored soils occupying a comparatively small part of four townships, Black Hammer, Caledonia, Spring Grove, and Wilmington, in the southwestern quarter of the county.

The upland soils of Houston County are derived mainly from loess. The loess mantle covers the county, with the exception of the steep hillsides and a few terrace remnants along the Mississippi and the lower ends of creeks and rivers that empty into the Mississippi. The terraces are composed of sandy and gravelly glacial material deposited by the great river. Farther up the valleys and lying at somewhat higher elevations are benches on which the sandy terrace material is covered by loess.

The surface relief of the northern half and the southeastern quarter of the county is that of the driftless area, with its bold relief of deeply eroded valleys and narrow ridges. The erosion forming this relief was very early, and Chamberlin and Salisbury state:[8]

> There can be little doubt that the present reliefs of the surface were mainly the work of post-Cretaceous times. The final sculpturing took place in the late Tertiary or in the period of transition to the glacial period.

This erosion has been so great that Chamberlin and Salisbury estimate[9] "that to produce a uniform plain having the same slope as the great rivers it would be necessary to cut down the heights half their altitude." As the valleys in Houston County range from 300 to 500 feet in depth, it would take a layer of material from 150 to 250 feet thick to fill them.

The drift material of the earlier glacial epoch, with an attenuated border that extended into the county from the west, has either been entirely removed by erosion or covered by loess. It has left exposed no material from which soils were formed, and only an occasional exposure of it may still be seen, notably about 2 miles southwest of Black Hammer. Residuary material from limestone has not developed into soils, either because the ridges were too steep for it to be retained or because it has been deeply buried by the loess mantle.

The forest cover consists of hardwoods, the various species of which have been discussed. The grasses of the prairie section were of many species, the most common of which were Reed's bentgrass, porcupine grass, grama grass, false redtop, foxtail grass, thin grass, slough fescue, panic grass, and pigeon grass.

The dark-colored soil, which occupies the prairie remnant in four townships in the southwestern part of the county, is Tama silt loam. The parent material of this soil is loess. A number of other dark-colored soils, which have developed over water-laid materials, include the Waukesha, Judson, O'Neill, Bremer, and Davenport soils on the higher terraces and the Cass and Wabash soils on the low terraces and flood plains.

The well-drained dark-colored soils are in general rather uniform in their characteristics. Their surface soils, which average about 12 inches thick, are high in organic matter, and this has given them their dark-brown or black color. The organic coloring extends into the layers below the surface layer in a diminishing amount, to a

[8] CHAMBERLIN, T. C., and SALISBURY, R. D. THE DRIFTLESS AREA OF THE UPPER MISSISSIPPI. U.S. Geol. Survey Ann. Rpt. (1884–85) 6: 222. 1885.
[9] CHAMBERLIN, T. C., and SALISBURY, R. D. Op. cit., p. 257, illus.

depth of about 2 feet, causing them to be brown or light brown. At a depth of about 3 feet the parent material is lighter in color and in some places lighter in texture.

Dark-colored soils have no well-defined horizons of illuviation or of eluviation as do the light-colored soils, and usually the texture changes little with depth in the profile from one layer to another. The surface layer is characteristically granulated, the granules being rather heavily coated with dark organic material. In the next lower layers the structure is very similar to that of the light-colored soils, the material consisting of small or medium-sized angular blocky aggregates.

The dark-colored alluvial soils differ more widely in character, depending on the composition of the parent material and the moisture conditions to which they were subjected during development. The Bremer soils had restricted drainage, both on the surface and internally, as a result of topographic position and the impervious character of the subsoil. The characteristics caused by excessive moisture are seen in the deep black color of the surface soil and the gray or mottled colors of the subsoil. The other terrace soils have dark-colored surface layers and well-oxidized brown layers below. The profile developed in these soils is very similar to that of Tama silt loam on the upland. The Cass and Wabash soils of the lower bottoms have the gray or mottled gray and brown subsoils characteristic of poorly drained soils.

The following description of Tama silt loam as observed along the Caledonia-Eitzen road, 5 miles south of Caledonia, is representative of the well-drained, dark-colored soils of Houston County:

1. From 0 to 9 inches, very dark grayish-brown mellow silt loam which is nearly black when moist. The material is very granular throughout the layer and is laminated but not in the same manner as Fayette silt loam, the material separating easily into well-formed granules. Gray coatings in the upper 5 or 6 inches appear as minute specks, becoming a little more noticeable in the lower 3 or 4 inches.
2. From 9 to 19 inches, grayish-brown silt loam which is very granular, the granules being larger than in layer 1 and of a maximum diameter of one-fourth inch. The gray coatings are somewhat more noticeable. Lamination is the same as in layer 1.
3. From 19 to 30 inches, light-brown silt loam which is slightly heavier in texture than the material in layer 2. The soil aggregates are larger, more angular, tend to be blocky, and range from one-half to three-fourths inch in diameter. The upper inch or two shows some slight lamination. The gray coatings are most abundant in this layer and, although not a prominent part of the color, show up plainly because of the lighter color of the soil material. Some organic material is on the surface of the soil aggregates. Abandoned worm and insect channels are very abundant.
4. From 30 to 49 inches, the parent material, with a transitional layer in the upper one-half foot. The material is yellowish-brown silt loam having no noticeable structure. The gray coatings persist to some extent in the upper 5 or 6 inches of the layer; in the lower 8 or 9 inches is some light-gray mottling.

Table 4 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of Tama silt loam.

TABLE 4.—*Mechanical analyses of Tama silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
322308	Surface soil, 0 to 9 inches	0.0	0.1	0.2	0.4	1.5	67.9	29.9
322309	Subsurface soil, 9 to 19 inches	.0	.1	.1	.2	1.2	67.2	31.1
322310	Subsoil, 19 to 30 inches	.0	.0	.1	.2	1.7	66.9	31.1
322311	Subsoil, 30 inches+	.0	.0	.0	.1	2.1	67.3	30.2

It is interesting to note the uniformity of the relative percentages of silt and clay in all layers. These percentages are practically the same as the percentages for the silt and clay in Fayette silt loam, which are 67.2 percent silt and 31 percent clay. These uniform proportions of silt and clay throughout the profile show that no eluviation of the upper layers and no accumulation of fine soil material in the B horizon has occurred.

Table 5 gives the results of pH determinations on samples of Fayette silt loam and Tama silt loam.

TABLE 5.—*pH determinations of samples of two soils from Houston County, Minn.*[1]

Sample no.	Soil type	Depth	pH	Sample no.	Soil type	Depth	pH
		Inches				*Inches*	
322301	Fayette silt loam	0–3	5.84	322308	Tama silt loam	0–9	5.72
322302	do	3–5	5.94	322309	do	9–19	5.02
322303	do	5–9	5.67	322310	do	19–30	5.25
322304	do	9–13	5.53	322311	do	30–49	5.49
322305	do	13–20	5.17				
322306	do	20–30	5.40				
322307	do	30–45	4.82				

[1] Determinations, using the hydrogen-electrode method, made by E. H. Bailey, Bureau of Chemistry and Soils.

The soils of the light-colored group differ considerably in the thickness and character of the different layers. As a rule, these soils contain only a small amount of organic matter, and the darker colored surface layers in the virgin soils are very thin, in few places exceeding 2 inches in thickness. Below the thin surface layer is a gray or decidedly grayish brown layer which is more or less podzolized. In the next lower layer the color gradually changes downward, becoming brown or yellowish brown in the lower part, and the texture becomes slightly heavier. At a depth ranging from 2 to 3 feet is the parent material which is commonly lighter in texture and more friable than the material in the layer above. In eroded areas these soils are thinner, and one or more of the layers may be thinly developed or absent. The surface layer, in places, may be immediately above the parent material.

Following is a description of a typical profile of Fayette silt loam as observed in an undisturbed or unmodified condition in woods composed of oaks, a few hickorys, elms, and basswood, 4 miles northeast of Caledonia:

A_0. A 2-inch layer of leaf mold overlying the surface soil, in which the lower one-half inch is fairly well decomposed and mixed with some of the mineral surface soil.

A_1. From 0 to 3 inches, grayish-brown light silt loam which is somewhat mottled in appearance, owing to the presence of small spots, about three-fourths inch in diameter, of gray podzolized material. Lamination is evident in the part colored with organic matter but is neither distinct nor platy. No lamination is present in the gray podzolized material. The dark-colored part shows some podzolization in the form of faint gray specks which become more prominent in the lower inch of the layer. Worm and insect burrows are abundant and give the layer a somewhat honeycombed appearance.

A_2. From 3 to 5 inches, a transitional layer between A_1 and A_3. The material has the same texture as the A_1 layer, but it has a lighter gray color. The gray color of the podzolized material is dominant and the mottled appearance of the A_1 layer has disappeared. At this depth leaching is beginning to have an accumulative effect, and the black organic matter is leached out before it can penetrate beyond this layer. Lamination has become a prominent part of the horizon, and gray coatings on the darker colored soil material have increased sufficiently to form a noticeable part of the color. The laminae are thin, about one thirty-second inch or less thick.

A_3. From 5 to 9 inches, the zone of greatest podzolization and lamination. The material is light-gray light silt loam, having a distinct floury feel. Lamination is very conspicuous, the soil breaking horizontally into thin plates, one sixty-fourth inch or less thick. The plates are heavily coated on both sides with light-gray material, and every tiny root hole is coated with this material. Some other coloring matter than gray is present, as crushing produces a grayish-brown color.

B_1. From 9 to 13 inches, a transitional layer to B_2. The texture is a little heavier than in the layers above, although the material is still silt loam. The color tends more toward light yellowish brown, although enough gray is present to give a gray cast. Lamination decreases in prominence from the top to the bottom of this layer, and gray coatings are much less noticeable than in the A_3 layer.

B_2. From 13 to 20 inches, silt loam material which is heavier in texture than that in any of the overlying layers. The color is yellowish brown. No lamination is present. The structure consists of small angular or blocky aggregates ranging from one-eighth inch to one-half inch in diameter. The material in this layer is slightly compact, although the aggregates are easily crushed with the fingers. The gray coatings are less abundant than in the overlying layers, but they are still prominent on the sides of structure particles and as "veinings" between the particles and along old root channels. Worm casts and burrows are abundant.

B_3. From 20 to 30 inches. The material has the heaviest texture of any part of the profile, being heavy silt loam which is almost silty clay loam. The color is yellowish brown. The structure consists of angular blocky aggregates somewhat larger than those in the B_2 layer, and the material has a rather compact consistence. The gray coatings gradually disappear with depth and are unnoticeable below a depth of 28 inches.

C. From 30 to 45 inches. The texture of the material in this horizon is light silt loam, and the color is light yellow somewhat mottled with light gray. The material has no structure but is very compact in place. Scattered throughout this layer are very small soft dark-brown iron concretions and many very small dark-brown iron stains.

In table 6 are shown the results of mechanical analyses of samples of the surface soil, the subsurface soil, and several layers of the subsoil of typical Fayette silt loam.

TABLE 6.—*Mechanical analyses of Fayette silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
322301	Surface soil, 0 to 3 inches	0.1	0.3	0.3	0.7	2.1	73.4	23.0
322302	Subsurface soil, 3 to 5 inches	.1	.1	.1	.3	1.7	75.5	22.3
322303	Subsoil, 5 to 9 inches	.0	.1	.2	.4	1.7	76.7	21.1
322304	Subsoil, 9 to 13 inches	.0	.0	.1	.2	1.6	69.3	28.8
322305	Subsoil, 13 to 20 inches	.0	.0	.0	.2	1.9	64.1	33.8
322306	Subsoil, 20 to 30 inches	.0	.0	.0	.2	1.6	65.5	32.7
322307	Subsoil, 30 inches+	.0	.0	.0	.2	1.5	67.2	31.0

The combined percentages of silt and clay range from 96.4 to 98.2 percent, with the silt content ranging from nearly twice to more than three times the amount of clay. The zone of greatest podzolization and lamination, from 5 to 9 inches, contains the smallest quantity of clay and the highest quantity of silt. The greatest clay content is in the middle of the B horizon (B_2), 13 to 20 inches. The high clay fraction in the first layer, 23 percent, might be explained in part by the presence of colloidal organic matter.

The extensive Dubuque silt loam may be regarded as a shallow phase of Fayette silt loam, having developed where the loess forms only a thin covering over the bedrock.

Boone sandy loam is a light-colored soil developed over sandstone. Plainfield sand on the terraces and the Ray and Sarpy soils of the first bottoms have developed from a mixture of water-laid materials.

SUMMARY

Houston County is the southeasternmost county of Minnesota.

The climate is well suited to growing corn and small grains. The mean annual temperature is 46.2° F., the average frost-free period is 162 days, and the mean annual precipitation is 31.17 inches.

Physiographically, the land surface of Houston County represents two old plains, the oldest of which survives as a low flat-topped ridge in the southwestern quarter. The surface comprising most of the county, or the youngest of these two old plains, has been eroded into an intricate pattern of deep valleys and ravines separated by narrow ridges.

With the exception of the southwestern corner, which is comparatively smooth, and a part of the central portion, which is an area of comparatively broad ridges, the greater part of the county is very rough. More than one-half the land is nontillable, consisting of valley sides and low stream bottoms.

The highest point (1,322 feet above sea level) is on the railroad at Spring Grove, and the lowest point (636 feet) is at Reno.

The population of the county in 1930 is given as 13,845. Caledonia, the county seat, has 1,554 inhabitants.

The county was first settled in 1848, and it was organized in 1854. Germans, Irish, Luxemburgers, Norwegians, Scotch, and people of Scotch and English descent were the early settlers.

Agriculture is the only important industry. The usual Corn Belt crops, corn, oats, barley, wheat, and clover and timothy hay, are grown. All the grain and hay are fed on the farms to dairy cattle

and hogs. The small grains are grown in combinations for livestock feed. With the exception of comparatively small quantities of flax, tobacco, and small fruits, no crops are sold for cash, but it is sometimes necessary to purchase feedstuffs outside the county.

Very little commercial fertilizer is used. Lime is needed, and more ground limestone is used each year In 1930, the 1,910 farms in the county averaged 174.6 acres in size. Owners operated 69.4 percent of the farms.

There are two principal groups of upland soils, the light-colored soils of the forested land and the dark-colored soils of the prairies. The light-colored soils, represented by Fayette silt loam and Dubuque silt loam, are by far the most extensive, and they occupy more than three fourths of the county. Fayette silt loam has a light-gray or light grayish-brown surface soil and a yellowish-brown subsoil. Dubuque silt loam is similar in appearance to Fayette silt loam, but it is a shallow soil, not more than 30 inches deep, and it overlies broken limestone. Tama silt loam, which occurs in the southwestern part of the county, is the sole representative of the dark-colored group. This soil is characterized by a dark-brown or nearly black surface soil and by a subsoil which is darker than that of Fayette silt loam or Dubuque silt loam. These three soils have developed from the same parent material, loess. The same crops are grown on all three soils, but because of its larger content of organic matter, Tama silt loam is the most productive. Dubuque silt loam is the least productive of the three, because of its shallowness and greater susceptibility to erosion.

The alluvial soils are not important agriculturally and are used almost entirely for pasture. The terrace soils in the vicinity of La Crescent, principally O'Neill fine sandy loam and Waukesha very fine sandy loam, are used for the production of raspberries and some truck crops. This is the only special utilization made of the soils in Houston County, and even here it is not entirely because of soil adaptability but is in part the result of the location near a good shipping point, La Crosse, Wis.

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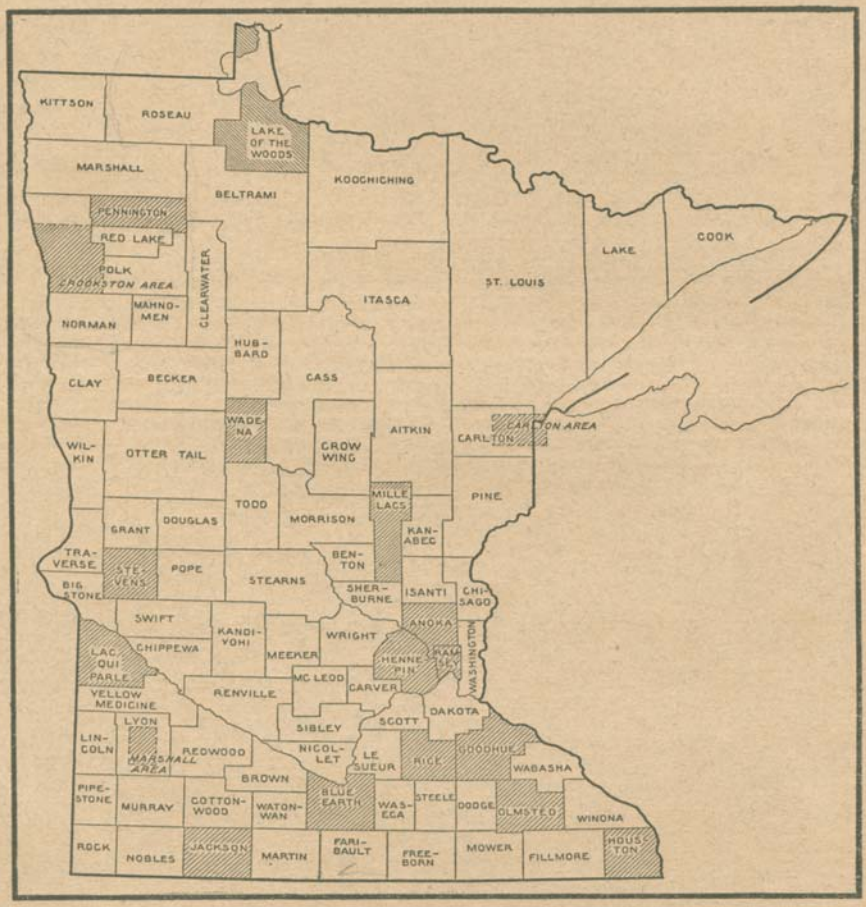
There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Minnesota, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

U. S. GOVERNMENT PRINTING OFFICE: 1934

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