SOIL SURVEY

Crawford County Pennsylvania

Series 1939, No. 18

Issued April 1954

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
PENNSYLVANIA STATE COLLEGE
SCHOOL OF AGRICULTURE AND EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have lived in one locality for a long time come to know about the soil differences on their own farms and on those of their immediate neighbors. What they do not know, unless a soil survey has been made, is how nearly their soils are like those at experiment stations or in other localities from which higher or lower yields are reported. They do not know whether these yields are from soils like their own or from soils that are greatly different. These similarities and differences among soils are known only after a map of the soils has been made. Knowing what kind of soil one has and comparing it with soils on which new developments have proved successful will remove some of the risk in trying new methods and varieties.

SOILS OF A PARTICULAR FARM

To find what soils are on any farm or other land, locate the tract on the soil that accompanies this report. This is easily done by finding the township the farm is known to be in and locating its boundaries by such landmarks as houses, roads, streams, villages, and other features.

Each kind of soil is marked with a symbol on the map; for example, all soils marked Vg are of the same kind. To find the name of the soil so marked look at the legend printed near the margin of the map and find Vg. The color indicated for the soil in the legend will be the same as the color in which it appears on the map. Vg stands for Venango gravelly silt loam. A section of this report tells what this soil is like, for what it is mainly used, and some of the uses to which it is suited.

How productive is Venango gravelly silt loam? Find this soil name in the left-hand column of table 5 and note the yields of the different crops opposite it. This table also gives expectable yields for all the other soils mapped, so that the different soils can be compared.

Read the section headed Land Use and Soil Management. Here Venango gravelly silt loam is grouped with other soils having about the same use and management practices.

SOILS OF THE COUNTY AS A WHOLE

If a general idea of the soils of the county is wanted, read the introductory part of the section on Soils. This tells where the principal kinds are found, what they are like, and how they are related to one another. Then study the soil map and notice how the different kinds of soils tend to be arranged in different localities. These patterns are likely to be associated with well-recognized differences in type of farming and land use.

A newcomer who considers purchasing a farm in the county will want to know about the climate as well as the soils; the principal farm products and how they are marketed; the kinds and conditions of farm tenure; kinds of farm buildings, equipment, and machinery; availability of schools, churches, highways, railroads, telephone and electric services, and water supplies; industries; and towns, villages, and population characteristics. This information will be found in the sections on General Nature of the Area and on Agriculture.

Students and others interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication on the soil survey of Crawford County, Pa., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE
and the
PENNSYLVANIA STATE COLLEGE
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SOIL SURVEY OF CRAWFORD COUNTY, PENNSYLVANIA

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United States Department of Agriculture in cooperation with the Pennsylvania State College School of Agriculture and Experiment Station

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[1] The Division of Soil Survey was transferred to the Soil Conservation Service Nov. 15, 1952.

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CRAWFORD COUNTY, in the northwestern part of Pennsylvania, is chiefly an agricultural region. As its soil and climate are well adapted to the dairy industry, it has become the third most important dairying county in the State. The production of feed crops—hay, corn, oats, and pasture—for the dairy cows is the chief use of cleared land. Potatoes, wheat, buckwheat, and vegetables are grown to some extent as cash crops. These crops and raw milk find markets in Cleveland, Pittsburgh, Buffalo, and New York. Poultry and egg production is also an important source of income. Oil wells, iron and steel mills, sawmills, and various other industries afford some employment. To help choose uses and farm practices to fit the different soils a cooperative soil survey was made by the United States Department of Agriculture and the Pennsylvania State College School of Agriculture and Experiment Station. Field work was completed in 1939, and, unless otherwise specifically mentioned, all statements in this report refer to conditions in the county at that time.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Crawford County, in the northwestern part of Pennsylvania, is bounded on the west by the State of Ohio, on the south by Mercer and Venango Counties, on the east by Warren County, and on the north by Erie County. Meadville, the county seat, is near the center of the county (fig. 1) and is 195 miles northwest of Harrisburg and 80 miles north of Pittsburgh. The county comprises an area of 1,016 square miles, or 650,240 acres.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Crawford County is included in the Allegheny Plateau section of the Appalachian Plateaus physiographic province. Topographic features vary greatly; almost level surfaces on the plateaus and in the valleys are in the western part of the county, gently and strongly rolling surfaces in the central and northeastern parts, and steep relief in the southeastern section. The two valleys in the western part of the county, occupied by Pymatuning Reservoir and Conneaut Creek and Conneaut Marsh, are surrounded by broad almost level to undulating uplands. The depth of stream dissection and the difference in elevation between the valley floors and the surrounding uplands vary from 150 to 300 feet, while in the rest of the county there is a drop of 300 to 400 feet from the plateaus to the larger stream flood plains.

The surface relief was greatly changed by the ice sheets that advanced from the north. The Illinoian glaciation completely covered the county, and the Wisconsin ice age covered all but a small part of the southeastern section. As the glaciers melted, the pulverized rock material was released and deposited as glacial till. Some outwash was carried long distances from the ice margin by runoff water from the melting ice, while some till was deposited directly with no sorting by water. The outwash and till together comprise glacial drift. Whenever there was a halt in the retreat or advance of the ice front, deposits accumulated near the edge of the ice and moraines were built up. The hummocky topography southwest of Sugar Lake is a result of the morainic process of deposition.

These glaciers planed off the highlands, gouged out and refilled the valleys that were parallel to the direction of the ice movement, and deposited drift in the valleys and on the uplands. The drift on the uplands, which is largely till, covers the bedrock to a general depth of 5 to 20 feet. Valley fill is sometimes 200 to 300 feet deep. The thinnest covering is on steep slopes and rounded knolls of the southeastern section of the county, which was covered only by the Illinoian glacial drift.[1a]

Titusville, at the New York Central and Pennsylvania Railroad station, has an elevation of 1,194 feet above sea level. Meadville and Conneautville have elevations of 1,078 and 949 feet, respectively.

The major streams and some of the smaller streams, except those in the southeastern part of the county, flow mostly in flat-bottomed valleys that are deeply filled with glacial outwash. The streams in general have low gradients and meander back and forth on the flat valley bottoms. Four lakes and many swampy areas are located in the low flat-bottomed valleys. Of these, Conneaut Lake is one of the largest natural lakes in Pennsylvania. The area beyond the line reached by the Wisconsin till has a separate drainage pattern, which is like the topography cut out by the streams of the unglaciated Allegheny Plateau farther east and south, and is dendritic with deep and narrow stream valleys.

With the exception of the northwestern corner, all of Crawford County is drained by southward-flowing streams. The central part of the county is drained by French Creek and its tributaries, the eastern by Oil Creek, the southwestern by the Shenango River and Crooked Creek, and the northwestern by Conneaut Creek and its tributaries.

[1a] LEGGETTE, R. M. GROUND WATER IN NORTHWESTERN PENNSYLVANIA. Pa. Geol. Survey Bul. W3 (ser. 4), 215 pp., illus., 1936. Harrisburg.

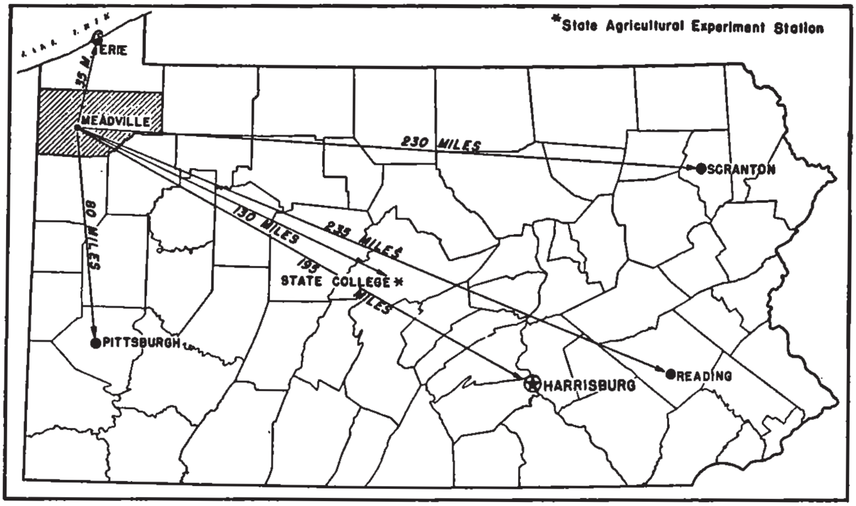

Figure 1.—Location of Crawford County in Pennsylvania.

CLIMATE

The continental climate of Crawford County is characterized by long winters, with occasional periods of extremely low temperatures and cool summers. The mean annual temperature of 47.6° F. is representative of a large part of the county, although the range in elevation from 850 to 1,900 feet causes some local variations in temperature and frosts. In general, the summers are cooler in the eastern part of the county than in the western part, and the growing season is probably 8 to 10 days shorter. Some difference in the length of the frost-free period is due to location with respect to air drainage. Land in the valleys, where the cold air settles on still nights, does not escape so many frosts as land along and adjacent to the upper slopes. High level uplands are less frequented by frosts late in spring and early in fall than valleys, owing to more air movement.

The moderating influence that Lake Erie has on land bordering it is not noticeable in Crawford County. At Erie, according to the United States Weather Bureau, the average frost-free season is at least 2 months longer than at Meadville. The average length of the frost-free season at Meadville is from May 21 to September 29, but frosts have occurred as late as June 17 and as early as September 10. This period of 131 days is long enough for the production of most crops, although frost sometimes damages corn before it is mature and late potatoes are frequently dug before they have finished growing.

Rainfall is usually well distributed throughout the year, and the annual precipitation of 41.70 inches recorded at Meadville is generally sufficient for maturing crops. Excessively wet springs occur occasionally; summer droughts are not frequent. Hailstorms and heavy downpours causing soil washing are infrequent, and little damage is ever reported. Heavy spring rains, cool weather, poor natural drainage, and lack of adequate tiling or ditching to relieve excess water delay planting on much of the level and heavier soils of the upland.

The normal monthly, seasonal, and annual temperature and precipitation at Meadville, which is representative of the county, compiled from records of the United States Weather Bureau station, are shown in table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Meadville, Crawford County, Pa.*

[Elevation, 1,080 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	29. 0	66	−20	3. 06	2. 11	3. 49	13. 2
January	25. 3	72	−35	3. 13	1. 38	3. 26	16. 6
February	24. 4	67	−34	2. 68	2. 90	2. 41	14. 2
Winter	26. 2	72	−35	8. 87	6. 39	9. 16	44. 0
March	34. 8	83	−22	3. 20	2. 89	3. 59	7. 0
April	45. 6	89	−5	3. 34	2. 57	2. 22	2. 6
May	57. 0	96	20	4. 04	1. 67	3. 95	. 1
Spring	45. 8	96	−22	10. 58	7. 13	9. 76	9. 7
June	65. 9	97	28	4. 04	4. 90	3. 58	0
July	69. 7	99	35	4. 15	4. 03	14. 51	0
August	67. 7	103	33	3. 65	2. 18	6. 63	0
Summer	67. 8	103	28	11. 84	11. 11	24. 72	0
September	62. 1	95	21	3. 60	3. 13	1. 55	0
October	50. 7	90	14	3. 41	3. 35	. 50	. 8
November	39. 0	78	−4	3. 40	. 67	6. 51	7. 2
Fall	50. 6	95	−4	10. 41	7. 15	8. 56	8. 0
Year	47. 6	103	−35	41. 70	[1] 31. 78	[2] 52. 20	61. 7

[1] In 1939. [2] In 1897.

WATER SUPPLY

The county is well supplied with ground water, both for household and large municipal and industrial uses. Small springs are numerous and are utilized to some extent, but they are not reliable sources in dry seasons. Dug wells are gradually being abandoned and replaced by drilled wells, which are less easily contaminated and have a more constant flow. The Pymatuning Reservoir covers 17,200 acres and provides storage of water for industrial areas.

VEGETATION

Before settlement by white men the county was covered with forest, except for a few patches of grassland along French and Oil Creeks, which were presumably in prairie. The original forest consisted of oak, maple, chestnut, black walnut, hickory, cherry, locust, tuliptree (yellow-poplar), ash, butternut, ironwood, mountain-laurel, bay, pine, hemlock, and spruce. The forest floor was open and comparatively free from underbrush. Much of the present forest, especially on abandoned areas, contains low-growth underbrush of hawthorn, wild apples, alder, huckleberry, and briers.

The predominant species of grasses on pasture and abandoned fields are largely poverty oatgrass (*Danthonia spicata*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), redtop (*Agrostis alba*), timothy (*Phleum pratense*), and wild white clover (*Trifolium repens*). In addition, weeds constitute a large part of the vegetation in many meadows, especially those that are not managed properly. The weeds include goldenrod (*Solidago graminifolia*), ox-eye daisy (*Chrysanthemum leucanthemum*), devils-paintbrush (*Hieracium aurantiacum*), wild carrot (*Daucus carota*), and ragweed (*Ambrosia artemisiifolia*). Numerous other weeds are scattered over the fields, but they are not abundant except in a few places. White clover, Kentucky bluegrass, and other better grasses are more plentiful where lime and phosphate have been applied.

ORGANIZATION AND POPULATION

Various Indian tribes once occupied this area. Although the Senecas were recognized as its nominal owners, it was utilized as a general hunting ground by both eastern and western tribes. The first white settlement was made in 1787 along French Creek in what is now the town of Meadville. Settlers were English and Irish and came from eastern Pennsylvania, Connecticut, and New York. The county was rapidly settled after the first few years. In 1800 Crawford County was separated from Allegheny County and included the present counties of Crawford, Erie, Mercer, Venango, and Warren. Warren County was the last to be formed from Crawford and was organized in 1819.

According to the 1950 census the population was 78,948 of which 27,895 was urban and 51,053 rural. The density of the rural population has remained uniform and the distribution is fairly even. In 1950 Meadville, the county seat, had a population of 18,972, and Titusville, 8,923. Other towns of importance are Cambridge Springs, Conneautville, Linesville, Cochranton, Saegerstown, Conneaut Lake, Springboro, and Spartansburg. Hydetown, Geneva, Blooming Valley, Townville, and Harmonsburg are villages that offer trading facilities for the surrounding communities. Cambridge Springs and Conneaut Lake are summer resort areas and therefore have a larger population in summer than in winter. Cambridge Springs has a number of springs and wells that yield mineral water reported to be of medicinal value, and hotels commercialize these supposed medicinal properties. In addition to these towns, Conneaut and Conandohta are pleasure resorts that provide local markets for farm products in summer.

INDUSTRIES

The principal industries other than agriculture in 1939 were the talon fastener and viscose manufacturing plants at Meadville, the iron and steel mills in Meadville and Titusville, and the oil industry in

Titusville and its vicinity. In addition there were many smaller manufacturing establishments in the area, as well as several commercial sawmills. The oil industry in the southeastern part of the county consists of refineries, storage plants, and hundreds of small oil wells that daily yield one-sixth to one-half barrel. The landowner receives one-eighth of all the production. The first oil well in the United States was drilled in 1859 by Col. E. L. Drake. This well was located about 1 mile south of Titusville in Venango County, and it exerted a great influence upon this section of the State, especially on the little village of Titusville that changed to a crowded city almost overnight.

TRANSPORTATION AND MARKETS

The county is well supplied with rail and bus transportation. The Erie Railroad traverses the central part of the county from north to south, passing through the towns of Cambridge Springs and Meadville. Both the Bessemer and Lake Erie and the Erie and Pittsburgh Railroads traverse the western part of the county north and south, running almost parallel to one another. The Pennsylvania Railroad has a branch line traversing the eastern part of the county from north to south, connecting towns with Oil City and Corry.

All sections of the county are reached by paved State or county highways. Many of the county roads are macadam or sand and gravel, although the largest proportion are graded dirt roads. No point in the county is more than 2½ miles from a graded or improved road.

The principal markets outside the county are Pittsburgh and Buffalo. Pittsburgh receives the largest share of milk, the main source of farm income, with Buffalo and New York as other markets for it. Cleveland is the largest consumer of the potatoes other than those used and sold within the county. Wheat, buckwheat, and other cash products are generally shipped east for milling. Berries, vegetables, and fruit are usually disposed of locally.

FARM, HOME, AND COMMUNITY IMPROVEMENTS

Modern farm equipment, including riding cultivators, binders, hay loaders, sulky plows, and a few combines, is in general use. Tractors are gradually replacing horses as a source of power.

Most of the farm buildings are substantially built. Some, however, were neglected in 1930–40 partly because of the low price of milk which was the chief source of income. The floors of most of the barns are of concrete, and sanitary conditions are maintained according to the State sanitation code.

The rural districts of the county are well supplied with schools and churches. The many one-room schools in operation are gradually being abandoned and supplanted by larger consolidated schools. Several small colleges are in the area, the largest of which is Allegheny at Meadville. Since telephones and electric lines extend throughout most of the county, most farms are within a few miles of these modern facilities.

AGRICULTURE

EARLY HISTORY

Agriculture in Crawford County dates from the latter part of the eighteenth century when the first white settlers cleared patches along

French Creek. These settlers raised corn, potatoes, vegetables, and fruit, and built mills for grinding grain and sawing lumber. The production of rye, largely for whisky, and buckwheat was begun soon after settlements were established. Sugar from maple trees provided a small income to many settlers. By 1820, 49 sawmills were operating in the county as a result of the expansion of the lumber industry. Its chief markets were along the Ohio, the lower Mississippi, and New Orleans. Since the manufacture of lumber was one of the chief sources of income, the development of agriculture was slow until much of the better timber had been removed.

At the beginning of the nineteenth century agricultural development was rapid, both in grain and livestock production. Along with cattle, swine and sheep production was important but began to dwindle in the late nineteenth century as the production of milk and butter became more profitable.

CROPS

Beginning with the development of agriculture, hay, corn, oats, and potatoes have been the most important crops in the county and sheep and cattle the most important livestock. At present the crops grown, ranking in order of their acreage, are hay, oats, corn, wheat, buckwheat, and potatoes.

Crawford County ranked fifth among the counties of Pennsylvania in acreage of hay harvested in 1949. Bradford County, the leading hay county in the State, harvested 95,466 acres, as compared with 66,999 acres that Crawford produced. Most of the hay is red and alsike clovers mixed with timothy.

All the oats grown are used on the farm for feed. Much of the straw is fed to horses in winter, and some is used for bedding. In 1949, 25,562 acres were harvested, yielding 804,326 bushels.

The total corn acreage varied between 8,000 and 20,000 acres from 1919 to 1939, with an increase to 28,244 acres in 1944. Silage corn became popular in this section with the advent of the silo, partly because silage corn does not require so long a growing season as the mature corn raised for grain.

This county is one of the leading buckwheat counties of the State and country. Most of the buckwheat is shipped east for milling. It is used chiefly for flour from which griddle cakes are made. The whole grain is good poultry food, and the straw is sometimes used for feed and is readily eaten by stock if it is well preserved.

Wheat production is uneven because farmers generally consider wheat growing commercially unprofitable, since frost-heaving breaks the root systems on many soils in winter. Wheat has an important value as bedding and as a protective nurse crop and winter-cover crop.

In total value, potatoes rank next to hay as the most important crop in the county. Other crops of less importance are rye, barley, dry beans, wild hay, sweetclover, and vegetables. Of these crops, vegetables occupied the largest acreage in 1949; 973 acres were used for vegetables other than potatoes, chiefly cabbage and corn.

Although small orchards are on practically all farms, little attempt is made to care for the trees and consequently little fruit is produced except for home use. Most of the fruit sold in the towns is shipped in from other States. There are 7 or 8 commercial apple orchards in the county consisting of 1,000 to 15,000 trees each and one peach orchard of about 500 trees. The climate of Crawford County is somewhat severe for peach trees. The 33 acres of strawberries produced 37,466 quarts in 1949. Grapes and raspberries are grown commercially as well as for home use.

The acreage of the principal crops and number of fruit trees and grapevines in stated years are given in table 2.

TABLE 2.—*Acreage of the principal crops and number of bearing fruit trees and grapevines in Crawford County, Pa., in stated years*

Crop	1919	1929	1939	1944
	Acres	*Acres*	*Acres*	*Acres*
Corn harvested for grain	16, 977	8, 508	20, 138	19, 501
Oats threshed	35, 084	28, 026	30, 266	25, 562
Wheat threshed	13, 312	5, 478	6, 493	10, 852
Buckwheat threshed	19, 363	11, 000	9, 821	6, 268
All hay	127, 349	109, 755	78, 363	66, 999
Timothy and timothy and clover mixed	120, 595	91, 400	67, 229	61, 904
Legumes cut for hay	28	316	1, 617	375
Sweetclover and lespedeza	1, 651	9, 890	338	(1)
Alfalfa	88	669	724	1, 577
Grains cut green	628	110	677	243
Other cultivated grasses	2, 140	6, 625	7, 242	2, 900
Wild, salt, or prairie grasses	2, 219	745	536	(1)
Silage crops	8, 808	9, 739	37	9, 547
Coarse forage	7, 128	3, 357	(1)	528
Potatoes	5, 158	5, 163	5, 720	1, 486
All other vegetables	206	657	883	973
Strawberries	116	89	101	33
Apple ... trees	198, 025	104, 135	52, 234	33, 439
Maple ... do	132, 546	(1)	76, 574	(1)
Peach ... do	53, 752	16, 239	5, 559	5, 453
Pear ... do	17, 175	12, 523	4, 246	3, 585
Cherry ... do	13, 176	7, 490	1, 293	2, 043
Plum and prune ... do	16, 354	9, 645	2, 893	2, 617
Grapevines	25, 390	30, 590	10, 024	5, 369

[1] Data not available.

FERTILIZER

Fertilizer is generally used on the farms. In recent years higher grade fertilizers that contain a smaller quantity of filler have been used. Potatoes, the most heavily fertilized crop, receive 400 to 1,000 pounds of 4–8–7,[2] 4–12–4, or 2–8–10 where the crop is sold commercially, although small plantings are less liberally fertilized. Soybeans, wheat, oats, and buckwheat generally receive 200 to 300 pounds of acid phosphate or superphosphate an acre. Some lime is also used on these crops, the lime largely benefiting the clover crop that follows. Ground limestone should be used when applied to the crop preceding clover as it is more slowly available than burnt lime. A large part of the manure on the farm is spread on land to be planted to

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

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corn, although on a few farms all the other crops, including pasture, receive some manure. Lime is generally applied for clover and alfalfa seedings, and this takes care of the lime needs of the other crops in the rotation to a large extent. Only a small proportion of pasture is limed and fertilized.

LIVESTOCK AND AGRICULTURAL PRODUCTS

Dairying in the county began with the bringing in of cattle by the early settlers. As the soil and climate were adapted to this industry, farmers expanded their dairies when markets developed. The number of milk cows has steadily increased, although less rapidly during the last 50 years. The butter market was by far the greatest outlet for the milk produced on farms and the chief source of cash income until 1900. During the period from 1910 to 1914 the first fluid milk shipping plants were established in the county, and by 1925 the type of dairying industry shifted over almost entirely to the sale of fluid milk for direct consumption. Pittsburgh is the chief outlet for milk, but a large proportion is also sold to various creameries and condensing and distributing plants in the county.

With the large acreage of feed crops and the marked gain in pasture land in farms, Crawford County now ranks fifth in the State in dairy cows. The Holstein-Friesian is the most popular breed, followed by Jersey and Guernsey and a few herds of Ayrshires. There are scattered herds of Hereford, Aberdeen Angus, and Shorthorns, but ordinarily the production of beef cattle is not so profitable as milk production in this section.

The few horses that are raised are of the heavy draft type—chiefly Percheron and Belgian breeds mixed. They are used mostly for farm work, but tractors are becoming increasingly popular. Sheep production dwindled as farming became more intensive and land values increased; whereas, swine production did not begin to decline until after 1910 when milk production increased markedly.

Poultry and egg production is an important source of income. The average farmer keeps about 100 chickens, and a few farmers specialize in poultry and eggs. White Leghorn is the favorite breed, but the average farmer prefers a mixed flock of several breeds.

Table 3 gives the number of domestic animals on farms in stated years.

TABLE 3.—*Livestock on farms in Crawford County, Pa., in stated years*

Livestock	1920	1930	1940	1950
	Number	*Number*	*Number*	*Number*
Horses	17,700	10,514	[1] 9,833	4,743
Mules	247	260	[1] 237	122
Cattle	55,774	61,670	[1] 51,880	57,077
Swine	22,485	9,153	[2] 9,571	9,585
Sheep	12,370	17,411	[3] 8,192	5,622
Goats	19	149	[2] 296	(4)
Chickens	323,745	313,871	[2] 258,654	[2] 201,125
Beehives	(4)	2,713	1,354	1,588

[1] Over 3 months old, Apr. 1.
[2] Over 4 months old, Apr. 1.
[3] Over 6 months old, Apr. 1.
[4] Data not available.

FARM LAND AND TENURE

Crawford County, with a land area of 650,240 acres, had 67.8 percent, or 441,171 acres, in farms in 1950. There were 112,829 acres of woodland classed as farm land. The 4,593 farms had an average size of 96.1 acres. The county had a large quantity of pasture land, including 20,987 acres of plowable pasture in addition to nonplowable pasture and woodland that was pastured. About 29,623 acres of land was cropland not harvested and not pastured and 144,006 acres was cropland harvested.

In 1950, 96.0 percent of the farms were operated by owners, 3.7 by tenants, and 0.3 by managers. Various systems or payments of rental are made. Sometimes the owner pays the taxes, repairs the buildings, and furnishes one-half of the fertilizer and seed in return for which he receives one-half of the proceeds from crops and part of the milk if he furnishes the stock. Other renters furnish the seed, fertilizer, and livestock and give one-third to one-half of the crop receipts to the owner of the land.

FARM INVESTMENTS AND EXPENDITURES

A scarcity of farm labor has existed for the last 20 years owing to the higher wages and shorter hours offered by manufacturers, contractors, and public works. The members of the family do most of the farm work on the average farms, and when extra help is needed, as during harvesting, day labor is employed. Some of the dairy farmers keep one or two men the entire year and pay them by the month, furnishing board and room or a house. Considering all the farms of the county, however, the average expenditure for labor is small.

More than 80 percent of the farmers buy livestock feed. Most of the feed is supplementary to the feed raised on the farm and consists of high-protein-carrying nutrients for milk production. Hog and poultry feed is also purchased by many farmers.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field. The soil scientist walks over the area at intervals not more than one-quarter mile apart and bores into the soil with an auger or digs holes with a spade. Each boring or hole shows the soil to consist of several distinctly different layers, called horizons, which collectively are known as the soil profile. Each of these layers is studied carefully for physical or chemical characteristics that affect plant growth.

The color of each layer is noted. The darkness of the topmost layer is usually related to its content of organic matter. Streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration. Texture, or the content of sand, silt, and clay, is determined by the feel and is checked by mechanical analysis in the laboratory. Texture has much to do with the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and how hard the soil may be to cultivate. Structure, or the way the soil granulates, and the quantity of pore space between particles indicate how easily plant roots can penetrate the soil and how easily water enters it. Consistence, or the tendency of the soil to break apart or to stick together, indicates how difficult it is to keep the soil open and porous under cultivation. The kind of rocks from which the soil has been developed, or its parent material, affects the quantity and kind of plant nutrients the soil may contain. Simple chemical tests show the reaction of the soil.[3] The depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features are observed.

On the basis of all these characteristics, soil areas that are much alike in kind, thickness, and arrangement of their layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil type has slopes that range from 2 up to 30 per cent (that is, slopes fall more than 2 feet but less than 30 in 100 feet of distance), the type may be mapped in three phases—a gently sloping phase (2 to 7 percent slopes), a sloping phase (7 to 15 percent slopes), and a moderately steep phase (15 to 30 percent slopes). A soil that has been eroded in places may be mapped in two or more phases—an uneroded phase (denoted by the name of the soil type only), an eroded phase, and perhaps a severely eroded phase. No eroded phases are mapped in Crawford County. A soil type will be broken into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of a soil, the frequency of outcropping bedrock, the extent of erosion, or artificial drainage are examples of characteristics that might cause a soil type to be divided into phases.

Two or more soil types may have similar profiles, that is, the soil layers may be nearly the same, except that the texture, especially of the surface layer, will differ. As long as the other characteristics of the layers are similar, these soils are considered to belong in the same soil series. A soil series, therefore, consists of all the soil types that have about the same kind, thickness, and arrangement of layers, except for texture, particularly of the surface layer, whether the number of such soil types be only one or several.

The name of a place near where a soil series was first found is chosen as the name of the series. Venango is the name of an important soil series found in Crawford County, Pa. Two types of the Venango series are found—Venango gravelly silt loam and Venango silt loam. These differ in the gravel content of the surface soil, as their names show. Venango silt loam is divided into three phases because some of it is gently sloping, some is sloping, and some is moderately steep. These phases are Venango silt loam (the normal phase) Venango silt loam, sloping phase, and Venango silt loam, moderately steep phase.

Areas that have little true soil are not designated with series and type names but are given descriptive names, such as Lake marsh and Alluvial soils, undifferentiated.

The soil type, or where the soil type is subdivided, the soil phase, is the unit of mapping in soil surveys. It is the unit or the kind of

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[3] 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, alkalinity; and lower values, acidity. Indicator solutions are used to determine the reaction of the soil. The presence of lime is detected by use of a dilute solution of hydrochloric acid.

soil that is most nearly uniform and has the narrowest range of characteristics. For this reason land-use and soil-management practices can be more definitely specified for it than for broader groups of soil that contain more variation.

SOILS

The soils of Crawford County have developed under a humid climate. All the present land forms, as valleys, hills, plains, and terraces, have received the imprint of glacial action, and glacial deposits are distributed unevenly over the underlying geologic formations. In some localities they are shallow and rock occurs within a foot of the surface, whereas in other places in the valleys glacial debris is 200 to 300 feet thick. The soils have developed from debris left by two distinct glacial periods—the Wisconsin, which is the more recent, and the Illinoian, which is much older. The older Illinoian glaciation originally covered the entire county, but did not leave so thick a mantle as the Wisconsin glacier and did not have so great an influence on the general topography. The Wisconsin glaciation, coming long after the Illinoian glacier had melted, scraped up and redeposited most of the material that had been left by the Illinoian ice sheet. In most of the valleys, the accumulations left by the ice were reworked by moving waters, and the material was built up into stratified layers of variable particle size, diversified in texture, thickness, and arrangement.

A large number of soils that are intimately associated have developed through soil-forming agencies acting on the mixture of glacial debris. The contribution to the drift of local sandstone and shale materials was considerable and greatly in excess of that from more distant sources. Most of the drift therefore is reworked material from local sandstone and shale beds and their original covering of soil. Consequently, the parent materials of Crawford County soils are not so variable as in many glaciated regions of the northern United States. The glacial till in the northwestern part of the county is thicker, contains more clay, and is less leached; in the southeastern part the older Illinoian drift is more thoroughly leached and weathered to a greater depth. The color of the till varies from dark yellowish brown to olive gray, the Illinoian till being more yellowish brown than the Wisconsin till.

Most of the till is gritty, gravelly, and slightly compact. The Wisconsin till is neutral or weakly calcareous below about 6 or 7 feet, except in the northwestern part of the county where it is calcareous within about 3 feet. In the southeastern part the Illinoian till is very strongly acid throughout. Soils of the terraces in the valleys and of the gravelly knobs and ridges (kames and eskers) are acid to a depth of 4 or 5 feet. The gravelly material is calcareous at a depth of about 8 feet, or the depth to which the lime has been leached. The proportion of the small fragments of limestone that occur in the deeper substrata of the glacial till is small and has little influence on productivity. The fragments generally lie at too great a depth and in cemented or compact layers that are hardly accessible to roots, even of deep-rooted plants.

Drainage is one of the outstanding factors that influences and limits the development of the soil profile and land utilization in the county. Some materials are saturated or waterlogged for a considerable period each year, during which time the movement of water from the ground is retarded. The relief of the land, as well as the character of the soil material, affects the movement of water, air, and roots in the soil.

Approximately one-third of the soils of the county can be considered as poorly drained or very poorly drained owing to the slow permeability of the subsoil, lack of adequate relief, or a combination of these two factors. These soils are best suited to pasture or forest but can be used for timothy hay, alsike clover, corn, and oats. The better drained soils are suited to such crops as potatoes, alfalfa, fruit, and vegetables. They are usually well aerated, developed on deeply weathered materials, and, except for the soils on the flood plains, are low in organic matter and nitrogen. In addition, there are steep and stony areas where crop production and tillage are impractical.

SOIL TYPES AND PHASES

In the following pages the soils of the county are listed alphabetically, their characteristics described in detail, and their agricultural relations discussed. Their distribution and location are shown on the soil map at the back of the report, and their acreage and proportionate extent are given in table 4.

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

Soil	Acres	Percent
Allis silt loam	189	([1])
Moderately steep phase	86	([1])
Sloping phase	305	0. 1
Alluvial soils, undifferentiated	5, 040	. 8
Atherton silt loam	13, 765	2. 1
Braceville silt loam	5, 744	. 9
Cambridge gravelly silt loam	1, 562	. 2
Steep phase	1, 842	. 3
Cambridge silt loam	65, 993	10. 1
Sloping phase	20, 728	3. 2
Canadice silt loam	4, 049	. 6
Caneadea silt loam	2, 847	. 4
Sloping phase	673	. 1
Chagrin loam	35	([1])
High-bottom phase	37	([1])
Chagrin silt loam	151	([1])
High-bottom phase	184	([1])
Chenango gravelly loam	8, 069	1. 2
Sloping phase	446	. 1
Chenango gravelly sandy loam	1, 107	. 2
Chenango loam	8, 822	1. 4
Chenango silt loam	13, 819	2. 1
Chippewa silty clay loam	8, 703	1. 3
Ellsworth silt loam	4, 083	. 6
Frenchtown silt loam	96, 873	14. 9
Gresham silt loam	1, 762	. 3
Hanover gravelly loam	792	. 1
Sloping phase	414	. 1
Hanover loam	3, 763	. 6
Hanover stony loam	393	. 1
Moderately steep phase	4, 094	. 6
Holly silt loam	25, 611	3. 9
High-bottom phase	1, 654	. 3
Kerrtown silt loam	883	. 1
Lake marsh	2, 068	. 3
Lobdell loam	81	([1])
Lobdell silt loam	611	. 1
High-bottom phase	81	([1])
Lordstown stony loam	892	. 1
Moderately steep phase	1, 352	. 2
Steep phase	1, 154	. 2
Mahoning silt loam	36, 886	5. 7
Marengo silty clay loam	2, 857	. 4
Massillon gravelly loam	3, 126	. 5
Massillon gravelly sandy loam	1, 417	. 2
Hilly phase	676	. 1
Meadville gravelly silt loam	1, 609	. 2
Meadville silt loam	46, 454	7. 1
Sloping phase	31, 815	4. 9
Meadville stony silt loam, moderately steep phase	12, 439	1. 9

[1] Less than 0.1 percent.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Crawford County, Pa.*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Middlebury loam	979	.2	Venango silt loam	61,010	9.4
High-bottom phase	82	(1)	Moderately steep phase	365	.1
Middlebury silt loam	3,461	.5	Sloping phase	5,384	.8
High-bottom phase	521	.1	Wadsworth silt loam	30,763	4.7
Muck, shallow phase	996	.2	Wayland silt loam	2,911	.4
Ottawa very fine sandy loam	1,093	.2	High-bottom phase	106	(1)
Painesville silt loam	885	.1	Wayne gravelly silt loam, moderately steep phase	362	.1
Sloping phase	146	(1)	Wayne silt loam	1,120	.2
Papakating silty clay loam	17,520	2.7	Sloping phase	378	.1
Peat	4,259	.7	Steep phase	447	.1
Rittman silt loam	23,797	3.7	Wooster gravelly loam	8,265	1.3
Sloping phase	2,335	.4	Rolling phase	3,597	.6
Shelmadine silt loam	1,472	.2	Steep phase	397	.1
Tioga loam	3,608	.6	Wooster loam	6,432	1.0
High-bottom phase	443	.1	Rolling phase	1,714	.3
Tioga silt loam	2,120	.3	Wooster stony loam	108	(1)
High-bottom phase	635	.1	Moderately steep phase	4,592	.7
Titusville silt loam	7,607	1.1	Total	650,240	100.0
Sloping phase	615	.1			
Trumbull silty clay loam	927	.1			
Venango gravelly silt loam	752	.1			

Allis silt loam (AL).—This poorly drained soil has developed from a thin mantle of glacial drift over acid gray shale or from material that has weathered in place from the underlying shale. Areas are on the brows of hills or on gentle slopes in the uplands, principally in the eastern part of the county. They are associated with the adjacent deeper Hanover, Titusville, Wooster, and Cambridge soils developed on Illinoian and Wisconsin tills. The smooth surface has slopes as steep as 7 percent in some places, but the gradient is usually less than 5 percent. One of the largest areas occurs about three-fourths mile east of Blooming Valley, and several other areas of more than 25 acres occur in East Fallowfield Township.

The surface soil is a 6- to 8-inch grayish-brown friable silt loam. In some places, where the texture is somewhat heavier, the soil has a tendency to puddle when cultivated in a wet condition. The upper subsoil to a depth of about 14 inches is mottled gray, yellow, and brown plastic silty clay loam that is underlain at a depth of about 28 inches by compact tight silty clay that rests on practically unweathered acid gray shale. The shale is at depths of 18 to 36 inches.

Use and management.—Since Allis silt loam is thin, poorly drained, and strongly acid, it is a poor crop soil. Most of it is cleared and farmed in conjunction with the surrounding soils. Yields are lower than those obtained on the Venango soils. It is best suited to pasture and hay crops, as the soil restricts root development and water movement below 8 to 10 inches. Artificial drainage is difficult and ineffective, as the underlying rocks are close to the surface and the subsoil is a compacted ground morainic till containing heavy clay and generally overlying impervious silt or clay shale.

Allis silt loam, moderately steep phase (ALM).—This phase differs from the normal silt loam in occupying slopes of 15 to 30 percent. As the steep slopes make cultivation difficult, most of it has never been cleared. A small part is used for pasture, as pasture plants are shallow-rooted and help to hold the surface soil in place. Tree growth is slow and stunted since the plant rooting zone is shallow.

Allis silt loam, sloping phase (ALS).—Small areas of this phase are in the central and eastern parts of the county. This soil differs from the silt loam principally in that it occupies smooth slopes of 7 to 15 percent rather than those up to 7 percent in gradient. Use is similar to that for the silt loam but runoff is more rapid and greater care must be exercised to prevent erosion.

Alluvial soils, undifferentiated (A).—Narrow areas of these soils are along most of the small streams. They include nearly level low wet depressions, gravel wash, stony bottoms, abandoned stream beds, and bodies of poorly drained and well-drained soils too intricately mixed to show individually on the map. The slope rarely exceeds 3 percent. Most of the areas are wet most of the year and vary in texture, color, and content of organic matter as well as in drainage conditions.

Use and management.—Alluvial soils, undifferentiated, are largely nonagricultural, as most of the areas are very narrow and subjected to frequent overflows. About 20 percent of the total acreage has been cleared and is used largely for pasture. In general, these soils are slightly better for pasture and timber than Holly silt loam, owing to inclusions of small areas of well-drained soils.

Atherton silt loam (AT).—This poorly drained soil occurs on nearly level terraces along most of the streams and seldom has slopes exceeding 3 percent. It is the heaviest of the soils on the stream and outwash terraces. The parent material is mostly of gray acid sandstone and shale origin. Although not a good agricultural soil in its present condition, the total area makes it an important soil. A large part occurs between the sloping upland and the well-drained Chenango soils, and a few areas occupy shallow depressionlike positions. Some of the largest bodies are mapped along the upper part of French Creek and its tributaries and the lower part of Sandy Creek. The soil occurs in close association with the Chenango and Braceville soils and is developed on similar parent material but under the influence of a higher water table.

The 6- to 10-inch surface soil is dark grayish-brown friable silt loam. The subsoil layer, to a depth of about 30 inches, is gray with mottlings of brown slightly compact gritty nuciform (nutlike) or blocky structured silty clay loam. The wet substratum consists of mottled brown and gray compact silty clay loam with numerous small rounded pebbles. Stratified layers of silt, clay, and gravel are typically developed under many areas. Little gravel appears on the surface although the subsoil generally contains some rounded small gravel.

Some areas of this soil have small inclusions of slightly better drained spots that would have been mapped as Braceville silt loam had they been larger. Slight elevation differences have influenced the stage of drainage and the color of the upper layers. A few small areas along Conneaut Creek, which have developed on heavier slack water deposits, have also been included. These soils have a neutral to slightly alkaline reaction at 3 feet or below, and a nearly black granular silty clay loam surface. They are closely related to the Canadice and Caneadea soils and would have been mapped separately as members of the Lorain series had they been more extensive. Their heavier texture probably makes them more productive but harder to work than the typical soil.

Use and management.—Only about one-third of Atherton silt loam is cultivated because it has inadequate natural drainage. Approximately two-thirds has been cleared, with 5 to 10 percent idle most of the time. Pasture supports a native vegetation of coarse moisture-loving grasses. White clover and Kentucky bluegrass do not thrive well unless drainage conditions are improved artificially. Poverty oatgrass, timothy, and redtop compose a large part of the pasture. Most of the cultivated areas are in corn, hay, and oats. Corn yields average 25 to 30 bushels an acre; oats, 20 to 25; and buckwheat, 15 to 18. Timothy and alsike clover average about 1 ton an acre, but red clover freezes out and therefore yields slightly less. As areas occur in low places with poor air drainage and a water table that is close to the surface most of the year, they are poor for fruit and not suited to potatoes and vegetables. Under existing economic conditions, most of this land offers better possibilities for pasture and forest.

The soil, however, may respond well to tile or ditch drainage because of the lighter texture of the subsoil. In its natural state it is similar to the Frenchtown and Mahoning soils in productivity and crop adaptations. Its higher content of organic matter makes it slightly superior to Venango silt loam, and it compares well with the better drained soils for hay production.

Braceville silt loam (Bs).—This soil occurs in small scattered bodies through most of the valleys in an intermediate position between the well-drained Chenango soils and the poorly drained Atherton. It has developed on outwash and stream terraces on similar parent material of gray acid sandstone and shale origin. It is found most frequently on nearly level areas along the larger streams in the central and eastern parts of the county. Slopes seldom exceed 3 percent. Surface drainage is moderate to slow in places, and subsoil drainage is slow below a depth of 15 to 20 inches, impeding the downward movement of moisture and roots. This soil is similar to Cambridge silt loam, which is developed on till, in drainage conditions, fertility, crop adaptations, and yields.

The grayish-brown friable silt loam surface extends to a depth of 6 or 8 inches. Underlying this is yellowish-brown or yellow friable silt loam that becomes more compact and heavier below a depth of 15 inches. Gray and brown mottlings begin at 15 inches and continue to the stratified layers of sand and gravel that begin at 4 to 6 feet. This soil is acid to 4 or 5 feet but generally calcareous at 6 to 10 feet below the surface. The content of organic matter is only fair.

Areas in which the subsoil is heavy and wet most of the year are found on the borders between this soil and the Atherton soil. An area of significant size one-half mile north of Jarvis Corners in Rockdale Township has a gravelly surface, and a few other small similar areas are included in the soil as mapped. In places clay lenses, varying from a few inches to as much as a foot thick, occur in the subsoil and substratum.

Use and management.—About 55 percent of the 80 percent of Braceville silt loam that is cleared is used for crops; the rest is used largely for pasture. As it occurs in small areas, it is farmed in conjunction with the surrounding soils. It is classed as a medium productive soil for general and shallow-rooted crops but is not well adapted to alfalfa or small fruit production. Pasture grasses, timothy, and alsike clover thrive better than on the better drained upland soils, although other crops are less productive. Artificial drainage may be beneficial if the tiles or ditches are at least 3 feet below the surface, as only the lower subsoil has restricted water movement and aeration.

Cambridge silt loam (Cs).—This moderately well-drained soil has developed on slightly calcareous olive-gray Wisconsin till that to a depth of 7 to 8 feet is weathered to yellowish brown and is leached free from carbonates. The till is derived principally from acid gray sandstone and shale and contains a little limestone. Bedrock is nowhere less than 3 feet below the surface, and in most places it is at least 10 to 12 feet deep. Surface relief is undulating to gently sloping, with gradients up to 7 percent. This soil, which probably includes a larger area of cultivated land than any other soil in the county, occurs chiefly in the central and southeastern sections.

The 7-inch plowed layer is grayish-brown friable silt loam. Between depths of 7 and 14 inches is yellowish-brown friable and weakly platy heavy silt loam. Below this and to a depth of about 24 inches is yellowish-brown silty clay loam strongly mottled with gray and brown and with a coarse platy structure. This layer is so hard in place that a pick is necessary to break it free from the surrounding soil. Mottled yellowish-brown silt loam till occurs below 24 inches and is also hard and platy but is not so dark. Farmers often speak of this soil as the brown hardpan soil. The surface in virgin areas is generally very strongly acid to a depth of about 30 inches and then strongly or medium acid to the calcareous unleached till at a depth of 6 or 8 feet. In the northwestern part of the county the subsoil and underlying till are somewhat heavier and less acid than elsewhere.

This soil occurs in close association with the Meadville and Venango soils and represents an intermediate drainage condition between them. Small areas of both were included in mapping. This silt loam is similar to Rittman silt loam in drainage, color, and kind of parent material but differs in that it is more friable throughout and does not have such a hard platy subsoil and substratum. There is a gradual change in characteristics from the eastern part of the county, where the Cambridge soils are dominant, to the southwestern part, where the Rittman soils occur. The boundary between areas is arbitrary. In some places near the boundary shown on the map there may be an intermingling of Rittman and Cambridge soils that have intermediate characteristics.

Use and management.—Approximately 85 percent of Cambridge silt loam is cleared, of which 65 to 70 percent is cultivated, about 15 percent is used for pasture, and less than 5 percent is idle. Yields are nearly the average for the county, with the exception of potatoes that have slightly lower yields. Owing to lack of drainage this soil is not so good for potatoes as Meadville or Wayne silt loams, although yields of 300 bushels an acre are occasionally obtained. In normal years corn yields 30 to 40 bushels; oats, 25 to 30; wheat, 15 to 20; buckwheat, 15 to 22; and potatoes, 100 to 150, depending on the quantity of fertilizer used, and clover and timothy, 1 to 1½ tons.

The hardpan is too close to the surface for free development of deep-rooted plants as fruit trees and alfalfa. Such crops as timothy, clover, wheat, oats, buckwheat, and pasture do well and are easily handled since the surface is smooth and adaptable to all types of farm machinery. Dairying is the most important industry on this soil.

Cambridge silt loam, sloping phase (Css).—Although occurring in close association with the silt loam and having the same general characteristics, this phase has had more of the surface layer removed by erosion in cultivated areas. The underlying till is not so deep, although it is more than 3 feet throughout the areas mapped and as much as 30 to 40 feet deep in some places. The slopes range from 7 to 15 percent in gradient and are fairly smooth with only slight ripples. A hard platy layer that is typical of the Cambridge soils has developed at 12 to 20 inches, restricting water movement, aeration, and root development.

Use and management.—About 60 percent of Cambridge silt loam, sloping phase, is cleared, of which 35 to 40 percent is cultivated; 15 percent, pastured; and 5 percent is idle. Crop yields are 10 to 15 percent below those obtained on the more level Cambridge soils. In seasons of normal rainfall corn averages 25 to 35 bushels an acre; oats, 20 to 30; buckwheat, 15 to 18; and clover and timothy, 1 to 1¼ tons. A larger proportion of this soil should be in pasture and hay crops that protect and preserve the surface soil.

Cambridge gravelly silt loam (CG).—This moderately well drained soil differs from the silt loam principally in the quantity and size of rock fragments on the surface. These fragments, mostly 3 to 4 inches in diameter but ranging to 8 to 10 inches, are large enough to interfere with cultivation. The grayish-brown surface soil, yellowish-brown subsurface layer, and hardpan development are similar to the corresponding layers of the silt loam. Areas occur mostly in the eastern and north central parts of the county on undulating relief with slopes up to 7 percent. About 50 to 60 percent is cultivated, largely to corn, hay, buckwheat, and wheat. The yields are almost the same as those obtained on the silt loam.

Cambridge gravelly silt loam, steep phase (CGT).—In virgin areas this soil is similar to the gravelly silt loam except it occupies steeper slopes of 15 to 30 percent gradient. It occurs in the central and eastern parts of the county, the largest areas bordering the town of Meadville on the west and northwest.

The soil is mostly in forest because the degree of slope, in addition to the gravel and stones, makes cultivation difficult. It is subject to erosion if it is cultivated, and crop yields are 20 to 30 percent below those obtained on the more level areas of the silt loam. Only about 15 percent is cleared and this is used mostly for pasture.

Canadice silt loam (CA).—Most of this poorly drained soil has developed on lake-laid (lacustrine) silt and clay deposits that occur as terraces along Conneaut and Cussewago Creeks. It occurs on undulating, gently sloping, and slightly hummocky relief with a slope range up to 7 percent. Although in close association with and related to the well-drained Painesville and the imperfectly drained Caneadea soils, it differs in that it has developed under higher water table conditions and is poorly drained. The largest areas occur around Conneaut Lake. Other areas are mapped near Little Cooley, northeast of Hartstown, and in the valley extending from Conneaut Lake to the county line where Conneaut Creek leaves the county northwest of Springsboro.

The typical surface soil to a depth of 6 to 8 inches is dark grayish-brown to gray friable heavy silt loam. This grades to a mottled light-gray and yellowish-brown slightly compact heavy silty clay loam with a very fine crumb structure. From 18 to 32 inches is gray splotched with brown dense heavy silty clay. The laminated substratum is hard compact brown silty clay with gray streaks. Absence of coarse material is conspicuous both in the surface and subsoil, and small pebbles are found in only a few spots. The lower layers are thinly laminated. The upper layers are strongly acid, but at 30 to 36 inches the soil material becomes mildly alkaline.

Use and management.—The agricultural value of Canadice silt loam is relatively low. A tight heavy-textured subsoil hinders the penetration of roots and the movement of water, and there is a tendency to clod readily if tilled when moist. About 60 percent has been cleared, and 35 percent is cultivated, largely to corn and hay. The relatively smooth surface is responsible for more of it being cleared than is practical. It is best suited to pasture and shallow-rooted crops. Yields are slightly below those obtained on the Venango soils, corn averaging about 24 bushels an acre; oats, 20 bushels; and hay, 1 ton. Alsike clover yields are fair but red clover yields are low.

Tile drainage would only slightly improve this soil, unless the tiles were placed close together, which might be more costly than the increased returns from general farm crops would justify. The organic-matter content is low compared with some of the other poorly drained soils as the Frenchtown and Mahoning. Applications of manure would make the soil more friable and easier to work. Owing to its gentle relief there is practically no erosion problem.

Caneadea silt loam (CD).—This imperfectly drained soil has developed from lake-laid silt and clay. The deposits as laid down were calcareous, but most of the carbonates have been leached out of the upper 2 or 3 feet. The gently undulating uneven hummocky relief ranges up to 7 percent in gradient. The soil is developed most extensively in the valley extending from Conneautville to Conneaut Lake, and other small bodies are northeast of Hartstown. It is closely associated with the well-drained Painesville soils and the poorly drained Canadice developed on similar material. It is also associated closely with the Ottawa soil that has developed on sandy material. Small gravel and angular sandstone fragments are in a few places in the upper layers.

The surface soil is grayish-brown very friable silt loam low in organic matter. From 8 to 14 inches is light yellowish-brown silt loam to silty clay loam. This is underlain by strongly mottled yellow and gray friable but somewhat silty compact clay loam to a depth of 30 inches. Below this depth, the material is a mixture of yellow and gray and grayish-yellow splotched with brown heavy silty clay loam that is sometimes blocky and dense. In some places the subsoil layers are slightly compact, and in others they are heavy and dense silty clay. The subsoil and substratum are alkaline to calcareous at depths of 2 to 5 feet. Small pebbles and angular sandstone fragments occur in a few places in the upper layers.

Use and management.—Farming on Caneadea silt loam and associated soils includes growing general crops and buckwheat for feeding livestock. About two-thirds of this soil has been cleared and one-third is used for crop production. A large proportion is abandoned. Acre yields of corn range from 25 to 30 bushels; oats, 20 to 25; buckwheat, 15 to 20; and clover and timothy, 1 to 1½ tons. Although better than Venango or Ellsworth soils in their natural state, this soil does not yield so well as the Cambridge and the better drained upland soils.

Caneadea silt loam, sloping phase (Cds).—Although similar to the silt loam, this phase occupies the more sloping area ranging from 7 to 15 percent. It has developed along the lower slopes of the valley that extends along Conneaut Creek to Conneautville, where most of the lacustrine soils occur. In the vicinity of Conneautville it has a characteristic heavy dense blocky subsoil under a thin friable yellow surface layer.

Use and management.—Caneadea silt loam, sloping phase, is managed and used for the same crops as the silt loam, but a larger part has been left in forest and more is used for hay and pasture. Yields are about 8 to 10 percent lower. Owing to lack of gravel and low organic-matter content, it gullies readily and more of it should be used for pasture, to which it is well suited.

Chagrin silt loam (Co).—This well-drained soil has been formed by recent deposition of soil material washed from the uplands onto the present flood plains or first bottoms. Some of the areas are subject to ordinary stream overflow, and all of them may be inundated for short periods by floodwaters, which deposit additional soil material on the flood plain. Areas are along most of the streams in the northwestern part of the county—most extensively in narrow and irregular-shaped bodies along Conneaut Creek, closely associated with the imperfectly drained Lobdell and the poorly drained Wayland soils developed on similar parent material. The parent material is derived largely from acid gray sandstone and shale with a little limestone. The relief is smooth to undulating, the gradient seldom exceeding 2 percent.

The 8- to 10-inch surface soil consists of brown or yellowish-brown to yellow very fine crumb silt loam. It is underlain by yellowish-brown very friable silt loam to a depth of about 3 feet. Below this it becomes more sandy and contains some stains of gray and rust brown in many places. The deeper material consists of stratified yellowish-brown silt and fine sand. Along the upper parts of streams and along small streams the sediment deposits are comparatively thin, whereas in the wider valleys the soil material ranges from 5 to 15 feet or more thick. The surface is strongly acid, but the subsoil is neutral to mildly alkaline and the parent materials may be calcareous in places. This soil differs from Tioga silt loam in that it has a neutral to mildly alkaline reaction in the subsoil rather than a strongly acid reaction. There is a good supply of organic matter.

Use and management.—About one-half of Chagrin silt loam is cultivated and one-third is used for pasture. The rest consists of woodland that supports a growth principally of elm, maple, oak, hickory, beech, and willow. Pasture is largely Kentucky bluegrass, timothy, Canada bluegrass, poverty oatgrass, and redtop. Natural productivity is relatively high, and the soil is rated among the most productive on flood plains in the county. The water-holding capacity and drought resistance are good and runoff is adequate. The soil is subjected to frequent or occasional floodwater overflows that reduce its value and limit crops. Less fertilizer is required than on an upland soil; nevertheless, most of the areas will respond to applications of lime and fertilizer. For truck crops, to which it is well suited, the use of complete fertilizer proves profitable.

Corn, timothy, clover, wheat, and pasture are the most important crops grown. Oats, buckwheat, alfalfa, potatoes, vegetables, and small fruits are also produced. Areas along Conneaut Creek produce excellent alfalfa that is rarely if ever damaged by floodwaters, as the creek overflows only once every 2 or 3 years and then only to a shallow depth. Oats and buckwheat often lodge because of the excessive supply of nitrogen in proportion to potash. These quick-growing crops will use large supplies of nitrogen in short periods of time, especially if the moisture supply is adequate. Potatoes do not grow so well on this soil, or on any of the bottom soils, as on the Chenango or Wooster soils. Wheat generally produces good yields in favorable seasons. In normal years wheat yields 15 to 25 bushels an acre; corn, 40 to 50; oats, 20 to 30; buckwheat, 18 to 22; potatoes, 100 to 200; red clover, 1½ to 2 tons; and alsike and timothy, 1¼ to 1¾ tons, depending on the type of fertilizer.

Chagrin silt loam, high-bottom phase (CoH).—This phase is similar to the silt loam except it lies a little higher above the stream beds and is rarely overflowed. It is a comparatively recent alluvial soil and has not been leached deeply. It occurs in narrow and irregular-shaped areas, principally along Conneaut Creek. The surface relief is smooth with a few depressions and old stream channels that have not been entirely filled in with stream deposits. Both surface and internal drainage are adequate, and the water-holding capacity is excellent. The 8- to 10-inch surface soil is brown to dark grayish-brown mellow silt loam, which is underlain by yellowish-brown friable neutral to mildly alkaline heavy silt loam to silty clay loam. The substratum is deep silty alluvium with a neutral or mildly alkaline reaction.

Use and management.—Chagrin silt loam, high-bottom phase, is farmed similar to the silt loam, but a larger proportion is in alfalfa to which it is well suited. Average yields over a period of years, because of its better position, are higher. Pasture on both soils is about equal. This phase contains a moderate quantity of organic matter and nitrogen. About 85 percent of the soil is cleared and two-thirds of it cultivated. The rest supports an excellent growth of timber, which, aided by an abundant supply of water, grows rapidly.

Chagrin loam (CL).—Like other soils on flood plains, this soil has been deposited recently by material from uplands and terraces. Practically none of it is protected from overflow. Runoff, however, is rapid and floodwaters recede sooner than on the less well-drained bottom soils. This well-drained soil occurs in close association with and along the same streams as Chagrin silt loam, with which it is similar in all characteristics except surface texture. It is found mainly along Conneaut Creek, with a few scattered bodies along smaller creeks in the northwestern part of the county. It is closely associated with the imperfectly drained Lobdell and the poorly drained Wayland soils developed on similar parent material. The parent material is derived principally from acid gray sandstone and shale but contains a little limestone.

The surface relief is generally smooth or slightly ridgy and in places slopes gently downstream. Most of it has a slope of less than 3 percent. The upper part of the profile is comparatively free from stone or gravel, although it is underlain by stone and gravel at 3 feet or below along some of the smaller creeks where the alluvial deposits are not so deep. Some areas of fine sandy loam surface soil are included. Narrow strips of fine sandy loam and loamy fine sand are common inclusions along stream banks. This soil differs from Tioga loam in that the subsoil and substratum are neutral to mildly alkaline rather than strongly acid. Organic-matter content is moderately high.

Use and management.—Dairy farming, with the production of hay, corn, wheat, and oats, predominates on Chagrin loam. Vegetable growing is also important. Yields are about 5 percent below those obtained on the silt loam. Hay and pasture do better than on upland or terrace soils, although the yields of small grain are lower than on the Chenango, Meadville, Rittman, or Cambridge soils.

Chagrin loam, high-bottom phase (CLH).—Where typically developed, this phase differs from the loam only in its position on higher bottoms or low benches. Such a position prevents or lessens the damage from flooding and thereby increases the agricultural value of the land. Most of this soil occurs in small elongated areas, principally along Conneaut Creek.

Use and management.—Chagrin loam, high-bottom phase, is used for the same crops as the loam and the silt loam, but a higher proportion is in alfalfa and fruit trees. Yields are slightly higher for crops than those obtained on the loam but not so high as those obtained on the silt loam. Wheat and hay are slightly better suited to the heavier textured soils. The neutral or alkaline subsoil makes this soil somewhat more suitable for alfalfa and clover than the Tioga soils that have strongly acid subsoil and substratum. It is a good soil for all the important crops commonly grown, as corn, timothy, clover, alfalfa, wheat, oats, and buckwheat.

Chenango silt loam (CT).—This is one of the best agricultural soils in the county and occurs in nearly all sections on level to gently undulating relief that seldom exceeds 7 percent. It is well drained and has developed on terraces from outwash plains and from material deposited by streams. The parent material was derived principally from acid gray sandstone and shale with some limestone.

The 7-inch surface layer is dark yellowish-brown to grayish-brown friable silt loam with a moderate quantity of organic matter. The upper subsoil layer to 18 or 20 inches is yellowish-brown friable silt loam with some small gravel. Underlying this to a depth of about 36 inches is darker yellowish-brown slightly compact nuciform-structured friable silt loam with some gravel. The substratum consists of loose to almost incoherent yellowish-brown sand and gravel that is usually stratified at lower depths. The soil is strongly acid to a depth of 6 or 7 feet, and calcareous material is generally at 7 to 10 feet.

Although a few variations occur, this soil is generally uniform. Small areas of the imperfectly drained Braceville soils are included and in some places the surface texture is a loam rather than a silt loam. This soil, closely associated with the imperfectly drained Braceville and poorly drained Atherton soils developed on similar parent material, is in somewhat less close association with all the upland soils.

Use and management.—Most of Chenango silt loam is cleared and used for cultivated crops. It is used largely for corn, corn silage, potatoes, clover, timothy, and oats. In normal years corn yields 35 to 50 bushels an acre; corn silage, 8 to 10 tons; oats, 28 to 40 bushels; red clover, 1¼ to 1¾ tons; alfalfa, 1½ to 2½ tons; timothy, 1¼ tons; buckwheat, 20 to 25 bushels; and potatoes, 125 to 200 bushels. Higher yields of potatoes are often obtained, depending on the quantity of fertilizer used. Although the subsoil is not so heavy-textured as the subsoil of the Wayne soils, this soil is nevertheless better suited to potato production because of its smoother surface. A larger proportion of this soil is used for potatoes than any other soil in the county. The good drainage, smooth surface relief, and the ease of workability make it adaptable to all crops grown in the county, as well as potatoes. It is especially well adapted to deep-rooted crops as red clover, alfalfa, and fruit trees. Its slightly heavier texture permits slightly higher yields than on other lighter textured Chenango soils and better yields than on any of the soils of the uplands. Oats and buckwheat do better than on the well-drained soils of the flood plains, as they do not lodge so much and the grain matures earlier.

Like most well-drained soils, this soil is naturally low in organic matter, nitrogen, phosphorus, and lime. Since deep-rooted legumes grow well, they should supply part of the nitrogen required by other crops. Lime should be applied often to insure good growth of legumes. If poorly drained land is on the same farm, this soil should be used less for pasture or buckwheat and more for legumes and row crops, since timothy and buckwheat do almost as well on the poorer drained soils. A well-balanced fertilizer is needed for potatoes. Manure with superphosphate is a good fertilizer for corn, oats, and some of the hay crops that contain legumes.

Chenango gravelly loam (Cn).—This well-drained soil is on outwash terraces and is most extensive along Pymatuning Reservoir and French, Woodcock, Little Sugar, Muddy, and Cussewago Creeks and the Conneaut Lake Basin. It occupies the same smooth level to undulating terraces as the other Chenango soils with slopes that range up to 7 percent. The parent material is of gray acid sandstone and shale origin. The soil differs from the loam in that there is a larger content of gravel in the surface soil. This gravel, generally small and rounded, interferes with cultivation only slightly.

The surface layer to a depth of about 7 inches is yellowish-brown friable gritty gravelly loam. The upper subsoil layer, extending to a depth of 20 inches, is yellowish-brown friable gravelly silt loam with a little organic matter. The lower subsoil, between depths of 20 and 30 inches, is yellowish-brown to brown friable gravelly loam with some compactness. This material grades to grayish-brown sand and gravel that is stratified at lower levels and calcareous at depths of 6 to 10 feet.

Use and management.—Chenango gravelly loam, which ranks high as an agricultural soil, yields about the same and is adapted to the same crops as the other Chenango soils. About 90 percent is cleared, and of this 70 to 75 percent is cultivated. Because of its depth, it is adapted to deep-rooted crops and fruit trees. A large part is in clover, timothy, potatoes, corn, and oats. Timothy, wheat, and buckwheat yields are only fair; however, the yields of corn, clover, oats, and potatoes are above those obtained for the entire county.

Because of the prevailing shortage of organic matter and nitrogen, every cropping system should include sod crops—clover, timothy, alfalfa, and bromegrass, or Ladino clover and orchard grass. More manure, or fertilizers high in nitrogen, should be used.

Chenango gravelly loam, sloping phase (Cns).—Slopes of this phase are from 7- to 15-percent gradient. The profile characteristics are essentially the same as those of the other Chenango loam or gravelly loam soils except the surface soil is thinner. Areas are in narrow strips mostly in valleys and about 1 mile north of Harmonsburg Station, 1 mile west of Skeltontown, about 2 miles southeast of Hartstown, and along Conneaut Creek and Conneaut Lake.

Use and management.—The agricultural value of Chenango gravelly loam, sloping phase, is somewhat lower than that of the gravelly loam since it is more subject to erosion, loses more rainfall through runoff, and is not so easily tilled. Nevertheless, it is fair agricultural soil and yields are nearly as high for all crops as on the other Chenango soils and higher than on many of the upland soils. It is slightly superior to the sloping phases of the upland soils and better for deeper rooted crops than the poorly drained soils and soils with hardpan on the smoother land. Alfalfa, red clover, corn, and small fruits are suited. Potatoes grow well, although the crop is more difficult to handle. Erosion is often detrimental when cultivated crops are grown extensively. About 75 percent of this phase has been cleared, of which 45 percent is in crops and the rest is in pasture or abandoned.

Chenango gravelly sandy loam (Ch).—This soil is similar to Chenango gravelly loam except it is more sandy both on the surface and in the subsoil. The substratum of all Chenango soils, however, is remarkably alike. This soil occurs on the terraces in small areas in association with the other Chenango soils and with the imperfectly drained Braceville and poorly drained Atherton soils developed on similar parent material. Most of it is almost level to gently undulating with slopes up to 7 percent. It is inferior to the other Chenango

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soils because it is more open and porous. It leaches more readily because rain water percolates through it very rapidly.

To a depth of 8 inches the soil consists of a yellowish-brown friable fine sandy loam or sandy loam with some small pebbles. The upper subsoil to a depth of 12 to 15 inches is light yellowish-brown friable loam. The lower subsoil is composed of yellowish-brown slightly compact but friable loam with considerable gravel.

Use and management.—Most of Chenango gravelly sandy loam is cleared, and about 85 percent of this is cultivated. It is adapted to all crops of the county and is better for vegetables, fruits, potatoes, and alfalfa than many of the heavier soils. Alfalfa can be successfully grown, and many of the roots penetrate to the calcareous layer that generally underlies the soil at 6 or 8 feet below the surface. Acre yields of corn are about 34 bushels; oats, 22 bushels; corn silage, 6 to 8 tons; and mixed hay and clover, 1 to 1¼ tons. Timothy, wheat, and alsike clover thrive almost as well as on heavier less well-drained soils.

This soil should be used less for pasture and hay crops and more for row crops, vegetables, and fruits. Manure with acid phosphate and lime should be applied often and in small quantities since the soil is low in organic matter and has a low water-holding capacity. Research data show that spring applications of fertilizer, especially nitrogen, give much higher crop yields than the same quantity applied in fall.

Chenango loam (CE).—This soil occurs in association with the other Chenango soils of the terraces and differs from the silt loam in the higher content of sand in the surface and subsoil and slightly lower water-holding capacity. The largest area occurs in the north-central part of the county close to Erie County along Conneaut Creek. The smooth relief is level to undulating with slopes up to 7 percent. Surface drainage is rapid and internal drainage good to excessive. The gravel substratum, slightly closer to the surface than in the silt loam, is encountered about 2½ feet below the surface. Both the surface soil and subsoil are strongly acid.

Use and management.—Chenango loam is an important crop soil. Of the 90 percent that is cleared, about 75 percent is in crops and the rest is pastured or abandoned. The crops grown, yields, and utilization are almost the same as on Chenango silt loam. Potatoes, corn, and oats yield about the same on the two soils, but clover, timothy, buckwheat, and bean yields are somewhat lower on the loam. This soil warms up early in spring and can be cultivated under almost any moisture conditions without harmful effects. Organic matter supplied through stable manure or by turning under sod crops is beneficial, and lime and phosphate applications are necessary for economical farming. Wheat and oats start more quickly than on the poorly drained soils but do not make so rank a growth, although the grain yields are as large. Occasionally clover and alfalfa fail to make a good start because of lack of organic matter and lime. This soil leaches rapidly, making efficient management essential to conservation of soil fertility.

Chippewa silty clay loam (Cc).—This very poorly drained soil has developed on both Wisconsin and Illinoian tills derived from acid gray sandstone, shale, and some limestone. The till is leached so that the entire profile within auger depth is medium to strongly acid. In all except the northwestern part of the county comparatively small areas are throughout the uplands and occupying low spots and depressions at the source of streams and seepage areas. Slopes are seldom greater than 2 percent. This soil occurs in association with and is related to the Wooster, Cambridge, Venango, and Frenchtown soils. It is more poorly drained than the Frenchtown soil and has the same relative position and profile as the Marengo. It is strongly acid throughout, whereas the lower subsoil of the Marengo soil is neutral or slightly alkaline.

The 10- to 12-inch surface layer is very dark grayish-brown to almost black silt loam to silty clay and is relatively high in organic-matter content. The subsurface layer is gray with a few splotches of brown heavy silty clay loam. The firm silty clay loam subsoil is gray to almost bluish gray in places and has a few yellowish-brown splotches. A few sandstone and shale fragments are scattered over the surface where small areas are at heads of drains.

Use and management.—Only one-third of Chippewa silty clay loam is cleared. Most areas are covered with bunchgrass and sedges or brush vegetation of willow, birch, hemlock, and yellow-poplar. The 2 or 3 percent that is cultivated is planted to corn, timothy, and vegetables. Yields are very low unless the soil has been artificially drained, and even then crops are late. As this soil occurs in seepage areas and depressions, it is not easily drained by artificial methods.

Ellsworth silt loam (EM).—This moderately well-drained soil has developed on calcareous Wisconsin till mainly of acid gray sandstone and shale origin but containing some limestone. It occurs in the northwestern part of the county in small areas in close association with the less well-drained Mahoning silt loam, from which it differs in occupying more elevated or sloping areas, as low ridges, knolls, and smooth slopes of 2 to 5 percent.

The surface soil to a depth of 8 inches is dark grayish-brown silt loam. The subsurface layer between 7 and 14 inches is yellowish-brown silty clay that is friable when moist and plastic and sticky when wet. Below about 14 inches is mottled gray and yellow alkaline silty clay to silty clay loam. Silty clay loam calcareous till lies below 30 inches. The layer between 7 and 14 inches is better aerated than the corresponding horizon in the Mahoning soil; therefore a few more plant roots penetrate this layer.

Use and management.—Crop yields on Ellsworth silt loam are about the same as on Mahoning silt loam, although corn frequently yields better on the Ellsworth soil owing to quicker runoff in spring. The same crops in about the same proportions are grown on the two soils, but a larger percentage of the Ellsworth soil is cleared and cultivated. There is little erosion since a large part is used for hay and pasture.

Frenchtown silt loam (Fs).—This poorly drained soil is scattered throughout most of the county on broad, almost level, areas and in smaller swales and depressions. It has developed on Wisconsin glacial till of sandstone and shale origin. Surface slope is rarely greater than 2 or 3 percent. The soil is intermediate in drainage between imperfectly drained Wadsworth and Venango soils and very poorly drained Chippewa and Marengo soils. The largest areas are in the southwest on the almost level divides or plateaus between the Shenango River and Crooked Creek and Crooked Creek and Conneaut Marsh. Many areas in the eastern part occupy swales in association with the Cambridge and Meadville soils and merge into the Chippewa soil.

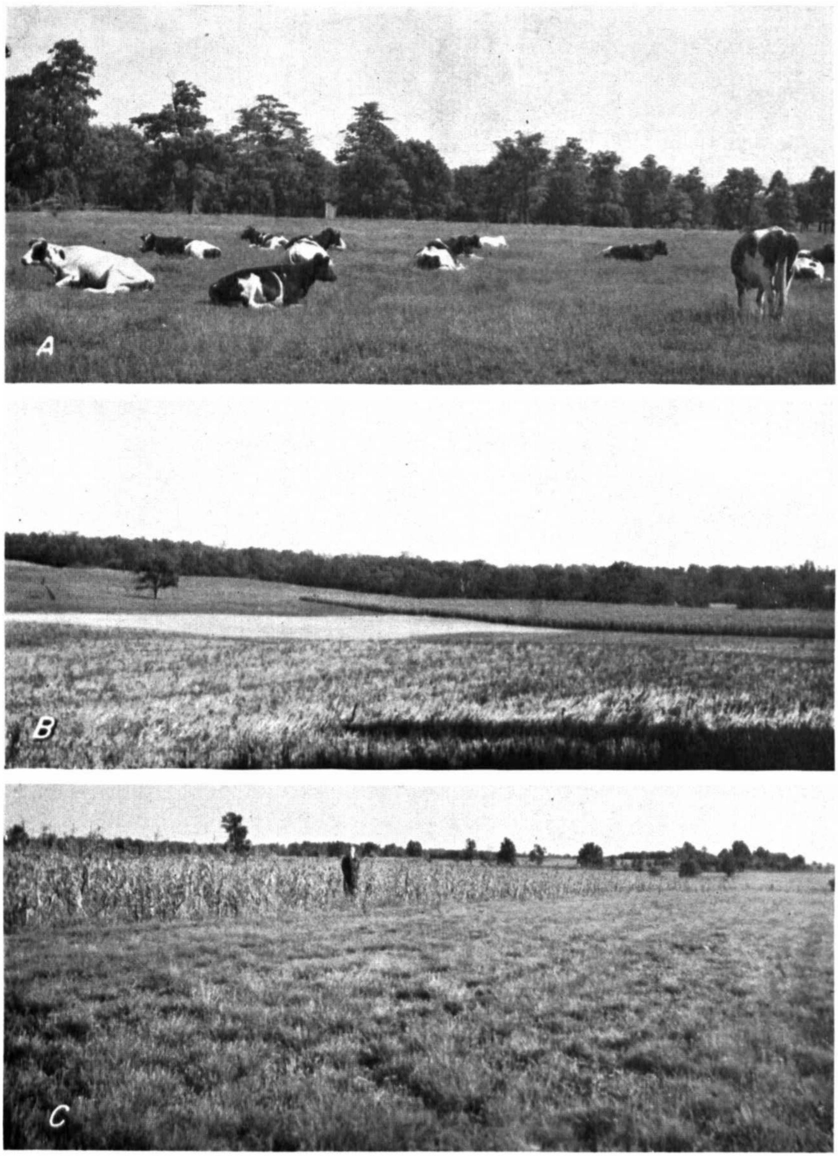
In cultivated fields the surface soil, to an average depth of 8 inches, is dark-gray or dark grayish-brown friable silt loam with considerable organic matter. To a depth of 30 inches the subsoil is gray mottled with brown and yellow noncemented but slightly compact silty clay loam. This grades into brown mottled with gray and yellow gritty gravelly slightly compact but friable loam to clay loam, which is partly weathered glacial till. Most of the till on which this soil has developed is over 10 feet deep and only in a few places is it less than 6 feet. Gravel and stones are scattered throughout the soil, subsoil, and substratum but do not interfere with tillage operations. About 80 percent of the fragments are angular and 20 percent rounded. The soil is acid throughout, although in a few places it rests on alkaline or calcareous till. The surface soil is strongly acid and the subsoil is medium to strongly acid depending on the depth of leaching.

Included in mapping are a few stony areas and some poorer drained spots of the Chippewa and Marengo soils and small elevated areas of the Venango or Wadsworth soils. Where Frenchtown silt loam is mapped next to the Mahoning soil, the boundary is sometimes arbitrary as the soils occur in about the same topographic position. The Mahoning soil is heavier, however, and rests on till higher in lime. Where the silt loam occurs in swales or near the base of slopes, it receives drainage from surrounding higher soils and the water seeps away more slowly and aeration, root development, and leaching are likewise restricted.

Use and management.—About 70 percent of Frenchtown silt loam is cleared, of which 30 or 40 percent is cultivated, 25 percent is used for pasture (pl. 1, *A*), and almost 10 percent is idle. Extensive areas are in old hay land. Since only shallow-rooted crops thrive well, timothy and clover are the principal crops. Corn, oats, and buckwheat are the important grain crops. Yields of most crops are slightly higher than on the Venango soils but lower than on the better drained soils. Timothy, alsike clover, and pasture, however, produce a ranker growth on Frenchtown silt loam, owing to the high organic-matter content. Red clover and wheat frequently freeze out, and alfalfa cannot be successfully grown without tiling and ditching to improve drainage.

Artificial drainage is more effective and beneficial than on the Mahoning or Venango soils because the subsoil is not so heavy or compact. Corn, oats, hay, and pasture are best suited to Frenchtown silt loam. Fruit trees cannot be grown successfully because of poor drainage. Woodland consists largely of elm, maple, hemlock, and some oak but includes hickory, ash, beech, aspen, and haw apples.

Gresham silt loam (Gs).—This imperfectly drained soil corresponds in most characteristics to Venango silt loam, but it is developed on the older Illinoian till rather than on Wisconsin till. Although both the Illinoian and Wisconsin tills are derived principally from gray acid sandstone and shale, the more deeply weathered Illinoian is darker yellowish-brown. Scattered irregular-shaped areas occur on smooth slopes of 2 to 7 percent in the southeastern part of the



A, Pasture on Frenchtown silt loam with maple grove in background.
B, Crops on Chenango loam with Venango silt loam and Meadville loam in left background; light-gray area is a plowed field on Venango silt loam.
C, Poor growth of corn on Venango silt loam.

county in close association with the well-drained Hanover, the moderately well-drained Titusville, and the poorly drained Shelmadine soils, which have developed on similar material.

The surface 6 to 8 inches is gray to grayish-brown friable silt loam with a small quantity of organic matter. At a depth of about 13 inches it is mottled gray and yellow friable heavy silt loam with some compaction. From 13 to 26 inches is mottled brown, gray, and yellow hard very compact silty clay loam that can be designated as a fairly well developed hardpan. The partly weathered till beneath this is dark yellowish-brown compact hard silty clay loam that is spotted and streaked with gray. This soil, like other soils developed on Illinoian till, is extremely acid in the surface and upper subsoil and strongly acid in the lower subsoil and substratum.

An included area in the extreme southeastern corner of the county is so stony that cultivation is impractical. Its use for pasture is reduced 25 to 30 percent, as large stones and boulders cover much of the surface.

Use and management.—Only shallow-rooted crops, such as oats, corn, timothy, alsike clover, buckwheat, and pasture grasses, should be grown on Gresham silt loam. The general profile characteristics of Venango silt loam that affect crop use and adaptations are applicable to this soil. The lime requirement, however, is somewhat higher on the Gresham soil.

Hanover gravelly loam (HG).—This well-drained soil has developed on Illinoian till derived from acid gray sandstone and shale with some limestone. It is similar to Wooster gravelly loam except it is leached deeper and developed over shallower and older till that is a paler yellowish brown because of weathering. Areas are in the southeastern part of the county on the tops of hills or ridges on gently undulating relief with slopes up to 7 percent. An area north of Titusville and another about a half mile north of the southeastern corner of the county are stony. The other areas contain gravel, but not enough to make cultivation impractical.

The surface 7 or 8 inches is yellowish-brown to grayish-brown loose friable loam, which is underlain by yellowish-brown friable silt loam or heavy loam to a depth of 36 inches. In some places there is slight mottling at depths below about 30 inches. The substratum consists of compact dark yellowish-brown till and fragments of sandstone overlying bedrock at 5 to 6 feet in most places. The upper layers are extremely acid but with increasing depth the soil is less acid and may be medium acid at 5 feet.

Use and management.—Hanover gravelly loam is well adapted to deep-rooted plants, including apple trees, alfalfa, and potatoes. Owing to the high degree of acidity and low organic-matter content, this soil does not produce large yields unless it is fertilized often. Like other sandy soils it responds rapidly to good treatment. Crop adaptation and yields are about the same as on Wooster gravelly loam. Crops suffer considerably from drought in long periods of dry weather in summer. Areas that are not too stony respond well to fertilizer and give good yields of potatoes, vegetables, and fruit when properly managed. Corn, oats, and buckwheat give better returns than pasture grasses or timothy and wheat.

Hanover gravelly loam, sloping phase (HGS).—This soil has developed on Illinoian till in the southeastern part of the county. It occupies 7- to 15-percent slopes. The surface and subsoil are similar to the gravelly loam, but most of the areas are somewhat more stony, making cultivation difficult. Many of the larger stones have been picked up. Areas within a radius of 3 miles northeast and east of Titusville are more stony than typical and have more sandy surface soil; consequently, they are used less for crop production.

Use and management.—Hanover gravelly loam, sloping phase, is similar to Wooster gravelly loam, rolling phase, in crop uses and yields. About half the soil is in woodland and the rest is used largely for pasture. Some of the cultivated areas are reverting to poor pasture or to woodland.

Hanover loam (HL).—This soil occurs only in the southeastern part of the county on the uplands. It is well drained and developed over comparatively shallow Illinoian till derived from and underlain by acid gray sandstone and shale. The fairly smooth surface slopes as much as 7 percent in places. The soil is associated with the moderately well drained Titusville, the imperfectly drained Gresham, and the poorly drained Shelmadine soils developed on similar parent material. In crop adaptations, yields, and all phases of agriculture, this soil is practically no different from Meadville silt loam. It is leached slightly deeper because it is older, having developed on the Illinoian till that was deposited several thousand years prior to the Wisconsin glacial period.

The 6- to 8-inch surface layer is dark yellowish-brown friable loam, which is underlain by yellowish-brown friable silt loam to silty clay loam to a depth of 20 to 30 inches, at which depth the compactness begins. The compact layer is faintly mottled gray, yellow, and brown gritty silt loam. Small quantities of angular sandstone and shale fragments appear throughout the soil. The surface and upper subsoil are extremely acid, and the lower subsoil and substratum are very strongly to strongly acid. Organic content is low.

Use and management.—About 80 percent of Hanover loam is cleared, and two-thirds of the total area is cultivated to the principal crops of the county. Like Meadville silt loam it is well suited to all crops grown in the county, including potatoes, apples, and alfalfa. It is not susceptible to erosion and can be cultivated under a wide range of moisture conditions with all types of farm machinery.

Hanover stony loam (HT).—This well-drained soil has developed from Illinoian till derived principally from acid gray sandstone and shale. It occurs in the southeastern part of the county in association with the other Hanover soils on gently sloping to sloping areas with gradients up to 15 percent. This soil is similar to Hanover loam except that there are many angular sandstone fragments lying on the surface. Most of them have a width of 12 to 15 inches, but a few range up to 2 or 3 feet. The presence of stone therefore is a great hindrance to tillage.

A large proportion of Hanover stony loam is in forest, but a few areas are pastured and some small areas are cultivated. If the land were cleared, about the same yields as obtained on Hanover loam could be expected but the soil would be more susceptible to erosion.

Hanover stony loam, moderately steep phase (HTM).—This soil is similar to the moderately steep phase of Wooster stony loam. It has developed on Illinoian till and local sandstone and occurs in the southeastern part of the county on moderately steep slopes of 15 to 30 percent. These slopes are smooth but their steepness and stoniness make cultivation difficult. Only a few areas are mapped; the largest area is immediately northeast of Hydetown.

This soil differs from Hanover gravelly loam in its position, the presence of angular stones up to 10 to 12 inches wide, and the shallower depth to bedrock, which is generally 3 to 8 feet below the surface. In places, at depths of 30 inches, the soil is faintly mottled, and in other places it closely approaches Lordstown stony loam, steep phase, in characteristics.

Use and management.—About one-third of the moderately steep phase of Hanover stony loam is in pasture and the rest is forested. This soil is too light-textured and steep for good pasture and is better suited to forest. A small proportion is used for corn and hay crops, but considering the difficulty of tillage operations yields are low and are comparable to those of Wooster stony loam, moderately steep phase.

Holly silt loam (Hs).—This poorly drained soil occurs along all of the larger and most of the smaller streams except those in the northwestern part of the county. Relief is flat with slopes seldom exceeding 3 percent. Internal and surface drainage are poor. This soil is closely associated with the well-drained Tioga soils and the imperfectly drained Middlebury soils developed from similar parent material. The parent material was derived mostly from acid gray sandstone and shale.

The surface 6 to 8 inches consists of gray heavy silt loam with a fine crumb structure. The silty clay loam or silty clay subsoil is gray with splotches of brown and yellow and is plastic when wet. This layer is practically free of roots and organic matter, and the lower part is wet most of the year as the water table is generally within 2 or 3 feet of the ground surface. Generally the reaction is strongly acid with little variation between the surface and subsoil. In this respect it differs from Wayland silt loam, which has a neutral or mildly alkaline reaction in the subsoil and substratum.

Variations include gradations toward very fine sandy loam and silty clay loam in the surface layer. There are also differences in the color of the upper layers in proportion to the quantity of organic matter contained and according to drainage conditions.

Use and management.—The use of Holly silt loam for crops is limited. About 30 percent is cleared and used almost entirely for pasture. White clover and Kentucky bluegrass will not thrive well since the soil is wet most of the year. Grasses that can withstand wet conditions, as Canada bluegrass, redtop, and poverty oatgrass and many weeds, as goldenrod, devils-paintbrush, yarrow, and rush, cover most of the areas. About 2 or 3 percent of the total area is planted to corn, timothy, and clover. Yields are poor; corn averages 20 to 30 bushels an acre and hay from ¾ to 1 ton. Pasture is as good as that on some of the better drained upland soils. Water-loving trees do well, although roots rarely penetrate below 8 to 10 inches deep. Native vegetation consists of a tree growth of willow, elm, hickory, maple, and shrubs in virgin areas.

Artificial drainage is the first requisite in improving this soil. Deep open ditches would drain the surplus water after heavy rains and relieve areas sooner after overflow. Lime and phosphate are also necessary for better pasture grasses.

Holly silt loam, high-bottom phase (HsH).—Areas of this phase are along the larger streams on slopes of 0 to 3 percent in association with the silt loam. It differs essentially from the silt loam in its position on the higher levels above stream beds. Most of the areas are overflowed only in exceptionally high floods. A few areas are above overflow, although they may receive some water from adjoining slopes. Both surface and subsoil drainage are poor.

Use and management.—Holly silt loam, high-bottom phase, is best adapted to pasture and forest. Approximately 40 percent of it is cleared, of which only about 5 percent is used for crops—mainly corn, timothy, and alsike clover. Oats, wheat, and buckwheat generally lodge because of excess water and high organic-matter content. Yields are about 5 percent higher than those obtained on the silt loam.

Kerrtown silt loam (Ks).—This soil occurs in close association with the Tioga soils. It has developed on flood plains from similar parent material but apparently under a grass vegetation, as the surface is relatively dark-colored and high in organic matter, like the soils developed on the prairies farther west. It occupies high-bottom positions on slopes of less than 3 percent. Good drainage and permeability allow rapid penetration of plant roots. Some areas of this soil are subjected to overflow during floods but the largest body, occurring near Meadville, is never overflowed. Its level position—from 6 to 15 feet above French Creek—and high organic-matter content make it the most productive soil in the county.

The 12- to 16-inch surface is very dark grayish-brown to nearly black very friable silt loam, which contains a high concentration of black soil humus. The surface soil is underlain by yellowish-brown friable silty clay loam, which begins at 16 inches and continues to 36. Organic matter imparts a dark color to the upper part of this layer. Below 36 inches is the substratum, a light yellowish-brown sandy material that is porous and loose. The surface is gravelly in some places, and where the soil occurs south of Hydetown, the surface is very fine sandy loam and the subsoil is slightly more sandy. Surface and subsoil are both strongly acid.

Use and management.—Practically all of Kerrtown silt loam is cultivated except where it is used for building lots or factory sites. Corn, alfalfa, wheat, oats, timothy, clover, and vegetables are the principal crops. Acre yields of corn in normal years range from 40 to 60 bushels; oats, 25 to 35; wheat, 20 to 30; alfalfa, 2½ to 3 tons; and clover, 1½ to 2½ tons. Since the soil warms early in spring, it is excellent for vegetables.

This soil gives higher yields where it is more heavily fertilized, responding to applications of nitrogen, phosphate, potash, and lime. The soil is well supplied with nitrogen, but additional nitrogen is essential where leafy vegetables are grown for the commercial market.

Lake marsh (Lm).—These marsh areas are low-lying and submerged level land bordering lakes covered mainly with a growth of cranberry grass, flag grass, cattails, rushes, sedges, and a few scattered trees. Water covers the land the entire year, and most of the material consists of brown to black fibrous partly decomposed vegetable matter or peat. A few areas, especially near the border of soil areas, have mixtures of sand, silt, and clay intermingled with peaty material. The largest areas are near Conneaut Lake and on the upper part of Pymatuning Reservoir bordering the open water. In its present condition, the land is nonagricultural and has practically no grazing value. A few areas are used for the production of muskrats and for fur farming.

Lobdell silt loam (Lb).—This imperfectly drained soil has developed on flood plains in small narrow and irregular-shaped areas along the small and large streams in the northwestern part of the county. The parent material is derived principally from acid gray sandstone and shale with a little limestone. It is an intermediate soil in position and drainage between the well-drained Chagrin and the poorly drained Wayland soils. Slopes seldom exceed 3 percent, and drainage is slow in the lower subsoil.

The 6- to 8-inch surface soil is dark grayish-brown very friable smooth silt loam. The subsoil is yellowish-brown or pale-yellow very fine crumb silt loam in the upper part and is underlain at 12 to 16 inches by mottled gray, yellow, and brown very fine crumb and firm mixed heavy and light material with a silt loam to silty clay loam texture. The soil is strongly or medium acid in the surface but is neutral to mildly alkaline in the subsoil and substratum. In this respect it differs from Middlebury silt loam that is strongly acid throughout.

Variations include gradations toward very fine sandy loam or silty clay loam in the surface layer. Color of the surface may also differ in proportion to the quantity of organic matter present and according to drainage. If the soil occurs along the lower courses of streamways or valleys, the deposit of material is thicker than in areas along the headwaters, many of which are traversed by old stream channels with a slow flow of water.

Use and management.—The shallow depth to the water table and the frequency of overflow limit the use of Lobdell silt loam. About 50 percent has been cleared, and about 20 percent of this is cultivated. The soil is generally farmed in conjunction with other bottom soils and is used largely for the production of clover, timothy, and corn, which do well, and oats, which have a tendency to lodge. Buckwheat and wheat produce only fair yields. Alsike clover yields better than red clover. Alfalfa cannot root deeply enough or withstand the flooding. Acre yields of corn in normal years range from 30 to 38 bushels; oats, 20 to 25; buckwheat, 15 to 18; and clover and timothy, 1 to 1¼ tons. Most vegetables except potatoes do well. Some sections of the bottoms are covered with a growth of willow, aspen, elm, hickory, maple, shrubs, and weeds.

Pasture is good and all grasses will grow well if phosphate and lime are used. Open ditch drainage or straightening and deepening the stream channels, especially those that are sluggish and shallow, would help improve drainage.

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Lobdell silt loam, high-bottom phase (LBH).—This phase occurs in the northwestern part of the county in association with the other Lobdell soils. It differs from the silt loam in position only, occurring at higher levels along stream valleys and above ordinary floods. In such locations there is less risk from inundation and the soil is more suitable for cultivation than the normal. In places the texture is very fine sandy loam or loam.

Use and management.—About two-thirds of Lobdell silt loam, high-bottom phase, is cleared and one-third cultivated, largely to corn, hay, oats, and wheat. Yields over a period of years are about 5 percent above those obtained on the silt loam, as this soil is generally fertilized a little heavier than the soils on the lower flood plain.

Lobdell loam (Lo).—This imperfectly drained soil occupies gradients up to 3 percent along streams. It occurs principally in the northwestern part of the county in close association with the well-drained Chagrin and the poorly drained Wayland soils developed on similar parent material, which is derived from acid gray sandstone, shale, and some limestone. This loam is similar to the silt loam except it contains more sand in the surface and subsoil.

Areas with fine sandy loam and silt loam surface layers are included in some places. In higher places or better drained locations, the surface soil is browner and the subsoil is almost like that of the Chagrin series. In depressions the soil approaches Wayland silt loam in character. Lobdell soils differ from Middlebury soils in that the subsoil and substratum are neutral or mildly alkaline rather than strongly acid.

Use and management.—About one-half of Lobdell loam is cleared, and at least one-third of it is in pasture. The rest is used principally for hay and corn. Yields are slightly lower than those obtained on the silt loam, especially yields of timothy and clover. This is an excellent pasture soil and is sufficiently well drained for white clover and Kentucky bluegrass. Lime and phosphate, however, are needed for best growth.

Lordstown stony loam (Ls).—This well-drained shallow soil has developed on a very thin mantle of glacial till or from the weathered residue of the underlying sandstone. It occurs where the underlying bedrock is close to the surface. The slope ranges to 15 percent. It is associated with the soils developed on both Wisconsin and Illinoian till and occurs on knolls and brows of hills in small areas throughout the central and eastern parts of the county. The largest areas are ½ mile east of Atlantic and 2½ miles east of Pettis.

A vertical exposure through the soil shows several distinct layers. The 8-inch surface soil is yellowish-brown to grayish-brown gritty easily friable loam that in places contains many stones up to 2 feet in diameter. The subsurface layer is light yellowish-brown friable stony loam. The subsoil, ranging from about 14 to 26 inches, is yellowish-brown friable gritty loam or silt loam, resting at a depth of 1½ to 3 feet on bedrock of broken acid gray sandstone. The material throughout the profile is very stony, nearly all of the pieces being angular fragments broken from the underlying rock. Many boulders of 2 to 4 feet in diameter are in wooded areas.

Use and management.—About 50 percent of Lordstown stony loam is cleared, 35 percent of which is cultivated, and the rest is in forest and woodland. Stones interfere greatly with tillage, but they are not numerous enough to prevent cultivation. Organic-matter content is low, and, owing to the shallowness to bedrock, the soil is inclined to be droughty. It is strongly acid throughout. Natural productivity is lower than that of the better drained soils of the county. The acre yields for the best adapted crops are: Corn, 18 to 30 bushels; clover and timothy, 4/5 ton; corn silage, 6 tons; and oats, about 22 bushels. Oat straw is generally short, but the grain is comparatively better. In good years potatoes do well, although they occasionally suffer from lack of moisture.

Manure is beneficial in improving the structure and water-holding capacity since sand content is high. Fertilizer should be applied more frequently and in smaller quantities than on heavier soils. This soil responds readily to manure and commercial fertilizer and can be cultivated under a wide range of moisture conditions.

Lordstown stony loam, moderately steep phase (Lsm).—This shallow well-drained soil has developed over sandstone with bedrock 18 to 48 inches below the surface. The profile is similar to that of Lordstown stony loam. The soil is commonly shallower on the upper part of the slope and deeper on the lower part. Most of the areas are on long slopes of 15 to 30 percent, chiefly in the eastern and central parts of the county. This land is of little importance to agriculture, as most of it is in forest. The cleared 5 percent is used for pasture.

Lordstown stony loam, steep phase (Lst).—This soil covers most of the steep land of the county with slopes greater than 30 percent, and it is important for forest purposes only. Timber growth is slow owing to low organic-matter content, low water-holding capacity, and high acidity. The largest areas occur near the towns of Titusville and Hydetown in the southeastern corner of the county. Another large area is in the southern corner along the west slope of French Creek. The depth to bedrock in most places ranges from 18 to 40 inches. A few areas of rock outcrop occur on the upper slopes. The soil is largely developed on residuum from the underlying sandstone and shale with a thin mantle of glacial till left in places. The profile is much like that of Lordstown stony loam. About 2 percent has been cleared and is being used for pasture.

Mahoning silt loam (Mh).—This soil is developed on calcareous Wisconsin till mainly of acid gray sandstone and shale origin but containing some limestone. Areas of it occupy almost level to undulating uplands in the northwestern part of the county, covering a large proportion of Beaver, Spring, and Conneaut Townships. Slopes seldom exceed 5 percent but may be as high as 7. Internal drainage is slow and runoff is slow in many places, especially in the northern part of Beaver Township. Aeration, oxidation, and root penetration are likewise restricted, and as a result there is little aeration in the lower subsoil. This soil occurs in close association with the moderately well-drained Ellsworth and the poorly drained Trumbull soils. It differs from the Frenchtown soil in the heavier texture throughout and the higher content of calcium in the subsoil. It is better supplied with organic matter than the other soils of the uplands, with the exception of the Frenchtown and Chippewa soils.

To a depth of 8 inches the surface soil is gray to dark-gray friable heavy silt loam to silty clay loam inclined to clod when plowed wet.

From 8 to 30 inches is mottled gray and yellow plastic silty clay, which is slightly compact. Below this is mottled gray, yellow, and brown slightly compact weathered but alkaline silty clay to silty clay loam till. The surface layer is strongly acid and the subsoil below 24 inches is alkaline to calcareous. A few angular sandstone and shale fragments are scattered throughout the layers, but they do not interfere appreciably with tillage operations.

In places where this soil borders the Cambridge, Rittman, and Frenchtown soils the texture of the surface and subsoil is lighter and more sandy and the subsoil neutral to slightly acid. In most places, however, especially in Beaver Township, the material is alkaline or calcareous at depths below 24 inches.

Use and management.—The natural productivity of Mahoning silt loam is not high in spite of the fact that it is one of the richest in plant nutrients in the county. Owing to lack of drainage, crops suffer from excessive moisture in periods of heavy rainfall and in spring. Of the 65 percent that is cleared, 35 percent is cultivated, 20 to 25 percent is in pasture, and the rest is idle. Corn, oats, and timothy and clover are the principal crops. Considerable buckwheat is grown, especially where corn has failed earlier in the season owing to excessive moisture. Potatoes and vegetables are not grown, except in small patches, as the soil is heavy and too wet a large part of the year. Red clover and wheat freeze out badly, but alsike clover withstands the intermittent thaws and freezes very well.

Yields of most crops are slightly higher than on the Venango soils and about equal to those obtained on the Frenchtown soil. Timothy does better than on some of the better drained soils owing to the higher content of organic matter. Oats and buckwheat rarely lodge as they do on the soils of the bottoms where the plentiful water supply combined with a high nitrogen content causes the plants to feed too fast without enough potash to strengthen the straw. In normal years corn yields average 25 to 30 bushels; oats, 20 to 25; buckwheat, 15 to 18; clover, ¾ to 1 ton; and timothy, 1 ton.

Second-growth beech, maple, yellow-poplar, and oak comprise most of the present forest. Pasture is largely composed of poverty oatgrass, Canada bluegrass, redtop, and timothy, showing the lack of proper fertilization, which accounts for the small quantity of white clover and Kentucky bluegrass.

A large part of this soil could be improved by deep ditch drainage to remove the excess surface water and thus allow earlier planting in spring. Owing to the heavy nature of the subsoil, tile drainage is not so effective as on the Frenchtown soil. It is beneficial, however, though it may not be practicable where only general crops are grown.

Marengo silty clay loam (Mc).—This very poorly drained soil has developed on slightly calcareous Wisconsin till that is derived from acid gray sandstone, shale, and limestone. In most places the till is leached to the extent that it is not calcareous within about 36 inches but is neutral or slightly alkaline. It occurs largely in the western part of the county in association with Rittman, Wadsworth, Frenchtown, Mahoning, and Trumbull soils. Areas occupy low places, depressions at the sources of streams, and seepage areas near the bases of slopes. The slope seldom exceeds 2 percent. Drainage is poorer than in the Frenchtown soil. This soil has the same relative position and profile as the Chippewa soil, but it differs in that the lower subsoil is neutral or slightly alkaline whereas the corresponding layer in Chippewa silty clay loam is strongly acid.

The 7- to 10-inch surface layer is very dark grayish-brown to almost black silt loam to silty clay. The subsurface layer is light gray with a few splotches of heavy brown silty clay loam. The gray to almost bluish-gray subsoil is very firm silty clay loam that has occasional yellowish-brown splotches. A few sandstone and shale fragments are scattered over the surface where small areas occur at heads of drains. This soil is strongly acid to about 24 inches, and below this it is neutral to slightly alkaline.

In a few places the parent material at a depth of about 30 or 36 inches is calcareous. The soil is slightly heavier than typical in some places, and in places the subsoil is silty clay. The organic-matter content is variable, but in most places it imparts a very dark color to the soil for 10 to 12 inches.

Use and management.—About one-third of Marengo silty clay loam is cleared. About 2 to 3 percent is cultivated, chiefly to corn, timothy, and vegetables; the rest is used for pasture. Yields are very low unless the soil has been artificially drained, and even then crops are late. Artificial-drainage methods are not very effective, as there are many seepage areas and depressions. Since this soil is naturally well supplied with nitrogen, none is needed in fertilizer combinations. The virgin areas are covered with bunchgrass and a brushy growth of willow, birch, hemlock, and yellow-poplar.

Massillon gravelly sandy loam (ML).—This well to excessively drained soil has developed on gray glacial outwash derived from acid gray sandstone and shale. It is on low ridges, knolls, and morainic topography throughout most of the county with a relief range of 5 to 15 percent. It occurs in association with all the soils of the uplands but is not widely developed. The soil differs from the Chenango soils chiefly in its rougher topography, origin, and lack of a well-developed subsoil. The Massillon soils differ from the Wooster soils principally in that the parent material is developed on outwash rather than loose till, has been assorted and stratified by moving waters, and contains a large proportion of sand and rounded gravel. One of the principal areas, which is typically choppy and hummocky, occurs on the east side of Conneaut Lake.

The surface soil is grayish-brown gritty loose friable gravelly sandy loam underlain at 8 to 18 inches by yellowish-brown gravelly and gritty slightly compact sandy loam. The lower subsoil and substratum consist of mixed sand, silt, and gravel, showing stratification in the lower depths. Free lime is encountered at 8 to 10 feet below the surface. Gravel is chiefly of water-worn fragments of shale and sandstone, together with a few pebbles of granite, gneiss, and limestone in the lower part. Surface and subsoil are strongly acid.

Use and management.—The loose porous nature, steep slope, and low organic-matter content make Massillon gravelly sandy loam one of the most droughty soils in the county. Approximately 50 percent is cleared and 25 percent—mostly smoother areas—is farmed. Alfalfa and fruit trees may give fair yields. Although it is not well suited to hay and pasture because of the low organic-matter content and sandy upper layers, it is used largely for these crops. Corn yields about 18 to

25 bushels an acre and oats 15 to 20 in normal years. Straw is generally short, but the grain develops comparatively better. Wheat and buckwheat growth is poor and often the harvester cannot cut low enough to catch the heads.

Under prevailing economic conditions this kind of land is more suitable for forest growth, with some of the smoother areas cultivated to vegetables, berries, or small fruits. Deep-rooted plants survive better than shallow-rooted ones. Addition of manure is the chief means of increasing the water-holding capacity. Erosion control is not so difficult in cleared areas, however, since considerable water can be absorbed in hard rains before runoff begins, owing to the porous structure.

Massillon gravelly sandy loam, hilly phase (MLL).—Small separate bodies of this soil occur throughout most of the county. The largest areas are 1½ miles northeast of Hartstown and ½ mile east of Conneaut Lake. They occupy steep slopes, knolls, kames, and eskers of about 15 to 30 percent gradient.

To a depth of 6 to 8 inches the soil consists of brown gritty sandy loam. It grades into light-brown or yellowish-brown loose porous loam or sandy loam. The lower layers are light yellowish-brown loose friable gravelly loam to loamy sand. There is little orderly arrangement of layers or regularity of structure on the steeper parts. For the most part, the material is porous, friable, loose, and strongly acid to 6 or 8 feet, at which depth is calcareous material.

Use and management.—Massillon gravelly sandy loam, hilly phase, is not important agriculturally, although about one-third of it has been cleared. Since the variations in relief make the land unsuitable for farming, most of it is in permanent pasture and only a small acreage is cultivated. Light texture and open structure tend to dry the soil rapidly. Crop yields are low. Fruit trees do well if they are fertilized frequently, but the soil is best suited to forest. Pasture grasses are short and sparse because the soil is droughty and generally low in fertility.

Massillon gravelly loam (MM).—Because of smoother topography, higher content of silt, and greater moisture-holding capacity, this soil was separated from the gravelly sandy loam. It corresponds closely to Chenango gravelly loam in most respects, but the surface is not so smooth. This well-drained soil has developed on outwash derived principally from acid gray sandstone and shale. It occurs mostly in valleys on undulating to mildly hummocky relief and smooth knolls with slopes up to 7 percent. A few small depressions are common in some of the larger areas. These irregular-sized areas are scattered throughout the county, the largest ones located 1 to 2 miles northwest of Cochranton, on the east side of Pymatuning Dam, and near the northeastern corner of Spring Township.

Profile development is similar to that of the gravelly sandy loam, but this soil is heavier throughout and less droughty. Consequently, it is a much better farming soil. The parent material is derived from stratified layers of sand, silt, and gravel. Most of the gravel is small and rounded and is derived chiefly from sandstone and shale, with a small percentage of igneous and limestone gravel. It is not large enough to interfere materially with tillage operations as it is smaller than the gravel in the till. The surface and subsoil are strongly acid, but in most areas the substratum is calcareous at depths of 6 to 10 feet.

Use and management.—Massillon gravelly loam is smooth enough for most farming operations and is a good soil for potatoes, corn, oats, and deep-rooted crops. About 85 percent is cleared and 65 percent is in crops. Crop yields are about equal to those obtained on Wooster loam and slightly less than those on Chenango loam. Alfalfa does well when limed. A few of the roots reach the calcareous material, which, however, is generally too compact for root penetration. Pasture grasses are generally sparse unless fertilized and manured heavily. The organic-matter and nitrogen content are naturally low. Constant cropping, without adequate returns to the land, has depleted much of the fertility. Without crop roots to take up the nitrates from the soil water, large losses may occur beween crop seasons through drainage water. Little erosion is evident. This soil will respond to applications of lime and complete fertilizer.

Meadville silt loam (Ms).—This soil has developed on fairly deeply leached Wisconsin till derived principally from acid gray sandstone and silty shale with a small limestone influence. It is one of the most important agricultural soils and occurs on slopes up to 7 percent on ridges and in slightly hummocky valleys over all the county except the northwestern and the southwestern parts. The largest areas are in the eastern and south-central parts. Both surface and internal drainage are good, although below 2 feet drainage and aeration are restricted. The soil readily absorbs sufficient moisture, however, to meet ordinary plant requirements, and plants do not suffer so much from lack of moisture as on the Wooster and other upland soils.

This soil is closely related to the Cambridge and Wooster soils, occupying a position intermediate between them. It differs from the Wooster soils in the more compact character of the lower subsoil, which overlies ground moraine, and in that it occupies a smoother surface. It differs from the Cambridge soils in being less compact in the lower subsoil and in the greater depth to the compact layers.

To a depth of 7 or 8 inches is grayish-brown friable silt loam. This layer is underlain by light yellowish-brown friable and permeable silty clay loam extending to a depth of 12 to 15 inches, below which is yellowish-brown friable nuciform structured silty clay loam with some small gravel. At a depth of 22 to 36 inches is yellowish brown with splotches of gray and brown compact heavy silt loam to silty clay loam. The slightly compact substratum, which is lighter textured than the subsoil, consists of gritty and gravelly loam and silt loam glacial till. Small rounded and angular sandstone and shale fragments are also mixed with the surface and subsoil but not in quantities that would hinder tillage operations. The surface soil in most areas is low in organic matter as a result of good surface drainage and a more rapid rate of organic-matter decay because of good aeration.

Throughout its occurrence in the county this soil is uniform. Small areas of other closely associated soils were included as it was mapped. In places the soil has a lighter texture, better aeration, and fewer mottlings in the lower layers. Areas on the lower parts of slopes adjoining the Frenchtown and Venango silt loams are not so well drained as the normal Meadville areas and are grayer.

Use and management.—Meadville silt loam is as good as any upland soil in the county. About 85 percent is cleared and 65 percent of this is used for crops, principally mixed hay, corn, oats, and buckwheat. In normal seasons clover generally yields 1¼ to 1½ tons an acre; corn, 35 to 40 bushels; oats, 25 to 35; and buckwheat, 18 to 22. It is a good soil for potatoes, small fruit, and deep-rooted crops. Alfalfa can be grown successfully if the soil is well supplied with lime, fertilizer, and proper legume bacteria. Although it is not so well adapted to alfalfa as the deep well-drained soils of the terraces and flood plains, it is better than the other upland soils, except the Wayne. Pasture or timothy is not so good as on the Cambridge soils because of the slightly lower organic-matter content.

Most of the soil is farmed in conjunction with surrounding soils, and, in general, treatment and management of the several soils are similar where planted to the same crop. This soil is readily tilled with all types of farm machinery and can be cultivated easier than most of the Wooster soils.

Meadville silt loam, sloping phase (Mss).—Areas of this phase occur in long and irregular-shaped bodies in association with the silt loam. The largest ones are in the central and eastern parts of the county developed over Wisconsin till. There is practically no difference in profile characteristics, but the sloping phase has steeper slopes (7 to 15 percent). As a result it is more difficult to handle and is more susceptible to erosion than the silt loam.

Variations include small areas where the surface is a loam and the compact layer is closer to the surface. A few bodies have sufficient stone and gravel to limit tillage operations.

Use and management.—All the crops of the county are grown on Meadville silt loam, sloping phase, but the proportion in hay and grass is greater than on smoother areas. This is necessary if erosion is to be controlled satisfactorily, and such a proportion should be included in the scheme of soil management on all slopes that are greater than 7 percent. About one-third is in forest, and almost one-half is used for crops. Yields are about equal to those obtained on the rolling phases of the Wooster soils but are 10 to 15 percent lower than on the normal phases.

Meadville gravelly silt loam (Mg).—A higher content of gravel and flagstones on its surface and throughout the soil differentiate this soil from the silt loam. Although mostly of small size, the pebbles range to angular stones 10 or 12 inches in diameter and are generally sufficient to make cultivation difficult. This soil is confined to small scattered areas largely in the southeastern part of the county. The slope ranges up to 7 percent in gradient. These gravelly and stony areas are not used so extensively for crops as the silt loam, and a large proportion is in pasture. Crop yields, however, are almost the same on both soils.

Meadville stony silt loam, moderately steep phase (Mvm).—Areas of this phase occupy almost one-half of the steeper slopes of the county, or those that range from 15 to 30 percent. Most of the areas are irregular long strips along the steeper slopes of the stream valleys throughout the central and eastern parts.

Use and management.—Because of stoniness and steep slopes entailing difficulty of cultivation with machinery and susceptibility to erosion, at least 75 percent of Meadville stony silt loam, moderately steep phase, has been left in forest. Approximately 15 percent is used for pasture and 5 percent for crops. Yields are 25 to 30 percent lower than those obtained on the silt loam in normal seasons.

Owing to its higher absorptive capacity, this soil will not erode so readily as those with the hardpan closer to the surface. As slopes are steep, however, sheet and gully erosion occur where the soil is exposed. Cleared land should be in pasture or hay unless terracing or strip cropping is practiced.

Middlebury silt loam (Mb).—This imperfectly drained soil has developed on flood plains in small, narrow, and irregular-shaped areas along many of the small and large streams. The parent material is derived principally from acid gray sandstone and shale. In position and drainage, this is an intermediate soil between the well-drained Tioga and the poorly drained Holly soils. Slopes seldom exceed 3 percent, and drainage is slow in the lower subsoil. Some sections of the bottoms are covered with a growth of willow, aspen, elm, hickory, maple, shrubs, and weeds.

The dark grayish-brown surface soil is very friable smooth silt loam 6 to 8 inches deep. The subsoil consists of yellowish-brown or light yellowish-brown fine crumb friable silt loam in the upper part and is underlain at 12 to 16 inches by mottled gray, yellow, and brown very fine crumb firm and mixed heavy and light material with a silt loam to silty clay loam texture. The soil is strongly acid throughout and thus differs from the Lobdell soils that are neutral or mildly alkaline in the subsoil and substratum.

Variations include gradations toward very fine sandy loam or silty clay loam in the surface layer. Color differences in the surface material are caused by the proportion of the quantity of organic matter contained and drainage. Along the lower courses of streamways or valleys, the deposit of material is thicker than along the headwaters. Many areas are traversed by old stream channels through which the flow of water is slower.

Use and management.—The shallow depth to the water table and the frequency of overflow limit the use of Middlebury silt loam. About 50 percent has been cleared and of this 20 percent is cultivated. It is generally farmed in conjunction with other soils on flood plains and is used largely for the production of clover, timothy, corn, and oats, to which it is well suited. Oats, however, have a tendency to lodge. Buckwheat and wheat produce only fair yields. Alsike clover yields better than red clover. This soil is not suitable for alfalfa because it has poor drainage. It produces good pasture and all grasses will grow well if the soil is limed and fertilized. Acre yields of corn in normal years range from 30 to 38 bushels; oats, 20 to 25; buckwheat, 15 to 18; and clover and timothy, 1 to 1¼ tons. Most vegetables except potatoes do well, but fruit growing is not suitable. This soil could be improved by open-ditch drainage or straightening and deepening the stream channels, especially those that are sluggish and shallow.

Middlebury silt loam, high-bottom phase (Mbh).—The largest areas of this phase are located along French Creek. This soil differs from the normal soil in that it occupies higher flood plain levels above ordinary floods, making it more suitable for cultivation with less risk of inundation. About two-thirds of the land is cleared and of this one-third is cultivated, largely to corn, hay, oats, and wheat. As more fertilizer is usually applied on this than on the lower bottom soils, yields are about 5 percent higher.

Middlebury loam (Me).—Although similar to the silt loam, this soil contains more sand in the surface and subsoil. It occupies the same kind of low position along streams where drainage is somewhat retarded. Fine sandy loam and silt loam inclusions are found in some places. In higher or better drained locations, the surface soil is browner and the subsoil is almost like the subsoil of the well-drained Tioga soils. In depressions the soil resembles the poorly drained Holly silt loam in character. It differs from Lobdell loam in that it is strongly acid throughout whereas the lower Lobdell subsoil is neutral or mildly alkaline.

Use and management.—About one-half of Middlebury loam is cleared. One-third of this is in pasture, and the rest is used principally for hay and corn. Yields, especially those of timothy and clover, are slightly lower than those obtained on the silt loam. This is an excellent pasture soil and is sufficiently well drained for white clover and Kentucky bluegrass. Lime and phosphate, however, are needed for the best growth of pasture plants.

Middlebury loam, high-bottom phase (Meh).—This phase differs from the loam principally in position. It occurs at higher levels along stream valleys and above ordinary floods and therefore is more suitable for cultivation with less risk of inundation. A fine sandy loam surface is in places.

Use and management.—About two-thirds of Middlebury loam, high-bottom phase, is cleared and of this one-third is cultivated, largely to corn, hay, oats, and wheat. On the average, yields are about 5 percent above those obtained on the loam because this soil is generally fertilized a little heavier than the lower bottom soils and there is practically no damage from flooding.

Muck, shallow phase (Mw).—This muck consists of 1 to 2½ feet of black soft spongy well-decomposed organic matter resting on plastic blue or grayish-blue heavy clay. The organic matter is mostly finely divided fibrous vegetable matter from sedges, wood, and grasses. This material contains a little fine mineral soil. Three-fourths of a mile southeast of Harmonsburg Station the black organic matter and peat are underlain by light-gray or almost white marl, which has been used commercially for its lime value. The principal areas occur in Conneaut Marsh, and other small areas are in various valleys, occupying depressions and narrow areas between the peat and higher land.

Use and management.—About 10 percent of muck, shallow phase, has been cleared and is used mostly for grazing. Vegetation, in cleared areas, consists of grass, huckleberry, and alder; the tree growth is largely of sumac, soft maple, birch, aspen, elm, and swamp oak. Artificially drained areas, which have heavy applications of phosphorus and potash, produce better corn, potatoes, celery, and onions than the better mineral soils. This land is not suited to small grains unless liberal applications of potash are applied; a rank growth of straw is generally produced and the grain lodges badly.

Proper drainage is the first requisite in improving muck soils, and the water table should be lowered to a depth of 3 to 4 feet below the surface. For meadows, 2 feet to the water table may be enough. Most of this land will drain freely if the water has a chance to get away. Ordinarily the distance between tile lines or lateral ditches should be about 100 feet.

Ottawa very fine sandy loam (Ov).—This well-drained soil occupies old glacial lake beds and terraces as a result of soil-forming agencies acting on stratified sandy materials laid down by water from the melting glaciers. The choppy and rolling to steep hanging-delta relief is characterized by indefinitely arranged narrow ridges, small knolls, hills, and knobs that surround small depressions. Slopes are 10 to 20 percent but may reach 30 percent. Relief is about the same as for Massillon gravelly sandy loam, but since the subsoil is heavier, this is a better agricultural soil. Organic-matter content is low, and the soil is inclined to be a little droughty. Most of this soil occurs between Harmonsburg and Conneautville in small irregular areas. It is usually in association with the Painesville, Caneadea, and Canadice soils. Some deposits have been removed and replaced by recent stream action, and the material is rather variable.

In cleared fields the 0- to 7-inch surface layer is yellowish-brown very fine sandy loam with some organic matter and small gravel. In places no gravel is encountered in the entire profile. From 7 to 16 inches is yellow or yellowish-brown loose friable fine crumb very fine sandy loam. The lower subsoil horizon from 16 to 40 inches is soft, loose fine crumb very fine sandy loam. The parent material consists of yellowish-brown to gray laminated loamy very fine sand and fine sand, which is almost incoherent but slightly compact. The entire profile is acid to a depth of 10 feet or more and shows extensive leaching.

In some exposures lack of uniformity is observed by color and textural variations within short distances. Small areas of silt loam are included with the soil as mapped and mottling often occurs in the subsoil.

Use and management.—About 75 percent of Ottawa very fine sandy loam is cleared and of this 40 percent is in crops, principally corn, clover, and timothy, and 35 percent is in pasture or abandoned. As some of it is too steep for use of binders, it is not used much for oats, wheat, or buckwheat. Some areas with good air drainage and not situated in a frost pocket are suitable for fruit growing.

Yields differ within the same field owing to local influences of soil character and type of management. Acre yields of corn generally range from 25 to 35 bushels; oats, 20 to 28 bushels; clover, 1 to 1½ tons; and timothy, 1¼ tons. Alfalfa gives fair yields if inoculated and limed. About 2 tons of ground limestone should be applied before clover or alfalfa is sown if none has been used in the past 5 or 10 years. Better results are obtained when lime is applied frequently in small quantities. Most pasture is poorly managed—lime or fertilizer is inadequate and weeds have crowded out the best grasses. Owing to the sandy texture, it is less well adapted to grass than most of the heavier soils and a larger proportion should be in timber.

Painesville silt loam (PM).—This well-drained soil has developed from lake-laid silt and clay that were once calcareous but have been leached free of carbonates to a depth of 2 to 3 feet as a result of soil-forming processes. Relief is gently undulating with slopes up to 7 percent. This soil is nearer the streams than the closely associated Caneadea soils and has better drainage. It occurs most extensively in the valley extending from Conneautville to Conneaut Lake and is also closely associated with the poorly drained Canadice soil developed on similar parent material.

The surface soil to about 8 inches is grayish-brown very friable silt loam low in organic matter. From 8 to about 14 inches is light yellowish-brown silt loam to silty clay loam underlain by yellowish-brown compact blocky silty clay loam that grades into olive-gray blocky calcareous silt and clay at about 30 inches. At lower depths the silt and clay are laminated. Small pebbles and angular sandstone fragments occur in a few places in the upper layers.

Use and management.—Use and yields of Painesville silt loam are similar to those of Caneadea silt loam, but deep-rooted trees and crops, as fruit trees and alfalfa, do better on the well-drained Painesville than on the imperfectly drained Caneadea.

Painesville silt loam, sloping phase (PMS).—Although similar to the silt loam, this phase occupies more sloping areas that range from 7 to 15 percent. It has developed along the lower slopes of the valley that extends from Conneaut Lake to Conneautville, where most of the lacustrine soils occur. Around the village of Conneautville it has a characteristic heavy dense blocky subsoil with a thin friable yellow surface layer.

Use and management.—Painesville silt loam, sloping phase, is managed and used for the same crops as the silt loam, but yields are 8 to 10 percent lower. A larger proportion has been left in forest and used for hay crops and pasture, to which it is better suited. Owing to the lack of gravel and low organic-matter content, the soil gullies readily and should be kept under a thick cover of grass.

Papakating silty clay loam (Pc).—This nearly level soil of the flood plains occurs along all the larger and many of the smaller streams in close association with both the Tioga and Chagrin soils. It is a permanently wet soil and under water in many places for the greater part of the year. It has practically no value for crops, but where drained it may be used for pasture in midsummer.

The 10- to 12-inch surface soil of dark grayish-brown waxy plastic silty clay loam is firm and shows considerable granulation. A transitional zone occurs between depths of 10 and 18 inches in which the material is mottled gray with splotches of brown silty clay with some dark organic matter. The subsoil is bluish-gray very firm plastic silty clay or clay. Both surface and subsoil have a medium to strongly acid reaction.

Use and management.—Papakating silty clay loam supports a tree growth of water-loving plants—willow, pin oak, elm, beech, hemlock, maple, and swamp alder. Only about 20 percent has been cleared and is used for pasture. Most of the pasture consists of coarse weeds, some redtop, and timothy. Huckleberries, alders, reeds, cattails, and haw apples overtop some of the better grasses.

Drainage would be difficult because of the low-lying position of the soil. The water table, however, could be lowered by deepening or straightening the main drainage channels through many of the areas, thus lengthening the growing season for plants on the soil by quicker removal of surface water. Most of the soil is best suited to hemlock forest and wildlife unless better drainage can be developed.

Peat (P).—The largest areas of Peat are between Crooked Creek and the upper part of Pymatuning Reservoir and in Conneaut Marsh between Conneaut Lake and French Creek. It also occurs in other large swamps that were created by glaciation. Relief is level, and the areas are almost entirely covered with a growth of trees consisting of willow, birch, hemlock, swamp maple, and aspen. Stagnant swamp water usually stands close to the surface.

This organic material consists of dark-brown to black soft fibrous very porous swamp vegetation that is partly decomposed and practically devoid of mineral soil particles. Most of it has been derived from reeds, sedges, cattails, and woody material. It is 10 to 12 feet deep and is underlain by bluish-gray heavy clay beds. The reaction is mildly acid, although at the head of Cussewago Creek it is about neutral. A few areas of muck that are blacker and more decomposed are included.

Use and management.—Less than 1 percent of Peat has been cleared and is being used for the production of vegetables and potatoes. Some is dried and sold commercially. When artificial drainage dries peat out, it is subject to disastrous fires. Such waste can be avoided by leaving the land in its natural state, developing it as better forest land, using it as refuges for wildlife, and impounding water rather than draining it away.

Rittman silt loam (Rs).—This moderately well-drained soil occurs principally in the southwestern part of the county. It has developed on slightly calcareous olive-gray deep Wisconsin till that is weathered to yellowish brown and leached free from carbonates to a depth of 7 to 8 feet. This till is derived principally from acid gray sandstone and shale and contains a little calcareous shale and limestone. It contains less sandstone fragments than the till from which the Cambridge soils have developed. Bedrock commonly is at 10 to 12 feet or more. Surface relief is undulating to gently sloping with a slope gradient up to 7 percent. Areas are in close association with the Wayne and Wadsworth soils and represent an intermediate drainage condition between them.

The 7-inch plowed layer is grayish-brown friable silt loam. Between depths of 7 and 18 inches is yellowish-brown friable weakly nuciform heavy silt loam. The lower subsoil from 18 to about 30 inches is dark yellowish-brown firm silty clay loam that is strongly mottled with gray and brown and has a compact blocky structure. It is firm in place. Below about 30 inches is mottled yellowish-brown silt loam or silty clay loam ground morainic till that is coarse, platy, and very firm in place. The soil is very strongly acid to a depth of about 30 inches and strongly or medium acid to the calcareous unleached till that is reached at a depth of 6 to 8 feet.

Use and management.—Of the 85 percent of Rittman silt loam that is cleared, 65 to 70 percent is cultivated, about 15 percent used for pasture, and less than 5 percent is idle. Yields are comparable to those on Cambridge silt loam. In normal years corn yields 30 to 40 bushels; oats, 25 to 30; wheat, 15 to 20; buckwheat, 15 to 22; potatoes 100 to 150; and clover and timothy, 1 to 1¼ tons. Yields vary, depending on the quantity of fertilizer used.

Dairying is the important industry of the farms located on this soil. The soil is suited to general farm crops, and yields are nearly average for the county as a whole, with the exception of potatoes which yield slightly less. Owing to lack of drainage, it is not so good for potatoes as the Meadville or Wayne silt loams, although yields of 300 bushels an acre are occasionally obtained. Timothy, clover, wheat, oats, buckwheat, and pasture do well and are easily handled since the surface relief is smooth and adaptable to all types of farm machinery.

Rittman silt loam, sloping phase (Rss).—This phase is closely associated with the silt loam and has the same general profile characteristics. More of the surface layer has been removed through erosion in cultivated areas. The underlying till is not so deep, although it is more than 3 feet throughout the areas mapped and 30 to 40 feet deep in some places. The slopes, which range from 7 to 15 percent in gradient, are fairly smooth with only slight ripples.

Use and management.—Of the 60 percent of Rittman silt loam, sloping phase, that is cleared, 35 to 40 percent is cultivated, 15 percent is in pasture, and 5 percent is idle. Crop yields are about 10 to 15 percent below those obtained on the silt loam. Corn averages 25 to 35 bushels an acre; oats, 20 to 30; buckwheat, 15 to 18; and clover and timothy, 1 to 1¼ tons in seasons of normal rainfall.

Shelmadine silt loam (Ss).—This poorly drained soil has developed on Illinoian till derived principally from acid gray sandstone and shale. It occupies nearly level to slightly depressed areas in the uplands in the southeastern part of the county, southeast of Thompson Creek and east of the East Branch of Sugar Creek. The slope seldom exceeds 2 or 3 percent. The soil is closely associated with the well-drained Hanover, the moderately well-drained Titusville, the imperfectly drained Gresham, and the very poorly drained Chippewa soils that are developed on similar parent material. These soils differ from the Frenchtown soil principally in that they have developed on Wisconsin till.

The 6- to 10-inch surface is dark grayish-brown friable heavy silt loam underlain by gray, with an intermingling of brown and yellow, plastic to slightly compact silty clay loam. The substratum is yellowish-brown till strongly mottled with gray and brown. The surface and subsoil are very strongly acid.

Use and management.—About one-half of Shelmadine silt loam is cleared and used for crops and pasture. The crop yields and adaptations are practically the same as those on Frenchtown silt loam. The soil differs principally in the greater depth of leaching and weathering, which accounts for the slightly higher degree of acidity. Slow drainage limits the use of the soil for crops. The large quantity of organic matter in the upper 10 inches, however, improves the physical condition considerably.

Drainage is the first factor to be considered in soil improvement. Open ditches supplemented by a few tile drains would increase the range of crops that could be grown, in addition to raising the yields of crops that have been grown without artificial drainage. If an adequate outlet can be found for excess water, the problem of subsoil drainage is easier than on the Venango and Mahoning soils, in which the compactness and heaviness of the subsoil limit water movement to the extent that tiles may not be very effective.

Tioga silt loam (Ts).—This well-drained soil occurs on recent alluvium, principally of acid gray sandstone and shale origin, that has washed from the uplands onto present flood plains or first bottoms. It is along most of the streams and in all sections of the county except the northwestern. It occurs most extensively in narrow and irregular-shaped bodies along French and Muddy Creeks in close association with the imperfectly drained Middlebury and the poorly drained Holly soils developed on similar parent material. Some areas are subject to ordinary stream overflow, and all may be inundated for short periods by high flood stages of the streams, which continue deposition of material. Relief is smooth to undulating with a downstream gradient that seldom exceeds 2 percent.

The surface 8 to 10 inches is brown or yellowish-brown to yellow very fine crumb silt loam. To a depth of about 3 feet is yellowish-brown friable very fine crumb silt loam. Below this it becomes more sandy and contains some gray and rust-brown stains in many places. The deeper material consists of stratified silt and fine sand. Along the upper parts of streams and along small streams the sediment deposits are comparatively thin; whereas, in the wider valleys, the soil material is 5 to 15 feet or more thick. The surface and subsoil are both strongly acid, and in this respect the Tioga soils differ from the Chagrin, which are neutral or mildly alkaline in the subsoil and substratum.

Organic matter imparts a dark grayish-brown color to the upper 8 to 10 inches, especially along French Creek. Natural productivity is high, as the soil is among the most fertile of the bottom soils and more fertile than any of the terrace or upland soils. The water-holding capacity and drought resistance are good, and runoff is adequate. Frequent or occasional overflows reduce the value and limit the crops. Small, narrow, erratic strips of lighter textured soil of loam and fine sandy loam are included where the soil is mapped along French Creek.

Use and management.—About one-half of Tioga silt loam is cultivated, and one-third is used for pasture. The rest consists of woodland that supports chiefly elm, maple, oak, hickory. beech, and willow. Pastures are largely Kentucky bluegrass, timothy, Canada bluegrass, poverty oatgrass, and redtop. Less fertilizer is required than on soils of the uplands, but most of the areas will respond to applications of lime, available phosphates, and potash. For truck crops, to which it is well suited, the use of nitrogen will prove profitable.

Corn, timothy, clover, wheat, and pasture are the most important crops grown and the ones to which this soil is best suited. In addition, oats, buckwheat, alfalfa, potatoes, vegetables, and small fruits are produced. Along many of the creeks, especially Oil Creek, alfalfa cannot withstand the deep and frequent floodwater inundations without serious damage. Oats and buckwheat often lodge because of the moisture and fertility conditions. These quick-growing crops will use a large supply of nitrogen in a short time, especially where the moisture supply is adequate. Potatoes do not grow so well on this soil or on any of the soils on flood plains as on the Chenango or Wooster soils. Wheat generally yields 15 to 25 bushels an acre in favorable seasons. Depending on the type of fertilization, corn averages 40 to 50 bushels an acre; oats, 20 to 30; buckwheat, 18 to 22; potatoes, 100 to 200; red clover, 1½ to 2 tons; and alsike and timothy, 1¼ to 1¾ tons.

Tioga silt loam, high-bottom phase (TsH).—Although similar to the silt loam, this phase lies a little higher above the stream beds and is seldom overflowed. It is, however, comparatively recent alluvium, and soil leaching has not advanced much. Areas are narrow and irregular along the principal streams of the county, chiefly along French Creek, north of Meadville, and near Cambridge Springs. Surface and internal drainage are adequate and the water-holding capacity is excellent. The surface relief is smooth with a few pot holes and old stream channels that have not been entirely filled in with stream deposits.

The 8- to 10-inch surface is brown to dark grayish brown very friable silt loam underlain by yellowish-brown friable heavy silt loam to silty clay loam. The substratum is deep silty alluvium. The soil contains a moderate quantity of organic matter and nitrogen.

Use and management.—Tioga silt loam, high-bottom phase, is farmed similarly to the silt loam, but a larger proportion is in alfalfa, which gives higher average yields because of the better drainage position of this phase. Pasture on both soils is about equal. About 85 percent of this soil is cleared and two-thirds of it is cultivated. The rest supports excellent timber growth that grows rapidly because of an abundant supply of water.

Tioga loam (TL).—Like the other bottom soils, this one has been formed recently. The material washed from uplands and terraces. Practically none of it is protected from overflow. Runoff, however, is rapid and floodwaters recede sooner than on the less well-drained bottom soils. The soil occurs in close association with the imperfectly drained Middlebury and the poorly drained Holly soils developed on similar material, along the same streams, and with the same characteristics as Tioga silt loam. The parent material was derived principally from acid gray sandstone and shale. Much of the soil occupies the well-drained flood plains along Oil Creek. Surface relief is generally smooth or slightly ridgy in places, sloping gently toward the stream or away toward poorer drained bottoms and downstream. The slope is less than 3 percent.

The surface and subsoil are slightly more porous and have a higher proportion of sand than the silt loam. The soil differs from Chagrin loam in being strongly acid throughout rather than having a neutral or mildly alkaline subsoil and substratum. The upper part is comparatively free of stone or gravel, although it is underlain by stones and gravel at 3 feet or below along some of the smaller creeks where the deposition is not so thick.

Areas included are well-drained fine sandy loams, the largest of which occurs 1 to 3 miles south of Cochranton. Narrow strips of fine sandy loam and loamy fine sand are common along stream banks.

Use and management.—The organic-matter content of Tioga loam is good, especially near Saegerstown and south of Meadville. Dairy farming, with the production of hay, corn, wheat, oats, and vegetables, predominates. Yields are about 5 percent below those obtained on the silt loam. Hay and pasture do better than on any upland or terrace soil, although the yields of small grain are generally lower than those produced on the Chenango, Meadville, or Cambridge soils.

Tioga loam, high-bottom phase (TLH).—Since this phase differs from the loam in occupying higher bottoms or low benches, the damage from flooding is prevented or lessened and thereby the agricultural value of the land is increased. Small elongated areas are mapped along French and Woodcock Creeks and a few of their tributaries.

Use and management.—Tioga loam, high-bottom phase, is good for all the important crops commonly grown, as corn, timothy, clover, alfalfa, wheat, oats, and buckwheat. The greatest proportion is in alfalfa and fruit trees. Yields are slightly higher than those obtained on the loam but not so high as those obtained on the silt loam. Wheat and hay are slightly better suited to the heavier textured soils. Reaction is strongly acid throughout the soil profile, and lime is needed for most crops, especially legumes. Applications of lime and fertilizer are essential for good stands.

Titusville silt loam (TT).—This moderately well-drained soil has developed on Illinoian till derived principally from acid gray sandstone and shale with a little limestone. It is similar to Cambridge silt loam, but since it is on the older Illinoian till, the parent material is weathered to a greater depth and the surface and subsoil are slightly more acid, becoming extremely to very strongly acid within the upper 4 feet. Below this depth the degree of acidity lessens and the reaction may be medium acid in the unweathered till or bedrock. This soil is closely associated with the well-drained Hanover, the imperfectly drained Gresham, and the poorly drained Shelmadine soils that are developed on similar parent material. All of this soil occurs in the southeastern part of the county near Titusville and occupies smooth ridges and slopes of less than 7 percent gradient.

The 6- or 8-inch surface soil is grayish-brown friable silt loam underlain by a 6- to 10-inch layer of yellowish-brown friable very fine crumb heavy silt loam. At 12 to 18 inches the very hard platy almost impervious subsoil of mottled yellow, gray, and brown silty clay loam is encountered. Small angular sandstone and shale fragments are common.

Use and management.—About 80 percent of Titusville silt loam is cleared and used for all the crops grown in the county in almost the same proportion as the other soils with a hardpan. Owing to the moderate supply of organic matter, impermeability of the lower subsoil, and ease of cultivation, this soil is best suited to corn, oats, clover, timothy, buckwheat, and pasture grasses. As on Cambridge silt loam, the shallow depth to the compact layer, or hardpan, restricts water movement, aeration, and root development. Alfalfa, apples, and potatoes, as well as general farm crops, cannot tolerate these restrictions. Timothy and pasture grasses thrive as well or better than they do on most of the better drained land.

All types of farm machinery can be readily used, except on a few small very stony areas near the base of slopes, east of Titusville, where cultivation is impractical. No practical or effective methods are known that will materially reduce the ill effects of the hardpan. Subsoiling, as well as dynamiting, offers only temporary relief.

Titusville silt loam, sloping phase (Ts).—Scattered areas of this soil occupy smooth slopes of 7- to 15-percent gradient in the southeastern part of the county. Aside from the slope this phase is similar to the silt loam. About 50 percent has been cleared and is used in almost equal proportion for pasture and crops. Yields of all crops grown are 5 to 10 percent below those obtained on the silt loam or on Cambridge silt loam.

Trumbull silty clay loam (Tc).—This poorly drained soil has developed on calcareous Wisconsin till derived from acid gray sandstone and shale with considerable limestone. It occurs in close association with the moderately well-drained Ellsworth, the imperfectly drained Mahoning, and the very poorly drained Marengo soils developed on similar parent material. It is principally in the northwestern part of the county. Small bodies are mapped northeast of Meadville in Eastmead and Woodcock Townships. The relief is level to almost flat, with slopes of less than 2 percent. In its natural state the lower part of the soil is moist most of the year. The land warms slowly in spring because of excessive water in or on the soil.

The 6- to 8-inch surface layer is mottled brown and dark-gray silt loam, which readily clods if tilled when wet. This is underlain by a strongly acid light-gray or almost white layer of friable highly leached silt loam. This layer averages about 6 inches thick and is underlain by mottled gray, yellow, and brown compact silty clay to a depth of 3 feet or more. The soil differs from the Mahoning soil in having a light-gray leached layer below the surface layer. The soil is developed from similar glacial till, which is calcareous below 3 feet.

Areas of this soil associated with the Frenchtown and Cambridge soils northeast of Meadville are not so heavy as those in the northwestern part of the county, and the subsoil is acid to 2½ to 3 feet.

Use and management.—About 60 percent of Trumbull silty clay loam has been cleared, but the acreage cultivated is small. Corn, oats, buckwheat, redtop, and timothy and clover are the principal crops, and the average yields are about 5 to 10 percent lower than those on the Mahoning and Frenchtown soils because of slower runoff after rains. The soil is fair grassland and is suitable for permanent pasture, but artificial drainage is essential before many crops or good pastures can be grown successfully.

Venango silt loam (Vs).—This imperfectly drained soil is intermediate in drainage between the Cambridge and Frenchtown soils. Seepage water from higher lying soils is partly responsible for the wet condition much of the year. The soil covers a large part of the central and south-central parts of the county and occupies smooth surfaces with 2- to 7-percent slopes. It has developed on slightly calcareous olive-gray Wisconsin till that is weathered to yellowish brown and leached free from carbonates to a depth of 7 or 8 feet. The till is derived principally from acid gray sandstone and shale and contains a little limestone. In a few places, however, it contains much calcareous material. Areas of this soil near or at the Wisconsin terminal moraine are leached free of carbonates to great depths.

This soil occurs in close association with the Meadville, Cambridge, and Frenchtown soils. It differs from the moderately well-drained Cambridge in that the hardpan and mottling is closer to the surface, and from the poorly drained Frenchtown in the browner surface soil, the lower organic-matter content, and the greater compaction in subsoil. The Venango soils are similar in drainage, color, and parent material to the Wadsworth but differ in that they have a hard platy subsoil and substratum. The Wadsworth soil is friable rather than hard in the lower subsoil and has a blocky or nuciform structure. As with the Cambridge and Rittman soils, there is a gradual change in characteristics from the eastern part of the county where the Venango soils are common to the southwestern part where the Wadsworth occurs. The boundary between these areas is arbitrary.

The surface soil to a depth of 6 inches consists of gray to grayish-brown friable silt loam that is light gray when dry. The upper subsoil is mottled yellow, gray, and brown heavy silt loam to silty clay loam to a depth of 12 to 14 inches. Underlying this to a depth of 30 inches is mottled gray, yellow, and brown compact platy silty clay loam. This material, locally known as a hardpan, is so hard that a pick is necessary to break it loose. It retards the movement of water and is almost impervious to root penetration. Below a depth of 30 inches is compact platy yellowish-brown with gray splotches slightly weathered glacial till. Below about 4 feet the till is less compact. The soil is very strongly acid above 30 inches, and the underlying parent material generally ranges from strongly acid to neutral. Gravel and angular fragments of shale and sandstone are scattered on the surface and throughout the subsoil in varying quantities but rarely in sufficient number or size to interfere materially with cultivation.

Small wet seepy strips and dark-colored spots of the Chippewa soil are included with this soil, especially on the lower slopes. Other inclusions are small areas of the Cambridge and Frenchtown soils and soils with heavy blocky silty clay subsoil derived largely from the underlying shale.

Use and management.—Extensive areas of Venango silt loam are abandoned. About 65 percent has been cleared. Of this 40 percent is used for crop production and a fairly large area is pastured. Timothy and clover are the principal crops, with an average proportion used for corn, oats, and buckwheat (pl. 1, *B* and *C*). Fast-growing crops as oats and buckwheat are well adapted, but corn growth is poor. Timothy and alsike clover produce fair yields, but red clover freezes out badly. Alfalfa is never successful. Oats and buckwheat do not lodge as they do on the Frenchtown and other soils that are higher in organic matter. Yields of all crops, however, are slightly less than on the Cambridge soils. Owing to a lower content of humus in the surface soil and a more acid condition throughout, the yields are also lower for most crops than on the Mahoning soil.

Natural productivity is low because the roots of most plants cannot develop normally. Fair surface drainage and runoff indicate adaptability to grasses or shallow-rooted grains, which do fairly well under poor subsoil drainage conditions. The water-holding capacity is small, as the soil water penetrates the hardpan slowly and more runoff occurs than on the better drained soils. Drought resistance is also low, since roots can penetrate only to shallow depths and the soil is slow to warm up after wet cold spells.

Tile drainage is seldom practical because it is economically unprofitable and does not remedy the hardpan condition. Subsoiling, although not always profitable, is probably the most effective method and is used by some farmers to break the compact layers. A larger proportion of the soil should be used for hay and pasture, to which it is best suited. Kentucky bluegrass and white clover stands can be obtained by addition of lime and phosphate, except on the most seepy spots.

Venango silt loam, moderately steep phase (Vsm).—The largest areas of this phase are mapped about 3 miles south of Meadville and 2 miles southeast of Riceville. The soil differs from the silt loam in topographic position, occupying slopes of 15 to 30 percent. Since these steep slopes make cultivation difficult, most of the land has never been cleared. A small part is used for pasture, to which it is best suited because grasses are shallow-rooted and help to hold the surface soil in place. Tree growth is slow and stunted since the roots penetrate only the surface 12 to 18 inches.

Venango silt loam, sloping phase (Vss).—This soil is in the central and eastern parts of the county, one of the largest areas being located 2 or 3 miles north of Centerville. It differs from the silt loam only in that it occurs on steeper slopes (7 to 15 percent). The slopes are smooth, but still the soil contains wet spots throughout most of the year, especially where it receives seepage water from higher lying areas. As with other Venango soils, agricultural value is low. The soil is easily eroded, as the upper layers are quickly saturated and runoff becomes rapid on cleared areas.

Use and management.—Approximately 60 percent of Venango silt loam, sloping phase, has been cleared and 35 percent of it is cultivated; the rest of the cleared area is used for pasture or abandoned. Yields are about 10 percent lower than those obtained on the smoother Venango soil. The same crops are grown as on the silt loam, but less acreage is in cultivated crops and a larger percentage is in hay and pasture, to which it is better suited. Hay and pasture are also effective in controlling erosion.

Venango gravelly silt loam (Vg).—This soil occurs in small areas on 2- to 7-percent slopes. It is similar to the silt loam, but the surface and subsoil have more gravel and stones, a few of which range up to 10 or 12 inches in diameter. These fragments of sandstone and shale are large enough to interfere considerably with cultivation. In a few places, as at the base of some of the slopes in the southern part of the county along Sugar Creek and its tributaries, the stones are so large and numerous as to lower the pasture value nearly 50 percent. About 50 percent has been cleared, and of this 35 percent is cultivated, largely to hay crops and corn. Yields are 5 to 10 percent below those obtained on the silt loam.

Wadsworth silt loam (WA).—This imperfectly drained soil is intermediate in drainage between the Rittman and Frenchtown soils. It has developed on slightly calcareous olive-gray Wisconsin till that is weathered to yellowish brown and leached free from carbonates to a depth of 7 or 8 feet. The till is derived principally from acid gray sandstone and shale and contains a little limestone. This soil occurs principally in the southwestern part of the county and occupies smooth surfaces with slopes of 2 to 7 percent. Seepage water from higher lying soils is partly responsible for the wet condition a large part of the year.

This soil occurs in close association with the Wayne, Rittman, and Frenchtown soils. It differs from the moderately well-drained Rittman in that it is mottled closer to the surface, and from the poorly drained Frenchtown in the browner surface soil, the lower organic-matter content, and more compact subsoil. It is similar to Venango silt loam in drainage and color, but the parent material is heavier textured and contains a higher proportion of shale and the subsoil is more friable throughout. As with the Cambridge and Rittman soils, there is a gradual change in characteristics from the eastern part of the county where the Venango soils are common to the southwestern part where the Wadsworth occur. The boundary between these two areas is arbitrary, and in the immediate areas where the two soils are adjacent there may be soils that have intermediate characteristics.

The surface soil, to a depth of 6 inches, consists of gray to grayish-brown friable silt loam that is light gray when dry. The upper subsoil is mottled yellowish-brown, gray, and brown heavy silt loam to silty clay loam to a depth of 12 to 14 inches. The layer below extends to a depth of about 30 inches and is silty clay loam to silty clay strongly mottled with gray, yellow, and brown. It is very firm in place and has a blocky to nuciform structure, thus differing from the corresponding horizon in Venango silt loam that is hard and platy. Below 30 inches is firm yellowish-brown glacial till with a coarse platy or nuciform structure. The soil is very strongly acid above 30 inches, and the underlying parent material generally ranges from strongly acid to neutral. Gravel and angular fragments of shale and sandstone are scattered on the surface and throughout the subsoil in varying quantities but rarely in sufficient number or size to interfere materially with cultivation.

Small wet seepy strips occupied by the Chippewa soil are included in the mapping, as well as a few small areas of Rittman and Frenchtown soils. In some places the material in the lower subsoil is compact and tight, but it is not so hard as the corresponding horizon in the Venango soils.

Use and management.—The natural productivity of Wadsworth silt loam is low, since the roots of most plants cannot develop normally because of the high-water table that occurs during the wetter parts of the year. The water-holding capacity is high, as the soil water penetrates the heavy subsoil slowly. Considerable runoff occurs when rainfall is heavy. Of the 65 percent that has been cleared, 40 percent is used for crop production. As with the Venango soils, extensive areas have been abandoned.

Timothy and clover are the principal crops, with a small proportion used for corn, oats, and buckwheat. Fast-growing crops as oats and buckwheat are well adapted, and timothy and alsike clover produce fair yields. Red clover freezes out badly, and alfalfa is never successful. Oats and buckwheat do not lodge as they do on the Frenchtown soil and the other soils that are higher in organic matter. Yields of all crops, however, are slightly less than on the Cambridge, Rittman, and Meadville soils. Owing to a lower content of humus in the surface soil and a more acid condition throughout, yields are also lower for most crops than on the Mahoning soil.

A larger proportion of this soil should be used for hay and pasture, to which it is best suited. Kentucky bluegrass and white clover stands can be obtained by addition of lime and phosphate, except on the most seepy areas or wet spots.

Wayland silt loam (Wy).—This poorly drained soil has developed on flood plains on flat relief. Slopes seldom exceed 3 percent in gradient. The parent material is derived from acid gray sandstone and shale with some limestone. Areas occur principally in the northwestern part of the county in close association with the well-drained Chagrin and the imperfectly drained Lobdell soils developed on similar parent material.

The surface 6 to 8 inches is gray mottled with dark-brown and yellowish-brown very fine crumb heavy silt loam. The subsoil is gray with splotches of brown and yellow silty loam or silty clay that is plastic when wet and friable when moist. It is practically free of roots and organic matter. The lower part of the layer is wet most of the year, as the water table is generally within 2 or 3 feet of the ground surface. The subsoil and substratum are neutral to mildly alkaline and thus differ from the strongly acid Holly silt loam.

Variations in the soil material include gradations toward very fine sandy loam and silty clay in the surface layer, and the color of the upper layers differs in proportion to the quantity of organic matter and according to drainage.

Use and management.—Wayland silt loam is used to about the same extent as Holly silt loam. About 30 percent is cleared and used almost entirely for pasture. White clover and Kentucky bluegrass will not thrive well owing to the wet condition of the soil most of the year. Grasses that can withstand wet conditions, such as Canada bluegrass, redtop, and poverty oatgrass, and many weeds, such as goldenrod, devils-paintbrush, yarrow, and rush, cover most of the areas. About 2 or 3 percent of this soil produces poor yields of corn, timothy, and clover. Acre yields of corn average 20 to 30 bushels, and hay ¾ to 1 ton. Pasture growth is as good as on some of the better drained soils of the uplands and, because of the neutral reaction in the lower part, is somewhat more suitable for clovers than is Holly silt loam. Water-loving trees do well, although roots rarely go deeper than 8 or 10 inches. Natural vegetation consists of a tree growth of willow, elm, maple, and alder shrubs in virgin areas.

Artificial drainage is the first requisite in improving this soil. Deep open ditches would drain the surplus water off after heavy rains and relieve areas sooner after overflow.

Wayland silt loam, high-bottom phase (Wyh).—This soil occurs along a few of the larger streams in association with the silt loam, from which it differs essentially in position. It occupies higher levels above stream beds. Most of the areas are overflowed only during exceptionally high floods. A few areas are above overflow, although they may receive some water from adjoining slopes. Both surface and subsoil drainage are poor.

Use and management.—Approximately 40 percent of Wayland silt loam, high-bottom phase, is cleared, of which only about 5 percent is used mainly for corn, timothy, and alsike clover. Oats, wheat, and buckwheat generally lodge when grown. Yields are about 5 percent higher than those obtained on the silt loam. The soil is best adapted to hemlock forest or pasture.

Wayne silt loam (Ws).—This well-drained soil has developed on Wisconsin till derived principally from acid gray sandstone and shale with a small quantity of limestone. Most of it occupies tops of hills or knolls in the uplands where the surface is comparatively smooth with slopes up to 7 percent. Other areas, however, are morainic and hummocky and not so well suited to cultivation. Agriculturally, it is one of the best soils of the uplands in the county. Some of the largest areas occur about 3½ miles north and northwest and 1½ miles southeast of Blooming Valley, 1 and 2½ miles east of the town of Atlantic, and in the vicinity of Westford. The soil is associated closely with the moderately well drained Rittman and the imperfectly drained Wadsworth soils developed from similar parent material. It differs from the Wooster soils in that the parent material is somewhat heavier textured, and as a result the soil is heavier throughout.

The 8-inch surface soil is grayish-brown to yellowish-brown friable silt loam. The subsoil layer to a depth of about 30 inches is yellowish-brown gritty friable silt loam to silty clay loam with some stone and gravel. The substratum consists of sandy loam to silt loam, which is slightly compact yet friable, and contains much gravel and stone, mostly sandstone. The underlying bedrock of sandstone and shale is at depths of only 4 to 6 feet on the tops of knolls. The lower soil seems to have developed largely from the residue of underlying material, while the upper layers developed from glacial till and contain more silt than the substratum. The soil as a whole, however, has but little better water-holding capacity than Wooster loam. About 30 percent of the gravel is water-rounded, and 70 percent is angular fragments of shale and sandstone, generally less than 6 inches in diameter. These fragments seldom interfere with tillage operations. The entire soil and substratum are strongly acid throughout.

Included are small areas of Meadville silt loam and Wooster loam, both of which have similar crop adaptations.

Use and management.—Owing to its smooth relief and friable consistence, Wayne silt loam is used extensively for crops. About 90 percent of the total area is cleared, 70 percent of which is under cultivation. The rest is largely in pasture. Pasture, field crops, fruit, and potatoes are the important uses of this soil. It is excellent for potatoes and one of the best for fruit trees in the county, especially apples. Its position assures it of good air drainage, and the friable nature of the subsoil allows the penetration of roots and water to adequate depths. It is adapted to all deep-rooted crops, including alfalfa, if inoculation, fertilizer, and lime requirements are met. Its consistence is more nearly ideal for many crops, especially potatoes, than that of many other soils, but the uneven surface somewhat lowers the retention of water and ease of tillage.

In normal years acre yields of corn generally range from 30 to 40 bushels; oats, 20 to 35; potatoes, 125 to 250, depending on fertilization; buckwheat, 18 to 25; mixed hay, 1 to 2½ tons; and timothy, 1 ton. If it is desired to grow alfalfa, it may be well to hold certain areas for potatoes and lime other areas as needed for clover and alfalfa.

Wayne silt loam, sloping phase (Wss).—This deep soil occurs mostly along the stream slopes in the southwestern part of the county and has a gradient of 7 to 15 percent. Like the silt loam, this soil has developed from material deposited as terminal-like moraines. Most of it has a decidedly hummocky or kame and kettle relief, which in many places accounts for the steepness of slope. In other places, as on slopes along streams, the surface is mildly hummocky or with a slope toward the stream. Structure and texture of the surface soil and subsoil do not differ appreciably from that of the silt loam.

Use and management.—Of the 60 percent of Wayne silt loam, sloping phase, that has been cleared, one-third is used for crops; the rest is in pasture or idle. Corn, timothy, clover, and oats are the principal crops grown. Most of the land is too stony and rough for intensive production of potatoes. Pasture is not so good as on some of the heavier textured less well-drained soils because this soil is not so retentive of moisture. The soil could be used for apple production where good air drainage will prevent frosts. Yields of all crops are about the same as those on the silt loam.

Wayne silt loam, steep phase (Wst).—Practically all of this soil is in forest and is important only for timber production. It occurs where the morainic glacial material was banked against steep hillsides, and the surface contours conform in some degree to the underlying rock. Slopes range from 30 percent upward in gradient. Except for slope, this soil is similar to the silt loam. The deeper soil material and its occurrence on the lower slopes where some water from higher lying areas can be received make it superior to the steeper and more shallow Lordstown soils.

Wayne gravelly silt loam, moderately steep phase (Wtm).—Although essentially the same as Wayne silt loam, this soil occupies the steeper slopes of 15- to 30-percent gradient. The proportion of small sandstone and shale fragments is larger, and, regardless of slope, tillage operations are difficult. The soil occurs principally in small areas on the steeper slopes in the southwestern part of the county. About 15 percent has been cleared and is used largely for pasture.

Wooster gravelly loam (Wg).—One of the important agricultural soils of the county, this well-drained soil is in scattered areas throughout the central and eastern parts. It has developed on loose Wisconsin till derived principally from acid gray sandstone and shale with a small quantity of limestone. Since it occurs chiefly on material deposited as terminal moraines, the surface is hummocky and in places difficult to handle with heavy farm machinery. Much of it has a typical kame and kettle topography composed of series of knolls, knobs, and small pot holes, or depressions. Slopes range up to 7 percent. The largest area is south of Sugar Lake.

This soil differs from Wooster loam in having more rounded gravel and angular shale fragments throughout, making tillage difficult in most places. Many of the larger stones, however, have been picked up where the soil has been used for crops.

The surface layer is pale-brown or light yellowish-brown loose friable gravelly loam 4 to 8 inches thick. The subsoil to a depth of 36 inches is yellowish-brown gritty very friable loam with considerable gravel, showing some compaction in the lower part and in the underlying substratum. The substratum consists of gravelly sandy loam terminal morainic till. This soil is low in organic matter and strongly acid throughout. The gravel is angular and rounded sandstone and shale fragments from 1 to 6 inches or more in diameter. As typicallv developed, this soil and the other Wooster soils are not stratified in the lower depths or substratum.

Use and management.—Wooster gravelly loam is a fair crop soil but would be considerably better if the surface were smoother and less gravelly. The organic-matter content is low, and the water-holding capacity and drought resistance are only fair. The soil is utilized principally for corn, clover, timothy, and oats—the four principal crops of the county. Associated with the other Wooster soils, it includes the best land for fruit trees in the county and is also well suited to potatoes, soybeans, and vegetables. Corn for grain yields comparatively better than corn for silage, as the low organic-matter and nitrogen contents are not conducive to rank growth of corn foliage. Clover yields are fair; timothy, wheat, and buckwheat yields are slightly lower than average for the county.

Some dairying is carried on in conjunction with the production of corn, oats, and hay. As the soil has a hummocky topography and is gravelly to cobbly, only about 70 percent has been cleared. Of this, 35 to 40 percent is used for crops, 20 percent is in pasture, and a large part is idle. Yields average about 5 to 10 percent less than on the smoother and less gravelly Wooster soils. Most of the idle areas are grown up in poverty oatgrass, timothy, velvetgrass, and devils-paintbrush.

Wooster gravelly loam, rolling phase (WGR).—Most of this phase has a decidedly hummocky or kame relief, which in many places accounts for its steep slope. In other places, as on slopes along streams, the surface is mildly hummocky or with a slope toward the stream of 7 to 15 percent. Areas are mostly in the eastern and central parts of the county along the intermediate slopes of many of the streams, the largest areas being south of Sugar Lake. This soil has developed from material deposited as moraines. It is similar to the gravelly loam in profile characteristics, but its occurrence on slopes lowers its agricultural value considerably.

Use and management.—Of the 60 percent of Wooster gravelly loam, rolling phase, that has been cleared, one-third is used for crops; the rest is in pasture or idle. Corn, timothy, clover, and oats are the principal crops grown. This is a good soil for apple orchards, provided the site has satisfactory air drainage and is not in a frost area. The phase is too gravelly and rough for intensive production of potatoes. Since it is not retentive of moisture, pasture is not so good as on some of the heavier textured less well-drained soils. Yields of all crops are 15 to 20 percent lower than those obtained on Wayne silt loam and 5 to 10 percent lower than those on the gravelly loam.

Wooster gravelly loam, steep phase (WGT).—Practically all of this soil is in forest, and it is important only for timber production. It occurs where the terminal morainic glacial material was banked against steep hillsides and is similar to the gravelly loam, except for the slope that ranges upward from 25 or 30 percent. The surface contour conforms in some degree to that of the underlying rock. The largest area occurs about 4 miles southeast of Townville and along the lower slopes of Deckard Run. The deeper soil material and its occurrence on the lower slopes where it can receive water from higher lying areas make it superior to the steeper and more shallow Lordstown soils for forest growth.

Wooster loam (WL).—This soil occurs on slopes up to 7-percent gradient in association with Wooster gravelly loam and Meadville silt loam. The morainic surface is of mild kame and kettle character, but since it is not so uneven as the relief of Wooster gravelly loam, it is easier to farm. Most of it, however, has a more billowy relief than the Meadville or Wayne silt loams. It is in the eastern part of the county close to the southeastern boundary of the Wisconsin till. The largest areas are 1½ miles southeast of Centerville, 3 miles south of Townville, and near Buells Corners.

Both the surface and subsoil layers are similar in structure and color to the corresponding layers of Wooster gravelly loam but differ in containing a smaller proportion of gravel. The water-holding capacity and organic-matter content are slightly lower than for Meadville silt loam, and, as a result, pasture and hay crops do not make so rank a growth. The subsoil below 28 or 30 inches is mottled and slightly compact in some places where it is associated with the Meadville soils.

Use and management.—About 70 percent of Wooster loam is cleared and of this 50 percent is cultivated (pl. 2), 15 percent is in pasture, and 5 percent is idle. Crop yields are about equal to those obtained on Wooster gravelly loam and slightly lower than those on Wayne and Meadville silt loams.

Wooster loam, rolling phase (WLR).—Long and irregular-shaped bodies of this soil occur in association with the loam. There is practically no difference in the profile characteristics of the two soils, but they differ in the degree of slope—the rolling phase occupying areas that range from 7 to 15 percent in gradient, which makes it more difficult to farm and more susceptible to erosion. The largest areas are located in the central and eastern parts of the county in the Wisconsin till regions.

Variations include small areas with a silt loam surface. A few bodies have sufficient stone and gravel to make tillage operations difficult.

Use and management.—All the crops of the county are grown on Wooster loam, rolling phase, but the proportion in hay and pasture is

A, Landscape showing relief and cultivation of Holly silt loam in foreground and Wooster loam in background.

B, Wooster loam on typical mild kame and kettle relief.

greater than on smoother areas. Such a proportion is good soil management for erosion control, especially on slopes greater than 7 percent. About one-third of this soil is in forest and 45 percent is used for crops. Yields are about equal to those obtained on the rolling phase of Wooster gravelly loam but are 10 to 15 percent lower than on the loam.

Wooster stony loam (WR).—Scattered areas of this soil are mostly in the northeastern part of the county. Except for the stones on the surface, it is similar to Wooster loam in most respects. Most of the stones are 8 to 12 inches in diameter or larger and are numerous enough to interfere materially with tillage. This soil occurs for the most part on terminal morainic relief on irregular slopes that range up to 15 percent in gradient. Row crops are grown in many places, but the proportion in forest and pasture is higher than on Wooster loam. Yields on the two soils are comparable.

Wooster stony loam, moderately steep phase (WRM).—This phase differs from the stony loam only in that it occupies steeper slopes of 15- to 30-percent gradient. It occurs principally in small areas on the steeper slopes and escarpments in the eastern and central parts of the county. A few areas so steep and rough that they prohibit the use of heavy farm machinery have been included with this soil. About 15 percent that has been cleared is used largely for pasture; the rest is in forest.

CROP YIELDS

Estimated yields of the more important crops that may be expected over a period of years on the soils of the county are given in table 5. In cases of lack of definite yield data, the estimates are summations of field observations and knowledge of soil adaptations. As only a few soils have been artificially drained, the figures given represent soils without this improvement.

TABLE 5.—*Crawford County, Pa., soils: Average acre yields that may be expected over a period of years*

[Yields are based on the average management practices common in the county, including the use of ordinary amendments, such as lime, commercial fertilizer, and manure. Blank spaces indicate that the crop is not generally grown, and that the soil is usually considered to be unsuited to its production]

Soil	Buckwheat	Corn		Oats	Wheat	Potatoes	Hay				Pasture (Cow-acre-days) [1]
		Grain	Silage				Red clover	Alsike clover	Timothy	Alfalfa	
	Bushels	*Bushels*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*	*Tons*	*Tons*	
Allis silt loam	15	24	5.5	20			0.8	0.8	0.9		50
Moderately steep phase	12	20	4.5	16			.6	.6	.7		40
Sloping phase	14	22	5.0	18			.7	.7	.8		45
Alluvial soils, undifferentiated		26						.8	.9		40
Atherton silt loam	16	27	7.0	22	13	105	.8	1.0	1.1		60
Braceville silt loam	20	36	8.0	26	17	125	1.3	1.2	1.2	1.2	70
Cambridge gravelly silt loam	19	34	8.0	28	16	115	1.3	1.2	1.2	.8	75
Steep phase		26		22			1.0	.9	.8		55
Cambridge silt loam	20	35	8.5	28	17	120	1.3	1.2	1.2	.8	75
Sloping phase	16	30	7.0	24	15		1.1	1.0	1.0	.7	65
Canadice silt loam	15	24	6.0	20	13	95	.7	1.0	1.0		55
Caneadea silt loam	17	28	7.5	23	15	110	1.2	1.1	1.1	1.0	65
Sloping phase	16	26	7.0	22			1.1	1.0	1.0	.9	55
Chagrin loam	18	42	9.0	25	16	120	1.5	1.3	1.3	1.5	85
High-bottom phase	20	43	10.0	28	18	130	1.6	1.3	1.3	2.0	90
Chagrin silt loam	20	44	10.0	26	19	130	1.7	1.4	1.4	1.7	90
High-bottom phase	22	45	10.5	30	21	135	1.8	1.4	1.4	2.2	100
Chenango gravelly loam	21	40	9.0	30	17	140	1.4	1.2	1.1	1.8	60
Sloping phase	18	32		24	16		1.2	1.0	.9	1.6	50
Chenango gravelly sandy loam	15	32	7.0	22	13	110	1.0	.9	.8	1.3	40
Chenango loam	22	41	9.0	31	18	145	1.4	1.2	1.2	1.8	65
Chenango silt loam	23	42	9.5	32	21	145	1.6	1.4	1.3	2.0	70

Cheppewa silty clay loam		14							.7		25
Ellsworth silt loam	16	28	7.5	24	14	105	.8	.9	1.0		60
Frenchtown silt loam	15	27	7.0	23	13	100	.8	1.0	1.1		60
Gresham silt loam	15	25	7.0	23	13	95	.8	.9	1.0		60
Hanover gravelly loam	16	34	7.0	25	14	130	1.2	1.0	.8	1.4	55
Sloping phase		32	6.5	24			1.1	1.0	.8	1.4	50
Hanover loam	21	38	9.0	30	18	130	1.4	1.2	1.2	1.5	75
Hanover stony loam	21	38	9.0	30	18	130	1.4	1.2	1.2	1.5	75
Moderately steep phase		26		21			1.0	.8	.7		40
Holly silt loam		24	6.0						.9		60
High-bottom phase	16	27	6.5					.9	1.0		65
Kerrtown silt loam		50	11.5	30	23	140	2.0	1.7	1.7	2.6	100
Lake marsh											
Lobdell loam	15	32	7.0	20			1.1	1.1	1.1	1.0	70
Lobdell silt loam	16	34	8.0	22			1.1	1.2	1.2	1.0	80
High-bottom phase	18	36	8.5	24		115	1.3	1.3	1.3	1.1	85
Lordstown stony loam	15	26	6.0	22		110	1.0	.8	.8		50
Moderately steep phase									.7		35
Steep phase											
Mahoning silt loam	16	27	7.5	23	14	100	.7	1.0	1.1		60
Marengo silty clay loam		14							.7		25
Massillon gravelly loam	17	34	8.0	26	14	130	1.2	1.1	1.0	1.5	50
Massillon gravelly sandy loam	13	20	4.5	16		90	1.0	.8	.7	1.1	30
Hilly phase							.8	.7	.7		25
Meadville gravelly silt loam	19	37	8.5	30	17	125	1.4	1.2	1.1	1.5	70
Meadville silt loam	21	38	9.0	30	18	130	1.4	1.2	1.2	1.5	75
Sloping phase	17	32	7.5	26	16	120	1.2	1.1	1.0	1.3	65
Meadville stony silt loam, moderately steep phase		27		22			1.0	1.9	.8		55
Middlebury loam	15	32	7.0	20			1.1	1.1	1.1	1.0	70
High-bottom phase	16	34	8.0	22		110	1.1	1.1	1.1	1.1	75
Middlebury silt loam	16	34	8.0	22			1.1	1.2	1.2	1.0	80
High-bottom phase	18	36	8.5	24		115	1.3	1.3	1.3	1.1	85
Muck, shallow phase											20
Ottawa very fine sandy loam	17	30	7.0	25			1.2	1.1	1.0	1.4	50
Painesville silt loam	17	28	7.5	23	15	110	1.2	1.1	1.1	1.0	65
Sloping phase	16	26	7.0	22			1.1	1.0	1.0	.9	55

See footnote at end of table.

TABLE 5.—*Crawford County, Pa., soils: Average acre yields that may be expected over a period of years*—Continued

Soil	Buckwheat	Corn		Oats	Wheat	Potatoes	Hay				Pasture (Cow-acre-days) [1]
		Grain	Silage				Red clover	Alsike clover	Timothy	Alfalfa	
	Bushels	*Bushels*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*	*Tons*	*Tons*	
Papakating silty clay loam											30
Peat											
Rittman silt loam	20	35	8.5	28	17	120	1.3	1.2	1.2	.8	75
Sloping phase	16	30	7.0	24	15		1.1	1.0	1.0	.7	65
Shelmadine silt loam	15	27	7.0	23	13	100	.8	1.0	1.1		60
Tioga loam	18	42	9.0	25	16	120	1.5	1.3	1.3	1.5	85
High-bottom phase	20	43	10.0	28	18	130	1.6	1.3	1.3	2.0	90
Tioga silt loam	20	44	10.0	26	19	130	1.7	1.4	1.4	1.7	90
High-bottom phase	22	45	10.5	30	21	135	1.8	1.4	1.4	2.2	100
Titusville silt loam	20	35	8.5	28	17	120	1.3	1.2	1.2	.8	75
Sloping phase	16	30	7.0	24	15		1.1	1.0	1.0	.7	65
Trumbull silty clay loam		25	6.5	22	15		.7	.9	.9		50
Venango gravelly silt loam	15	24	6.5	22	13		.8	.8	1.0		60
Venango silt loam	15	25	7.0	23	13	95	.8	.9	1.0		60
Moderately steep phase									.8		40
Sloping phase	15	22	6.0	20	12		.7	.8	.9		50
Wadsworth silt loam	15	25	7.0	23	13	95	.8	.9	1.0		60
Wayland silt loam		24	6.0						.9		60
High-bottom phase	16	27	6.5					.9	1.0		65
Wayne gravelly silt loam, moderately steep phase		26		21			1.0	.8	.7		40
Wayne silt loam	18	36	8.0	28	16	140	1.4	1.2	1.0	1.6	65
Sloping phase	18	36	8.0	28	16	140	1.4	1.2	1.0	1.6	65
Steep phase											

Wooster gravelly loam	17	35	7.5	26	14	135	1.3	1.1	.9	1.5	60
Rolling phase	----	32	6.5	24	----	----	1.1	1.0	.8	1.4	50
Steep phase	----	----	----	----	----	----	----	----	----	----	----
Wooster loam	18	36	7.5	28	16	125	1.2	1.1	1.0	1.4	65
Rolling phase	----	32	6.5	24	----	----	1.1	1.0	.8	1.4	50
Wooster stony loam	18	36	7.5	28	16	125	1.2	1.1	1.0	1.4	65
Moderately steep phase	----	26	----	21	----	----	1.0	.8	.7	----	40

[1] Cow-acre-days, used to express the carrying capacity of pasture land, is the product of the number of animal units carried per acre multiplied by the number of days that animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit per acre for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit on 4 acres for 100 days rates 25.

LAND USE AND SOIL MANAGEMENT[4]

The agriculture of the county has been fairly stable since 1900. Growing feed crops for dairy cows is the chief use of the cleared land, supplemented with potatoes, wheat, and buckwheat as cash crops.

Most farmers follow a general system of crop rotation: (1) Corn, oats, clover, and timothy; (2) corn, buckwheat, clover, and timothy; and (3) corn, wheat, clover, and timothy. Other crops, as potatoes, alfalfa, soybeans, and barley, are substituted in the rotation on many farms. On the soils of the flood plains smaller quantities of oats, potatoes, and buckwheat are grown than on the soils of the uplands. Clover and timothy hay, which covers the largest acreage of any crop in the county, is generally plowed under after the second year for corn. Manure is often applied to the sod land before it is plowed for corn. Potatoes may follow hay crops and buckwheat may follow corn or be sown on land where corn or some other crop could not be planted in spring because of excess water. Owing to its short growing period, buckwheat has an important place in the farming system.

Pasture grasses and clover are generally sown with wheat or oats that are considered nurse crops for the grasses and legumes. It is not good practice to sow pasture grasses with buckwheat or soybeans, as these crops grow throughout the summer and shade the seedlings too much. Crawford County is second in pasture land acreage in Pennsylvania, yet pasture tends to be neglected. A good pasture that has been limed, fertilized, and properly grazed is seldom weedy. With few exceptions, weeds, poverty oatgrass, and moss are signs of soil acidity and low fertility.

Established seed varieties developed in the northeastern United States are largely used. Plant breeders continually develop new crop varieties, so hybrid corn and new kinds of wheat, oats, soybeans, and other crops will replace those now used. West Branch Sweepstakes and Cornell 11 are the popular corn varieties. Leading varieties of oats are Cornellian, Keystone, and Patterson, and of buckwheat, Sulverhull and Japanese. Both hard and soft red winter wheat are sown; most widely used are Pennsylvania 44, Fulcaster, and Kharkof. Stinking smut and hessian fly, serious wheat pests, are best controlled by preventive methods. If practicable, late sowing, rotation of crops, and plowing under of the stubble soon after harvest are recommended.

Potato varieties include Irish Cobbler, Russet Rural, and others of the Rural variety group. Most of the potato seed for commercial production is imported from Michigan and Maine. The late-maturing varieties generally yield higher than the earlier potatoes. The most successful growers of potatoes spray Bordeaux 5–5–50 mixture from 8 to 14 times to each crop to control the early and late blight diseases.

On farms with only one or two soil types, soils are sometimes used for crops not suited to them. Apples, for example, may be planted on Venango or Frenchtown soils. Fruit and intensive crops, as potatoes, should be grown only on the best-drained soils on the farm. Apple trees are more resistant to disease on better drained soils that allow deeper rooting. Roots must have air to live, so it is natural that water-saturated subsoils are poor for root growth.

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[4] Fertilizer and insect and disease control recommendations in this section were appropriate when this report was prepared (1939). Contact your county agricultural agent or the State Experiment Station for current recommendations.

For convenience in discussing their management and showing their occurrence on the map, the soils have been grouped on the basis of physiography as soils on till, lake-laid materials, outwash and stream terraces, and flood plains. Subgrouping has been made on the basis of drainage, slope, and stoniness. Each of these groups is shown by one color on the soil map, and the soils in each group are as follows:

1. Well-drained nonstony soils with gentle slopes on till:
   - Hanover loam
   - Hanover gravelly loam
   - Meadville gravelly silt loam
   - Meadville silt loam
   - Wayne silt loam
   - Wooster gravelly loam
   - Wooster loam
2. Well-drained nonstony soils with moderate slopes on till:
   - Hanover gravelly loam, sloping phase
   - Meadville silt loam, sloping phase
   - Wayne silt loam, sloping phase
   - Wooster gravelly loam, rolling phase
   - Wooster loam, rolling phase
3. Steep soils and stony moderately sloping soils on till:
   - Allis silt loam, moderately steep phase
   - Cambridge gravelly silt loam, steep phase
   - Hanover stony loam, moderately steep phase
   - Lordstown stony loam:
     - Moderately steep phase
     - Steep phase
   - Meadville stony silt loam, modately steep phase
   - Venango silt loam, moderately steep phase
   - Wayne gravelly silt loam, moderately steep phase
   - Wayne silt loam, steep phase
   - Wooster gravelly loam, steep phase
   - Wooster stony loam, moderately steep phase
   - Wooster stony loam
4. Moderately well drained gently sloping soils on till:
   - Cambridge gravelly silt loam
   - Cambridge silt loam
   - Ellsworth silt loam
   - Rittman silt loam
   - Titusville silt loam
5. Moderately well-drained soils with moderate slopes on till:
   - Cambridge silt loam, sloping phase
   - Rittman silt loam, sloping phase
   - Titusville silt loam, sloping phase
6. Imperfectly drained soils with gentle to moderate slopes on till:
   - Gresham silt loam
   - Mahoning silt loam
   - Venango gravelly silt loam
   - Venango silt loam
   - Venango silt loam, sloping phase
   - Wadsworth silt loam
7. Poorly drained soils on uplands and terraces:
   - Allis silt loam
   - Allis silt loam, sloping phase
   - Atherton silt loam
   - Canadice silt loam
   - Chippewa silty clay loam
   - Frenchtown silt loam
   - Marengo silty clay loam
   - Shelmadine silt loam
   - Trumbull silty clay loam
8. Well and imperfectly drained soils on lake-laid materials:
   - Caneadea silt loam
   - Caneadea silt loam, sloping phase
   - Painesville silt loam
   - Painsville silt loam, sloping phase
9. Well-drained and imperfectly drained nearly level to gently sloping soils on outwash and stream terraces:
   - Braceville silt loam
   - Chenango gravelly loam
   - Chenango gravelly sandy loam
   - Chenango loam
   - Chenango silt loam
   - Massillon gravelly loam
10. Well-drained moderately sloping to hilly soils on outwash:
    - Chenango gravelly loam, sloping phase
    - Massillon gravelly sandy loam
    - Massillon gravelly sandy loam, hilly phase
    - Ottawa very fine sandy loam

11. Well-drained soil on flood plains:
- Chagrin loam
- Chagrin loam, high-bottom phase
- Chagrin silt loam
- Chagrin silt loam, high-bottom phase
- Kerrtown silt loam
- Tioga loam
- Tioga loam, high-bottom phase
- Tioga silt loam
- Tioga silt loam, high-bottom phase

12. Imperfectly drained soils on flood plains:
- Lobdell loam
- Lobdell silt loam
- Lobdell silt loam, high-bottom phase
- Middlebury loam
- Middlebury loam, high-bottom phase
- Middlebury silt loam
- Middlebury silt loam, high-bottom phase

13. Poorly drained soils on flood plains:
- Alluvial soils, undifferentiated
- Holly silt loam
- Holly silt loam, high-bottom phase
- Papakating silty clay loam
- Wayland silt loam
- Wayland silt loam, high-bottom phase

14. Organic soils:
- Lake marsh
- Muck, shallow phase
- Peat

The well, moderately well, and imperfectly drained soils on till, lake-laid materials, and outwash and stream terraces (groups 1, 2, 3, 4, 5, 6, 8, 9, 10) are all managed in much the same way. They all have relatively light-colored plow layers and relatively low humus or organic-matter content in the upper layers. Fall plowing is feasible on the lighter textured soils and highly desirable except on the steeper slopes where erosion may be a problem. The surface of the heavier textured soils is likely to run together more with fall plowing, and spring plowing is more satisfactory. In fertilizing these better drained soils, a satisfactory system should be used to meet the nitrogen needs for corn, wheat, oats, buckwheat, and other nonleguminous crops. Phosphorus content is low. The quantity of potassium is fairly high, but the available supplies, especially in the surface soil, are generally low, and the addition of some potash fertilizer is profitable, especially where little manure is used. Where manure is applied, each ton supplies 5 pounds of phosphoric acid, 10 pounds of nitrogen, and 8 to 10 pounds of potash.

Potatoes usually pay for liberal fertilization; without manure a 1–2–2 ratio furnishing 200 to 248 pounds of plant nutrients, as contained in 1,000 to 1,200 of 4–8–8 fertilizer is recommended. The total plant-nutrient content might be increased to 240 to 260 pounds for early potatoes; with manure, 800 pounds of a 5–10–5 would be good.

The principal results usually obtained from fertilizer on corn are more rapid early growth, early maturity, and increased yields. Phosphorus seems to be the limiting element, although it is seldom used, as most of the manure without fertilizer is used on land planted to corn. With manure and a good sod, 200 pounds of superphosphate in the planter may be adequate. Without manure 3–12–6 or 4–12–4 supplying 40 pounds of plant nutrients may be more profitable.

Oats, soybeans, and buckwheat seldom pay for high fertilization but respond well to about 200 pounds of superphosphate per acre. In the absence of recent manuring, a 2–12–6 fertilizer supplying 35 to 40 pounds of plant nutrients may be profitable. Phosphorus and potash, where needed, help the clovers sown in the grain.

Wheat is responsive to fertilizer, especially on the lighter soils. Where manure is applied before sowing the wheat or the crop preceding the wheat, 250 to 300 pounds of superphosphate is usually all that will be profitable. If no manure has been applied for 2 years, potash should be added. Some nitrogen, in a ratio of 1–6–3 or 2–6–3, as 300 pounds of 2–12–6 on late seedings, is also beneficial on the better drained soils that are low in organic matter. Recent experiments show that best results from nitrogen are obtained when it is applied in spring rather than fall. Requirements of the clover crop were considered in the above recommendations.

Alfalfa should be sown only on the better drained soils, and red clover does well on all soils suited to alfalfa. Alfalfa or clover seeded alone, where manure has been applied, will be benefited by 300 to 600 pounds of superphosphate. An application of a 1–6–3 or 1–4–2 ratio supplying 80 to 160 pounds of plant nutrients on soils low in organic matter is desirable if manure is not used. If properly inoculated these legumes, after getting a good start, should obtain most of their nitrogen from the air and not draw so much on the nitrogen supply of the soil.

The timothy crop is greatly increased if it is top-dressed early in spring with 16 to 20 pounds of nitrogen, as in about 100 pounds of nitrate of soda, sulfate of ammonia, or similar material.

Most of the permanent pasture of the county needs lime and fertilizer. Lime, the first essential, should be applied until the soil pH is 6.0 to 6.5 for most crops, and 7.0 for alfalfa. Superphosphate should be applied at the rate of 300 to 600 pounds an acre every 4 to 5 years, and some potash may be needed on the more sandy soils. Fertilization every few years and liming at frequent intervals should maintain satisfactory production. Winter application of manure with 50 pounds of superphosphate to a load is an ideal treatment. Lime with fertilizer will bring in white clover and Kentucky bluegrass, thicken the turf, and greatly improve the quality and quantity of grazing.

All the soils of the county are naturally very acid in their virgin state and require lime for most crops when cleared of their forest growth. From determinations of the soil reaction and the quantity of lime required to neutralize the soil, all the soils should be limed, especially for good growth of clover or alfalfa.

The quantity of lime to be applied depends on what a farmer wants to grow, the type of lime to be applied, and the cost. Although 3 to 5 tons of lime an acre are required to neutralize many of the soils, 1 to 2 tons an acre harrowed in where clover is to be sown on cropland limed in previous years generally gives good alsike and fair red clover stands. After following this procedure continuously in 3 or 4 rotations the lime requirement will be reduced considerably, and fair results can be expected from mixing alfalfa seeded with clover on the better drained soils. An initial application of 2 or 3 tons of finely ground limestone, which would also take care of clover requirements, is recommended where alfalfa is sown alone, and then 1 ton an acre every rotation is necessary. Selecting the proper type of soil is the first essential for deep-rooted crops, as alfalfa will not thrive on such soils as Venango, Atherton, Mahoning, Frenchtown, and others that restrict root growth below 8 to 12 inches.

Soybeans, oats, wheat, Kentucky bluegrass, and cabbage, as well as clover and alfalfa, fail to thrive in a very strongly acid soil. Tomatoes, corn, buckwheat, rye, redtop, and timothy grow well on sour soils, although they react favorably to applications of lime on soils that have a strongly acid reaction. Most of the soils in the county are strongly acid, except those in the northwestern part. Potatoes seldom respond to lime where the soil reaction is above pH 5.3. Potato scab may be much more serious on fields where lime has been applied, so that in a rotation with potatoes lime should be applied, if at all, after rather than before the potatoes are to be grown.

Although the quantity of lime required to neutralize these soils may be 3 or 4 tons an acre, it is not always advisable to use that much even for alfalfa or red clover, as these crops will grow satisfactorily in an acid soil with a pH of 6.0 to 6.5 if the soil is liberally supplied with phosphorus and potassium.

The well and imperfectly drained soils of the flood plains (groups 11 and 12) are better adapted to corn, hay, and pasture than to other crops grown. The high-bottom phases of the soil types in these groups are adapted to a wider range of crops than the soils at lower levels and nearer the streams where floodwaters overflow the land more frequently. Following the regular crop rotations is less essential on these lowland soils than on less productive soils of the uplands, since some of them are in position to receive fertility and sediments from higher areas. Most of the lowland soils are only slightly leached.

In fertilizing crops on the soils of the flood plains, little nitrogen needs to be used, as the soils are generally well supplied with it. In fact, crops as oats and buckwheat grow too fast and lodge, owing to the high content of moisture and nitrogen. Both potash and phosphorous fertilizers should be added to balance the nitrogen content. The organic-matter content can be increased by applications of stable manure and the growing of more grasses and legumes. A sod of alfalfa and bromegrass on the well-drained soils would aid greatly in increasing active soil humus.

The poorly drained soils (groups 7 and 13) are darker colored and higher in organic matter than the lighter colored better drained soils. As they contain more nitrogen than the better drained soils, they do not need as much nitrogen in fertilizers, especially where land is to be planted to wheat, oats, buckwheat, and permanent pasture. Potatoes, requiring heavy applications of quickly available nitrogen, should have it applied in small quantities at regular intervals throughout the growing season. For best production potatoes should always be planted on the best drained soils. Manure is beneficial and aids greatly in improving the physical condition of the heavier soils. It is probably needed more on the well-drained soils that are lowest in organic matter. Most pasture grasses do well. White clover and Kentucky bluegrass, however, grow only if lime and phosphate are used; otherwise they are supplanted by a coarse growth of grass and weeds. The Chippewa, Marengo, and Papakating soils (in groups 7 and 13) are very poorly drained and are used mostly for pasture and forest. Only coarse sedges will grow on them unless they are drained, limed, and fertilized.

Lake marsh, Muck, and Peat (group 14) are also included among the soils with very poor drainage and are unsuited to cultivation in their natural condition. Some areas of Muck have been drained and used for vegetables.

CONTROL OF RUNOFF AND EROSION

Erosion in the county is fairly well controlled, owing to the system of farming that keeps most of the land under protective plants as hay, pasture, and forest. Many of the evidences of surface erosion and a few of gully erosion could be controlled under practical soil management methods. Many fields with slopes over 15 percent have been cultivated for nearly a hundred years, and about half the surface soil has been removed. The farmer cannot influence the rainfall nor the steepness of slope, but he can maintain soil conditions under sod crops that help in the absorption of a large part of the normal rainfall.

Under similar conditions, different soils vary in the extent to which they are affected by erosion. A given quantity of rain may produce no runoff on a deep porous soil, while most of the rain will be lost from a shallow compact soil or an exposed subsoil. In discussing the erosion problem many of the soils can be grouped together; for instance, there is practically no erosion on the nearly level soils of the terraces and flood plains. The degree of slope is the most important factor in the quantity of erosion under similar cropping systems, although character of the soil material is very significant.

The soils suffering most from erosion and those that are most susceptible to surface erosion are those with heavy or compact subsoil that lies fairly close to the surface. These include the Allis, Venango, Cambridge, Caneadea, Canadice, Titusville, and Gresham silt loams having slopes greater than 7 percent. Because the compact layers interfere with absorption and retention of water and seepage and runoff from higher land occur, erosion becomes more serious, especially on the longer slopes. The Venango and Cambridge soils, the only soils in this group having slopes greater than 20 percent, should be in permanent pasture or planted to trees if they are not already occupied by growing timber. If pasture land is badly needed, permanent pasture on the slopes from 7 to about 20 percent would be fairly efficient in preserving the surface soil if the area were not overgrazed. Crop yields are low on the Venango, Wadsworth, and Gresham soils and where feasible these soils should be used for pasture. Liberal applications of lime and fertilizer are required to get good pasture on these soils.

Slopes of 7 to 15 percent of the Wayne, Wooster, Meadville, Massillon, Ottawa, and Hanover soils can be cropped without serious losses if a high percentage of the land is kept in legumes. Crops as corn, wheat, and potatoes should seldom be grown more than once in 4 or 5 years on slopes greater than 15 percent, unless strip cropping is practiced.

Some effective methods for the control of erosion and runoff in the production of feed crops and potatoes are: (1) Keep the steeper cultivated slopes in grass, pasture, or meadow and reforest the slopes where erosion is most difficult to control. (2) Keep up a good supply of organic matter to aid root development, improve soil structure, and increase infiltration rate. (3) Plow, plant, and cultivate on contour lines, that is, across or around the slope. (4) Practice strip cropping on longer slopes if they are being used for cultivated crops. (5) Avoid making wheel tracks, particularly deep ones, either directly or diagonally up and down the slope.

DRAINAGE

More than 50 percent of the soils of the county have poor or imperfect drainage. Surface erosion is more likely to occur where underdrainage is poor. Runoff should be prevented as much as possible because it carries away large quantities of soil, lime, and fertilizer that should remain for crop production. Tile drainage facilitates soil aeration, encourages deeper rooting of crops, enabling them to better withstand drought and to obtain more plant nutrients from the subsoil; and may increase the capacity of heavy soils to absorb water, thereby lessening surface runoff and erosion. There has been little artificial drainage, since the cost is often greater than the increased values from the crops in an area where most crops are supplementary to dairying.

The soils with gray or mottled yellow, gray, and brown subsoils would produce larger yields if better drainage could be developed. Row crops may be grown successfully in years when rainfall is less than usual, but if rainfall is average or above, they will not do well. The moderately well drained soils with mottled layers at 16 to 18 inches or deeper are sufficiently well drained for most of the crops of the county except alfalfa. These soils could be improved somewhat by a combination of tiles and ditches, although under the present farming system artificial drainage may not be economical.

The drainage of many soils can be improved by the use of open ditches that can be installed more cheaply than tile drains and may actually be more effective in quick removal of excess surface water. Straightening and deepening many of the sluggish drainageways would relieve the soils of the flood plain of excess water and reduce flooding to some extent. Stream channel deepening and straightening of Cussewago Creek might improve the drainage of the Papakating, Holly, and Wayland soils and widen their range of crop adaptation.

The Mahoning, Frenchtown, Atherton, Canadice, Marengo, Chippewa, and Shelmadine soils of the uplands and terraces can be improved by open drains to hasten the removal of surface water. Ordinary systems of tile drainage would improve the Frenchtown, Atherton, and Shelmadine soils considerably because they are sufficiently porous to allow lateral movement of subsoil water to the tile drains. On many of the flatter areas great care must be exercised in tiling in order to obtain an even grade and uniform fall to a satisfactory outlet. The rate of fall may be increased toward the outlet, but it should never be decreased without inserting a silt well, as checking the current may cause the tile to become choked with silt. Under the present system of dairy farming with general crops, it is doubtful that the expense of tile drainage will be justified by increased yields on the heavier soils, which are difficult to drain properly because of the compact hardpan or claypan conditions that exist in the soils of the uplands that have been developed over hard glacial ground morainic material.

The Wadsworth, Venango, and Gresham soils are the most difficult to drain effectively, for they occur on slopes subject to seepage water and are underlain by heavy hardpan layers that are impervious. It is unlikely that the increase on yields from draining these soils would justify the cost of drainage. The Allis soils can hardly be improved by artificial drainage, as they are heavy, plastic, and too shallow to bedrock.

The depth to which tile is buried in soils depends on crops to be grown, character of soil material, and spacing distance between tile lines. Deep-rooted alfalfa would need deep tile drainage. Wheat, small grains, pasture, and alsike clover would respond well to medium depth drains. About 4 feet, for instance, is only a fair depth for orchard drainage. Tile lines must be below the frost level, or about 30 inches below the surface.

The drainage of peat areas presents difficult problems, and, unless specialized crops are grown, it is better to consider the cost thoroughly before attempting to drain. Peat deposits shrink and subside after drainage, and if overdrained they may be a serious fire hazard in dry weather. A few small mixed muck and peat areas might be profitably reclaimed for high value vegetable crops provided the cost of draining is moderate.

The quantity of white clover and Kentucky bluegrass in many pastures could be increased if the water table were lowered to 2 feet or more beneath the surface. On wet land these grasses fail because of shallow rooting and serious frost heaving in winter and spring.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of environment acting on the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the soil material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

Crawford County lies principally within the Gray-Brown Podzolic soil region. Following the melting of the ice of the different glacial periods, the remaining glacial drift and water-laid deposits were encroached upon and covered with a growth of conifers and mixed hardwoods. Later the forest became a mixed hardwoods type, mainly beech and maple with scattered stands of hemlock and white pine. Soils developed under this type of vegetation did not accumulate much organic matter, the quantity incorporated depending on the character of drainage. Soils occurring in depressions and on level land generally contained larger quantities of vegetable matter and nitrogen than soils occupying well-drained situations. All the virgin soils had a layer of partly decomposed leafmold with 1 to 4 inches of surface soil rich in organic matter, but as the land was cleared and brought under cultivation this material decayed rapidly.

Although most of the parent materials consist of the products of glaciation, they nevertheless show some relation to the underlying glacial drift and rocks, particularly in the southeastern section of the county. The geologic rock strata, though appearing to be horizontal, dip in a southerly direction at the rate of about 15 to 20 feet to the mile. These strata are indurated sediments of Devonian, Pennsylvanian, and Mississippian ages. The Pottsville formation of Pennsylvanian age is a sandstone conglomerate with intervening shale beds. With few exceptions it occurs only in that part of the county lying southeast of a line joining the southwest and northeast corners. In this area the larger streams flow in valleys cut below the Pottsville, and thus the Pottsville is left only on the divides between the streams. The central part of the county is underlain by the Pocono group of Mississippian age. This formation consists of massive and thin-bedded sandstone with sandy shale and irregular limestone beds. The northwestern part of the county is underlain by thin-bedded sandstone and shale of the Conewango and Chemung formations of Devonian age.

Most of the soils of the county have been derived largely from the till of the late Wisconsin glaciation. This till is to a large extent of local derivation and consists mainly of material from sandstone and shale mixed with a little material, some of which contains lime carbonates, that was brought in from localities farther north. Rocks of Canadian derivation—greenstone, limestone, granite, and gneiss—are common. Varying quantities of rounded and angular pebbles, cobbles, and boulders are scattered over the surface and through the till. The depth of this mantle of heterogeneous material over the underlying rock formations is variable. The drift on the upland is fairly thick, averaging 8 to 15 feet except for the much thicker morainic deposits, kames, and eskers. The valley fill, however, is more than 200 feet thick in many places, and in one well in the city of Meadville, 475 feet of outwash and valley fill was encountered.

In the northwestern part of the county north of the Cleveland moraine, the Wisconsin till seems to be somewhat younger than in the rest of the county. The soils have been exposed to the soil-developing processes for a shorter time, and the carbonates have not been leached to so great a depth. The deep glacial drift is characteristic only of the area covered by the Wisconsin ice sheet. The Illinoian drift in the southeastern part of the county is medium thin, usually a 2- to 10-foot deposit on uplands, but reaches a depth of more than 50 feet in places in the smaller valleys. Nowhere has it been found more than 200 feet thick.

The soils and parent materials of the Illinoian drift show markedly deeper weathering and oxidation than the material of the Wisconsin glaciation. The parent material is generally friable with less evidence of compaction. In some places cobblestones and boulders compose a large part of the deposits, but on the steeper slopes where practically no ice-laid material has been left the material resembles residuum from local sandstone and shale.

Calcium carbonate and the other more soluble basic salts have been mostly leached out of the profiles of the soils, bringing about an acid condition both in the surface and the subsoil except in the soils developed from heavier glacial till or lacustrine material. The Ellsworth, Mahoning, Trumbull, Marengo, Canadice, and Caneadea soils in the northwestern part of the county have alkaline or calcareous substrata.

The well-drained soils have prevailingly light-brown or yellowish-brown plow layers with a low content of organic matter. The yellowish-brown subsoils are free of mottlings and become heavier textured at a depth of 16 to 30 inches. The till is friable, although it is inclined to be compact and contains many small angular and rounded pebbles. The pH of the surface soil ranges from 4.0 to 5.5; the highest degree of acidity occurs immediately beneath the surface soil where leaching has been most complete. The subsoil generally ranges in acidity from a pH of 4.7 to 6.0. The parent material has a slightly acid to alkaline reaction, depending upon location.

In addition to the mixing of materials by ice action, large deposits of soil material were made in glacial lake waters that occupied several of the valleys. These lacustrine deposits occur continuously from Conneaut Lake north to Conneautville, and other large deposits are along the Shenango River and near the headwaters of Muddy Creek. Sediments laid down in the areas covered by these old lakes include materials ranging from medium sand to clay. Some areas of these lake sediments were later reworked and redeposited by streams that flowed through the valleys after the lakes disappeared.

The soil-forming agencies, operating on the materials covering the county, have been largely restricted by lack of drainage, and most of the soils show this influence by the development of mottled layers. Lack of drainage is correlated largely with relief in the western part of the county; whereas, in the rest of the county the character of the soil materials and the underlying strata play an important role in the soil drainage linked in with the topography.

Following is a description of a profile of Wooster loam, which may be considered a well-drained soil in a virgin area, 1¼ miles south by southwest of Sugar Lake:

A_1. 0 to 1½ inches, dark grayish-brown loose loam with organic matter and roots.

A_2. 1½ to 8 inches, light yellowish-brown with some grayish-brown gritty very friable loam with well-decomposed organic matter; profuse rounded and angular gravel.

B_{21}. 8 to 26 inches, yellowish-brown gritty very friable loam; considerable gravel ½ to 2 inches in diameter.

B_{22}. 26 to 36 inches, yellow and brownish-yellow slightly compact but very friable gritty heavy loam almost free of roots and gravel.

The material throughout the entire profile is acid. Podzolization is probably as far advanced on the Wooster soils as on any other soils, and a gray leached layer varying from ¼ to 1½ inches thick is noticeable in some places.

Closely resembling the Wooster soils are the Hanover and Wayne soils. The Hanover soils have developed on Illinoian till and differ in the deeper degree of leaching, stronger color of the till, smoother surface topography, and shallower depth to bedrock. The Wayne soils have developed on Wisconsin till in the southwestern part of the county and differ from the Wooster soils in that the till from which they were developed is heavier, and the subsoil shows a very distinct heavier texture and a well-developed nuciform structure.

The following profile description of Chenango loam was observed 1 mile northeast of Drakes Mills in a virgin area.

A_1. 0 to 1½ inches, dark grayish-brown mass of roots, organic matter and granular loam.
A_2. 1½ to 6 inches, light yellowish-brown very friable loam with some well-decomposed organic matter and roots.
B_{21}. 6 to 20 inches, yellowish-brown friable easily pulverized nuciform to blocky structured silt loam with roots and small gravel; gravel is largely clean and free.

Below 32 inches is yellowish-brown gravel and sand that is loose and almost incoherent, becoming stratified at a depth below 5 feet. Compact, cemented, calcareous material, which contains many small limestone and granite pebbles, is generally encountered at 8 to 10 feet.

The Chenango soils, being underlain by sand and gravel, are inclined to be more droughty than the Wooster soils in spite of their more favorable position. Closely associated with the Chenango are the imperfectly drained Braceville and the poorly drained Atherton soils, which occur on flat stream terraces.

The Massillon soils, confined to kames, eskers, and hummocky areas, represent piles of material dumped and assorted by melting ice. The following profile is typical of Massillon gravelly sandy loam observed in an esker east of Conneaut Lake:

A_1. 0 to 2 inches, dark grayish-brown mat of organic matter, roots, and soil.
A_2. 2 to 9 inches, grayish-yellowish gritty very friable sandy loam; upper part is slightly darker than the lower, owing to the greater content of organic matter.
B_{21}. 9 to 18 inches, yellowish-brown gritty, gravelly slightly compact sandy loam; compact aggregates are fragile and readily break into a structureless mass.
B_3. 18 to 40 inches, dark yellowish-brown sand and gravel that are loose, porous, and cleanly washed.
C. 40 inches +, sandy and gravelly substratum stratified in many places and resting on cemented calcareous material at 8 to 12 feet below the surface.

Occurring on topography almost like that of the Massillon soils is the well-drained Ottawa. It has developed on deltaic deposits in several valleys of the county. A typical profile of Ottawa very fine sandy loam consists of:

A_1. 0 to 4 inches, dark grayish-brown very friable very fine sandy loam with a relatively large quantity of organic matter.
A_2. 4 to 9 inches, pale-yellow very friable very fine sandy loam with a small quantity of organic matter and roots.
A_3. 9 to 16 inches, yellow very friable very fine sandy loam; very faintly compact; holds together in weak aggregates 2 and 3 inches in diameter.
B_2. 16 to 40 inches, yellow soft very fine crumb very fine sandy loam.
C. 40 to 50 inches, yellowish-gray loose, almost incoherent, very fine crumb loamy very fine sand; underlain by thinly laminated material showing distinct varves in most places; rust-colored seams and cemented iron-oxide coatings are common.

Both the subsoil and parent material are strongly acid. Roots readily penetrate all the layers.

Other soils formed in lake-laid deposits include the Caneadea, Painesville, and Canadice series. The Painesville are well-drained soils on silt and clay; the Caneadea, imperfecty drained; and the Canadice, poorly drained. All these soils show lamination to some extent in the parent material. Following is a description of Canadice silt loam observed 1 mile southwest of Conneaut Lake:

A_1. 0 to 2 inches, very dark grayish-brown very friable fine crumb silt loam with mass of roots and organic matter.

A_2. 2 to 7 inches, light yellowish-brown granular or nuciform friable heavy silt loam.

B_{21}. 7 to 18 inches, mottled light-gray and yellowish-brown slightly compact silty clay loam with a nuciform to blocky structure; under pressure the clods break into a structureless mass.

B_{22}. 18 to 32 inches, gray splotched with brown dense blocky silty clay that is hard when dry and plastic when wet; duller in color than above layers and practically free of roots.

The substratum is heavy compact silt and clay free of coarse material and varved or laminated at lower depths. The material is acid to a depth of about 20 inches and gradually becomes more alkaline and finally calcareous in the lower part.

The Meadville soils represent an intermediate position in drainage, compaction, and surface smoothness between the Cambridge and Wooster soils. The following is a profile description from a cultivated area of Meadville silt loam observed about 1 mile east of Pettis:

A_p. 0 to 8 inches, brown friable silt loam with a small quantity of organic matter and some rounded and angular fragments of sandstone and shale.

B_{21}. 8 to 14 inches, yellowish-brown friable heavy silt loam of weak very fine crumb structure; the dark color is due to some organic matter.

B_{22}. 14 to 26 inches, yellowish-brown friable silty clay loam pierced by roots and containing some angular and rounded gravel; has no compaction and no distinct structure.

B_{23}. 26 to 40 inches, yellowish-brown with mottlings of gray and brown moderately compact and platy silty clay loam; penetrated by only a few roots, many of which spread horizontally as they contact the upper part.

The underlying material is compact partly weathered glacial till containing numerous sandstone and shale fragments that are mostly less than 6 inches in diameter.

The color and structural profiles of the Cambridge and Titusville soils differ from the Meadville in having more compact and distinctly platy structured subsoils and in the shallower depth to the compactness, which is 12 to 20 inches below the surface. The Cambridge soils are developed on Wisconsin till and the Titusville on Illinoian till. The Rittman soils have the same general profile characteristics, but they have the compact platy subsoil developed to a much less degree and are more friable throughout.

Below is a profile description of Cambridge silt loam observed 2 miles northeast of Little Cooley:

A_1. 0 to 2 inches, very dark grayish-brown very friable silt loam with mat of roots and organic matter.

A_2. 2 to 6 inches, light yellowish-brown friable single-grained silt loam with a small quantity of organic matter.

B_1. 6 to 14 inches, yellowish-brown friable weak blocky heavy silt loam with many roots.

B_{21}. 14 to 20 inches, mottled yellowish-brown, gray, and brown compact material of hard coarse platy structure; penetrated by only a few roots, some of which spread parallel with the surface.

B_{22}. 20 to 36 inches, yellow and rusty-brown splotched with gray moderately compact silty clay loam with a platy structure.

The substratum differs little from the 20- to 36-inch horizon, except it is slightly less compact and has a slightly acid to neutral reaction. The upper layers have a pH of about 4.3 to 5.0. Angular and rounded water-smoothed fragments of sandstone and shale are mixed throughout the soil but are mostly noticeable in the lower subsoil and the underlying till.

Farther down in the drainage scale are the Venango, Gresham, and Wadsworth soils. The Venango soils occupy slopes and knolls and owe their compactness to seepage, ice compaction, or cementation. Typical Venango silt loam in Crawford County does not have as well-developed hardpan as the related Volusia throughout the State.

A profile description of Venango silt loam is as follows:

A_1. 0 to 2 inches, very dark grayish-brown partly decomposed mass of organic matter and silty soil.

A_2. 2 to 7 inches, grayish-brown loose friable silt loam with very fine crumb structure.

B_1. 7 to 14 inches, mottled gray, yellow, and rusty-brown nuciform and easily pulverized but slightly compact heavy silt loam.

B_2. 14 to 36 inches, mottled gray yellowish-brown very compact silty clay loam with a platy structure; very hard in place but breaks up easily when removed.

C. 36 inches +, yellowish-brown with splotches of gray compact firm gritty silty clay loam; generally slightly acid and only slightly weathered.

Both the surface soil and subsoil are acid, the pH ranging from about 4.5 to 6.0.

Gresham silt loam differs from Venango silt loam mainly in having a brighter color in the parent material, deeper leaching, and a slightly lower pH as is characteristic of the soils developed on Illinoian till compared with those developed on Wisconsin till. Gray silty material is found along fractures and root holes, and streaks and splotches of manganese are in the Gresham subsoil. The Rittman soils are developed on Wisconsin till and are like the Venango except they do not have a distinct hardpan.

The Frenchtown soil differs from the Venango in its occurrence on smooth or almost flat situations which for the most part are less than 2 percent in slope. It is poorly drained and has a higher content of organic matter and practically no compaction in the subsoil. The Shelmadine soil is similar to the Frenchtown in all respects, but it has developed over Illinoian till.

The Ellsworth, Mahoning, and Trumbull soils are located largely in the northwestern part of the county and are developed on heavy Wisconsin till that is alkaline to calcareous. The Trumbull soil is more poorly drained than the Mahoning and has a light-gray or nearly white leached subsurface layer 4 to 8 inches thick. It occupies practically flat or level positions in slight depressions around drainage heads where runoff is slow. The Ellsworth soil is not mottled within 15 or 18 inches of the surface.

A description of Mahoning silt loam observed 1½ miles west of Beaver Center follows:

A_1. 0 to 1½ inches, very dark grayish-brown friable silt loam with a mass of roots and organic matter.

A_2. 1½ to 7 inches, light-gray friable silt loam of fine granular structure; the organic matter is well decomposed and intimately mixed with the soil.

B_1. 7 to 32 inches, gray with rusty-brown and yellow plastic silty clay loam; some light-gray silty colloidal material in the factures; gritty and of blocky structure; contains very few roots.

C. 32 inches +, brown mottled with gray and yellow gritty gravelly slightly compact but friable silt loam to clay loam with a blocky structure.

The material is acid to a depth of 20 to 30 inches, and the underlying soil is alkaline. Only a few small fragments of sandstone and shale are associated with this soil, which is typical of the more sloping soil areas.

Permanently wet soils on till include Chippewa and Marengo soils that occupy heads of drains and depressions and, aside from the degree of drainage and darker surface soil, resemble the Frenchtown. The Chippewa soil has developed on acid material and the Marengo on alkaline material.

The Lordstown and Allis soils are shallow, and bedrock occurs at 18 to 40 inches below the surface. The Lordstown soils are loose and friable and occur over sandstone; whereas the Allis rest on shale and are heavy and highly mottled. Both are strongly acid, as is the material from which they have been derived.

The alluvium in this county, mainly local in origin except for areas along French Creek, occurs in narrow flood plains along most of the streams. Owing to its recent deposition and disturbance by overflow, well-defined profile layers are not present, although the high-bottom phases have heavier textured B horizons and the profile exhibits a slightly greater degree of leaching than the typical soils that are overflowed frequently. The well-drained brown sediments are classed in either the Tioga or Chagrin series, depending on the reaction. The poorly and very poorly drained soils are members of the Wayland, Holly, and Papakating series. The Middlebury and Lobdell soils represent an intermediate condition of drainage. Kerrtown silt loam, closely resembling and associated with the well-drained Tioga soils, is seldom overflowed and is characterized by a thick almost black surface soil that was presumably formed under prairie or grassland conditions. Alluvial soils, undifferentiated, consist of soils too intricately mixed to show individually on the map.

Organic soils, composed of vegetable matter in various stages of development, have accumulated for the most part in old lake beds and swamps. These deposits are classed as Peat, Lake marsh, and Muck. Most of the Muck is shallow and consists of 1 to 3 feet of well-decomposed black organic matter over grayish-blue plastic clay. Peat and Lake marsh are fibrous brown slightly decayed woody and sedgy materials.

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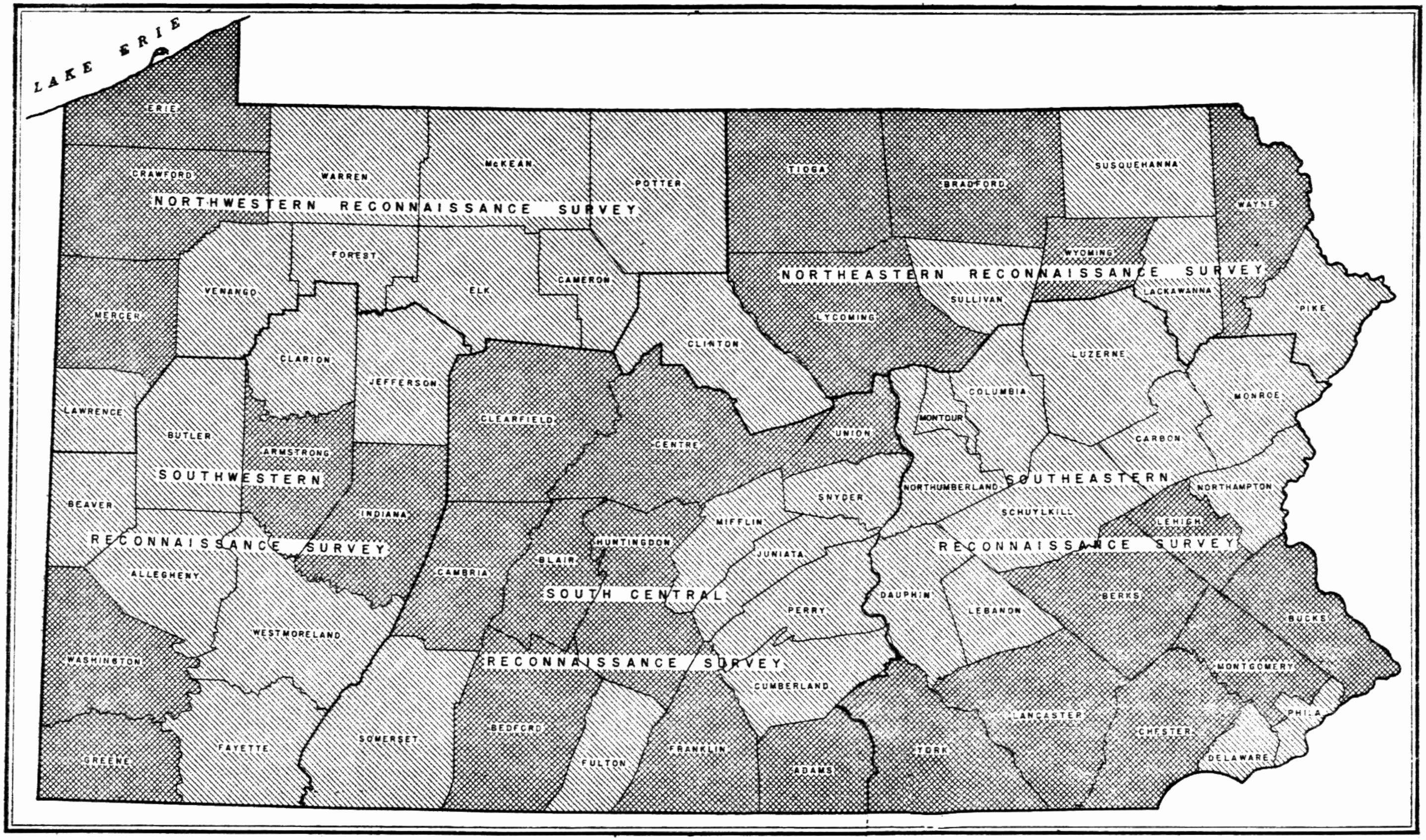

Areas surveyed in Pennsylvania shown by shading. Reconnaissance surveys shown by northwest-southeast hatching; cross hatching indicates areas covered by both detailed and reconnaissance surveys.

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