
Soil Survey

Logan County Ohio

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UNITED STATES DEPARTMENT OF AGRICULTURE
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SOIL SURVEY OF LOGAN COUNTY, OHIO

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United States Department of Agriculture, Bureau of Chemistry and Soils, in cooperation with the Ohio Agricultural Experiment Station

COUNTY SURVEYED

Logan County is in west-central Ohio (fig. 1). It has an area of 458 square miles, or 293,120 acres. Bellefontaine, the county seat, is 31 miles north of Springfield, 58 miles northwest of Columbus, and 99 miles southwest of Toledo.

The county is part of a broad physiographic unit known as the till plains (8)¹. East and southeast of Bellefontaine, which is near the center of the county, is a highland section in which dissection is very thorough. In this section glacial till has been superimposed upon an erosional remnant of dark-colored bituminous shale.² The slopes tend to be round at

the top, but they become increasingly steep near the base. Bordering Hadley Bottom, Marmon Valley, and the tributaries of Mad River the basal slopes in many places have an inclination of more than 15°. On these slopes surface drainage ranges from rapid to very rapid. In this part of the county the virgin forest belonged to the beech-maple association,³ but now the dominant species of trees are maple and



FIGURE 1.—Sketch map showing location of Logan County, Ohio.

¹ Italic numbers in parentheses refer to Literature Cited, p. 47.

² MOSES, CLARENCE FLAVEL. GEOLOGY OF THE BELLEFONTAINE OUTLIER. Ohio State University thesis, 1922.

³ Vegetative associations based on the following thesis: DILLER, O. D. THE VEGETATION OF LOGAN COUNTY, OHIO. Ohio State University, 1932; and on personal interview with Edgar N. Transeau, Ohio State University.

oak. The steeper slopes are largely forested or are kept in sod in order to prevent damage from erosion. Approximately 50 percent of this part of the county is now under cultivation.

Campbell Hill, 2 miles northeast of Bellefontaine, has an elevation of 1,550 feet above sea level and is the highest point in Ohio. In many other places in this county, elevations of more than 1,450 feet are recorded.

Southward from Macochee Creek the slopes are long and well rounded; and the land surface is at a much lower elevation, ranging, in most places, from 1,250 to 1,350 feet. Approximately 80 percent of this section of the county is under cultivation. The virgin forest belonged to the oak-maple association, and the present tree growth is in many places almost entirely maple.

To the northeast, north, and northwest of Macochee Creek the highland merges at a much lower level into a plain, on which the relief is characterized by low undulating sags and swells and the difference in elevation over large areas is only a few feet. This plain continues southward from Degraff to the county line. Elevations above sea level on this plain are as follows: Walnut Grove, 1,150 feet; a point 1 mile east of Big Springs, 1,106 feet; Ridgeway, 1,059 feet; East Liberty, 1,100 feet; Russells Point, 1,008 feet; Santa Fe, 1,010 feet; and a point 1 mile south of Quincy, 1,078 feet. Natural surface drainage over large areas of this undulating plain is poor and, previous to settlement, much of the land was in a semiswampy condition. Under virgin conditions the less well drained land supported a swamp type of forest,⁴ and under such conditions dark-colored soils developed. The better drained land supported a beech-maple forest, with small scattered areas of an oak-maple forest where the soils were well drained, owing to loose porous underlying materials or to development on slopes bordering streams. In those areas where beech predominated, the soils are largely imperfectly drained and light colored, with mottled subsoils. Since settlement of this plain, most of the land has been cleared and the swampy areas artificially drained, and at present 85 or 90 percent of the land is under cultivation.

Southwest and west of the plain, as far as Miami River, the country is rolling and locally includes areas with moderately steep slopes surrounding undrained depressions. In this kettle-hole type of relief are many small lakes and numerous areas of organic soils. The elevation over most of this part of the county ranges from 1,050 to 1,150 feet. The oak-hickory forest association originally was present in well-drained places in this section, and the undrained depressions supported a varied vegetation ranging from swamp to bog associations. Over a considerable part of this section, soils with brown silty surface soils and granular subsoils, underlain by very gravelly glacial drift, have developed. The well-drained light-colored soils are highly prized for general farming, and the associated dark-colored soils are very valuable for the production of special crops. Approximately 90 percent of this section is under cultivation.

Fairly broad areas of high terraces border the stream valleys, but the bottom lands along most of the streams are narrow. The eleva-

⁴ See footnote 3, p. 1.

tion of the high terraces along Mad River ranges from approximately 1,200 to 1,220 feet, and in many places these terraces are as much as 70 feet above the lower terraces. The lower terraces, in many places are gently sloping and merge with the first bottoms. Oak-maple was the dominant virgin forest association on the terraces, although along the upper reaches of Mad River and its tributaries, a mesophytic forest association was dominant in places.

A few square miles in the northeastern and eastern parts drain eastward through tributaries of Scioto River, and the rest of the county drains to the southwest through Miami River and its tributaries. Drainage conditions in the soils of the first bottoms are variable, but most of them are moderately well drained or well drained. Miami River is a sluggish stream with a very narrow flood plain, except in the vicinity of Indian Lake, where large areas frequently are inundated. The soils of the bottom lands along Mad River and Macochee Creek contain a dark-colored mucky layer in some part of the profile. At Zanesfield this layer is at the surface, but farther south it commonly occurs at various depths in the subsoil.

The settlement (4) of Logan County was possible only after an expedition, led by Gen. Benjamin Logan in the fall of 1786, destroyed Mac-o-chee, a village of the Shawnee Indians, located near the present site of West Liberty. Although there was an Indian reservation within the county until the spring of 1832, the first actual settlement by whites was made about 1806. The county was organized March 1, 1817, and in 1820 Bellefontaine was laid out as the county seat. Settlement was rapid. The early settlers came largely from Kentucky and Virginia.

According to the 1930 census the population in that year was 28,981, of which 19,438 were classed as rural. Of the rural population, 10,679 are classed as farm population and 8,759 as nonfarm. Of the total population, 96.9 percent are native-born white, 0.9 percent foreign-born white, and 2.2 percent Negroes. The rural population reached its maximum about 1900 when it was 23,771, and since that time it has decreased slightly. In 1930 Bellefontaine had a population of 9,543. Although it is the most important shipping center, a number of small towns distributed over the county serve as additional trading and shipping points.

The county is served by the Cleveland, Cincinnati, Chicago & St. Louis Railway of the New York Central system, which provides transportation facilities from points within the county to Indianapolis, Cleveland, and Buffalo; and branches of the New York Central provide outlets to St. Marys and Columbus. The Detroit, Toledo & Ironton Railroad passes through Quincy. Bus lines operate in all directions from Bellefontaine.

Of the 902 miles of public roads, 50 are hard-surfaced, 818 are surfaced with gravel or stone, and only 34 are of earth construction. High-tension electric-power lines and telephone lines are well distributed.

Most of the schools are consolidated, and a large proportion of the students finish high school and continue their education in neighboring colleges. Churches of different denominations are conveniently located throughout the county.

Indian Lake, an artificial reservoir maintained by the State, provides outdoor recreation for thousands of people from Ohio and neighboring States each summer. The preparation of housing facilities, entertainment, and food for these vacationists furnishes employment for a large number of people. Employment is also furnished by a cannery in Degraff, the railroads, wholesale houses, and various industries in Bellefontaine.

CLIMATE

For the most part the climate is favorable to the prevailing types of agriculture. Periods of high temperatures sometimes occur during July and August, and subzero temperatures during the winter and in March, but such extremes are of short duration. On the average, during less than 45 days each year the temperature remains continuously below freezing for a 24-hour period, and freezing temperatures prevail only during 90 to 120 days each year. The average annual frost-free period is 158 days, from May 5 to October 10, but frost has occurred as late as May 28 and as early as September 14.

The rainfall is well distributed, the greater part falling during the spring and summer when it is most needed for crop production. Occasionally an excessive amount of rainfall during April and May interferes with the preparation of the land for crops; droughts during July and August may reduce crop yields; and at times floods along Miami and Mad Rivers do considerable damage. On the imperfectly drained light-colored soils and heavier dark-colored soils in the northern part of the county, considerable damage is caused by the winter-killing of wheat and clover.

The ground is covered with snow an average of less than 10 days each year. Although occasional fogs cover the valleys adjacent to Zanesfield, dense fogs are of rare occurrence over the rest of the county.

During a few days each year the sun is completely obscured by clouds, but from 100 to 120 clear days may be expected annually. The actual amount of sunshine compared to the total possible is approximately 40 percent during the winter, 50 to 60 percent during the spring, 60 to 70 percent during the summer, and 50 to 60 percent during the autumn (5).

The prevailing winds, which are from the southwest, have an average velocity between 8 and 10 miles an hour, but much stronger winds may accompany thunderstorms or hailstorms, and occasionally they do considerable damage.

Table 1, compiled from the records of the United States Weather Bureau station at Bellefontaine, gives the more important climatic data which are fairly representative for the county as a whole.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Bellefontaine, Logan County, Ohio

[Elevation, 1,260 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1934)	Total amount for the wettest year (1858)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	29.1	63	-20	2.74	1.54	5.12	6.2
January.....	26.4	71	-20	3.00	1.10	2.50	10.0
February.....	26.7	65	-21	1.93	.79	3.00	8.0
Winter.....	27.4	71	-21	7.67	3.43	10.62	24.2
March.....	38.1	85	-2	3.64	2.80	.90	5.0
April.....	48.1	90	15	3.30	1.57	10.40	1.4
May.....	58.9	97	20	3.50	.54	8.30	(¹)
Spring.....	48.4	97	-2	10.44	4.91	19.60	6.4
June.....	68.2	98	34	3.95	4.14	6.30	0
July.....	72.7	101	41	4.02	.92	3.70	0
August.....	71.2	106	39	3.24	4.96	2.70	0
Summer.....	70.7	106	34	11.21	10.02	12.70	0
September.....	65.2	98	28	3.03	2.45	1.42	0
October.....	53.5	87	15	2.80	.71	6.34	.3
November.....	40.6	79	5	2.61	1.49	3.51	2.2
Fall.....	53.1	98	5	8.44	4.65	11.27	2.5
Year.....	49.9	106	-21	37.76	23.01	54.19	33.1

¹ Trace.

AGRICULTURAL HISTORY AND STATISTICS

Agriculture in this county antedates the period of settlement by the whites, as the Indians were growing maize, beans, pumpkins, squashes, peas, cucumbers, melons, and possibly potatoes before they were driven westward. They cultivated small fields until the virgin fertility of the land was exhausted.

The white settlers practiced a self-sufficing type of agriculture as did the Indians. Corn was grown for consumption in the home, and wheat as a cash crop to be shipped to New Orleans. Markets were far removed, the prices of farm products were very low, and Spanish dollars, supplemented by muskrat skins and whisky, were the common mediums of exchange. Conditions rapidly improved after the building of the Mad River & Lake Erie Railroad which was opened from Springfield to Sandusky in 1844.

Corn has been the leading farm crop in Logan County for many years, and its acreage increased from 24,932 acres during the decade 1850-59⁵ to 59,590 acres during the decade 1920-29. The acre yields during the latter period averaged 35.7 bushels. Yellow Clarage and Woodburn are the most popular varieties on both the light and the dark soils, but considerable Blue Clarage is grown. In recent years, Coils White Cob Yellow Dent has been introduced on the light-colored soils.

⁵ All the 10-year averages are taken from bulletins of the Ohio Agricultural Experiment Station (3, 6).

Oats were of minor importance during the earlier development of agriculture, but since 1910 the acreage devoted to this crop has increased greatly and the annual acreage has exceeded that of wheat. The yield during the period 1920-29 averaged 32.7 bushels an acre. Miami, Fulghum, and Sixty-Day are the common varieties.

The production of wheat increased until 1890, but since that time it has gradually decreased. In the decade preceding 1890 an average of 40,052 acres were sown to wheat each year, and this was larger than the average corn acreage for the same period. Trumbull and Fulhio are the common varieties of wheat.

Barley and rye are cereal crops of minor importance.

The 1930 Federal census reports 41,691 acres in hay crops which produced 53,970 tons. Mixed stands of clover and timothy were the largest in both acreage and total yield. Clover alone was second in acreage but third in yield, and alfalfa was second in total yield. The 1935 census reports the total acreage of hay and forage crops as 47,600 acres, of which 27,838 were timothy and clover mixed, 1,450 acres of clover alone, 14,761 acres of alfalfa, and the remainder in other tame grasses, grains cut for hay, legumes for hay, and corn and sorghums for silage.

Red clover predominates, although some alsike and mammoth clovers and sweetclover are grown. Timothy rarely is grown alone. Alfalfa is mostly of the Kansas and Northwestern Common varieties. Soybeans are increasing in importance, and, according to the 1935 census, 3,466 acres were sown to this crop in 1934.

Special crops of less importance include potatoes and sweetpotatoes, sweet corn, celery, lettuce, peas, and a variety of other vegetable crops which are raised largely for consumption in the home. There are few commercial orchards, but apples, peaches, pears, cherries, plums, and small fruits, including grapes, strawberries, raspberries, and blackberries, are grown on practically every farm for family use.

Maple sugar and sirup are produced locally. Other forest products are unimportant.

The use of commercial fertilizer began prior to 1880, but it was not used extensively until about 1910. In 1929, 879 farms reported an expenditure of \$59,046 for fertilizer, an average of \$67.17 a farm reporting. Wheat is fertilized more extensively than any other crop. Ordinarily, 200 pounds of 0-20-0⁶ an acre are applied at seeding time on both the light and the dark soils. Mixtures analyzing 2-12-6, 0-24-12, and 0-16-0 are used occasionally on the light-colored soils and 0-14-6 or 2-12-6 on the dark soils. When corn is fertilized, 150 pounds an acre of 0-20-0 are applied in the row. Oats are rarely fertilized except to increase the chances of obtaining a vigorous stand of the succeeding legume. New and old seedings of alfalfa are fertilized with 0-20-10 or 0-20-20.

In 1930 additional labor was hired on 46.2 percent of the farms. Native white labor was available at rates ranging from \$30 to \$40 a month plus subsistence, and day labor at \$2 plus one meal. Most of the demands for additional labor during seeding, harvesting, and at other times is taken care of by exchange of work between neighbors.

⁶ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

The farms range in size from less than 3 to more than 1,000 acres, but most of them are between 50 and 174 acres. Between 1920 and 1930 the number of farms of less than 175 acres decreased considerably and the number of larger farms correspondingly increased. The greatest decrease occurred in the farms that ranged in size from 50 to 99 acres. The average size of farms in 1935 was 99.7 acres. The improved land, which includes cropland and plowable pasture, averaged 68.9 acres a farm. The average value of farm property, according to the 1930 census, was \$8,445, of which 50 percent represented land, 32 percent buildings, 5 percent implements, and 13 percent domestic animals. The average acre value of farm land and buildings was \$65.60 in 1930 but dropped to \$47.69 in 1935.

The value of land is controlled by the prices of farm products and, as a result, it has fluctuated greatly. In 1820, Congress reduced the price of public lands in Ohio from \$2 to \$1.25 an acre, in order to prevent widespread agricultural bankruptcy, and granted permission for partial payments previously made to be applied as full payments on parts of farms, with the remainder reverting to public ownership. After 1830 conditions rapidly improved, and by 1850 the value of land and improvements in Logan County averaged \$16 an acre. From this date a gradual rise in the value of land reached a climax of \$46 an acre in 1880. Afterward land declined in value until about 1900 when the average value was \$37 an acre. Following 1900, values rose rapidly and reached a second climax about 1920 when the average acre value was \$120.72. This was followed by a rapid decline and at present (1933) land values have declined more than 50 percent from their 1920 value.

Tenancy reached its maximum in 1920 when 36.8 percent of the farms were rented. In 1930 tenancy had declined to 34.8 percent, but rose to 36 percent in 1935. Only a small number of tenants pay cash rent; most of them rent on a yearly basis but remain on the same farm for a number of years. The common terms of leases of livestock farms are as follows: The tenant furnishes labor, work animals, implements, and one-half of the other livestock; the landlord furnishes the rest of the livestock and the land. All expenses and receipts are shared equally. Under the system of grain rent, the tenant furnishes labor, work animals, and implements; the landlord furnishes the land; and all expenses and receipts are shared equally. These rental systems vary locally to suit various conditions.

Most of the farms have well-built frame houses, without modern conveniences but with well-kept lawn, shrubbery, and shade trees, and they are well equipped with barns, outbuildings, and many with silos. Most of the buildings are well painted and kept in good repair. The fields are enclosed with woven-wire fences.

In 1930, 1,180 farms reported 120,072 acres provided with drainage.

Light modern machinery is used. Tractors are common, but most of the farmers depend on teams of draft horses for general farm work. In most sections the draft horses average 1,400 pounds each.

General farming, combined with dairying and the fattening of some cattle, is the main agricultural activity, although on a few farms the breeding of livestock, poultry raising, or the production of special crops furnish the main source of income. In 1932 the gross

cash income, amounting to \$1,624,000, was derived as follows:⁷ From dairy products, 27 percent; hogs, 25 percent; poultry, 16 percent; cattle, 8 percent; sheep, 8 percent; wheat, 5 percent; and other, 11 percent. The gross income averaged \$6.28 an acre, or \$663 a farm. The chief sources of income on most farms are the sale of dairy products, hogs, and eggs. Wheat is the only field crop commonly sold for cash, but in those sections where the dark-colored soils predominate, some corn is sold. Vegetables, fruits, and forest products are minor sources of income.

Most farms are well equipped for both the production and feeding of livestock. Enough colts are raised to maintain a sufficient number of work horses of high quality. Only a few mules are used on the farms.

The dairy type of farming is best developed south and southwest of Bellefontaine. The dairy herds are commonly of high quality, with Jersey, Guernsey, and Holstein-Friesian cattle predominating.

The feeding and breeding of beef cattle are of minor importance. Both are most common in the more level sections. Some of the cattle to be fed are shipped in from the West.

Hogs are the most important livestock on almost every farm. Lard types, such as Poland China and Duroc-Jersey, predominate.

Sheep are mostly of the mutton type, with grade Shropshires predominating.

Chickens are almost equally divided between general-purpose and egg-laying breeds. A few small flocks of both Bronze and Narragansett turkeys are distributed over the county.

Cleveland and Buffalo are the main livestock markets, and some animals are trucked to Columbus. A farmers' cooperative association in Bellefontaine, a condensery in Ridgeway, and a creamery in Degraff are the principal markets for dairy products.

In addition to supplying the local markets the farmers produce enough tomatoes, sweet corn, and peas to supply a cannery in Degraff.

Special crops, such as celery, lettuce, and onions, which are produced in excess of the local needs, are sold largely in Springfield and Columbus.

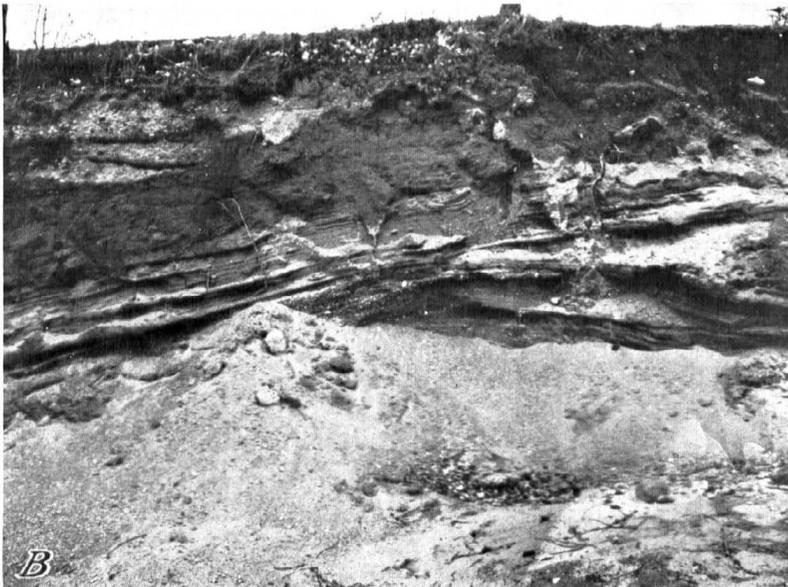
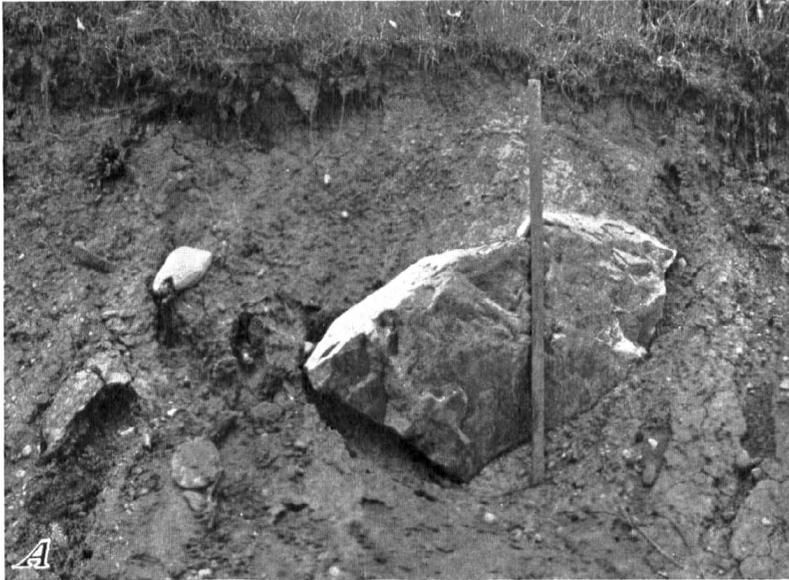
SOIL-SURVEY METHODS AND DEFINITIONS

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 soil⁸ and its content of lime and salts are determined by simple tests. Drainage, both internal and

⁷ WALLRABENSTEIN, P. P., and FALCONER, J. I. THE ESTIMATED GROSS CASH INCOME FROM THE SALE OF AGRICULTURAL PRODUCTS FROM OHIO FARMS, BY COUNTIES—1932. Ohio State Univ. Col. Agr. and Dom. Sci., Dept. Rural Econ. Bull. 60, 7 pp. 1933. (Mimeographed.)

⁸ 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.



A, Heterogeneous character of the glacial till, about 2½ miles northwest of West Liberty, showing a boulder of exotic origin. *B*, Stratified gravel and sand of glacial origin along Macochee Creek, about 3½ miles northeast of West Liberty. The Fox soils have developed from this kind of material.



A, White oak wood lot on Bellefontaine silt loam, broken phase, 1 mile southwest of Gest. B, Characteristic relief of Bellefontaine silt loam, broken phase, 1 mile southwest of Richland. On the left is a cultivated area of Carlisle muck.

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. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

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, Genesee, Crosby, and Brookston are names of important soil series in this 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 silt loam and Miami silty clay 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 frequently are 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 cultivated 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 sloping or 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, 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

On the basis of their most striking characteristic, most of the soils of Logan County may be classified in two groups—light-colored soils and dark-colored soils. The light-colored soils include what are locally known as beech-maple, clay, and gravelly land, and the dark-colored soils as black land. In the light-colored soils, even in their virgin condition, the amount of organic matter is low, whereas in the dark-colored soils organic matter has accumulated, giving rise to a distinctly dark color. Muck consists of material practically all of which is of organic origin.

In addition to color, other characteristics sharply distinguish the soils of the two main groups. The dark soils are poorly drained and, under virgin conditions, they supported a swamp type of vegetation, such as swamp white oak, ash, slippery elm, soft maple, and sycamore. There were a few openings where prairie grasses or marsh vegetation prevailed. The light-colored soils are better drained and occupy knolls, slopes, and gravelly hilltops. Originally they were covered by such trees as hard maple, oak, hickory, beech, and black walnut. The dark-colored soils have neutral or alkaline crumbly heavy surface soils and mottled or drab subsoils which are heavy and plastic. Owing to their high organic and limy clay content, these soils undergo great changes in color and volume with variations of moisture. With an excess of moisture, they are very dark, smooth, plastic, and have a strong tendency to become gummy or sticky. On drying, the surface materials break into lighter colored fine granules, and during dry periods large cracks extend to a great depth into the subsoils. As they occupy depressions, they receive additions of fine sediments rich in organic matter, nitrogen, and other plant nutrients from the surrounding light-colored soils. In addition, organic acids from the decaying plant materials, which have accumulated throughout the centuries, have reacted with the mineral grains of the soil and made available further additions of plant nutrients. Little of all this has been lost in drainage waters, therefore, these soils are veritable storehouses of plant nutrients.

In contrast, the light-colored soils, because of their better drained situations, have developed under conditions which have tended to keep them low in plant nutrients, particularly nitrogen. With few exceptions, they are acid in both the surface soils and subsoils. The water table is above the subsoil only during short periods when the soil is saturated, and frequently during dry periods it is too low to be readily reached by crop roots. The surface soils are more silty and not so granular as those of the dark-colored soils because of their low organic and clay content. The content of clay has been increased in the subsoils at the expense of the surface soils; consequently, in some soils the heavy subsoil inhibits the movement of ground water and air and the growth of plant roots. Surface run-off from cleared sloping land has removed a considerable part of the upper soil material which is rich in plant nutrients. It is necessary, if these soils are to be maintained in a high state of fertility, that crops be rotated, and that crop residues and manures, supplemented by commercial fertilizers, be carefully preserved and returned to the land.

As these two groups have strongly contrasting drainage features, their distribution is closely related to the local relief. In places where drainage courses are poorly established, large areas of dark-colored soils occur; where the local relief consists of sags and swells, the soil patterns are very intricate, with light-colored soils on the knolls and dark-colored soils in the depressions; and where the slopes are well rounded, there are practically no dark-colored soils.

In the county as a whole, about 32 percent of the soils are dark-colored and about 68 percent light-colored. The larger areas of dark-colored soils are in the eastern, northeastern, and northwestern parts.

The parent material consists of glacial till (pl. 1, *A*) of both the early and late Wisconsin epochs. The early Wisconsin drift occurs only in the southeastern part of the county. Bedrock underlying the drift consists dominantly of Silurian limestone, although some dark-colored noncalcareous shale of Devonian age is north and northeast of Bellefontaine. A few outcrops of shale or limestone occur on the steeper slopes, but in most places the hard rock formations are too deep to have any direct influence on the soil. Both the early and late Wisconsin drifts contain a high proportion of local limestone and shale materials, and only small quantities of exotic materials. The texture is variable and ranges from gravel to very heavy clay loam. In the northern part of the county the drift is dominantly gravelly very heavy clay loam, in which the heaviness is the outstanding characteristic, but south and southwest of Bellefontaine it is gravelly light clay loam. Along Mad River, and to a less extent in other parts of the county, are long narrow belts of stratified gravels (pl. 1, *B*) which have been deposited by glacial streams. In the vicinity of Indian Lake and northeast and east of Degraff are areas of laminated clays and silty clays, which are glacial lake-laid deposits. In the heavier drift the depth to calcareous material commonly ranges from 18 to 24 inches, but in the lighter drift the depth ranges from 25 to 40 inches, with the deepest leaching occurring in the older drift sheet.

The distribution of crops over the county is very significant. With a well-distributed and ample rainfall, a large amount of sunshine, warm summers, moderately cold winters, and favorable growing season, the climate is well adapted to a diversified type of agriculture. Corn is the leading crop, supplemented by such cereal crops as wheat and oats, and a variety of forage and hay crops.

Corn grows under a wide range of soil conditions, but it produces maximum yields on soils that are well supplied with nitrogen and other easily available mineral nutrients, have an abundance of moisture during the early stages of growth, and are well aerated. The dark-colored soils of medium texture, which have been artificially drained, are almost ideal for this crop.

On the dark-colored soils, wheat tends to grow luxuriantly, develop weak straw, and lodge, and it frequently winter-kills because of slow drainage. For these reasons, wheat is better adapted to the light-colored soils and is most extensively grown in the southern part of the county, where they predominate. On the dark-colored soils, wheat is largely replaced by oats in the rotation.

Legumes frequently winter-kill on the dark-colored soils. This is particularly true of alfalfa, which is a minor crop on these soils but is extensively grown on some of the light-colored soils. The light-

colored soils are chosen for orchards, because of the low water table and better air drainage. On the other hand, the dark-colored soils are preferred for vegetables, particularly the leafy varieties, because of their abundant supply of nitrogen.

The light-colored soils were preferred by the early settlers because they were easier to clear and cultivate, required little artificial drainage, and were free from malarial swamps. They produced well for the first few years but, as soon as their virgin fertility was depleted, careful farming was required in order to keep crop production at a high level. The common rotation on these soils is corn, small grain, and a legume, the legume occasionally being plowed under as a soil amendment. Manure is conserved carefully and returned to the land.

On farms composed of an intricate mixture of light and dark soils, separate management is impossible, and the fertility of the light-colored soils is increased at the expense of the dark-colored soils by applying all manure and crop residues to the areas of light-colored soils.

Where the dark-colored soils occur in extensive areas, a rotation occasionally is used, with corn occupying the land more than 1 year out of every 3. The maintenance of soil fertility on these soils is not a major problem, as, where they are well drained artificially, rotation of crops with a legume will aid in the maintaining of a high state of fertility.

In the following pages the 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 2.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in Logan County, Ohio*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Bellefontaine silt loam.....	12, 052	4. 1	Brookston silty clay loam, heavy-textured phase.....	46, 144	15. 7
Bellefontaine silt loam, slope phase.....	7, 104	2. 4	Toledo silty clay loam.....	1, 408	. 5
Bellefontaine silt loam, broken phase.....	6, 080	2. 1	Toledo silty clay loam, gravelly substratum phase.....	768	. 3
Fox silt loam.....	14, 016	4. 8	Toledo silty clay.....	2, 432	. 8
Fox silt loam, slope phase.....	2, 944	1. 0	Westland silty clay loam.....	1, 472	. 5
Rodman gravelly loam.....	320	. 1	Abington silty clay loam.....	4, 864	1. 7
Russell silt loam.....	5, 504	1. 9	Abington silt loam.....	384	. 1
Russell silt loam, slope phase.....	3, 584	1. 2	Clyde silty clay loam.....	3, 456	1. 2
Miami silt loam.....	9, 196	3. 1	Bono silty clay loam.....	3, 768	. 3
Miami silt loam, shallow phase.....	22, 080	7. 5	Wabash silt loam.....	1, 664	. 6
Miami silt loam, slope phase.....	13, 952	4. 8	Wabash silty clay loam.....	2, 432	. 8
Miami silt loam, steep phase.....	2, 088	. 9	Sloan silt loam.....	1, 408	. 5
Miami silty clay loam.....	54, 404	18. 6	Sloan silty clay loam.....	3, 584	1. 2
Miami silty clay loam, slope phase.....	10, 240	3. 5	Algiers silt loam.....	1, 408	. 5
Genesee silt loam.....	3, 200	1. 1	Walkkill silty clay loam.....	128	(¹)
Genesee silt loam, high-bottom phase.....	660	. 3	Carlisle muck.....	2, 624	. 9
Genesee silty clay loam.....	3, 968	1. 4	Carlisle silty muck.....	640	. 2
Eel silty clay loam.....	3, 968	1. 4	Edwards muck.....	192	. 1
Alluvial soils, undifferentiated.....	2, 240	. 7	Warners loam.....	128	(¹)
Crosby silty clay loam.....	23, 040	7. 9	Warners silt loam.....	512	. 2
Crosby silt loam.....	3, 136	1. 1	Gravel pits.....	128	(¹)
Fulton silty clay loam.....	2, 368	. 8	Made land.....	64	(¹)
Fulton loam.....	64	(¹)	Lake marsh.....	1, 152	. 4
Fulton silt loam, gravelly substratum phase.....	128	(¹)	Total.....	293, 120	
Brookston silty clay loam.....	8, 064	2. 8			

¹ Less than 0.1 percent.

LIGHT-COLORED SOILS

Although the light-colored soils are, with a few exceptions, low in organic matter, have silty surface soils and heavier subsoils, are slightly acid in both the surface soils and subsoils, and have been leached of a considerable part of their plant nutrients, they have different characteristics which influence their capacity and adaptation for crop production. On the basis of these characteristics they are divided into three subgroups, each of which contains a number of series and types. These subgroups are named for the dominating soil series, as the Bellefontaine subgroup, the Miami subgroup, and the Crosby subgroup.

BELLEFONTAINE SUBGROUP

The Bellefontaine subgroup includes Bellefontaine silt loam; Bellefontaine silt loam, broken phase; Bellefontaine silt loam, slope phase; Fox silt loam; Fox silt loam, slope phase; and Rodman gravelly loam which is a nonarable soil. These soils, with the exception of Rodman gravelly loam, have common characteristics, such as grayish-brown silty surface soils, brown subsurface soils, reddish-brown silty clay loam subsoils, and gravelly substrata which are high in calcareous material. The surface soils are friable, easily worked, and rarely form clods or puddle under cultivation. The upper subsoil layers are very crumbly light silty clay loam, in which distinct cleavage lines have developed, providing good aeration and free movement of ground water. The clay content is sufficiently high to give them good water-holding capacity. The lower 2- to 4-inch layers of the subsoil are commonly a deeper reddish brown and have a gravelly clay loam texture. At a depth ranging from 20 to 23 inches this material is abruptly underlain by very gravelly material which is high in limestone. Although the lower part of the subsoil has a high content of clay, it contains sufficient gravel to give it a loose porous texture which is essential to the free movement of ground water and air. This is clearly shown by the uniform reddish-brown color indicating good oxidation of the iron. This part of the soil profile is sweet and may contain fragments of limestone, the surface soil is neutral or slightly acid, and the upper part of the subsoil is distinctly acid.

As these soils are uniformly well drained, tile drainage is unnecessary. Typical Bellefontaine silt loam and Fox silt loam occupy land that is favorable to agriculture, and they are highly prized for the production of corn, wheat, and alfalfa. In fact, a large proportion of the alfalfa and wheat produced in the county is grown on these soils. The common rotation is corn, wheat, and alfalfa or clover. Frequently, alfalfa is left more than 1 year. Corn yields range from 35 to 70 bushels an acre with yields of 50 or 60 bushels during most years where the land is well farmed. Wheat ordinarily yields 25 to 30 bushels an acre, and alfalfa, from three cuttings, yields 3 tons. Possibly 98 percent of the area of these soils is in cultivation.

The original forest growth belonged to the oak-maple and oak-hickory associations. Black walnut trees are common along fence rows. These soils are most extensively developed south, southwest, and west of Bellefontaine where they occupy large areas associated with their slope phases. Bellefontaine silt loam, together with its two phases, is the most extensive soil of this subgroup.

Bellefontaine silt loam.—The 3-inch surface layer of Bellefontaine silt loam is grayish-brown silt loam which contains a noticeable amount of coarse silt. The subsurface layer is brown heavier silt loam that grades, at a depth of 11 or 12 inches, into the upper subsoil layer of slightly reddish brown gritty silty clay loam. Below a depth of 19 inches the subsoil is reddish-brown gravelly clay loam. This rests on loose gravelly material which, in some places, is stratified at a depth of 24 or 25 inches. This soil occurs on the uplands where it occupies undulating or slightly rolling relief.

Bellefontaine silt loam, slope phase.—The slope phase of Bellefontaine silt loam is confined to areas, most of which are too steep to be farmed without considerable damage through erosion. The soil profile is similar to that of the typical soil, except that in many places it is much shallower to gravel. Many small areas of Rodman gravelly loam are included in mapped areas of this soil. This sloping land is considered good for permanent pasture and is commonly utilized for bluegrass pasture or open woodland pasture. Possibly 35 percent of the land is cultivated.

Bellefontaine silt loam, broken phase.—Bellefontaine silt loam, broken phase, is similar to Bellefontaine loam, slope phase, except in topographic position. It is developed in more or less hummocky areas (pl. 2, *A* and *B*), which include many short slopes and some kettle holes, that are too small to be separated on the map. In many small areas on these slopes the subsoil is exposed, due to erosion, and the fertility of the land is considerably reduced. Small areas are west, northwest, and southwest of Bellefontaine, and fairly large areas lie south of that city. The use and productivity of this soil are approximately the same as of Bellefontaine silt loam, slope phase.

Fox silt loam.—Fox silt loam differs from Bellefontaine silt loam in topographic position and character of the substratum. It has a similar grayish-brown or brown surface soil, a reddish-brown heavier upper subsoil layer, and a red gravelly clay lower subsoil layer. It is underlain by assorted and stratified gravels. In this county it occurs in three characteristic topographic positions: (1) On high terraces along Mad River (pl. 3, *A*) and Macochee Creek, at elevations of about 1,200 feet above sea level; (2) on lower terraces along the same and other streams; and (3) on outwash plains. The relief everywhere is flat, and the land is particularly well adapted to the use of farm machinery.

A number of variations are included in Fox silt loam, because of their small extent. In one the subsoil is yellow instead of brown or reddish brown, as in a few small areas northwest of Lakeview. In another variation the surface soil is grayish-brown silt loam, the upper subsoil layer mottled gray and brownish-yellow silty clay loam, and the lower subsoil layer dull-brown silty clay loam. This variation occurs in three small areas along Mad River between $1\frac{1}{4}$ and 2 miles northeast of West Liberty. In a third variation the surface soil is a light-gray silt loam, and the subsoil is mottled gray and yellow silty clay loam. This variation is probably due to an interbedded layer of clay within the gravel, which holds up the soil moisture. It occurs in small areas one-half mile northwest of Huntsville and 1 mile northeast of Richland. This variation is similar to

the soil which, in other counties where it is more extensive, is designated Homer silt loam. The variations are not considered so productive as is typical Fox silt loam. This is particularly true of the Homerlike soil which produces very low yields of corn and is likely to be more acid than the surrounding Fox soil. A few areas of Warsaw silt loam also have been included with Fox silt loam as mapped. In these areas, the surface soil is dark-gray silt loam, and it is underlain by a dull-brown or yellowish-brown subsoil. Small areas of the included Warsaw silt loam are along Miami and Mad Rivers.

Eastward from Indian Lake along South Fork Miami River, a few areas are included with Fox silt loam, in which the underlying material is yellow or brownish-yellow sand instead of gravel. Southward from Indian Lake along Miami River, there are a few small included areas, in which the surface soil is reddish-brown heavy silt loam 6 or 8 inches thick, and the subsoil is reddish-brown gritty silty clay loam. At a depth ranging from 20 to 25 inches the subsoil merges abruptly into yellowish-brown gravelly calcareous light clay loam. This is underlain by stratified gravel which, at a depth ranging from 30 to 40 inches, rests on glacial drift.

A few areas of Fox loam also are included. The largest of these are along South Fork Miami River south of Belle Center. In them the texture of the surface soil is loam, and of the subsoil is sandy clay loam. These areas produce about the same yields as does Fox silt loam, but they drain faster and are easier to work because of the greater amount of sand in both the surface soil and subsoil.

Fox silt loam, slope phase.—The slope phase of Fox silt loam occupies the escarpments and breaks where the flatter areas of the typical Fox soil merge with the bottom lands. These areas are similar in use and value to corresponding areas of Bellefontaine silt loam, slope phase. Their present use is chiefly for pasture and woodland, although small areas are farmed in conjunction with adjacent soils. Yields of most crops are distinctly lower than on typical Fox silt loam.

Rodman gravelly loam.—The surface soil of Rodman gravelly loam consists of a 2- to 4-inch layer of very dark brown gravelly loam underlain by gravel. It occupies steep slopes (pl. 3, *B*), such as in kame areas or along terrace escarpments. This is a nonarable soil which is utilized only for pasture and forestry. The largest body is along the north valley wall of Macochee Creek, approximately 4 miles northeast of West Liberty.

MIAMI SUBGROUP

The Miami subgroup comprises soils of the Miami and Russell series on the uplands and alluvial soils of the Genesee and Eel series on the flood plains. These soils are moderately well drained or well drained. This subgroup includes Russell silt loam; Russell silt loam, slope phase; Miami silt loam; Miami silt loam, shallow phase; Miami silt loam, slope phase; Miami silt loam, steep phase; Miami silty clay loam; Miami silty clay loam, slope phase; Genesee silt loam; Genesee silt loam, high-bottom phase; Genesee silty clay loam; Eel silty clay loam; and alluvial soils, undifferentiated.

The Miami and Russell soils have grayish-brown neutral or slightly acid surface soils, yellowish-brown or brown acid heavier subsoils, and are underlain by brownish-yellow calcareous gravelly clay loam. The common crop rotation is corn, wheat, timothy, and clover, or clover with oats replacing wheat to a considerable extent when this rotation is used on Miami silty clay loam.

These soils have a definite distribution in the county, correlated with other geographic features. Russell silt loam is confined to the section of early Wisconsin glacial drift, and the Miami soils are confined to the section of late Wisconsin till deposits. Miami silt loam occurs only on the smoother parts of the highland east and southeast of Bellefontaine. The shallow phase of Miami silt loam is extensively developed in the southeastern part of the county in the vicinity of Middleburg and west and southwest of Bellefontaine. Miami silty clay loam is the most extensive of these soils. It occurs in the northern part of the county, with strips extending southward along both the eastern and western sides.

Soils of the Genesee and Eel series are flood plain soils included in the Miami subgroup because they are moderately well drained or well drained and are geographically associated with other soils of this subgroup. With the exception of the high-bottom phase of Genesee silt loam these soils frequently are covered with water. As they are alluvial soils, they have no consistent differentiation as to light-textured surface soils and heavier subsoils. They are neutral or, in some places, calcareous from the surface downward. They are differentiated into two series on the basis of color. The Genesee soils have a uniform brown color without any suggestion of mottling to a depth of 36 or more inches, whereas the Eel soils are brown in the surface layer—a dull dingy brown in some places—and are slightly mottled with gray below a depth of 15 inches. Practically all areas of the Genesee and Eel soils are under cultivation, except where they consist of small narrow bottoms between slopes occupied by other soils or are badly cut by stream channels. Corn is the principal crop, although other crops are grown, particularly alfalfa which is grown on the Genesee soils. Soils of the Genesee series are considered the more productive.

Russell silt loam.—Russell silt loam is considered the best soil in this subgroup for general agriculture. It has developed on long gentle slopes and is uniformly well drained. In cultivated fields the surface soil is grayish-brown silt loam which continues with little change to a depth of 10 or 12 inches. This material merges with a brown light silty clay loam subsoil which increases in heaviness with depth. Below a depth of 24 inches, the color changes to yellowish brown and the texture to gritty silty clay loam which is noticeably lighter than that of the subsoil. This material grades into gravelly light clay loam which is calcareous at a depth ranging from 30 to 40 inches. Russell silt loam is slightly acid in the surface soil, moderately acid in the subsoil, but neutral, in places alkaline, below a depth of 24 inches.

This soil is easily cultivated, and about 95 percent of it is under cultivation. The subsoil, where undisturbed, is composed of well-defined structural fragments that, under moist conditions, crush with slight pressure to fine crumbs. Because of these factors, it has



A, Wheat on Fox silt loam, with wooded areas of Bellefontaine silt loam, slope phase, in the background, about 2 miles southwest of Zanesfield along Mad River; B, sloping land, characteristic of Rodman gravelly loam, 4 miles northeast of West Liberty along Macochee Creek.



A, Gullies in Russell silt loam, slope phase, 5 miles northeast of West Liberty along a tributary of Macochee Creek. These gullies are from 200 to 300 feet long, and some are more than 12 feet deep. B, Close-up of a gully in Russell silt loam, slope phase.

a porous structure favorable to the movement of ground water and air, and it is penetrated readily by plant roots. It contains sufficient clay, however, to give it a good water-holding capacity. Under conditions of careful farming, in which large quantities of manure and crop residues are returned to the land and are supplemented by commercial fertilizers, high crop yields are obtained. Corn yields range from 35 to 60 bushels an acre, wheat from 20 to 25 bushels, and clover produces about 1½ tons of hay. Alfalfa is well adapted to this soil but is not grown extensively.

In only a few small areas at the heads of small drainageways is internal drainage slow. The surface soil in such areas is grayish-brown silt loam, and the subsoil is yellowish brown slightly mottled with gray. These areas have been included with Russell silt loam because they are too small to be separated on the map. In other counties, this included soil was mapped as Fincastle silt loam.

Russell silt loam, slope phase.—Russell silt loam, slope phase, includes those areas of Russell silt loam where the slopes are long and moderately steep. The soil profile is similar to that of typical Russell silt loam except that in many places the material in the subsoil has a red tinge and is shallower to unweathered material. The surface soil erodes under cultivation and, on some slopes, long narrow gullies have cut deeply into the parent material (pl. 4, *A* and *B*).

Not more than 50 percent of this sloping soil is under cultivation. It is considered very desirable for bluegrass pasture. The forest growth is dominantly hard maple and oak. On many farms the maple trees are utilized for the production of maple sirup.

Miami silt loam.—The topmost 4-inch layer of Miami silt loam is grayish-brown gritty silt loam, and the subsurface layer is yellowish-brown slightly heavier silt loam which extends to an average depth of 10 inches. The subsoil is yellowish-brown or brown silty clay loam which, at a depth ranging from 25 to 30 inches, grades into a brownish-yellow calcareous clay loam substratum. In cultivated fields the surface soil is light brown or yellowish brown, owing to mixing of the material in the surface and subsurface layers, and in many places it is very shallow, due to erosion.

Most areas of Miami silt loam are slightly acid in the surface soil and moderately to strongly acid in the upper part of the subsoil. The soil occupies slightly rolling areas or ridge tops. The most characteristic features are its gritty friable surface soil, its well-developed subsoil which contains more clay than the subsoil of Russell silt loam but shows no evidence of waterlogging, and the loose friable character of its substratum.

Miami silt loam is not considered so desirable as Russell silt loam for the production of crops. The surface soil in cultivated fields in most places is not so deep, and the subsurface soil below plow depth, in some places, is slightly mottled, indicating slower movement of air and ground water. A few areas of Miami silt loam have short moderately steep slopes which make their utilization as cropland impractical. Corn yields range from 25 to 45 bushels an acre, with an average of approximately 35 bushels; wheat yields average approximately 20 bushels; and oat yields range from 30 to 35 bushels. Approximately 90 percent of this soil is under cultivation.

Miami silt loam, shallow phase.—Miami silt loam, shallow phase, is similar to typical Miami silt loam in the surface soil and subsoil, but it is much shallower, the depth to calcareous material ranging from 18 to 22 inches. It generally occurs on smoother land, consequently cultivated areas have not been damaged so greatly by erosion. Crop yields and farm management are similar on the two soils, although a slightly higher proportion of the shallow soil is cultivated.

Miami silt loam, slope phase.—Miami silt loam, slope phase, includes gentle to moderately steep slopes of Miami silt loam. It is mapped in association with both typical Miami silt loam and Miami silt loam, shallow phase. The soil is similar to typical Miami silt loam except that it is much shallower, and in many places calcareous material is only a few inches from the surface. In many cultivated areas, because of erosion, the subsoil is exposed. Approximately 50 percent of this soil is under cultivation, and the other 50 percent is nearly equally divided between farm wood lots and bluegrass pasture. Crop yields on the cultivated areas average much lower than those obtained on typical Miami silt loam.

Miami silt loam, steep phase.—The steep phase of Miami silt loam occurs only on the steep slopes along the upper reaches of Mad River and its tributaries. The soil is similar to that of the slope phase of Miami silt loam, but it contains a few outcrops of dark-colored shale. This land is nonarable, and practically all of it is forested.

Miami silty clay loam.—Miami silty clay loam is locally known as clay land. The topmost 3-inch layer is grayish-brown silt loam. This is underlain by mottled gray and yellowish-brown heavy silt loam which extends to a depth of 7 inches. The upper part of the subsoil is brownish-yellow heavy silty clay loam which grades, at a depth of 17 inches, into grayish-brown or dull-brown stiff silty clay. This material merges with dull grayish-yellow calcareous clay which is unweathered and in many places only slightly oxidized. In most places the surface soil and upper part of the subsoil are moderately acid.

Miami silty clay loam is typically developed in undulating or gently rolling areas. This soil contrasts with Miami silt loam in its heavy surface soil, dense plastic subsoil, and shallowness to calcareous material. It is much more difficult to cultivate than is Miami silt loam, as the surface soil clods easily and tends to form a crust after hard rains. It warms late in the spring and is inclined to heave during freezing weather. The dense plastic subsoil and underlying glacial drift greatly retard the movement of air and ground water, and, as a result, crops may be injured both by waterlogging and lack of moisture. These factors make the soil poorly adapted to wheat, and oats are the small grain most frequently used in the rotation. Crop yields vary greatly, as they are so dependent on climatic conditions as well as on management of the land. Average yields are lower than those obtained on Miami silt loam.

Areas of Miami silty clay loam are associated with areas of its slope phase and with small areas of Crosby or Brookston soils, on the long gentle slopes; and in small higher lying areas it is intricately interwoven with the Crosby and Brookston soils and with small areas of the slope phase. In those areas associated with the slope phase,

approximately 50 percent of Miami silty clay loam is in bluegrass pasture or open woodland, but in the other association, practically all of it is under cultivation.

In one variation included with Miami silty clay loam in mapping, the surface soil is somewhat browner than that of the typical soil, the subsoil is slightly reddish brown, and the substratum is a more gravelly clay loam. This variation occurs in a number of small areas widely scattered over the northern part of the county, but it is most extensive west and northwest of Bellefontaine. This included soil is slightly more productive than the typical soil. A variation occupies small areas along Stony Creek and its tributaries. In these areas the substratum consists of smooth laminated clay instead of unstratified material. The agricultural value of this soil is similar to that of the typical soil.

Miami silty clay loam, slope phase.—Miami silty clay loam, slope phase, occurs on moderately steep slopes. The soil profile is similar to that of typical Miami silty clay loam, but the individual layers are much thinner. Soil of this phase is utilized largely as permanent pasture or woodland. Many areas, which have been cultivated, are severely eroded and gullied.

Genesee silt loam.—Genesee silt loam is brown mellow friable silt loam to a depth of 36 or more inches. It contains large supplies of available plant nutrients which are replenished by frequent overflows, and it is particularly well suited to corn. It is generally friable, moderately porous, and well aerated, yet the water table is sufficiently close to the surface to furnish an abundance of soil moisture.

As corn is least likely to be damaged by overflows, and because of its high yield, this soil is kept in this crop as much as possible. Yields of 75 bushels an acre are common. Genesee silt loam is associated with the silt loam soils of the upland and terraces.

Genesee silt loam, high-bottom phase.—Genesee silt loam, high-bottom phase, is similar to typical Genesee silt loam, except that it occupies slightly raised benches which ordinarily are not subject to overflow. In a few places the soil of this phase has a slightly heavier texture than the typical soil at a depth ranging from 18 to 24 inches. Soil of this phase is best developed along the upper course of Mad River. In most places it is underlain by gravel at a depth ranging from 6 to 8 feet.

In both Hadley Bottom and Marmon Valley, the surface soil in small areas has a purplish-gray tint, owing to the influence of the dark-colored Ohio shale which is found in great abundance both in the soil and in the underlying material. In the upper part of Hadley Bottom, a few areas having a silty clay loam texture are included in mapping.

Crop yields are similar to those obtained on typical Genesee silt loam, except in areas where the Ohio shale material predominates, and here the yields are lower. More attention is given to crop rotation on this soil than on the overflow land.

Genesee silty clay loam.—Genesee silty clay loam is similar to Genesee silt loam, except in texture of the soil material. It contains more clay throughout than the silt loam and consequently is somewhat more difficult to plow and cultivate and more likely to clod.

Drainage is somewhat slower. It has, however, essentially the same agricultural value and use. It is used chiefly for the production of corn. A few areas are in alfalfa (pl. 5, A).

Genesee silty clay loam occurs chiefly in the first bottoms along Miami River and Muchinippi Creek. The associated upland soils are chiefly Miami silty clay loam and Crosby silty clay loam.

Eel silty clay loam.—Eel silty clay loam has a brown silty clay loam surface soil. Below a depth of 15 inches, the subsoil is dull dingy-brown silty clay loam slightly mottled with gray. The substratum in most places is dull brownish-yellow or gray gravelly heavy clay loam till, in few places containing gravel.

Eel silty clay loam is developed mainly along drainageways and small streams in the northern part of the county where it is associated with the silty clay loam soils of the uplands.

Eel silt loam, a soil of small extent, is combined on the map with Eel silty clay loam. Most of these included areas are in the southwestern part of the county.

Both the silty clay loam and the included silt loam are approximately as high in plant nutrients as are the corresponding Genesee soils, but crop yields do not average so high, largely because of slower drainage and poorer aeration. Yields ranging from 50 to 60 bushels of corn are common in favorable seasons. Much of the land is in pasture.

Alluvial soils, undifferentiated.—Alluvial soils, undifferentiated, occupy small narrow bottoms surrounded by rather steep slopes and small bottoms that are severely cut by stream channels, thereby making cultivation impracticable. The texture of the materials ranges from very fine sandy loam to silty clay loam, with silt loam predominating. Most of the areas are in permanent pasture.

CROSBY SUBGROUP

The Crosby subgroup includes members of two series, the Crosby and Fulton, which have light brownish-gray or gray surface soils; and highly mottled, gray, brownish-yellow, and brown heavy subsoils. They occupy flat and gently undulating land, and natural drainage is very slow. Owing to the heavy impervious subsoils of these soils, crops are severely damaged during wet periods by waterlogging and during dry periods by lack of moisture. Artificial drainage is necessary in order to farm these soils successfully. The gray surface layers have been leached of a considerable part of their readily available plant nutrients. In most places these soils are acid in both the surface soils and upper part of the subsoils. Crop yields are low. Yields of corn range from 25 to 30 bushels an acre, wheat from 12 to 15 bushels, and oats from 25 to 30 bushels. In exceptional years corn in some areas may yield 50 bushels an acre, and in other areas, where the subsoil is particularly tight, yields as low as 10 bushels are common. The rotation commonly practiced is corn, oats, clover, and timothy. These soils are unfavorable for the production of wheat. They are low in nitrogen, warm slowly in the spring, and have a tendency to heave during protracted periods of freezing and thawing. Because of these conditions, and because of the acidity of the soils, it is difficult to obtain good stands of clover.

The soils included in this subgroup are Crosby silty clay loam, Crosby silt loam, Fulton silty clay loam, Fulton loam, and Fulton silt loam, gravelly substratum phase.

Crosby silty clay loam is the most extensive soil in this subgroup. It occurs in the eastern, northern, and western parts of the county. Crosby silt loam is confined largely to the southwestern part, although a few areas are in other parts. The Fulton soils are inextensive. They occur principally in the vicinity of Indian Lake and Marl City.

Crosby silty clay loam.—The 3-inch surface layer of Crosby silty clay loam consists of brownish-gray heavy silt loam which becomes lighter in color when dry. It is underlain by mottled gray, grayish-yellow, and brown heavy silt loam which extends to a depth of 10 inches. In cultivated fields these layers are mixed, giving rise to a very light brownish-gray plow soil. The material of the topmost 2 or 3 inches of the subsoil is mottled dull-brown, gray, and yellow silty clay loam. This is abruptly underlain by the lower subsoil layer of yellow heavy silty clay mottled with brownish gray or dull brown. At a depth ranging from 18 to 22 inches this material grades into dull brownish-gray or dull-gray calcareous dense gravelly clay loam.

The characteristics of this soil that are unfavorable for crop production are (1) the heavy-textured surface soil which is low in organic matter and for this reason puddles easily and forms clods, (2) the dense plastic subsoil which is slow in absorbing and giving up water, and (3) the heavy substratum which is almost as impervious as the subsoil. These characteristics make artificial drainage costly, result in poor aeration and slow circulation of ground water, and create soil conditions unfavorable to the accumulation of nitrates.

The favorable characteristics are the abundance of lime comparatively near the surface and the nearly level relief.

Crosby silty clay loam in most places is intricately associated with Brookston silty clay loam, heavy-textured phase, and in these places, the Crosby soil occupies the slight elevations and the Brookston soil the depressions. Approximately 60 percent of Crosby silty clay loam is cultivated.

Crosby silt loam.—Crosby silt loam has a thicker and more silty surface soil, a lighter textured subsoil, and a lighter textured more gravelly substratum than has Crosby silty clay loam. In most places the silt loam is intricately associated with areas of Brookston silty clay loam. Small areas, in which the surface soil is light-gray silt loam, the subsurface soil medium-gray heavy silt loam, and the subsoil a highly mottled gray and yellow silty clay loam, are included with this soil in mapping. In other counties, where such soil is more extensive, it is mapped as Bethel silt loam. These areas are recognized readily by their light-gray surface color and their lower productivity. Areas of Crosby silt loam are slightly higher than areas of the associated Brookston soil. From 70 to 75 percent of Crosby silt loam is under cultivation.

Fulton silty clay loam.—In Fulton silty clay loam the 5-inch surface layer consists of medium-gray or brownish-gray heavy silty clay loam. This is underlain by brownish-gray silty clay loam which ex-

tends to a depth of 10 inches. The subsoil is mottled dull-brown and gray heavy silty clay loam in the upper few inches and similarly colored silty clay below. At a depth of 24 inches the subsoil grades into brownish-gray calcareous laminated heavy silty clay. Because of its heavy texture throughout, this soil is only slightly weathered. In many places it is neutral in the surface layer and calcareous at a very slight depth. A few areas of Fulton silt loam are included with this soil as mapped. In the silt loam areas, the silty surface layer is thicker and the subsoil is more highly mottled than is typical.

Fulton loam.—The surface soil of Fulton loam ranges from brown loam to fine sandy loam to a depth of 10 inches. This layer is underlain by mottled brownish-gray and yellowish-brown fine sandy clay loam which, at a depth ranging from 25 to 30 inches, grades into dull brownish-gray distinctly laminated and assorted silts and very fine sands, which are calcareous. This soil is neutral or only slightly acid in the subsoil.

Fulton loam occurs only in the vicinity of Indian Lake. It is a better agricultural soil than are the other members of this subgroup, but it is unimportant agriculturally because of its small total area.

Fulton silt loam, gravelly substratum phase.—Fulton silt loam, gravelly substratum phase, is a soil of very small extent, occurring only in the vicinity of Marl City. The 8-inch surface soil is dull grayish-brown heavy silt loam, and the subsoil is dull-brown heavy silty clay loam slightly mottled with gray, which grades into distinctly laminated silty clay at an average depth of 20 inches. This material rests on stratified gravel deposits at a depth ranging from 30 to 60 inches. In a few small areas the surface soil is fine sandy loam and the subsoil is friable fine sandy clay loam. Both the surface soil and subsoil have a neutral or alkaline reaction.

Practically all of this soil is under cultivation. Yields of 40 bushels of corn an acre are obtained, and yields of other crops are correspondingly high.

DARK-COLORED SOILS

The dark-colored soils include mineral soils which are high in organic matter, and the organic soil—muck—in which there is very little mineral material. These differ greatly in their physical and chemical characteristics and must be managed differently. The mineral soils are heavy textured, high in plant nutrients, and are used for the production of general farm crops; and the organic soils are loose and chaffy at the surface, low in potash, and are used for the production of special crops in addition to the general farm crops. Both are widely distributed over the county, although the total area of organic soils is not large.

South of Bellefontaine the dark-colored mineral soils are developed in only a few places in the uplands and occupy small areas at the heads of drains, but in other parts of the county, they are intermixed with the light-colored soils and increase in extent toward the north-western, northeastern, eastern, and southeastern parts of the county where locally they occupy fairly extensive areas. They are high in organic matter and nitrogen and are well supplied with the other essential plant nutrients. In places where the water table has been

lowered by artificial drainage, they are particularly well suited to corn. In areas where these soils predominate, as in the vicinity of Santa Fe, corn is commonly sold from the farms, whereas on the light-colored soils, most of the farmers find it necessary to purchase feed to supplement that grown on the farm. With proper artificial drainage and with a rotation of crops in which clover is included, the fertility of these soils is easy to maintain. Their heavy textures are to a large degree compensated by their good structure, and good tilth ordinarily can be maintained. Although smooth and plastic when wet, the surface soil, on drying, breaks to fine granules, and cracks extend far into the subsoil. These factors give good aeration and allow easy penetration by plant roots deep into the subsoil where they can obtain an abundant supply of moisture.

A few areas of swamp around Indian Lake have been included in the Wabash, Sloan, and Toledo silty clay loams. They support a dense growth of trees—mainly swamp oak, red maple, swamp ash, sycamore, cottonwood, and willows. The swamp areas are indicated on the map by symbols.

DARK-COLORED SOILS OF THE UPLANDS AND TERRACES

The dark-colored soils of the uplands and terraces include Brookston silty clay loam, with a heavy-textured phase, Toledo silty clay loam, with a gravelly substratum phase, Toledo silty clay, Westland silty clay loam, Abington silty clay loam, Abington silt loam, Clyde silty clay loam, and Bono silty clay loam.

Brookston silty clay loam.—Brookston silty clay loam is one of the more productive dark-colored soils and is practically all under cultivation. It is associated with the silt loams of the light-colored upland soils and is confined to small areas southwest, south, and southeast of Bellefontaine. The surface soil, to a depth of 8 inches, consists of dark-gray crumbly silty clay loam which dries to lighter colored fine granules. This is underlain, to an average depth of 12 inches, by brownish-gray silty clay loam which breaks on drying into medium-gray coarser granules that are more resistant to fracture, indicating less organic matter but about the same content of clay. The underlying layer is highly mottled gray, dull-brown, and in places yellow, coarsely granular heavy silty clay loam. This material is dense and plastic when wet, but on drying breaks to broad prisms which merge into one mass with depth, owing to increased moisture. At a depth ranging from 36 to 40 inches this material grades into light-gray gravelly clay loam slightly mottled with brown. This is the calcareous unweathered glacial till. Siliceous pebbles are common on the surface, also a few boulders which are mostly igneous rock. The mottled layer contains many small gritty particles of igneous or metamorphic rock and a few fragments of dolomitic limestone.

Brookston silty clay loam is developed in many places as a fringe around darker colored areas of Clyde silty clay loam or as small areas at the heads of natural drainageways. The color, texture, and depth to limy material varies considerably. Near the upper edges of the Brookston areas, the color of the surface soil is gray and the texture heavy silt loam, but near the center of the areas, the surface soil is darker and is heavier textured. The areas associated

with Russell silt loam are lighter in color and siltier than those associated with the Bellefontaine, Miami, and Crosby soils.

Brookston silty clay loam, heavy-textured phase.—Brookston silty clay loam, heavy-textured phase, is the most extensive dark-colored soil in the county. It is intricately associated with Miami silty clay loam and Crosby silty clay loam, and in many sections it is the dominant soil. It differs from Brookston silty clay loam in having a lighter colored but heavier textured surface soil, a less mottled but heavier subsurface soil, and in being underlain by very dense plastic silty clay. In a typical profile, the soil, to a depth of 8 inches, is medium-gray or dark-gray smooth heavy silty clay loam or silty clay. This breaks to lighter colored coarse granules, but the mass is very sticky and plastic when wet. This material is underlain by medium-gray smooth silty clay streaked with dull brown, which extends to a depth of 14 inches. Below this the material is light-gray heavy silty clay streaked and mottled with dull brown, the brown coloration increasing with depth. This material is very dense and plastic when wet but, on drying, breaks into dense hard clods. At a depth of 30 inches it is underlain by coarsely mottled gray and dull-brown heavy silty clay containing some pebbles which are dominantly limestone. A few inches deeper this material grades into a matrix of similarly colored limy material.

Like typical Brookston silty clay loam, this heavy-textured soil varies considerably in both color and texture. The areas of heavier soil are commonly referred to as "jack-wax land." They are difficult to work except under a limited range of moisture conditions. This soil warms slowly in the spring and has a marked tendency to heave. In fields where it predominates, wheat is seldom grown in the crop rotations. Corn yields are not quite so high as on Brookston silty clay loam, although yields of more than 50 bushels an acre are common. About 80 percent of the land is under cultivation.

Toledo silty clay loam.—Toledo silty clay loam differs from Brookston silty clay loam, heavy-textured phase, largely in the composition of the substratum which is smooth plastic gray silty clay of lake-laid origin instead of glacial till. Small pebbles, which characteristically occur on the surface and scattered through the profile of Brookston silty clay loam, heavy-textured phase, are absent in Toledo silty clay loam, giving the latter soil a smoother, more plastic consistence. It occurs chiefly in the vicinity of Indian Lake, and a few bodies are east of Degraff. Some areas included with this soil in mapping are subject to occasional overflow. Crop yields are similar to yields on Brookston silty clay loam, heavy-textured phase, and about the same proportion of the land is cultivated.

Toledo silty clay loam, gravelly substratum phase.—Toledo silty clay loam, gravelly substratum phase, occurs only in the vicinity of Marl City. It differs from typical Toledo silty clay loam, in that it rests on stratified gravel at a depth ranging from 36 to 48 inches, above which the material consists of a well-defined deposit of laminated clay. In some areas the texture of the surface soil is heavy silt loam instead of silty clay loam. In a few small bodies the gravelly substratum is replaced by marl. Soil of this phase is easier to cultivate and slightly more productive than is typical Toledo silty clay loam.

Toledo silty clay.—Toledo silty clay occurs only in the vicinity of Indian Lake. It is lighter colored and is not considered so productive as is Toledo silty clay loam. The topmost 10-inch layer consists of medium-gray silty clay stained and streaked with brownish yellow. This grades abruptly into yellowish-gray silty clay which breaks into coarse clods having yellowish-brown glossy surfaces. Below a depth of 30 inches the material is light-gray laminated clay, slightly streaked with yellow. Because of its heavy surface soil and dense subsoil, Toledo silty clay is a difficult soil to farm. Approximately 80 percent of the land is under cultivation.

Westland silty clay loam.—Westland silty clay loam differs from Brookston silty clay loam in topographic position and character of the underlying material. It occupies depressions on gravelly terraces. Some areas on the low-lying terraces are subject to overflow. The 10-inch surface soil consists of very dark gray silty clay loam. It is underlain by mottled gray, dark-gray, and dull-yellow silty clay. Below this, at a depth of about 25 inches, is mottled gray and yellow calcareous gravelly fine sandy loam which grades into stratified gravel or sand.

Included with Westland silty clay loam are a few areas of Westland silt loam which differs from the silty clay loam only in the texture of the surface soil. This layer contains a higher proportion of silt and is, therefore, somewhat looser, more friable, and more easily tilled.

The productivity of Westland silty clay loam is similar to that of Brookston silty clay loam, and yields of 70 or 75 bushels of corn an acre are common. Approximately 95 percent of this soil is cultivated.

Abington silty clay loam.—The topmost 8- to 10-inch layer of Abington silty clay loam is very dark gray granular silty clay loam. The succeeding layer, to a depth of 20 inches, is a dark-gray, slightly streaked with dull brownish yellow and lighter gray, smooth silty clay. This is underlain, to a depth ranging from 30 to 35 inches, by medium-gray, mottled with light gray and yellow, smooth plastic clay. With increasing depth the material grades into bluish-gray stratified clay that is calcareous at an average depth of 60 inches. The surface soil and underlying material, to a depth of 60 inches, range in reaction from neutral to slightly alkaline.

Abington silty clay loam is developed from water-laid terrace deposits of the Wisconsin glacial period. It is developed in depressions and is, in most places, surrounded by brown well-drained soils of the Fox series, which occupy higher elevations and are underlain by sand or gravel.

The land is naturally poorly drained. Undeveloped areas are swampy or covered with water throughout most of the year, and artificial drainage is necessary before this soil can be utilized for crop production. The original vegetation consisted of a swamp type of forest.

A 3-year crop rotation is commonly used on this soil, consisting of corn, wheat, and red clover. Oats may be substituted for wheat and sweetclover for the red clover. Corn is fertilized with from 100 to 125 pounds an acre of a complete fertilizer or 0-16-0. Small grain is given from 200 to 250 pounds of a complete fertilizer. Corn yields

range from 35 to 65 bushels an acre, with an average yield of 45 bushels; wheat yields range from 15 to 35 bushels, with an average of 20 bushels; and oat yields range from 25 to 65 bushels, with an average of 40 bushels. Owing to the rank growth of stalk, some loss of grain due to lodging is reported. Damages to both the small-grain and clover crops, caused by soil heaving, is said to occur frequently during the winter and early spring.

Owing to the heavy sticky character of the surface soil, Abington silty clay loam can be worked advantageously only during the late spring and summer and under a narrow range of moisture conditions. Most farmers find it advantageous to break land of this character during the late fall or winter for use the succeeding season. Approximately 80 percent of this soil is under cultivation.

Abington silty clay loam occurs in fairly large areas on terraces bordering Buckongahelas Creek and its tributaries and along the upper course of Cherokee Run, as well as on some other terraces. It covers a total area of 7.6 square miles.

Abington silt loam.—The characteristics of Abington silt loam are very similar to those of Abington silty clay loam. The topmost 12-inch layer is very dark gray or black silt loam which breaks under air-dry conditions to fine granules. This is underlain, to a depth of 20 inches, by gray, slightly streaked with dull brownish yellow and light gray, silty clay loam or heavy silt loam. The underlying material, to a depth of 35 inches, is mottled medium-gray, light-gray, and dull brownish-yellow smooth silty clay. With increasing depth this material grades into bluish-gray stratified silt or silty clay, which is calcareous below a depth of 60 inches. The reaction above this depth ranges from neutral to slightly alkaline.

This soil is developed from water-laid terrace deposits of the Wisconsin glacial period. It occupies areas which range from level to slightly depressed. Most of the bodies are narrow shallow depressions bordered by well-developed brown soils of the Fox series.

This soil has developed under poorly drained conditions and under a swamp type of forest vegetation. Approximately 85 percent of the land has been artificially drained and is under cultivation. Owing to the silty character of the surface soil, the land is easier to drain and handle with farm implements than is Abington silty clay loam. Crop rotations and methods of fertilization are similar to those practiced on the silty clay loam. The range in crop yields is somewhat similar on both soils, but the average yields of small grains and clovers are from 5 to 10 percent higher on Abington silt loam, owing to less damage from soil heaving during the late winter and early spring.

Clyde silty clay loam.—Clyde silty clay loam is widely distributed in small areas southwest of Bellefontaine, near Lewistown, and east of Indian Lake. It occupies shallow depressions surrounded by a border of Brookston silty clay loam, or alone occupies well-defined depressions in the uplands. Typically the surface soil, to a depth of 8 inches, consists of black silty clay loam which crumbles readily to dark-gray fine granules. This merges downward into very dark gray stiff silty clay which is sticky and plastic when wet but tends to become granular on drying. At an average depth of 15 inches, it is underlain by coarsely mottled gray and dull brownish-yellow

heavy silty clay. In this layer, dark gray predominates in the upper part and light gray in the lower part. The material breaks into large clods which reduce, with drying, to coarse granules. When wet it is very dense and plastic, smoothing out between the fingers into long ribbons. At an average depth of 36 inches, this material merges with dull-yellow and gray gravelly calcareous clay loam.

Crop yields are similar to those obtained on Brookston silty clay loam, but more thorough artificial drainage is required to fit the land for crops.

A few small areas, in which the surface soil is black chaffy silty loam high in organic matter, are included with Clyde silty clay loam. This material is underlain by a light-gray heavy silty clay which grades into bluish-gray silty clay at an average depth of 30 inches. One of the larger of these included areas occupies a few acres along Buckongahelas Creek, approximately 3 miles northwest of Bellefontaine. Other small areas border areas of muck. This soil is not so productive as is typical Clyde silty clay loam.

Bono silty clay loam.—Bono silty clay loam is similar in the upper layers to Clyde silty clay loam, but it is underlain by laminated silty clay or clay. It occurs in association with Toledo silty clay loam along Stony Creek and its tributaries.

The surface soil, to a depth of 8 inches, is black heavy silty clay loam which is smooth and plastic when wet. This merges into black heavy dense silty clay which extends to a depth of 15 inches. The underlying material is mottled medium-gray and dull-brown silty clay in which the gray color becomes lighter with depth. At a depth of about 3 feet the substratum of dull brownish-gray calcareous laminated silty clay is reached and, below a depth ranging from 48 to 60 inches, the material is bluish-gray laminated clay.

Bono silty clay loam is not so desirable for crop production as is Clyde silty clay loam. The heavy texture of the surface soil makes plowing and cultivation difficult, and the dense plastic underlying material is very difficult to drain. Much of this land is subject to flooding and frequently is left idle. About 50 percent is used for cropland, and the remainder is in permanent pasture and forest. In favorable years corn yields from 50 to 60 bushels an acre. Areas of Carlisle muck are associated with this soil in many places, but many areas of this muck are too small to be separated on the map and are therefore included with the Bono and other soils.

DARK-COLORED SOILS OF THE FLOOD PLAINS

Dark-colored soils of the flood plains predominate in the upper reaches of Miami River, Mad River, and numerous small streams. Although these soils are subject to overflow, and have poor natural drainage, most of them are very productive; consequently, where they occur in wide enough tracts, it has proved profitable to straighten and deepen the natural drainageways, in order that these soils might be farmed. Corn is the principal crop. Yields ranging from 60 to 70 bushels an acre are common, and yields as high as 100 bushels have been reported. Because of the frequent overflows, it is not a common practice to apply commercial fertilizers on these soils. Wheat rarely is grown, because of the danger from floods, and both wheat and oats tend to develop a rank growth of straw and to lodge. In places

where artificial drainage is good, these soils produce luxuriant stands of legumes.

Wabash silt loam and Wabash silty clay loam are the darkest of these soils. Other soils in this subgroup include Sloan silt loam, Sloan silty clay loam, Algiers silt loam, and Wallkill silty clay loam.

Wabash silt loam.—Wabash silt loam is variable in its characteristics. The surface soil, to a depth of 6 inches, is black heavy silt loam which contains a high percentage of organic matter. This merges with black silty clay loam which may rest on calcareous gravel at a depth of 16 inches. In places where the gravel lies at a greater depth, the material of this layer grades into dark-gray sticky silty clay loam slightly mottled with dull brown.

This soil is confined largely to narrow stream bottoms, and in most places it is shallow to gravel. Approximately 75 percent of it is in permanent pasture or open woodland. The small proportion under cultivation is very productive.

Wabash silty clay loam.—Wabash silty clay loam is developed mainly along Miami River south of Indian Lake. The topmost 10-inch layer of the surface soil is very dark gray or black silty clay loam. At a depth of 20 inches the material grades into a dull-gray plastic silty clay. This may be underlain by gravel or may grade into smooth laminated clay, both of which are calcareous.

Approximately 50 percent of this soil is under cultivation. It is very productive but not quite so easily worked as is Wabash silt loam.

Sloan silt loam.—Sloan silt loam is a lighter colored soil than Wabash silt loam. It occupies narrow stream bottoms. The topmost 8-inch layer is medium-gray friable silt loam. This grades into brownish-gray silt loam which extends to a depth of 12 inches. The underlying material is mottled gray and brown silt loam, with medium gray predominating in the upper part and light gray below a depth of 30 inches. Below a depth of 36 inches the character of the material is variable, ranging from unstratified glacial drift to stratified gravel. South of Zanesfield along Mad River the soil material is underlain, at a depth ranging from 20 to 30 inches, by very dull gray or black silty clay loam that is high in organic matter, and this layer is underlain by gravel.

Approximately 75 percent of Sloan silt loam is under cultivation, and it is considered one of the most productive soils of the flood plains.

Sloan silty clay loam.—The material comprising Sloan silty clay loam is more uniform than that of Sloan silt loam. The total area is small, but the soil is widely distributed over the county, occurring on the flood plains of the larger streams.

The topmost 6-inch layer is dark-gray crumbly silty clay loam which is very easily worked. This is underlain by a dark-gray heavier silty clay loam which extends to a depth of 24 inches. Below this depth the material is light-gray, slightly mottled with dull brown, silty clay loam.

This soil is considered very productive, and about 75 percent of it is under cultivation.

Algiers silt loam.—Algiers silt loam is developed mainly along Mad River, where it is the dominant soil on the flood plain. The

topmost 8- to 12-inch layer is brown well-oxidized friable silt loam. This is underlain by very dark gray or black silty clay loam which is high in organic matter, and the woody structure of many of the plant remains through it can be recognized. This material, in turn, is underlain, at a depth ranging from 48 to 72 inches, by stratified gravel.

Algiers silt loam is one of the most highly productive soils for corn. Its loose, friable, and well-drained surface layer furnishes good aeration and is well supplied with plant nutrients. The underlying dark-colored layer is also rich in plant nutrients and in addition acts as a reservoir for water. Approximately 98 percent of this soil is cultivated.

Wallkill silty clay loam.—Wallkill silty clay loam is a soil of small extent on the flood plains and occurs largely southeast of Degraff.

The topmost 15-inch layer is mottled gray and dull-brown silty clay loam. This is underlain by medium-gray, streaked with dull brown, silty clay. At an average depth of 30 inches, this is replaced by black colloidal muck, which is underlain by stratified layers of colloidal, woody, and fibrous organic materials.

Practically none of this soil is under cultivation. Under natural conditions it supports a hydrophytic vegetation consisting largely of coarse marsh grasses, sedges, and willows. In a few areas included with this soil, as mapped, the texture is silt loam.

ORGANIC SOILS

Small areas of organic soils are widely distributed over the county, but they are most numerous west and southwest of Bellefontaine. The smaller areas are cropped with the adjoining mineral soils, and they produce very good crops of corn, although they are deficient in potash. They are used to some extent for the production of soybeans which frequently are sown as a catch crop to replace wheat or oats killed by excess water. The larger areas are used for the production of such special crops as onions, potatoes, celery, lettuce, and occasionally mint.

These soils include Carlisle muck, Carlisle silty muck, Edwards muck, Warners loam, and Warners silt loam.

Carlisle muck.—Carlisle muck, which is nonacid, is the most extensive organic soil. The 12- to 18-inch surface layer in cultivated areas is black finely divided or powdery organic residue which, when dry, is moved freely by the wind. It is underlain by stratified layers of colloidal, woody, or fibrous brown or black organic material (pl. 5 *B*), all which contains numerous small shells. The organic material ranges from 3 to more than 12 feet in thickness. It is underlain by gravel, clay, or marl. Most of the special crops are grown on this soil, as it can be drained readily by placing tile in the muck (pl. 6, *A* and *B*).

Some areas of muck having a clay substratum are included on the map with typical Carlisle muck. This muck is identical in the surface layer with Carlisle muck and, at a depth ranging from 20 to 30 inches, it is underlain by silty clay or clay. These included areas are utilized largely for pasture, as it is impractical to drain them by tiling. Also included in an area of Carlisle muck, 4 miles west

of West Liberty along the county line, is a body of soil that would have been mapped as Greenwood peat had it been larger. This soil differs from Carlisle muck in that the organic material is composed largely of remains of sphagnum moss which forms the principal vegetation. The underlying material consists of brown coarse fibrous stems of the moss, in which is intermixed organic materials of minor importance. It extends to a depth ranging from 35 to 40 feet. The organic material in the surface layer is acid. The peat area is nonarable.

Carlisle silty muck.—Carlisle silty muck differs from Carlisle muck only in the topmost 12-inch layer which consists largely of brown or mottled brown and gray silt loam overwash. This material is a very desirable addition, as it makes the surface layer more compact, prevents blowing, and adds to the content of mineral plant foods. The total area is small.

Edwards muck.—Edwards muck is identical in its surface characteristics to Carlisle muck but at a depth ranging from 20 to 36 inches, it is underlain by marl. Practically all of this muck is in pasture or forest. The total area is small.

Warners loam.—Warners loam consists of an 8- to 12-inch layer of black finely divided organic residue over marl. In cultivated fields many patches of marl occur on the surface. This soil is of little value for crop production. Small areas border Rush Lake south of Marl City.

Warners silt loam.—Warners silt loam consists of an 8- to 12-inch layer of mineral soil over marl. This soil is of little value for crop production. Small areas occur near Marl City.

MISCELLANEOUS LAND TYPES

Gravel pits.—Gravel pits, the larger of which are indicated on the map, occur within areas of gravelly soils, especially those of the Bellefontaine and Fox series.

Made land.—Made land comprises extremely variable materials from excavations, grades, and city dumps. The largest area is on the eastern shore of Indian Lake. At the edges of cities and towns, some made land is used for building sites and for flower and vegetable gardens, but most of such land is poor and difficult to cultivate.

Lake marsh.—Lake marsh includes tracts of land around Indian Lake, which are constantly covered by shallow water. These areas support a dense growth consisting principally of waterlilies and sedges, with some cattails.

MANAGEMENT OF THE SOILS OF LOGAN COUNTY °

The purpose of the following discussion is to call attention to the limitations of the soils of this county and to outline, in a general way, the treatments most likely to yield satisfactory results. Profitable crop production can be achieved by building up the fertility of the soil to a high level and thereafter maintaining its productive capacity. The soils have been grouped, in order that those requiring similar treatments may be discussed together. The suggestions made

° This section was written by G. W. Conrey, associate in agronomy, Ohio Agricultural Experiment Station.

are based on studies of the soil, in the field and laboratory, on test plots on the experiment farms, also on the experiences of farmers.

The soils are placed in four groups as follows: (1) Light-colored soils of the uplands and terraces, (2) dark-colored soils of the uplands and terraces, (3) alluvial soils, and (4) organic soils. In general the light-colored soils contain less organic matter, are more acid in reaction, and are better drained than the dark-colored soils. The most important factor in the management of both the light- and dark-colored soils is the maintenance of a high organic-matter content.

LIGHT-COLORED SOILS OF THE UPLANDS AND TERRACES

BELLEFONTAINE SUBGROUP

The soils included in the Bellefontaine subgroup are Bellefontaine silt loam, Bellefontaine silt loam, broken phase, Fox silt loam, and Rodman gravelly loam. These are naturally well drained soils, owing to their topographic position and the open, porous character of their subsoils. The most important factor in the management of these soils is that of establishing a crop rotation which will reduce erosion to a minimum and provide a high content of organic matter.

The Bellefontaine soils are well suited to the growth of alfalfa and wheat; row crops such as corn should be grown infrequently because of the hazard of soil erosion. Owing to rapid oxidation, the maintenance of a high content of organic matter is one of the major problems on the Bellefontaine soils. The following 5-year rotation has proved successful on these soils: Alfalfa and timothy, 3 years; corn, 1 year; and wheat, 1 year. This rotation provides sufficient organic matter and also helps to reduce the rate of erosion by keeping a good cover on the ground 4 out of 5 years. An 0-14-6 fertilizer is recommended for wheat and an 0-12-12 fertilizer (in the row) for corn, in addition to an application of manure (9).

On the Fox soils, erosion and winter injury are not serious as they are on the Bellefontaine soils. On these soils a rotation of corn, 1 year; wheat, 1 year; and alfalfa, 2 years may be used and still maintain a high level of productivity. For the Fox soils an 0-12-12 fertilizer is recommended for corn and an 0-14-6 for wheat. All else being equal, these soils need more potash than do the Bellefontaine soils.

Rodman gravelly loam and Bellefontaine silt loam, broken phase, which are included in this subgroup, are nonarable soils because of extreme droughtiness caused by the gravelly subsoil. These areas should be used for pasture or tree land.

MIAMI SUBGROUP

The soils of this subgroup—members of the Russell and Miami series—range from moderately well drained to well drained and have slightly acid surface soils. With proper attention to liming, crop rotation, and tiling, these soils are excellent for alfalfa and wheat. On the steeper areas, erosion is a major problem, and therefore it is wise, if possible, to leave such areas in pasture.

The Russell and Miami silt loams are good soils for the production of alfalfa and small grains. A recommended rotation includes 2 years of legumes, 1 year of corn, and 1 year of wheat. Organic

matter does not oxidize so fast in the Miami and Russell soils as in the Fox and Bellefontaine, but it is important that it be added to the soil. As the reaction of the soils of this subgroup is pH 5.5-6 (medium acid) lime should be applied at the rate of about 1 ton of ground limestone an acre. Top dressing wheat with manure is a desirable practice. An 0-14-6 fertilizer is recommended for small grains, alfalfa, and corn. The rate of liming necessary on these soils is given in table 3.

TABLE 3.—*Four soils of the Miami subgroup, with ordinary reactions and suggested applications of lime*

Soil type	Unlimed reaction	Acres application of lime ¹ to give pH 6.5
	pH	Tons
Russell silt loam.....	5.6	1¼
Miami silt loam.....	5.8	1
Miami silt loam, shallow phase.....	6.2	½
Miami silty clay loam.....	5.8	1½

¹ In terms of agricultural ground limestone.

Miami silty clay loam has a heavier subsoil than has the silt loam and is therefore more difficult to drain. Tiling may be necessary on some of the more level areas of the Miami soils, but it is especially needed on Miami silty clay loam. A 2-14-4 fertilizer is recommended on this soil for wheat; an 0-14-6 may be used in the row for corn, unless there was not a good legume crop the preceding year. In the latter instance, a 2-14-4 fertilizer is recommended. Until lime has been applied on Miami silty clay loam, a 3-year rotation of 1 year of clover and timothy, 1 year of corn, and 1 year of wheat is suggested.

On the steep and sloping phases of these soil types, erosion is a serious problem when intertilled crops are grown. The steeper areas should be left in permanent pasture, and long rotations (4 or 5 years) should be practiced (2).

CROSBY SUBGROUP

The soils of the Crosby subgroup are the most unproductive in the county. They include the Crosby and Fulton soils. The surface soils are brownish-gray or gray, indicating a lack of organic matter. The soils occupy level or gently undulating areas and have poor surface drainage and underdrainage. Owing to the heavy impervious subsoils, crops are severely damaged by waterlogging during wet periods.

Although among the more extensive soils, Crosby silty clay loam is one of the least productive naturally, but it can be made to produce satisfactory yields under good management.

Because this soil has a tight impervious subsoil, the first step in its improvement should be better drainage. It is necessary to place the lines of tile closer together on this light-colored soil than is required for adequate drainage on the associated dark-colored soils.



A, Alfalfa on Genesee silty clay loam, about 1½ miles southeast of East Liberty;
B, Carlisle muck, showing the coarse fibrous material, 5½ miles southwest of Bellefontaine.



A, Tussocks of grass on Carlisle muck, $3\frac{1}{2}$ miles southwest of Bellefontaine.
B, Celery on Carlisle muck, $1\frac{1}{4}$ miles southwest of Gest. On the right, the celery is being bleached between boards; on the left, the overhead sprinkling system is shown.

If the better types of legume-hay crops are to be grown, liming will be necessary, as this soil is strongly acid in reaction.

Table 4 gives the reactions of the more important soils of this subgroup, and suggested applications of lime for their improvement.

TABLE 4.—*Important soils of the Crosby subgroup, with ordinary reactions and suggested applications of lime*

Soil type	Unlimed reaction	Acre application of lime ¹ to give pH 6.5
	<i>pH</i>	<i>Tons</i>
Crosby silt loam ²	5.5	1½
Crosby silty clay loam.....	5.0	2
Fulton loam.....	6.5	0
Fulton silty clay loam.....	6.5	0

¹ In terms of agricultural ground limestone.

² In places where the depth to carbonates ranges from only 18 to 24 inches, the soil is somewhat less acid—pH 6—and will require proportionately less limestone.

Applications of 1½ or 2 tons of lime an acre will be required to give a reaction favorable to alfalfa or sweetclover. The rotation to be used on these areas depends on whether or not lime has been applied. On the unlimed areas, a rotation of timothy and clover, 1 year; timothy, 1 year; corn, 1 year; and small grain, 1 year may be used. In places where the soil has been limed, sweetclover may be substituted for red clover in the rotation. Alfalfa is not recommended for this soil, owing to the difficulty of securing adequate drainage. By plowing under heavy sods, organic matter, which is naturally low in this soil, may be supplied. The fertilizer treatment recommended is the same as that for the Miami soils, but, owing to the low fertility of the soils of the Crosby subgroup, a heavier application is desirable. The following recommendations are made: For wheat, from 350 to 400 pounds an acre of 0-14-6; and for corn, a row application of 200 pounds of 0-12-12 an acre in addition to a liberal application of manure.

Crosby silt loam, which occurs mainly in the southwestern part of the county, differs from Crosby silty clay loam in that it is somewhat lighter in texture throughout and therefore is more easily drained by tile. It has the same deficiencies in organic matter as has the silty clay loam, and it is, for the most part, acid in reaction. The quantity of lime required to give a reaction favorable for the production of sweetclover or alfalfa is somewhat less than for the silty clay loam, that is, 1 to 1½ tons an acre of ground limestone. For some areas, in which the calcareous subsoil lies within a depth ranging from 18 to 24 inches of the surface, a lighter application of lime will serve to give the legumes a start until the roots have penetrated the more calcareous subsoil. Recommendations made for the silty clay loam, as regards crop rotation and fertilizer treatment, apply to this soil.

The Fulton soils, which occur only in the vicinity of Indian Lake, are naturally poorly drained, are for the most part about neutral in reaction, and are somewhat more fertile than the Crosby soils. The

recommendations, as regards rotation and drainage, for the Fulton soils are the same as those for the Crosby. Fertilizers should be of about the same analyses, although the rate of application may be lower—300 pounds an acre for wheat and 175 pounds in the row for corn.

DARK-COLORED SOILS OF THE UPLANDS AND TERRACES

The dark-colored soils of the uplands and terraces are the best agricultural soils of the county, after good artificial drainage has been obtained. They are well supplied with organic matter and have a high nitrogen content. For the most part these soils are only slightly acid or neutral in reaction and do not need to be limed.

Adequate drainage is the first essential in the utilization of these soils. The Brookston, Clyde, Toledo, and Bono soils have heavy-textured subsoils. Because of the fragmental structure of the subsoils, good drainage by tiling can be obtained by placing lines of tile about 4 rods apart. The Westland and Abington soils are underlain by gravel. In places where the depth to gravel is more than 30 inches, conditions for drainage by tiling are essentially the same as those for the Brookston soils.

Corn is the most important crop on these soils. A desirable rotation is sweetclover or alfalfa, 1 year; corn, 1 year; and wheat, 1 year. On the broad flat areas, wheat may winter-kill badly; under such conditions it is desirable to substitute oats in the rotation. For wheat, a fertilizer treatment of 200 pounds an acre of 0-14-6 is recommended, and for corn from 100 to 125 pounds of 0-14-6 an acre, in the row, in addition to an application ranging from 6 to 8 tons of manure. Although these soils are naturally fairly high in organic-matter content, the maintenance in the soil of a supply of actively decomposing organic material is important.

Where the Crosby and Brookston soils occur in the same field, it is difficult to adjust the treatment to that recommended for each. It is suggested that a somewhat heavier application of manure be applied to the Crosby soils. These light-colored areas will also require liming, and the tile drains must be placed somewhat closer together than in the Brookston soils.

ALLUVIAL SOILS

The chief limitation in crop production on the alluvial soils is the risk of damage resulting from floods. Inadequate natural drainage limits crop production on the Eel, Sloan, and Wabash soils. All these soils are neutral in reaction. Corn is the most important crop produced, and tiling is necessary for its production. It will be impossible to tile some areas, however, because of the lack of satisfactory outlets: such areas can be used for pasture. A desirable rotation on these soils is corn, 2 years; wheat, 1 year; and alfalfa, 2 years. The wheat crop occasionally will be damaged by spring floods in places where the land is not protected from overflow. Fertilizers are not commonly used, but it would be desirable to make a moderate application of a high-potash fertilizer, such as 150 pounds an acre of 0-12-12 on the wheatland and 100 pounds an acre in the row on the cornland.

ORGANIC SOILS

The organic soils are naturally very poorly drained, high in organic matter and nitrogen, and low in the mineral elements. Their reaction ranges from neutral to acid. Following adequate drainage, these soils are used for the production of corn and special crops such as onions, celery, and some others. Excellent yields of potatoes are obtained on the well-drained areas. Because of their low content of mineral elements, it is necessary to use fertilizers high in potash as well as in phosphoric acid. The fertilizer recommended for corn is an 0-12-12 in the row at a rate ranging from 100 to 150 pounds an acre. In those places where corn is grown continuously for several years, a 3-9-18 fertilizer is desirable. For potatoes and common truck crops a 3-9-18 fertilizer, applied at a rate ranging from 500 to 1,000 pounds an acre, is recommended.

PRODUCTIVITY RATINGS

Table 5 gives productivity ratings for the important soil types and phases mapped in Logan County.

TABLE 5.—Productivity ratings of important soils in Logan County, Ohio¹

Soil type	Productivity rating for Ohio ²	Crop productivity index ³ for—							
		Corn	Wheat	Oats	Mixed hay	Red clover	Alfalfa	Pasture	Potatoes
Bellefontaine silt loam.....	3	5 (7)	6 (9)	5 (6)	6 (8)	8 (10)	8 (10)	8 (9)	5 (8)
Fox silt loam.....	2	6 (8)	8 (10)	6 (7)	8 (9)	9 (10)	8 (10)	9 (10)	6 (9)
Russell silt loam.....	3	5 (7)	5 (8)	5 (7)	5 (7)	6 (9)	6 (9)	7 (8)	4 (7)
Miami silt loam.....	3	5 (7)	6 (8)	5 (7)	5 (8)	6 (9)	6 (9)	7 (8)	4 (7)
Miami silty clay loam.....	4	4 (6)	4 (7)	4 (7)	5 (7)	5 (8)	5 (7)	7 (8)	4 (6)
Crosby silt loam.....	5	2 (5)	3 (5)	3 (5)	4 (6)	4 (6)	1 (5)	5 (7)	1 (5)
Grosby silty clay loam.....	6	2 (4)	2 (4)	3 (5)	4 (5)	3 (6)	1 (4)	4 (6)	1 (4)
Fulton silty clay loam.....	5	3 (5)	4 (7)	4 (7)	4 (7)	3 (6)	3 (5)	5 (7)	3 (5)
Brookston silty clay loam.....	1	3 (10)	3 (7)	3 (8)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Toledo silty clay loam.....	1	3 (10)	3 (7)	3 (8)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Toledo silty clay.....	2	2 (9)	3 (7)	2 (8)	6 (9)	4 (9)	1 (9)	3 (10)	0 (3)
Westland silty clay loam.....	1	3 (10)	3 (7)	3 (8)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Abington silty clay loam.....	1	2 (10)	3 (6)	2 (7)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Clyde silty clay loam.....	1	2 (10)	3 (6)	2 (7)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Bono silty clay loam.....	1	2 (10)	3 (6)	2 (7)	6 (10)	5 (10)	3 (10)	4 (10)	0 (4)
Genesee silt loam.....	2	9 (10)	5 (6)	6 (7)	9 (9)	9 (10)	9 (10)	8 (9)	5 (8)
Eel silty clay loam.....	3	4 (7)	3 (4)	4 (6)	4 (8)	5 (9)	3 (7)	5 (9)	3 (5)
Wabash silt loam.....	1	3 (10)	-----	2 (6)	6 (9)	4 (10)	4 (10)	4 (9)	0 (3)

¹ Table taken from CONREY, G. W., and PASCHALL, A. H. A KEY TO THE SOILS OF OHIO. Ohio Agr. Expt. Sta. Spec. Cir. 44, 32 pp., illus.

² 1 is the highest productivity rating.

³ 10 is the highest productivity index.

Special Circular 44 of the Ohio Agricultural Experiment Station, entitled "A Key to the Soils of Ohio," gives further information concerning the classification and productivity of the soils of the State and explains the figures in the table as follows:

Two different ratings are used in the tables; first, a State-wide productivity rating, and second, a crop production rating or crop productivity index. In the State-wide productivity rating the most productive soil (with good soil management) is rated as "1" and the least as "10". In the crop production rating or crop productivity index, the most productive soil for any given crop is rated as "10", and all other values are lower. A soil with an index of "5" will yield only

one-half as much as one with an index of "10". Two values are given for each crop—the first, for the soil without artificial drainage, fertilizer treatment, manure, or lime, and the second, for the soil with adequate drainage and a good system of soil management (including the use of manure and fertilizer and of lime where the soil is acid).

Table 5 shows that the silty clay loams of the Brookston, Toledo, Westland, Abington, Clyde, and Bono series, and Wabash silt loam, rate for general productivity among the best soils in the State. It is also seen more specifically that, under the better practices of management, these soils are high producers of corn, mixed hay, red clover, alfalfa, and pasture. On the other hand, the indexes that are not in parentheses indicate that they do not rate high for these crops unless proper management is provided, which in most instances includes artificial drainage.

MORPHOLOGY AND GENESIS OF SOILS

Logan County is centrally located in the region of Gray-Brown Podzolic soils. This region extends from the prairies of western Indiana eastward to the Atlantic coast and covers a very large total area. The climate is characterized by warm summers, moderately cold winters, high rainfall, and a low rate of evaporation. The regional soil profile has developed under a deciduous forest cover, and the immediate surface soil has received noticeable contributions of bases through the decay of leaves and woody tissues. The profile is moist throughout the greater part of the year and leaching is continuous except during short periods when the ground is frozen or very dry. The well-shaded surface, covered by a thin slightly moist mulch of leaves, provides favorable environmental conditions for the rapid decay of organic matter and its dissemination throughout the upper few inches of soil. This process is furthered by activities of earthworms, insects, and simple forms of plant life. Organic acids released through the decay of plant remains have greatly increased the solvent properties of the ground water. Humic acids also have, to a less degree, entered into combination with bases released from the decaying organic matter to form dark-colored humates which determine the shade of color of the topmost few inches of soil. As the process of solution is more rapid than that of disintegration, the mature soils are light colored, low in organic matter, and acid in reaction. They have developed well-defined eluvial and illuvial horizons.

The eluvial horizon is high in silica and low in sesquioxides. It is leached of its soluble bases and is acid, except in the immediate surface layer. The illuvial horizon contains accumulated clay and sesquioxides. It is leached of its soluble bases and is acid in reaction.

The influence of glacial material on the development of the soils in this county is very apparent. In well-drained situations where the glacial drift is loose gravelly clay loam, light-colored silt loams have developed; and in especially gravelly areas a reddish-brown color predominates in the subsoils. Where the drift is heavy the resultant mature soils are shallow, with dense heavy subsoils.

The relative age of the glacial materials also is apparent in the soils. Early Wisconsin drift is leached and oxidized to a greater depth than the late Wisconsin, and the surface soil is more silty—an evidence of greater eluviation. The texture of the drift is, to a large

degree, due to its mineralogical composition; limestone and noncalcareous shale materials predominate, with smaller amounts of exotic materials, of which granite, granitic schist, gneiss, and diorite are most common. Large boulders of granite, granitic schist, gneiss, and diorite are widely distributed. As these rocks are more resistant to the weathering agencies of this general region than limestone and shale materials, they or their mineral components are widely distributed as small gritty particles throughout the leached part of the soil. The ratio of limestone to shale material has an important effect on the texture of the drift. Where shale is present in large quantities the drift contains a high percentage of clay, is very heavy and plastic, and is lower in calcium carbonate. The soils developed from this drift are not so fertile as are those developed from the more limy material.

In most places the underlying bedrock is at too great a depth to have a direct influence on the soil, but it has a profound influence on the physiography and, consequently, on the relief and drainage of the soils. The maximum relief of approximately 600 feet is greater than that in any other county in the Wisconsin glacial drift region in Indiana, Ohio, or southern Michigan. This is because glacial deposition was made on a rugged preglacial topography, of which the general surface configuration was to a large degree retained. East of Bellefontaine near Campbell Hill, where the highest elevation occurs, the glacial drift overlies an erosional remnant of Ohio shale. In this vicinity the relief is mature, drainage is well established, and light-colored mature soils prevail. At lower elevations, where the underlying strata are limestone, drainage is poorly established and dark-colored soils prevail.

The well-developed soils belong to two main groups—light-colored soils and dark-colored soils. The light-colored soils include the mature soils and those which have developed under imperfect drainage, whereas the dark-colored soils include those which have developed under poor drainage and a hydrophytic vegetation.

In Logan County the regional mature profile is represented by soils of the Miami, Bellefontaine, Fox, and Russell series. A profile of Miami silt loam examined in a fresh road cut 2 miles southeast of Pickrelltown shows the following characteristics:

1. 0 to one-fourth inch, leaves, twigs, and other forest debris in various stages of decay.
2. $\frac{1}{4}$ to 3 inches, grayish-brown silt loam which contains a noticeable amount of coarse silt and very fine sand. This layer is somewhat darkened in the upper inch owing to colloidal coatings of organic matter. The work of earthworms is very evident. Numerous worm casts and similarly colored coatings are along root channels and other openings within the soil.
3. 3 to 10 inches, brown heavy silt loam slightly laminated in the upper 4 inches. Some gray silty material from the upper horizon has penetrated this layer, and linings of the same material are along root channels and worm holes.
4. 10 to 13 inches, brown silty clay loam which is rather compact but crushes to fine crumbs. This is the transitional zone between the eluvial and illuvial horizons.
5. 13 to 20 inches, brown heavy silty clay loam, with a sprinkling of gray silty material on the outsides of structural particles. This layer breaks into well-developed granules, averaging one-half inch in diameter, which crush to fine crumbs.

6. 20 to 28 inches, brown silty clay with dull brown or grayish brown on the outsides of the structural particles which are larger and more resistant to crushing than those of the overlying layer. Lines which serve as drainage are not so well established in this layer. Small gritty particles of igneous and metamorphic rocks are distributed throughout it.
7. 28 to 36 inches, dull yellowish-brown silty clay loam which contains highly weathered fragments of limestone and dolomite as well as exotic materials. The structure is very feebly expressed, as the material breaks into coarse crumbs. This layer is the transitional zone between the illuvial horizon and the underlying glacial drift.
8. 36 inches +, dull brownish-yellow gravelly silty clay loam, slightly mottled with gray, which effervesces with dilute hydrochloric acid. This material is oxidized late Wisconsin glacial drift, in which the texture is variable. Oxidation extends to a depth ranging from 6 to 8 feet.

The soil in which this profile was observed is in a wooded area where white oak and hard maple are the dominant trees. It occupies a smooth well-drained slope of approximately 6 degrees. The elevation is 1,390 feet above sea level.

The outstanding characteristics of this profile are (1) the well developed textural zonation of materials in which silt predominates in the upper 13 inches, whereas clay predominates in the horizon between depths of 13 and 28 inches; (2) the tendency toward a single-grain structure in the upper 13 inches, whereas between depths of 13 and 28 inches, well-developed structural characteristics are evident, and drainage lines are well established; (3) the thin surface layer which is high in organic matter and soluble bases, due to decaying leaves and other organic materials, whereas the rest of the eluviated horizon and the illuvial horizon have been leached of most of their soluble bases and are acid in reaction; (4) the low content of sesquioxides in the eluvial horizon and their accumulation in the illuvial horizon between depths of 13 and 28 inches; and (5) the relatively higher content of silica in the eluvial horizon in contrast to that in the illuvial horizon.

The Miami soils occur in large areas in Western Ohio, central and northern Indiana, and southern Michigan. They are typical of the Gray-Brown Podzolic soils group as it occurs west of the Appalachian region (1).

Table 6 gives the mechanical analysis of Miami silt loam from Grant County, Ind., which is typical of these soils.

TABLE 6.—*Mechanical analysis of Miami silt loam from Grant County, Ind.*

Sample No.	Horizon	Depth	Fine gravel (2-1 mm)	Coarse sand (1-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.1 mm)	Very fine sand (0.1-0.05 mm)	Silt (0.05-0.005 mm)	Clay (0.005-0 mm)	Colloid (0.002-0 mm)	Organic matter by H ₂ O ₂
			Inches	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
10341.....	A ₁ ...	0 - 1½	0.1	2.1	3.5	6.4	6.0	46.0	29.7	18.1	6.0
10342.....	A ₂ ...	2¼ - 0	.1	2.0	3.5	6.4	5.7	47.0	32.5	20.2	2.5
10343.....	B.....	11½ - 23½	.0	1.4	2.1	4.8	4.8	25.1	60.6	50.6	.7
10344.....	C.....	27 - 48	.1	2.8	2.9	6.0	6.5	38.2	42.9	31.0	.3

The mechanical composition does not vary significantly except in the colloid and clay fractions. The accumulation of clay in the B

horizon is typical of the podzolic soils. It is noted that the percentages of clay and colloid in the parent material (C horizon) are higher than in the A₁ and A₂ but lower than in the B because the colloid has been carried downward by percolating waters and, in part, has been deposited in the B horizon. The percentages of organic matter removed by the hydrogen peroxide treatment, preliminary to mechanical analysis, agree fairly well with the percentages of organic matter shown in table 7, which gives a chemical analysis of samples of Miami silt loam taken from the same place.

TABLE 7.—Chemical analysis of Miami silt loam

Sample No.	Horizon	Depth	SiO ₂		Fe ₂ O ₃		Al ₂ O ₃		MgO		CaO		K ₂ O		Na ₂ O		TiO ₂		MnO		P ₂ O ₅		SO ₃		Ignition loss		Total		Organic matter		N	pH
			Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.			
10341	A ₁	0 - 1½	72.32	2.75	9.63	0.66	1.26	2.11	0.87	0.75	0.13	0.11	0.13	9.56	100.28	7.19	0.32	7.0														
10342	A ₂	2½ - 9	75.49	2.95	10.58	.70	.76	2.25	.87	.78	.10	.11	.07	5.25	99.91	2.79	.16	6.4														
10343	B	11 - 24	64.29	6.52	16.54	1.66	.90	3.16	.73	.71	.12	.14	.06	5.73	100.56	.83	.09	6.3														
10344	C	28 - 48	47.48	4.30	11.39	4.78	12.59	2.48	.66	.53	.09	.11	.09	15.86	100.36	.34	.06	7.9														

The high percentages of silica in the A₁ and A₂ horizons reflect the large quantity of silt shown by the mechanical analysis, since the silt is principally silica. The accumulation of iron oxide and aluminum oxide in the B horizon is due to the higher percentages of these two constituents in the colloid, which has accumulated in this layer. The high percentages of calcium oxide and magnesium oxide in the C horizon, together with the carbonate carbon dioxide present, indicate the presence of calcium carbonate and magnesium carbonate, probably as dolomitic limestone. The high percentages of potassium and sodium oxides indicate considerable unweathered mineral. The percentages of titanium dioxide, manganous oxide, phosphorus pentoxide, and sulphur trioxide are not indicative of anything unusual. The higher ignition losses in the A₁ and C horizons reflect the organic content of the A₁ horizon and the carbonate content of the C horizon. The hydrogen-ion concentration is normal for this type of soil. The more basic reaction in the surface horizon is due to the presence of base exchange calcium in this layer. That of the C horizon is due to the presence of carbonates of calcium and magnesium.

The chemical analysis of the colloids extracted from the four horizons of the same samples of Miami silt loam are shown in table 8.

TABLE 8.—Chemical analysis of Miami silt loam (colloid)

Sample No.	Horizon	Depth	SiO ₂		Fe ₂ O ₃		Al ₂ O ₃		MgO		CaO		K ₂ O		Na ₂ O		TiO ₂		MnO		P ₂ O ₅		SO ₃		Ignition loss		Total		Organic matter		N
			Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.			
10341	A ₁	0 - 1½	44.86	7.40	22.04	1.67	1.71	2.98	0.29	1.05	0.22	0.51	17.78	100.51	10.20	0.86														
10342	A ₂	2½ - 9	47.46	7.94	22.98	1.39	1.20	2.90	.22	.70	.12	.40	0.22	14.90	100.43	6.82	.53														
10343	B	11 - 24	47.07	11.50	23.33	2.09	.96	4.37	.24	.67	.09	.33	.12	9.45	100.27	1.63	.19														
10344	C	28 - 48	46.13	10.66	22.97	2.14	2.65	4.25	.22	.60	.08	.37	.17	9.53	99.77	1.63	.18														

The percentages of silica and alumina are essentially constant throughout the profile; that of iron oxide, however, increases in the B horizon and drops off again in the C horizon. This iron-oxide accumulation in the B horizon is characteristic of the podzolic profiles. It will be noted that a considerable portion of the iron oxide presumably present in the original colloid has been leached from the A₁ and A₂ horizons. The increase in calcium oxide in the C horizon, together with its carbon dioxide content, indicates the presence of calcium carbonate of colloidal dimensions in the parent drift. The high percentage of potassium oxide in the B and C horizons may be taken to indicate a low degree of weathering with respect to the potassium minerals in these horizons. The sodium content is low through the colloid of all the horizons; this indicates that the sodium is probably leached out before it is fragmented to colloidal dimensions. The percentages of titanium dioxide, manganous oxide, phosphorus pentoxide, and sulphur trioxide are not significant in this study of the gross composition of the colloid. The percentage of organic matter indicates a wide distribution of particle size in this soil, there being relatively small increase of organic matter in the colloid fraction as compared with the whole soil.

Miami silt loam, shallow phase, differs from typical Miami silt loam largely in having calcareous parent material much nearer the surface. Miami silty clay loam is developed from very heavy glacial till. In this soil the horizons are much thinner and heavier textured than those of Miami silt loam. The silty clay loam in many places is slightly mottled in the subsurface soil, indicating slow internal drainage. The depth of leaching and oxidation are both much less than in Miami silt loam. Areas mapped as Miami silty clay loam include much soil recognized elsewhere as St. Clair silty clay loam. The St. Clair soils are distinguished from the Miami by being much heavier, particularly in the C horizon, with slower internal drainage, and by grayer soil colors, with a tendency to mottling in the A₂ and upper part of the B horizons. The mechanical analyses given in table 9 illustrate the textural composition of St. Clair silty clay loam rather than Miami silty clay loam, and indicate that the soil mapped as Miami silty clay loam in Logan County is a complex of Miami and St. Clair soils.

TABLE 9.—*Mechanical analyses of Miami silty clay loam from Logan County, Ohio*¹

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
273945	Surface soil, ¼ to 2 inches.....	0.5	1.6	1.9	4.1	2.9	46.4	42.6
273946	Subsurface soil, 2 to 6 inches.....	.6	1.3	1.8	4.1	3.0	45.5	43.7
273947	Subsoil, 6 to 10 inches.....	.1	.8	1.2	2.7	2.0	35.5	57.7
273948	Subsoil, 10 to 17 inches.....	.3	.7	.8	2.2	2.1	23.0	71.0
273949	Subsoil, 17 to 21 inches.....	.2	.6	.8	2.3	1.8	21.4	72.9
273950	Subsoil, 21 to 25 inches.....	.6	.8	.8	2.3	2.1	18.8	74.6
273951	Subsoil, 25 inches+.....	1.1	1.4	1.4	2.3	2.4	26.7	64.7

¹ These analyses indicate that the sample is more representative of St. Clair silty clay loam than of Miami silty clay loam.

Bellefontaine silt loam is developed from very gravelly drift which is high in calcareous material. In local areas the drift is im-

perfectly stratified. Because of its loose substratum, this soil has developed under much better drainage conditions than has Miami silt loam; consequently, it is not so thoroughly leached, and the iron compounds are more thoroughly oxidized, giving a reddish-brown color to the subsoil. The surface soil is more silty than that of the Miami soil, and the lower part of the subsoil is neutral gravelly clay loam that includes dark-colored soft concretions containing manganese.

The profile of the Fox soils is similar to that of the Bellefontaine soils, but they are developed only from stratified gravel deposits. They occupy nearly level terraces or outwash plains.

Russell silt loam is the mature soil developed on early Wisconsin glacial drift. It has been exposed to soil-forming processes for a much longer period than have the Miami soils. It has a distinctly brown very silty surface soil which is somewhat thicker than that of the Miami soils, and in it the amount of coarse silt is very noticeable. The subsoil is brown silty clay loam with no evidence of mottling and a well-developed fine-granular structure. Between the subsoil and the unweathered glacial drift is a distinct transitional zone, in which the material is yellowish-brown silty clay loam and is lighter textured than the subsoil. This horizon shows very little evidence of structure, the material breaking into fine crumbs. The reaction is neutral or slightly acid. The depth to the unweathered glacial drift ranges from 25 to 40 inches in Logan County, but southward the depth of leaching increases and, near the southern border of the early Wisconsin drift in Ohio, leaching extends to a depth of 60 inches. Oxidation extends to a depth of 8 feet or deeper. The vegetation on Russell silt loam is dominantly oak and hard maple.

Crosby silt loam is in many places intricately intermixed with the Miami soils. It is developed from similar material but occupies less well drained situations. Both surface and internal drainage are slow, and the type of vegetation is somewhat different. On the Crosby soil, beech is dominant, whereas on the Miami soils, oak, hickory, and maple are characteristic. Crosby silt loam has undergone very little erosion under natural conditions and has been saturated with water for much longer periods during the course of its development, and this has resulted in more solution of materials from the surface horizon and more deposition of very fine materials within the illuvial horizon. Consequently, the Crosby soil is highly leached in the surface soil and has a dense heavy subsoil high in colloidal material. A considerable part of the iron has been removed from the surface horizon and segregated with incomplete oxidation in the subsoil. Consequently, a light-gray color predominates in the surface horizon, whereas in the subsoil mottled colors prevail. A profile of Crosby silt loam, in an area approximately 2 miles southeast of Quincy, one-fourth mile east of the southwest corner of section 16, shows the following characteristics:

1. 0 to one-half inch, leaves, twigs, and other forest debris in various stages of decay.
2. $\frac{1}{2}$ to 3 inches, dark brownish-gray crumbly silt loam which is darkest in the upper part. The material in this layer has a single-grain structure and is held together by a mass of small roots. It is slightly laminated. The activities of worms and insects are very evident.
3. 3 to 9 inches, intricately mottled pale grayish-yellow and light-gray friable silt loam which, on crushing, becomes pale yellow. The material in

this layer is slightly laminated, with a strong tendency to a single-grain structure. Dark-colored coatings along root channels and similarly colored worm casts are present but are not so plentiful as in the overlying layer.

4. 9 to 12 inches, yellow or brownish-yellow light silty clay loam, with light-gray coatings on the structural particles. The material breaks into coarse granular polygons which crush to fine crumbs. This layer is somewhat heavier in the lower part and is the transitional zone between the eluvial and illuvial horizons.
5. 12 to 20 inches, dull brownish-yellow heavy silty clay loam intricately streaked with dull gray. This layer contains some very small iron concretions. The structure is well developed. The material breaks into fine clods which have dull-brown slickened surfaces. Fillings of gray silty material are common along drainage lines and between structural particles. The material in this layer is much heavier than that in the overlying layer and is only penetrated by the larger roots. At its lower limit it grades abruptly into unweathered glacial drift.
6. 20 inches +, pale-yellow and gray gravelly clay loam glacial drift which effervesces with dilute hydrochloric acid. The texture ranges from light gravelly clay loam to dense heavy silty clay.

The area in which this profile was observed is a wooded area, dominantly of beech with some maple and oak. The relief is flat, and the elevation is 1,090 feet above sea level.

Crosby silty clay loam is similar to Crosby silt loam but it is developed from heavier parent material. The individual soil layers are thinner and heavier textured. In many places this soil is only mildly acid, and the depth to calcareous material is very slight. Crosby silty clay loam, as mapped in this county, includes some areas of Nappanee silty clay loam which is distinguished from the Crosby soil by the much heavier texture of the B and C horizons.

Fulton silty clay loam differs from the Crosby soil in the character of the parent material which is laminated clay or silty clay. In the Fulton soil leaching is to a very slight depth. In most places the soil is sweet at the immediate surface and calcareous within a depth of 15 inches. Because of its heavy plastic material and consequent slow drainage, dull gray is the dominant color in both the surface soil and subsoil. Fulton loam is developed from interbedded layers of fine sand, silt, and clay, and it is more mottled than Fulton silty clay loam.

The dark-colored mineral soils have developed in depressions under poor drainage and, consequently, under the influence of hydrophytic vegetation comprising swamp forest associations or water sedges and cattails. These soils have received additions of fine sediments, rich in organic matter and soluble bases, from the surrounding soils. The translocation of fine materials within the solum has not taken place, therefore they have not developed well-defined textural horizons. Under virgin conditions the ground was covered with water for long periods, and even during the driest seasons the water table remained close to the surface. This produced anaerobic conditions which inhibited the decay of organic matter and favored its accumulation within the soil. The accumulated organic matter has had a marked influence on the development of these soils. It has given them a dark color in the topmost 8- or 10-inch layer. The humic and other acids have greatly increased the solubility of the alkalies, alkaline earths, and PO_4 ions and, to less extent, have reacted with the soluble bases to form humates which further accentuate the dark color. The high organic content has increased the pore space, re-

sulting in better aeration and higher water-holding capacity. It has increased the capacity of the soil to change volume with moisture fluctuations and has reduced the cohesive power of the clay. High-silica colloids in these soils have an even more important effect on their shrinkage and expansion properties. It is well known that high-silica clays expand and contract greatly with variations in water content.

Poor drainage has brought about a reduction of the iron compounds so that mottled or drab colors prevail even where the content of organic matter is low. As these soils have developed under poor drainage conditions and as they have developed from parent material high in calcium carbonate, they have lost little through leaching, and are high in soluble calcium. The high calcium content has flocculated the clay particles, giving the soil a favorable consistence. It has rendered insoluble the toxic iron, manganese, and aluminum compounds and has retarded the loss of potassium and manganese through the drainage waters (7).

Brookston silty clay loam is one of the most typical of the dark-colored soils. A profile of an area of this soil located one-fourth mile east of the southwest corner of section 22 on the county line south of Quincy, shows the following characteristics:

1. 0 to 8 inches, dark brownish-gray crumbly silty clay loam.
2. 8 to 12 inches, brownish-gray silty clay loam which does not contain so much organic matter as the overlying layer. The material in this layer crushes to slightly larger crumbs.
3. 12 to 40 inches, coarsely mottled gray and dull-brown heavy silty clay loam. The material in this layer is dense and plastic when wet but under moist conditions crushes to coarse crumbs. It contains numerous gritty particles of igneous and metamorphic rocks and a few fragments of limestone or dolomite.
4. 40 inches +, light-gray gravelly loam mottled with brown, which effervesces with dilute hydrochloric acid. This is the unweathered glacial drift. Oxidation extends to a depth ranging from 4 to 6 feet.

This profile was observed in an uncultivated area near the center of a large shallow depression from which the trees have been removed. The elevation is 1,090 feet above sea level.

Brookston silty clay loam, heavy-textured phase, is lighter colored in the surface soil but is heavier textured throughout than the typical soil. It is developed from very heavy gravelly clay loam.

Clyde silty clay loam is the darkest poorly drained upland soil. It has a very dark gray surface soil and a bluish-gray or mottled subsoil, in which drab colors prevail. Where associated with the Brookston soils it occupies the more poorly drained situations. In many places it is developed under a cover of water sedges and cattails.

Westland silty clay loam occurs in depressions on terraces. The color is comparable to that of the Brookston soils, but at a depth ranging from 25 to 40 inches, the Westland soil is underlain by stratified sand or gravel.

The Abington soils are terrace soils comparable to the Clyde soils of the uplands, but, as in the Westland soil, the substratum consists of stratified sand or gravel.

The Toledo soils are comparable in color to the Brookston soils, but the small pebbles and grit, characteristically occurring on the surface and scattered throughout the solum of the Brookston soils,

are absent, and the materials composing the individual soil layers are smooth and plastic. The substratum consists of calcareous laminated silty clay or clay.

Bono silty clay loam is similar in the upper layers to Clyde silty clay loam. It is underlain by calcareous laminated silty clay or clay.

In many depressions that formerly were lakes, conditions have favored the accumulation of organic soils which, with one exception, are nonacid. Carlisle muck is the most extensive organic soil. In a pit in one of the areas mapped as Carlisle muck, known as the Lewistown cranberry bog, 2 miles south of Lewistown, the following characteristics were observed:¹⁰

1. 0 to 13 inches, grayish-black finely divided or powdery organic matter.
2. 13 to 52 inches, reed-hypnum peat—brown or dark-brown fibrous reed peat partly decomposed. It contains thin bands of light-brown well-preserved leaves and stems of hypnum mosses. The dark-colored residue is derived from various herbaceous plants and seeds of bogbean, or marsh trefoil (*Menyanthes* sp.). The material is more or less sticky when moist and shows considerable shrinkage when dry. It is slightly acid in reaction (pH 6.5) and grades sharply at the 37-inch level into yellowish-brown coarse fibrous reed peat which is slightly decomposed, layered, and porous and brittle when dry. Dark-colored residue and seeds of marsh plants are present in small quantities. At the lower level a sharp demarcation occurs, separating this material from the underlying material.
3. 52 to 93 inches, sedimentary peat—dark-brown organic sediments consisting of a mixture of fragments of roots and rhizomes of reedlike grasses, sedges, and flattened rootstocks of waterlilies, embedded in soft structureless material derived from submerged aquatic vegetation associated with open water. The material below the 64-inch level is dense, plastic, and more or less laminated, and it shrinks greatly and hardens when dry. It contains seeds of water plants (*Najas* sp.) and thin bands of coarse-fibered underground stems from reeds. At a greater depth toward the 86-inch level the sedimentary peat is grayish brown, fine textured, and contains well-preserved leafy tissues of a variety of pondweeds (*Potamogeton* sp.). The material below the 86-inch level is neutral in reaction (pH 7) and grades into olive- or greenish-brown colloidal organic sediments which are dense and rubbery, break with a conchoidal fracture, and become hard when dry. Near the 93-inch level the organic debris is lighter in color, contains mineral material, small white granules of lime carbonate, and grades into the underlying bluish-gray clayey mineral soil which lies at a depth ranging from 93 to 110 inches.

Edwards muck differs from Carlisle muck, in that the thickness of the organic layer is less than 36 inches and it is underlain by marl.

The recent soils are those occupying the flood plains. In these soils the horizons have been determined by deposition. The series distinctions are based largely on color and drainage conditions. All the soils are sweet or calcareous.

The Genesee soils are brown and well oxidized to a depth of 36 or more inches. The Eel soils are brown and well oxidized in the upper 20 inches, and below this depth are dingy brown and in some places are mottled with gray. They are imperfectly drained. The Sloan soils are medium gray or dark gray to a depth of 36 or more inches and are poorly drained. The Wabash soils are black in the surface layers and very dark gray or black below a depth of 10 inches. These soils are underlain by gravel at a slight depth. Drainage is poor.

¹⁰ The description of this profile was furnished by A. P. Dachnowski-Stokes, in charge of peat investigations, Soil Survey Division, Bureau of Chemistry and Soils.

In the Algiers soils the upper 20 inches consist of brown well-oxidized recent overwash. This is underlain by very dark gray or black silty clay which is high in organic matter. The remains of roots and other woody tissues are recognizable in many places in this layer. Subsoil drainage is poor. In the Walkkill soil the upper 12- or 15-inch layer is mottled brown and gray poorly oxidized overwash. This is underlain by a dark-colored mucky substratum. Vegetation on this soil consists largely of water sedges, cattails, and willows. The soil is waterlogged.

Table 10 gives the results of mechanical analyses of samples of two soils from this county.

TABLE 10.—Mechanical analyses of 2 soils from Logan County, Ohio

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Crosby silt loam:	<i>Inches</i>	<i>Percent</i>						
273962½	10 - ½	0.2	9.1	5.0	10.2	7.2	42.6	25.7
273963	½- 3	.7	2.3	2.3	3.9	4.0	58.3	28.4
273964	3 - 9	.7	2.3	2.4	4.0	4.0	57.8	28.9
273965	9 -12	.7	2.0	2.1	3.7	4.0	51.8	35.8
273966	12 -20	.4	1.6	2.0	3.8	4.4	31.7	56.0
273967	20+	2.7	4.4	4.3	7.9	9.4	35.8	35.5
Miami silt loam:								
273968	0 - 4	.9	3.5	4.0	7.8	7.9	54.0	21.8
273969	4 - 9	1.3	2.7	3.0	6.0	5.9	47.0	34.1
273970	9 -13	.7	2.1	2.5	5.2	5.4	32.8	51.4
273971	13 -19	.7	1.9	2.3	5.7	6.3	27.0	56.2
273972	19+	2.4	4.4	3.4	7.3	10.0	40.3	32.2

1 Includes organic matter.

Table 11 gives the results of pH determinations on several soil profiles. These determinations were made in the laboratories of the Bureau of Chemistry and Soils by the hydrogen-electrode method.

TABLE 11.—pH determinations of several soil profiles from Logan County, Ohio

Soil type and sample No.	Depth	pH	Soil type and sample No.	Depth	pH
Fox silt loam:	<i>Inches</i>		Miami silty clay loam—Contd.	<i>Inches</i>	
273901	0 - 2½	7.3	273947	6 -10	4.8
273902	2½-10	6.8	273948	10 -17	4.9
273903	10 -14	6.4	273949	17 -21	4.9
273904	14 -20	5.6	273950	21 -25	7.2
273905	20 -23	7.4	273951	25+	8.2
273906	23 -32	7.9	Crosby silty clay loam:		
273907	32+	8.6	273952	0 - 4	6.0
Russell silt loam:			273953	4 -10	4.7
273908	0 - 2	5.5	273954	10 -13	5.1
273910	2 -10	5.3	273955	13 -22	7.3
273911	10 -14	6.4	273956	22+	8.4
273912	14 -22	5.3	Crosby silt loam:		
273913	22 -34	6.7	273962½	0 - ½	7.6
273914	34+	8.0	273963	½- 3	7.2
Bellefontaine silt loam:			273964	3 - 9	6.2
273937	0 - 3	7.6	273965	9 -12	5.8
273938	3 -11	6.4	273966	12 -20	6.2
273940	11 -15	6.1	273967	20+	8.5
273941	15 -20	7.6	Miami silt loam:		
273942	20 -80	8.3	273968	0 - 4	8.1
273943	80+	8.8	273969	4 - 9	7.9
Miami silty clay loam:			273970	9 -13	7.8
273944	0 - ½	7.2	273971	13 -19	7.9
273945	½- 2	6.3	273972	19+	8.7
273946	2 - 6	5.6			

SUMMARY

From its earliest development the type of agriculture in Logan County has been chiefly determined by three factors—climate, soils, and markets.

The climate is favorable to the production of a large variety of crops. The average length of the frost-free period is 158 days, the summers warm, the winters moderately cold, the percentage of sunshine high, the rainfall well distributed, and the rate of evaporation low.

The soils are derived from materials of glacial origin and are little influenced by the underlying limestones and shales. Over the greater part of the county the material is glacial till, consisting of a heterogeneous mixture of clay, sand, and gravel. This has been deposited over an uneven preglacial terrain and, to some extent, has assumed its form. The present relief is greater than that in the surrounding territory. This has contributed to a wide variation in soil characteristics.

Associated with the heterogeneous glacial till are stratified materials of both running- and quiet-water origin; the former consist of gravel and sand and the latter of silt and clay. Stratified gravel occurs principally as long narrow terraces at two distinct levels along Mad River and its tributaries. Areas of minor importance occur in various parts of the county. Light-colored soils of the Fox series and dark-colored soils of the Westland and Abington series are developed from these deposits.

Stratified deposits of silt and clay are of minor importance. They occur largely in the vicinity of Indian Lake. Dark-colored soils of the Toledo and Bono series are derived from these deposits, with lighter colored soils of the Fulton series occupying the slight elevations.

Light-colored soils of the Miami, Crosby, Bellefontaine, and Russell series are developed from the glacial till in the well-drained situations; whereas, where drainage is poorly established, dark-colored soils of the Brookston and Clyde series prevail. In many places the soil pattern is very intricate, with light colors prevailing on the slight elevations and dark colors in the depressions.

Logan County is centrally located in the region of Gray-Brown Podzolic soils. In this region the well-drained soils are light colored. They have developed under a deciduous forest, high rainfall, and low rate of evaporation. The downward movement of ground water is continuous, except during short periods, throughout the year. This has resulted in the solution of soluble bases and other plant nutrients from the soil and their removal through drainage waters, leaving the surface soil and upper subsoil layers mildly or moderately acid, except the immediate surface layers of virgin areas, where the continuous decay of tree leaves has replenished the supply of soluble bases. There has also been a mechanical transfer of fine materials from the surface layers to lower horizons. This has given rise to light-textured surface soils and heavier textured subsoils.

The light-colored soils are relatively infertile, and many of them have subsoils so impervious as to retard free movement of ground water and air. This is particularly true of the Crosby and Fulton

soils which, in addition, occupy flat areas and require considerable artificial drainage, in order that they may be utilized for crop production. Soils of the Miami, Bellefontaine, Fox, and Russell series are mildly leached, require no artificial drainage, and respond well to fertilization.

The dark soils have developed under conditions favoring the accumulation of organic matter and nitrogen. They are relatively unleached. Given artificial drainage, corn is well adapted to them, but small grains are not so well adapted.

The early farming was on a self-sufficing basis, largely because of lack of markets. A wide variety of crops was grown. No attention was given to rotation of crops or to the adaptation of crops to certain soils. The light-colored soils were preferred because they were easy to clear and cultivate and required little or no artificial drainage.

With the development of railroads, agriculture was reorganized and became more dependent on outside markets. Crops, such as flax and hemp, were no longer grown, and more attention was given to the production of livestock.

Corn is the leading crop and is supplemented by small grains (wheat and oats) and legumes. Corn is the leading crop because it is well adapted to the climate and produces large yields on the dark-colored soils and also on many of the light-colored soils where they are properly farmed. Its importance here is as hog feed, the sale of hogs constituting one of the main sources of farm income.

Oats are a small grain easily adapted to a rotation. They provide a good nurse crop for legumes and are excellent feed, supplementing corn for livestock. In addition, they can be sown in the spring, which avoids the danger of winter-killing on poorly drained soils.

The production of wheat has varied greatly. As it is largely a cash crop, periods of high prices have greatly stimulated increases in acreage. During the last few years it has largely been restricted to the light-colored soils.

Legumes are necessary in the rotation because of their value for soil improvement, in addition to their value as hay and forage crops.

Livestock and livestock products constitute the chief sources of farm income. They find ready sale in nearby markets, and transportation rates are not excessive. The production of livestock distributes the farmers' work and income throughout the year. Manure is one of the best soil amendments and is important in maintaining soil fertility, especially of the light-colored soils. In 1932 the sale of hogs and dairy products constituted 52 percent of the total farm income. The rougher parts of the county are particularly well adapted to dairying. Bluegrass grows luxuriantly on the nonarable slopes and makes excellent pasture.

Organic soils are of minor importance in the county as a whole, but on a few farms the sale of special crops produced on them adds materially to the farm income.

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Areas surveyed in Ohio shown by shading. Reconnaissance surveys shown by northwest-southeast hatching; crosshatching indicates areas covered by both detailed and reconnaissance surveys.

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