

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Eaton County, Michigan

By

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COUNTY SURVEYED

Eaton County is in the south-central part of the Lower Peninsula of Michigan. (Fig. 1.) Charlotte, the county seat, is 20 miles southwest of Lansing, the capital of the State. The area of the county is 578 square miles, or 369,920 acres.

As only a few small areas are characterized by low rounded hills, few of which attain a height of more than 60 or 70 feet, the county as a whole may properly be considered a plain cut by a few shallow valleys. The plain is a product of glacial deposition, and the shallow valleys and low hills are mainly of glacial origin.

Although most of the valleys are rather broad, shallow, and inclosed by gentle slopes, the Grand River Valley at Grand Ledge is an exception. For a distance of about a mile, a ledge of outcropping bedrock has been cut through to a depth of about 50 feet, and here the valley is narrowed to a channel with precipitous slopes which are incised by a very few short ravines. The remainder of the Grand River Valley within the county, like the valleys of Thornapple River and Battle Creek, ranges from one-fourth to 1 mile wide and is inclosed by gentle slopes. Very few of the tributary streams follow deeply cut channels, and where such channels do occur, they extend only short distances back from the master streams.

A considerable part of the surface of the county consists of broad plainlike divides which have been little invaded by natural drainage courses. A conspicuous example of this configuration is in the northwestern part, where practically all the drainage of the greater part of Sunfield and Roxand Townships has been artificially effected.

The crests of very few of the hills and ridges are more than 75 feet above the floors of the associated swamps or valleys. The first impression of the relief is a lack of orderly arrangement in land forms. An intricate association of wet and dry land, small plains, and rolling areas is characteristic of the county. Though no conspicuous geographic divisions are characterized by uniform surface expression, a rough grouping into level, undulating, and rolling or hilly lands may be made. These features, which are associated with outwash



FIGURE 1.—Sketch map showing location of Eaton County, Mich.

plains, till plains, and terminal moraines, respectively, retain their original constructional forms with no appreciable alteration by post-glacial erosion.

Two distinct narrow plains cross the southern and central parts of the county in a general east-west direction. One of these constitutes the Battle Creek Valley between Bellevue and Charlotte and extends eastward, including Eaton Rapids, beyond the county line. The other follows along Thornapple River Valley from Vermontville to a point near Potterville and eastward to Grand River at Dimondale. Three smaller plains, developed on higher levels, occur, one near Kalamo, one south of Sunfield, and the other south of Mulliken.

The greater part of the more hilly land is included in two belts, one extending roughly east and west across the central part of the county and the other along the southern boundary line in the vicinity of Olivet. Smaller isolated areas of hilly land occur in the extreme southwestern and northeastern corners.

The remainder of the county, probably 65 per cent of the total area, is characterized by undulating or gently rolling surface relief.

The average elevation is about 900 feet above sea level, or about 325 feet above the level of Lake Michigan. The maximum difference in elevation between the highest and lowest points is only about 225 feet. The lowest point, approximately 775 feet above sea level, is where Grand River flows out of the county near Grand Ledge. The highest points, which are slightly less than 1,000 feet above sea level, are probably in the morainic hills near West Windsor and in the vicinity of Olivet. The land of the county has a slight general slope from south to north.¹

The streams find outlets through Battle Creek and Thornapple and Grand Rivers to Lake Michigan. The headwater streams of Battle Creek and Thornapple River have their sources in the swamps and lakes of the county. There are comparatively few streams, and their haphazard courses are determined by the constructional valleys which they follow. Little stream erosion has been effected, and no dendritic drainage pattern, such as is characteristic of older land formations, has developed.

Abundant wholesome water is available from wells at a depth ranging from 25 to 75 feet, and such wells afford the principal supply of water for home use. Many of the wells are bored deep enough to penetrate into the sandstone bedrock, as the water there is softer than in the overlying glacial-drift formation. Springs are not common, although a few occur near the foot of the valley slopes, especially in the vicinity of Grand Ledge. Most of the small streams carry clear water, and during seasons of normal rainfall most of the permanent pastures are adequately watered by these streams.

Although more than 20 small lakes are in the county, their aggregate area is less than 1,000 acres. A few summer resorts are located on the shores of Pine and Narrow Lakes, and a few summer residents have built cottages along the shores of Saubee and Saddlebag Lakes. Many of the lake beds consist largely of marl, and very few of the lakes have sandy beaches or bottoms.

The first permanent white settlement in Eaton County was made in the southwestern part in 1833. Other settlers followed a few years

¹ Elevation data from United States Geological Survey topographic maps.

later, locating in the vicinity of Charlotte and other parts of the county. Many of the earlier settlers came from Ohio, New York, Vermont (11),² and other eastern States. The county was organized December 29, 1837, and was named for Secretary of War J. H. Eaton. The influx of settlers was steady and rather rapid for a period of several decades, and probably 50 per cent of the land in the county had been put into farms by 1860. The 1930 census reports a total population of 31,728, of which 20,027 are classed as rural. Of the rural population, 13,786 are classed as rural farm and 6,241 as rural nonfarm. Native-born whites number 30,449, and the remainder of the inhabitants are foreigners and negroes. The population is well distributed over all parts of the county, although it is more dense in the vicinities of the towns and in the extreme northeastern corner near Lansing. The extreme southeastern part is the most sparsely settled.

Charlotte, the county seat, with a population of 5,307, is the largest town. Other towns serving as well-distributed trading points are Grand Ledge, with a population of 3,572; Eaton Rapids, with 2,822; Bellevue, with 1,029; Olivet; Vermontville; Dimondale; Potterville; Mulliken; and Sunfield.

At the time of settlement by the whites, the entire county, with the exception of a few small marshy areas, supported a heavy forest. Only a few scattered wood lots of original forest remain. Although no map of the original forest cover is available, it is evident that some of the dry sandier plains and morainic hills of the southern part of the county supported a cover consisting of a much higher percentage of oak than did other parts. Many of the remnants of the original forest in this part consist of an almost pure oak stand. A broad correlation of original forest types and certain soil characteristics existed. Generally speaking, a maple-beech type of forest originally occupied the medium or heavy textured well-drained soils. The poorly drained mineral soils supported an elm-ash-silver maple type of cover which also included some hickory, basswood, and swamp white oak. On lands of intermediate drainage different mixtures of these two types of forest grew. Most of the forest on the sandier well-drained soils contained less hard maple and more oaks. On parts of the plains, the trees were sufficiently scattered to allow more or less grass growth. Such areas were locally referred to as "prairies" or "oak openings," an example of which was the Charlotte prairie. A small proportion of black walnut, sycamore, butternut, ironwood, red cedar, and wild black cherry were widely scattered through the forests.

The swamps differed widely as to the vegetal cover, largely according to the degree of decomposition of the organic material and the height of the water table. The open marsh areas supported a cover consisting dominantly of bluejoint and various sedges. The raw peat deposits, or heath bogs, have a shrubby cover consisting mainly of leatherleaf, blueberry, and scattered tamarack, with chokeberry and stunted ash growing around the borders. Hypnum and Sphagnum mosses form a dense ground cover. The muck or peat land with lower water tables supports a mixed cover including tamarack, poplar, willows, and some spruce and white birch, with elm, ash, soft maple,

² Italic figures in parentheses refer to Literature Cited, p. 46.

and swamp white oak dominating the best-drained areas. Tamarack was originally much more abundant than at present, but much of the stand has been injured by fire and has been cut for fuel. Following the burning of the raw peat of the bogs, spirea, with some wild rose and winterberry, became dominant in many places, and the tamarack of the original cover gave way to more soft maple and poplar in the second growth. The second growth on the poorly drained mineral soils consists of the same species as grew in the original forest. Cut-over areas of well-drained soils ordinarily reforested with the original species if protected from fire. It is supposed that the forests of the heavier-textured rolling lands were characterized by a heavier herbaceous undergrowth than were those of the dry sandier plains. Such an undergrowth was, however, seemingly rather light throughout this region. Kentucky bluegrass, locally spoken of as June grass, is the dominant wild grass of the forested upland.

Eaton County is provided with excellent means of transportation. It is served by four railroad systems, the New York Central, Michigan Central, Pere Marquette, and Grand Trunk, which connect practically all the towns of the county and provide direct communication with Lansing and other outside markets. Paved roads traverse the county, and excellent gravel-surfaced roads reach all parts and are maintained in excellent condition. Probably 95 per cent of the township roads, which follow practically all section lines, have been surfaced with gravel. Schools, churches, and local markets are easily accessible to all communities. Gas and electric-power lines traverse the county and free mail delivery accommodates all sections. Rural telephones are common.

Three clay-products companies, a milk factory, and two furniture factories at Grand Ledge, a cement plant at Bellevue, woolen mills at Eaton Rapids, and furniture and milk factories at Charlotte are the principal manufacturing industries within the county. A rather large number of people living in the extreme northeastern part find employment in the city of Lansing.

CLIMATE

The climate of Eaton County is somewhat insular, but to much less degree than that prevailing immediately along the shore of Lake Michigan. The salient features of the climate are moderately cold winters with about 35 inches of snow, mild, pleasant summers, moderate precipitation, and low wind movement.

The difference between the mean winter and summer temperatures is rather wide, 45.2° F.

No great variations in climatic conditions occur within the county, as the local range in elevation is slight, although the average frost-free period may be a few days longer in the extreme southwestern part than in the northeastern part. Local differences in susceptibility of crops to frost are due largely to valleys or depressions, especially when the soils are wet, as in the muck areas. Such differences are given some consideration in locating orchard sites or in selecting soils for certain kinds of truck crops.

The rainfall is rather evenly distributed throughout the growing season and is normally sufficient for satisfactory crop growth.

Extremely low or excessive amounts of rainfall are not common, although yields are sometimes reduced more or less, owing to short periods of drought, especially on the more porous sandy soils. The seeding date of such crops as corn and oats is sometimes delayed for short periods by heavy precipitation during March and April. The degree of protection which fall-sown grain and alfalfa receive from snow differs from winter to winter, but ordinarily the snow blanket is sufficient to prevent frequent loss from freezing and heaving. Destructive hailstorms are very rare. The rainfall is gentle, heavy downpours being very unusual.

The average frost-free season covers a period of 141 days, from May 16 to October 4, which is ample for the maturing of corn and other crops common to this region. Frosts have occurred as late as June 23 and as early as September 3, but at such unusual dates they are rarely destructive except on the organic soils. Most crops on soils having good air and water drainage may be expected to grow before and after the frost dates recorded by the Weather Bureau.

Prevailing winds are southwesterly; high velocities are seldom reached; and tornadoes are extremely rare. Evaporation is low, and the humidity is moderately high. The sunshine ranges from 65 to 70 per cent of the possible amount during summer and is usually about 25 per cent of the possible amount during winter.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation as recorded at the United States Weather Bureau station at Charlotte.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Charlotte, Eaton County, Mich.

[Elevation, 919 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1920)	Total amount for the wettest year (1902)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	26.2	62	-23	1.50	3.30	0.65	7.6
January.....	22.2	63	-26	1.48	1.11	2.00	10.5
February.....	21.9	59	-28	1.12	.45	1.97	7.1
Winter.....	23.4	63	-28	4.10	4.86	4.62	25.2
March.....	34.5	87	-12	1.89	1.04	1.94	7.0
April.....	46.0	87	4	2.43	3.15	6.96	1.0
May.....	56.7	92	23	3.11	1.46	.65	.3
Spring.....	45.7	92	-12	7.43	5.65	9.55	8.3
June.....	66.5	99	32	3.14	2.50	6.49	0
July.....	70.8	100	40	2.62	2.01	6.03	0
August.....	68.5	101	37	2.61	3.08	5.57	0
Summer.....	68.6	101	32	8.37	7.59	18.09	0
September.....	61.9	97	27	3.10	1.33	2.18	0
October.....	50.6	91	15	2.06	.90	4.15	.2
November.....	38.6	74	4	1.90	1.30	.40	1.4
Fall.....	50.4	97	4	7.06	3.53	6.73	1.6
Year.....	47.0	101	-28	26.96	21.63	38.99	35.1

AGRICULTURE

Agriculture in Eaton County had its beginning with the advent of the first settlers in 1833. Like other pioneer agriculture of the region it consisted primarily of growing such crops as corn, wheat, and potatoes, chiefly for home use. The first farms were located on the plains which were stone free and relatively easy to clear and put into cultivation. Along with the farm crops, some livestock, furs, and lumber soon became sources of income. For several decades the influx of settlers was steady and lands were rapidly cleared and put into cultivation. This led to a more extensive agriculture consisting of the production of such crops as corn, hay, wheat, oats, and potatoes, together with the raising of livestock. The United States census reports indicate that such a type of agriculture, with orchards, gardens, and small acreages of buckwheat, barley, rye, tobacco, and hops, prevailed 50 years ago when the rural population of the county was slightly more than at present.

Some of the changes which have come about in the agricultural crops of the county during the last half century are the addition of two important crops, beans and alfalfa, and an increase in the acreage of oats, rye, barley, and hay at the expense of that of wheat and potatoes. The number of apple trees has been reduced to about one-sixth the number reported 30 years ago. The production of hops and tobacco has been discontinued, and maple-sugar products have steadily decreased.

Census reports covering the last 50 years indicate no general wide changes in acre yields of the more important crops. Slight increases in acre yields of wheat, hay, and potatoes are indicated, but those of corn, oats, barley, beans, and rye seem to have fluctuated without any general trend of change.

Table 2 shows the important crops in Eaton County, their acreage, and their yields, as reported by the 1930 census.

TABLE 2.—*Acreage and yield of the principal crops in Eaton County, Mich., in 1929*

Crop	Acres	Yield	Crop	Acres	Yield
Corn:		<i>Bushels</i>			<i>Bushels</i>
Harvested for grain.....	11,065	378,717	Buckwheat.....	176	1,192
		<i>Tons</i>	Potatoes.....	1,528	74,746
Cut for silage.....	7,299	40,357			<i>Tons</i>
Cut for fodder.....	5,932		Hay.....	44,989	68,001
Hogged or grazed off.....	1,279		Timothy and (or) timothy and clover mixed.....	23,666	32,875
		<i>Bushels</i>	Clover.....	12,029	18,210
Wheat.....	37,009	760,587	Alfalfa.....	8,821	16,405
Oats:			Other tame grasses.....	141	191
Threshed.....	23,640	676,825	Wild grasses.....	33	27
Cut and fed unthreshed.....	341		Small grains cut for hay.....	109	83
Barley.....	6,441	106,975	Annual legumes for hay.....	190	210
Rye.....	613	8,818	Sugar beets.....	451	3,152

The 1930 census reports 732 acres of vegetables harvested for sale in 1929, with a total value of \$63,836. Six acres were devoted to asparagus, which was valued at \$1,114; 40 acres to snap beans, valued at \$1,863; 217 acres to cabbage, valued at \$14,025; 22 acres to cantaloupes, valued at \$1,206; 15 acres to carrots, valued at \$2,731; 12 acres to celery, valued at \$3,002; 93 acres to sweet corn, valued

at \$3,974; 91 acres to cucumbers, valued at \$3,461; 71 acres to onions, valued at \$13,003; 20 acres to peas, valued at \$2,524; 60 acres to tomatoes, valued at \$6,248; and 37 acres to mixed vegetables, valued at \$5,299.

Livestock industries have become more important sources of farm income in recent years. The value of dairy products, excluding home use, shows an increase from \$181,676 in 1899 to \$1,573,372 in 1929. A similar increase has taken place in poultry and poultry products, the value of poultry raised in 1929 amounting to \$336,175, and chicken eggs produced were valued at \$419,088. The raising of swine, sheep, and beef cattle has not kept pace with dairying and poultry raising.

Tables 3 and 4 give the value of different farm products by classes in 1929, and the number and value of animals on farms April 1, 1930, respectively.

TABLE 3.—*Value of crops and livestock products produced in Eaton County, Mich., in 1929*

Crop	Value	Livestock and products	Value
Cereals.....	\$1,633,355	Butter, cream, and whole milk sold.....	\$1,573,372
Other grains and seeds.....	1,012,596	Butter churned.....	52,657
Hay and forage.....	959,342	Wool shorn (unwashed).....	101,678
Vegetables (including potatoes and sweetpotatoes).	175,955	Poultry raised.....	336,175
Fruits and nuts.....	81,713	Chicken eggs produced.....	419,088
All other field crops.....	64,048	Honey produced.....	12,102
Farm garden vegetables (excluding potatoes and sweetpotatoes) for home use.	57,998	Total.....	2,495,072
Trees, plants, vines, flower and vegetable seeds, and bulbs sold.	17,054	Total agricultural products..	6,676,667
Flowers, plants, and vegetables grown under glass.	32,036		
Forest products cut on farms.....	147,498		
Total.....	4,181,595		

TABLE 4.—*Number and value of livestock on farms of Eaton County, Mich., April 1, 1930*

Livestock	Number	Value	Livestock	Number	Value
Horses and colts.....	8,210	\$860,988	Sheep and lambs.....	59,483	\$454,813
Mules and mule colts.....	175	18,952	Goats and kids.....	84	355
Asses and burros.....	1	90	Chickens.....	198,355	186,455
Cattle.....	28,132	1,725,829	Bees (hives).....	1,768	9,547
Swine.....	11,851	151,851	Total value.....		3,408,880

The use of commercial fertilizers is not universal over the county, although it is increasing. Many of the farmers still rely principally on barnyard manure for soil enrichment. In 1929, \$170,047 were spent on 2,243 farms, or 66.2 per cent of all farms, for fertilizer (including lime). This was an increase from \$7,570 spent for this purpose in 1899. Practically all commercial fertilizers are purchased ready mixed. The use of lime is increasing. Ground limestone and hydrated lime are the common forms, and marl is used to less extent. Farmers in general are becoming more appreciative of the importance of liming and fertilizing their land (9).

The total amount expended for labor in the county in 1929 was \$295,208, or an average of \$187.31 for each of the 1,576 farms reporting such expenditure. The census reports indicate that about half the farms of the county employed labor in 1909, 1919, and 1929. At present farm labor is plentiful, but for the last 15 years it has been very scarce. Most of the laborers are native-born whites. Some Mexicans and other foreigners are employed, especially in growing sugar beets. At present farm wages range from \$2 to \$3 a day, or from \$35 to \$75 a month, depending on the kind of work, the skill of the laborer, and the character of the contract with regard to incidentals of subsistence.

The range in size of farms in this county is not great. Farms of more than 174 acres amount to 10.5 per cent of all farms and those of less than 49 acres amount to 24 per cent. The 80-acre farm is probably the most common. The census reports indicate a constant increase in the average size of farms from 79.1 acres in 1880 to 97.8 acres in 1930. The increase in size has been accompanied by a corresponding decrease in the number of farms. The percentage of the county area in farms increased from 92.8 per cent in 1880 to 96.3 per cent in 1900, but during the last 30 years this percentage has decreased to 90.6 per cent as indicated by the 1930 census. The increase and decrease was in accord with the increase and decrease of the population.

The 1930 census reported 79.9 per cent of the farms operated by owners, 19.7 per cent by tenants, and 0.4 per cent operated by managers. The percentage of farms operated by owners has gradually decreased from 91.8 per cent in 1880, and the percentage operated by tenants has shown a corresponding increase.

Although a few farms are rented for cash, between 85 and 90 per cent are rented on the share system. This system varies in detail, according to improvements, proximity to market, productiveness of the soil, and the kind and number of livestock kept. In general farming, however, the common agreement is that the land is furnished by the owner, the labor by the tenant, and the other expenses and the proceeds are equally divided.

According to the 1930 census, the average value of land and buildings a farm is \$8,067, which is an almost 100 per cent increase over that of 30 years ago. The percentage of the capital invested in land has been reduced about 30 per cent during the last 30 years and a similar relative increase of about 50 per cent has been made in the investment in buildings and implements. The farm buildings are in general of good quality and are well kept. Of the \$8,067 invested in the average farm, 42.3 per cent is invested in land, 39.9 per cent in buildings, 6.8 per cent in implements, and 11 per cent in domestic animals.

Most of the cattle, both beef and dairy, are of high grade. Well-bred horses are the principal work animals. The majority of farmers still rely wholly on horses. From 25 to 30 per cent of them own tractors and other heavy machinery.

Very little farm land is changing hands at the present time, except in trade for city property. Land values vary greatly, according to location, improvements, and character and condition of the soil.

Most of the farms are operated on a conservative basis, avoiding extremes of either extensiveness or intensiveness, and depending largely on average results. The revenue on the typical farm of the

county is derived from a variety of sources. This practice tends to eliminate risk and dangerous speculation and provides a more uniform distribution of both income and expenses throughout the year. The livestock industry has made this possible, and more than 50 per cent of the farm income is derived from this source.

Eaton County is no exception to the surrounding agricultural region which has been greatly influenced by the marked industrial expansion and growth of manufacturing centers nearby. This has encouraged the production of a variety of farm products and stimulated the production of specialized crops to some extent. The increased demand for dairy products is especially significant. According to the census, the average number of livestock on each farm is more than 30 head, including cattle, work animals, sheep, and swine. Nearly one-third of the farm animals are dairy cattle.

Practically all the hay, corn, and oats, which together occupy nearly 60 per cent of the total cultivated area of the county, are used as feed for the livestock. Wheat, beans, potatoes, sugar beets, and apples, which occupy more than 25 per cent of the cultivated acreage of the county, are, in the main, sold as cash crops. Barley, rye, buckwheat, vegetables, fruits, and other crops grown on small acreages are used in part on the farm and in part for market. The utilization of the crops accords with the diversified character of the agriculture of the county.

Wheat is the most important cash crop, and the income from this crop ranges from \$500,000 to \$750,000 a year. Although a small part of the crop is milled at small local mills, the greater part is handled through elevators and shipped to outside markets. The large proportion of well-drained soils in the county adapted to wheat and the short hauls to flour mills are important factors accounting for the fact that more than one-sixth of the cultivated land is devoted to this crop.

Beans are another important cash crop. The relative extensiveness of this crop in Eaton County is accounted for through geographic location and the large aggregate acreage of favorable soils, such as the Miami and Conover. Beans usually take the same place as corn in the rotation, and, as they do not require so much moisture as corn, it may be that they have partly replaced corn on the predominating light-colored soils. The crop is marketed through local elevators, similarly to wheat.

Most of the potato crop is marketed through local cooperative organizations and shipped in car lots to outside markets. This is a less-important cash crop, the income from this source being little more than \$100,000 in most seasons.

Although sugar beets are strictly a cash crop, they are not of great relative importance either as regards acreage or total value. In the northern part of the county, especially in the greater part of Sunfield and Roxand Townships, where Conover loam is the dominant soil, conditions are favorable to the production of this crop. In adjoining counties, the same and closely related soils are also extensive. A sugar-beet factory was located in Lansing, probably largely for this reason.

Apples afford the principal source of income from orchards. Most of them are sold locally, in Lansing, and in other near-by cities,

although a part of the crop is trucked to more distant markets, and some apples are manufactured into cider. Other fruits, such as grapes, peaches, pears, plums, cherries, and strawberries, are grown, principally for home use, and surpluses are offered on the local market.

The production of onions and cabbage, as truck crops, is confined mainly to the larger areas of Carlisle muck. Other trucking cash crops, including carrots, lettuce, celery, and cauliflower, are grown on the organic soils and also on a few small farms near Lansing. The greater part of these special crops is sold on the local markets, in Lansing, and in Battle Creek, and a part is sent to more distant cities. A few local sauerkraut factories are in operation.

As heretofore indicated, dairying is the principal branch of the livestock industry and the most important adjunct to the general-farming scheme. Two types of dairying are carried on—specialized dairying and that carried on in a small way in conjunction with general farming. Although a few farmers conduct specialized dairies located close to the towns, probably more than 90 per cent of the dairy products of the county are produced on the general farms. Most of the milk and cream consumed in the local towns and cities is from the specialized dairies. The milk from the general farm dairies is sold to milk factories, such as the one at Charlotte; to creameries; and to butter, cheese and ice-cream factories, and other dairy-manufacturing plants in Lansing and other near-by cities.

The relative importance of this industry is indicated in the reports of the Federal census, which reports an annual income of about \$1,500,000 from the sale of dairy products. This sum is about equal to the total value of the corn, oat, and wheat crops, and it represents the principal cash income of the farms.

Holstein-Friesians predominate among the dairy cattle, with Guernseys and Jerseys in smaller numbers. A rather large number of purebred sires are in the county, and the interest in improving the dairy herds is increasing.

The dairy industry is encouraged, not only by the market afforded by near-by manufacturing centers but also by climatic and soil conditions. Areas of alluvial and dark-colored soils are widely scattered over the county, and some of these occur on most of the farms. These soils are high in moisture and fertility and are well adapted to the production of corn and pasture grasses, and the cool climate is favorable to grass production. The success of the industry is to a large extent due to the excellent growth of grass, especially on soils that have not been, up to this time, successfully used for the production of other crops. In addition, more than 50 per cent of the soils are well adapted to and encourage a crop rotation built up around a small-grain and hay cropping combination which stimulates the production of hay. The greater part of the hay consists of clovers and alfalfa, the growing of which is required by the naturally low nitrogen or organic content of the light-colored soils. These deficiencies of the dominant light-colored soils encourage the consumption of the hay crop on the farm and the return of the barnyard manure to the soils. Thus the character of the soils, the economic and climatic factors, together with the desirability of uniform distribution of labor, expenditures, and cash income, largely account for the present profitable position occupied by dairying as an adjunct to general farming.

A similar place on the general farm is taken by the less-important industries of beef cattle, sheep, swine, and poultry raising. The factors accounting for the development of these industries are similar to those which have encouraged dairying.

Beef cattle are of much less importance than dairy cattle, the number kept being roughly about one-fourth and the value about one-fifth that of dairy cows. Some are raised on the farm, but probably the greater number are shipped into the county and fattened for outside markets. Considerable income is realized from the sale of veal calves from the dairy cows. Sales are usually cooperative and assisted by the county agricultural agent.

The relative importance of sheep is indicated by reports of 59,483 head, at a total value of \$454,813, in 1930. More than \$100,000 is received annually for wool. Most farmers keep sheep, but greater proportional numbers seem to be on the larger farms, especially where the pastures are large. Most of the sheep are raised locally, but some are shipped in as feeders, the number being largely determined by the yield of feed crops. When conditions favor heavy crop yields, the number of feeders increase accordingly. This simple method of adjusting the number of livestock to the quantity of feedstuffs and the small amount of labor and expense necessary are factors stimulating the sheep industry. The general interest in sheep as a part of the farm scheme probably in part accounted for the location of the woolen mills at Eaton Rapids, and perhaps the local market offered by these mills may have stimulated sheep raising. Sheep of the Shropshire, Leicester, Rambouillet, and Merino breeds are most numerous. Both coarse-wool and fine-wool sheep are kept, but the former predominate.

Among the popular breeds of swine are the Duroc-Jersey, Poland China, and Chester White.

The value of poultry kept is about the same as that of swine. A few farms specializing in the poultry industry are near the towns and cities, but it is estimated that more than 75 per cent of the poultry products are produced in comparatively small proportions for both home and market use by practically all farmers. Poultry is a reliable source of a side-line small income. White Leghorn, Plymouth Rock, and Wyandotte are very common breeds. Probably more than 50 per cent of the poultry products are sold to outside markets. A few ducks and turkeys are raised on some farms.

Beef cattle, sheep, swine, and poultry products are marketed in a similar manner. They are in part offered to meet the local demands, but are mainly sold cooperatively and shipped to distant markets. More of the poultry products are demanded by near-by towns and cities. Beef cattle, sheep, and swine are shipped to packing plants, usually to Detroit or Buffalo.

Corn, oats, wheat, beans, and hay (mostly clovers, timothy, and alfalfa), are the principal crops. No universal system of rotation is practiced, although corn, beans, and potatoes usually follow the hay crops; oats and barley usually follow corn, and on many farms wheat follows oats but may follow corn (for silage), early beans, or summer fallowing. The rotation is varied according to the character of the dominant soils on the farm, the type of farming practiced, and other conditions.

Land for corn is plowed either in the fall or as early in the spring as weather conditions allow. It is especially desirable to plow the heavier-textured soils in the fall in order that they may have the beneficial effect of winter freezing and thawing. Fall plowing has other advantages, such as more thorough incorporation of organic matter and lessening the chances of insect pests. The land is thoroughly harrowed; and if plowed in spring, it is rolled. Most farmers seed, cultivate, and harvest corn with modern machinery. A part of the crop is converted into silage and a part is shocked in the fields and husked for grain (3).

As oats usually follow corn, beans, or potatoes, the seed bed is ordinarily prepared by thoroughly disking it in early spring. However, if the fields are weedy, plowing is necessary. Oats are usually seeded in early May and harvested when they reach the dough stage (1).

As fields to be seeded to wheat are usually plowed in August for seeding in September, corn (for grain), late beans, and potatoes are not always harvested sufficiently early to allow the sowing of wheat. Consequently wheat often follows oats in the rotation. Following plowing, the fields are rolled and harrowed until a firm seed bed of good tilth has been made. Seeding and harvesting of the small-grain crops are done with modern machinery. On a few farms on well-drained light-textured or droughty soils, fields are summer-fallowed preparatory to seeding. If plowing is done immediately after the preceding crops have been removed, a growth of weeds is prevented and more moisture is conserved for the wheat crop.

The greater parts of the clovers and timothy are seeded in wheat fields in early spring or with oats or barley. Common red clover is most popular, although some mammoth clover is grown, and alsike is often seeded on the more poorly drained soils. Some sweetclover is grown, especially on the lighter-textured soils, as it is an excellent soil-amendment crop as well as a good pasture or hay crop. The low organic content of the dominant soils of the county has been a factor in giving the clovers the large acreage and the prominent place in the rotation which they enjoy. Owing in part to these facts and in part to the fact that horses are no longer kept in the cities in large numbers, timothy is gradually giving way to clovers and alfalfa (8).

Alfalfa is one of the best hay crops. Although the acreage is much less than that devoted to clover and timothy, it is rapidly increasing. The initial expense of land preparation and seeding is somewhat greater than for clover; but as alfalfa is a perennial and usually occupies the land from four to six years, greater care and expense of preparation are warranted. The crop is planted in different ways and at different dates, ranging from early spring (seeding with barley, oats, or buckwheat, or sometimes even with wheat) to early August (seeding alone). The present tendency, however, seems to be toward more seeding without a companion crop or with only about 1 bushel an acre of oats or barley in the spring, as these methods insure a greater amount of available moisture for the early growth of the young plants. Alfalfa is restricted to soils having good drainage. If an acid condition prevails, applications of lime are generally beneficial. The quality of the hay is very good, yields are ordinarily greater than those of red clover and timothy, and the cost of produc-

tion compares favorably with that of other hay crops. This deep-rooting legume affects the soil favorably, both chemically and physically (2).

Other less extensively grown crops are beans, potatoes, and sugar beets, of which the bean crop is the most important. Beans and potatoes take the same place in the rotation that corn does, and the seed-bed preparation and cultivation are essentially the same as for the corn crop. The sugar-beet crop is restricted to soils of comparatively high contents of both moisture and organic matter. In an effort to reduce the cost of hoeing and cultivating to a minimum, many farmers plant beets following clean-cultivated crops, such as corn, beans, or potatoes. Fall plowing, when possible, is recommended by the Michigan Agricultural Experiment Station for a properly prepared seed bed and as a precaution against insect pests. More complete information regarding these crops can be obtained on request from the Michigan Agricultural Experiment Station at East Lansing (10, 4). Information pertaining to less extensively grown crops in Eaton County, including truck crops, mint, buckwheat, melons, small fruits, and tree fruits, is available through various bulletins published and distributed by the Michigan State College at East Lansing.

The problems of soil management in Eaton County are not unlike those of surrounding counties. Mineral soils having moderate or good natural drainage occupy about 75 per cent of the county. Previous to occupation by the whites, the land supported a heavy forest which prevented the growth of grass and a rich accumulation of organic matter. Leaching has removed some of the plant-food material, especially lime, to a depth ranging from 2 to 4 feet. The natural fertility, even in the virgin condition, was much lower than that of prairie soils. Practically all the land in the county has been under cultivation more than 50 years, and a large part for 75 or more years. Throughout this long period, or until very recently, practically no concern has been manifest regarding soil management with a view to permanent agriculture. This practice of relying entirely on the inherent productiveness of the soil has resulted in depletion of the virgin fertility. During the last few years, farmers as a whole have begun to show more concern, and the agriculture of the county is now in the process of passing from the purely exploitive stage to one in which measures are being taken to maintain productiveness of the land and increase crop yields. Some of the problems uppermost in the minds of farmers particularly concerned in soil management are the following: Artificial drainage where necessary, the use of lime where needed, a proper rotation of crops including as much clover and alfalfa as practical, and the incorporation of as much organic matter into the soils as is consistent with the type of farming practiced. Many of the more progressive farmers endeavor to keep sufficient livestock to consume the feed crops, and they apply the manure, supplemented by liberal quantities of proper commercial fertilizers, to the soils.

Details, helpful information, and suggestions regarding these fundamental problems and how they may best be put into practice, is offered by the Michigan State College through the extension workers and a number of available bulletins.

SOILS AND CROPS

The soils of Eaton County differ widely in color, texture, consistence, fertility, and moisture conditions. Such soil characteristics, which are significant as regards productivity, change rapidly from place to place, resulting in a condition which is especially pronounced in this part of the glacial region, namely, that of a complex intermingling of different soils occurring for the most part in small ill-defined bodies.

The soils range in texture from loose sands to clays. The loams, which predominate, occupy 77.7 per cent of the area of the county. The range in color is from light gray to nearly black and is accompanied with a similar range in drainage conditions. In consistence the range is from tenacious silty clays to loose incoherent sands.

Tilth conditions are in general good. It is estimated that probably more than 95 per cent of the cultivated land is easy, or free, working, and that the aggregate area on which tillage operations are made very difficult by numerous stones, steep slopes, or refractory clays, is almost negligible. The total area seriously disturbed by wind-blown sand is insignificant.

The soils have developed under a forest vegetation, and the organic content is moderately low in all places of adequate natural drainage.

Observation, chemical analyses, and experiments indicate that, taking the average of southern Michigan as a standard, only about 5 per cent of the mineral soils of Eaton County are comparatively low in natural fertility; about 35 per cent range from low to medium; about 50 per cent from medium to high; and about 10 per cent are relatively high. As a whole the soils of the county may be rated as somewhat above the average of the central-southern region of Michigan in respect to both natural fertility and productiveness.

It is estimated that about 90 per cent of the mineral soils of the county are acid to a depth ranging from 20 to 60 inches.

Most of the mineral soils have developed, at least for a long time, under good drainage. Some, however, have been subjected to excess moisture and others have occupied positions which, for the greater part of the time, were moderately well drained but periodically saturated. Thus the mineral soils of the county may be placed into three broad groups according to color, moisture conditions, and associated characteristics, such as degree of acidity and organic content. These are natural factors which bear relationship to plant growth, crop adaptation, and agricultural productivity.

For convenience in the following discussion these main soil groups are designated as (1) well-drained soils, (2) imperfectly drained soils, and (3) poorly drained soils. This grouping and nomenclature are necessarily rather broad and imperfect in some details. The grouping is based on natural and original drainage conditions, as those conditions are largely responsible for the present soil characteristics. In addition to the three main groups of mineral soils, three types of alluvium, or first-bottom land, and a number of types of organic soils are separately recognized and described.

As shown on the accompanying soil map, the soils of the county occur for the most part in small areas, so intermingled that soils of all the main groups mentioned occur on practically every large farm.

Miami loam is the dominant soil of the group of well-drained light-colored soils, Brookston loam is representative of the poorly drained dark-colored soils, and Conover loam dominates the second group, which is characterized by drainage conditions and color intermediate between those of the light-colored, or well-drained, and the dark-colored, or poorly drained, soils.

The well-drained soils are the most important and most extensive, occupying about 65 per cent of the county. The soils of this group have largely determined the prevailing agriculture, so far as soil type has been a factor. Soils of this group occur widely over the county and dominate all parts except two townships in the northeastern corner.

Soils of the second group occur, in the main, distributed in a way very similar to those of the poorly drained soils, although the soils of this group typically occupy the lower gentle slopes, in many places forming a border to soils of the poorly drained group. Conover loam, the predominant soil of this group, is the most extensive soil in Sunfield and Oneida Townships in the northwestern part of the county, where it occupies a broad flat watershed.

The poorly drained dark-colored soils predominate in no large areas, but they occupy depressions, promiscuously scattered over the county, and elongated valleys and swales whose courses make a close network over the entire county.

These soil groups, occurring in similar relationships and proportions, extend well into or through adjoining counties.

Artificial drainage has been installed in most areas of the poorly drained and imperfectly drained soils, and the ground water table has been lowered several feet. Even at present, however, the soils of these two groups are not nearly so thoroughly drained as are the naturally well-drained soils. They are, except for a few small areas, adequately drained to fit them well for the production of such crops as corn, grasses, and other heavy moisture feeders.

The agriculture of the county, as well as the general soil conditions, is typical of that prevailing throughout this region. The close proximity to densely populated manufacturing centers has stimulated, to some extent, the production of special truck and fruit crops and the raising of poultry, although general farming, consisting principally of the production of corn, small grains, and hay grown primarily as feed for livestock kept on the farm, predominates. A somewhat less distinct type of farming, including the production of such cash crops as beans, wheat, and sugar beets, with less livestock products and feed crops, is not so common. With the exception of the very small percentage of farms devoted to the growing of special crops, which is thought to be largely due to close proximity to cities, the prevailing agriculture of the county may be considered as rather mixed. It may be accounted for largely by the climate and the character and adaptability of the predominant soils of the county.

Wheat demands the greatest quantity of moisture in the spring and early summer, when even the more droughty soils are rarely very low in moisture, and the same is, to somewhat less extent, true of oats. Even though the growth of wheat responds very favorably on dark-colored soils, its chances of injury from freezing and heaving

are much less on soils of better natural drainage and moderately low moisture content, such as Miami loam. On the other hand, corn and beans make their heaviest demands for moisture late in the summer when the moisture content of most soils is apt to be low. Such crops are, therefore, better adapted to soils of comparatively high moisture content, such as the Conover soils, or probably better yet to the poorly drained soils, as the Brookston.

The differences in organic matter and nitrogen content between the poorly drained and the well-drained soils are also influential factors. Even though the advantage in natural fertility held by the well-drained soils might favorably affect wheat production, provided a very heavy growth of vegetation at the expense of the grain did not develop, it is thought that greater returns are realized from this extra quantity of nitrogen through the corn crop, as corn demands a soil high in both natural fertility and moisture. As these crops alone occupy the greater part of the cultivated acreage they may be considered as fundamentally representing the prevailing agriculture of the county. Also, as the outstanding crops of the prevailing agriculture and the well-drained soils to which they are best adapted are dominant, it is evident that the character and adaptability of the soils, together with the climate, have largely determined the agriculture.

The influence, in this respect, of the poorly drained soils is subordinate to that of the well-drained soils, but nevertheless evident. The poorly drained soils contain more organic material in the surface soil, are richer in nitrogen, and are relatively high in moisture content. Their adaptability to, and heavy yields of, feed crops, including corn and grasses, encourage the livestock industry which is an important part of the present farm scheme. Also, the high productivity of these soils, together with the ease of soil management, doubtless accounts for the profitable production of some crops.

The difference in the adaptability and requirements of soils of the well-drained and poorly drained groups is appreciated by most farmers, but owing to several factors, including the mixed occurrence of soil types in Eaton County and the cultural methods employed, it is seldom practical to comply with such requirements in detail. It is true, however, that on most farms barnyard manure is applied to the well-drained soils rather than to the poorly drained soils, and in a more general way a discrimination is made in the use of commercial fertilizers, including lime, in favor of the well-drained soils. Also, well-adapted crops are frequently grown on the poorly drained soils several successive years, but the characteristics of the well-drained soils demand a more rigid adherence to crop rotation. Doubtless a greater percentage of the poorly drained soils is devoted to corn and a smaller percentage to wheat than of the well-drained soils. Sugar-beet growing is confined almost entirely to the poorly drained soils.

In the following pages, the soil groups and the individual soil types are described in detail and their crop adaptations are discussed. The soil map accompanying this report shows the distribution of the soils in the county, and Table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreege and proportionate extent of the soils mapped in Eaton County, Mich.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Miami loam	112,064	30.3	Crosby loam	6,016	1.6
Miami silt loam	3,392	.9	Berrien loamy sand	576	.1
Hillsdale sandy loam	15,424	4.2	Berrien fine sandy loam	960	.3
Hillsdale loam	24,576	6.6	Brookston loam	8,384	2.3
Bellefontaine sandy loam	6,144	1.7	Brookston clay loam	1,408	.4
Bellefontaine loam	4,928	1.3	Gilford loam	14,464	3.9
Fox loam	3,904	1.0	Maumee loam	896	.2
Fox sandy loam	5,824	1.6	Genesee fine sandy loam	1,728	.5
Oshtemo loamy sand	4,352	1.2	Griffin loam	3,392	.9
Warsaw loam	1,280	.3	Kerston muck	6,208	1.7
Tuscola silt loam	640	.2	Carlisle muck	23,296	6.3
Parma loam	1,792	.5	Houghton muck	320	.1
Ottawa loamy fine sand	576	.1	Rifle peat	8,704	2.3
Coloma loamy fine sand	1,020	.5	Greenwood peat	192	.1
Conover loam	75,904	20.5	Clay pits	128	.1
Brady loam	16,960	4.6			
Bronson loam	13,568	3.7	Total	369,920	

WELL-DRAINED SOILS

The naturally well drained soils, which predominate in the county, are relatively light colored, rather low in organic material, medium to low in content of moisture, and they occupy for the most part a relief which subjects them to more or less loss from erosion. Practically all the soils of the group contain sufficient sand to insure good tilth. They range rather widely in texture, although probably 95 per cent of them are loams and sandy loams. Barnyard manure is very effective on these soils, and commercial fertilizers may be expected to return profits under favorable conditions. These soils require rotation of crops and other practices of good soil management if the acre yields are to be increased or even maintained.

All the general farm crops are grown on the soils of this group, owing partly to the requirements of rotation and partly to economic factors. Small grain and hay seem to dominate, together occupying probably 75 per cent of the cultivated land, and beans and corn probably occupy the greater part of the remainder.

The Miami, Hillsdale, Bellefontaine, Fox, and Oshtemo soils represent about 97 per cent of the total area of the group of well-drained soils. The Warsaw, Tuscola, Ottawa, Parma, Coloma soils represent only about 3 per cent of the well-drained group and are therefore almost wholly insignificant as regards extent of area and agricultural importance.

Miami loam.—Miami loam is the dominant soil of the well-drained group and the most important agricultural soil of the county. More than 90 per cent of this soil has been cleared and put into cultivation, and its influence on the development of the prevailing agriculture is obvious.

This soil occurs in all parts of the county. It occupies well-drained areas ranging from undulating to rolling in relief.

The surface soil in cultivated fields is gray-brown loose friable loam. Although the quantity of organic matter is small, much less than that of the poorly drained soils, it is probably slightly higher in this soil than in most of the other well-drained soils. The organic material

of the cultivated soil is finely divided and thoroughly incorporated. The total content is not sufficient to produce granulation of the soil, but the quantity of silt and sand is ample to insure excellent tilth, aeration, and rapid absorption of water.

The subsoil is largely silt and clay, with minor proportions of coarser material. On slightly drying, the material falls apart easily into brown angular particles about one-half inch in diameter. Close examination reveals that the brown color is caused by a thin coating or film of very fine textured material. The subsoil is retentive of moisture, and it is likely that the brown film covering the angular particles assists materially in conserving a more equable supply of moisture for growing plants during droughty periods. On crushing the soil particles between the fingers, the mass is distinctly yellowish brown, and a freshly cut surface shows a color similar to the crushed material. In the lower part of the subsoil the yellowish-brown color is not nearly so prevalent or may disappear entirely. The subsoil is permeable to air and water, and plant roots extend to considerable depths without apparent difficulty. The material is rather firm in mass, but it is moderately easy to dig with a spade when ordinarily moist. On drying, hardness and difficulty of digging increase. When wet the material is sticky; but when dry, the particles are brittle and are crushed between the fingers with difficulty. The particles of sand and grit occurring in the silty clay mass are very harsh or sharply angular.

Organic matter was not abundant even in the virgin condition, and under cultivation this constituent apparently decreases, necessitating soil-amendment crops, applications of barnyard manure, and crop rotations. Although this soil can not withstand trampling and tillage abuse as well as most soils richer in organic matter, the textural composition is favorable, and fields are temporarily pastured by some farmers. Injury resulting from erosion differs widely from place to place, principally according to the degree of slope. Some gullying has developed in local spots, but this type of erosion is not common. Sheet erosion affects a considerable proportion of this and other soils of the well-drained group, but in few places disastrously.

This soil is not so rich in some of the more important elements of plant nutrients as are the poorly drained soils, although its natural fertility is well up to the average of the region and slightly greater than in many of the sandier soils of the well-drained group. The physical characteristics are favorable to normal water and air circulation, without excessive leaching, therefore probably a greater proportion of available nutrients are present than might be expected of soils with unfavorable physical characteristics. The surface soil and upper subsoil layer react acid almost without exception, but below a depth ranging from 2 to 3 feet lime is sufficiently abundant in most places. Applications of lime are often made preparatory to alfalfa seedings and occasionally for clovers, although in some places these legumes grow successfully without the use of lime. Most farmers, however, agree that the use of lime with these crops is highly advisable. This soil receives its proportion of the barnyard manure, and many farmers use commercial fertilizers with the wheat and bean crops, and sometimes with corn and oats. The belief that the use of manure is profitable seems to be universal, and the small number of

farmers who still question the advisability of fertilizer applications is negligible.

Miami loam is closely associated with the Hillsdale soils and in places with even more sandy soils. Where such associations are most intricate, variations in small areas are to be expected. On the more nearly level areas, the surface soil is slightly darker and the subsoil is somewhat more inclined to contain whitish-gray and yellow splotches. On the steeper slopes, where erosion has removed the original surface soil, the tilth of the soil has become impaired and the organic content is very low.

All the important crops of the county are grown on this soil. Although corn is more economically produced on, or is better adapted to, the poorly drained soils, it is also grown to considerable extent on Miami loam in rotation with other crops. Yields commonly range from 30 to 60 bushels an acre, with an average of probably about 40 bushels. Wheat and oats are well adapted, and these small-grain crops and hay occupy probably about three-fourths of the cultivated area of this soil. It is estimated that corn and beans probably occupy nearly one-fourth of the area each year. The yield of oats may be expected to be between 35 and 75 bushels, with a probable average of 45 bushels an acre, and the average yield of wheat is about 20 bushels less. The average yield of beans is between 12 and 15 bushels.

This is an excellent wheat soil. Being well drained, heaving and freezing are much less destructive than on the poorly drained soils. It is a good truck-garden soil. Apples do well and small orchards are numerous. Sugar beets are seldom grown.

Superphosphate alone or a 2-16-2³ mixture is probably the most common commercial fertilizer used with small grain; and if the field occupies a rather unproductive area of the soil, applications of nitrate of soda or sulphate of ammonia are sometimes applied in spring. Superphosphate alone, or a 2-16-0 mixture, is probably most commonly used with corn when any commercial fertilizer is applied, and 2-16-2 and 2-12-2 are popular mixtures for beans. Fertilizer applications are ordinarily rather light, commonly ranging from 100 to 250 pounds an acre.⁴

Miami silt loam.—This is an inextensive soil, only 3,392 acres being mapped in the county. With the exception of a few areas near Mulliken, near Kingsland, and in northeastern Eaton Township, it occurs only in the southwestern corner of the county.

With the exception of the slightly heavier texture, a higher silt content, a smaller proportion of sand, and other incidentally associated characteristics, Miami silt loam is essentially similar to Miami loam. The surface relief is very similar to that of the loam. Surface drainage is about the same for both soils, but the downward movement of water is probably slightly slower in the silt loam than in the loam, owing to the heavier texture of the silt loam. Most of the crumb particles, into which the subsoil breaks on drying, are smaller and are more conspicuously developed in the silt loam. In most places the surface soil of Miami silt loam, especially where erosion has been

³ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

⁴ Recommendations regarding the use of commercial fertilizers under Michigan conditions can be obtained from Mich. Agr. Expt. Sta. Circ. Bul. 53 (7).

active, is somewhat more sticky when wet and slightly tighter when dry than the surface soil of Miami loam.

The moisture range is a little less favorable to tillage, and injury resulting from trampling and injudicious tillage methods is thought to be slightly greater with the heavier soil. Owing to the heavier texture of the surface soil of the silt loam, a rotation including soil-amendment crops is indispensable to the maintenance of proper tilth. Otherwise, the adaptability, yields, and problems of management are very much the same as for Miami loam, so far as the important crops of the region are concerned.

Hillsdale sandy loam.—This soil is characterized by undulating or rolling relief which is probably, on the whole, slightly more bold than that of the Miami soils. It occurs widely distributed over the central and southern parts of the county, in association with the Miami and other more sandy soils. An area in the vicinity of Olivet is the largest in which this soil predominates. This is one of the more extensive soils of the county, occupying 15,424 acres.

The surface soil of a plowed field is gray-brown loose friable sandy loam. The organic content, although not high, is sufficient to give the surface soil a brown tint, and it is fairly durable. The surface soil of Hillsdale sandy loam is somewhat looser and more open than the surface soil of the Miami soils.

The crumb structure, or the tendency to break down into small angular particles, characteristic of the subsoil of the Miami soils is absent from the subsoil of Hillsdale sandy loam. The yellowish-brown sandy clay constituting the subsoil of Hillsdale sandy loam is friable and under moderate moisture conditions, breaks down into a structureless mass when crushed. The color remains about the same in the crushed material as it is in lumps or on freshly cut surfaces. On drying, this material does not assume the degree of hardness that characterizes the dry subsoil material of the Miami soils. The character of the subsoil is such as to allow rather rapid movement of water, free aeration, and as compared with the Miami soils, it reflects the effects of dry periods on crop yields to a greater extent.

Stones are of rather common occurrence and in some places interfere with cultivation to some extent, but they are never sufficiently numerous to render land untillable. It is common practice to remove the stones from the fields. A peculiarity in regard to the stones is that a large proportion of them are dark colored, somewhat rounded, and rather uniform in size, ranging from 8 to 10 inches in diameter. Owing to the relatively high proportions of sand and silt, the plow soil is easily maintained in a good state of tilth.

The lime has been removed from this soil to a slightly greater depth than from the Miami soils. The depth to limy material is more variable in the Hillsdale soil, but in most places it ranges from 4 to 5 feet.

With no significant exceptions, the same crops are grown on both the Miami and the Hillsdale soils, but slight differences in the degree of adaptability of the soils exists. For instance, corn, although grown on Hillsdale sandy loam, is not so well suited to this soil as to Miami loam, but apples and peaches may be expected to do slightly better on the Hillsdale soil. Deficient rainfall during the growing season is reflected to a little greater extent in yields of beans and hay on the Hillsdale soil.

Hillsdale sandy loam, as shown on the map, is fairly uniform but includes textural variations which are common to most of the soils of Michigan. Light-textured variations are to be expected where areas of Coloma and Bellefontaine soils are adjacent, and loamy variations are apt to occur where Miami loam is closely associated.

The need of lime, barnyard manure, commercial fertilizers, and rotations including soil-amendment crops is deemed a little more necessary with the Hillsdale soils than with the Miami.

Hillsdale loam.—Hillsdale loam is fundamentally very similar to Hillsdale sandy loam, the principal difference being the slightly heavier texture of the surface soil of the loam.

This soil occupies a total area of 24,576 acres. Its distribution in the county, lay of land, drainage, color of both surface soil and subsoil, structure, and chemical characteristics are very similar to corresponding characteristics of Hillsdale sandy loam.

So far as the important crops of the county are concerned, crop adaptations and problems of soil management are the same for both soils. Owing to the slight difference in texture, the loam is a little more retentive of moisture and, largely for this reason, less susceptible to crop loss from the effects of droughty periods.

Bellefontaine sandy loam.—The general field appearance of this soil is characterized by the brownish-gray color of the loose gravelly sandy loam surface soil and by its comparatively hilly relief. The surface soil has a low content of organic matter, barely sufficient to impart a light-brown tint, and the organic matter is not so durable as in the heavier soils.

The subsoil is a reddish-brown mixture of gravel, sand, and clay. The quantity of clay is sufficient to render the material sticky when moist and moderately hard when dry. The subsoil layer varies considerably in thickness. In some places it may be only 8 or 10 inches thick and in others may range from 24 to 30 inches, but in most places it is thick enough and sufficiently retentive of moisture to carry the common crops through ordinary short periods of drought.

Beneath the subsoil, a substratum of loose sand, gravel, and stones extends to a depth of several feet. This material is used for surfacing roads. Gravel pits are of common occurrence on areas of this soil.

This soil is mapped in widely scattered bodies, although the aggregate area is only 6,144 acres. The greater part occurs along the slopes flanking Grand and Thornapple River Valleys. This soil also occupies the eskers, or "hogback" ridges, the principal one crossing the main road about 4 miles northeast of Charlotte and extending intermittently for 6 or 7 miles. Other areas are mapped along the slopes of Scipio Creek near Vermontville, along Sebewa Creek south of Sunfield, and in the southern part of the county in the vicinities of Bellevue and Olivet.

With few exceptions, this soil occupies some of the steepest slopes in the county, although a very small proportion of the land is too steep for cultivation. Erosion is rather active in most places, but gullying is not common. Stones are characteristic, but in few places do they occur in sufficient numbers to seriously interfere with tillage except where the surface has been severely worn by sheet erosion.

Owing to alterations resulting from erosion, variations in the thickness of the surface soil, or depth to the subsoil, are common. Close

association with Bellefontaine loam necessitated the inclusion of small areas of slightly heavier texture, and in some places boundary lines separating Bellefontaine sandy loam from the Hillsdale soils inclosed small areas resembling the Hillsdale soils.

With one exception, Bellefontaine sandy loam is very similar to Hillsdale sandy loam in respect to natural productivity, crop adaptation, and soil management. The principal difference is that the Bellefontaine soil is usually richer in lime, and limy materials are nearer the surface. The Bellefontaine soils are variable in this respect, though for the most part, their reaction is acid to a depth ranging from 2 to 3 feet, but beneath this the lime content is high. The chances of success with such crops as alfalfa and sweetclover, without the use of lime, are somewhat better on the Bellefontaine soils.

Bellefontaine loam.—Bellefontaine loam differs from Bellefontaine sandy loam in that the loam is slightly heavier in texture, with a higher content of silt and clay in the surface soil and subsoil, and the surface relief of the loam is probably a little milder.

The distribution of Bellefontaine loam is somewhat similar to that of Bellefontaine sandy loam, although little of the loam is developed in the northern half of the county. The largest areas and the greater part of the total area are mapped in Kalamo Township, and smaller areas occur along the slopes of Grand River Valley and in the vicinities of Bellevue and Olivet.

The advantage of a slightly heavier texture makes the loam more retentive of moisture and slightly more productive than the sandy loam. The difference in loss from erosion, though slight, is probably in favor of the loam. Otherwise these two Bellefontaine soils are essentially identical.

Fox loam.—One of the most outstanding features of the general surface relief of the county is the smooth sandy plains, such as the one extending from Bellevue to Charlotte and southeast through Eaton Rapids. These plains were referred to by early settlers as "prairies" or "oak openings," but at present they are more often locally spoken of as sandy plains or gravelly plains. The plains are nearly level and have very little surface run-off, although they are, for the most part, well drained, in many places even droughty, owing to the free passage of water through the gravelly substratum. Small gravel scattered here and there over the surface are of common occurrence, but these soils are practically stone free. Although the texture ranges from sand to silt loam, all the plains are sufficiently sandy to insure favorable tillage over a wide range of moisture conditions.

The plow soil of Fox loam is loose grayish-brown loam having a moderate or low organic-matter content. The subsoil is a reddish-yellow mixture of sand, gravel, and clay, with the clay in sufficient proportions to render the mass retentive of moisture and distinctly sticky when wet. On drying, the material hardens considerably but not sufficiently to materially interfere with root penetration. The subsoil stands out conspicuously in both color and texture. It is much heavier in texture than is the soil mass above or the sand-gravel substratum beneath. The thickness of this reddish-yellow clayey layer ranges from a few inches to nearly two feet. The loose friable mass of soil overlying the clayey subsoil is thinner and heavier textured where the subsoil layer is thicker.

Fox loam is one of the principal soils developed on the well-drained parts of the sandy plains. The reddish-yellow clayey subsoil serves a much-needed function in crop production, as this soil is, at best, sensitive to periods of low rainfall. The contact between the reddish-yellow subsoil and the open gravelly substratum beneath is conspicuously abrupt.

Although small bodies of this soil occur in every township, their aggregate area in the county is only 3,904 acres. The more extensive bodies are near Kalamo, west of Eaton Rapids, and in the vicinities of Charlotte, Bellevue, Dimondale, and Carlisle.

Fox loam is only moderately fertile, but chemical analyses of samples of this soil from southern Michigan indicate it is not abnormally low in any of the essential plant-food materials. Though the surface soil to a depth ranging from 20 to 30 inches is acid, lime becomes more plentiful in the lower part of the subsoil, and it is abundant in the gravelly substratum which in most places is less than 3 feet beneath the surface.

It is generally conceded by the farmers that liming is beneficial to such crops as alfalfa and sweetclover, although in some places where the root system has extended downward to the limy material, these crops have done well without applications of lime. Even in these places, the crops are usually slow in becoming established.

Practically all the regional crops are grown on the Fox soils, but the degree of adaptability differs rather widely, as heavy moisture feeders, such as corn, ordinarily suffer from deficient moisture. Crop rotation and fertilization are necessary for satisfactory yields of most crops.

The problems of soil management and the use of soil-amendment crops and fertilizers are very much the same as on Hillsdale sandy loam, and the yields from most crops grown on these two soils are about the same.

Fox sandy loam.—Fox sandy loam is separated from Fox loam on a slight textural difference. The two soils are very closely associated and have about the same distribution over the county. The surface soil of Fox sandy loam contains a slightly larger proportion of sand which makes it a little more open and loose than the corresponding layer of Fox loam. The reddish-yellow sand, gravel, and clay subsoil is, in most places, somewhat less thick in the sandy loam, and its depth from the surface is slightly greater.

Occupying the drier sandy plains, in association with Fox loam, Fox sandy loam is underlain by the open gravelly substratum, which accounts for the rapid drainage and susceptibility to droughtiness characterizing the Fox soils. The sandy loam is ordinarily slightly less retentive of moisture than the loam, owing to the difference in thickness of the subsoil layer. Other than this the two soils are identical as regards agricultural use, tillage practices, and methods of soil management.

Oshtemo loamy sand.—In many places throughout the sandy plains the reddish-yellow clayey subsoil layer is very weakly developed, being only an inch or two thick. Where this layer is so weakly developed, a higher percentage of sand characterizes the entire soil body from the surface downward, and the soil areas are separated on the accompanying soil map as Oshtemo loamy sand.

The aggregate area of this soil is 6.8 square miles. More than half of it occurs along Thornapple River Valley in Chester and Vermontville Townships, and a few areas are mapped in Battle Creek Valley south of Charlotte. About one-third of the total area is south and northeast of Eaton Rapids on what is probably the sandiest part of the plains in the county.

The areas just south of Eaton Rapids are more sandy than typical and would have been correlated as Plainfield sand had their total area been sufficient to justify such a separation. That part of the soil mapped east and northeast of Eaton Rapids is very low in organic matter, and the surface soil is lighter in color than that part mapped on the plains along Thornapple River and Battle Creek. The brownish-yellow color is a slight variation from the color of the typical soil as mapped generally in the State.

Where typically developed, as in the areas east and northeast of Eaton Rapids, Oshtemo loamy sand is slightly lower in some of the elements of soil fertility than either of the Fox soils. There is no doubt that it is more droughty and therefore less productive, owing to the very thin development of the clayey subsoil layer. The degree of acidity is a little more pronounced, and the limy material in most places occurs at a slightly greater depth. Those areas of the soil mapped on the valley plains along Thornapple River and Battle Creek are a little more productive than the typical soil, owing to the slightly higher content of organic matter in the surface soil.

Although the greater part of this soil is used for growing all the general agricultural crops produced in the county, its range of adaptability, though similar to that of Fox sandy loam, is narrower. Oshtemo loamy sand as typically developed is, when considered as to economical general crop production, a marginal soil, and some abandoned farms located largely on this and closely related soils, were observed during the progress of the field work. It is better adapted to special crops, such as melons and berries.

Warsaw loam.—The original forest cover of the plains differed from place to place according to moisture conditions, character of the soils, and other factors. These differences were not only in the type of forest but in the density of the stand. On a number of plains, or fragmentary parts of plains, in southern Michigan the original forest grew sufficiently open to allow a rather heavy grass vegetation, or where a dense forest was present, it had occupied the land for a comparatively short time. Such a combination of forest and grass vegetation originally occupied an area of the sandy plain where Charlotte now stands, hence the Charlotte prairie of the early history of the county. On parts of the plain where grass originally grew, more organic matter has accumulated in the surface soil. This darker-colored soil, Warsaw loam, may be considered a semiprairie soil.

Warsaw loam, to a depth of 8 or 10 inches, is very dark brown loam. Between depths of 10 and about 26 inches the material is brown gritty clay underlain by a substratum of sand and gravel. The upper layers are acid, but the substratum is alkaline.

Two square miles of Warsaw loam are mapped in this county, and about three-fourths of this is in the city of Charlotte. It is probable that the proportion of grass in the original vegetation was not so great in Eaton County as in other places in the State, where the soil is more typically developed.

With the exception of the very dark brown, but not black, surface or plow soil, this soil is very similar to Fox loam. The higher percentage of organic matter in the surface soil gives Warsaw loam a slight advantage in natural fertility, which is reflected in crop yields to a greater or less extent. As most of this soil occurs in Charlotte, garden truck, flowers, and fruit are the principal crops. Gardens do well if precipitation is near normal, but, as on all sandy plain soils, long dry periods are very injurious.

This soil in other counties is devoted to about the same crops as commonly grow on the Fox soils, and tillage methods and soil management are about the same. Warsaw loam is probably a little more productive than the Fox soils, and yields probably average slightly higher.

Tuscola silt loam.—About 3 miles southwest of Charlotte a few areas are separated in mapping, which are very different from the other soils occurring on the plain. The soil of these areas is decidedly heavier in texture. The surface plow soil is grayish-yellow silt loam, and the organic content seems to be rather low. Although the firmness of the surface soil is sensed in walking across a field, being in this respect similar to the Miami soils, the content of silt is sufficient to impart a mellow tilth and prevent baking and clodding.

The similarity between the subsoil of this soil and that of Miami silt loam is very striking. The subsoil consists of yellowish-brown silty clay, but at a depth ranging from 3 to 4 feet the upper part of a bed of sand is reached under Tuscola silt loam.

Only 1 square mile of this soil is mapped in Eaton County. Although its total area is insignificant, its soil characteristics are rather striking. The fundamental physical characteristics of both the surface soil and subsoil are similar, respectively, to those of corresponding layers of the Miami soils, giving rise to common tillage problems; but the nearly featureless plain which Tuscola silt loam occupies and the sand substratum underlying the subsoil separate this soil from the Miami soils and relate it more closely to the Fox soils.

Lime seems to have been leached to a greater depth than in either the Miami or Fox soils. The surface soil, subsoil, and upper part of the sand substratum give an acid reaction with Soiltext, indicating the need of lime.

Parma loam.—In a few places in the county outcrops of bedrock occur, and a total of nearly 3 square miles is underlain by rock at a depth of less than 6 feet. The soil of such areas is correlated as Parma loam.

This soil is necessarily variable, as the depth to bedrock ranges from a few inches to 6 feet, and the underlying rock ranges from dominantly limestone to dominantly sandstone. In the vicinity of Bellevue, where more than 80 per cent of the soil is developed, the underlying rock consists largely of limestone, whereas the other small areas, one about 2 miles southeast of Charlotte along Battle Creek and the others near Grand Ledge along Grand River, are underlain by rock consisting mainly of sandstone. The soil overlying sandstone is somewhat lighter in texture, but it is variable as to degree of acidity.

A distinguishing feature of this soil is the peculiar ocher color characterizing the subsoil. This color seems more pronounced in the area overlying limestone at Bellevue.

The plow soil is grayish-brown mellow loam with an admixture of more or less bright yellow where bedrock most nearly approaches the surface. The organic content is about the same as that of the Miami soils. The tilth is favorable, but on becoming wet the soil is rather sticky.

The subsoil is bright-yellow or ocher-yellow moderately heavy sandy clay. It is friable when normally dry but becomes sticky when wet. It is rather retentive of moisture.

The small area of this soil developed in the county is of little agricultural importance. The town of Bellevue covers a large part of the total area. The underlying rock at Bellevue is being quarried for use in the manufacture of cement. The small patches included in fields of associated soils are devoted to the crops commonly grown on the Miami or Hillsdale soils. Crop yields are only fair.

Ottawa loamy fine sand.—The largest area of Ottawa loamy fine sand mapped in Eaton County is about 3 miles southwest of Eaton Rapids. The remainder of the soil occurs in small isolated areas thinly scattered over the southeastern part of the county. This is an inextensive soil, less than 1 square mile being mapped. It is one of the sandier soils of the well-drained group.

The plow soil is yellowish-gray loose loamy fine sand having a very low content of organic matter. The subsoil is yellow porous fine sand extending to a depth ranging from 3 to 6 feet. The layer beneath this is variable but of a heavier texture and dominantly yellow, with blotches of gray and brown.

As it occurs in small isolated patches, this soil is cropped with the associated soils. It is lacking in lime and some other plant-food constituents to a considerable depth. Its natural productivity is comparatively low, and applications of lime and crop rotations, including soil-amendment crops, are necessary to avoid a spotted appearance of crops on fields where patches of this soil occur. Its general relationship to agriculture is similar to that of the other sandier soils of the well-drained group.

Coloma loamy fine sand.—Coloma loamy fine sand consists of light sandy material to a depth of several feet. The surface relief of the land is rolling, in places distinctly hilly. Drainage is excessive, and, owing to the open structure of the sandy soil mass, internal movement of both water and air is exceedingly free.

The surface soil is yellow-gray loose loamy fine sand which is not seriously subject to wind shifting. The organic content is very low both under forest cover and in cultivated fields, but it is ordinarily sufficient to stain the surface soil to a depth of 2 or 3 inches. It is not very durable under tillage. Grayish-yellow or brownish-yellow loosely coherent sand containing very little fine material extends below the surface soil to a depth of several feet.

Some stones occur both over the surface and in deeper parts of the soil. They are not so numerous, however, as in the Hillsdale soils.

The greater part of this soil occurs in small isolated bodies scattered in nearly all parts of the county. A few areas are mapped along the slopes of Grand River Valley east of Grand Ledge, near Olivet, south of Bellevue, in the vicinity of Eaton Rapids, and west of Vermontville.

The total area of this soil is only 1,920 acres, and the land is of slight agricultural importance. It is too droughty for the economical production of corn. Probably 50 per cent is devoted to small grains

and hay. A rather large proportion of the rye crop of the county is grown on this soil. Probably 25 or 35 per cent of the land is devoted either to forestry or pasture, although the soil is not a heavy grass producer.

This is one of the most droughty, most acid, and least productive soils of the well-drained group and under prevailing economic conditions is probably best devoted to forestry and pasture.

Included with areas of Coloma loamy fine sand are bodies near West Windsor, Pine Lake, Olivet, and Potterville, and west of Eaton Rapids, in which the soil differs from the typical Coloma soil in that clayey lenses, layers, or patches and pockets occur scattered haphazardly throughout the soil mass from the surface to a depth of several feet. Some peach orchards were observed on this land during the course of the survey.

IMPERFECTLY DRAINED SOILS

The soils of this group are characterized by moisture conditions intermediate between those of the poorly drained dark-colored soils on the one hand and the well-drained light-colored soils on the other. The group includes the Conover, Brady, Bronson, Crosby, and Berrien soils, the Conover, Brady, and Bronson soils occupying about 95 per cent of the total area covered by the group. These soils have an intermediate position, not only as regards moisture conditions, but as regards organic content, color of the surface soil, distribution and quantity of lime in the surface soil and subsoil, susceptibility to extreme amounts of precipitation, and consequently to natural productivity and crop adaptation.

Under existing soil conditions and the prevailing agriculture of the county, small-grain crops are better adapted to the well-drained soil group than to the group of soils of intermediate or imperfect drainage. They are, nevertheless, better adapted to the soils of the intermediate group than to the poorly drained dark-colored soils. Corn, though probably best adapted to the poorly drained soils, may be expected to return more profitable yields on the soils of the intermediate group than on the light-colored well-drained soils.

Sugar beets, though probably best adapted to the poorly drained dark-colored soils, are extensively and satisfactorily grown on the Conover and similar soils, but are rarely grown on the well-drained light-colored soils. The greater part of the acreage of this crop is grown in the northern part of the county. This may be due, in part, to the proximity of the sugar-beet factory at Lansing, but as the intermediate group of soils is more extensively developed here, the character of the soils is probably the dominant factor influencing the distribution of this crop.

The common field crops are grown, but usually a higher percentage of land is devoted to corn and a lower percentage to wheat and hay than of the well-drained light-colored soils.

Conover loam.—Miami loam being a well-drained soil, and Brookston loam naturally very poorly drained, the gentle slopes connecting these two soils present a drainage condition too high in moisture and organic-matter content for Miami loam but too low for Brookston loam. On such slopes typical Conover loam is developed. Also, in many places, especially in Sunfield and Roxand Townships, this soil occupies flat heavy-textured till plains which

have been little invaded by natural drainage. It is also mapped in small depressed areas along narrow valleylike drainage ways crossing the fields. Areas in the last-named position have received considerable material washed in from the flanking short slopes. During the process of mapping it was necessary in many places to make textural concessions in favor of drainage conditions.

Conover loam is the most extensive of the imperfectly drained soils and one of the more important soils of the county. It occupies 75,904 acres, or 20.5 per cent of the total area of the county. It is widely distributed throughout all townships.

The surface soil is dark grayish-brown mellow loam. The plow soil is moderately well supplied with organic matter, is retentive of moisture, and the tilth is good. Just beneath the plow soil, the subsurface material, in most places, is pale yellowish-gray or gray loam showing faint splotches of yellow. The subsoil is moderately heavy granular clay loam, showing gray, yellow, and brown colors. The physical character of the subsoil material is such that roots can thoroughly penetrate all parts, affording plants a most complete contact with the moisture and the plant-food materials. The texture is sufficiently heavy and the structure is favorable to render the subsoil highly retentive of moisture, but the land responds well to tile drainage.

The original natural drainage of the greater part of this soil was much poorer than at present. Most of the larger areas in the northwestern part of the county have been tiled, and the level of the ground water has been lowered from 1 to 3 feet. The regulation of drainage is the greatest need of this soil.

This soil is apparently rather high in natural fertility. The organic content, though not so high as that of the Brookston soils, is higher than that of the more rolling well-drained light-colored soils. The organic material is finely divided and thoroughly incorporated with the mineral part of the plowed soil, and it is rather durable. Growing crops indicate a comparatively high percentage of nitrogen, and there is no apparent reason to believe that other important plant-food elements are low. Although the surface soil, to a depth ranging from 20 to 30 inches, ordinarily gives a weak or moderate acid reaction with Soiltex, it is not strongly acid, and limy materials occur in the lower part of the subsoil and in the clayey substratum.

This is one of the more desirable of the general agricultural soils of the county, and it ranks relatively high as a crop producer. For this reason a large proportion, probably more than 90 per cent, of the land has been cleared and put into cultivation, and the remainder is devoted partly to forested pasture but principally to cleared pasture. The soil is a heavy grass producer.

Although all the important crops of the county are grown on this soil, corn, hay, oats, beans, and sugar beets predominate. It is estimated that nearly 50 per cent of the land is devoted to corn; 25 or 30 per cent to oats, wheat, and hay; and 10 or 15 per cent to beans, with sugar beets and cabbage figuring prominently in the small acreage devoted to special crops. Truck crops are grown to some extent, but, owing to topographic location, heavy texture, and high moisture content, this soil is rather slow to warm up in spring, which results in late seeding of such crops and a higher susceptibility to frost damage. It is, however, well adapted to growing cabbage.

Late seeding is offset to some extent by the rapid growth caused by the natural productivity of the soil. The amount and distribution of rainfall largely determine the degree of success of truck crops on this soil, too much rain being especially detrimental. Acre yields of corn or oats commonly range from 45 to 85 bushels, with an average, probably, of about 50 bushels. Bean yields range from 18 to 20 bushels an acre, hay about 2 tons, and sugar beets about 9 tons.

This soil, like others of the same group, does not, as a rule, receive the attention that the lighter-colored well-drained soils demand, but the more progressive farmers are beginning to appreciate the necessity of good management. Barnyard manure is beneficial to all important crops, and some is used, but the associated well-drained soils are favored in this respect, and the same is true in regard to the use of commercial fertilizers. The use of commercial fertilizer is not common, but on fields composed dominantly of Conover loam, superphosphate alone is often applied to land planted to small grain or corn and a complete mixture to land devoted to sugar beets or cabbage. Applications of fertilizer are in general light, ranging from 150 to 250 pounds an acre.

Brady loam.—This soil occupies the gravelly plains and is geographically associated with the Fox or Bronson soils, which occupy higher and better-drained situations, and with Gilford loam which includes the wettest part of the plains. That is, Brady loam, like Conover loam, occupies an intermediate position between the well-drained and the poorly drained soils. This soil is rather extensive, 26.5 square miles being mapped. Its distribution over the county is rather wide and similar to that of the Fox soils. Some of the larger areas are south and west of Grand Ledge, east of Charlotte, and west of Eaton Rapids. It is estimated that about 80 per cent of this soil is in cultivation and devoted to about the same proportions of the different crops as are grown on Conover loam.

The plowed surface soil is dark-gray loose friable loam. The dark color is caused by the moderately high content of organic matter which is thoroughly decomposed, well mixed with the mineral constituents, and rather durable under cultivation. Small quantities of gravel over the surface and through the soil are characteristic. The subsurface soil is lighter gray, owing to the absence of organic matter. The subsoil is composed of a mixture of sand, gravel, and clay and is texturally similar to the subsoils of the Fox soils, but it is characterized by gray, yellow, and brown splotches caused by imperfect drainage or periodic saturation, instead of the reddish-yellow color of the well-drained Fox soils.

An unconsolidated bed of sand and gravel makes up the substratum beneath the subsoil, but the thickness of the gravel bed is variable, clayey material occurring in many places within a depth of 6 feet. The substratum is in a saturated condition for the greater part of the time.

Although the texture of the subsoil and substratum of Brady loam differs from that of the corresponding layers of Conover loam, the two soils are very similar as regards lime content, natural fertility, productiveness, normal moisture conditions, agricultural use, and soil management.

Bronson loam.—The characteristics of Bronson loam distinguishing it from Brady loam are such as arise from a rather slight difference

in degree of natural drainage. Bronson loam is characterized by a slightly lower water table, somewhat better drainage, and not quite so much organic matter in the surface soil.

The plow soil of Bronson loam is grayish-brown loose loam. Immediately beneath the plow soil the color is more nearly pale yellowish gray or gray. The subsoil is composed of sandy gravelly clay, sufficiently high in content of clay to render the material sticky when wet and moderately hard and brittle when dry. The upper part of the subsoil in most places is predominantly tinged with red, but at a greater depth, where the moisture content increases, more gray and yellow splotches appear. The sand and gravel substratum is very similar to that of Brady loam, but it is typically a little more removed from a water-logged condition. This is one of the more important soils in the imperfectly drained group. It is nearly as extensive as Brady loam, 13,568 acres being mapped. Its distribution is very similar to that of the Fox soils and Brady loam, with which it is associated. It occurs in all townships of the county, but nearly half the total area is near Charlotte, mostly on the Battle Creek plain, and a fairly large total area is mapped on the plain along Thornapple River.

The surface soil to a depth ranging from 20 to 30 inches is, on the whole, slightly more acid than is that of Brady loam, but beneath this the material is high in lime. The organic matter and nitrogen content of Bronson loam are probably slightly lower than of Brady loam, and Brady loam is probably a little more productive.

Bronson loam is not so well suited to the growing of corn or sugar beets as is Conover loam, but wheat is probably more economical and more commonly grown on the Bronson soil. Such distinctions in adaptability are, however, very slight, and the agricultural use is about the same for both soils.

General farm practice favors the use of lime, barnyard manure, and fertilizers.

Crosby loam.—Crosby loam is not an important agricultural soil in Eaton County. Only 6,016 acres are mapped, and, with the exception of a few scattered areas farther west, the soil occurs only in the southern, central, and southeastern parts of the county. Its surface relief ranges from undulating to nearly level like that of Conover loam.

In well-cultivated fields the dry friable surface soil has a light-gray cast, tending to become nearly white in extreme development. The outstanding characteristic of this soil and the principal difference between it and Conover loam is the low content of organic matter, associated with moderately poor drainage conditions. Just beneath the plow soil the nearly white color, in places, is slightly more conspicuously developed to a depth of 12 or 14 inches.

The subsoil is rather heavy sandy clay or clay loam colored gray, yellow, and brown, very similarly to the subsoil of Conover loam. The subsoil of Crosby loam is somewhat tighter or less penetrable, and this difference is much more noticeable when the moisture content is lowest.

The indistinct changes, as they occur in many places in the field, between Crosby loam and Miami loam or Conover loam, account for variations in the color of the surface soil, which are more conspicuous in a freshly plowed field. Examination of the lower part of the subsoil indicates some variation in degree of tightness from place to place.

Those areas of the soil developed in the extreme southeastern part of the county are more nearly typical of Crosby loam, but the scattered areas in the south-central part are not quite so light in color and seem to be slightly more productive.

Studies of this soil as it occurs farther south, in Indiana, where it is much more extensive and more typically developed, indicate it to be lower in nitrogen and usually in phosphorus than are the darker soils. It is also somewhat more acid in the surface soil to a depth ranging from 20 to 30 inches than is Conover loam.

Not so much corn is grown on this soil as on Conover loam, and a somewhat larger proportion of the land is devoted to small grains and hay. Crosby loam, though not naturally well drained, is less retentive of moisture than is Conover loam, and it is also less productive. Although probably 90 per cent of Crosby loam has been cleared and cultivated to crops, a part of the land in Hamlin Township has been abandoned during recent years. During seasons of evenly distributed rainfall, yields in general are moderately good, but extreme moisture conditions are distinctly reflected in crop returns.

Berrien loamy sand.—This is one of the less-important agricultural soils of the county. It is inextensive and occurs in small widely distributed areas, which is characteristic of other sandy soils in the county.

The plowed surface soil is grayish-brown loose loamy sand containing only a small quantity of organic matter. The open sandy material in most places extends to a depth ranging from 3 to 5 feet where it rests on a heavier-textured poorly drained layer. Just above this layer the sandy material in most places is of a lighter color, with coarse splotches of faint yellow, showing evidence of periodic leaching and water-logging.

This soil is somewhat variable in reaction, but in most places it is slightly or moderately acid to a depth ranging from 20 to 36 inches, below which lime is abundant.

Although this soil is a little more productive under average conditions than are the sand soils of the rolling uplands, the Berrien soils are not very dependable in this respect. They are cultivated to general field crops, together with surrounding soils, because of their occurrence in small scattered bodies. Berrien soils in many places are lower producers than are the surrounding soils, and for this reason they are sometimes given heavier applications of barnyard manure, fertilizers, or lime. Fair yields of corn, potatoes, and other crops may normally be expected.

Berrien fine sandy loam.—Berrien fine sandy loam differs from Berrien loamy sand in that the texture of the topsoil of the former is fine sandy loam. In other respects the two soils are essentially identical.

This soil, like the loamy sand, occurs in nearly all parts of the county in small areas, with an aggregate of only 960 acres. Like Berrien loamy sand, it is of minor agricultural importance but is planted to the general crops grown on the soils of this group in association with the surrounding soils.

POORLY DRAINED SOILS

The darkest-colored mineral soils of the county, Brookston loam, Brookston clay loam, Gilford loam, and Maumee loam comprise the

poorly drained group of soils, which is not very extensive. These soils are characterized by poor natural drainage, a high percentage of organic matter in the surface soil, high moisture content, comparatively high natural fertility, and nearly neutral or slightly alkaline reaction. They are the highest-ranking soils of the county in natural fertility, and when properly tile-drained, are well adapted to the growing of corn, grasses, sugar beets, cabbage, celery, and a number of less important crops. As these soils occupy low-lying or depressed situations, they are in position to receive additional materials leached or carried out of the surrounding well-drained soils. Such a process is continually enriching these soils at the expense of the well-drained soils of the adjacent higher lands.

Perhaps from 50 to 65 per cent of these soils has been put into cultivation, and the remainder is used mostly for growing timber or for pasture. The pasture is excellent, but artificial drainage is necessary for cultivated crops.

It is estimated that from 55 to 65 per cent of the cultivated acreage is devoted to corn, from 15 to 20 per cent to small grains (mostly oats) and hay crops, and probably from 8 to 10 per cent to beans and sugar beets.

Brookston loam.—Brookston loam is in all essentials typical of the poorly drained dark-colored soils. The more noticeable characteristics of this soil are the very dark color of the surface soil and the nearly flat or depressed positions of the areas.

This soil is not very extensive, 13.1 square miles being mapped. It occurs in scattered areas in all parts of the county, but nearly one-half of the total area is developed in the north-central and northwestern parts.

The surface soil to a depth ranging from 6 to 12 inches is dark-gray or very dark gray loam which is sufficiently high in organic matter to impart a granular structure to the plow soil. The organic material is very finely decomposed and thoroughly incorporated as an integral part of the soil body. The organic content adds greatly to the nitrogen content and partly accounts for the rapid growth of plants, and it also materially affects the structure of the soil. It enables the soil to withstand trampling and abuse by injudicious tillage methods and materially improves the tilth. It tends to prevent baking or compaction of the surface soil and a cloddy condition following plowing. Owing to the high content of organic matter, the moisture content is more stable and affords growing plants a more equable moisture supply. The organic matter is very durable under cultivation.

The subsoil is heavy textured, consisting principally of clay and silt, but some coarser materials are scattered throughout the mass. This layer is penetrated by roots where artificial drainage has been effected, and on slightly drying and shrinking the material breaks into small particles. The spaces between the particles render the subsoil readily permeable to water, which probably accounts for the fact that it will drain for considerable distance back from the tile. The physical characteristics of the subsoil material cause it to be retentive of a good moisture supply for plants throughout the growing season. The color is dominantly gray, but many splotches of yellow and brown are characteristic.

The Brookston soils are typically underlain by a substratum of gray clayey material, though patches of lighter-textured materials occur.

Some of the smaller areas of these soils have received more or less colluvial wash from the surrounding soils, and in many places this deposition is sufficiently thick to cause radical variations from the typical soil.

Natural drainage is very poor, but much of the land has been tile-drained, though not everywhere thoroughly. Less than half of the land remains in its original state as regards drainage.

The surface soil in some places gives a slightly acid reaction, but in few places is as much as moderately acid, according to the Soiltext test. At a depth ranging from 18 to 24 inches the subsoil is neutral or alkaline in reaction, and at a greater depth an abundance of limy material occurs. Farmers give practically no attention to soil acidity on this or the other poorly drained soils. Barnyard manure is sometimes used, usually with favorable results, but practically no commercial fertilizers are used. Rarely superphosphate alone is applied to oats or corn. A complete fertilizer is usually applied to sugar beets.

Probably from 50 to 60 per cent of the cultivated acreage of this soil is planted to corn. The moisture content is ordinarily too high for dependable wheat yields, as freezing and heaving is likely to disturb a proper establishment of the root system if not entirely to destroy the crop. Oats do a little better, but this crop is not so commonly grown on Brookston loam as on the well-drained soils. About 20 per cent of the land is devoted to small grains and hay. A large proportion of the sugar beets produced in the county is grown on this soil. Cabbage and celery are also special crops.

Brookston clay loam.—Brookston clay loam occurs in rather small areas and occupies 2.2 square miles. With the exception of an area east of Devil Lake, in southeastern Brookfield Township, and a few small bodies near Mulliken, practically all of this soil occurs in the southwestern corner of the county in association with Miami silt loam. It is very similar to Brookston loam and is separated from that soil on a basis of comparatively slight differences arising from the heavier texture of the clay loam. In practically all essential characteristics the two Brookston soils are identical.

It is probable that the heavier texture may necessitate the placing of tile drains at closer intervals, and that trampling and tillage abuses may prove slightly more injurious to the tilth of the surface soil. Also, probably, a somewhat smaller percentage of the clay loam has been taken out of pastures and put under cultivation. Otherwise the agricultural use, natural fertility, and management of the two soils are fundamentally the same.

Gilford loam.—The general appearance of Gilford loam is not unlike that of Brookston loam. It occupies nearly flat or slightly depressed positions, is high in organic-matter content, and presents a general appearance of poor natural drainage as does Brookston loam. Both soils are nearly neutral in the surface soils and highly calcareous in the lower part of the subsoils and in the substrata. They are very similar as to productiveness and agricultural use, and no significant differences regarding the kind and respective proportions of the various crops grown on the two soils exist.

This is one of the more extensive of the poorly drained soils, covering a total area of 22.6 square miles. It is mapped in every township,

the larger areas lying south and west of Grand Ledge and west of Eaton Rapids.

This soil differs from Brookston loam in the textural composition of the subsoil and substratum. Gilford loam is developed in the wettest part of the plains and, like most soils of the sandy plains, the subsoil is composed of a mixture of sand, gravel, and clay, resting on a sand and gravel substratum. The substratum, like that beneath Brady loam, varies as to thickness, heavy clayey material occurring in many places within a depth of 4 feet, and in other places alternate layers of sandy gravel and clayey material occur. This substratum provides a natural underpass for drainage water, which does not exist under Brookston loam. Long periods of either low rainfall or extremely high rainfall may be expected to reflect these differences in the two soils by the rate of crop growth. Excessive rainfall is usually slightly more injurious to crops on the Brookston soils, whereas continued dry periods are slightly more harmful to growing crops on Gilford loam.

Maumee loam.—Maumee loam is a very inextensive soil of the dark-colored poorly drained group. A few small areas are north of Potterville and east of Charlotte, and in a few places northwest of Dimondale this soil occurs as a border soil along the edges of Old Maid Swamp.

The distinguishing characteristic of this soil is the surface 10 or 12 inch layer of black loamy mucky material. The plow soil is loose and fluffy and consists of about 50 per cent organic material thoroughly mixed with sand, silt, and other mineral matter. The subsoil is dull-gray or mottled sandy loam which grades downward to sand or gravelly sand, containing some form of lime. This soil, almost without exception, is intermediate between Gilford loam or Brady loam on the one hand and the organic soils on the other. Under natural conditions the lower part of the subsoil and the substratum remain in a saturated condition the greater part of the time. Artificial drainage is not difficult to install, and in most places the water table has been lowered somewhat by this means.

The depth of the loamy surface layer differs from place to place, usually being somewhat greater where the soil approaches the organic soils and less near the boundaries of the mineral soils. The greater part of the land is in pasture.

The small widely distributed cultivated areas are either cropped with the associated poorly drained soils, or to such truck crops as onions, cabbage, celery, and cauliflower, in association with Carlisle muck. In Eaton County, Maumee loam is of practically no agricultural importance, owing to its inextensiveness and its manner of occurrence. In other counties, sugar beets and mint are grown.

ALLUVIAL SOILS

Only about 18 square miles of bottom land occur in the county. Probably from 75 to 80 per cent of it lies along Grand and Thornapple Rivers and the remainder along Battle, Scipio, and Sebewa Creeks and smaller streams. The greater part of the bottom land is subject to overflow, and principally for this reason it is devoted largely to pasture and forestry.

The alluvial soils differ widely in texture, color, natural moisture conditions, and in quantity and distribution of organic material.

Textural composition is that resulting from stream deposition, and the color and content of organic matter have been influenced by the prevailing degree of natural drainage. On the basis of such differences, the soils of the stream bottoms have been separated into Genesee fine sandy loam, Griffin loam, and Kerston muck.

Genesee fine sandy loam.—Genesee fine sandy loam includes the higher or naturally better drained parts of the recent-alluvial plains and is developed along Thornapple and Grand Rivers. This soil is distinguished from the other alluvial soils by the characteristic brown color of both the surface soil and subsoil, together with more thorough drainage.

The surface soil of Genesee fine sandy loam, to a depth of 8 inches, is dark-brown fine sandy loam. Between depths of 8 inches and 3 or more feet the material is yellowish-brown fine sandy loam which in places is mottled in the lower part. The soil is alkaline throughout.

This soil is somewhat variable in texture. The greater part of that mapped along the Grand River plain north of Eaton Rapids approaches a silt loam in texture, and that developed along the Thornapple River Valley is slightly lighter than typical. However, such variations are not sufficiently extensive to justify additional separation.

Only 2.7 square miles of this soil are mapped. Probably 60 per cent of the land is used for pasture and forestry, and the remaining 40 per cent includes practically all the cultivated part of the recent-alluvial plains. The small total area of this soil devoted to crops renders it comparatively unimportant agriculturally, although corn, small grain, and hay crops are grown. It is a rather productive soil, except in the lighter-textured areas. The soil contains sufficient lime for crop requirements, and its cropping value is largely determined by its susceptibility to overflow.

Griffin loam.—Griffin loam adjoins areas of Genesee fine sandy loam, but it lies at slightly lower levels and has poorer drainage. As compared with the Genesee soil, it is higher in organic content, darker in color, and slightly more susceptible to overflow.

The soil varies somewhat in color but in most places is dark brown with gray and conspicuous rust-brown spots occurring at a depth of an inch from the surface and continuing downward. Where the texture is lighter, along Thornapple River, the color is not so dark and the splotches of gray and brown are less conspicuous. In most places the soil material is rather mellow or friable.

This soil is not extensive in Eaton County. Practically all the land is devoted to pasture, and there is more or less tree growth. The soil is naturally fertile and the moisture content is normally high, insuring an excellent stand of grass and a vigorous tree growth.

Griffin loam occurs along both large and small streams, and variations in texture are to be expected. Slightly more than 50 per cent of this soil is mapped along Thornapple River, and here the texture is somewhat lighter than at other places and the growth of bluegrass is not quite so vigorous.

Kerston muck.—Kerston muck, like Griffin loam, occurs only along the stream bottoms, but it is unlike Griffin loam in that organic matter, or mucky material, constitutes more than 50 per cent of the soil material to a depth of more than 3 feet.

Kerston muck represents a condition in which alternate layers of organic matter and mineral soil materials occur on flood plains. The alluvium was deposited in a rather haphazard manner, and a wide variation as to the proportions of muck and mineral soil material is to be expected from place to place. The organic matter probably accumulated in place for the most part, but some transportation of this material by stream action has doubtless taken place.

Kerston muck is not extensive in Eaton County. The soil is comparatively loose in place and when thoroughly mixed presents a brown or dark-brown color. The material is poorly drained at the surface and becomes saturated at a depth ranging from 2 to 3 feet. It is apparently medium to high in fertility, but adverse drainage conditions and susceptibility to flooding restrict its use to pasture or woodland. A very heavy stand of bluegrass grows in places where the luxuriant forest has been either thinned or cut.

This soil occurs along Grand and Thornapple Rivers, Scipio and Battle Creeks, and other streams of moderate size throughout the county.

ORGANIC SOILS

The organic soils, mucks and peats (excluding Kerston muck), occupy 8.8 per cent of the area of the county. They occur in bodies of all shapes and range in size from less than 1 acre to more than 2,000 acres. Areas are mapped in every township, but probably 80 per cent of the the mucks and peats have been deposited in the east-central and southern parts of the county. These organic deposits occur in swamps, bogs, marshes, and in valleys and other depressed situations. Most of the areas were originally occupied by shallow lakes, and the greater part of the organic material was accumulated at that time in water. A few small areas, however, occupy slope positions which have been kept permanently wet by seepage.

The muck and peat soils vary widely as to texture, structure, moisture condition, degree of decomposition, color, and chemical character. On the basis of such characteristics the organic soils have been separated into four types.

In mapping, it has been necessary to include more variations within a type than are ordinarily allowed in mapping mineral soils. The depth of the deposits ranges from 12 inches to more than 25 feet. The mineral substratum underlying the more shallow deposits may be marl, sand, or clay. In many places around the borders of the areas are gradational strips which range from shallow peat and muck to Maumee, Gilford, or Brookston soils.

Carlisle muck.—This is the most important type of organic soil in Eaton County, both in extent and in agricultural worth. It is estimated that about 70 per cent of the organic soils of the county are included in this type. Although probably less than 10 per cent of Carlisle muck is cultivated, probably 85 per cent of the cultivated muck land is of this type. It represents the organic soil which is most advanced in degree of decomposition and generally highest in lime and phosphorus.

Carlisle muck is characterized by a very dark brown or black surface soil which is distinctly granular in structure and loamy in texture. Ordinarily the material a few inches beneath the surface is more finely divided and inclined to be pasty when wet, but when very dry it

becomes hard and horny and breaks with an angular or conchoidal fracture. In some places the plow soil is slightly shifted by the wind when very dry (5). The material to a depth ranging from 15 to 18 inches has been so thoroughly broken down, or completely modified, that all identity of the original vegetation has disappeared. Beneath a depth of 18 or 20 inches the material is not so thoroughly decomposed, and it becomes more peaty with increasing depth. Below a depth ranging from 24 to 30 inches, wide variations as to the kind of material and degree of decomposition may be expected.

Carlisle muck ranges from nearly neutral to alkaline in reaction. Analyses of this type of muck from different parts of the State indicate that it is rich in lime and phosphorus but generally poor in potash. Although ordinarily more than 75 per cent of the material is combustible, or organic, matter, this muck is higher in mineral matter than are the other muck and peat soils, except the Kerston type.

The land originally supported a heavy forest cover consisting principally of elm, ash, and soft maple, with some tamarack, swamp white oak, poplar, and willow. It is now devoted to forest, pasture, and special crops. Where the forest has been removed or severely thinned, excellent pastures, composed principally of bluegrass, with less timothy, alsike, and redbud, are supported. During the course of the survey a number of such pastures were observed on Old Maid Swamp northwest of Dimondale. Probably 50 or 60 per cent of this swamp is used thus, and from 30 to 40 per cent is still in forest.

The principal crops are mint, onions, and cabbage, with some carrots, turnips, celery, cauliflower, sugar beets, and potatoes. Some corn is grown, but it does not always mature and is used for silage. Oats and barley have been grown on a small acreage, but the rank growth of straw, at the expense of grain, and consequent lodging are serious difficulties. The principal factors in the management of this type of muck include drainage or proper level of the water table, quantities and mixtures of commercial fertilizers applied, and precautions in regard to plowing, preparation of the seed bed, and cultivation. Although it is necessary to lower the natural level of the water table in most places, care should be taken to avoid overdrainage. Heavy applications of commercial fertilizer high in potash seem to be profitable with most crops. If the initial plowing is too deep, it may prove detrimental by disturbing moisture circulation, and rolling is usually necessary in the proper preparation of a seed bed (6, 7).

Houghton muck.—The surface soil of Houghton muck is typically dark-brown or nearly black finely divided fibrous material. In the shallow deposits, beneath the surface layer, at a depth of 6 or 8 inches, is a layer of rather black pasty slimy muck resting on the mineral substratum. In the deeper deposits the muck grades, at a depth ranging from 18 to 24 inches, into fibrous or mossy peaty material.

This type of muck is not strongly acid, ranging from nearly neutral to slightly alkaline. Decomposition has not advanced to so great an extent as in Carlisle muck but to greater extent than in Greenwood peat. The ash content, or inorganic material, is also lower in this muck than in Carlisle muck.

One of the most conspicuous associated features of Houghton muck is the absence of trees. A uniform cover of sedges and bluejoint comprises the natural vegetation.

Houghton muck occupies only 320 acres in the county and is of little agricultural importance. One of the largest areas is just north of Pine Lake, and small areas occur in other places, most of them in the southern half of the county.

The land is used to produce marsh hay and pasture in this county, but small areas are in cultivation in other parts of the State. Under cultivation, however, the requirements regarding drainage, proper preparation, and skillful use of commercial fertilizers are even more rigid for this soil than for Carlisle muck.

Rifle peat.—Rifle peat has about the same range of distribution over the county as Carlisle muck but is only about one-third as extensive. This type of peat holds an intermediate position between Carlisle muck and Greenwood peat in respect to degree of decomposition, content of lime, average natural depth to the water table, and potential value as a crop producer.

To a depth of a few inches the material is very dark brown, loamy, and granular, with many woody fragments occurring over the surface. Below a depth of 2 or 3 inches, it is typically less compact, coarser, and shows less decomposition. At a depth greater than 2 feet the material, like that at a similar depth in Carlisle muck, may be expected to range from raw, fibrous, felty, or mossy peat to partly decomposed woody material.

The vegetable growth characterizing Rifle peat as developed in Eaton County is a combination composed largely of poplar, with a few white birch, willows, tamarack, and a shrubby growth including red-osier dogwood and high huckleberry. Tamarack is dominant in some places and in others it is very rare.

This soil is devoted mostly to pasture and to much less extent to forestry. Very little of the land has been drained with the intention of attempting cultivation. The cost of putting this land into cultivation and working it down to a satisfactory tilth, along with proper drainage regulation, is probably slightly greater than for Carlisle muck. That part cultivated is handled and used in very much the same way as Carlisle muck.

Greenwood peat.—Greenwood peat typically occupies heath bogs. It is of very small extent and valueless for the production of the staple farm and truck crops of this part of the State. It occurs in small isolated areas, and only 192 acres are mapped in the county.

This is the rawest, coarsest, least compact, most acid, and lightest colored of the organic soils. The color of the material ranges from yellowish brown to reddish brown.

This peat is very strongly acid, and the water table is ordinarily at or very near the surface. Huckleberry, Cassandra, Kalmia, chokeberry, cotton grass, pitcherplant, and Sphagnum and other mosses are characteristic growths. The land supports practically no trees.

SOILS AND THEIR INTERPRETATION

The soils of Eaton County have developed from drift of the late Wisconsin glaciation under conditions characterizing the region of gray-brown forest soils, in which the county is located. Both mineral and organic soils are represented, the mineral soils comprising 91.2 per cent of the area of the county.

The mineral soils may be separated into two divisions on a basis of the relative moisture content during the period of development as follows: (1) Soils containing average amounts of moisture for the region, or well-drained soils; and (2) soils which have been subjected to either continual or periodic saturation or high moisture content during the period of development. The first division, or the well-drained soils, is estimated to occupy about 70 per cent of the total area of mineral soils.

The well-drained soils are representative of the gray-brown podzolic soils which occupy the central and east-central parts of the United States east of the Mississippi. The leaching of soluble bases, including magnesium and calcium carbonates, and the removal of sesquioxides from the surface layers are dominant in the soil-forming process. The depth to which carbonates are leached and the degree of clay concentration in the B horizons are slightly greater here than farther north, but both are less than in soils farther south.

The well-drained soils may be divided into groups on the basis of the texture or consistence of the different horizons, as follows: (1) A group characterized by a comparatively high percentage of clay throughout the solum and parent material; (2) a group with a clayey B horizon, but an unconsolidated sand and gravel substratum; (3) a group which is open, porous and comparatively high in percentage of sand to a depth ranging from 4 to more than 5 feet; and (4) a group underlain at a slight depth by indurated bedrock.

The first group includes the Miami and Hillsdale soils which comprise 42 per cent of the area of the county.

Following is a profile description of Miami loam taken in an original maple-beech forested area in the southeastern corner of the NW. $\frac{1}{4}$ sec. 17, T. 4 N., R. 3 W., where the undulating surface relief is typical of Miami loam:

1. A thin accumulation of litter and forest mold.
2. From 0 to 2 inches, dark mellow loam, or humous soil, containing a high percentage of organic matter much decomposed and thoroughly incorporated in the soil. The reaction is medium acid.
3. From 2 to 8 inches, light-gray floury loose loam with a high content of silt and slight development of a platy or laminated structure. The material crumbles easily into a structureless mass. The reaction is strongly acid.
4. From 8 to 16 inches, light-yellow or grayish-yellow loose friable loam, platy in the upper part, becoming granular below. Very acid.
5. From 16 to 36 inches, clay loam breaking into irregular angular particles about one-half inch in diameter. The color of the structure particles is brown but when crushed is yellowish brown. A thin coating of very fine textured brown material on the structure separates accounts for their brown color. When wet the material is sticky; when dry it is difficult to crush between the fingers. The reaction is acid.
6. Imperfectly weathered pale grayish-yellow calcareous heavy sandy loam or loam till, containing a few stones. The material is variable in color, structure, and texture. It is hard when dry.

Table 6 gives the pH values and illustrates the reaction profile of the Miami soils. The hydrogen-electrode method was used in the determinations.

TABLE 6.—*pH determinations of Miami soils in Eaton County, Mich.*¹

Sam- ple No.	Soil type	Depth	pH	Sam- ple No.	Soil type	Depth	pH
304409	Miami silt loam.....	<i>Inches</i> 0-5	6.82	304413	Miami loam.....	<i>Inches</i> 0-2	5.39
304410	do.....	5-12	5.70	304414	do.....	2-8	5.22
304411	do.....	12-30	6.49	304415	do.....	16-36	6.96
304412	do.....	40-50+	8.25	304416	do.....	36-60+	8.33

¹ Determinations by E. H. Bailey, Bureau of Chemistry and Soils.

Table 7 gives the results of mechanical analyses of samples of the surface soils, subsurface soils, and subsoils of Miami silt loam and Miami loam in Eaton County, Mich.

TABLE 7.—*Mechanical analyses of Miami soils from Eaton County, Mich.*

MIAMI SILT LOAM								
No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>				
304409	Surface soil, 0 to 5 inches.....	1.0	4.2	7.7	14.4	8.4	34.3	30.0
304410	Subsurface soil, 5 to 12 inches.....	1.4	4.6	8.2	14.7	8.3	33.9	28.8
304411	Subsoil, 12 to 30 inches.....	.8	3.2	5.7	10.4	6.7	22.3	50.8
304412	Subsoil, 30 to 50+ inches.....	.4	1.4	3.1	6.4	4.9	25.7	58.0
MIAMI LOAM								
304413	Surface soil, 0 to 2 inches.....	1.0	4.2	9.4	16.2	8.8	40.0	20.3
304414	Subsurface soil, 2 to 8 inches.....	.9	4.3	9.6	13.9	8.5	43.7	19.1
304415	Subsoil, 16 to 36 inches.....	1.0	4.2	8.0	17.8	11.4	25.3	32.4
304416	Subsoil, 36 to 60+ inches.....	2.5	7.4	9.6	19.5	12.5	28.9	19.7

Owing to the variable character of the surface relief, drainage, and parent materials of the soils of this region, details of the profile described are departed from, although this profile represents the prevailing profile of the well-drained light-colored soils in most essential respects. The brown colloidal film referred to as covering the structure particles is less noticeable in places, and it is usually less strongly developed in the lower part of the B horizon. Some profiles examined show sufficient differences in the upper and lower parts of the B horizon to justify a subdivision, but this is ordinarily no more than a transitional zone, such as may be expected between horizons. The contacts between the successive horizons are not everywhere so sharp or distinct as in the profile described.

The Hillsdale soils differ from Miami loam in that they have not developed the granular structure which characterizes the B horizons of the Miami soils, the carbonates have been leached to a somewhat greater depth, and the soils throughout are somewhat lighter in texture and more siliceous.

The second subgroup of the well-drained soils, which are characterized by clayey B horizons and unconsolidated sand and gravel substrata, includes the Fox, Bellefontaine, Warsaw, and Tuscola soils. This group represents only 6.1 per cent of the total area of county.

The characteristics common to these soils are the conspicuous red sand, gravel, and clay B horizons and the sand and gravel substrata.

The characteristics of these soils are represented by the following profile description of Fox loam examined about 1½ miles northwest of Bellevue, where the surface is level.

1. Less than 1 inch of litter and leaf mold from deciduous trees.
2. From 0 to 2 inches, loose structureless dark grayish-brown loam stained with organic matter. The reaction is slightly acid.
3. From 2 to 14 inches, dull-yellow loose structureless heavy sandy loam or light loam, which is slightly acid.
4. From 14 to 36 inches, red gritty gravelly sandy clay, in which the clay content is sufficient to render the mass sticky when wet and moderately hard and brittle when dry. The reaction is medium acid.
5. From 36 to 48 inches, a faint yellow and gray open loose sand and gravel mixture which is very strongly alkaline.

The usual variations in the thickness of the several horizons are characteristic of these soils. Where the red clayey horizon is thinner and the surface layer is lighter textured, the sandy loam type is mapped. These soils occupy outwash plains.

The Bellefontaine soils show a profile essentially very similar to that of the Fox soils, but that of the Bellefontaine soils is not so uniform, and these soils occupy a more rolling relief. Also, the substrata are less uniform, consisting of a more heterogeneous mass of sand, gravel, clay, and stones. These soils occupy eskers, kames, and moraines.

Warsaw loam differs from Fox loam in a higher content of organic matter and a thicker darker-colored surface soil.

Tuscola silt loam occupies outwash plains, as do the soils of the Fox and Warsaw series, but it is separated from the Fox and Warsaw soils on the basis of the heavier-textured solum and absence of gravel in the A and B horizons. The Tuscola soil reacts acid to a greater depth than the Fox and Warsaw soils, and it is underlain by fine sand instead of a sand and gravel mixture.

The third subgroup, the open porous sand soils of the well-drained division, occupies less than 2 per cent of the total area of the mineral soils of the county. It includes the Coloma, Oshtemo, and Ottawa soils. The organic content of these soils is slightly lower than that of the heavier-textured soils, and its loss under cultivation is more rapid. Carbonates, if originally present, have been leached to a greater depth in these than in any other soils in the county. An acid reaction may be expected to a depth ranging from 40 to 60 inches.

The Coloma soils occupy rolling morainic positions. They consist typically of loose incoherent sand to a depth of several feet. The sand may be underlain by various mixtures of sand, clay, and stones.

Oshtemo loamy sand is differentiated from the Coloma soils primarily on the basis of its assorted parent materials, its location on outwash plains, and the very faintly developed clayey sand and gravel layer at a depth ranging from 20 to 30 inches beneath the surface. This layer is typically only 1 or 2 inches thick and contains scarcely enough clay to render the material binding when moist. The substratum is of more uniform sand and gravel composition, and more fine gravel occurs in all parts of the profile than is characteristic of the Coloma soils.

Ottawa loamy fine sand consists of open sandy material to a depth ranging from 4 to 6 feet where it is underlain by a clayey substratum.

The fourth subdivision of the well-drained soils is represented by Parma loam which is underlain by indurated bedrock at a depth of less than 6 feet. A characteristic of this soil is the bright-yellow or ocher-yellow color of the clay loam subsoil, or zone of maximum clay content.

The soils which have been subjected to excess moisture conditions either continually or periodically may be subdivided for convenience of discussion and comparison into the following groups: (1) A group comparatively high in clay content in all horizons of the solum and substratum; (2) a group having a comparatively heavy textured solum but an open pervious substratum; and (3) a group composed largely of sand to a depth ranging from 40 to 60 inches but underlain by a clayey substratum.

This division of soils, which is characterized by imperfect natural drainage, represents a little more than 37 per cent of the area of the county. The soils differ considerably as to degree of excess moisture, but none is perfectly drained. The range of organic content and degree of darkness in color is also moderately wide but, with textural variations accounted for, all soils of this division are richer in organic matter and darker colored than are those of the well-drained groups. Leaching has not progressed so far in these soils as in soils of the well-drained groups. With the parent material about the same, the poorly drained soils are richer in total nitrogen, calcium, phosphorus, and potash. With drainage conditions the same, the heavier-textured soils are more basic, and, given similar textural profiles, the most poorly drained soils are more alkaline in reaction. The A_2 , or sub-surface, horizon shows the stronger evidence of leaching, which is more pronounced in the sandier soils. It is also generally true that where the greatest amount of leaching has taken place in this horizon, more intense brown or yellow colors are shown in the next layer beneath. This coloration is not so pronounced in Eaton County as in the northern part of the State, where humic hardpans have developed in some of the poorly drained sandy soils.

Conover loam includes about 50 per cent of the poorly drained division. The natural drainage of this soil is somewhat better than that of the Brookston, Gilford, and Maumee soils but is about equal to that of the Brady, Bronson, Crosby, and Berrien soils.

A representative virgin profile of Conover loam which was examined, in a relatively dry condition, in an area of nearly flat surface relief 1 mile west of Hoytville, Roxand Township, is described as follows:

1. About one inch of partly decayed forest litter.
2. From 0 to 6 inches, grayish-brown loose mellow loam having a nut structure, stained dark with thoroughly incorporated organic matter, containing numerous roots, and giving a slightly acid or alkaline reaction.
3. From 6 to 14 inches, pale yellowish-gray friable loam which breaks into rather hard slightly porous lumps when dry, tends toward a laminated or platy structure, contains some roots, is very low in organic matter, and reacts slightly acid.
4. From 14 to 32 inches, clay loam, breaking into irregular angular lumps from one-fourth to one-half inch in diameter. In color the lumps are mixed splotches of dull yellow, brown, and gray but when crushed are yellowish gray. The material is a little more moist than that in the horizons above, contains some roots, has darker-colored material along the root channels, and is alkaline in reaction.

5. From 32 to 50 inches, friable sandy clay which is lighter textured than the material in the layer above and has an increasing moisture content. The material breaks into irregular lumps of mixed yellow and drab-gray colors, which when crushed are pale yellowish gray. The imperfectly weathered, or upper part, of the parent material, is composed of calcareous glacial till.

This profile is typical of the Conover soils and includes all their important characteristics. Variations in the thickness of the leaf-litter layer, in the color and thickness of the surface horizon, and in the texture of the entire profile are to be expected.

Crosby loam, like Conover loam, is a member of the first group of the poorly drained division, owing to its comparatively heavy texture profile. The Crosby soils differ from the Conover soils in that they have a lighter-colored surface soil, owing to a low content of organic matter, and they probably have a slightly less permeable B horizon. The leaching of carbonates seems to have been more thorough in the Crosby soils which are less productive.

The texture profile of the Brookston soils is very similar to that of the Conover soils, but the Brookston are the most poorly drained soils of this group. The leaf mold and organic content of the surface soil is somewhat greater in the Brookston soils, and they are slightly richer in calcium, nitrogen, phosphorus, and potash. The profiles of the Brookston soils show more drabbish-gray and less yellow and brown colors than do the profiles of the Conover soils.

The second group of the poorly drained soils includes the Brady, Bronson, and Gilford soils, which are characterized by clayey horizons in the solum and by sand and gravel substrata. These soils occupy imperfectly drained parts of outwash plains and old glacial drainage valleys.

Natural drainage of the Brady soils is very similar to the drainage of Conover loam. The Brady soils are characterized by a certain proportion of gravel in the A and B horizons, are underlain by unconsolidated sand and gravel, and occupy a plain.

Bronson loam differs from Brady loam in being slightly better drained, showing more red and yellow coloration in the B horizon, and in having a lighter-colored surface soil with a little lower content of organic matter.

Gilford loam has a Brady texture profile subjected to poorer drainage. It is the most poorly drained member of this group. It is slightly higher in organic matter, has a darker surface soil, and is richer in basic materials than are the Brady soils.

The third group of the poorly drained soils includes the Berrien and Maumee soils which are open and sandy to a depth of 3 feet or more. The total acreage of this group is almost negligible.

The Berrien soils are comparatively low in organic matter, show considerable brown or yellow coloration in the lower part of the solum, and are underlain by heavier-textured substrata.

The outstanding characteristic of Maumee loam is that the surface layer to a depth of 12 inches is composed of about equal parts of mucky material and mineral soil materials. The lower horizons are largely of sand and gravel composition.

The division of alluvial soils represents only 3.1 per cent of the area of the county and includes the Genesee and Griffin soils and Kerston muck. These soils occur only on the flood plains of the

streams. In profile development the Genesee and Griffin soils are the most youthful mineral soils in the county. The source of most of this material is local. These soils are comparatively high in natural fertility, but they differ as to average moisture conditions, organic content, texture, and color.

The Genesee soils occur in the better-drained bottoms, where the organic content is less and the predominant colors are yellow and brown. Little or no mottling is developed in the upper 30 inches.

Griffin loam represents that part of the mineral alluvial material having poor drainage. The organic-matter content is higher and the dominant color is grayish brown, with conspicuous splotches of rust brown or yellow from the surface downward.

More than one-half of the alluvial deposits is correlated as Kerston muck which is characterized by alternate layers of mineral alluvium and muck. The muck is partly transported, but most of it has accumulated in place.

About one-twelfth of the area of the county is covered with organic deposits (peat and muck). These deposits range in thickness from a few inches to more than 25 feet but most commonly are between 3 and 6 feet thick. The mineral substratum is variable, but in most places it is of a sand-clay composition, although marl deposits are rather widely distributed. A very small percentage of these soils is highly acid. Practically all the organic soils have a high organic content, that is, they contain 75 per cent or more of combustible materials. These soils show a wide range in such characteristics as stage of decomposition, texture, structure, color, character of parent material, depth of water table, natural moisture conditions, and chemical composition. On the basis of such characteristics, the deposits have been separated into four broad types, or groups.

Carlisle muck represents about 70 per cent of the organic soils in the county. This is a high-lime muck.

Following is a description of a typical virgin profile of Carlisle muck examined in the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 28, T. 2 N., R. 4 W. The vegetation on this area consists of elm, silver maple, ash, some basswood, and swamp white oak. At the time the sample was taken, the soil was very dry, and large cracks from 6 to 12 inches wide had developed from shrinkage.

1. From 0 to 6 inches, black granular loamy finely divided muck.
2. From 6 to 18 inches, black muck which when dry is rather horny, hard, and tough and when wet is soft, slimy, and pasty. This layer contains many roots and has a tendency to lamination.
3. From 18 to 40 inches, dark-brown partly decomposed mucky material, roots, and woody fragments.

Rifle peat differs from Carlisle muck in that it is not quite so well decomposed, is slightly lower in lime, and in most places the dark color is less intense.

Greenwood peat is yellow or brown in color, little decomposition has taken place, and the material is extremely acid in reaction.

The distinguishing characteristics of Houghton muck are that it occupies treeless marshes and is derived mainly from grasses, sedges, and rushes.

SUMMARY

Eaton County is in the south-central part of the Lower Peninsula of Michigan, near Lansing. The land area is 578 square miles.

The surface features range from nearly level to undulating and rolling. Plains, in part dry and in part swampy, low-rounded hills, broad glacial drainage valleys, and small lakes characterize the surface features. The elevation above sea level ranges from approximately 775 to 1,000 feet.

The county was organized in December, 1837. The 1930 census gives the population as 31,728.

Comparatively few perennial streams traverse the county, and no dendritic drainage system has developed. It is estimated that 50 per cent of the land is naturally sufficiently drained for cultivation, 20 per cent, including peats and mucks, is very poorly drained, and 30 per cent is intermediate in drainage conditions.

The land originally supported a forest cover. A maple-beech type of forest occupied most of the well-drained land, and more oaks grew in the sandier areas. An elm-ash-silver maple association grew on the lower situations. Tamarack, poplar, and willows were common on the organic soils.

Excellent transportation facilities, with four railroads and paved and gravel-surfaced roads, are provided.

The main features of the climate are moderately long cold winters, very pleasant summers, a mean precipitation of about 27 inches (including melted snow), about 35 inches of snowfall, low wind movement, and low evaporation. The average frost-free season is nearly five months.

Farming began in the county about 1833. Agriculture at present consists mainly of growing such crops as corn, oats, and hay, and the keeping of livestock. In conjunction with general farming, one or more money crops, such as wheat, beans, potatoes, or sugar beets, are grown by many farmers. A few poultry, dairy, and truck-crop farms are operated. The size of farms ranges from 40 to 260 acres, 80 acres being the most common size.

About 50 per cent of the soils are naturally well drained. They are comparatively low in organic matter, are light colored, and react acid to a depth ranging from 30 to 50 inches. This group includes the soils of the Miami, Hillsdale, Bellefontaine, Fox, Oshtemo, Warsaw, Tuscola, Parma, Ottawa, and Coloma series, but the first three named include more than 95 per cent of the land occupied by the group.

About 30 per cent of the soils have grayish-brown surface soils, are intermediate in drainage and other respects between the well-drained light-colored soils and the poorly drained dark-colored soils. The Conover, Brady, Bronson, Crosby, and Berrien soils are included in this group.

The dark-colored poorly drained mineral soils include the Brookston, Gilford, and Maumee soils and represent about 7 per cent of the area of the county.

The Genesee and Griffin soils and Kerston muck occupy stream-bottom land and comprise about 3 per cent of the county.

About 9 per cent of the county consists of muck and peat soils. These are classified in four types, Carlisle muck, Rifle peat, Houghton muck, and Greenwood peat.

General public improvements, good homes with modern comforts and conveniences, excellent buildings, and other farm fixtures evidence the success of agriculture as an industry in Eaton County.

Facilities for transportation, travel, and communication are good, and the prevailing wholesome social structure reflects credit on the people of the county. Climatic conditions are healthful, land prices are reasonable, and close proximity to densely populated centers affords an extensive market for a wide variety of farm products.

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