Series 1936, No. 12 Issued February 1942

Soil Survey

Clinton County Michigan

By
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Michigan Agricultural Experiment Station
and
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SOIL SURVEY OF CLINTON COUNTY, MICHIGAN

By G. A. JOHNSGARD, in Charge, T. E. NIVISON, H. T. ROGERS, R. L. DONAHUE, J. T. STONE, and G. M. WELLES, Michigan Agricultural Experiment Station, and M. M. STRIKER, J. W. MOON, and Z. C. FOSTER, Division of Soil Survey,[1] Bureau of Plant Industry, United States Department of Agriculture [2]

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United States Department of Agriculture in cooperation with the Michigan Agricultural Experiment Station

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COUNTY SURVEYED

Clinton County occupies an area of 571 square miles, or 365,440 acres, in the south-central part of the Lower Peninsula of Michigan (fig. 1). St. Johns, the county seat, is 20 miles north of Lansing, the capital of the State.

This county is in the eastern lake section of the Central Lowland physiographic province of the United States. The land surface of the county consists of level to rolling glacial plains. Old lake-bed plains extending westward from Saginaw Bay comprise a small area in the northeastern part. Areas of nearly level land occur on the old lake

[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

[2] J. O. Veatch, Michigan Agricultural Experiment Station, acted in an advisory capacity during the progress of the field work.

plain, till plains, and outwash plains, but the greater part of the county is characterized by low undulations or swells of smooth contour, which grade into shallow depressions with only slight changes in elevation. Long steep slopes are uncommon. Numerous swampy depressions and small lakes occur in the more rolling country, especially in the southeastern part of the county. Old glacial valleys, ranging in depth from 20 to 60 feet, and in width from a few hundred yards to 3 miles, traverse the county in an east-west direction. The Maple River, Hayworth Creek, Stony Creek, and the Lookingglass River, which occupy these valleys, have not greatly altered the original surfaces either by dissection or by deposition. The larger streams have developed very few tributaries. Exceptions occur in the valleys of the Grand and Lookingglass Rivers, but even here sharp dissection is restricted to a strip, in most places less than 1 mile wide, adjacent to the respective river valleys. As a result of this weak development of the natural drainage system, numerous areas of wet land occur both as depressions and as level plains. Figure 3 and table 8, in the section on Land Uses and Agricultural Methods, include a description of the land of this county.

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

The average elevation of the county is slightly less than 800 feet above sea level and 220 feet above the level of Lake Michigan, with a maximum elevation of about 900 feet in the southern part of Bath Township and a minimum of less than 670 feet in the Maple River Valley in the western part of Lebanon Township. Chandler Marsh, in Bath Township, has an elevation of about 845 to 850 feet, and the summit of Bradshaw Hill, in Duplain Township, is about 775 feet above sea level. The elevation in the vicinity of St. Johns ranges from about 800 to 850 feet; at Fowler it is about 750 feet, at De Witt 850 feet, and at Elsie 725 feet.[3]

A dense forest growth, consisting largely of deciduous trees, comprised the cover, which existed when the early pioneers came into this

[3] Data on elevations from U. S. Geological Survey maps.

section. A few small oak openings, commonly referred to as "prairies," were said to have existed; Prairie School northwest of St. Johns is situated in one of these so-called prairie areas. A general correlation existed between the character of the soil and the forest cover. A hard maple-beech type of forest, including associated species, such as hick-

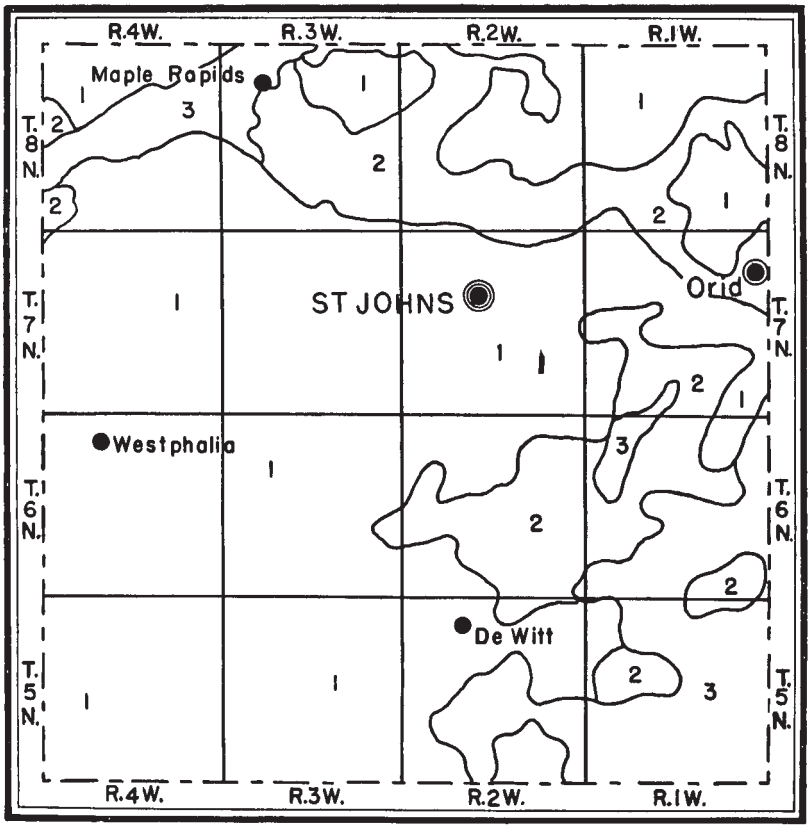

FIGURE 2.—Proportionate distribution of first-class agricultural land in Clinton County, Mich.: 1, 67 percent or more; 2, 33 to 67 percent; 3, less than 33 percent.

ory, oak, elm, ash, basswood, and black cherry, occupied the well-drained uplands, where the soils are of intermediate to heavy texture. As the soils become more sandy, the percentage of oaks increases, and the well-drained soils of sandy loam or lighter texture had a cover in which oaks were dominant. In a few places, white pine grew on the sandiest soils. Poor drainage in the mineral soils favored the elm-ash-red maple-swamp white oak association, with basswood, shagbark hickory, and sycamore less numerous. Soils of intermediate drainage supported mixtures of the species of the well-drained and poorly drained lands in various proportions. Black walnut, butternut, ironwood, sassafras, and cottonwood were scattered through the forests.

The vegetation in the muck and peat swamps varied with the degree of decomposition of the organic materials making up these soils and the height of the water table. The drier deposits, which generally are made up of highly decomposed materials, formerly had a forest cover

similar to that on the poorly drained mineral soils. The more poorly drained deposits, in which less decomposed materials occurred, supported a tamarack cover, together with aspen, willow, red maple, and various shrubs. The wettest sites, occupied by very slightly decomposed materials, supported a leatherleaf-heath bog type of vegetation or a marsh sedge and grass cover.

Early lumbering operations and subsequent clearing of the land have left only scattered wood lots as remnants of the original forest cover. Most of the wood lots consist of second growth rather than virgin forest. A considerable proportion of the swampland has been allowed to remain in forest.

The first recorded settlement in Clinton County was made in 1826 at the site of the village of Maple Rapids, by George Campau, for the purpose of trading with the Indians. At the time of this first settlement the Government Land Survey of the county had not been completed, but the principal meridian had been surveyed in 1824, and the county survey was completed in 1831. Numerous scattered settlements were made in most parts of the county during the period 1832–40, and from that time on the number of settlers increased rapidly for the next 40 years (*1*).[4]

Clinton was chosen as a name for the county when it was organized March 12, 1839, in honor of De Witt Clinton, of Erie Canal fame. The county seat was originally located at De Witt, and the transfer to St. Johns, the present county seat, took place in December 1857 (*1*).

New York, Pennsylvania, the New England States, Ohio, Indiana, and other parts of Michigan contributed the greater number of the early settlers. The present population is distributed more or less uniformly, but it is concentrated to some extent in the southern part of the county, suburban to the city of Lansing. The density of settlement of rural areas seems to correlate closely with the quality of the land. The better lands support a denser and for the most part a more thrifty population than the poorer lands. Some of the poorer lands have been more densely settled in the past, but the fact that a considerable decrease in population has taken place is suggested by numerous abandoned farms and few that are newly established.

A total population of 24,174, of which 83.7 percent, or 20,245 people, are classed as rural, is reported by the 1930 census. This same census reports the density of population as 42.3 persons per square mile. The 1935 census reports the farm population of 13,787 as 100 percent white.

St. Johns, the county seat, with a population of 3,929 in 1930, is the largest town and the business center of the county. A market for peppermint oil and a stockyard that specializes in the distribution of kosher meat to eastern markets are two of the unusual business enterprises of this city. St. Johns is essentially a rural market dependent largely on the farm trade for its existence. Other towns conveniently located as trading points are Ovid with a population of 1,131, Elsie with 664, Maple Rapids with 476, Fowler with 561, Bath, Shepardsville, and Eagle. The towns of Westphalia, De Witt, Wacousta, Eureka, Hubbardston, and Matherton (the last two partly in Ionia County) lack railroad facilities but nevertheless are important local markets and trading centers. De Witt is the site of a meat-packing company, which is of considerable importance as a local livestock market.

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[4] Italic numbers in parentheses refer to Literature Cited, p. 71.

Transportation facilities are good. Four railroads, the Ann Arbor, Grand Trunk, Pere Marquette, and Michigan Central, connect most of the towns and serve as convenient means of trading with large markets outside the county. Some points in the south-central and northwestern parts of the county are from 15 to 20 miles from railroad shipping points, but a system of paved highways and gravel-surfaced roads makes marketing by motortruck comparatively easy. Probably 95 percent of the township roads, which follow almost all of the section lines, are surfaced with gravel.

Most farm products are transported by truck to local and other markets in the State. Most of the sugar beets grown are transported by truck to a sugar factory in Lansing.

A good system of rural grade schools has been developed, and all the larger towns have high schools. Churches are common in the rural districts, and numerous township halls are used as centers for community enterprises. Electrification of the rural communities has been taking place at a rapid rate, and electricity is available on a large number of the farms. Rural free delivery of mail reaches all sections, and telephones are common in the rural districts as well as in the towns.

Industrial plants in Lansing, particularly the automobile factories, afford work for many residents of Clinton County. Mining is of very little importance, but some coal is mined in the southwestern part of the county along the Grand River. Some small factories in St. Johns and towns adjacent to the county furnish labor for a small number of individuals.

CLIMATE

The climate of Clinton County is somewhat insular in character because of the proximity of the Great Lakes. The influence of these bodies of water on the climate, however, is much greater in the areas immediately adjacent to the lakes. The salient features of the climate are moderately cold winters and mild, pleasant summers, with moderate precipitation and low wind movements. Periods of extremely hot or cold weather usually are of short duration.

Precipitation is almost uniformly distributed throughout the year, with the amount during the winter slightly below that during the other seasons. The summer rains usually are not of a beating nature, and in the fall and spring the precipitation often takes the form of slow, misty, drizzly rains. Torrential rains and destructive hailstorms are rare. Precipitation during the growing season is sufficient to insure satisfactory growth of most crops, although crops on the sandier soils often suffer to a certain extent from shortage of moisture during the hottest part of the summer. The time of planting of some crops, particularly on the nearly level areas of heavy soils, is often delayed because of excessive rains in early spring. Fall rains sometimes interfere with harvesting operations. Some injury due to freezing and thawing, which cause heaving of fall-sown crops and perennials, is noticeable, particularly on the poorly drained soils, but the covering of snow generally is sufficiently thick to prevent severe injury.

Differences in elevation are insufficient to cause marked climatic variations throughout the county, but local variations are of considerable importance as regards the production of special crops. Crops in the moister depressions, particularly on the organic soils, are subject

to greater frost injury than similar crops on the higher lying and drier sites.

No Weather Bureau station is situated in Clinton County, but the data from the stations at Owosso, Shiawassee County, about 15 miles east of the eastern boundary of Clinton County, and at East Lansing, Ingham County, are believed to be fairly representative of climatic conditions in this county.

The average frost-free period at Owosso covers 144 days, with the average date of the latest killing frost on May 12 and the average date of the earliest on October 3. Killing frosts have occurred as late as June 24 and as early as September 10, but these extreme variations from the average are not common. Most crops are capable of growing before and after the dates for killing frosts given by the Weather Bureau, and frost injury of the common field crops is rare. The average length of the frost-free season at East Lansing is 160 days, extending from May 4 to October 11. The latest and earliest frosts recorded at this station are May 28 and September 8, respectively.

Prevailing winds are from the southwest, and winds of high velocity are uncommon; tornadoes are extremely rare. High humidity exists throughout the year, but the atmosphere usually is not uncomfortably humid. The sunshine ranges from 65 to 70 percent of the possible amount during the summer and from 20 to 25 percent of the possible amount during the winter.

Tables 1 and 2 give the normal monthly, seasonal, and annual temperature and precipitation as recorded at the United States Weather Bureau stations at Owosso and East Lansing.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Owosso, Shiawassee County, Mich.*

[Elevation, 739 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1903)	Total amount for the wettest year (1921)	Snow, average depth
	° F.	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	26.9	62	−14	1.65	0.70	2.71	7.9
January	23.3	62	−22	1.74	1.20	.46	10.1
February	22.8	68	−26	1.47	2.30	1.32	9.0
Winter	24.3	68	−26	4.86	4.20	4.49	27.0
March	33.6	83	−8	2.24	.20	4.43	6.0
April	46.2	88	8	2.55	3.20	5.08	1.2
May	58.1	95	20	3.41	.80	.84	.3
Spring	46.0	95	−8	8.20	4.20	10.35	7.5
June	67.4	101	31	2.91	.80	3.24	.0
July	72.7	104	40	3.24	1.70	1.66	.0
August	69.9	103	37	2.54	2.80	7.67	.0
Summer	70.0	104	31	8.69	5.30	12.57	.0
September	63.8	99	27	3.03	1.45	5.08	.0
October	51.6	90	15	2.71	.40	4.25	.1
November	38.6	76	−1	2.46	1.10	3.03	2.4
Fall	51.3	99	−1	8.20	2.95	12.36	2.5
Year	47.9	104	−26	29.95	16.65	39.77	37.0

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Lansing (East Lansing), Ingham County, Mich.*

[Elevation, 856 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1930)	Total amount for the wettest year (1883)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	27.2	70	−25	2.07	0.91	1.36	9.6
January	22.4	65	−26	1.82	2.53	1.53	11.5
February	22.9	66	−25	1.90	1.41	4.50	10.7
Winter	24.2	70	−26	5.79	4.85	7.39	31.8
March	32.2	82	−14	2.35	1.47	.71	8.3
April	45.6	88	3	2.58	1.97	1.90	1.7
May	56.9	96	23	3.42	3.36	5.66	.4
Spring	44.9	96	−14	8.35	6.80	8.27	10.4
June	66.4	99	33	3.51	2.79	11.35	.0
July	70.9	102	37	3.10	.50	11.27	.0
August	68.5	102	30	2.82	.18	.18	.0
Summer	68.6	102	30	9.43	3.47	22.80	.0
September	61.4	99	21	2.91	1.42	2.34	(1)
October	50.3	90	7	2.47	1.00	3.66	.4
November	37.5	75	−4	2.48	.96	3.98	4.6
Fall	49.7	99	−4	7.86	3.38	9.98	5.0
Year	46.8	102	−26	31.43	18.50	48.44	47.2

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

The first permanent settlements were made in the decade 1830–40 by emigrants from New York, Pennsylvania, the New England States, Ohio, and the previously settled parts of Michigan (*1*). Early agriculture was of necessity of a subsistence type, including the growing of such crops as corn, potatoes, and wheat for home consumption. An income sufficient to supply materials that could not be produced on the land was derived from the sale of farm crops, livestock, furs, alkaline salts from wood ashes, and lumber.

The influx of settlers was steady for several decades, and the land cleared for cultivation was greatly increased until about 1900, when a maximum area was included in farms. As clearing of the land progressed and facilities for trading improved, a change toward a more extensive type of agriculture took place, with an increase in the production of corn, wheat, hay, oats, potatoes, and livestock. The early settlers followed a system of agriculture similar to that carried on in the sections from which they emigrated, but changes were made in response to the capabilities of this new land and a rather uniform diversified system of farming developed.

Industrial expansion and the introduction of new crops have had a marked influence on agricultural practices. Development of city markets for dairy products and special crops, which has accompanied industrial expansion, has been important in bringing about changes in types of farming. Introduction of new crops, such as alfalfa and sugar beets, together with greatly increased acreages in field beans,

and a decrease in the acreage of wheat have been important changes during recent years. The acreage of wheat has been reduced from 70,165 acres in 1879 to 30,418 acres in 1934, and there has been an increase in the acreage of field beans, corn, hay crops, oats, and several other crops of less importance, such as barley, rye, and grapes. Production of such special crops as peppermint, of truck crops, such as onions, and of sugar beets has increased greatly in the last two decades, but the total area used for these crops is still comparatively small. Table 3 gives the acreage devoted to the principal crops in Clinton County in stated years from 1879 to 1934, as reported by the Federal census.

TABLE 3.—*Acreage of the principal crops in Clinton County, Mich., in stated years*

Crops	1879	1889	1899	1909	1919	1929	1934
Corn:	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
For grain	20,420	25,880	35,638	36,463	30,181	10,211	23,016
For silage					5,896	5,949	[1] 11,536
For forage			660	955	6,982	10,358	
Oats	14,487	32,386	31,179	36,045	33,919	23,863	31,647
Wheat	70,165	54,410	63,224	26,979	34,521	37,241	30,418
Barley	944	1,446	922	3,152	8,822	8,597	4,974
Rye	25	427	677	3,822	8,117	985	1,461
Dry beans			5,068	17,782	13,980	30,393	31,588
All hay	29,761	45,094	47,725	49,582	51,442	41,080	70,157
Timothy				17,029	8,219		
Timothy and clover				26,672	37,798	22,967	19,346
Clover alone			10,553	3,884	3,529	8,379	443
Alfalfa			18	112	1,043	8,948	17,734
Other tame grasses			36,158	394	334	375	[2] 1,560
Wild grasses			668	349	382	123	
Grains cut green			328	1,142	110	118	585
Annual legumes					27	170	30,489
Potatoes	2,355	2,680	2,512	2,112	1,452	1,205	2,112
Sugar beets			78	788	1,978	500	2,985
Strawberries			111	62	53	51	57
Raspberries			95	38	52	57	
	Trees	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*
Apples		231,087	252,030	157,212	62,573	46,577	53,268
Peaches		9,821	44,323	19,268	4,710	3,141	3,339
Pears		6,115	11,730	8,057	3,073	2,353	3,335
Plums and prunes		7,026	23,477	4,964	3,785	4,327	4,289
Cherries		20,056	28,541	8,382	6,040	4,735	5,352
	Vines	*Vines*	*Vines*	*Vines*	*Vines*	*Vines*	*Vines*
Grapes			10,814	6,261	7,677	8,425	12,718

[1] For silage and forage.
[2] Includes wild grasses.

Table 4 gives the value of agricultural products, by classes, in 1929, and the value of livestock in 1930, as reported by the Federal census.

TABLE 4.—*Value of agricultural products, by classes, in Clinton County, Mich., in 1929, and value of livestock in 1930*

Crops	Value	Livestock and livestock products	Value
Farm garden vegetables (for home use only)	$45,004	All domestic animals	$3,353,064
Forest products, cut on farms, for home use and for sale	199,149	Dairy products sold	1,578,046
Cereals	1,552,067	Poultry raised and eggs produced	819,795
Other grains and seeds	1,064,590	Bees	6,799
Hay and forage	785,853	Honey	8,518
Vegetables (including potatoes and sweetpotatoes)	119,663	Wool	116,804
Fruits and nuts	91,210	Total	5,883,026
All other field crops	150,348	Total agricultural products	9,890,910
Total	4,007,884		

Table 5 gives the number of livestock on farms and ranges, as reported by the Federal census in 1930 and 1935. These numbers are not fairly comparable, as the 1930 census reports the number as of April 1, which includes the spring increase, and the 1935 census reports the number as of January 1, before the spring increase.

TABLE 5.—*Number of domestic animals on farms and ranges in Clinton County, Mich., as reported by the Federal census for 1930 and 1935*

Kind of livestock	April 1, 1930	January 1, 1935	Kind of livestock	April 1, 1930	January 1, 1935
Horses	8,494	8,062	Swine	20,102	13,692
Mules	217	189	Chickens	202,024	214,048
Cattle	26,794	25,799	Bees (hives)	1,259	--------
Sheep	65,930	46,021			

An increase in the number of dairy cattle has taken place, with a subsequent decrease in the number of beef cattle. Sheep, swine, and chickens have decreased in number since 1920. Horses have declined in number, but they still supply the power for farm operations on most farms. The 1935 census reports the number of cows and heifers 2 years old or over on farms on January 1 as 16,648, of which 16,066 were milked in 1934, producing 8,203,525 gallons of milk. The butter churned on farms in 1934 amounted to 106,247 pounds. Wool shorn in 1934 amounted to 348,690 pounds. Chickens raised in that year numbered 284,905, and 1,720,100 dozens of eggs were produced.

The present system of farming is of a general type, with a sufficient variety of crops grown to insure an income under most conditions. Production of special crops is carried on by some farmers in the regular farming program in conjunction with the growing of the common farm crops, but there are also a small number of special-crop farms. Fruits (mainly apples), truck crops, and peppermint are special crops furnishing an income to a small number of farmers. Vegetables, tree fruits, and small fruits are grown on most farms for home consumption.

Livestock of good quality is raised on most farms. The Holstein-Friesian, Guernsey, and Jersey breeds of dairy cattle are common, and Shorthorns, locally called Durhams, are the most popular dual-purpose and beef breed. Duroc-Jerseys, Chester Whites, and Poland Chinas outnumber the other breeds of swine, and sheep of the Shropshire, Hampshire, and Southdown breeds are very popular. Good horses showing the characteristics of the Belgian and Percheron breeds are most common. Chickens are the most common type of poultry, with the Barred Plymouth Rock, White Leghorn, and Rhode Island Red breeds outnumbering others. Turkeys, ducks, geese, and guinea fowls are raised on some farms.

The use of commercial fertilizer has greatly increased during the last 25 years. The 1910 census figures show only 5.8 percent of the farms spending an average of $24.98 for fertilizers, whereas the 1930 census shows 66.4 percent of the farms spending an average of $73.70 for fertilizers. In spite of this increase, most farms depend largely on barnyard manure to maintain the productiveness of the soil. Applications of commercial fertilizers are generally below those recommended

for maximum returns, and the analysis of the fertilizer materials is given insufficient consideration. Most commercial fertilizers are sold as complete fertilizer, although some farmers apply only one or two of the common fertilizer components where necessary. Special crop production demands fertilizers of special types and analyses.

Liming of the sandier soils for alfalfa and red clover has almost invariably given good results. The dark-colored heavier textured soils are not in great need of lime, but some good results have been obtained from liming the better drained lighter colored heavy soils, such as Miami loam. Marl, which may be obtained locally, beet-sugar factory lime, and ground limestone are the most common liming materials.

Farm labor is supplied largely by the farm operators and their families or by local laborers. Some Mexicans and other foreign laborers are employed in the sugar-beet fields.

The 1935 census gives the average size of farms as 107.1 acres. Farm units of 80 acres are the most common. Some farms include less than 40 acres or more than 160 acres. According to the 1930 census, farms had an average value of $10,238 in that year, distributed as follows: Land 37.4 percent, buildings 42.1 percent, implements 8.8 percent, and domestic animals 11.7 percent. A marked reduction in the percentage valuation of land, as compared with other items in the farm unit, has taken place within the last 30 years. Farm values at the time of the survey (1936) were somewhat lower than in 1930.

The tendency has been toward larger farms during the last two or three decades, but the total area of land in farms has actually decreased from 97.5 percent of the total area of the county in 1900 to 93.2 percent in 1935. Increased size of farms has been brought about by combination of smaller holdings to make more economical farming units and is probably a result of the introduction of power machinery combined with a change toward a slightly more extensive type of agriculture.

The 1935 census reported 3,181 farms in the county on January 1, of which owners operated 75.4 percent, tenants 24.4 percent, and managers 0.2 percent. There was a slight increase in tenancy between 1930 and 1935, and a much greater number of farms were operated by tenants in 1935 than in 1880. The most common system of rental is the crop-share system, in which the landowner furnishes the land, the tenant furnishes the labor, and the other expenses are divided. Cash rental also is fairly common.

Most of the farm buildings are large, of good construction, and kept in good repair. There is a correlation between the quality and size of farm buildings and the quality of the soils, as most of the good buildings are on the better soils.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or

railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [5] and its content of lime and salts are determined by simple tests.[6] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a soil map but must be mapped as (4) a complex.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Miami, Hillsdale, and Coloma are names of important soil series in Clinton County.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Miami loam and Miami silt loam are soil types within the Miami series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type there may be areas that are adapted to the use of machinery and the growth of culti-

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[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[6] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

vated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a slope phase or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Clinton County differ greatly in texture, color, natural fertility, and chemical and physical composition. Intermediate and heavy-textured soils are dominant, with loams occupying about 60 percent of the total area, soils heavier than loam about 20 percent, and sandy loams and sands collectively about 11 percent. Heavy clays and loose incoherent sands are of small areal extent. Organic soils occupy about 8 percent of the county, and lakes and streams comprise less than 1 percent.

Physical properties, such as consistence and moisture-holding capacity, are determined largely by the texture, structure, and composition of the soil material, and natural drainage is of major significance in the determination of soil colors. Poor drainage allows an increased accumulation of organic matter in the surface soil, with the result that the poorly drained soils are generally darker than soils developed under better drainage. Natural fertility is influenced greatly by both the texture of the soil materials and the drainage conditions under which the soil has developed. Poorly drained soil materials of intermediate to heavy texture have maintained the largest supply of the common plant nutrients. The intermediate to heavy-textured soils are notably the most productive for general crops.

The uncultivated or undisturbed well-drained soils possess the following layers, or horizons: (1) Dark-gray or dark grayish-brown surface material containing a high proportion of organic matter and generally less than 3 inches thick; (2) a light brownish-yellow or light yellowish-gray horizon low in content of organic matter and clay; (3) yellowish-brown or reddish-brown more or less sticky and compact material higher in clay than any other part of the soil profile. These three horizons, combined, in few places are more than 4 feet thick, and they overlie unconsolidated materials ranging in texture from coarse sand and gravel to heavy clay loam. Some of the extremely sandy materials may not display the compact clayey horizon, and the degree of development of all horizons differs greatly in materials of different textures. The well-drained soils are acid in the upper horizons, but a plentiful supply of lime occurs at depths of 3 to 4 feet. The underlying glacial drift is easily penetrated by the roots of most plants. As

poorer drainage conditions are approached the following changes take place in the soil profile: (1) The surface horizon becomes thicker and darker, (2) gray and yellow colors become more prominent below the surface layer, (3) the contrast between horizons below the surface layer becomes less marked, and (4) the reaction of the surface soil tends to approach neutrality. The most poorly drained mineral soils possess the following type of profile: (1) Very dark gray or black material, high in organic matter, and in many places more than 5 inches thick; (2) a horizon of gray or bluish-gray materials, mottled with yellow and rust brown, grading into materials similar to those underlying the well-drained soils, with no sharp line of demarcation. Organic soils—peats and mucks—merely represent an excessive accumulation of organic materials over the mineral soil materials as a result of very poor drainage or the filling of former lakes with vegetation.

The agriculture of Clinton County consists largely of diversified general farming. Winter wheat and field beans are the principal cash crops, with some corn, hay crops, oats, and barley sold for cash but more commonly marketed through the sale of livestock and livestock products. Sugar beets and special crops, such as peppermint, onions, and fruits, are sources of cash income on many of the farms in addition to the common agricultural crops. A small number of farms devoted entirely to the production of special crops are in various parts of the county.

Soil conditions play an important part in the determination of the most satisfactory type of agricultural practices. The distribution pattern of soil types is rather complex, but the ordinary rectangular land divisions are generally characterized by an association of soils that can be well placed into use as a farm unit. The field boundaries follow soil boundaries in only a few places. General farming is practiced in all parts of the county with only slight modification from one place to another in response to local soil conditions. The soils are of medium to high fertility for this part of Michigan, and the common agricultural crops are grown with good to excellent results. Over most of the county the range of soil conditions on any one farm is not sufficient to complicate farming operations greatly, and most of the common farm crops respond well over a fairly wide range of soil conditions. Such crops as sugar beets and field beans produce better on the imperfectly drained soils of intermediate to heavy texture, and some special crops are grown with good success on soils of rather definite character. The character of the soil has much to do with determining the location of special-crop farms as well as the specific area occupied by special crops on the general farms.

The soils of this county are divided into three main groups according to their location and composition: (1) Mineral soils of the uplands and terraces; (2) soils of the stream bottoms; and (3) organic soils.

In the following pages the different soils are described in detail and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in Clinton County, Mich.*

Soil type	Acres	Percent	Soil type	Acres	Percent
Miami loam	64,192	17.6	Gilford loam	3,904	1.1
Miami loam, rolling phase	21,504	5.9	Granby loamy sand	1,280	.4
Miami silt loam	14,592	4.0	Maumee loam	640	.2
Hillsdale sandy loam	5,504	1.5	Berrien-Griffin complex (stony)	384	.1
Hillsdale sandy loam, rolling phase	3,328	.9	Washtenaw loam	7,680	2.1
Hillsdale loam	2,688	.7	Wallkill loam	1,856	.5
Bellefontaine sandy loam	7,296	2.0	Brookston-Washtenaw complex	8,128	2.2
Bellefontaine loamy sand	1,792	.5	Genesee fine sandy loam	448	.1
Coloma loamy sand	1,472	.4	Genesee loam	256	.1
Ottawa loamy fine sand	896	.2	Griffin sandy loam	1,088	.3
Fox sandy loam	10,816	2.9	Griffin clay loam	3,072	.8
Fox loam	2,048	.6	Griffin loam	2,752	.8
Oshtemo loamy sand	6,528	1.8	Kerston muck	768	.2
Plainfield sand	384	.1	Carlisle muck	8,000	2.2
Hillsdale-Oshtemo complex (stony)	1,216	.3	Carlisle muck, shallow phase	3,456	.9
Conover loam	51,456	14.1	Carlisle muck, burned phase	256	.1
Conover silt loam	34,240	9.4	Rifle peat	10,368	2.8
Brady loam	11,968	3.3	Rifle peat, shallow phase	320	.1
Brady sandy loam	1,792	.5	Rifle peat, burned phase	3,776	1.0
Bronson loam	8,768	2.4	Houghton muck	4,224	1.2
Berrien sandy loam	8,320	2.3	Houghton muck, burned phase	320	.1
Berrien loamy sand	2,624	.7	Gravel pits	256	.1
Brookston clay loam	18,112	4.9			
Brookston loam	16,896	4.6	Total	365,440	------
Macomb loam	3,776	1.0			

MINERAL SOILS OF THE UPLANDS AND TERRACES

Natural drainage affords the most satisfactory basis upon which to group the mineral soils of the county in regard to their capability for use. For convenience of discussion the upland mineral soils are subdivided into the following groups: (1) Well-drained soils, (2) imperfectly drained soils, (3) poorly drained soils, and (4) soils of the upland depressions.

The group of well-drained soils is more extensive than any of the other groups, and the soils of the Miami series are the most extensive in this group. The Conover soils dominate the intermediate drainage group, and members of the Brookston series are the most widely distributed of the poorly drained soils. The soils of these three series collectively occupy more than 60 percent of the total area of the county, and they are very important in the determination of the type of agriculture practiced.

WELL-DRAINED SOILS

Most of the well-drained soils occupy land that is sufficiently sloping to insure free external drainage. Some of the soils developed from sandy and gravelly materials on nearly level surfaces also exhibit good drainage characteristics. The soils of this group are comparatively light in color, low in content of organic matter, more or less acid in reaction, subject to considerable seasonal variation in moisture content, and, because of the relief of most of them, are subject to more or less water erosion. The character of the land surface where these soils occur is such that numerous minor variations in depth of horizons, texture, and color must be included within each soil type, but each area outlined on the map represents a unit within which the range of soil conditions is comparatively narrow.

Textures in the soils of this group cover a wide range, but loams and sandy loams are dominant. The physical composition is such that good tilth can usually be maintained.

Fertilization with barnyard manure gives very good results, and commercial fertilizers (*9*, *10*) have been successfully used for most crops. Good management practices, including crop rotation and methods of organic matter maintenance, such as the use of green-manure crops, must be followed if yields are to be increased or even maintained. In some soils good management may result in building the soil above its natural productivity level. Liming is essential for best results in the growing of most crops on the sandier well-drained soils (*12*).

About 85 percent of the area occupied by the soils of this group is used for the production of crops. The largest acreage is used for growing small grains and hay crops, and a fairly extensive acreage is used for growing corn and beans. The system of crop rotation practiced on most farms results in poor use of some of these soils, particularly the more steeply sloping areas, which are subjected to considerable erosional activity where they are clean cultivated.

The members of the Miami, Hillsdale, Bellefontaine, Fox, and Oshtemo series collectively occupy about 97 percent of the area of well-drained soils and have much to do with determining the type of agriculture practiced in this county. The Coloma, Ottawa, and Plainfield soils and the Hillsdale-Oshtemo complex make up the remaining 3 percent. The Miami soils represent the heaviest textured members of the group; the Hillsdale, Bellefontaine, and Fox soils are of intermediate textural range; and members of the Oshtemo, Coloma, Ottawa, and Plainfield series include the sandiest soils. The Miami, Hillsdale, Bellefontaine, and Coloma soils occupy areas of undulating to rolling relief, and in general the Fox, Oshtemo, and Plainfield soils occupy almost level land. The Ottawa soil may occur in either sloping or level areas. The Hillsdale-Oshtemo complex includes a considerable range of relief and occurs along the Maple River Valley in the northwestern part of the county.

Miami loam.—The profile of cultivated Miami loam consists of the following horizons: (1) To plow depth, medium grayish-brown friable loam, slightly acid in reaction and medium to low in organic matter; (2) light grayish-yellow friable loam, medium to strongly acid in reaction and generally not more than 6 inches thick; (3) yellowish-brown compact clay loam, sticky when wet, but breaking to firm angular particles, less than one-half inch in their greatest dimension, when dry. This material is medium to slightly acid in reaction and continues to a depth of 3 to 4 feet, where it grades into (4) yellowish-gray calcareous loam or clay loam parent material having a coarser structure than that in horizon 3. A small quantity of gravel and a few stones are common throughout the entire soil mass. Roots of the common crop plants penetrate the soil with ease, and many reach a depth of more than 5 feet. The greatest concentrations of roots are in horizons 1 and 3.

Soil having this profile, or slight variations from it, covers a large proportion of the area mapped as Miami loam; but numerous variations, individually of small extent but collectively occupying from 25 to 50 percent of some areas, occur as part of the unit. Included small depressions and level areas in many places approach the Conover and

Brookston soils in profile characteristics. Some small sandy spots resembling the Hillsdale and other sandy soils are included. Erosion has two primary effects, namely, (1) removal of the surface horizons, with consequent exposure of the underlying clay loam material, and (2) deposition of material on the lower slopes and in depressions. The latter soil condition is mapped as Washtenaw loam where the areas are sufficiently large to be mapped as separate units.

Although Miami loam occurs in nearly all parts of the county, it is best developed and most extensive in the southern townships. It is more extensive than any other soil and occupies a total area of 100.3 square miles. Most of the individual areas are large.

Miami loam is developed from calcareous glacial drift on undulating to gently rolling land. The high clay content of horizon 3 insures retention of moisture.

The original forest cover on this soil consisted largely of beech, sugar maple, and oak, with some elm, hickory, ash, basswood, and wild cherry; but only scattered wood lots including largely second-growth trees of the original species remain.

Although Miami loam is lower in content of essential plant nutrients and lower in moisture-retaining capacity than some of the more poorly drained soils, it is well above the average for the group of well-drained soils in both respects. The soil mass is easily penetrated by roots, and the presence of an abundance of lime at a comparatively slight depth insures sufficient of this material for most plants. Good tilth can be maintained with little difficulty. Possibly 90 percent of this soil is used for the production of cultivated crops. The fact that this soil constitutes a large part of many of the good farms of the county indicates that it has responded well to the common practices of farm management. All the important crops are grown, with cereals dominant. Wheat, with an average acre yield of about 20 bushels; oats, with a yield of about 45 bushels; hay crops; and beans, with a yield ranging from 12 to 15 bushels, collectively occupy between 60 and 80 percent of the total area, and other cereal crops and corn occupy a fairly large acreage. Apple orchards and gardens are productive on this soil.

Barnyard manure and green-manure crops almost invariably give good results, and commercial fertilizers have come into popular use (*9*, *10*). Complete fertilizers, such as 4-16-4, 2-12-6, 2-12-2,[7] are the mixtures most commonly used. Phosphoric acid, applied largely as superphosphate, and nitrogen, applied as sulfate of ammonia or as nitrate of soda, are in common use where complete fertilizers are not necessary. Most cereal crops respond well to the proper use of commercial fertilizer, and corn and hay crops have responded well on many farms. Applications ranging from 100 to 250 pounds of these fertilizers to the acre at the time of seeding or as a top dressing are most common. Lime is beneficial on many areas in establishing a stand of alfalfa and some of the clovers.

Growing intertilled crops and failure to maintain a cover crop during the winter in many places result in severe sheet erosion. Practices that maintain or increase the supply of organic matter are recommended. Drainage of wet spots associated with this soil is accomplished by means of tile and open ditches.

[7] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

Miami loam, rolling phase.—Miami loam, rolling phase, is distinguished from Miami loam primarily on the basis of relief, or lay of the land. The rolling phase includes the Miami soil on rolling to hilly land, and some slopes may exceed a gradient of 15 percent. The profile of the rolling phase is very similar to that of the typical soil, but generally is less thick, and the underlying drift contains a higher percentage of coarse materials. Transitional areas, in which the soils resemble the Bellefontaine and Hillsdale soils, are common, and some areas with a gradient less than that most typical of this soil are included because of their small size.

This soil is most extensive in the southeastern part of the county, where it occupies rounded hills of the terminal moraines and till plains. Locally, very steep short slopes are included. The aggregate area of Miami loam, rolling phase, is 33.6 square miles.

The lay of the land allows rapid run-off, so that both sheet and gully erosion have damaged many cultivated fields. As a result of the increased run-off, the moisture-retaining capacity is lower than in Miami loam.

The forest cover is similar to that on Miami loam, with possibly a higher proportion of oaks. A larger proportion of this land remains in forest and permanent pasture than of Miami loam, but most of the area is used with the associated soil for the common range of crops. Yields are generally lower than those obtained on typical Miami loam, and management practices that retard erosion are essential for best results. Any extensive areas of this soil would probably be used to the greatest advantage as pasture or forest. In the areas where this soil is associated with other hilly soils and where swampy depressions are common, the fields are of irregular pattern and heavy machinery is used with difficulty.

Miami silt loam.—The profile of Miami silt loam is similar to that of Miami loam, but a higher percentage of silt and clay is present throughout the soil mass. Horizon 3 occurs at slighter depth and in many places has a less uniform brown color than in Miami loam. Miami silt loam has a slightly higher content of organic matter in the plow soil than Miami loam and contains a greater supply of the essential plant nutrients as well as being more retentive of moisture and slightly less acid in reaction. The two soils occupy areas of similar range in relief, but Miami silt loam occurs most commonly on the till plains as slight undulations in association with Conover silt loam and the Brookston soils. Variations similar to those in Miami loam are common, but the proportion of Conover transitional soils is higher in the areas mapped as Miami silt loam, and as a result of the gentler slopes a lower proportion of the land is eroded.

Miami silt loam occupies a total area of 22.8 square miles, largely in the central and western parts of the county. An area of somewhat heavier texture than the average for this soil occurs west of Fowler on what is locally called Hickory Ridge. This heavier textured soil should be more carefully managed than the more extensive areas of Miami silt loam.

A system of crop rotation and management similar to that employed on Miami loam is most common on Miami silt loam. The somewhat better suitability of this soil than of Miami loam to beans and corn,

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together with its close association with the Conover and Brookston soils, has resulted in an increase in the acreage of these crops. The cereals and hay crops do very well, and yields of all the common crops are somewhat higher than those obtained on Miami loam. Heaving of winter crops, due to alternate freezing and thawing of the ground, is somewhat more common than on Miami loam.

Almost all of this soil is used for cultivated crops, and the farms on which it occurs are generally prosperous. The area of heavier textured Miami silt loam west of Fowler is slightly lower in quality than the general run of this soil for the production of most crops. Some small farm wood lots, composed of trees similar to those in wood lots on Miami loam, but including a slightly larger proportion of elm and shagbark hickory, are on this soil.

Good tilth is maintained with little difficulty, but cultivation under proper moisture conditions is important. The slope is sufficient to insure free run-off without serious erosional losses, but drainage of the associated depressions, by means of tile and open ditches, is beneficial.

Hillsdale sandy loam.—In cultivated areas of Hillsdale sandy loam the profile has the following horizons: (1) To plow depth, light grayish-brown friable sandy loam, medium to strongly acid in reaction and containing a low to medium percentage of finely divided organic matter; (2) light grayish-yellow friable sandy loam, strongly acid in reaction and from 8 to 12 inches thick; (3) yellowish-brown compact sandy clay loam, somewhat sticky when wet but breaking into firm irregular particles that crumble readily when dry. The material in this horizon is medium to strongly acid in reaction. (4) At a depth ranging from 40 to 50 inches the material consists of limy yellowish-gray friable sandy loam or clayey sandy loam glacial drift. Gravel is common throughout the soil material, and some larger stones occur in some areas. Roots of the common plants penetrate all parts of the soil, but horizons 1 and 3 are definite zones of root concentration.

This soil occurs in small bodies with a rather small total area. Few of the bodies, which occur in most parts of the county, exceed 80 acres in size. Transitions to the associated Bellefontaine, Coloma, and Miami soils are common, and the proportion of the total area characterized by the profile described above is rather small. Erosion has altered the profile on the steeply sloping areas, by both removal and deposition of materials.

Hillsdale sandy loam occupies undulating to rolling land on the till plains and terminal moraines. External drainage is free to excessive on the more strongly sloping areas, and the porous character of the soil allows rather free percolation of water. Most of this soil is cultivated, but some is occupied by wood lots containing oak, sugar maple, beech, hickory, and scattered wild cherry and sassafras.

The agricultural use of this soil is determined largely by the character of the more extensive associated soils and the crop rotation in use rather than by the character of the soil. Most of the common crops are grown, and yields range from good to fair. The soil is of medium natural fertility and of medium water-holding capacity. The yields of cereal crops, hay crops, corn, and beans are lower than those obtained on the Miami soils. Fruits, potatoes, and truck crops can be grown successfully.

Liming promotes increased yields of many crops and is particularly beneficial in obtaining stands of alfalfa and some clovers. Barnyard manure, green-manure crops, and commercial fertilizer, similar to the mixtures applied on Miami loam, are most commonly used.

Sheet erosion has taken place on practically all of the slopes under cultivation, and shallow gullies and some wind erosion may be noted in places. Practices that include straight rows and clean cultivation result in severe loss by erosion.

Hillsdale sandy loam, rolling phase.—The distinction between typical Hillsdale sandy loam and its rolling phase is based on relief. The profile, native vegetation, and other characteristics of the two soils are similar, but the rolling phase includes the steeply sloping and rolling to hilly areas of the Hillsdale soils. Most of this soil occurs in bodies of less than 20 acres, in most parts of the county, but it is most extensive in the southeastern townships. It is not an extensive soil.

The soils with which the rolling phase of Hillsdale sandy loam is associated have much to do with determining its use. In the more hilly parts of the county and in areas where irregular-shaped swampy lowlands are common associates, much of this soil is used for pasture or remains in wood lots. Many of the areas surrounded by the better soils are farmed with the associated soils. Crop yields are somewhat below those on the less strongly rolling Hillsdale sandy loam; but small nearly level areas, which are included in places, are used successfully for various crops. Where cultivation of this soil is necessary, intertilled crops should be avoided because of the danger of severe erosion. Pasture and forest seem to be the most practical uses for this soil, particularly in the more extensive areas.

Hillsdale loam.—Hillsdale loam is essentially similar to Hillsdale sandy loam in general profile characteristics. A loam texture in the surface soil and a slightly higher percentage of clay throughout the soil serve as a basis for distinguishing this soil from Hillsdale sandy loam. In general Hillsdale loam is somewhat higher in organic matter and essential plant nutrients, as well as being more retentive of moisture, than Hillsdale sandy loam. The two soils occur in areas of similar relief, but Hillsdale loam more commonly occupies undulating to almost level land.

Hillsdale loam, as mapped, includes variations similar to those occurring in Hillsdale sandy loam; but some of the more nearly level areas, where the soil approaches Conover loam in general profile characteristics, are included with Hillsdale loam. Individual areas, few of which exceed 40 acres in extent, occur in most parts of the county. A small total area is mapped.

Hillsdale loam is intermediate in most characteristics between Miami loam and Hillsdale sandy loam, and a system of management including crop distribution similar to that used on Miami loam is the most common where any sizable areas of Hillsdale loam occur. Generally, the type of management is determined by the character of the more extensive associated soils. Almost all of this soil is used for cultivated crops, but some of it supports wood lots composed of mixtures of the species of trees growing on Hillsdale sandy loam and Miami loam. The yields of cereal crops, hay crops, beans, and corn are slightly below those obtained on Miami loam, but Hillsdale

loam responds well to good practices of management. The use of barnyard manure, green-manure crops, and commercial fertilizers generally gives good results, and liming is beneficial to most crops, particularly some of the legumes. Some injurious sheet and gully erosion occurs on the more steeply sloping areas.

Bellefontaine sandy loam.—In cultivated areas the profile of Bellefontaine sandy loam has the following horizons, or layers: (1) To plow depth, light grayish-brown friable sandy loam, medium to strongly acid in reaction and containing a small quantity of finely divided organic matter; (2) light grayish-yellow loose friable light sandy loam, strongly acid in reaction, in most places ranging from 8 to 15 inches in thickness; (3) reddish-brown sandy and gravelly clay loam, medium to strongly acid in reaction. This material is somewhat sticky when moist but breaks into irregular firm chunks when dry. All the above horizons are somewhat variable in thickness. (4) At a depth ranging from 3½ to 5 feet, a heterogeneous mass of sand, gravel, and stones of various sizes, containing a small quantity of clayey and silty material, is reached. The percentage of limestone in the parent material generally is high, and an alkaline reaction prevails. Gravel and stones are common throughout the soil and on the surface, and gravel pits are common in areas mapped as Bellefontaine soil. Roots are concentrated in horizon 1 and the upper part of horizon 3, but many of them extend into horizon 4, where an abundance of lime occurs. The heterogeneous character of the parent material results in considerable textural variation, with transitions to the Miami, Hillsdale, and Coloma soils common.

Bellefontaine sandy loam occurs most commonly on knobs and ridges of the terminal moraines and on slopes adjacent to drainage valleys, but it is mapped also on the till plains. Erosional activity has altered the profile considerably in most cultivated areas. The more level areas are distinguished from Fox sandy loam by the heterogeneous character of the substratum in the Bellefontaine. This soil is most extensive in the more hilly parts of Bath and De Witt Townships, but smaller bodies occur in most parts of the county.

The steep slopes on which this soil most commonly occurs allow rapid run-off, and the porous character of the soil material allows free percolation, with the result that a rather low supply of water is retained for crops. Most of the common crops suffer reduction in yields during dry seasons.

This soil at one time supported a forest cover similar to that on Hillsdale sandy loam, with a slightly higher proportion of hard maple and beech.

The use of this soil is determined to considerable extent by the character of the associated soils. About 75 percent of the land has been cleared and cultivated at some time, but most of the steeply sloping areas and those intimately associated with swampy depressions are now used for pasture or remain in wood lots. The more level areas respond well to good management and are used for the common crops. Probably less than 50 percent of the total area is now used for cultivated crops, under a system of management similar to that practiced on Hillsdale sandy loam. The natural fertility of this soil is intermediate to low, and yields of cereal crops, hay crops, and corn are somewhat below those obtained on the Miami

soils. Beans are not usually grown on this soil, but fruit trees and truck crops have been grown successfully. Alfalfa and clovers ordinarily require an application of lime to insure a stand, but, once this is established, fair to good yields of hay are obtained. Management practices that tend to maintain or build up the organic-matter supply and reduce erosional losses are recommended.

Barnyard manure, green-manure crops, and complete fertilizers are used successfully. The friable character of the soil allows maintenance of good tilth under most conditions.

Bellefontaine loamy sand.—Bellefontaine loamy sand contains a considerably higher percentage of sand than Bellefontaine sandy loam. The essential characteristics of the profiles of the two Bellefontaine soils are similar, but the loamy sand is generally lower in organic matter, more strongly acid in reaction, lower in content of clay, consequently less retentive of moisture, and generally lower in content of lime. Although the two soils have a similar range of relief, the loamy sand generally occupies more strongly rolling and hilly areas. The parent materials of the two soils are similar, but the content of clay and limestone rock materials is lower in Bellefontaine loamy sand than in Bellefontaine sandy loam. Gravel pits have been opened in areas of this soil, and many boulders are noticeable on the surface and throughout the soil. Transitions to the Coloma soils occur commonly, and small areas of Bellefontaine sandy loam are included in mapping. The native vegetation includes a considerably larger proportion of oaks than that on Bellefontaine sandy loam.

This soil is mapped mainly in the hilly sections of Bath and De Witt Townships but also in scattered areas in other parts of the county.

More than 50 percent of the land has been cleared and cultivated at some time, but at present probably 75 percent of the total area is used for pasture or remains in forest. The low natural fertility and the low moisture-retaining capacity of Bellefontaine loamy sand and the steeply sloping surface on which it occurs almost prohibit the successful production of most crops. Some of the more level areas are farmed under a system of management similar to that practiced on Bellefontaine sandy loam, but yields are lower. Some fruit and truck crops are grown with fair to good yields, and hay crops make fair yields, although they suffer badly during dry seasons. Pasture and forest seem to be the best uses for this soil.

Erosion can be prevented easily if the soil is properly managed, but cultivation and overgrazing may result in damage by both water and wind.

Coloma loamy sand.—The plow soil of Coloma loamy sand consists of loose incoherent yellowish-gray sand, acid in reaction and containing a low percentage of organic matter. This is underlain by loose yellow sand, acid in the upper part but in most places containing a small quantity of lime at a depth of 4 to 5 feet. Lenses of somewhat clayey material and a few stones may be present in places, and transitions to the Bellefontaine soils and Hillsdale sandy loam occur. Although roots are concentrated near the surface, they are in many places distributed throughout the soil to a depth of several feet. This soil is inextensive in Clinton County. The

largest areas are in the more hilly parts of Bath, Greenbush, and De Witt Townships.

This soil represents the extremely sandy materials of the rolling to hilly terminal moraines. Some small areas have been mapped on till plains, but most of the soil is on the rounded knobs of the terminal moraines. The extremely porous character of this soil and the steepness of the slopes on which it generally occurs prevent the retention of sufficient moisture for most crops, with the result that yields are low. The natural fertility is low, and the steepness of some of the slopes makes cultivation difficult. Some of the more level areas have been used for growing the common crops, with fair results. Fruits, melons, potatoes, and truck crops will do well if water can be supplied. Application of fertilizers and lime and practices that maintain or build up the supply of organic matter are essential for even fair results on this soil. Clean cultivation often results in losses by wind and water erosion.

The agricultural use of this soil is similar to that of Bellefontaine loamy sand, but a slightly larger proportion of Coloma loamy sand is used for special crops and less for cultivated crops. Wood lots, in which the trees are predominantly oaks, are numerous, and some scattered pines are reported to have grown in some places on this soil.

Coloma loamy sand occurs most commonly in association with other soils poorly suited to production of the common field crops, so that forestry and pasture seem to be the most satisfactory use for this land.

Ottawa loamy fine sand.—Ottawa loamy fine sand is similar to Coloma loamy sand in general profile characteristics to a depth ranging from 3 to 5 feet. Below this depth the Ottawa soil becomes somewhat mottled with gray and yellow and retains a considerably higher percentage of moisture than the Coloma soil. This moisture is available to deep-rooted plants. Lenses of clay or a continuous clay layer occur at a depth ranging from 4 to 6 feet. The fertility is slightly higher than that of the Coloma soil.

Ottawa loamy fine sand occupies areas of level to rolling land, and transitions to the Coloma, Plainfield, and Berrien soils are common. Some small clay spots occur in the more rolling areas and on the slopes adjacent to drainage valleys.

Ottawa loamy fine sand occupies a very small acreage, most of which is in Bath and Greenbush Townships.

The agricultural use of the land is similar to that on the Coloma soils, but a slightly larger proportion of the total area of Ottawa loamy fine sand is in cultivation, particularly for special crops, such as fruit. The fertility is low, but the soil is somewhat more retentive of moisture than Coloma loamy sand, and deep-rooted plants can be expected to make better growth. The native vegetation and the system of management are similar to those on the Coloma soils.

Ottawa loamy fine sand is more commonly associated with somewhat more productive soils than is Coloma loamy sand, and it is used in the regular crop rotation suited to the associated soils. Application of lime, barnyard manure, and commercial fertilizer are necessary to prevent a spotted appearance of crops where Ottawa loamy fine sand occurs in a field consisting largely of the heavier textured and more productive soils. Farm orchards and gardens are commonly located on the small spots of Ottawa or Berrien soils that may occur in association with the heavier soils.

Fox sandy loam.—Cultivated areas of Fox sandy loam have the following horizons: (1) To plow depth, light grayish-brown friable sandy loam, medium to low in organic matter and medium to strongly acid in reaction. This is underlain by (2) light yellowish-brown or buff friable sandy loam, strongly acid in reaction and low in organic matter. This material extends to a depth between 16 and 20 inches, where it grades into (3) reddish-brown sandy gravelly clay loam, medium to slightly acid in reaction. This material is sticky when moist, and, although it is compact when dry, roots penetrate it with ease. At a depth ranging from 30 to 40 inches, this material, in turn, is underlain by calcareous stratified grayish-yellow sand and gravel. Gravel pits are common in this soil, and gravel occurs throughout the soil mass.

Fox sandy loam is generally rather uniform in character. The most common variations include gradations to the more sandy Oshtemo soil, the moister Bronson soil, and the Bellefontaine soils.

A total area of 16.9 square miles of Fox sandy loam is mapped. The largest areas are in Essex, Greenbush, Duplain, Bath, and Victor Townships.

Fox sandy loam occupies level to undulating outwash plains, terraces, valley train deposits, and low beach ridges. Areas of steep slopes are confined to terrace breaks and to the slopes of pot-holelike depressions in the otherwise almost level plains. The relief of areas on which the Fox soils occur does not allow rapid run-off, but the pervious character of these soils allows free internal drainage.

The native vegetation was of a type similar to that which grew on the Bellefontaine soils. Some small oak openings or sparsely wooded prairies are said to have existed on this soil.

General farming of the type practiced on the Miami soils is the most common use of this soil. The lower moisture-retaining capacity and the lower fertility of the Fox soils result in considerably lower yields of wheat, corn, oats, beans, and other crops than those obtained on the heavier soils. Seasons of low rainfall often are characterized by drought injury to the common crop plants. The rather strongly acid reaction of the surface soil inhibits the growth of some plants, particularly the legumes, but the abundant supply of lime at a comparatively slight depth will satisfy the needs of these plants if sufficient lime is added to the surface soil to allow the plants to establish a root system. Fruits, potatoes, and some truck crops do very well on these soils.

Good management practices, which include liming and the building up of the organic matter, are essential for the maintenance of these soils at a high level of productivity. Erosion by water is of comparatively little importance because of the nearly level land surface, but wind erosion may cause some damage where practices involving clean cultivation are carried on. This soil may be tilled over a great range of moisture conditions, and power requirements are low.

Fox loam.—Fox loam is essentially similar to Fox sandy loam in all respects except that the loam contains a somewhat higher content of silt and clay throughout. Transitions to the Bronson soils and Fox sandy loam are common. A small total area of Fox loam is associated with Fox sandy loam. Few individual areas are more than 80 acres in extent.

A slightly higher content of plant nutrients and greater moisture-retaining capacity in Fox loam result in higher yields of the common

agricultural crops than are obtained on Fox sandy loam, but the management practices and responses are very similar on the two soils. The results of poor management are not evident so soon on the heavier textured Fox loam as on the sandier member of the series, because of the slightly greater durability of Fox loam.

Oshtemo loamy sand.—Oshtemo loamy sand is distinguished from Fox sandy loam by a higher content of sand throughout. The reddish-brown clayey horizon that occurs in the Fox soils is very weakly developed or is absent from Oshtemo loamy sand; the soil is more strongly acid in reaction, and the underlying stratified sand and gravel are considerably lower in content of limestone. The more common variations include transitions to the Fox, Plainfield, Berrien, Bronson, and Bellefontaine soils. Some stony areas of Oshtemo loamy sand are mapped in the vicinity of Maple Rapids.

A fairly large total area is mapped. The distribution, character of the land surface, and geologic formations on which this soil and the Fox soils occur are similar. The native vegetation is very similar to that on Bellefontaine loamy sand. The level land surface of this soil does not allow free run-off, but the extremely porous soil allows free internal drainage.

Possibly 75 percent of the area of Oshtemo loamy sand has been cleared and cultivated at some time in the past. A system of management similar to that practiced on Fox sandy loam is in general use. The low capacity for the retention of moisture and the low fertility of this soil do not favor high yields of most crops, but fruits and potatoes are grown and produce fair to good yields. Liming and practices that maintain or increase the content of organic matter are essential if this soil is to be maintained in a state of even moderate productivity.

Water erosion is of no great importance on this soil, but wind erosion may reach serious proportions where clean cultivation is practiced.

Plainfield sand.—The profile of Plainfield sand consists of a thin covering of humous soil, in most places not more than 2 inches thick, overlying incoherent yellow sand. In plowed areas the surface horizon is yellowish gray to plow depth. Transitions to the Oshtemo, Coloma, Ottawa, and Berrien soils may be noted in areas mapped as Plainfield sand.

The distribution, relief, drainage, and geologic formation underlying this soil are similar to those of the Fox and Oshtemo soils. The small total area of this soil lies largely on outwash plains and valley train deposits.

The native vegetation is similar to that on the Coloma soils. Much of the area of Plainfield sand has been cleared at some time, but its very low productivity for the common crops has resulted in much of it being devoted to pasture, wood lots, or special crops. Yields of all the common farm crops are low on areas that still remain under cultivation. The soil is strongly acid in reaction, and the capacity for the retention of moisture is low, with the result that crops may suffer badly from a shortage of water during dry seasons. The production of special crops, reforestation, and pasture seem to be the best uses to which this land can be put under present economic conditions. Water erosion is comparatively unimportant, but wind erosion may be serious where clean cultivation is practiced.

Hillsdale-Oshtemo complex (stony).—The Maple River Valley and the valley around The Island, in the northwestern part of the county, are characterized by an association of land features that is distinct from anything else in the county. These valleys are bordered by steep slopes, which blend into a series of undulating to gently rolling terracelike areas as the present river bottom land is approached. The soils are very stony, and their character is too variable to allow the use of any of the foregoing soil-type names. The dominant surface textures are sands or sandy loams, and the profiles approach those of the Hillsdale, Bellefontaine, Fox, and Oshtemo soils in various places. Some small areas of wetter soils are included in mapping.

The parent material of these soils consists of glacial materials that have been reworked by running waters, and a combination of removal and deposition of materials is suggested by the character of the deposits.

The excessive stoniness, together with the variability of these soils, almost prohibits their use for cultivated crops. Some fruits are grown, and fair yields are obtained. Only a very small proportion of the small acreage of this soil complex is used for cultivated crops, but more than 50 percent of the total area has been cleared at some time. The most satisfactory uses of this land seem to be for pasture and forest. This dry sandy land affords good early season pasture for livestock, and the associated bottom land and Berrien-Griffin complex provide good late-season pasture. Possibly liming and the use of phosphate fertilizer would greatly benefit the quality of the pasture, but the application of these materials has not been practiced. The native vegetation consists of trees and grasses similar to those on the Hillsdale and Bellefontaine soils.

IMPERFECTLY DRAINED SOILS

Most of the imperfectly drained mineral soils of the uplands and terraces are intimately associated with areas of the well-drained and poorly drained mineral soils, but some extensive uniform areas have been mapped in some parts of the county. The land surface on which these imperfectly drained soils occur for the most part is level to undulating, and movement of water over the land is slow, with the result that a large proportion of the total precipitated moisture is retained by the soil. Erosion by water and wind is not a serious problem.

The crops grown on these soils are similar to those grown on the well-drained soils, and soil texture is probably the most important factor in determining differences in crop adaptation within this group. Crops such as sugar beets and field beans benefit greatly from the high moisture content of these soils, and yields are considerably higher than on the well-drained soils. Yields of corn, oats, and grasses are also somewhat higher than on well-drained soils of similar texture. The preparation of a seedbed and the seeding of crops on these soils may be retarded somewhat by a high moisture content during the early spring, but tile drainage of the slight depressions, which are characteristic of the surface on which these soils occur, aids greatly in drying them after wet periods. Some crops, such as winter wheat, alfalfa, and some clovers, that remain on the land over winter may be damaged somewhat by heaving caused by freezing and thawing of the soil, particularly in the more poorly drained spots, but the damage in any certain year generally

is insufficient to reduce markedly the yield of these crops. Most of these crops are used in a rotation for only 2 or 3 years in succession, so it is probable that the decrease in yield as a result of winter-killing during that period may not be great. The higher moisture supply during the growing season and the higher content of plant nutrients result in yields of these winter crops equal to or above those obtained on the well-drained soils, when winter injury is not severe.

The imperfectly drained soils occupy a total area of 186.2 square miles, and soils of the Conover series compose about 72 percent of that area. Soils of the Brady and Bronson series cover about 19 percent of the area, and the remaining 9 percent is largely mapped as soils of the Berrien series. The relief of the land surface and general uniformity of areas upon which the Conover, Bronson, and Brady soils occur allows the establishment of uniform rectangular fields.

The Conover soils are imperfectly drained associates of the Miami soils and Hillsdale loam. The Brady soils are developed from stratified sandy and gravelly materials, and for the most part they occur on glacial drainage valley deposits, terraces, or outwash plains, in association with the Fox, Oshtemo, and Bronson soils. The Bronson soils are developed from a thin covering of stratified sand and gravel materials over clay. The Berrien soils are developed where a thin covering of imperfectly drained sand overlies clay at a comparatively slight depth.

Conover loam.—Conover loam in most places is associated with Miami loam and Brookston loam, and it is developed from the same type of calcareous glacial till. Some extensive uniform plains of Conover loam occur, particularly in the central and western parts of the county.

Cultivated areas of Conover loam have the following horizons: (1) To plow depth, medium-brown to dark grayish-brown friable loam, slightly acid to slightly alkaline in reaction and well supplied with organic matter; (2) yellowish-gray friable loam, slightly acid in reaction and generally less than 6 inches thick; (3) yellowish-gray and gray mottled somewhat compact coarsely granular slightly acid to alkaline clay loam. This material is cohesive when wet and compact when dry. At a depth of less than 40 inches in most places this grades into (4) grayish-yellow calcareous loam or clay loam glacial till.

As the characteristics of the Conover soils are intermediate between those of the Miami and Brookston soils, variations approaching these two soils are common in areas mapped as Conover loam. Some small sandy spots approaching Berrien sandy loam in character are included, and in places a small quantity of gravel is scattered over the surface. The larger areas of Conover loam are rather uniform in character, but considerable variation exists where this soil is mapped in a transitional position between the well-drained and poorly drained soils or as a border around swamps.

This soil is extensive in most parts of the county, and the largest areas are mapped on the level to undulating plains in the central part. Only a very small total area is mapped on rolling to hilly land.

Most of Conover loam occupies areas of level to undulating relief, and internal and external drainage are slow. The parent material is similar to that from which the Miami soils have developed, and the native vegetation was of a type intermediate between that on the Miami and Brookston soils. A hard maple-elm association, including

ash, basswood, shagbark hickory, white oak, and red maple, was most common.

Conover loam is among the most desirable soils in the county for growing general farm crops, and probably from 80 to 90 percent of the area occupied by this soil has been cleared and is used for cultivated crops. The rest is largely in wood lots and pasture. Some injury to winter crops by heaving, brought about by freezing and thawing, may occur, but this injury generally is not serious. Almost all of the common crops are grown successfully, but corn, oats, wheat, hay crops, field beans, and sugar beets occupy the largest acreage. Possibly 50 percent of the area is used for growing corn, 25 to 30 percent for oats, wheat, and hay, and 10 to 15 percent for field beans. Acre yields of 45 to 60 bushels of corn, 18 to 20 bushels of field beans, and average yields of 2.5 tons of hay and 9 tons of sugar beets are common on this soil.

The soil responds well to good management practices and the judicious use of fertilizers. Barnyard manure, green-manure crops, complete commercial fertilizers, and superphosphate have been used with good results.

Artificial drainage of slightly depressed areas, characteristic of this soil is beneficial. Tile drainage is preferable to open-ditch drainage.

Conover silt loam.—Conover silt loam is similar to Conover loam in broad soil characteristics, such as thickness and color of the different horizons and general lay of the land. The silt loam occurs in the more level and uniformly heavier textured soil areas. It occurs in conjunction with Miami silt loam and Brookston clay loam to a greater extent than does Conover loam, which in many places is associated with Miami loam, Hillsdale loam, and Brookston loam. A total area of 53.5 square miles is mapped.

Conover silt loam is high in fertility, has excellent moisture-holding capacity, and is comparatively easy to till. This is especially true of the areas in the more level till plains in the central and western parts of the county. Numerous fields are situated entirely or predominantly on this soil.

As compared with the corresponding horizons of Conover loam, the plow soil of Conover silt loam contains somewhat more organic matter, horizon 2 is generally thinner, and horizon 3 is heavier textured. Some tile drainage is used to drain slightly depressed areas, or excessive surface water may be carried off by plow furrows or narrow shallow ditches. Fall plowing is essential to maintain good tilth. The surface is left in a rough and uneven state, and preparation of the seedbed is done in the spring for corn and beans—the crops that usually are first in the rotation after plowing. The native forest cover is similar to that on Conover loam, with more elm and white oak and less beech and hard maple.

An area of somewhat heavier textured soil than normal for this soil is mapped in association with some heavier textured Miami silt loam in an area west of Fowler. The quality of this heavier soil is slightly below that of the general run of Conover silt loam.

The slightly heavier texture and the associated higher moisture content make this soil more favorable for field beans, sugar beets, and corn and somewhat less favorable for alfalfa than Conover loam. Good tilth is somewhat more difficult to maintain than on the loam, and

clodding often results if the soil is tilled when the moisture content is high. The use of green-manure crops has given very good results on this heavier soil. Use of the land and responses to management are very similar to those of Conover loam.

Brady loam.—Cultivated Brady loam has a profile consisting of the following horizons: (1) To plow depth, dark grayish-brown friable loam, slightly acid in reaction, medium to high in organic matter, and containing numerous small pieces of gravel and some cobblestones. (2) Grayish-yellow friable heavy sandy loam or loam, mottled with yellow and having a slightly acid reaction. This horizon in few places is more than 12 inches thick. (3) Mottled gray and yellowish-gray coherent gravelly sandy clay, slightly acid in reaction. At a depth ranging from 30 to 36 inches this material grades into (4) stratified gray and yellow calcareous sand and gravel, generally saturated with water and underlain at a variable depth by clay.

Brady loam is fairly uniform as mapped, but some small spots of Brady sandy loam are included. In the old drainage valleys some depositions of alluvium may be found in places on this soil and in a few places the soil approaches Conover loam in characteristics. Transitions to the drier Bronson soils and the wetter Gilford soils are included.

Brady loam occupies a total area of 18.7 square miles. The most extensive areas are in the old glacial drainage valleys that traverse the county, but a few areas are mapped on outwash plains. The Stony Creek Valley includes a large acreage of this soil, and some has been mapped on the lake plain in the northeastern part of the county. This soil is developed in level to gently undulating areas, from sandy and gravelly materials of glacial deposition. The lay of the land is such that external drainage is slow, but the porousness of the soil allows free percolation to the ground water table.

The native forest cover consisted largely of elm, black ash, swamp white oak, basswood, silver maple, red maple, and shagbark hickory. About 75 percent of this soil is used for cultivated crops, and the rest is used largely for wood lots and pasture. In many places the natural fertility and moisture content of Brady loam are somewhat lower than those of Conover loam, and yields of most crops are also lower. The porousness of the material underlying these soils allows considerable seasonable variations in the soil moisture content. The crops grown are similar to those grown on Conover loam. Good responses to barnyard manure, green manure, and commercial fertilizers are obtained in most places, and some areas respond favorably to applications of lime. Good tilth can be maintained with little difficulty. In some areas small stones may interfere somewhat with cultivation.

Some areas of Brady loam are improved by artificial drainage. The porousness of the substratum allows fairly free lateral movement of water, and open-ditch drains may be used with good results. Dredging of the stream channels in some places may lower the water table sufficiently to cause injury to plant growth. Winter injury of some crops is noted on this soil during some seasons.

Brady sandy loam.—Brady sandy loam is similar to Brady loam, but the sandy loam contains a higher percentage of sand throughout, the clayey horizon is not so strongly developed, the content of organic matter is slightly lower, and the reaction is more strongly acid.

The distribution of Brady sandy loam is similar to that of Brady loam, and the agricultural use is much the same for the two soils, but the sandy loam is much less extensive. Crop yields are slightly lower than on Brady loam, and management practices that include the maintenance of organic matter and liming are recommended. The soil responds well to applications of barnyard manure, commercial fertilizers, and green-manure crops. In many places plants suffer from a shortage of moisture during dry seasons. Overdrainage may be more serious on the sandy loam than on the loam because of the lower water-holding capacity of the sandier soil. Some slight wind erosion may occur on this soil where clean-cultivated crops are grown.

Bronson loam.—Cultivated areas of Bronson loam have the following profile: (1) To plow depth, medium-brown or dark grayish-brown friable loam, medium to slightly acid in reaction and containing numerous pieces of gravel. Sufficient finely divided organic matter to impart a somewhat brown color is present. (2) A 4- to 8-inch layer of yellowish-brown friable loam, slightly acid in reaction. The color of this horizon is not so light as that of the corresponding horizon in the Fox soils. (3) Strong-brown or yellowish-brown slightly acid somewhat coherent gritty loam or clay loam, which becomes somewhat mottled with yellow in the lower part and ranges from 12 to 20 inches in thickness. This material is somewhat sticky when wet and compact when dry. (4) Moist stratified calcareous yellow and gray sand and gravel. A substratum of clay occurs at a depth ranging from 4 to 8 feet. Gravelly material is common throughout the soil mass, and some cobbles are on the surface and throughout the soil.

Drainage conditions are intermediate between those of the Fox and the Brady soils, and transitions to those two soils are common. In areas where the sandy and gravelly covering is thin this soil approaches the Conover soils in character. A considerable range in the thickness of the sandy and gravelly covering over the clay is noticeable.

Bronson loam occurs in most parts of the county, generally associated with the Fox and Brady soils, but some areas are mapped on the clay plains where there is a sandy and gravelly cover. This is a fairly extensive soil.

Bronson loam is developed from sandy and gravelly materials in level to gently undulating areas. External drainage is slow, and internal drainage is retarded by the clayey substratum. The native vegetation consisted of hard maple, beech, oak, hickory, basswood, and scattered silver maple, red maple, and elm.

Most of the individual areas of this soil are so small that the character of the associated soils determines their use, but the larger areas are used in much the same way as Fox loam. Yields of most crops are somewhat higher on Bronson loam than on Fox loam, because of the higher moisture content and higher fertility of the Bronson soil. Yields compare favorably with those obtained on Miami loam. Amendments of barnyard manure and commercial fertilizers, as well as the use of green manures, are beneficial to crops on this soil. Artificial drainage is not necessary in most places.

Small areas of Bronson sandy loam are included on the map with Bronson loam. This included soil is essentially similar to Bronson loam in almost all respects, except that the sandy loam contains a higher percentage of sand throughout, contains less clay, and has a lower mois-

ture-retaining capacity, more acid reaction, lower percentage of organic matter, and lower content of plant nutrients. Transitions to Fox sandy loam, Bronson loam, and Berrien sandy loam are common. In general characteristics, crop adaptations, and crop responses, this soil approaches Berrien sandy loam possibly as closely as it does Bronson loam. The total area is less than 1 square mile. Distribution is similar to that of typical Bronson loam, but most of the individual areas are too small to allow this soil to be used as a unit, and the type of management is determined largely by the character of the associated soils. Liming of this soil is beneficial to many crops, and responses to applications of barnyard manure and of green-manure crops are generally good. Yields of the common agricultural crops are somewhat below those on typical Bronson loam and somewhat above those on Fox sandy loam. Fruits and potatoes do well.

Berrien sandy loam.—Cultivated Berrien sandy loam consists of the following horizons: (1) To plow depth, medium-gray sandy loam, medium to low in organic matter and medium acid in reaction; (2) yellow and gray light sandy loam, in places slightly stained with brown in the upper part and slightly acid in reaction. This material becomes moist and somewhat mottled at a depth ranging from 20 to 36 inches, and clay occurs at a depth of 2 to 5 feet. The reaction becomes neutral or slightly alkaline at a depth ranging from 20 to 35 inches.

Berrien sandy loam occurs in most parts of the county, but it is only moderately extensive, and most of the individual areas are small. Transitions to somewhat drier sands and somewhat wetter sands are common, also transitions to Hillsdale sandy loam and the Ottawa and Plainfield soils. Several small areas of soil, somewhat drier than the average, are mapped as Berrien sandy loam in the northeastern part of the county adjacent to the Maple River.

Berrien sandy loam occupies level to undulating land, and external drainage is slow. Internal drainage is good to the water table or to the clayey substratum, which impedes further downward percolation. The original vegetation consisted largely of oak and hickory, and beech and maple were common where the soil is associated with heavier soils.

The character of the associated soils largely determines the use of this soil. Yields of the common agricultural crops are lower on Berrien sandy loam than on the heavier associated soils, and larger applications of barnyard manure and commercial fertilizer are often made on the Berrien soil than on the heavier soils. Liming and practices to maintain the organic-matter content give good results. Berrien sandy loam is well suited to the growing of fruits, and many farm orchards are on this soil. Potatoes also do well. Crops on Berrien sandy loam often suffer from a shortage of water during the later part of the growing season, and some damage from wind erosion may occur where the soil is clean cultivated.

One small area included with Berrien sandy loam in the central part of section 34, Eagle Township, is underlain at a depth ranging from 4 to 6 feet by shale and sandstone bedrock. The lower part of the subsoil is characterized by the presence of a large number of sandstone boulders and sandstone rock fragments. This area is somewhat better drained than the more typical areas of Berrien sandy loam. In the characteristics of the soil itself and in the nature of the substratum it more nearly resembles the soil rec-

ognized and mapped elsewhere in southern Michigan as Parma sandy loam. The area in Clinton County is used only as wood lot and pasture. A number of excavations have been made in an attempt to locate stone of commercial value, and the area is indicated on the soil map by a quarry symbol.

Most of the areas are comparatively small or narrow and are used in conjunction with the heavier textured soils. Few fields are composed entirely of this soil, and most of the areas were cleared at the same time as the associated soils. This soil on many farms, where isolated or adjacent to buildings, is used for farm orchards (mainly apples), potatoes, garden crops, hay, and pasture. Commercial fertilizers, green and barnyard manures, and lime are essential for best growth of these crops. Approximately one-half of the cleared land is used for the common farm crops. Good management includes applications ranging from 1 to 3 tons of lime at intervals of 4 to 6 years, use of barnyard and green manures, and liberal applications of phosphate on the hay and pasture crops. Fertilizers are commonly used on land for small grain and corn. Penetration of water is rapid, and erosion is negligible.

Berrien loamy sand.—Berrien loamy sand is similar to Berrien sandy loam in all respects except that Berrien loamy sand has a more sandy surface soil and a somewhat higher percentage of sand throughout the soil mass. In many places the depth of the sandy covering over the clay is somewhat greater in the loamy sand, and the soil is more strongly acid, less retentive of moisture, and in general less productive of the common crops.

Berrien loamy sand occurs in small areas in most parts of the county, but it occupies only a small total area. It is most commonly associated with and used in conjunction with other very sandy soils, and its agricultural value is low. Some transitions to the Plainfield, Ottawa, Coloma, Oshtemo, and Granby soils are included in mapping.

Yields of the common agricultural crops are low on this soil, but fruits, potatoes, and truck crops can be grown with fair to good yields. Wind erosion may cause serious damage where clean cultivation is practiced, and liming and the maintenance of organic matter are essential in order that this soil may produce even moderate yields of the common crops.

POORLY DRAINED SOILS

The poorly drained soils occur on level plains or in depressions in association with the soils of better natural drainage. Some extensive areas of poorly drained soils are on the plains in the northeastern and west-central parts of the county. The high water-retaining capacity and the high content of plant nutrients make the heavier textured soils of this group particularly favorable for growing such crops as sugar beets, corn, grasses, and field beans. Alfalfa and wheat often suffer from winter-killing and heaving, but good results are obtained with these crops where an efficient system of artificial drainage is established. A high moisture content during the spring often delays preparation of the seedbed and the time of seeding, but the high fertility and high retentive power for moisture favor rapid growth of most crops during the summer. Periods

of excessive moisture may often result in crop damage on these soils because of the slowness with which water runs off the surface. Erosion is negligible.

Crop adaptations within the group are determined largely by the texture of the soil. The heavier textured soils are considered among the most productive in the county for general crops in places where proper drainage is installed. The sandiest soils are not so low in plant nutrients as the better drained soils but, because of the association in which they generally occur and their physical character, are more likely to be used for truck or special crops, such as mint, or to remain uncultivated and be used for pasture.

The poorly drained soils occupy a total area of 70.3 square miles, of which members of the Brookston series occupy about 78 percent. The remaining 22 percent includes soils of the Gilford, Macomb, Granby, and Maumee series and the Berrien-Griffin complex (stony). Brookston loam and Brookston clay loam occupy depressed or level areas. They are developed from materials similar to those from which the Miami and Conover soils have developed. The Gilford soils are poorly drained associates of the Brady, Bronson, and Fox soils, and the Macomb soils are characterized by a thin surface layer of wet sandy and gravelly material but otherwise are like the Brookston soils. The Granby soils are wet soils developed from deep sands, and the Maumee soils are swamp-border soils, generally somewhat mucky in character in the surface layer, with underlying materials of variable texture. The Berrien-Griffin complex (stony) represents the poorly drained soils of the Maple River Valley in the northwestern part of the county.

The native vegetation on these soils consisted of elm, silver maple, red maple, swamp white oak, basswood, black ash, shagbark hickory, and a scattered growth of sycamore. About 75 percent of the area included in the poorly drained soils is used for cultivated crops.

Brookston clay loam.—Cultivated areas of Brookston clay loam are characterized by a profile consisting of the following horizons: (1) To a depth ranging from 7 to 10 inches, very dark gray or black granular clay loam, which is neutral to slightly acid in reaction and contains a high proportion of finely divided organic matter. This material is sticky when wet and firm when dry. It is underlain by firm coarsely granular moist bluish-gray clay loam mottled with yellow and rust brown. This material is very uniform to a considerable depth, and the reaction in most places is nearly neutral, becoming slightly alkaline at a depth of 2 to 3 feet.

Most of this soil is fairly uniform, but some transitions to the Macomb and Conover soils are included. Some uncultivated areas have a slightly mucky surface soil.

A total area of 28.3 square miles is mapped. The largest areas are in the northeastern part of the county and in the vicinity of Fowler. Small areas are associated with the heavier soils in most parts.

Brookston clay loam is developed from heavy-textured glacial drift on level areas. Both external and internal drainage are poor. The native forest cover consisted of elm, swamp white oak, silver maple, red maple, basswood, shagbark hickory, and black ash.

About 75 percent of the area mapped as Brookston clay loam has been drained and is in use for cultivated crops, and the rest

is used for pasture and wood lots. Corn, sugar beets, hay crops, and field beans are the most extensively grown crops on this soil, and yields are generally higher than on the drier soils. Often alfalfa, winter wheat, and other winter crops are injured by freezing and thawing, which cause heaving on these soils, but, if proper drainage is provided, yields of these crops ordinarily are high.

Brookston clay loam must be tilled under optimum moisture conditions in order to obtain a good seedbed. Clodding results when the soil is cultivated when wet, and the compactness of the soil makes cultivation difficult when it is too dry. The use of green-manure crops gives good results, possibly partly because of the influence of the added organic matter on the physical character of the soil and partly because of improved plant nutrition in the soil. Ordinarily a good response to applications of barnyard manure is obtained, and complete commercial fertilizers produce good results from some crops. Some superphosphate is used, and sugar beets generally are fertilized with materials high in potash and phosphoric acid. Tile drainage is essential for best results on this soil.

Brookston loam.—Brookston loam is similar to Brookston clay loam in many respects. Brookston loam, however, has a higher percentage of sandy material in the surface horizon and throughout the soil mass. The areas mapped as the loam are subject to more variation than those mapped as the clay loam, particularly where Brookston loam occurs in depressions intimately associated with the better drained soils. Some of the areas represent lake bottoms and originally were covered by a thin layer of muck. Most of the larger areas on the plains are fairly uniform, but they include soil transitional to the Macomb and Gilford soils. The areas associated with the better drained soils are subject to frequent flooding by run-off, and proper drainage in many places demands considerable expenditure for labor. The larger and more uniform areas are much easier to handle as land units. Artificial drainage can be accomplished with less difficulty on the loam than on the clay loam because of its greater permeability.

Brookston loam can be maintained in good tilth with less difficulty than Brookston clay loam, and less power is required for tillage. The general crop adaptations and management practices on the two soils are much the same, but yields of sugar beets are slightly lower on the loam than on the clay loam. Yields of other crops are similar on uniform areas of the two soils.

Macomb loam.—Macomb loam occurs mainly in association with the Brookston soils. The largest areas are on the lake plain in the northeastern part of the county, but small areas occur in other parts. To plow depth, this soil consists of medium-gray or dark-gray loam underlain by pale-yellow and gray mottled moist sandy gravelly material, which overlies clay, similar to that underlying Brookston loam, in most places at a depth of less than 30 inches. The underlying soil material is calcareous at a depth of 2 to 3 feet. The most common inclusions in this soil as mapped are small areas of Macomb sandy loam and some small spots of Brookstonlike soil. Some areas of Macomb loam are stony and cobbly.

Macomb loam is cropped in a similar manner to the Brookston soils with which it is associated. Management practices are much the same as those on Brookston loam, but yields of most crops are somewhat

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lower. Sugar beets are not so commonly grown on Macomb loam as on the Brookston soils, but field beans are grown on a larger proportion of the total area of the Macomb soil. The Macomb soils in general are more variable in texture than the Brookston soils. Artificial drainage is essential for the best results on Macomb loam.

Gilford loam.—Gilford loam occupies level land, and it is similar to the Brady soils in profile characteristics. The plow soil is somewhat darker and higher in organic matter, the soil material is somewhat limy throughout, and the moisture content is higher. The materials underlying the surface soil consist of gray and yellow mottled wet sand and gravel containing some thin clayey layers, but the soil in some areas has a rather uniform sand and sandy clay mixture below the surface layer. Comparatively impervious clay occurs in most places at a depth ranging from 3 to 5 feet. In some areas on the borders of swamps the surface soil is slightly mucky.

The distribution of areas of this soil is similar to that of the Brady soils, and members of the Brady, Bronson, and Fox series are the most common associates. Texturally this soil is intermediate between Brookston loam and Granby loamy sand. The appearance of cultivated fields is similar to that of Brookston loam, and crop adaptations and management practices and responses are very similar on the two soils. Yields of the crops generally grown on these poorly drained soils are somewhat lower on Gilford loam than on the Brookston soils.

The perviousness of the subsoil in the Gilford soil allows fairly free drainage through widely spaced ditches without the use of tile. This pervious character of the underlying soil material, however, is reflected in many places by a shortage of moisture for the growth of crops during some seasons. The use to which these soils are put depends largely on the installation of artificial drainage. Most of the undrained areas are in wood lots and pasture, whereas the drained areas are used with the associated soils for the common agricultural crops.

Granby loamy sand.—Granby loamy sand includes the poorly drained sandy soils of the level plains and depressed areas. The plow soil is dark-gray or almost black loamy sand high in organic matter. It is underlain by gray moist sand somewhat mottled with yellow and rust brown. The gray sand is saturated at a depth of 1 to 2 feet, and in places comparatively impervious clay occurs at a depth ranging from 3 to 5 feet. The surface soil normally is nearly neutral in reaction, but some spots of slightly acid soil are included in mapping. Most of the more acid areas are associated with the sandy better drained soils. Transitions to the Maumee, Gilford, Berrien, and some other sandy soils, and some areas of somewhat more productive sandy loam, also are included in mapping.

Only a small total area is mapped. Most of the individual areas are less than 20 acres in size. This soil occurs most commonly in the northeastern lake plain and in the glacial drainage valleys, but small areas are mapped in other parts of the county.

Granby loamy sand generally is too wet for crop production unless artificial drainage is supplied. The sandy character of the soil allows poor retention of moisture where the soil is too thoroughly

drained, and crops frequently suffer during dry seasons. Much of the Granby soil mapped in the depressed areas or in association with the better drained soils is of low agricultural value. The more uniform level areas are used with fair results for such crops as corn and hay, and potatoes do well, but as a whole the soil is less durable under cultivation than the clay soils—Conover and Brookston—developed under similar natural drainage conditions. Good-quality pasture may be grown on this soil, and considerable areas are used for wood lots and pasture.

Maumee loam.—Maumee loam is characterized by a layer of very dark brown or black mixed mucky organic matter and mineral material, which generally is about 1 foot thick but becomes somewhat thicker as areas of the true organic soils are approached. This material is underlain in most places by moist or wet material ranging in texture from sand and sandy loam to very sandy and gravelly clay. Transitions to the Granby and Gilford soils are common. Maumee loam is of very small extent. It occurs most commonly in small patches along the edges of swamps or in level and depressed areas. Cultivation of the very shallow muck in many places results in a Maumeelike soil.

Maumee loam is used with associated organic soils for special crops, such as peppermint, onions, and truck crops, or for pasture and wood lots. Some corn and cereals are grown with fair to good yields in places where the land is drained and fertilized. Most areas of this soil are too small to warrant their use for special crops unless the associated soils are of such character as to favor special crop production. Responses to management are similar to those on the shallow muck soils.

Berrien-Griffin complex (stony).—The Berrien-Griffin complex (stony) is associated with the Hillsdale-Oshtemo complex (stony) and includes imperfectly drained or poorly drained level, undulating, and depressed areas. The high moisture content of these soils in many places is due to poor surface drainage, but in other places seepage waters from the higher slopes serve to keep the soil moist. All this soil complex is excessively stony, and the component soils are darker, of greater fertility, and higher in content of moisture than the soils composing the Hillsdale-Oshtemo complex. Spots of soil similar to the Berrien, Brady, Gilford, Macomb, and Brookston soils of the uplands and the Griffin soils of the bottom lands are included in the areas of this complex. The complexity of distribution and small size of the areas of these soils prevents their mapping in detail. The geologic origin of the materials is similar to that of the materials in the Hillsdale-Oshtemo complex (stony), but some small areas of recent alluvium are included in mapping.

The excessive stoniness, wetness, and variability of the soils composing this complex almost prohibit the use of the land for cultivated crops. Although a fairly high percentage of the land has been cleared, only a very small proportion of the total area is in use for farm crops, with fair to good yields. Pasture and forest seem to be the most suitable use for this land. The high moisture content and high fertility favor good yields of grass during the late summer, and the drier associated soils furnish good early pasture.

SOILS OF THE UPLAND DEPRESSIONS

Most soils of the level and sloping uplands of Clinton County can be included in mapping units within which a narrow range of drainage conditions and soil textures dominate. Some small depressed areas display a considerable range of drainage conditions and textures of materials, as well as more or less deposition of materials eroded from adjacent slopes. Most areas of these soils are small, but their presence in fields has an important bearing on the use and value of the land. Not all of these soils are well adapted to growing cultivated crops, and in many places they remain as wasteland or afford cover for wildlife.

A total area of 27.6 square miles has been included in this group of soils, most of the individual bodies of which are irregular in shape and of small size. The Brookston-Washtenaw complex includes the extremely variable depressed areas within which the soil association is too complex to allow mapping of all details. Small bodies of some of the more extensive upland soils are included in many places. Washentaw soils include areas in which materials eroded from adjacent soils have been deposited over dark-colored wet mineral soils, and Wallkill soils include areas in which materials eroded from adjacent slopes have accumulated over organic soils. Some small intermittent ponds are included with the Wallkill soils. The small size of these areas, combined with the small scale of the map, have necessitated mapping of the individual areas on the basis of the dominating soil condition rather than attempting to delineate all variations in the complex soil association generally characteristic of these areas.

The native vegetation is similar to that on other imperfectly drained and poorly drained mineral soils.

Washtenaw loam.—Washtenaw loam occupies depressed areas in association with most of the other soils and consists largely of loamy material, generally exceeding 1 foot in thickness, that has been eroded from the adjacent slopes and deposited on the original mineral soil. The texture of the soil is variable, but loam and silt loam dominate, and some loamy sand and clay loam are included. The character of the soil on the slopes from which the wash comes has much to do with determining the texture of this soil. The plow soil in most places is medium to high in organic matter and rather dark, but some areas adjacent to extremely eroded slopes may include deposits of lighter colored subsoil materials. Some small alluvial fans and deltas are included with Washtenaw loam on the map, as well as some spots of Wallkill-like soils.

In general Washtenaw loam occupies small drainage swales and depressions of irregular shape, and most of the individual bodies are less than 3 acres in extent. This soil is mapped largely in the southern half of the county in association with the rolling to hilly Miami, Bellefontaine, and Hillsdale soils.

The small extent, complex pattern of distribution, and intimate association of this soil with some of the more extensive soils has prevented mapping all the areas, and some small spots may be included as variations within the more extensive soils. These soils are used with the associated soils for the production of a variety of crops.

A high content of plant nutrients and a high moisture content favor a luxuriant growth of most crops, but plants often mature more slowly

than on the drier and less fertile associated soils, with the result that many fields of grain in which this soil occurs do not ripen uniformly. Most hay crops do very well, but alfalfa often suffers winter-killing and may be injured during seasons of excessive moisture. The presence of a large number of areas of this soil in a field will complicate tillage operations. In some places artificial drainage may be beneficial in the use of this soil. Late frosts in spring and occasional flooding sometimes injure the crops.

Wallkill loam.—Wallkill loam occupies depressed areas, commonly associated with the Miami, Bellefontaine, and Hillsdale soils or occurs as borders around bodies of peat and muck. The soil consists of a covering of accumulated eroded material, similar to that in Washtenaw loam and more than 1 foot thick, overlying peat or muck. Some small "cat holes," or intermittent ponds, are included with Wallkill loam. A small total area is mapped.

Most areas of Wallkill loam are too wet to allow their use with the associated soils, and many fields are laid out to avoid inclusion of them. Artificial drainage generally is expensive, considering the small area affected. Deep excavations through hills are necessary to tap many of the pot holes, which this soil most commonly occupies. Crop responses on cultivated areas are very similar to those on Washtenaw loam, and some areas are used with good results for the production of truck crops and garden crops.

Brookston - Washtenaw complex.—The Brookston - Washtenaw complex occupies depressions or low-lying flat areas in association with most of the soils of the rolling to hilly lands. In most places the surface is level or undulating, drainage is fair to poor, and the soils are subject to extreme textural variation. Almost every combination of imperfectly drained soils, poorly drained soils, organic soils, and Washtenaw and Wallkill soils are included in areas mapped as this soil complex. The small extent of the individual soils and their intimate association prohibits their being mapped in detail.

The uses to which this land is put depend largely on the character of the associated soils and the drainage. In the more variable and wetter or sandier areas, generally associated with the more sandy and more strongly sloping soils, the land is left uncultivated; but in the more uniform and better drained areas, in which heavy-textured soils dominate, the land is used with the associated soils, and yields in general are somewhat less than those obtained on the Conover or Brookston soils. In most places drainage is necessary for best results in the use of the soils of this complex and their extreme variability in many places results in difficulty of management.

SOILS OF THE STREAM BOTTOMS

A total of 13.1 square miles of soils of the stream bottoms is mapped in this county. These soils occur on the flood plains of most of the larger streams, and the largest areas are mapped along the Grand, Lookingglass, and Maple Rivers. Most of the bottoms are almost level, but others are characterized by a complex billowy microrelief. The soil texture ranges from fine sandy loam to silty clay loam, and imperfect to poor drainage is the most common condition.

The small width and irregular shape of the areas occupied by these soils, the extreme variability in natural drainage, and the danger of flooding during the growing season do not favor their use for many of the common crops. The soils are high in the common plant nutrients and organic matter, and where drainage is sufficient good yields of some crops may be obtained. An excellent grass cover is on most of the cleared areas, and the yields of pasture crops on these soils are high. A large proportion of these soils remains uncleared, and wood lots and pasture are the principal types of land use.

Series separations are based largely on the natural drainage of these soils, the height above the normal water level of the streams, and the frequency of flooding. The soils of the Genesee series include the better drained higher lying bottoms that are subject to flooding at infrequent intervals, the Griffin soils include the frequently flooded low-lying less well drained bottoms, and Kerston muck consists of a mixture of mucky materials and mineral alluvium on the stream bottoms.

Genesee fine sandy loam.—The surface soil of Genesee fine sandy loam consists of dark grayish-brown friable fine sandy loam medium to high in finely divided organic matter and neutral in reaction. At a depth of 6 to 8 inches the soil material becomes brown in color, somewhat more limy, and the content of organic matter is lower than in the surface soil. This material continued to a depth ranging from 2 to 4 feet, where a periodically saturated mottled grayish-brown and rust-brown limy material occurs. In many places a stratified condition is noted throughout the profile. This soil represents the better sandy alluvial materials, and, although a range of texture from loamy sand to light loam are included, the fine sandy loam dominates in areal extent. Most of the sandier variations occupy natural levees adjacent to the streams. The surface is level to billowy, with some small areas of Griffinlike soils occurring in the slight depressions.

This is a very inextensive soil. The largest areas occur along the Grand and Lookingglass Rivers. The native vegetation consists of elm, sugar maple, silver maple, red maple, basswood, black ash, and swamp white oak, with some beech on the drier sites.

Most of the uniform areas of this soil are used for the production of such crops as corn, hay, and small grains. Yields generally are high, and amendments are not so necessary as on most of the upland soils. Uncultivated areas support a forest growth, and sparsely forested areas produce excellent pasture.

Genesee loam.—Genesee loam is similar to Genesee fine sandy loam in most respects, the primary difference lying in the fact that the loam contains a higher percentage of fine materials throughout the soil mass than the sandy loam. Genesee loam also is somewhat higher in moisture content and plant nutrients. The texture ranges from light loam to silt loam, but loam is probably the average texture in most areas. Some small areas of old alluvium are included.

The distribution, native vegetation, and relief are very similar to those of Genesee fine sandy loam, but possibly a larger proportion of Genesee loam occurs along the smaller streams. A very small total area is mapped. Uniform areas are highly productive of corn,

hay crops, and small grains, but most of this land remains uncultivated and produces a good growth of trees or excellent pasture.

Griffin sandy loam.—Griffin sandy loam includes the wetter sand or sandy loam bottom soils. The surface soil generally is dark gray or black. It contains fine rust-brown mottles, is alkaline in reaction, and is high in finely divided organic matter. Evidence of recent deposition is common. At a depth of less than 15 inches the material changes to gray moist or wet stratified sandy and silty material mottled with yellow and rust brown. Textural variations are numerous, and some spots approaching Kerston muck in character are included.

This soil is associated with Genesee loam and is not extensive. It is used largely for wood lots and pasture, but some small cleared areas produce good yields of certain crops if the land is drained. A high content of plant nutrients and moisture support excellent summer pasture and a good growth of trees of species similar to those on the poorly drained upland mineral soils.

Griffin clay loam.—Griffin clay loam includes the heavier textured wet bottom soils. The surface soil consists of dark clay loam or heavy silt loam, high in finely divided organic matter and in many places somewhat stratified. This is underlain by bluish-gray and yellow moist material mottled with yellow and rust brown. Some small concretions occur in places. Some stony areas are mapped in the vicinity of Maple Rapids.

This soil is most extensive on the level bottoms of the Maple River near Maple Rapids. Some small depressions of heavy-textured alluvium are included with Griffin clay loam. This is one of the most extensive soils of the bottom land.

Most areas of this soil are too poorly drained for the production of crops, but some of the more level areas in the vicinity of Maple Rapids, which have been cleared and drained, produce good yields of sugar beets, corn, and some other crops. Drainage of this soil requires dredging of the stream channel along which it occurs because of an insufficient gradient for the free movement of drainage water when the river is at normal level. The fertility is high, and the management of this soil is similar to that of Brookston clay loam. Most of the areas mapped as Griffin clay loam remain in forest, with a dense stand of trees of the same species as those growing on the poorly drained upland soils. Some of the depressed areas are ponded and support a willow-alder-buttonbush type of cover. Excellent late summer pasture is obtained on cleared areas of this soil or in places where the forest cover is sparse.

Griffin loam.—Griffin loam is similar to the other Griffin soils in general profile character, but in most places the texture ranges from light loam to light clay loam. In the valley of Stony Creek some areas of Griffin loam consist of a thin covering of alluvial materials overlying moist sandy and gravelly materials at a depth of 2 to 3 feet. Evidence of very recent deposition is lacking in many areas. The presence of pervious materials at a comparatively slight depth facilitates drainage, and dredging of Stony Creek has resulted in sufficient lowering of the water table to allow the use of some areas of this soil in a manner similar to that of the associated Brady and Gilford soils. The range of crops grown

on Griffin loam is somewhat limited, and occasional flooding makes the production of most crops hazardous. A high level of fertility is shown by good yields of some crops. Most of the soil mapped as Griffin loam occupies small bodies and remains in use for wood lots and pasture. This is one of the most extensive soils of the bottom land in the county.

Kerston muck.—Kerston muck includes wet bottom soils consisting of mixed muck and mineral soil or alternate layers of muck and mineral alluvium. The surface material may vary from mucky material to recent mineral alluvium, similar to that of the Griffin soils, with the mucky materials generally making up more than 50 percent of the soil mass to a depth of 3 feet or more. The reaction of the soil mass is neutral to slightly alkaline, and the moisture content is very high. A small total area of Kerston muck is mapped, mainly along the smaller streams or in depressions in the larger stream bottoms.

The extreme wetness and variability of Kerston muck do not favor its use for cultivated crops, and a large proportion of it remains in wood lots or produces a fair to good grade of pasture. Some small patches have been cleared and are in use with the associated soils of the bottom land. Truck crops do well on the drained areas.

ORGANIC SOILS

Organic soils, exclusive of Kerston muck, occupy an area of 48 square miles, or about 8 percent of the total area of Clinton County. Probably 85 to 90 percent of these soils are mapped in the southern half of the county. The individual areas range in size from less than 1 acre to more than 3,500 acres. Two large areas occur in the vicinity of St. Johns. Smaller bodies are scattered over the northern half of the county. Organic soils occupy lake basins, drainage valleys, and seepage spots where the moisture supply has been sufficiently high to favor an excessive accumulation of organic materials. The areas of peat and muck soils are very nearly level. The materials consist of deposits of plant residues varying greatly in the degree of decomposition and ranging in thickness from about 1 foot to more than 50 feet. The shallow deposits are generally underlain by sand or clay, but marl also is common. Transitions to the poorly drained mineral soils are common along the borders of areas of organic soils and in bodies where the organic covering is thin.

The uses to which these organic soils are adapted depend on their drainage, lime content, degree of decomposition of the organic materials, and depth to and character of the underlying organic and mineral materials. A well-developed system of artificial drainage is essential for the best results in the use of these soils for cultivated crops, but some fair crops have been grown in exceptionally dry years in places where drainage is poorly developed. Control of the water level is desirable; otherwise these soils are subject to excessive wetness or excessive dryness. For best results the water table should be maintained at a depth of 30 to 36 inches from the surface during the growing season (*3*).

The muck soils include the darker and more highly decomposed materials and generally have a slightly acid to slightly alkaline reaction.

They represent the better soils for the production of certain special crops. The less highly decomposed materials are strongly acid in reaction and are included in the general class of peats. Burning may result in the accumulation of ash in the surface layers, and an alkaline reaction may result.

About 70 percent of the organic soils remains uncleared. The cleared and cultivated muck areas are used largely for the production of special crops, but some of the common farm crops have been grown with fair success (*3*). Where applications of fertilizers are very large the yields of some crops on many areas are exceptionally high, compared with those obtained on the mineral soils. The production of crops on these soils is hazardous because of the danger of frost injury or excessive wetness during any month of the growing season. Management practices involving special soil treatments are essential for successful crop production on these soils (*4*, *5*).

Carlisle muck and Rifle peat, each with a burned phase and a shallow phase, and Houghton muck, with a burned phase, are mapped. The distinctions between these soils are based on the degree of decomposition and the textural character of the materials in the deposits.

Marl, which is associated with these soils in many places, has considerable value locally as liming material for both the mineral and organic soils.

The character of the mineral substratum is indicated in all the shallow organic soils because of the important bearing it may have on their management.

Carlisle muck.—Carlisle muck occurs in lake basins and drainage valleys and as a border around areas of some of the other organic soils. The deeper deposits are characterized by a surface layer, 10 to 12 inches thick, which consists of slightly acid to slightly alkaline very dark brown or black granular organic material. This is underlain in some places by slightly acid to alkaline compact dark-brown or black material, which is somewhat gelatinous when wet and breaks with a conchoidal fracture when dry. More commonly the material below the surface layer consists of dark-brown granular peat, which is somewhat more acid than the surface soil and becomes fibrous and rather strongly acid at a depth ranging from 18 to 24 inches. The character of this underlying organic material is subject to considerable variation, and mineral material, in places mixed with marl, occurs below a depth of 3 feet. In many places the shallower deposits are not underlain by fibrous materials at any depth but consist of highly decomposed gelatinous nonfibrous materials directly overlying the mineral soil material. Transitions to the poorly drained mineral soils are common, and some small bodies of other organic soils may be included.

An area of 12.5 square miles is mapped as Carlisle muck, 5.4 square miles as the shallow phase, and 0.4 square mile as the burned phase. The largest area of Carlisle muck, aggregating about 2 square miles, occurs north of St. Johns, but a considerable acreage is mapped in the southern part of the county, and some scattered bodies are in the northern townships. Individual areas are of irregular shape, and most of them do not exceed 300 acres in size.

The native forest cover consisted of a dense stand of elm, silver maple, red maple, swamp white oak, black ash, basswood, scattered

aspen, tamarack, and whitecedar. Between 25 and 50 percent of the total area of this soil still remains uncleared. The cleared area is used largely for the production of a good grade of pasture and for special crops. Bluegrass, alsike clover, and reed canary grass make a good growth on this soil and furnish good late-season pasture. Special crops, such as onions, peppermint, truck crops, sugar beets, and potatoes, may be grown successfully if drainage is supplied and if proper soil amendments are made. Corn and some of the other common farm crops are grown, and fair to good yields are obtained. Crops grown on this soil are subject to much more frequent frost injury than crops on the upland soils, and serious damage may result in any month during the growing season. Corn is often harvested for silage because early frost interferes with proper ripening of the grain. Most of the peppermint, for which the St. Johns area is famous, is grown on this soil.

Heavy applications of fertilizers high in phosphoric acid and potash are recommended for most crops on Carlisle muck, and nitrogen and some materials, such as copper sulfate, sodium chloride, manganese sulfate, and sulfur, give good results under certain conditions. Lime is used to correct a too acid soil condition, and sulfur is often used to acidify the more alkaline soil. Applications of barnyard manure and the use of green manures give excellent results in many places.

Drainage and control of water are essential for the best results in the management of all organic soils. Tillage can be accomplished with a small amount of power, and packing of the seedbed is recommended. Wind erosion may seriously damage the organic soils, particularly during dry seasons, and windbreaks are planted in many places for soil and crop protection.

Drainage is accomplished by a combination of open ditches and tile drains. Many of the bodies of this soil occur at considerable distance from an outlet for drainage waters, and installation of an efficient system of drains is very expensive.

Carlisle muck, burned phase.—The burned phase of Carlisle muck is similar to typical Carlisle muck in all respects except that the mineral substratum occurs at a depth of less than 3 feet in the shallow phase. The fibrous acid peaty material that generally occurs in the deeper deposits is absent in many places in the shallow phase.

This is not an extensive soil. One large area is north of St. Johns, and a large area lies south of that city in association with the areas of deeper Carlisle muck.

Soil management is similar to that practiced on the areas of deeper Carlisle muck, and responses to treatments are similar on the two soils. Decomposition of the organic material may result in a sufficient decrease in thickness of the shallow muck soils to injure seriously their utility for the production of special crops. The character of the mineral substratum has an important bearing on crop responses and methods of management of the areas of this shallower soil. Many plants benefit from the nutrients they obtain from the underlying mineral soil.

Carlisle muck, burned phase.—The burned phase of Carlisle muck has the general characteristics of typical Carlisle muck, but fires have destroyed some of the soil material. A temporary alkaline

reaction, which may result after burning, must be corrected by the use of sulfur or some other materials. Burnouts interfere with cultivation of some of the more severely burned areas of this soil, but the slightly burned areas are used in much the same way as unburned Carlisle muck.

Rifle peat.—The surface material of Rifle peat to a depth ranging from 3 to 8 inches is granular and mucky in character, very similar to the surface material of Carlisle muck, and the reaction is slightly acid to medium acid. This surface layer is underlain by a medium-acid to strongly acid brown slightly fibrous peaty material, which becomes more decidedly fibrous, lighter brown, and more strongly acid in reaction with increasing depth. The constituent plant materials in these fibrous organic materials are variable. This organic soil exceeds 3 feet in thickness. As it is intermediate between some of the other organic soils in profile character, transitions are common. Borders of Carlisle muck and poorly drained mineral soils occur around most bodies of this soil.

Included with Rifle peat in mapping are a few small areas that are practically identical with the organic soil recognized and mapped as Greenwood peat in larger areas lying to the northward in Michigan. The material in these areas consists of brown fibrous strongly acid peat, which becomes lighter brown and generally more strongly acid with increasing depth. Such areas may be recognized by their native vegetation consisting of leatherleaf, highbrush blueberry, other shrubs, mosses, grasses, sedges, and scattered tamarack. All such areas remain uncleared and have very little potential use for ordinary farm crops. Small areas of such peat have been used elsewhere for the production of cranberries and blueberries.

A total area of 16.2 square miles of Rifle peat is mapped. The individual areas range from less than 1 acre to more than 2,000 acres in size. The most extensive areas are in the southeastern part of the county. Chandler Marsh includes an extensive area of this soil, and numerous smaller bodies occur in all parts of the southern half of the county. Some scattered areas are mapped in the northern townships. This soil occurs most commonly in irregular-shaped old lake basins.

The native vegetation consisted of tamarack, whitecedar, and scattered elm, red maple, silver maple, red-osier dogwood, and aspen. Only about 10 to 15 percent of this soil is cleared. Brush and second-growth aspen cover most of the uncleared areas. The cleared areas are used for pasture or for the production of crops similar to those grown on Carlisle muck. Liming is more generally necessary on this soil than on Carlisle muck, and larger applications of fertilizers are generally made. The somewhat raw character of the organic material in many places is reflected in poor crop responses during the first year or two of cultivation, but cultivation seems to favor decomposition, and after several years of cultivation the plow soil cannot be distinguished from that of some areas of Carlisle muck.

Management practices and responses to management are similar to those on Carlisle muck. Deep plowing is harmful in places because of a mixing of comparatively raw materials with the plow soil. Pasture of fair to good quality may be produced on this soil where the land is cleared.

The fact that this soil occurs in large bodies, which demand cooperative effort in the development of a proper system of drainage, or as isolated basins, which are drained with difficulty, may partly account for the comparatively small areas in use for crop production.

Rifle peat, shallow phase.—Rifle peat, shallow phase, is similar to typical Rifle peat in all respects except for the presence of a mineral substratum at a depth of less than 3 feet in the shallow phase. Management practices and crop responses are similar on the two soils, but methods of maintaining the organic matter are suggested for preservation of this soil. The character of the mineral substratum has an important bearing on management practices and crop responses on this soil, as many plants feed on the underlying mineral soil.

This is a very inextensive soil. It occurs mainly in one area north of St. Johns, in association with Carlisle muck.

Rifle peat, burned phase.—Many areas of Rifle peat have been subjected to more or less burning, and the effects on the deposits are variable. Areas that have been uniformly burned merely have had the surface materials removed over a large proportion of the area, and charred materials and ashes remain on the surface or at a comparatively slight depth as evidence of this burning. Other areas that have been burned deeply have large holes, representing the burnouts.

The use of the uniformly burned areas may differ greatly from that of the unburned areas, as the quality of the soil generally is reduced by the removal of the mucky surface material. Recent burning may result in a temporary alkaline reaction, and applications of sulfur may be necessary to render the soil usable for crop production. Deep burnouts interfere with cultivation.

Almost all of this soil is covered with aspen and other brush. The largest bodies of burned Rifle peat occur in the southeastern part of the county, and Chandler Marsh contains the largest individual area.

Houghton muck.—The surface layer of Houghton muck, to a depth of 6 to 8 inches, consists of slightly acid dark-brown or black finely fibrous organic material. This is underlain by a more fibrous brown organic material, which may become more acid with increasing depth. The fibrous character of the surface layer and a higher water table distinguish this soil from Carlisle muck and Rifle peat. Houghton muck supports a vegetation consisting of sedges and grasses, together with scattered trees and shrubs. This soil commonly occurs as a border around lakes, in filled lake basins, and in seepage spots. Only a few square miles are mapped. The largest bodies are along the Lookingglass River in Victor and Bath Townships. More than 80 percent of this soil remains uncultivated, and much of the uncultivated land is used for pasture. Some marsh hay is obtained in dry seasons. The cultvated areas are used in much the same way as Carlisle muck and Rifle peat, for a similar range of crops. Much of Houghton muck is somewhat wetter than these soils, and the establishment of an efficient system of drainage is difficult in many places. Yields of most crops are somewhat lower than those obtained on Carlisle muck and Rifle peat.

Small areas of peaty soil are included, which are lighter in color, less decomposed, more strongly acid in reaction, and have a higher water table. A few very small areas of a shallow phase of Houghton muck differ from the typical soil in the presence of the mineral sub-

stratum at a depth of 3 feet or less. The material in these shallow areas is generally somewhat dark colored and more completely disintegrated than in the typical deep soil. Under equal drainage conditions the shallow areas probably would have a slightly higher agricultural value. Areas of the included peat occur on the marshy borders of lakes or in other extremely wet marshy areas. The soil is drained with difficulty, and it remains almost entirely uncultivated. The most extensive individual areas are in the southeastern part of the county. The extremely wet character of this soil and the difficulty of drainage make its use for cultivated crops problematical.

Houghton muck, burned phase.—Houghton muck, burned phase, differs from typical Houghton muck in much the same way the burned phase of Rifle peat differs from the unburned, or normal, Rifle peat. No extensive areas of the burned phase of Houghton muck are mapped.

PRODUCTIVITY RATINGS

The soils of Clinton County are rated in table 7 according to their productivity for the more important crops and are listed in the order of their general productivity under common practices of management, the most productive first. Ratings are given for two general levels of management—the common and the better practices. In evaluating individual soil types, as mapped, the purity of the type is a modifying factor. The descriptions of the individual soils in the preceding pages should be consulted.

TABLE 7.—*Productivity ratings of soils in Clinton County, Mich.*

Soil (type, phase, and complex) [1]	Crop productivity index [2] for—																												General productivity grade [4]		Remarks concerning use, crops, type of farming, workability, and erodibility	Land classification [5]
	Corn (grain)		Corn (silage)		Wheat		Oats		Barley		Rye		Mixed timothy and clover		Red clover		Alfalfa		Beans		Sugar beets		Potatoes		Apples [3]		Pasture [3]					
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
Conover silt loam [6]	90	100	90	100	90	100	90	100	80	100	---	---	90	110	90	110	80	90	90	100	70	90	60	---	60	---	100	120	1	1	General farming	Excellent cropland.
Brookston loam, drained	100	110	100	110	80	100	100	110	80	100	---	---	80	100	80	100	60	90	80	100	80	100	50	---	---	---	90	100	1	1	do	
Conover loam [6]	90	100	90	100	80	100	90	100	90	100	---	---	90	100	90	100	70	90	80	100	60	90	60	80	70	---	90	120	1	1	do	
Brookston clay loam, drained.	90	100	90	100	70	90	90	100	80	100	---	---	80	100	80	100	60	80	80	100	80	100	40	70	---	---	90	110	2	1	General farming	Good to excellent cropland.
Miami silt loam	80	100	80	100	80	100	80	100	70	90	80	---	80	100	80	100	60	80	70	90	60	80	60	80	80	---	90	120	2	1	General farming; moderately erodible.	
Brady loam, drained	80	100	80	100	80	100	80	100	80	100	---	---	80	100	80	100	60	80	70	90	70	90	50	80	---	---	80	110	2	1	General farming	
Bronson loam	70	90	70	90	80	100	70	90	70	90	90	---	80	100	80	100	70	90	70	90	50	70	60	90	80	---	80	110	2	1	General farming; easily tilled.	
Genesee loam [7]	70	90	80	100	70	90	80	100	70	90	80	---	90	100	80	110	70	90	70	90	70	90	70	90	---	---	80	110	3	1	Subject to some overflow; may occur in narrow irregular strips.	Good cropland.
Macomb loam, drained	80	100	80	100	70	90	80	100	70	90	80	---	80	100	80	100	60	80	70	90	70	90	50	70	---	---	80	110	3	1	General farming; some stone.	
Miami loam	70	90	70	90	70	100	70	90	70	90	80	100	70	90	70	100	70	90	70	90	60	70	60	80	90	110	80	110	3	1	General farming; moderately erodible.	
Gilford loam, drained	80	100	80	100	60	80	70	90	60	80	---	---	80	100	80	100	50	80	70	90	70	90	60	90	---	---	80	100	3	1	General farming	
Washtenaw loam [6] [7]	80	100	80	100	60	80	80	90	60	80	80	---	80	100	80	100	60	90	70	90	70	90	40	70	---	---	90	130	3	1	General farming; subject to some overflow; small grains subject to lodging.	
Maumee loam, drained	70	80	70	90	60	70	70	90	50	70	70	---	70	90	80	90	50	70	70	90	60	90	40	80	---	---	70	100	3	2	General and truck farming.	
Hillsdale loam	70	90	70	90	70	90	70	90	60	90	80	100	60	90	60	90	50	80	60	90	50	70	60	90	90	110	70	100	3	2	General farming; moderately erodible.	
Brady sandy loam, drained.	70	90	70	90	70	90	70	90	70	90	70	---	70	90	70	90	60	70	70	90	60	80	50	70	---	---	80	100	3	2	General farming	

Genesee fine sandy loam.[7]	70	90	70	80	70	80	70	90	60	80	70	90	80	90	70	90	60	80	60	90	60	80	60	90	---	---	80	100	4	2	General farming; some irregular and narrow areas; subject to overflow.
Griffin loam, drained [7]	70	90	70	90	50	80	70	90	70	80	80	100	80	100	80	100	60	80	70	90	70	90	60	80	---	---	90	110	4	2	do
Griffin clay loam, drained.[7]	70	90	70	90	60	80	70	90	50	70	70	90	90	100	80	100	60	80	70	90	70	90	---	---	---	---	70	100	4	2	do
Fox loam	60	80	60	80	70	90	70	80	50	80	80	---	70	80	60	80	50	70	60	80	50	70	60	90	90	---	70	90	4	2	General farming; easily tilled.
Miami loam, rolling phase.	60	80	60	80	70	90	70	80	60	80	70	90	60	90	60	90	60	80	60	70	40	60	50	70	80	100	70	100	4	2	General farming; moderately to very erodible; medium workability.
Brookston-Washtenaw complex, drained.[7]	60	80	70	90	60	80	70	90	60	80	---	---	70	90	60	80	50	80	70	90	60	90	40	70	---	---	80	110	4	2	General farming; subject to some uneven ripening and lodging of grain.
Carlisle muck, drained	70	---	70	90	---	---	---	---	---	---	---	---	50	100	---	---	---	50	---	---	30	70	40	80	---	---	80	100	4	2	Truck crops, corn, mint, pasture.
Hillsdale sandy loam	60	80	60	80	60	80	60	80	---	---	70	90	60	80	50	80	40	70	50	70	50	70	60	90	80	100	60	80	4	2	General farming, fruits, vegetables; moderately erodible.
Griffin sandy loam, drained.[7]	60	80	60	80	60	70	70	80	40	70	60	80	70	90	70	90	60	80	60	80	60	80	60	80	---	---	60	80	4	2	General farming; some narrow, irregular-shaped areas; subject to overflow.
Fox sandy loam	50	70	60	70	60	80	60	70	50	70	60	80	50	70	50	70	50	70	50	70	---	---	50	80	80	100	60	80	5	3	General farming; easily tilled.
Carlisle muck, shallow phase, drained.	---	---	60	80	---	---	50	70	---	---	---	---	40	90	---	---	---	---	---	---	20	70	40	80	---	---	70	90	5	2	Truck crops, corn, mint, pasture.
Wallkill loam, drained [7]	---	---	50	90	50	100	60	80	---	---	---	---	50	90	60	90	---	---	---	---	---	---	50	80	---	---	70	100	5	2	General farming; subject to some overflow; grains subject to some lodging and drowning out.
Berrien sandy loam	50	80	50	80	60	80	60	80	50	70	60	80	70	90	60	80	40	70	50	70	30	50	60	90	80	110	50	70	5	3	General farming, vegetables, apples.
Granby loamy sand, drained.	50	70	60	70	60	70	60	80	40	60	60	80	60	80	50	70	40	60	60	80	50	70	40	70	---	---	60	80	5	3	General farming, vegetables, hay.

Fair to good cropland.

Fair to poor cropland.

[1] Soils are listed in the approximate order of their general productivity under the common practices, the most productive first.

[2] The soils of Clinton County are given indexes that indicate the estimated production of each crop in percentage of the standard of reference. The standard represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of the regions in which the crop is most widely grown. The indexes in column A refer to yields obtained under the common practices of management in Clinton County and include the use of some commercial fertilizer and lime; those in column B refer to the higher yields obtained under the generally better practices that include the greater use of legumes, green and barnyard manures, commercial fertilizers, and improved plant varieties.

[3] The indexes for apples and pasture are comparative for the soil types of this and adjoining counties and are not based on standards of reference because of insufficient data.

[4] This classification indicates the comparative general productivity of the soils under prevailing soil-management practices (A) and also under the better or more intensive practices (B). The general productivity grade numbers are derived from the assigned crop indexes. Actually, of course, more variations in management practices exist than have been indicated by columns A and B, and so there may be a greater range in general productivity of each soil type.

[5] This is a classification to indicate in a general way the relative productivity and physical suitability of the soils for the common crops, pasture, and forest. Of course, "Excellent cropland," etc., in Clinton County, generally mean that the soils are also similarly adapted to grasses and trees.

[6] These naturally imperfectly drained soils are commonly artificially drained to some degree, adequate for production of the common crops, by means of backfurrows, furrow ditches, a few tile, etc. The indexes apply to these conditions.

[7] These soils of the bottoms and depressions are subject to variations of flooding, deposition, drainage, pattern of distribution, and, consequently, of use and management. As a result, these indexes are even less exact than the others.

TABLE 7.—*Productivity ratings of soils in Clinton County, Mich.*—Continued

Soil (type, phase, and complex)	Crop productivity index for—																												General productivity grade		Remarks concerning use, crops, type of farming, workability, and erodibility	Land classification
	Corn (grain)		Corn (silage)		Wheat		Oats		Barley		Rye		Mixed timothy and clover		Red clover		Alfalfa		Beans		Sugar beets		Potatoes		Apples		Pasture					
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
Bellefontaine sandy loam	50	70	50	70	60	80	50	70	---	---	60	80	50	70	50	70	40	70	50	70	---	---	50	80	70	100	50	70	5	3	General farming, fruit; moderately erodible; medium workability.	Fair to poor cropland.
Hillsdale sandy loam, rolling phase.	50	70	50	70	50	70	50	70	---	---	60	80	50	70	40	70	40	70	50	70	---	---	50	70	60	90	50	70	5	3	General farming, fruit, pasture; moderately erodible.	
Houghton muck, drained	---	---	60	80	---	---	50	70	---	---	---	---	40	80	40	70	---	---	---	---	---	---	50	80	---	---	50	70	[8] 6	3	Truck crops, corn, pasture	
Rifle peat, drained	---	---	60	80	---	---	50	70	---	---	---	---	40	80	40	70	---	---	---	---	---	---	50	80	---	---	50	70	[8] 6	3	do	
Bellefontaine loamy sand	40	60	40	60	50	70	40	60	---	---	50	70	40	60	30	50	30	60	40	60	---	---	40	70	60	80	40	60	6	4	General farming, pasture, fruits; gravel pits.	
Ottawa loamy fine sand	40	50	40	60	40	60	40	60	---	---	40	60	40	60	30	50	30	50	40	60	---	---	40	60	60	80	40	60	6	4	Fruits, vegetables, hay; wood lots.	
Rifle peat, shallow phase, drained.	---	---	50	80	---	---	---	---	---	---	---	---	40	80	---	---	---	---	---	---	20	60	30	70	---	---	40	70	[8] 6	4	Truck crops, corn, pasture wood lots.	
Kerston muck, drained [7]	---	---	60	80	---	---	---	---	---	---	---	---	50	100	60	100	---	---	---	---	30	80	30	70	---	---	80	90	[8] 6	3	do	
Coloma loamy sand	40	60	30	50	30	50	30	50	---	---	40	60	30	60	30	50	30	60	40	60	---	---	40	70	60	80	40	60	7	4	Fruit, vegetables, general crops. Danger of soil blowing.	
Oshtemo loamy sand	30	50	30	50	40	50	30	50	---	---	40	60	30	60	30	50	40	60	40	60	---	---	40	70	50	70	30	40	7	4	Vegetables, fruits, general crops.	
Berrien loamy sand	40	60	30	50	30	50	30	50	---	---	40	60	40	60	30	50	30	50	40	60	---	---	40	70	50	70	40	60	7	4	Vegetables, fruits, hay, general crops. Danger of soil blowing.	
Hillsdale-Oshtemo complex (stony).	---	---	---	---	---	---	---	---	---	---	---	---	60	[9] 80	---	---	---	---	---	---	---	---	40	[9] 80	50	80	50	80	7	4	Pasture: wood lots. Difficult to till.	
Berrien-Griffin complex (stony):	---	---	---	---	---	---	---	---	---	---	---	---	60	[9] 80	---	---	---	---	---	---	---	---	---	---	---	---	60	90	7	4	do	
Carlisle muck, burned phase, drained.	---	---	50	80	---	---	40	70	---	---	---	---	40	90	---	---	---	---	---	---	30	60	30	70	---	---	50	80	7	4	Truck crops, corn, pasture.	
Houghton muck, burned phase, drained.	---	---	50	70	---	---	40	70	---	---	---	---	40	80	---	---	---	---	---	---	20	50	30	70	---	---	40	70	7	4	do	
Rifle peat, burned phase, drained.	---	---	50	70	---	---	40	70	---	---	---	---	40	80	---	---	---	---	---	---	20	50	30	70	---	---	40	70	7	4	do	
Plainfield sand	20	40	20	40	30	50	20	40	---	---	40	60	30	50	20	50	20	40	---	---	---	---	30	60	40	60	30	50	8	6	Truck crops, pasture; wood lots.	

Brookston loam, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Brookston clay loam, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gilford loam, undrained[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Macomb loam, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Brookston-Washtenaw complex, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Griffin loam, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Griffin clay loam, undrained.[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Brady loam, undrained[7]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Granby loamy sand, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Griffin sandy loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Brady sandy loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Wallkill loam, undrained	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Maumee loam, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carlisle muck, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carlisle muck, burned phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carlisle muck, shallow phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Houghton muck, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Houghton muck, burned phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Houghton muck, shallow phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Kerston muck, undrained	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Rifle peat, undrained	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Rifle peat, burned phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Rifle peat, shallow phase, undrained.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Brookston loam, undrained.[7]						
Brookston clay loam, undrained.[7]						
Gilford loam, undrained[7]						
Macomb loam, undrained.[7]						
Brookston-Washtenaw complex, undrained.[7]	40	60	9	8	Wood lots; pasture	
Griffin loam, undrained.[7]						
Griffin clay loam, undrained.[7]						
Brady loam, undrained[7]						
Granby loamy sand, undrained.						
Griffin sandy loam, undrained.	30	50	10	9	do	
Brady sandy loam, undrained.						Wood lots and pasture land.
Wallkill loam, undrained						
Maumee loam, undrained.						
Carlisle muck, undrained.						
Carlisle muck, burned phase, undrained.						
Carlisle muck, shallow phase, undrained.	10	---	10	---	do	
Houghton muck, undrained.						
Houghton muck, burned phase, undrained.						
Houghton muck, shallow phase, undrained.						
Kerston muck, undrained						
Rifle peat, undrained						
Rifle peat, burned phase, undrained.	5	---	10	---	do	
Rifle peat, shallow phase, undrained.						

[7] These soils of the bottoms and depressions are subject to variations of flooding, deposition, drainage, pattern of distribution, and, consequently, of use and management. As a result, these indexes are even less exact than the others.

[8] The productivity grade numbers for these mucks and peats reflect the variations in yields that result from yearly climatic fluctuations as well as the influences of distinct management practices.

[9] These indexes refer to yields obtained from the areas partly cleared of stone.

NOTE.—Absence of indexes indicates that the crop is not commonly grown on the particular soil type.

The rating compares the productivity of each of the soils for each crop to a standard, namely, 100. This standard index represents the approximate average acre yield obtained without amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as are soils with the standard index. Soils given amendments, such as lime, commercial fertilizers, and irrigation, and unusually productive soils of comparatively small extent may have productivity indexes of more than 100 percent for some crops.

The following tabulation sets forth some of the acre yields that have been established as standards of 100. These figures represent the average long-time yields of crops of satisfactory quality on the better soils of the United States, without the use of amendments.

Crop:		
Corn (grain)	bushels	50
Wheat	do	25
Oats	do	50
Barley	do	40
Rye	do	25
Beans	do	25
Potatoes	do	200
Corn (silage)	tons	12
Timothy and clover hay	do	2
Red clover hay	do	2
Alfalfa hay	do	4
Sugar beets	do	12

The crop productivity indexes in column A refer to yields obtained under the common practices of soil and farm management. These practices include the use of legumes, the return to the land of the barnyard manure produced on the farm, the use of lime for alfalfa, the application of some commercial fertilizers to the cultivated crops and small grains, and the inclusion of some pasture land in the rotation. These common practices, of course, vary somewhat with the different associations of soil types. For example, more feed crops and more pasture land generally are included in the rotation on farms consisting largely of the more rolling or lighter textured soils, such as Hillsdale sandy loam, Miami loam, rolling phase, and Fox sandy loam, than are included on farms consisting largely of Conover silt loam, Brookston loam, and Miami silt loam, where the cash crops—sugar beets and beans—are more important.

The indexes in column B refer to yields obtained from the better practices of management that are carried on in Clinton County and include the greater use of legumes, green and barnyard manures, commercial fertilizers, improved plant varieties, longer rotations, and other means of soil improvement. Under the better practices productivity is maintained at a higher level, although the total production of a particular crop, such as corn or oats, over a short period may be lower, because of the longer period of hay in the rotation. The longer rotations are used especially on the more rolling, lighter textured, or less fertile soils, whereas on the better soils, such as the Conover and Brookston, the better practices are more largely confined to increased fertilization and improved plant varieties.

Two sets of ratings have been given for a number of the soils to indicate their productivity under natural conditions of poor drainage and under conditions of artificial drainage. Conover silt loam, Conover loam, and Washtenaw loam are naturally imperfectly drained, and by the use of some artificial means such as backfurrows, furrow ditches, and tile, drainage is improved and they become well adapted to the common crops. Ratings are given for this usual condition of improved drainage. Certain of the poorly drained mineral soils and organic soils have been given the same rating for pasture, as it is impossible by limited observations to distinguish any differences in the carrying capacities of these soils.

The principal factors determining the productivity of land are climate, soil (this includes a long list of physical, chemical, and biological characteristics), slope, drainage, and management, including the use of amendments. Actually, no one of these factors operates separately from the others, although some one may dominate. The soil type itself is conceived by the modern soil scientist to represent "the combined expression of all those forces and factors that, working together, produce the medium in which the plant grows." Crop yields over a long period furnish the best available summation of these associated factors, and, therefore, are used where available. In this rating of the soils of Clinton County, most of the indexes are based on estimated yields rather than on actual reported yields. This is necessary because of a lack of definite information. Interviews with farmers have been the most common source of information on which the estimated yields or indexes are based. The indexes for apples and pasture do not refer to yield standards, inasmuch as definite yield informatioin regarding these items was particularly indefinite. The indexes for pasture are based primarily on the ability of the soil types to support a growth of Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*P. compressa*).

The soils are listed in the order of their general productivity under the common practices, and productivity grade numbers are assigned in the column "General productivity grade." The general productivity grade is based on a weighted average of the indexes for the various crops, using the approximate areal extent and value of the various crops in the county as bases. Since marked differences exist in the suitabilities and uses of soils of markedly different characteristics, no uniform set of weightings of crop indexes can well be given to all the soils. Separate weightings of the indexes are set up to apply to groups of rather similar soils. If the weighted average is between 90 and 100, the soil type is assigned a grade of 1; if it is between 80 and 90, a grade of 2 is assigned, and so on. Since it is difficult to measure or express mathematically either the exact significance of a crop in local agriculture or the importance and suitability of given soils for particular crops, the weightings are used only as guides. In Clinton County the productivity grades have been assigned from an inspection of the crop indexes rather than from detailed careful computations.

Productivity tables do not present the relative roles that soil types, because of their extent and the pattern of their distribution, play in the agriculture of the county. The tables give a characterization to

the productivity of individual soil types. They cannot picture the total quantitative production of crops by soil types without the additional knowledge of the acreage of the individual soil types devoted to each of the specified crops.

Economic considerations have played no part in determining the crop indexes. Therefore, they cannot be interpreted into land values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land.

The brief statements under the heading "Remarks" (etc.) are offered to characterize further the soils and to give the reader a better understanding of some of the physical characteristics or the roles that the soils play in local agriculture.

The column "Land classification" summarizes in a simple way the productivity and use capabilities of the various soils by placing them in a few groups on the basis of their relative suitability for farming, pasture, and forest. It is conceivable that changes in farming, shifts in the values of present important crops, newer uses of lands, and different kinds of management may alter this classification. The association of soil types or the particular pattern of distribution that they form on any individual farm or group of farms may have a very important influence on the use and value of the farm land. Such conditions are not adequately covered by this classification to make it equally applicable to all farms in the county. Thus, some of the muck areas, for short periods or during some particular year, have given the highest economic returns per acre for mint and other special crops, although muck areas, as such, do not seem to justify the highest general agricultural rating in the county. The order of the soils is fairly representative for these soils of the Gray-Brown Podzolic region centering about southern Michigan, northern Indiana, and northern Ohio, where management practices are similar, and the principal uses of land are for corn, small grains, hay, and pasture.

LAND USES AND AGRICULTURAL METHODS

Several distinct land type areas [8] or soil associations occur in Clinton County. Each of these includes a similar range of relief, a similar group of soils, and approximately the same relative proportion of the various soils. A nearly similar soil distribution pattern occurs repeatedly in any one land type area.

Individual soil types have definite potentialities for the production of a particular crop or group of crops, and the character of the dominant soils, as well as the pattern of distribution, on any farm may largely determine the quality of the land on that farm. Association of similar soils, differing only in relative proportions of the individual soil types and in the distribution patterns of these types, may result in land of markedly different utility and quality. On the other hand, two farms may be composed of very different associations of soils and the quality of both farms might be high except for different groups of crops under a somewhat different type of management. A quality classification of land for general crops is shown in figure 2. The land

[8] VEATCH, J. O. THE IDEA OF THE NATURAL LAND TYPE. Soil Sci. Amer. Proc. 2: 499–503, illus. 1937. [Processed.]

type is defined strictly on the basis of the physical character of the land, but these differences in physical character are reflected in land use, so that each land type area is characterized by a system of land use distinct from that of any other area. These differences in land use may be sufficiently extreme to be reflected in the distribution pattern of cleared and uncleared land, or they may merely be represented by minor adjustments in the relative proportion of various crops and slight modifications of management practices.

Figure 3 is a map of the land type areas of Clinton County. Table 8 includes descriptions of these land types and notes regarding the character of land use in each area.

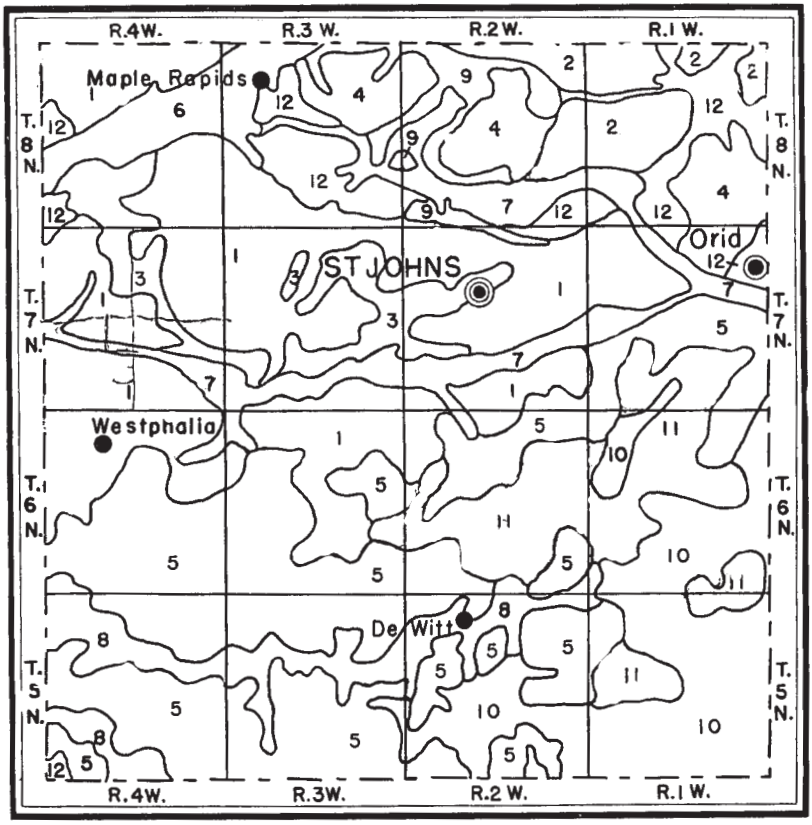

FIGURE 3.—Types of land in Clinton County, Mich., as described in table 8.

TABLE 8.—*Description of land types and character of land use in Clinton County, Mich.*

Legend No.	Land characteristics					Land use data				
	Texture[1] and organic-matter content of mineral soils	Natural drainage of mineral soils	Swampy organic soils	Poorly drained mineral soils	Relief and geologic features	Cleared land	First-class land in uncleared areas	Average size and shape of wood lots	Land use	Notes
			Pct.	*Pct.*		*Pct.*	*Pct.*			
1	Loams, silt loams, and clay loams, medium to high in organic matter.	Imperfect to poor.	0–5	25–30	Level to undulating till plain and subdued moraines.	90–100	95	Less than 25 acres, rectangular.	General farming	Land in cultivation, all of good quality. Artificial drainage beneficial and well developed.
2	Loams, clay loams, and sandy loams, high to medium in organic matter.	Poor	0–5	75–85	Level lake plain	75–85	80	About 40 acres, rectangular.	do	Land largely of good quality. Drainage essential for best results. Some land still needs improved drainage.
3	Loams and silt loams, medium in organic matter.	Good to imperfect.	0–5	15–20	Undulating to gently rolling till plains and terminal moraines.	80–95	90	50–100 acres, rectangular.	do	Land largely of good quality. Some drainage of depressed areas would be beneficial in land use.
4	Loams, clay loams, and sandy loams, medium to low in organic matter.	do	0–5	15–20	do	80–95	85	About 30 acres, rectangular.	do	Land in cultivation largely of good quality. Drainage of some soils would be beneficial.
5	Loams and sandy loams, medium to low in organic matter.	Good to excessive.	5–10	10–15	Gently rolling and undulating till plains and terminal moraines. Swamps not extensive.	75–90	50	Variable size, largely 20–50 acres; some irregular, some rectangular.	General farming, special crops.	Land in cultivation largely of good quality. Much of the poorer land is in wood lots.
6	Sandy loams and sands, low to medium in organic matter; loams, high in organic matter.	Excessive to poor on bottoms.	0–5	20–25	Valley cross section; steep slopes and undulating to level bottoms.	40–60	10	Continuous strip along stream valley.	Pasture and wood lots.	Excessive stoniness prohibits cultivation. Pasture, wildlife propagation, and forestry recommended.
7	Loams and sandy loams, medium to high in organic matter; sands and sandy loams, low in organic matter.	Poor to good	15–20	40–50	Valley cross section; largely level valley-train and terrace materials, some narrow valley slopes included.	75–90	30	Variable size, largely strips along stream valleys, and irregular.	General and special crop farming, pasture.	Cultivated land largely of good to fair quality. Some artificial drainage would be beneficial.
8	Sandy loams and loams, low in organic matter; loams, high in organic matter.	Excessive to poor on bottoms.	0–5	5–10	Valley cross section; steep slopes, level valley-train deposits and narrow wet bottoms.	60–75	10	Continuous strips along stream valleys.	General farming, pasture and wood lots.	Cultivated land of fair to good quality. Erosion may be a problem.

9	Sandy loams and loams, low in organic matter.	Excessive to good.	0–5	5–10	Sloping lake plain and valley borders and level beach deposits.	70–85	25	40–60 acres, variable size, rectangular.	General farming, special crops, and pasture.	Cultivated land of fair quality. Erosion may be a problem.
10	Sandy loams, sands, and loams (largely); low in organic matter.	do	30–40	8–13	Rolling to hilly terminal moraines, level outwash plains; and broad swampy bottoms; largely rounded hills and broad swampy lowlands.	40–60	5	Variable size, largely continuous sprawling irregular areas.	Wood lots, special and general crops, pasture.	Cultivated land of fair to poor quality. Considerable abandonment of farms. Expansion of forestry, pasture, and wildlife propagation recommended.
11	Loams and sandy loams, low in organic matter.	do	20–25	5–10	Gently rolling to rolling terminal moraines and till plains; considerable swamp lowland.	65–80	20	40–100 acres, some small spots; largely irregular but some rectangular blocks.	General farming, special crops, and pasture.	Cultivated land of fair to good quality. Erosion may be a problem, and only less sloping lands should be cultivated. Pasture and forestry should be expanded.
12	Generally sandy loams and sands, low to medium in organic matter; sandy loams and loams, medium to high in organic matter.	Good to imperfect.	0–5	10–15	Level to undulating outwash plains, beaches, terraces, and valley-train deposits.	80–90	35	15–30 acres, rectangular.	General farming and pasture.	Cultivated land largely of fair to good quality. Good management essential to keep soils productive.

[1] Dominant texture listed first.

Land type 1 is characterized by a level to undulating land surface and medium to dark-colored soils of intermediate to heavy texture. Almost all of the land is in use for farm crops, with field beans, hay crops, corn, and small grains growing on the largest acreage, and some sugar beets are grown. The range of soil conditions on any one farm generally is not extreme, and fields of very uniform soil character and rectangular shape are common. Wood lots occupy good land, and they occur as small rectangular areas, which are used largely for combined wood lots and pasture. All the land is of good quality for general crop production, farm buildings are of good quality, and most of the farmers are thrifty. Land type 10, on the other hand, is characterized by a high percentage of light-colored sand and sandy loam soils and a high percentage of strongly rolling land. Large irregular-shaped areas of low-grade swampy organic soils occur. About 50 percent of this land type still remains uncleared, and much of the cleared land is of poor quality. Uncleared areas are of irregular shape, and in many places the boundaries between cleared and uncleared land follow steep slopes or the borders of swamps. The crops consist largely of the small grains, hay crops, and corn. Field beans and sugar beets occupy a very small area. Selective use of land for a particular crop is very important for best results on this land. A larger proportion of the cleared land of this land type is used for pasture than is true of land type 1, and a much smaller proportion of the wood lots are used for pasture in land type 10. Numerous farms have been abandoned in land type 10, the number of farms per square mile is less than in land type 1, and most of the farm buildings are fair to poor. The differences in land character and land use in these two land types are outstanding, and they are reflected in the distribution of cleared and uncleared land as well as the kinds of crops grown and the distribution of the various crops.

The contrast between the land in land type 1 and the land in land type 5 is not so extreme as that between the land in land type 1 and the land in land type 10. Differences in land use between land types 1 and 5 are reflected largely in differences in the relative acreages occupied by different crops.

The higher percentage of organic soils in land type 5 than in land type 1 favors the production of more special crops in land type 5 (*7*). A similar group of crops is grown on the mineral soils in the two land types, but the larger proportion of better drained land in land type 5 favors a larger acreage of alfalfa, wheat, and other cereals, and a smaller acreage of sugar beets, beans, and corn. The proportion of First-class land is somewhat smaller in land type 5 than in land type 1, wood lots are more extensive, not so uniformly rectangular, and most of them occupy some of the poorest land on the farms. Apparently the land is of sufficiently high quality to allow for successful farming in land type 5 because farmers appear to be thrifty and very few farms have been abandoned. Farm buildings, however, are generally of better quality in land type 1 than in land type 5, and of poorer quality in land type 10 than in land type 5. Similar comparisons could be made for all land type areas with differences between some areas slight and between others extreme. Data on which these comparisons are

based are included in table 8. Notes regarding the distribution of crops are based largely on observations.

Slightly more than 85 percent of the land in Clinton County is now cleared and largely in use for general farming. Of the remaining 15 percent about one-third is classified as potential First-class land. The uncleared First-class land occurs in small blocks as farm wood lots, and any considerable expansion of the First-class cultivated land acreage would take place largely by clearing small wood lots on a large number of farms. No extensive areas of uncleared First-class land that would warrant the development of new farms are present in the county. An increase in size of farms would probably be beneficial in many places.

The distribution of the potential First-class cropland is suggested in table 8 and the accompanying land map.

Crop adaptations are largely determined by the character of the individual soils, so the discussion of soil management for the production of specific crops will be based on soil type characteristics rather than on the characteristics of the broader land types. The grouping of soil types for this discussion will be based on textural and drainage similarities.

The intermediate- to heavy-textured soils are all very well adapted to growing cultivated crops, and a large proportion of these soils is in that use. The well-drained soils of this textural range are well adapted to growing wheat, oats, barley, rye, alfalfa, clovers, and field beans. Corn does well, but the more steeply sloping land planted to this crop is subject to serious soil erosion under present prevailing cultural practices. Nonleguminous hay crops, potatoes, and fruits may be grown successfully. The imperfectly drained soils are somewhat better adapted to growing annual crops, such as corn, field beans, oats, and barley, and a large acreage ordinarily is devoted to these crops. Excellent growth of some hay crops may be expected, but alfalfa and some other perennials may suffer from heaving, due to freezing and thawing of the ground during the winter. The high moisture-retaining capacity and high fertility of the poorly drained soils of this group favor the growth of such crops as sugar beets, corn, and field beans, and a comparatively large proportion of the area of these soils is used for these crops. Hay crops also do very well.

The exceptionally dense forest cover allowed the growth of only a sparse cover of grasses on the forest floor, so the native pasture is poor, but excellent pastures may be obtained on all these soils where the land is cleared or where the forest is somewhat open. The quality of pasture is good, and all these soils produce an abundant growth of pasture crops.

These intermediate- to heavy-textured soils have been largely cleared, but they supported excellent stands of timber at one time. The well-drained soils were characterized by a beech-sugar maple association, and the poorly drained soils supported a cover consisting principally of elm, soft maple, and basswood. The quality of the timber was good, but the rate of growth was slow; and these soils generally are considered of too high value for cultivated crops to allow extensive areas to remain uncleared. Most farms on these soils include small wood lots, which supply wood for fuel and afford good opportunities for the

propagation of wildlife. Many of the wood lots, however, are poorly managed.

The sandy loams and sands produce a variety of crops similar to those on the heavier textured soils, with yields usually considerably lower on the sandier soils. A larger proportion of the sandy soils remain uncleared, and a larger proportion of the soils in cultivation are utilized for the production of special crops, such as fruits and truck crops.

Native pasture on many of these soils is poor, but cleared areas produce fair to good early season grazing. The carrying capacity of the soils is not so high as that of the heavier textured soils, and many pastures are overgrazed, with the result that the vegetal cover is sparse and erosion may cause considerable damage. Proper use of these soils results in good pasture during some seasons.

The trees native to these soils are of good quality, but they grow slowly. The low value of many of these soils for farming, however, warrants the maintenance of extensive wood lots and pastures. Only the more level areas should be farmed, and special efforts must be made to manage the soils properly for the maintenance of fertility if good results are to be obtained.

Usually the river bottoms are too wet for crop production, but some cleared areas produce a variety of crops similar to those on the poorly drained mineral soils. Yields are often high, but flooding during the growing season may seriously damage crops.

Native pasture is poor because of the dense forest growth, but the cleared areas yield an excellent quality of late season pasture. The carrying capacity is usually very high where a good stand of grasses has become established. A common practice includes pasturing of wood lots on these soils.

The wet condition of these soils and the density of the forest cover have discouraged clearing for cultivation, and a large proportion of them remain under forest. The timber is of good quality, but the trees are slow-growing.

Only the less acid organic soils are used for crop production (7), with most of the cultivated area used for special crops. Some of the common farm crops are grown with fair success. Artificial drainage is essential for the best results on these soils, and soil amendments are different from those used on the mineral soils.

Native pasture is poor on the forested organic soils and fair on the marshy areas. A good grade of pasture may result from clearing and partial drainage on Carlisle muck. The planting of such grasses as reed canary grass on cleared areas of this and other swamp soils may be economic. The forest cover on some of the organic soils provides only a poor quality of timber. Most of the trees are slow-growing and of low value, but the poor adaptability of these soils for the production of the common farm crops warrants the maintenance of extensive wood lots.

Management practices that include crop rotations, applications of barnyard manure, and the use of green-manure crops and commercial fertilizers are used by most of the successful farmers in the county. Methods of management that maintain or build up the organic matter supply are highly beneficial in keeping the soil in good physical condition for crop production. Liming of the more acid soils is the gen-

eral practice. Artificial drainage of the wetter land and practices involving prevention and control of erosion are included in a scheme of good land management. Erosion is not extremely destructive, and its prevention and control are largely a matter of proper land use rather than a problem of installation of engineering structures.

Experimental work at the Michigan Agricultural Experiment Station (*10*) has resulted in good responses to the use of barnyard manure, green-manure crops, and commercial fertilizers on soils similar to those in Clinton County. The soil organic matter is, in addition to its physical benefits to the soil, the storehouse of much of the plant nutrients, particularly nitrogen; so it is essential that the supply of organic matter be maintained. Most of the well-drained soils and some others will show responses to applications of nitrogenous fertilizers for a variety of crops; phosphoric acid almost invariably gives an increase in yield; and potash is generally deficient in the sandy and organic soils. Some less common fertilizer materials have shown good responses in a number of places, and applications of lime are highly beneficial to most crops on the more acid soils, particularly the sandy soils.

Table 9 gives the recommended fertilizer mixtures and rates of application for the most common crops for a range of soil conditions. Organic soils are used largely for the production of special crops, and special types of management and fertilization are practiced. Additional information regarding the use of fertilizers may be obtained from the soils department, Michigan State College (*9*, *10*).

TABLE 9.—*Fertilizer recommendations for wheat, rye, oats, barley, corn, field beans, and alfalfa on soils* [1] *in Clinton County, Mich.*

Kind of soil	Fertilizer recommended for—			
	Wheat, rye, oats, and barley [2]	Corn [3]	Field beans [4]	Alfalfa
	Pounds per acre	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*
Well drained:				
Sandy loams and sands.	150 to 300 of 4-16-8 or 3-12-12.	125 to 175 of 4-16-8	200 of 4-16-4	250 to 350 o 0-8-24.
Loams and heavier soils.	150 to 250 of 2-12-6 or 4-16-4.	100 to 150 of 2-16-8 or 0-20-0.	200 of 4-16-4 or 2-16-8.	150 to 250 of 0-14-6 or 0-20-0.
Imperfectly drained:				
Sandy loams and sands.	200 to 300 of 2-16-8 or 3-12-12.	125 to 200 of 4-16-8 or 2-12-6.	200 of 4-16-4 or 2-12-6.	250 to 350 of 0-8-24.
Loams and heavier soils.	150 to 250 of 2-12-6, 4-16-4, 2-16-8, or 0-20-0.	100 to 150 of 2-16-8 or 0-20-0.	200 of 2-16-8 or 0-20-0.	150 to 250 of 0-14-6 or 0-20-0.
Poorly drained:				
Sandy loams and sands.	150 to 200 of 2-12-6	125 to 200 of 2-12-6	200 of 2-12-6	250 to 350 of 0-8-24.
Loams and heavier soils.	150 to 250 of 2-12-6, 4-16-4, 2-16-8, or 0-20-0.	100 to 150 of 2-16-8 or 0-20-0.	200 of 4-16-4 or 0-20-0.	150 to 250 of 0-14-6 or 0-20-0.
Organic:				
Alkaline and low lime.	(5)	(5)	(5)	
High lime	250 to 400 of 0-8-24, 0-10-20, or 0-8-32.	250 to 350 of 0-8-24, 0-10-20, or 0-8-32.	200 to 500 of 0-8-24, or 0-10-20.	

[1] Soils well supplied with lime give better results than those insufficiently supplied (*9*).
[2] Top dressing of sandy soils with 75 to 150 pounds of sulfate of ammonia often gives good results. Applications generally made with the seed.
[3] Results of experiments in general do not warrant application of fertilizer for corn. If fertilizer is used, apply with seed.
[4] Apply in bands above and below seed; do not apply with seed.
[5] Require special reaction adjustments before most crops are recommended.

Serious erosion of the gully type occurs in only a few areas in the county, but more or less removal of surface soil by sheet erosion is common in all cultivated areas of sloping land. This is particularly true on some of the heavy-textured soils. The exposure of many clayey spots on slopes results from removal of the surface soil to considerable depth. As the surface soil contains most of the plant nutrients, the productive capacity of many soils suffers considerably as a result of losses through sheet erosion. Some wind erosion may damage the sandy soils and organic soils. Prevention and control of erosion can be established by the maintenance of sod or forest cover on the more steeply sloping areas, the use of cover crops, and the growing of clean-cultivated crops only on land of low slope gradient.

Most farmers use some of the following types of equipment for tilling the land: Medium-turn moldboard plow, packer or culti-hoe, duckfoot cultivator, spike-tooth harrow or drag, disk harrow, spring-tooth harrow, weeder, and culti-mulcher. Cultivation of the sandier soils is avoided as much as possible, in order to prevent loss of moisture. The heavier textured soils benefit greatly by plowing and other mechanical treatments to break up clods. Fall plowing is recommended on the more level areas of heavy-textured soils, as the action of freezing and thawing materially improves soil structure. Land that is subject to destructive erosion should be plowed in the spring. Heavy-textured soils should be plowed only under optimum moisture conditions, in order to prevent clodding. In preparation of the seedbed, packing of all soils is recommended. Different types of harrows and other cultivating implements are useful under special conditions where plowing is not necessary or as an aid in preparing the seedbed after plowing. A manure spreader and equipment for sowing and harvesting the common crops are part of the usual farm equipment. Special-crop farms demand a special type of farm equipment. Cultivators and weeders should be used only a sufficient number of times to insure control of weeds, otherwise excessive losses of moisture will result by evaporation from the disturbed soil. Insufficient amounts and improper seasonal distribution of moisture limit plant growth probably more than any one factor.

Artificial drainage is accomplished by the use of open-ditch and tile drains. All the poorly drained mineral soils and organic soils require the installation of a system of artificial drains for the production of cultivated crops, and many of the imperfectly drained soils can be managed more easily and successfully if a system of artificial drainage is installed. A considerable aggregate area of land on individual farms would benefit from new or improved drainage. Good arguments may be presented for additional drainage of wet loam and clay lands, but additional drainage of lakes and the larger bodies of peat swamps and marshes now in a wild state should be given careful consideration. Community cooperation is essential for the installation of a proper system of drainage in sections where poorly drained land is extensive.

A number of rotations have been used successfully on soils similar to those in Clinton County. The sandy loams and other sandy soils should be handled under a rotation that includes leguminous crops, catch crops, and cover crops, together with green manures and as much sod as possible (*2*). A corn-wheat-oats-clover (or alfalfa)

rotation has given good results on the sandy soils of moderate to high fertility. The less fertile sandy soils probably would do better under a rotation of sweetclover-wheat-corn-alfalfa or rye-sweetclover-corn-alfalfa, in which the rye or the sweetclover is used for green manure. In many places potatoes can be worked into the rotation successfully. The heavier textured well-drained soils respond well under a wheat-corn-clover rotation, with wheat-beans-corn-clover used where the moisture content is somewhat higher. Sweetclover may be introduced and used as a green-manure crop with good results, and some special adjustments of the rotation may be made where sugar beets are grown. The rotation on organic soils is of a very special type and cannot be covered here. All soils on sloping land should be kept out of clean-cultivated crops and in sod crops as much of the time as possible.

Some of the more common varieties of crops preferred in this county are (*11*): Winter wheat—Redrock, Berkeley Rock, Baldrock, American Banner; corn—Clement White Cap, Duncan Yellow Dent, Polar Dent, M. A. C. Yellow Dent, Golden Glow, Jewett 8-row Flint, Ferden Yellow Dent, Northwestern Dent, Wisconsin 25, Longfellow Flint, King Philip Flint; oats—Wolverine, Worthy, Markton, Iogold; barley—Spartan, Glabron, Wisconsin Pedigree 38; beans—Michigan Robust, Red Kidney; potatoes—Russet Rural, White Rural, Russet Burbank, Irish Cobbler, Bliss Triumph, Katahdin; sweetclover—common white, Grundy County Dwarf, Hubam; red clover; mammoth clover; and alsike clover.

Rust and smut may damage grain crops considerably in some years, and some varieties of wilt may be destructive. The hessian fly and corn borers have caused considerable damage during some seasons, and often insects are injurious to some of the special crops.

Pigeongrass (foxtail), quackgrass, wild mustard, field bindweed, sorrel, and thistles of various kinds are the most common noxious weeds. Quackgrass and field bindweed are probably the most difficult to control, but continued clean cultivation will usually clear a field of any of these weeds.

MORPHOLOGY AND GENESIS OF SOILS

Clinton County is located in the south-central part of the Lower Peninsula of Michigan and in the north-central part of the region of Gray-Brown Podzolic soils in the State (*8*). The soils have developed under a cool, moist climate influenced to some extent by the proximity of the Great Lakes. The average annual precipitation of about 30 inches is distributed rather uniformly throughout the year, with the amount during the summer slightly exceeding that during the winter. The fall, winter, and spring rains are prevailingly of a slow, drizzly, cool type, and the humidity is high throughout most of the year. The ground is frozen during most of the winter. Podzol soils appear from 30 to 60 miles farther north.

The parent material of the soils consists of medium- to heavy-textured calcareous drift of the late Wisconsin glacial period (*6*). The drift covering is sufficiently thick to mask completely any direct influence of the underlying bedrock on the soils, except in one small

area mapped as Berrien sandy loam in the southern part of Eagle Township. The drift consists of the transported residue of weathering material and rock fragments of shales, limestones, and sandstones, with smaller proportions of crystalline rock materials from more distant sources included. Till plains, terminal moraines, outwash plains, glacial lake-bed plains, and broad valleys, outlets for old glacial lakes, represent the major physical features in the county. The till, for the most part, is heavy in texture; the terminal moraine deposits are variable petrologically, but intermediate textures dominate, and sand, gravel, and boulders are included. The outwash plains and valleys are characterized by sandy and gravelly materials, and the lake plains display a considerable range of texture of surface soil materials, which generally are underlain by till clay.

The county was originally covered by a dense forest of deciduous trees, mainly hard maple, beech, and oaks on the better drained sites, and elm, soft maple, swamp white oak, black ash, and basswood the most common species on the more poorly drained mineral soils. The forest floor was sparsely covered with an understory of shrubs, herbaceous plants, sedges, and grasses. Tamarack, whitecedar, poplar, and shrubs were common in the swamps, and scattered bogs were covered by leatherleaf, highbush blueberry, and other shrubs. Some marshy areas had a cover consisting largely of grasses and sedges. The native forest consisted of species that prefer soils high in bases and of medium to high moisture-holding capacity. The trees on the heavier textured and more calcareous soils fed heavily on the bases and deposited a leaf litter which was converted into a mild mull type of humous soil by the soil organisms. The driest sandy soils in many places had a thinner, more acid type of humous soil. In general the soils are not extremely acid, in spite of the action of a podzolic type of soil formation.

The surface configuration represents an early stage in the geologic erosional cycle. The constructional glacial surface has been only slightly altered by the development of a system of drainage, and more than 50 percent of the county consists of imperfectly and poorly drained plains and swampy lowlands. Many of the streams occupy glacial drainage valleys, and the present erosional cycle has resulted in only short extensions of tributary drains from the larger stream valleys.

Most of the county is a level to gently rolling plain, and there are only a few areas of steeply sloping land. A small area in the southeastern part of the county is characterized by an association of rounded hills and broad swampy lowlands, and some small areas of steep slopes occur in other places. The slopes are not sufficiently steep to hinder the development of the complete regional profile in any part of the county, but some soils on the most steeply sloping land have shallow solums. Undulating to level land is characterized by imperfectly to poorly drained soils, except where the parent material is sufficiently porous to allow free percolation of water. Half-Bog soils occur in the more level areas where a high moisture content has been maintained in the soil throughout its period of development. Bog soils include the peats and mucks of the swampy lowlands and seepage areas.

Most of the soils represent the results of the soil-forming processes on materials that presumably have been in place practically undisturbed, so far as major geologic processes are concerned, for several thousand years. Some recent accelerated erosion, greater than that normal for the soils under natural conditions, has resulted in mutilation of the original soil profile in places, with the consequent destruction of some of its morphologic features. Deposits of local flood-plain alluvium represent accumulating parent materials or very young soils.

All the soils developed under conditions of good drainage have a Gray-Brown Podzolic type of profile. Distinctions between these soils are based largely on differences in the degree of development of the various profile features and on variations in the petrologic character of the parent materials, which are largely responsible for these differences. The soils of the Miami series are representative of this group, and the following description of a profile of Miami loam, as observed in a second-growth beech-maple-oak wood lot in De Witt Township, represents a normal virgin profile for the well-drained Gray-Brown Podzolic soils of this region.

A_{00}. A 1-inch cover of freshly fallen beech, maple, and oak leaves.

A_0. A ½-inch layer of brown moist partly decomposed leaves and leaf fragments.

A_1. 0 to 4 inches, dark brownish-gray friable moist loam having a somewhat coarse crumb structure in place but crumbling to a friable mass on removal. Some earthworm holes and casts are present, and lighter colored materials fill many of the worm holes. The material is medium to high in finely divided organic matter. Small tree roots and grass roots are numerous. The pH value is 5.5 to 6.0. Small fingers of this dark soil may extend 1 or 2 inches into the next lower horizon.

A_2. 4 to 8 inches, medium grayish-yellow slightly vesicular moist friable loam having a weak platy structure in the upper part but becoming coarsely granular in the lower part. This material is somewhat brittle and breaks down to a fine crumb structure under slight pressure. It is definitely brittle and powdery when dry. Some streaks of darker colored materials from the horizon above occur in worm holes and root holes. Roots are much less numerous than in the A_1 horizon. The pH value is 5.0.

B_1. 8 to 12 inches, medium grayish-yellow, somewhat vesicular, moist, friable loam, splotched with yellowish-brown somewhat coherent more clayey material of an angular-granular structure. The more clayey yellowish-brown material increases in amount with depth. Some streaks of darker materials occur in worm holes and root holes. Grass and tree roots are numerous. The pH value is 5.0.

B_{21}. 12 to 24 inches, yellowish-brown or reddish-brown moist coherent clay loam slightly streaked with lighter colored material in the upper part but becoming uniformly brown at a depth of about 15 inches. This material is sticky when wet. Angular nut-sized fragments from one-quarter to one-half inch in diameter break readily under pressure, showing a lighter yellowish brown color on the inside. Coatings of darker brown occur on faces of the aggregates and walls of root channels. Some darker materials from the surface layer are in root holes and worm holes. Roots are plentiful in the upper part of the layer but less numerous in the lower part. Roots are concentrated mainly on the cleavage faces of the aggregates, but there is some penetration of the aggregates by roots. The pH value is 5.5.

B_{22}. 24 to 42 inches, brown, dark-brown, or slightly reddish brown moist sandy clay loam having similar structure to that in the B_{21} horizon. This material is somewhat more friable on removal and less sticky when wet. Grass and tree roots are less numerous than in the B_{21} horizon. The pH value is 5.5. The material is somewhat streaked with yellow in the lower part.

C_3. 42 inches +, yellowish-gray or grayish-yellow calcareous friable heavy loam or sandy clay loam glacial till having a fragmentary structure. Few roots are in this layer. The pH value is 7.5. Carbonates are present.

Small gravelstones occur throughout the entire soil mass.

Miami loam has developed from materials of intermediate texture under conditions of good external drainage. The profile has a mild humous or mull type of A horizon, a highly siliceous eluviated A_2 horizon, and a B horizon of concentration of fine materials, largely clayey compounds of iron and aluminum. Bases have been sufficiently depleted to allow a slightly acid reaction to prevail throughout the solum, and destabilization of fine material in the A horizon has been sufficient to allow translocation. The brown color of the B horizon suggests that aeration has allowed considerable oxidation of iron compounds in that horizon; but the lack of a uniformly red color, such as is possessed by the most highly oxidized iron compounds, suggests that oxidation may not be complete or that dehydration has not advanced very far. Part of the apparent concentration of clay in the B horizon may be due to removal of bases rather than entirely due to accumulation of translocated clay. A concentration of translocated clay is suggested by the colloidal coatings on the outsides of the aggregates in the B horizon. Possibly the conditions under which deflocculation of iron compounds took place and the size of the colloidal iron particles may have been responsible for these differences in color. Considerable chemical and physical data have been published on the Miami soils in various bulletins of the United States Department of Agriculture.

The Hillsdale, Bellefontaine, and Fox soils display color, texture, and reaction profiles similar to those of the Miami soils, although there are several minor points of difference. All these soils are developed from coarser textured materials than those from which the Miami soils developed, and the horizon of illuviation in most places is deeper and more strongly acid than in the Miami soils, because of the lower base content of the parent materials and the weaker resistance that these coarse materials offer to the action of the soil-forming processes. The more porous character of these soils may allow percolation of a larger proportion of the water that falls on the surface, with a resultant larger volume of water effective in leaching.

The Hillsdale soils are developed from sandy loam or light loam parent materials, and they are similar to the Miami soils in general profile characteristics, except for a lighter texture throughout the profile. The Bellefontaine and Fox soils have developed from coarse calcareous sandy and gravelly materials, and in general they have a darker brown or slightly reddish brown color in the B horizon and a deeper development of the A_2 horizon than do the Miami soils. The Bellefontaine soils occur on gravelly moraines and kames, and the Fox soils are developed on plains and terraces from calcareous outwash materials.

The Coloma, Ottawa, Oshtemo, and Plainfield soils have developed under good drainage from sandy materials low in clay or clay-forming minerals, with the result that the B horizon in many places is so weakly developed that it cannot be easily recognized by field observations. Some evidence of the process that develops the true Podzol may be found in some of these soils. An ash-gray layer, in few places more

than 1 inch thick, occurs here and there immediately below the humous soil, and a slight staining by translocated organic materials is noticeable beneath the ash-gray material. It is possible that soils that develop a strong texture profile with an extremely sandy A_2 horizon may display this same weak development of the Podzol profile. One such spot was noted in studying an area of Fox soil. The Ottawa soil displays evidence of a high moisture content at considerable depth.

The clay that has concentrated in the B horizon of the soils developed from the coarser parent materials has probably been liberated by weathering of shale fragments, impure limestones, and other mineral and rock materials in the glacial drift. Much of the clay in the finer textured soils is geologic clay and a result of weathering processes before and during the glacial period rather than the result of post-glacial weathering. Some of the glacial debris no doubt represents materials that were parts of preglacial soils. Studies of the character of soil colloids in these fine-textured soils are complicated considerably by this presence of geologic colloid, because it cannot be assumed that all the colloid in the soil is an equilibrium product of the environment in which the soil occurs.

Some oak openings or small areas of grass vegetation are reported to have been present in an area northwest of St. Johns, but the soils are not distinctly different from those developed under forest cover, and it is doubtful whether any soils displaying the Prairie soil profile occurred in this county. The profiles of the soils in these so-called prairie areas are similar to those of the Fox and Bronson soils.

The soils of the imperfectly drained group are characterized by modified Gray-Brown Podzolic profiles approaching the Planosols in character, and definite evidence of periodic high moisture content exists in the profile. The following description of a profile of Conover silt loam, as observed in a second-growth elm-hard maple-beech wood lot in Dallas Township, illustrates the general characteristics of the soils of this group. The Conover soils represent the imperfectly drained members of the Miami catenary association.

A_{00}. A 1½-inch layer of freshly deposited elm, hard maple, and beech leaves and twigs.

A_0. A ½-inch layer of stained brown partly decomposed leaf fragments and twigs.

A_1. 0 to 5½ inches, very dark gray moist friable silt loam, which has a small-nut structure in place but crumbles readily to soft crumbs on removal. Earthworm casts and holes are numerous, and some lighter colored materials from the A_2 horizon are in the worm and root holes. The material is medium to high in finely divided organic matter. The pH value is 6.0 to 6.5.

A_2. 5½ to 9½ inches, medium grayish-yellow somewhat vesicular moist friable loam, mottled with yellow and displaying a weakly platy structure. Grass and tree roots are less numerous than in the A_1 horizon. The pH value is 5.0 to 5.5.

B_1. 9½ to 16 inches, light grayish-yellow slightly vesicular moist friable heavy loam, mottled with yellow and having a weakly developed granular structure in place. Tree roots and grass roots are numerous. The pH value is 5.5.

B_2. 16 to 30 inches, medium-gray coherent moist clay loam, mottled with yellow and having a somewhat blocky structure in place. Most of the blocks are about one-half inch in diameter, and when dry they may be broken down to a crumbly mass under considerable pressure. Only a few roots are in the lower part of the layer. The pH value is 5.5.

C. 30 inches +, yellowish-gray or gray moist coherent calcareous light clay loam till having a fragmentary till structure in place. Grass and tree roots are scarce. The pH value is 7.5. Some carbonates are present.

Small gravelstones are scattered throughout the entire soil mass.

Conover silt loam presents a profile similar to the profile of the Miami soils in several respects. The Conover soil has developed in gently undulating areas from materials similar to those that make up the parent materials of the Miami soils. The low slope gradient on which the Conover soil occurs prohibits free run-off, with the result that the soil has a very high moisture content during some seasons, which favors an accumulation of a large volume of organic matter, and the mull horizon is darker and deeper than in the better drained soils. The soil is sufficiently dry during some seasons to allow downward movement of percolating water and removal of bases by leaching. Sufficient depletion of bases has taken place to allow deflocculation and translocation of fine materials, with the result that definite horizons of eluviation and illuviation have developed. The A_2 horizon is similar to that in the Miami soils, but the B horizon is characterized by a mottled yellow and gray color, which suggests that the Conover soil has developed under moister conditions than the Miami. It is somewhat firmer in place than the B horizon of Miami loam. The base content of the Conover soil is somewhat higher than that of the Miami soil.

Internal drainage is poor in the Conover soil, and unless some erosion of the land results in improved external drainage a true Planosol may eventually develop. In some places there is evidence that the B horizon has already become sufficiently impervious to retard the movement of percolating waters to a point where a temporarily suspended water table exists in the lower A horizon or upper B horizon for a long enough time to allow reducing conditions to dominate in determining the soil color. This profile is a result of an alternating or simultaneous action of the process that is operating toward formation of the Gray-Brown Podzolic soils and the gleization process. Although the B horizon is definitely an illuvial horizon, its color suggests a low degree of oxidation of iron compounds. In the event of improved drainage these soils would probably become almost identical with the Miami soils.

The Brady soils have developed under moisture conditions similar to those under which the Conover soils have developed, but the parent material of these soils is largely sand and gravel. They represent imperfectly drained members of the Fox catena. The Brady soils generally are developed in areas having a high water table. The porous character of the soil materials allows considerable fluctuation of the water table, with the result that the action of the gleization process probably dominates throughout the profile during some seasons, and the normal process that is acting toward the formation of the Gray-Brown Podzolic soils dominates during other seasons. The resulting color profile is very similar to that of the Conover soils, although the A horizon is somewhat darker. The Bronson soils represent a condition where a rather thin sandy and gravelly covering overlies somewhat impervious clay. The suspended water table over the clay maintains the soil in a sufficiently moist condition to prohibit a high degree of oxidation of the iron compounds in the B horizon. This profile

more nearly approaches the normal Gray-Brown Podzolic soil color profile than any other soil of the imperfectly drained group. Most of the other soils of this group are imperfectly drained because of periodic wetting and drying from the surface downward. The Bronson soils display imperfectly drained characteristics largely because of a higher moisture content due to the existence of a high content of moisture in the lower part of the solum. Both the Brady and Bronson soils display definite horizons of eluviation and illuviation.

The Berrien soils represent a condition similar to that in the Bronson soils, as the profile consists of a shallow covering of sandy material over impervious clay. The sand is so low in fine materials that the A and B horizons are very weakly developed. Some of the most sandy soils of this group may display a weak development of a profile suggestive of the true Podzol.

The poorly drained mineral soils of this region are included in the Half-Bog intrazonal group, but it is thought that a grass and sedge vegetation may have contributed considerably to their present character, and possibly they are more or less intermediate between the Half-Bog and the Wiesenboden soils. The Brookston soils represent the Half-Bog members of the Miami catena. The following description of a profile of Brookston loam, as observed in an elm-basswood-hard maple wood lot in Ingham County, is representative of the group of poorly drained soils:

1 (A_{00}). A 1- to 2-inch cover of moist elm, basswood, and maple leaves.
2 (A_0). A ½-inch layer of brown largely decomposed leaf fragments containing numerous fungal mycelia.
3 (A_1). 0 to 8 inches, very dark gray or black moist friable loam high in finely divided organic matter and having a nut structure in place. The nut-sized aggregates are from one-fourth to three-fourths inch in diameter, are somewhat vesicular, and crumble readily to a mellow mass under slight pressure. Earthworm casts and holes are numerous, and some lighter colored materials from lower horizons are in the worm and root holes. Roots of plants are concentrated in this horizon. The pH value is 6.0 to 6.5. This material is very wet in the lower part and becomes somewhat lighter in color.
4 (G_1). 8 to 15 inches, bluish-gray or olive-drab wet sandy clay loam, slightly mottled with yellow and having a massive appearance in place. Angular aggregates from one-half to three-quarters inch in diameter result when this material is removed, and the soil material is slightly sticky and coherent in character. Worm and root holes filled with darker colored materials from the horizon above are numerous, and some scattered roots are present. The pH value is 5.5 to 6.0.
5 (G_2). 15 to 36 inches, olive-drab wet sandy clay loam, in which the yellow mottling is more pronounced than in the horizon above. This material appears massive in place, but somewhat vesicular structural aggregates slightly larger than those in the horizon above result on removal. This material is sticky and coherent in character. Some worm and root holes are present. The pH value is 6.0.
6 (C). 36 inches +, light bluish-gray saturated calcareous sandy clay loam mottled with yellow. The structural aggregates are similar to those in the horizon above, and the soil material is somewhat sticky on removal. The pH value is 8.0.

Some gravel and sandy loam spots occur throughout the soil mass.

This soil occupies areas of level land where internal and external drainage are poor. The high moisture content of the soil throughout much of the year has favored an accumulation of a deep mull-like humous soil, which is high in finely divided organic matter. Pos-

sibly a marsh vegetation, which existed on these soils previous to the forest, contributed considerably to the development of this humous soil. Only a slight removal of bases has taken place, and the soil mass is only slightly acid to a slight depth. No appreciable translocation of colloidal materials has taken place, and observable horizons of eluviation and illuviation are absent. Gleization has been the dominant process in the determination of soil character, and the dominance of gray and yellow colors suggests reduction and hydration of the iron salts. Probably the only important changes that have taken place during soil formation have been dependent on the degree of saturation of the soil mass with moisture. High moisture conditions must have prevailed most of the time, otherwise some characteristics of the regional profile, found in the well-drained soils, would be more strongly developed in these soils. Depletion of bases may be partly by leaching downward, but it seems likely also that rising capillary waters would bring bases to the surface, where they could be carried away by drainage waters. A high carbon dioxide pressure that might exist under these conditions of poor drainage would favor a transformation of much of the calcium carbonate of the parent material into the more soluble and less alkaline calcium bicarbonate.

The Macomb soils have developed in places where a thin covering of sandy and gravelly material overlies materials similar to those from which the Brookston soils developed. This covering of coarser material allows more variation in moisture content in the upper part of the soil mass than is true of the Brookston soils. The transitional zone between the coarse material and the more impervious material in many places is characterized by a decided yellow color and may represent a zone in which hydrated iron compounds have been concentrated by a combination of upward movement from the more clayey materials by capillary waters and downward movement from the coarser materials by eluviation.

The Gilford soils represent the most poorly drained soils developed from sandy and gravelly materials. They are the poorly drained associates of the Brady soils and the wettest soils in the Fox catena.

The Granby soils are Half-Bog soils developed from sandy materials. The Maumee soils represent a thin accumulation of mucky materials over mineral soil. They are typical Half-Bog soils and occupy a transitional position between the Granby soils and the organic soils.

The organic, or Bog, soils consist of deposits accumulated under conditions of poor drainage and containing more than 30 percent of organic materials. The swampy areas in which these soils occur generally represent old lake basins that have been filled by aquatic or hydrophytic plant residues. Some seepage areas are characterized by Bog soils. The character of the organic materials making up the deposits is subject to considerable variation primarily in type of materials, degree of decomposition, and base content. These differences are largely reflections of the height of the water table, the base content of the water, and the ecological cycles represented in each deposit. Definite stratification is noted in these deposits, but generally the various strata merely reflect changes that have taken place in the height of the water table or in the character of the plant association during different periods of deposition of the organic materials. The

following description of a profile of Carlisle muck, as observed in a wood lot in Olive Township, is representative of the lake-filled basin type of Bog soil.

(1) 0 to 6 inches, brownish-black granular highly decomposed woody muck.
(2) 6 to 15 inches, very dark brown or black firm moderately well decomposed woody organic material.
(3) 15 to 36 inches, very dark brown woody and fibrous peat derived from a mixture of reeds, deciduous trees, and shrubs.
(4) 36 to 72 inches, alternate layers of yellowish-brown and yellow fibrous reed, moss, and sedge peat, most of which is slightly decomposed but displays many plant remains in a very good state of preservation.
(5) 72 to 180 inches, olive-green sedimentary peat, largely very finely divided and colloidal in character. Shells are mixed with the peat in some layers. Seeds are numerous, and the entire mass is of a gelatinous character.
(6) 180 inches +, bluish-gray saturated soft calcareous clay.

Carlisle muck is the most highly decomposed and best drained of the Bog soils. The woody peat in the upper layers of the soil has been deposited by vegetation that represents the climax type for the Bog soils in this region. Farther downward in the deposit, materials that represent successively earlier ecological stages in the filling of the basin are reached. The deposit has reached a stage where building up of materials is slow, and possibly decomposition of materials about equalizes deposition. In the event of tapping the swamp by the development of a system of drainage, this organic deposit would eventually decompose.

The existence of the highest pH value at the surface and a gradual increase in acidity with depth in these soils suggests that very little translocation of basic materials has taken place. Very little material would be deflocculated under conditions of a high pH value, so it is difficult to conceive of any great amount of translocation of colloidal materials under the prevailing conditions of reaction. The low degree of decomposition and the high water table, which prevail in the more acid deposits, prohibit any appreciable evidence of development of eluvial and illuvial horizons. The base content, height of the water table, and condition of aeration are of utmost importance in determining the speed with which decomposition will take place.

Rifle peat is similar to Carlisle muck as described, except that the base content is lower, the degree of decomposition is less, and an earlier stage in the evolution of the Bog soil is represented.

Houghton muck represents the marsh stage in the filling of a lake basin. This soil is composed of materials less decomposed than Carlisle muck.

The Genesee, Griffin, and Kerston soils of the stream bottoms are alluvial soils that have accumulated by seasonal deposition of materials on their surfaces, with the result that they have not been in place, undisturbed, for sufficient time to allow the development of distinct profile characteristics as a result of the action of the soil-forming processes. Evidence of poor drainage exists in many places at some depth in these soils, and the better drained members may show a slight depletion of bases. The Washtenaw and Wallkill soils consist of recent deposits of local alluvium over other dark-colored soils.

Some eroded areas are characterized by B-C soils because of removal of the A horizon, and in some places complete removal of the

solum of the original soil has taken place and the parent material is at the surface.

SUMMARY

Clinton County occupies a land area of 571 square miles in the south-central part of the Lower Peninsula of Michigan, near Lansing. The land surface is largely undulating and gently rolling, but some hilly areas and broad swampy lowlands occur in some parts of the county. Streams traverse the county from east to west, largely in old glacial drainage valleys. Natural drainage is poorly developed, and extensive poorly drained plains and swampy lowlands occur in most parts of the county. Much of the better land has been artificially drained.

Originally, almost the entire county was covered by forest. A beech-hard maple cover was most common on the well-drained soils, and oaks were more numerous on the well-drained sandy soils. The wetter mineral soils supported an elm-ash-soft maple cover, and tamarack, poplar, and shrubs were common on the organic soils.

The climate is temperate, with winters moderately cold and summers mild and pleasant. The average annual rainfall of about 30 inches is fairly uniformly distributed throughout the year, but the amount during the months composing the crop-growing season is slightly more than that during the other months.

General farming, which includes the production of such crops as corn, oats, and hay and the raising of livestock, is the common practice. Wheat, field beans, potatoes, and sugar beets are grown as cash crops on many farms, and some farms produce only special crops. Poultry is raised, and garden crops and fruits are grown on most farms. Farms are most commonly between 40 and 160 acres in size, with 80-acre farms the most numerous.

The mineral soils are divided into three groups. The first, or group of well-drained soils, includes the Miami, Hillsdale, Bellefontaine, Coloma, Fox, Oshtemo, Plainfield, and Ottawa soils and the Hillsdale-Oshtemo complex (stony); the second, or group of imperfectly drained soils, includes the Conover, Brady, Bronson, and Berrien soils; and the third, or group of poorly drained mineral soils, includes the Brookston, Macomb, Gilford, Granby, and Maumee soils and the Berrien-Griffin complex (stony). In addition to the soils of these three groups, the Genesee, Griffin, and Kerston stream-bottom soils, the Washtenaw and Wallkill soils, the Brookston-Washtenaw complex, and the Carlisle, Rifle, and Houghton organic soils are mapped. The Miami, Conover, and Brookston soils have an important role in determining the character of the agriculture of the county.

The county has been divided into 12 land types on the basis of the relief of the land and the distribution of soils. Each land type is characterized by a distinct land use.

About 85 percent of the land is in use for the production of cultivated crops, and farms are generally of good quality. Some areas of poor land are in cultivation, but many of the farms show some selective use of land with the poorer areas left uncultivated. Land quality is reflected in the quality of farm buildings and in the general thrift of the people on the land.

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

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(1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

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