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Soil Survey

Niagara County New York

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS PROVIDE a foundation for all land use programs. The report on each survey and the map that accompanies the report present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (a) Those interested in the area as a whole; (b) those interested in specific parts of it; and (c) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, docks, urban sites, industries, community cooperatives, resettlement projects, and areas for private or public forests, recreation, and wildlife management. The following sections are intended for such users: (1) General Nature of the Area, in which physiography, drainage, climate, settlement, population, transportation, and markets, are discussed; (2) Agriculture, in which a brief history of the agriculture is given and the present agriculture described; (3) Productivity Ratings, in which the productivity of the soils is given and a grouping of soils according to their relative physical suitability for agricultural use is presented; (4) and Land Use and Agricultural Methods, in which the present use and management of the soils are described, their management requirements discussed, and suggestions made for improvement in management.

Readers interested chiefly in specific areas—such as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. The reader's first step is to locate on the map the tract with which he is concerned. The second is to identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them. The third step is to locate in the table of contents in the section on Soils the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. He will also find useful information in the sections on Productivity Ratings and on Land Use and Agricultural Methods.

Students and teachers of soil science and allied subjects, including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology, will find their special interest in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils, in which are presented the general scheme of classification of the soils of the area and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on General Nature of the Area, Agriculture, Productivity Ratings, and the first part of the section on Soils of particular value in determining the relations between their special subjects and the soils in the area.

This publication on the soil survey of Niagara County, N. Y., is a cooperative contribution from the—

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SOIL SURVEY OF NIAGARA COUNTY, NEW YORK

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

CONTENTS

NIAGARA COUNTY borders the southern shore of Lake Ontario in the extreme northwestern corner of New York. An escarpment, the Niagara, divides the county into two plains—the Ontario, on the north, and the Huron, on the south. Fruit and vege-

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

table growing is confined mainly to the Ontario plain, where the tempering influence of Lake Ontario is most pronounced. The less well-drained soils of the Huron plain are used mostly for hay, grain, and pasture, and dairying assumes a prominent place. Fruit growing dominates the agriculture of the county. Dairy, poultry, and other likestock products are a major source of farm income, and vegetable and field crops are of considerable importance. Development of water power has led to the establishment of many industries employing electrical processes at Lockport and Niagara Falls. Lumber products are manufactured at North Tonawanda. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1937 by the United States Department of Agriculture and the Cornell University Agricultural Experiment Station. The essential features may be summarized as follows.

SUMMARY OF THE SURVEY

Situated in the northwestern corner of New York, with the Niagara River on the west and Lake Ontario on the north, Niagara County lies in the Eastern Lake section of the Central lowland physiographic province and comprises parts of the Huron and Ontario plains. The Niagara escarpment, a steep northward slope a few rods to 2 miles wide, separates the two. The soils have developed principally from materials deposited through glacial action. The underlying formations from which most of the soil-forming materials were derived are wholly sedimentary and of Paleozoic age, ranging from Ordovician to late Silurian. Only comparatively small areas of the parent material are exposed by weathering.

The surficial deposits, mostly of the Quaternary period, include glacial drift and associated lacustrine materials. The drift covers about half of the land surface; lake-laid deposits, recent alluvium, and residual materials the rest. The drift, chiefly of Wisconsin age, occurs in the forms of kames, eskers, and sheets of outwash sand and gravel; the lacustrine materials were laid down around the shores of lakes as the ice retreated, and associated with them are beds of sand and gravel deposited in the channels of streams that flowed into the lakes.

The soils have developed under a forest cover predominantly of maple, beech, oak, and ash. The well-drained soils, occupying a relatively small area, are light-colored and low in organic matter; the imperfectly drained are gray; and those with poor drainage are dark gray to nearly black.

The soils are placed for discussion in seven groups, based on profile characteristics, as follows:

1. Soils developed principally from stratified fine sediments. These include Dunkirk, Newfane, Arkport, and Berrien soils of good to fair drainage and suitable for orchards; Collamer, Fulton, and Schoharie soils of heavy and imperfect drainage—many orchards are on the Collamer soils but are shorter lived or lower yielding than those on well-drained soils, and Fulton and Schoharie soils are best suited to hay and grain; and Allendale, Wauseon, and Rimer soils, too wet for fruit trees and used mainly for hay and some grain and vegetables.

2. Soils developed from unassorted gravelly and stony materials, including the Ontario, Hilton, Clarkson, Cazenovia, and Lyons series.

Ontario, a well-drained excellent soil, is used for fruit, grains, alfalfa, and vegetables. Hilton is very extensive on the Ontario plain but a rather poor soil for orchards, owing to imperfect to poor drainage and a compact subsoil. Clarkson is fairly well drained but shallow in places and has a total area less than that of either the Ontario or the Hilton soils. Cazenovia is well drained and a fair to good soil, but the area is too limited to be more than locally significant. Lyons is a poorly drained dark-colored soil associated with the other members of the group and best suited to pasture.

3. Soils developed from stratified sand and gravel deposits, made up of the Alton, Somerset, and Medina series. Alton soils, gravelly, porous, and well to excessively drained, are well suited to fruit and vegetable production. Vegetables sometimes suffer from moisture deficiency, but the roots of trees extend deep enough to utilize subsoil water. Somerset soils, imperfectly to poorly drained, are used in places for pears and plums. Where artificially drained they make good soils for vegetables. Medina soil, a very minor type with bedrock close to the surface, is used principally for field crops.

4. Soils developed largely from bedrock include members of the Lockport, Farmington, and Brockport series. Lockport, a poorly drained and heavy soil, with red shale at 24 to 30 inches, is poor for fruit, but in many places is used for pears and plums. Farmington, a very shallow and stony soil, with limestone at a depth of 8 to 15 inches, though too dry for crops, is used for pasture land or forest. Brockport relief is level to gently sloping, and drainage is fair to good; the soil is used for alfalfa, clover, wheat, corn, and to a certain extent for orchards.

5. Soils developed on flood plain deposits are of the Hamlin, Tonawanda, and Eel series. Hamlin is well drained and, where not subject to flooding, an excellent soil. Tonawanda soils are heavy and wet and are used mainly for hay and pasture land. Eel soils are developed from imperfectly drained flood plain deposits.

6. The soils of the sixth group, though developed under poor to very poor drainage conditions from silty and clayey glacial-lake sediments, are extensively used and include members of six series. Toledo, Poygan, and Wolcottsburg soils are best suited to hay and pasture under natural conditions, but where drained are used for small grains and corn, and, in the case of the Wolcottsburg, for vegetables. Granby, Colwood, and Wayland soils are mainly wasteland or are forested, owing to a swampy condition.

7. The miscellaneous soils and land types constitute a nonagricultural group. The mucks are undrained, and the group of alluvial soils, undifferentiated, is mapped on Goat Island in the Niagara River at the crest of the falls.

Niagara County lies entirely within the region of the Gray-Brown Podzolic great soil group.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Niagara County is in the northwestern corner of New York (fig. 1), its western boundary, the Niagara River, and its northern, Lake Ontario, here forming the international line between the United States and the Dominion of Canada. With an east-and-west extent of 30

miles and an average width of 17 miles, the approximate land area is 533 square miles, or 341,120 acres. Lockport, the county seat, is 20 miles northeast of Buffalo and 55 miles west of Rochester.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Niagara County lies in the Eastern lake section of the Central Lowland physiographic province. This section, in turn, is divided into the Erie, Huron, and Ontario plains, and the county occupies part of the last two of these. The Ontario plain extends from the shore of Lake Ontario to the foot of the Niagara escarpment, and the Huron plain from the crest of the escarpment southward beyond the county line.

The Niagara escarpment consists of a steep northward slope, along which perpendicular bluffs are exposed in places. The crest has an elevation of slightly more than 600 feet. It is steeper and narrower in the western part, ranging in width from only a few rods at Lewis-

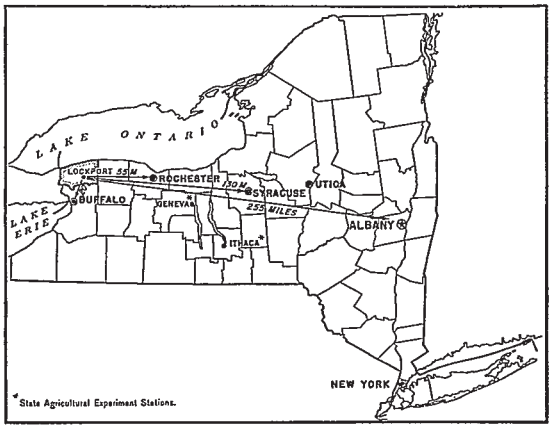

FIGURE 1.—Location of Niagara County in New York.

ton to nearly 2 miles in the eastern part. North of the 400-foot contour line the nearly level lake plain slopes at the rate of 20 feet a mile toward the lake, 8 miles distant. The surface of the lake is 246 feet above sea level, and the lake shore is nearly everywhere bordered by low bluffs 15 to 60 feet high. The land surface is fairly uniform, though diversified by the broad, shallow valleys of the minor streams. The minor irregularities of relief have a northeast-southwest trend, as indicated chiefly by the courses of the streams, most of which flow northeastward.

Along the inner margin of the Ontario plain—in some places close to the base of the escarpment and in others more than 4 miles north of it—runs a low but well-marked rather sinuous ridge, which rises 10 to 30 feet above the level of the surrounding land and extends in a general westerly direction from Johnson Creek in the eastern part of the county to Ridge Road, where it turns southwestward to Wrights Corners. The ridge is not well developed across the valley of Eighteenmile Creek, but it reappears near Warrens Corners and extends westward to the base of the escarpment east of Lewiston. Although low and in places inconspicuous, the ridge is an important

topographic feature, as it is traversed by a main highway—United States Highway No. 104, or the Ridge Road—and is everywhere thickly settled. It represents an old beach ridge formed by a predecessor of Lake Ontario (*4*),[2] and a well-worn Indian trail followed it before the advent of white men.

For the last few miles of their courses, the larger streams flowing into the lake descend through narrow gorges 10 to 30 feet deep. About 4 miles above its mouth Eighteenmile Creek flows through a gorge that is 70 feet deep and ⅛ mile wide and has precipitous walls in places. The broad, shallow valley of the Niagara River crosses the Ontario plain on the west.

About half the area of the county is occupied by the Huron plain, the central part of which, extending from Wolcottsville westward past Tonawanda, is nearly flat and slopes gently westward from an altitude of 600 feet or more on the east to 570 feet along the Niagara River. The evenness of the greater part of the surface is broken here and there by low narrow northeast-southwest irregular ridges ranging from ¼ to nearly 2 miles in length and rising 20 to 50 feet above the general land surface. West of Lockport a long narrow ridge roughly parallel to the Niagara escarpment lies along the northern margin of the plain. This ridge rises 20 to 40 feet above the plain, reaching an altitude of 660 feet at one or two points near Pekin and 680 feet about 2 miles east of Dysinger. East of Lockport the surface is more or less irregular and there are several low ridges having a general east-west trend.

The general elevation of the Huron plain is 600 feet, ranging from 575 feet at the mouth of Tonawanda Creek to a maximum of 680 feet near Dysinger. The elevation at Lockport is 600 feet, which is also the elevation at Niagara Falls. The Ontario plain has an elevation at the base of the escarpment ranging from 400 feet at Lewiston to 500 feet at the point where it leaves the county on the east.[3]

Drainage of the Ontario plain is northward into Lake Ontario. The streams have crooked channels, which meander through comparatively narrow and not deeply cut flood plains. Within the plain there are several broad flat or slightly depressed basinlike areas having imperfectly developed outlets. The drainage of these and of numerous other flat areas has been attempted by ditching, but most of the ditches are too small to give efficient drainage and many are choked with weeds and shrubs. A large part of the soils of the lake plain is imperfectly to poorly drained.

Drainage of the Huron plain is southward into Tonawanda Creek, which flows westward and empties into the Niagara River. As on the Ontario plain, drainage here is not well developed. The almost flat surface makes artificial drainage a problem because of the slow runoff.

CLIMATE

The climate of Niagara County is influenced to a marked degree by its proximity to Lake Ontario. When cold waves sweep down from Canada, the difference in temperature between areas on the northern and those on the southern sides of the lake frequently amount to 20 degrees Fahrenheit or more (*9*). The prevailing di-

[2] Italic numbers in parentheses refer to Literature Cited, p. 73.
[3] Elevation data from U. S. Geological Survey topographic maps.

rection of the wind is southwest, and, in passing over the lake, the temperature of the air is modified so that it tempers the heat of summer and the cold of winter. As a result, the spring season is retarded and the fall extended. The relative freedom from excessive cold as well as a long growing season is responsible for intensive fruit growing. The gradual change from fall to winter insures maturity of fruit twigs and buds, and the low temperatures of early spring prevent premature swelling of buds and consequent frost injury.

The mean annual temperature at Fort Niagara, on the lake at the mouth of the Niagara River, is 47.3° F. About 12 miles south of the lake at Lockport at an elevation of 520 feet, the mean annual temperature is 47.2°. Although these figures indicate little variation between these two places, actually there is a difference of 1 to 2 weeks in the date of maturity of similar crops. It is recognized that immediately adjacent to the lake injury from spring frosts is less than on and south of the escarpment.

The frost-free period at Lockport is 164 days; the average date of the last killing frost in spring is May 4 and the first in fall is October 15. Frosts have occurred, however, as late as May 28 and as early as September 19. Loss of the fruit crop from frost injury in spring is rare, though peaches are injured more frequently than other fruits. During the winter of 1935 the temperatures in February were the lowest on record, and approximately a third of the peach trees and many apple trees were killed.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Lockport, Niagara County, N. Y.*[1]

[Elevation, 520 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	28.7	68	−8	2.07	3.11	4.77	11.3
January	25.1	69	−12	2.32	1.69	2.06	14.3
February	23.6	69	−24	1.87	1.34	3.86	13.3
Winter	25.8	69	−24	6.26	6.14	10.69	38.9
March	32.8	79	−9	2.10	1.12	2.62	7.0
April	44.3	87	4	2.53	.48	4.01	2.1
May	55.4	92	26	2.83	1.30	7.18	.1
Spring	44.2	92	−9	7.46	2.90	13.81	9.2
June	64.9	95	24	3.06	.25	2.54	0
July	70.3	103	41	3.30	1.27	4.78	0
August	69.8	97	39	2.67	.48	5.21	0
Summer	68.3	103	24	9.03	2.00	12.53	0
September	62.0	94	30	2.63	4.33	3.43	0
October	50.9	88	20	3.05	1.71	2.68	.2
November	39.0	78	1	2.32	.49	3.34	3.7
Fall	50.6	94	1	8.00	6.53	9.45	3.9
Year	47.2	[2] 103	[3] −24	30.75	[4] 17.57	[5] 46.48	52.0

[1] From U. S. Weather Bureau records.
[2] In July 1936.
[3] In February 1934.
[4] In 1899.
[5] In 1893.

The area along Lake Ontario is the driest part of the entire State, the annual precipitation being 27.28 inches at Fort Niagara and 30.75 inches at Lockport. The heaviest precipitation is in summer, and at Fort Niagara 12.89 inches falls during the growing season from May to September. This is sufficient for fruit trees that are deep-rooted and able to draw on the subsoil supply, but field and vegetable crops sometimes suffer from a lack of moisture on the light-textured soils.

Long-continued droughts are rare, but less than normal rainfall for short periods in spring and summer is not infrequent and causes considerable loss to vegetable growers, especially on the Alton soils of the ridge. Excessive spring rains sometimes interfere with pollination and result in short fruit crops.

Normally farm work can be performed as late as November, and much of the plowing is done in fall. This is a good practice where susceptibility to erosion is not great, because of the slowness with which some of the heavier soils dry out in spring.

The normal monthly, seasonal, and annual temperature and precipitation at Lockport, as compiled from records of the United States Weather Bureau, are given in table 1.

VEGETATION

Before occupation by white men the entire area was heavily forested. The higher, drier land bore a heavy growth of sugar maple (hard maple) and red maple (soft maple); black walnut; white, red, post, bur, and black oaks; basswood; tuliptree (yellow poplar); hickory; elm; beech; and chestnut. On the lower lying land was a tangle of vegetation with large trees of elm, black ash, soft maple, white-cedar, and tamarack, and bushes of alder, huckleberry, and cranberry. Much of the lower lying flat land was swampy and covered with water for several months of the year. Settlement was confined for many years to the ridges and higher lying areas, because of the wetness of the flat land and the difficulty of establishing artificial drainage.

The present forests, on areas too wet to drain, consist of second- and third-growth trees of the original species. Aside from furnishing firewood and fence posts for farm use no revenue is derived from this source.

ORGANIZATION AND POPULATION

The area of which Niagara County is a part was one of the first of the Great Lakes country to be visited by white men. The waterways of the St. Lawrence River and the Great Lakes brought adventurers into this area during the seventeenth century. In 1678 La Salle established a trading post at the village that now bears his name, and also Fort Niagara, the most important French post west of Montreal. The post was taken by the British in 1759 and held until 1796. During the Revolutionary War it was the headquarters for marauding parties of Indians and Tories in their depredations against the Mohawk settlements.

All of Niagara County except a strip 1 mile wide along the Niagara River and the Indian reservations was embodied in the Holland Land Purchase. After the extinction of the Indian title in 1799 it was rapidly surveyed and opened for settlement. The first settlements were on the ridge, along the escarpment, and along the lake shore, which represented the well-drained lands.

In December 1813, Fort Niagara was again taken by the British

and held until the close of the War of 1812. During that occupation all the settlements and villages were burned, and it was some years after the war before settlement again began in earnest. The completion of the Erie Canal (now known as the Barge Canal) in 1825 gave a great impetus to the agricultural development of the region, as it provided a good means of transportation and permitted a rapid flow of trade with eastern centers of population and industry. Niagara County was set up as a distinct unit in 1808. It has maintained its present boundaries since 1821, when part of it was taken to form Erie County.

According to the Federal census the population doubled from 31,132 in 1840 to 62,491 in 1890, and between 1930 and 1940 it grew from 149,329 to 160,110. The 1940 rural population was 37,448, or 23.4 percent of the total.

Most of the rural people are descendants of the original settlers, many of whom came from the New England States, eastern New York, and New Jersey. The population of the southern part is largely of German descent. Bergholtz and Wolcottsville were settled by German immigrants, for whom the land was obtained in advance of their coming. The industry and thrift of these people were factors in the development of the heavy wet soils of the southern part of the county.

In 1940 Lockport had a population of 24,379, Niagara Falls 78,029, and North Tonawanda 20,254. These cities furnish excellent markets for a considerable part of the vegetables and much of the fruit raised in the county. Buffalo (population 575,901), only a few miles to the south, is an important market for the county, and both Buffalo and Niagara Falls maintain large public markets where farmers can dispose of their produce to the highest bidders. Important villages are Lewiston and Youngstown, on the Niagara River, Wilson and Olcott, on the lake shore, and Middleport, in the eastern part of the county.

TRANSPORTATION

The lines of two railroads, the Erie, extending from Niagara Falls through North Tonawanda, where it leaves the county, and the New York Central (Rochester Division and Falls Road), traversing the county from east to west, carry large quantities of fruit and canned goods to outside markets. The Barge Canal, connecting the Great Lakes with the Hudson River, crosses the southeastern part of the county.

An excellent county and State highway system makes transportation by truck an important factor in the disposal of produce. The 1940 census reports that of 3,871 farms in the county, 2,984 were situated on hard-surfaced roads; 520 on roads of gravel, shale, or shell; 239 on improved dirt roads; and 66 on unimproved dirt roads. On April 1, 1940, there were 4,382 automobiles on 3,238 farms, 1,814 motortrucks on 1,618 farms, and 2,703 tractors on 2,410 farms.

CULTURAL AND INDUSTRIAL DEVELOPMENTS

The school system is unusually good, with centralization proceeding rapidly. The excellent system of roads facilitates the transportation of children by bus. Of 3,664 farm dwellings within one-fourth of a mile of an electric-distribution line, 3,385 were lighted in 1940 by elec-

tricity from a power line, and 26 by home plants. Telephones were reported by 1,367 farms.

Lockport, Niagara Falls, and North Tonawanda are important manufacturing centers. At Niagara Falls the great development of water power has led to the establishment of a number of industries employing electrical processes and to considerable general manufacturing. Lockport also is a manufacturing center largely because of the power developed there. North Tonawanda is a center for the manufacture of lumber, which is brought by water from points on the upper lakes. As these towns are practically at the beginning of the Barge Canal they are centers of commerce, and Lockport, the market town for most of the area, owes much of its growth to its location on the canal at the point where it descends the escarpment through a series of locks. Fishing is an important industry of the towns bordering the Niagara River and Lake Ontario.

AGRICULTURE

The favorable climate, fairly large acreage of good soils, and excellent markets contribute to a diversified and prosperous agriculture and to the production of a variety of crops in salable quantities. The northern half of the county between the escarpment and the lake is the most important from an agricultural standpoint. The soils are superior and the growing season is longer. The southern half is an area of heavy-textured, imperfectly and poorly drained soils; little fruit is grown; and the agriculture is based mainly on the production of hay and grain.

EARLY AGRICULTURE

The first crops grown in the county were those necessary to meet the needs of people in a wilderness. Very few articles were brought in, and none were shipped out. While the land was being cleared for cultivation, the production of potash salts from wood ashes was an important industry and furnished the only source of cash income.

The completion of the Erie Canal (now Barge Canal) in 1825 gave a great impetus to settlement and agricultural development. It provided a means of cheap transportation for the surplus products, which formerly could not be marketed. Previously all the timber was burned on the ground, but thereafter much lumber was manufactured and shipped to eastern markets. Not only did the completion of this waterway provide an outlet to eastern markets, but it also greatly stimulated local consumption through the increased number of people it brought to the region during construction.

The agriculture immediately following the completion of the canal was based mainly on grain growing and livestock raising. Wheat has continued as an important crop up to the present time, but livestock raising in general and sheep raising in particular have become of secondary importance. The decline dates from the decade following the Civil War, when competition from the West became severe.

CROPS

Prior to 1850 the leading crops were wheat, oats, barley, corn, peas, beans, and flax. Census returns for 1880 show that in 1879 hay occupied the largest acreage, followed by wheat, barley, corn, oats, and potatoes. In 1939 hay still led all field crops in acreage and was fol-

lowed by wheat, oats, corn, market vegetables, potatoes, and barley.

Trends in the agriculture during the period 1879 to 1939, as revealed by the acreage of the principal crops and the number of fruit trees and grapevines, are shown in table 2.

TABLE 2.—*Acreage of principal crops and number of fruit trees and grapevines in Niagara County, N. Y., in stated years* [1]

Crop	1879	1889	1899	1909	1919	1929	1939
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Oats	21,389	30,385	34,286	33,080	14,302	18,518	20,015
Wheat	46,644	39,571	40,614	26,717	33,652	22,237	24,102
Corn, all						15,033	19,323
Grain	22,606	13,547	22,467	19,261	11,310	4,140	10,692
Silage, fodder, and other purposes					[2] 4,845	10,893	8,631
Barley	22,732	17,436	4,649	1,472	2,382	2,581	2,852
Mixed grains						3,815	2,165
Dry peas			336	176	30	61	38
Dry beans			3,980	5,265	307	1,363	1,815
Buckwheat	971	1,360	853	1,519	1,712	2,437	2,009
Potatoes	4,163	4,657	5,951	6,918	4,019	2,197	1,991
Cabbage					1,026	2,151	2,700
Tomatoes					1,926	2,227	2,951
Sweet corn					481	521	843
All other market vegetables					1,233	2,615	3,299
Hay, all	47,242	63,793	65,382	65,206	65,620	62,225	50,724
Timothy or clover, alone or mixed			[3] 3,967	62,681	62,149	55,797	31,594
Alfalfa			36	195	570	2,222	5,605
Other tame hay			61,303	2,278	2,700	3,380	12,486
Wild hay			76	52	201	826	1,039
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Apples—trees		1,033,454	924,086	804,155	816,508	949,583	637,430
Cherries—do		27,035	33,282	61,786	115,139	105,348	115,572
Peaches—do		168,097	554,107	591,350	925,041	506,047	468,188
Pears—do		156,356	388,472	381,710	520,118	394,495	222,179
Plums and prunes—do		36,742	184,133	180,801	206,970	174,029	138,813
Grapes—vines			602,421	358,312	670,048	1,402,930	940,086

[1] Fruit trees and grapevines as of the census years 1880, 1890, 1900, 1910, 1920, 1930, and 1940.
[2] Forage only.
[3] Clover only.

Much of the soil that was too wet for the production of fruit returned fair yields of wheat. This was an important crop in the early agriculture because of accessible markets and because its rather high unit value made shipments possible to fairly distant markets. The present relatively large acreage of wheat, an acreage that was exceeded, but only slightly, by just two other counties of the State in 1939, is due to several factors. Wheat, which can be grown on soils having considerable range in drainage conditions, is planted and harvested at times when the orchards do not need attention. Besides serving as poultry feed, it furnishes a quickly disposable cash crop for which there are excellent markets at Buffalo and Niagara Falls.

Oats and corn have maintained a fairly constant acreage since 1879. Both are feed crops and are raised principally for use on the farm, although a considerable quantity of oats is sold. By far the principal hay crop is timothy or clover, alone or mixed. Alfalfa is increasing in importance. In addition to the crops grown for hay, seed was harvested in 1939 on 204 acres of alfalfa, 124 acres of clover, 78 acres of grass, and 40 acres of sweetclover.

At one time barley was important, but at present it is only a minor crop. Fairly large acreages of mixed grains, buckwheat, and dry peas and beans also are grown.

The growing of market vegetables has an important place in the

present agriculture, and 9,763 acres were used for this purpose in 1939. The more important vegetables, exclusive of potatoes, are cabbage, tomatoes, sweet corn, peppers, eggplant, muskmelons, and green peas.

Fruit growing has been the most important phase of the agriculture for a number of years. It is most intensive in the district north of the escarpment to Lake Ontario, where the tempering influence of the lake on the climate is most pronounced. Tree fruits, nuts, and grapes occupied a total area of 38,722 acres in 1940, a substantial decrease from the 51,546 acres reported in 1930.

The first orchards of size were planted about 1813, and these produced fruit mainly for home use and for cider. Between 1825 and 1850 was the period of intensive planting. All these early orchards were from seedlings, but later better varieties were top-grafted on the older trees. About 1875, peach, pear, and cherry orchards were set out. As reported by the 1940 census, this is the leading peach-producing county of the State; it ranks second in the number of bearing apple trees; and third in the production of apples; it is also the second most important grape-producing county in the State. The Niagara grape, a leading variety of the Northeast, was originated at Lockport in 1872.

The relative importance of the several sources of farm income may be gaged from the value of farm products sold, traded, or used by the farm homesteads, in 1929 and 1939, as given in table 3.

TABLE 3.—*Value of farm products sold, traded, or used by farm households in 1929 and 1939 in Niagara County, N. Y.*

Product	1929	1939
Crops sold or traded	$4,560,944	$3,068,167
Field crops	(1)	513,394
Vegetables	(1)	655,852
Fruit and nuts	(1)	1,569,935
Horticultural specialties	(1)	328,986
Forest products sold	59,350	6,359
Livestock sold or traded	619,019	349,598
Livestock products sold or traded	2,200,024	1,748,422
Dairy products	(1)	951,425
Poultry and poultry products	(1)	773,038
Other livestock products	(1)	23,959
Total, products sold or traded	7,439,337	5,172,546
Farm products used by farm households	888,392	740,937
Total	8,327,729	5,913,483

[1] Not available.

LIVESTOCK

Livestock raising, especially sheep raising, was important in the early agriculture of the area and continued to be so until the opening of the West after the Civil War. At present cattle and sheep raising is of secondary importance. Table 4 gives the numbers of livestock reported by the Federal census.

TABLE 4.—*Number of livestock on farms in Niagara County, N. Y., in stated years*

Livestock	1880	1890	1900	1910	1920	1930	1940
Horses	14,665	16,483	14,585	15,510	12,975	7,553	[1] 6,535
Mules	46	125	50	205	227	198	[1] 97
Cattle	20,831	19,617	22,244	19,833	19,358	20,825	[1] 18,785
Sheep	33,231	38,448	37,160	28,241	11,915	13,955	[2] 6,798
Swine	17,258	21,047	17,110	17,502	16,713	7,666	[3] 7,919
Chickens	[4] 160,564	207,032	217,000	[4] 261,290	255,281	[1] 319,012	[3] 295,965

[1] Over 3 months on April 1.
[2] Over 6 months on April 1.
[3] Over 4 months on April 1.
[4] All poultry.

The number of horses has declined markedly since 1920 because tractors have replaced them for farm work on many of the fruit farms. Very few horses are raised in the area; most of them come from the Middle West.

Poultry raising has been increasing in importance as a farm enterprise and during 1940 there were 295,965 chickens over 4 months of age. In 1939, 475 farms were classed as poultry farms.

USE OF FERTILIZERS

A considerable quantity of commercial fertilizer is used in the county, especially on fruit and vegetable farms. In 1939, $256,048 was expended for fertilizer and $15,187 for liming materials; 8,588 tons of commercial fertilizer, much of it nitrogenous for use in orchards, and 3,967 tons of liming materials were used. Ammonium sulfate, sodium nitrate, and calcium nitrate are the three most common nitrogenous fertilizers. Superphosphate alone is used to a considerable extent by vegetable growers, as well as complete fertilizers, such as 10–20–10,[4] 5–10–5, and 4–6–4. Although some lime is applied for cabbage, alfalfa, and other crops, the applications are not large, owing to the fact that many of the important soils are neutral or only slightly acid, and lime is abundant in the subsoils and substrata.

EXPENDITURES FOR LABOR AND EQUIPMENT

Farm labor has been a problem in recent years as the farmers must compete with employers in the nearby cities, many of whom can pay higher wages. The expenditures of 2,142 farms for farm labor in 1939 amounted to $985,700. Many of the larger fruit farms employ year-round help, but most of the fruit harvesting offers seasonal work, so that a large part of all farm labor hired is seasonal.

Other important farm expenditures in 1939 were $718,186 for feed on 2,705 farms, $554,684 for implements and machinery on 1,545 farms, $372,028 for building materials on 2,185 farms, and $320,704 for gasoline, kerosene, and oil on 2,770 farms.

SIZE OF FARMS

The average size of farms in 1940 was 71 acres, as compared with 70.3 acres in 1930. One reason for small size is the unusually high density of the rural population (70.2 persons to the square mile). The number of farms in 1940 was 3,871, of which 1,578 included less than 50 acres, and 1,003 more than 100 acres.

According to the 1940 census all land in farms totals 274,687 acres, 80.5 percent of the area of the county, of which 175,936 acres represented cropland harvested in 1939, a decided reduction from the 190,142 acres harvested in 1929. Improved land totaled 234,865 acres, including cropland harvested, 4,247 acres on which crops failed, 24,240 acres of idle cropland, and 30,442 acres of plowable pasture. Farm woodland occupied 15,416 acres, and all other land in farms covered 24,406 acres.

FARM TENURE

The proportion of tenancy is low. It was less in 1940 than in 1930—14.3 percent as compared with 17.7 percent. Tenancy is on a share basis in the majority of cases. Under this system the owner

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

furnishes seed, fertilizer, and machinery and receives half the produce in return. Some of the fruit farms are rented on a cash basis, in which case the owner furnishes only the machinery necessary for operation.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field and the recording of their characteristics, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road and railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called collectively the soil profile. Each horizon of the soil, as well as the underlying parent material, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The chemical reaction of the soil and its content of lime and salts are determined by simple tests.[5] The drainage, both internal and external, and other external features, as the relief or lay of the land, are taken into consideration, and the interrelation of the soil and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features that influence the adaptation of the land for growing crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped into classification units, the principal three of which are (1) series, (2) type, and (3) phase; some areas—as made land and lake marsh—that have no true soil are called (4) miscellaneous land types.

The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage conditions, and other important internal characteristics, and the same range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Newfane and Dunkirk are names of important soil series in Niagara County.

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

A soil phase is a variation within the type, differing from it in some minor feature, generally external, that may be of special practical

[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. Indicator solutions are used to determine the reaction of the soil. The presence of lime is detected by the use of a dilute solution of hydrochloric acid.

significance. For example, within the normal range of relief for a soil type some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Differences in relief, stoniness, and degree of accelerated erosion may be shown as phases. Even though no important differences may be apparent in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, some soils having differences in stoniness may be mapped as phases even though these differences are not reflected in the character of the soil or in the growth of native plants.

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

SOILS

The soils of Niagara County have developed under a forest cover in which maple, beech, oak, and ash predominate. The mean annual precipitation of 30.75 inches, the mean temperature of 47.2° F., and the frost-free period of 164 days at Lockport are nearly uniform for the entire area.

Parent materials from which the soils have developed vary widely. Along the Niagara escarpment, where the gray hard fine-grained dolomite and limestone of the Niagara group are exposed or have but a shallow covering, the soils have been influenced to some extent by the character of the underlying rocks. In places along the more gradual northern slope of the escarpment in the western part of the county light grayish-brown soft calcareous shale is reached at a slight depth, and fragments of this shale are present in the subsoil. Farther out on the lake plain, principally north of the ridge, red soft easily disintegrated shale lies beneath a thin mantle of soil.

The ridge has a shallow covering of sandy and gravelly soil derived from rounded or water-worn fragments of sandstone underlain by deep beds of stratified gravel and sand. North of the escarpment, on its lower slopes and covering a large part of the Ontario plain, large areas have a shallow covering of glacial till, consisting of sharp stone fragments intricately mixed with more finely ground rock material, sands, and clay. This till occurs in places as low broad ridges, most noticeably south of the escarpment, but on the Ontario plain it occupies mainly large flat areas having no outstanding topographic characteristics.

Near the lake the parent materials consist of thin layers of clay, silts, and sands laid down in the still waters of a formerly more extensive lake. These lacustrine deposits are everywhere underlain by glacial till at a depth of 12 inches to many feet. Some areas are also covered by thin deposits of stratified sands, and on numerous ridges and mounds the sand seems to have been deposited, in part, by the wind. In the valleys adjacent to the streams the soils are only slightly developed, as they come from recently deposited sediments.

In addition to differences in soils that correspond to differences in

basic parent material, there are numerous other differences that correspond to variations in drainage conditions, which range from a permanently wet condition to excessively rapid drainage. The fact that soils developed from lake-laid materials are closely associated with those developed from glacial till in areas of similar relief makes the soil pattern decidedly complex. This is especially true in the area north of the escarpment. Good surface and internal drainage have resulted in the formation of grayish-brown, yellowish-brown, or brown soils, with slightly lighter but unmottled colors in the subsoil. Soils developed under imperfect drainage conditions have dark-gray to grayish-brown surface soils and a rust-mottled upper subsoil layer, in which the dominant color ranges from light brown to gray. Poorly drained soils are characterized by dark-gray or nearly black surface layers underlain abruptly by light-gray layers that grade into less gray highly mottled materials.

The principal type of agriculture is fruit growing, followed by the production of vegetables, grain, and hay. Although favorable climatic conditions have been responsible for the importance of the lake-plain area in the production of fruit and for the dominant position this activity holds in the agriculture of the county, the character of the soils determines the distribution of the orchards. The soil factor of greatest importance in successful fruit raising is drainage (*5*). Orchards are limited largely to the well-drained and imperfectly drained soils; best yields of fruit, particularly of peaches and cherries, are obtained on the well-drained soils.

With the exception of tomatoes and cabbage, vegetables, which tolerate a fairly wide range of drainage conditions, are grown on the lighter-textured soils of the northern half of the county. Here the soils warm early in spring and are easy to work. These factors largely determine the choice of soil for the production of vegetables, which rank next to fruit in agricultural importance.

Grain is grown mainly on the well-drained and imperfectly drained soils. Hay, especially timothy and clover, tolerates wetter conditions than fruits and vegetables; consequently, it is the main crop on the large areas of poorly drained soils in the southern part.

On the soil map the different types and phases are indicated by letter symbols, color, and rulings, and the boundary separating two soil types is shown by a line drawn in the field. A soil boundary may be a transition zone several rods in width through which the characteristics of one soil gradually change to those of another. The factors used in differentiating soils vary widely. In places they are marked and may be noted from an inspection of the surface. For example, a nearly black poorly drained soil is easily distinguished from a brown well-drained one, and clays are easily distinguished from sands. In other places the separation may be based on depth to or condition of the subsoil, with no indication at the surface. In many places two contiguous soils are equally good for some crops but not for others. In any two soils the natural conditions may be changed by the way in which each soil has been managed, so that both have much the same crop adaptations and may be equally productive although originally unlike. Such changes are frequently brought about by artificial drainage.

The soils are arranged in groups on the basis of their profile characteristics (1) grayish-brown, yellowish-brown, and reddish-brown

soils developed principally from stratified fine sediments, containing very little coarse gravel or stone and showing stratification in the subsoil. The series in this group are Dunkirk, Newfane, Arkport, Berrien, Collamer, Allendale, Fulton, Schoharie, Wauseon, and Rimer. (2) Grayish-brown, brown, and reddish-brown soils developed from unassorted gravelly and stony materials include members of the Ontario, Hilton, Clarkson, Cazenovia, and Lyons series. (3) Grayish-brown or yellowish-brown soils developed from stratified sand and gravel deposits belong to the Alton, Somerset, and Medina series. (4) Brown and reddish-brown shallow soils developed largely from bedrock include members of the Lockport, Farmington, and Brockport series. (5) Reddish-brown, yellowish-brown, and gray soils developed on flood-plain deposits are, in places, subject to periodic flooding. The Hamlin, Tonawanda, and Eel series belong in this group. (6) Dark soils developed under poor to very poor drainage conditions from silty and clayey sediments are members of the Toledo, Poygan, Wolcottsburg, Granby, Colwood, and Wayland series. (7) Miscellaneous soils and land types include Carlisle muck and its shallow phase, alluvial soils, undifferentiated, made land, lake marsh, and quarries.

As this grouping is based on selected profile characteristics to show relations among soils it bears only a general relation to the productivity or the adaptability of the soils for particular crops. Such a grouping would have to be based on all characteristics important for that crop.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Niagara County, N. Y.*

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Allendale fine sandy loam	10,112	3.0	Hilton gravelly fine sandy loam	1,664	0.5
Alluvial soils, undifferentiated	192	.1	Hilton gravelly loam	17,344	5.1
Alton coarse sandy loam	2,432	.7	Compact subsoil phase	15,296	4.5
Alton gravelly fine sandy loam	1,600	.5	Hilton silt loam	3,456	1.0
Alton gravelly loam	4,096	1.2	Compact subsoil phase	4,736	1.4
Arkport very fine sandy loam	768	.2	Lake marsh	128	(2)
Smooth phase	1,472	.4	Lockport gravelly loam	1,024	.3
Berrien fine sandy loam	13,248	3.9	Lockport silt loam	7,168	2.1
Berrien loamy fine sand	1,280	.4	Undulating phase	960	.3
Brockport silt loam	640	.2	Lyons silt loam	2,112	.6
Carlisle muck	1,152	.3	Made land	1,216	.3
Shallow phase	1,664	.5	Medina gravelly silt loam	192	.1
Cazenovia silt loam	960	.3	Newfane sandy loam	3,584	1.0
Clarkson gravelly loam: [1]			Ontario loam	12,992	3.8
Shallow phase	3,328	1.0	Ontario silt loam	4,416	1.3
Clarkson gravelly silt loam	2,432	.7	Shallow phase	12,736	3.7
Collamer silt loam	25,536	7.5	Poygan clay	26,240	7.7
Collamer silty clay loam	1,664	.5	Quarries	256	.1
Colwood silt loam	2,688	.8	Rimer fine sandy loam	320	.1
Dunkirk fine sandy loam	6,016	1.8	Schoharie silty clay	4,224	1.2
Dunkirk silt loam	512	.2	Schoharie silty clay loam	31,168	9.1
Dunkirk silty clay loam	22,272	6.5	Somerset gravelly fine sandy loam	1,344	.4
Rolling phase	64	(2)	Somerset gravelly loam	5,696	1.7
Eel silt loam	3,968	1.2	Toledo silty clay loam	6,080	1.8
Colluvial phase	2,368	.7	Tonawanda silt loam	15,360	4.5
Farmington stony loam	1,152	.3	Tonawanda silty clay loam	18,496	5.4
Steep phase	1,600	.5	Wauseon fine sandy loam	1,216	.3
Fulton silty clay loam	12,928	3.8	Wayland silt loam	768	.2
Granby fine sandy loam	5,248	1.5	Wolcottsburg silt loam	2,752	.8
Hamlin silt loam	4,736	1.4			
High-bottom phase	2,048	.6	Total	341,120	100.0

[1] Where data are given for phases only, the normal type is not mapped in the county.
[2] Less than 0.1 percent.

In the following pages the soils are described in detail and their agricultural importance is discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

SOILS DEVELOPED PRINCIPALLY FROM STRATIFIED FINE SEDIMENTS

The soils developed principally from stratified fine sediments are grayish-brown, yellowish-brown, and reddish-brown and occupy all the immediate lake shore part of the county and a considerable area between the escarpment and the lake. The less well-drained heavy-textured members occur in large areas south of the escarpment. Typically, these soils occupy level areas, although a rolling phase of the Dunkirk series has been mapped and the Arkport soils are rolling. All the soils of the group have developed on water-laid sediments ranging from clays in the Collamer and Schoharie soils to sands in the Newfane and Berrien soils. Drainage is good in the Dunkirk, Newfane, Arkport, and Berrien and imperfect in the Collamer, Fulton, Schoharie, Wauseon, and Rimer soils.

The well-drained soils of the group are among the best soils in the county and are especially good for fruit trees. They are also used with success for the production of vegetables and field crops. The imperfectly drained Collamer soils are used extensively for orchard fruits, but average yields are lower than on the well-drained soils. Members of the Fulton and Schoharie series are better suited to the production of hay and grain for which they are principally used.

The Dunkirk soils are the most important members of the group. They are characterized by grayish-brown or yellowish-brown surface and subsurface layers and yellowish subsoils in the lighter textured members. The silty clay loam generally has a reddish cast in the subsoil material. In a few places some gravel is present on the surface. The subsoil and substrata are generally stratified silts and fine sands.

The Newfane soils consist of brown, medium and fine sandy loam material, containing some fine gravel throughout. They are limited mainly to the area around Olcott along the lake shore and are considered the finest in the county for peaches. The Arkport soils have brown sandy surface soils with pinkish very fine sandy loam subsoils that are calcareous at a depth of 30 to 36 inches. The smoother areas are designated on the map as a smooth phase. Where the slopes are not too steep, Arkport soils are good and are adapted to many crops.

The Berrien soils are brown and sandy. In many places the fine sandy loam has a compact and somewhat mottled subsoil. The loamy fine sand presents a dunelike appearance in many places. The fine sandy loam occurs principally north of the escarpment, and the loamy fine sand occurs both north and south of it. They are of intermediate value for fruit growing and are used mainly for this purpose. The Collamer soils have a nearly level surface. The surface soil is grayish brown or brownish gray and overlies a gray and rust-mottled subsurface layer. The subsoil is heavy tight calcareous clay. The Allendale soil is dark-colored and poorly drained, and occupies flat or depressed areas in association with the Berrien soils. The Fulton soil has a dark brownish-gray surface layer, brownish-gray subsurface, and highly mottled pinkish clay subsoil. It is developed mainly north of the escarpment, where it is used chiefly for hay and pasture, with wheat and corn occupying a small acreage.

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The Schoharie soils are characterized by brownish-gray surface and light-gray mottled subsurface soils with red calcareous heavy clay subsoils. These soils as mapped are in reality a complex; where the land surface is slightly convex the gray-mottled subsurface layer is replaced by a pinkish-brown layer. Owing to the complex association of the flat and slightly undulating areas it is impossible to show them separately on the map. Schoharie soils are used almost exclusively for hay, pasture, and grain.

The Wauseon and Rimer soils are minor types. The former has a dark-gray surface layer and a yellowish-brown sandy subsurface layer overlying mottled clay subsoil; the latter has a dark sandy surface soil overlying heavy compact stony or clayey subsoil.

SOILS DEVELOPED FROM UNASSORTED GRAVELLY AND STONY MATERIALS

The soils developed from unassorted gravelly and stony materials are grayish-brown, brown, and reddish-brown and include those in which the parent material is mainly glacial till. Till consists of sharp rock fragments intricately mixed with finer particles deposited by glacial action and not assorted or stratified as are sediments deposited by streams or in still water. It varies, however, in character of rock material and degree of compaction, and soils developed from it vary not only with the type of till but also according to drainage conditions. For these reasons there are in Niagara County five distinct series of soils all developed from parent materials deposited as glacial till. These series are the Ontario, Hilton, Clarkson, Cazenovia, and Lyons.

The Ontario soils have developed from till in which the larger part of the sharp stone fragments is reddish-brown sandstone and gray limestone. Drainage is good. The Hilton soils, because of their extent, are among the most important of the entire county. They occupy low flat ridges and nearly level areas, range in color from dull brown to grayish brown or gray, and have well-developed gray and mottled layers, below which is a heavy compact zone grading into a more friable highly calcareous deep subsoil. Drainage is only moderately well developed. The Clarkson soils differ from the Ontario soils in that they are redder and have a higher content of red shale fragments in the parent material. The Clarkson soils are faintly mottled and are underlain at relatively shallow depths by red clay shales similar to those underlying the Lockport soils. The Cazenovia soils are closely related to the Ontario soils, but have a redder color and a well-developed heavy-textured subsurface layer. Lime is found at a shallower depth than in the Ontario soils. The Lyons soil has developed from parent materials similar to those of the Ontario soils, but under poor drainage conditions. It has a dark surface soil and a mottled compact subsoil.

This group of soils is important in the agriculture of the county. The Ontario soils are good and are well adapted to the important crops. The Hilton soils are the most extensive. During favorable seasons production is good, but in wet seasons orchards and field crops suffer because of inadequate drainage. They are found between the escarpment and Lake Ontario and are widely used for apples, pears, plums, field crops, and vegetable canning crops. Average yields are less than those of the well-drained soils of the same region. The Clarkson soils are intermediate in general quality because of their somewhat shallow

depth and imperfect subsoil drainage. The Cazenovia soil is closely related to the Ontario soils and has similar crop adaptations, but the total area is small. Because of poor drainage, the Lyons soil is used chiefly for pasture.

SOILS DEVELOPED FROM STRATIFIED SAND AND GRAVEL DEPOSITS

The soils developed from stratified sand and gravel deposits are grayish brown or yellowish brown and are characterized by rounded gravel in the surface layer and by stratified beds of gravel and sand in the subsoil. This group includes members of the Alton, Somerset, and Medina series.

The Alton soils are deep and well drained and are acid to a depth of 30 to 36 inches. They are developed principally along the Ridge Road, where they owe their origin to the beach ridge built up by glacial lakes, and are utilized intensively for fruit and vegetable growing and for residential purposes. The Somerset soils have brownish-gray gravelly surface material and gravelly subsoils, but they also have heavy material in the deeper subsoil or substratum. They are not so well drained as the Alton soils and are used mainly for vegetables and fruits that will tolerate imperfect drainage. The Medina soil, a minor type used principally for field crops, consists of a thin layer of gravelly alluvium on terraces too high to be overflowed and is underlain at a depth of 3 feet by red shale similar to that underlying the Lockport soil.

SOILS DEVELOPED LARGELY FROM BEDROCK

The soils developed largely from materials accumulated through the weathering of bedrock in place are gray, brown, reddish-brown and shallow—the surface color depending on the degree of drainage and character of parent rock. Partly disintegrated rock material is encountered at depths of 18 to 30 inches. Lockport, Farmington, and Brockport series are included in the group. The surface of the Lockport soils is heavy and the subsurface is reddish brown. Dull-red soft shale of the Queenston formation is present at a depth of 24 to 30 inches. The value of these soils for agriculture is determined by drainage. Typically they are flat and poorly drained, but the undulating phase of Lockport silt loam is sufficiently rolling to allow fairly rapid runoff of excess surface water. The Lockport soils are used mainly for hay and pasture, with some fruit growing on the undulating phase. The Farmington soils, underlain at shallow depths by limestone rock, have brown surface soil and yellowish-brown subsoil. They are used mainly for pasture, as boulders and outcrops of rock are common and the water-holding capacity is low. The steep phase of the stony loam is too precipitous for agricultural use and is mainly in forest or waste areas. The Brockport soil varies from gray to brown and has heavy surface and subsurface texture. The underlying rock is dull-gray calcareous shale. This soil is of minor importance and occurs only in small areas south of Middleport.

SOILS DEVELOPED ON FLOOD-PLAIN DEPOSITS

Soils developed on flood-plain deposits are reddish brown, yellowish brown, and gray and being of recent origin they have little profile development except color changes. The group includes members of the Hamlin, Tonawanda, and Eel series. They show a bedded or stratified arrangement of the layers, which is characteristic of alluvial sed-

iments. They are adapted mainly to hay and pasture, as flooding is common on the first bottoms. Hamlin silt loam, high-bottom phase, lies above the reach of most flood waters and is an excellent soil for general purposes.

SOILS DEVELOPED FROM SILTY AND CLAYEY SEDIMENTS UNDER POOR TO VERY POOR DRAINAGE CONDITIONS

The soils developed from silty and clayey sediments under poor to very poor drainage conditions include members of the Toledo, Poygan, Wolcottsburg, Granby, Colwood, and Wayland series. They are characterized by dark surface materials and heavy highly mottled subsoils. Because of poor drainage, these soils are either forested or used for pasture, with a small acreage of somewhat better drained soil producing hay and small grains.

The Toledo soil has a neutral or slightly acid surface layer and a calcareous subsoil. The parent materials are lake-laid silt, clay, and fine sand. This soil, occurring south of the escarpment, has a black surface layer and bluish-gray heavy subsoil. Much of it is occupied by woodland, but some is planted to corn, small grains, and hay. The Poygan soil occupies flat and slightly depressed areas adjacent to and frequently surrounded by Schoharie soils. When dry it cracks and bakes badly. It is used for corn, small grains, pasture, and hay. The Wolcottsburg soil has a dark surface soil and mottled reddish-brown silty subsoil. Undrained, it is used as pasture; under artificial drainage, good yields of vegetables and field crops are produced. Under natural conditions, the Granby and Colwood soils are very poorly drained and have a thin organic mat over light-gray subsoil. The distinction between them is one of texture. The Wayland soil is permanently wet and has developed from recent alluvium along minor streams. It is too wet for any use except pasture and trees.

MISCELLANEOUS SOILS AND LAND TYPES

The group of miscellaneous soils and land types includes Carlisle muck and its shallow phase; alluvial soils, undifferentiated; made land; lake marsh, and quarries.

DESCRIPTIONS OF SOIL UNITS

Allendale fine sandy loam.—This dark-colored soil occurs on low, flat, or depressed areas in association with Berrien soils. The 6- to 8-inch surface soil is gray or grayish-brown friable fine sandy loam, which gives way abruptly to brown or yellowish-brown fine sandy loam, highly mottled with rusty brown and yellow. When the soil is wet, the color is characteristically dark gray or nearly black. There is no definite structure, but the horizon shows a slight compaction. This layer is 10 to 12 inches thick and is underlain to a depth of 2½ feet by light-brown or grayish-brown firm fine sandy loam slightly mottled with gray. The lower subsoil is generally loamy fine sand, resting in places on compact calcareous till or heavy reddish calcareous clay. The reaction is slightly acid to a depth of about 30 inches and is neutral or alkaline from there downward to the calcareous substratum. The total area mapped is 15.8 square miles.

Since poor drainage is due mainly to low position, it is difficult to provide artificial drainage through open ditches. The tight or com-

pact substratum reduces loss of excess water through the soil to a minimum. In Niagara County this soil differs slightly from much of the type as originally mapped in Michigan in that it has somewhat poorer drainage.

Some areas have a microrelief in which small rounded knolls or ridges of brown sand are surrounded by the darker typical soil. These small higher lying areas are too small to be indicated as separate areas on the map. This condition is most common just north of the ridge near the eastern boundary of the county.

Alluvial soils, undifferentiated.—This land type consists of mixtures of well-drained to poorly drained alluvial soils and stream wash too intimately associated to map separately. It is dominated by brown fine sandy loam underlain at a depth of 6 to 10 inches by small rounded water-worn gravel. It is found only on Goat Island, a park area in the Niagara River at the crest of the falls covered with forest trees of maple, beech, oak, and pine. The total area mapped is 0.3 square mile.

Alton coarse sandy loam.—The surface soil consists of brown or dark grayish-brown loose and friable coarse sandy loam containing a small quantity of small rounded gravel. At a depth of 8 inches this material grades into yellowish-brown gravelly coarse sandy loam that is more compact than the surface layer. This material continues to a depth of 20 inches and is underlain by thin layers of sand and fine gravel. Sand and thick beds of coarse gravel or cobbles are encountered at 30 inches and continue for some depth. The surface soil is acid, but the subsoil below 30 inches usually effervesces freely with dilute hydrochloric acid, indicating the presence of carbonate of lime. Cementation of the gravel in the substratum with calcium carbonate is frequently observed in deep exposures. Alton coarse sandy loam is typically developed on the beach ridge, on which was a naturally dry Indian trail before the present Ridge Road became a highway across the entire group of lake-front counties. The area traversed is everywhere intensively utilized for agricultural and residential purposes.

The only other place where Alton coarse sandy loam occurs is along the Niagara River in the vicinity of Lewiston. Here the general profile is the same, but the material has a different geologic origin. The type along the ridge occupies a nearly continuous strip of one-eighth to one-quarter mile wide, but the areas along the Niagara River are considerably wider. The total area mapped is 3.8 square miles.

The parent material was deposited by water. The ridge represents the old shore line of glacial Lake Iroquois; the areas along the Niagara River are outwash plains formed by rivers during the glacial epoch. Drainage is good to excessive. The average precipitation during the growing season is about 13 inches, but whenever it is much less, the crop yields are materially reduced. Vegetable crops suffer from moisture deficiency, and about once in 5 years partial losses occur as a result of dry weather. Fruit trees, however, are able to draw on the ground-water supply, because they root very deeply.

The root distribution of apple trees in the horizons of eight different soils is shown graphically in figures 2 to 9. Each figure represents the large and small root ends exposed in the profile, as seen on the wall of a trench 6 feet long that had been excavated beneath the branches of

the tree, 10 feet from the trunk and at right angles to the radius (fig. 2).

Alton coarse sandy loam is used intensively. Farms are small and are used mainly for fruit and vegetable growing. Apples, peaches, and cherries are the most important fruits—the soil is especially good

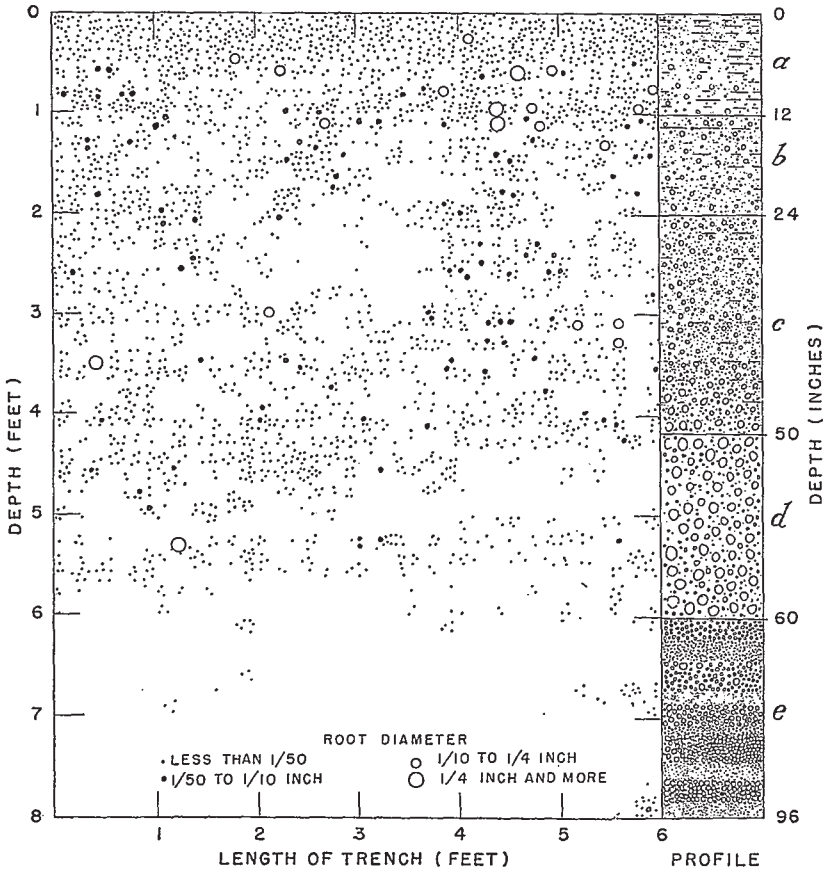

FIGURE 2.—Root distribution of a 100-year-old Northern Spy apple tree growing on Alton coarse sandy loam, as shown by root ends at face of trench 10 feet from tree. Soil profile description: *a*, Dark grayish-brown coarse sandy loam; *b*, yellowish-brown open coarse sandy loam; *c*, brown open gravelly sandy loam, becoming more gravelly with depth; *d*, fine and coarse rounded gravel coated with light-gray calcareous material; *e*, alternate beds of coarse sand and small gravel. This open, well-aerated loam probably makes a larger volume of soil available to the trees than any other in the county.

for the latter two. When moisture is sufficient this soil is well suited to vegetable production, as it is easy to work and warms early in the spring. Vegetables include tomatoes, green peas, beans, eggplant, peppers, melons, cucumbers, and sweet corn. Much of the produce is sold at roadside markets, and any surplus is trucked to public markets in Niagara Falls and Buffalo.

The natural fertility level is low, but response to fertilization is rapid and high. Apple trees commonly receive 5 to 10 pounds of

nitrate of soda or ammonium sulfate per tree, depending on the age and vigor. Vegetables commonly get 1,000 to 2,000 pounds an acre of complete commercial fertilizer.

Average per acre yields for apples are 175 to 275 bushels of graded fruit, tomatoes 6 to 12 tons, melons as high as 200 bushels, peaches 135 bushels, and cherries 6,000 pounds.

Alton gravelly fine sandy loam.—This soil has a profile similar to that of the coarse sandy loam but contains a considerable quantity of fine gravel mixed with the surface soil. The 8-inch surface layer is brown or yellowish-brown loose gravelly fine sandy loam. Most of the gravel is small, ¼ to 1 inch in diameter. To a depth of 20 inches the subsurface material is light yellowish-brown loose porous gravelly coarse sandy loam. The subsoil and substratum are somewhat yellow medium and coarse sands interstratified with beds of gravel. Where the soil is associated with Newfane sandy loam the subsoil contains more sand and less gravel than normal.

The largest areas are along the Ridge Road and between Wrights Corners and Olcott. Smaller areas are in the northwestern corner. This soil has a total area of 2.5 square miles. Utilization, management, and yields are similar to those for Alton coarse sandy loam.

Alton gravelly loam.—The 8-inch surface layer is medium-brown gravelly loam with much round gravel on the surface, some of it having a diameter of 2 to 3 inches. Between a depth of 8 and 20 inches is brown or light yellowish-brown friable gravelly loam with thin interbedded layers of loose sand in places. This material grades into a dark-brown or reddish-brown layer of gravelly silt loam or gravelly clay loam, somewhat compact when dry and slightly plastic in a moist condition. This layer continues to a depth of 28 to 30 inches and is underlain by stratified layers of gray gravel and sand in which some cementation by lime has taken place. These stratified deposits may continue to a depth of 10 to 25 feet. The surface and subsurface layers are acid, the subsoil at a depth of 30 inches is sweet, and the substratum is calcareous.

The largest and most typical areas are in the vicinity of Wrights Corners and between this place and Olcott (pl. 1, *A*). Other fairly large areas are found along the Niagara River between Lewiston and Youngstown. The aggregate area is 6.4 square miles. In general the relief is level to undulating. The parent material is greatly stratified and was laid down as outwash plains and deltas. Drainage is good to somewhat excessive but not to the extent of that in the coarse sandy loam.

Alton gravelly loam is one of the most highly valued soils of the county and is used extensively for vegetable and fruit production because of its light texture, ease of working, and speed with which it warms in spring. It does, however, have a low moisture-holding capacity and high fertilizer requirements. Common management and fertilization are the same as practiced on Alton coarse sandy loam. Yields may average slightly higher over a period of years.

Just north of Gasport are a few areas that have free lime within a depth of 18 to 24 inches. This material is closer to the surface than is normally characteristic. In the area around Olcott several large and small areas of a superior grade of soil are included in the type. These areas have a higher productive capacity because of the

higher percentage of fine material in the soil, less large gravel, and a somewhat smoother relief. Southwest of Olcott are several areas where the surface gravel is abundant and large enough to interfere with cultivation. South and east of Royalton there are a few isolated areas that have a ridge or kamelike relief. These are mapping inclusions and not typical Alton gravelly loam.

Arkport very fine sandy loam.—This soil has developed from well-drained sandy lake-laid sediments. The texture is finer than in the Newfane soil, and the color is somewhat more pink than in either the Newfane or the Berrien. The 8-inch surface layer is a grayish-brown mellow very fine sandy loam that acquires a mealy or very fine crumb structure under cultivation. The subsurface layer, to a depth of 18 inches, is light yellowish-brown firm light silt loam or very fine sandy loam that grades into pink or light reddish-brown sandy and silty materials. In some places this layer is replaced by one of moderately compact sandy clay. Below a depth of 30 inches the subsoil is composed of bedded fine and very fine calcareous pinkish-gray sands that are moderately compact in places. Along the lake shore east of Olcott there are more silty layers in the subsoil than is typical. In a very few small areas west of Olcott the sand averages medium to fine in texture, rather than very fine.

This soil (totaling 1.2 square miles) occurs mainly in two areas—one east of Lockport and the other along the lake shore about 2 miles east of Wilson. The relief is moderately to strongly rolling. The area east of Lockport has a hummocky surface, showing some influence of wind action. In some areas the present relief is the result of geologic erosion. Drainage is good but not excessive. Surface runoff is rapid on the steeper areas and causes considerable washing on cultivated and bare soil.

This is a good soil for tree fruits, grapes, vegetables, and crops sold to canning factories. Management, rotation, and fertilization are similar to those practiced on Dunkirk fine sandy loam and Newfane sandy loam. Yields on the uneroded areas are possibly 5 to 10 percent less than on Newfane sandy loam, and they are still less where accelerated erosion has been severe.

Arkport very fine sandy loam, smooth phase.—The smooth phase has profile characteristics similar to those of the typical soil, but differs in having smooth relief. The total area is 2.3 square miles. The principal areas are south and east of Lockport and on the Niagara-Orleans County line. Owing to the smoother surface, this soil has a somewhat higher value than the typical soil; it is used for the same purposes, but is less difficult to farm.

Berrien fine sandy loam.—This is one of the most widely distributed soils north of the escarpment. It has an 8-inch surface soil of grayish-brown fine sandy loam having a finely granular or single-grain structure, and is underlain to a depth of 25 inches by yellowish-brown friable loamy sand or fine sandy loam. At a depth of 30 to 40 inches this material rests on a layer of somewhat compact loamy sand containing fairly numerous yellow and brown mottles and, in many places, small irregular iron concretions. This layer, which ranges in thickness from 10 to 18 inches, considerably impedes but does not prevent the penetration of roots. The material beneath shows much variation. In some places heavy clay alternates with sandy layers; in

A, Young peach orchard on Alton gravelly loam near Olcott. *B*, View overlooking the escarpment east of Lewiston. Farmington stony loam in the foreground, Dunkirk silty clay loam and Collamer silty clay loam in the background. *C*, Vineyard on Ontario loam at the base of the Niagara escarpment.

A, Potatoes and cabbage growing on Dunkirk silt loam. *B*, Mature wheat on Dunkirk silt loam.

others less compact medium or fine sand extends downward to a depth of 6 to 8 feet or more; and in still others strata of gravel or compact glacial till lie below the compact mottled layer. Everywhere, however, the compact mottled layer is present, and a clay or till layer lies at a lower depth, which may be 8 to 10 feet below the surface. In most places the material is more or less calcareous at a depth of 4 or 5 feet. Important variations in this soil include a range in color of the surface layer from grayish-brown to brown—a condition associated with the incorporation of organic matter—and in places the presence of small quantities of fine gravel or pebbles on the surface and mixed in the subsurface layer.

This soil occupies fairly long continuous bodies and smaller isolated areas throughout the northern part of the county between the escarpment and Lake Ontario. It is associated with Hilton, Lockport, Collamer, and Allendale soils and covers a total of 20.7 square miles. The relief is level to slightly undulating, the sharper undulations caused in part by the wind.

Most of the parent material consists of lake-laid sand, and the rest consists of glacial-outwash sands and delta deposits.

Surface drainage is well established, but owing to the presence of the compact mottled layer, internal drainage is only moderately well developed. The compact till or clay beneath the Berrien soils interferes with the movement of water through the substratum and probably causes intermittent waterlogging in spring.

This is a good soil for orchards (*10*) and compares favorably with the Dunkirk and Alton soils. Owing to its light texture, fairly heavy fertilization and application of organic matter are needed. The sandy nature of the soil makes it well suited to peach and cherry orchards. Besides orchard crops, tomatoes and peas for the canning factories, cucumbers, melons, eggplants, and other vegetables are of considerable importance. Winter wheat, corn, and timothy and clover are the common field crops.

Although the lower subsoil layer is calcareous at a depth of 4 or 5 feet, the surface, subsurface, and upper subsoil layers are acid, indicating a need of lime for cabbage and alfalfa. The common system of fertilization calls for 4 to 8 pounds of sodium or calcium nitrate or ammonium sulfate for each apple tree (fig. 3) in mature orchards and 300 to 500 pounds an acre of a complete fertilizer for tomatoes, in many places applied by hand in the smaller fields. Unless it has been heavily manured, the land planted to other vegetable crops receives 200 to 400 pounds of a complete fertilizer, as 2–8–10 and 4–12–4.

When the orchards are fertilized as above, apples yield 100 to 275 bushels an acre, tomatoes 5 to 10 tons, peaches 100 bushels, and cherries 5,000 pounds. Approximately 30 percent of the land is used for orchards, 20 percent for vegetable crops, 20 percent for field crops, 10 percent for hay, 10 percent for pasture, 5 percent for woods, and 5 percent is idle.

Berrien loamy fine sand.—This soil occurs as low mounds and low broad ridges in association with Berrien fine sandy loam and consists largely of wind-blown material. The 8-inch surface layer of grayish-brown or brown loose loamy fine sand grades into yellowish-brown loamy sand or fine sand that continues to a depth of 24 inches. The upper part of this layer is friable and open; the lower

part, slightly compact. Between depths of 24 and 36 inches the material consists of slightly compact light yellowish-brown loamy fine sand. Below this is moderately compact medium to fine sand containing numerous mottles or stains of dark brown and, in places, a few soft iron concretions. At a depth of about 50 inches is dark-red compact silty till, mottled with rust brown and containing some limestone fragments.

Although the arrangement and texture of the horizons are uniform in the upper 4 feet, lenses of clay, gravel layers, or glacial till are

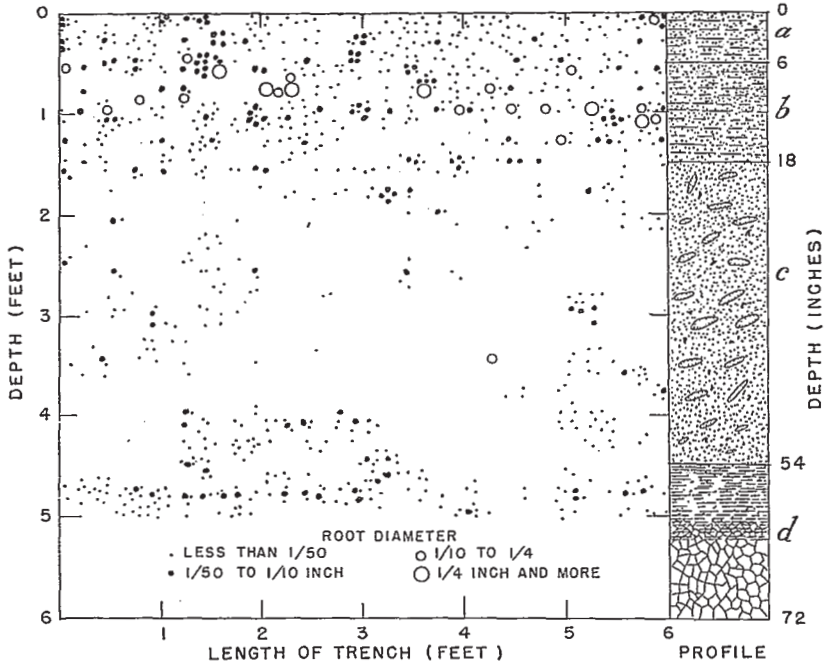

FIGURE 3.—Root distribution of an 85-year-old Rhode Island Greening apple tree growing on Berrien fine sandy loam, as shown by trench. Soil profile description: *a*, Dark grayish-brown mellow fine sandy loam; *b*, yellowish-brown friable fine sandy loam; *c*, yellowish-brown moderately compact but friable fine sandy loam highly mottled with light gray and rusty brown; *d*, reddish-brown silty clay moderately compact in upper part and grading to very dense material with blocky structure at 63 inches. The depth of the heavy compact substratum largely determines the volume of soil available to the roots.

reached in places at greater depth. The thickness of sandy material becomes less at the edges of the areas, and heavy clay or till substrata appear near the surface.

This soil is less extensive than the fine sandy loam. The largest and most typical areas of its 2.0 square miles are in the eastern part of the county north of the ridge, and a few dunelike areas are in the extreme southeastern corner near Tonawanda Creek.

Drainage is excessive throughout the surface and subsurface layers, but the lower subsoil may be saturated for considerable periods, owing to the compact nature of the substratum. The reaction is acid down to, but not including, the calcareous till or clay.

The soil has less body than the fine sandy loam and tends to blow easily if left unprotected. It is not very productive; trees root deeply but require heavy fertilization. Although used to some extent for orchards, it probably is better suited to peaches and cherries than apples. Besides tree fruits, vegetables, hay, and wheat also are grown. Yields average 10 to 20 percent lower than on Berrien fine sandy loam.

Brockport silt loam.—The surface soil is dark grayish-brown very granular heavy silt loam containing a small quantity of gravel. Below a depth of 9 inches it grades into a lighter gray clay in lumps ¼ to 1 inch in diameter. From a depth of 24 to 30 inches, light grayish-brown thinly laminated material grades into disintegrated shale. This soil is slightly acid or neutral in the surface layer and calcareous in the subsoil.

The total area of 1.0 square mile is mapped only in the section between Gasport and Middleport on the crest of the escarpment. Relief is moderately level to gently sloping, and drainage is fair to good. The parent material was formed mainly through the weathering in place of underlying soft gray calcareous shales, but there has been a small contribution from glacial till. This soil is used for alfalfa, clover, wheat, corn, and to a certain extent for orchards. Crop yields approximate those on Ontario silt loam, shallow phase.

A few areas included with the silt loam have a silty clay loam surface texture and less depth to the underlying shale. There also may be more glacial boulders scattered over the surface of these heavy-textured areas.

Carlisle muck.—An excavation in the muck reveals 10 to 15 inches of black granular thoroughly decomposed organic material overlying brown fibrous peat. In places the decomposition has progressed to a depth of 2 feet or more. Blue sand or clay underlies the organic deposits at a depth of 30 to 50 inches.

Normally poor drainage is the limiting factor in the utilization of muck areas. In the Pekin area during the past few years, however, drought has been more of a problem than excess water. At the present time, about 35 acres of this area is under intensive irrigation from wells.

Carlisle muck is not an extensive land type (1.8 square miles) in Niagara County. Two small areas are south of Ridge Road. The only areas of any size under cultivation are southwest of Pekin in the town of Cambria and south of Middleport in the town of Royalton. About 100 acres of the Pekin area are used for onions, cauliflower, potatoes, asparagus, carrots, lettuce, beets, and other vegetables. The area south of Middleport is approximately 150 acres in extent, and is used for potatoes, onions, celery, and beets.

The cultivated areas are heavily fertilized, and vegetable yields are considerably higher than on mineral soils. The uncleared part of this muck has a forest cover of elm, silver maple, and ash.

Carlisle muck, shallow phase.—In the shallow phase the surface layer is about 11 inches thick and is composed of dark-brown to black highly granular well-decomposed organic matter. Light-gray fine sandy loam mottled with brown occurs at a depth of 11 to 15 inches, where it grades into pink fine or very fine calcareous sand. Below a depth of 30 inches is reddish gravelly loam alternating with layers

of silt. In places the sands underlying the organic surface are replaced by tight plastic blue clay. This phase occupies 2.6 square miles in sags and depressions that are impossible to drain and supports a growth of elm, ash, willow, and silver maple.

Cazenovia silt loam.—This soil occurs on slopes of the ridges where glacial till and lacustrine deposits are mixed, and is closely associated with the Ontario and Schoharie soils. The 8-inch surface layer is dark grayish-brown granular silt loam, in places containing a noticeable quantity of gravel. From a depth of 8 to 15 inches is light-brown or grayish-brown silt loam with mottlings of light gray, which grades into dark reddish-brown compact silty clay with a well-developed massive fragmental structure that continues to a depth of 26 inches and this, in turn, is underlain by reddish-brown compact gravelly silty clay loam exhibiting a definite nut structure. Nodules or streaks of lime are present. Below 38 inches the material is pink highly calcareous gravelly glacial till.

The aggregate area of 1.5 square miles is mapped principally south and southeast of Lockport and along the base of the escarpment between Lockport and Lewiston. It is somewhat superior to the Hilton soils in agricultural value because internal drainage is better, but it is not so good as the Ontario soils. The sloping relief provides adequate surface runoff.

Winter wheat, oats, alfalfa, corn, and hay are the principal crops. The areas along the escarpment support a few orchards. The yields are nearly the same as on Ontario silt loam.

Clarkson gravelly loam, shallow phase.—This shallow phase is associated with the Lockport and Hilton soils. It is distinguished from the Hilton soils by redder color and the presence of red shale bedrock at relatively shallow depths. The 8-inch surface layer of brown or slightly reddish-brown granular gravelly loam grades into a darker reddish-brown heavy silt loam having an angular-cloddy structure. Angular gravel and stones are mixed with the material. Between depths of 15 and 24 inches the material is dull-red heavy silt loam or silty clay loam that may show considerable gray and brown mottling. From 24 to 36 inches the material is red friable glacial till resting on dull-red soft shale. The soil is slightly acid in the surface layer, practically neutral at a depth of 12 to 15 inches, and carries free lime at a depth of 24 inches. The only variation of importance within this phase is in the degree of drainage. Drainage is moderately well established and is closely related to the relief. The slightly undulating areas that allow fairly rapid runoff are free from mottling, but mottling in the soil on more level areas indicates imperfect subsoil drainage.

This phase covers a total area of 5.2 square miles north of the escarpment, in fairly large areas that have a southeast-northwest trend—the largest and most typical are in the eastern part of the county, but small areas are scattered throughout the Ontario plain from the Orleans County line westward to the town of Wilson. The soil lies on nearly level or slightly undulating land or on low broad ridges. The parent material is glacial till derived from limestone, sandstone, and considerable red shale of the Queenston formation. It is this red shale that contributes the red color to the soil.

Ranking somewhat above the Hilton soils in agricultural value, this

phase is used for apple, pear, and plum orchards, winter wheat, cabbage, tomatoes, hay pasture, oats, and corn. Apple trees are fertilized with nitrate of soda or ammonium sulfate, cabbage and tomatoes with 200 to 800 pounds an acre of a complete fertilizer, as 5–10–5 or 4–16–4. The land for winter wheat may receive an application of 2–8–10 or superphosphate alone in quantities varying from 200 to 400 pounds an acre. Oats and corn are fertilized with phosphate alone. Manure is used on hay or cornland. Lime is not used extensively. Very little alfalfa is grown, and the presence of lime at a depth of 24 to 30 inches satisfies the lime requirements of clover, though normal yields are probably 5 percent lower than on Hilton gravelly loam.

Clarkson gravelly silt loam.—This soil has a lighter textured subsoil, is deeper to bedrock, and on the average is better drained than the shallow phase of Clarkson gravelly loam, with which it is associated. It is a better soil for fruit, but is not so important owing to the limited area. The surface layer consists of reddish-brown granular silt loam with considerable angular gravel and small stones. Between depths of 8 and 16 inches the subsurface layer is lighter reddish-brown firm silt loam that grades into dull-red slightly compact gravelly loam. The lower subsoil layer is light-red calcareous gritty-loam glacial till containing numerous red shale fragments. The underlying shale bedrock is seldom less than 40 inches below the surface.

The total area of this soil is 3.8 square miles. It is mainly in the northeastern part of the county in association with the shallow phase of Clarkson gravelly loam and the Lockport soils. It occurs on areas with low broad ridge or undulating relief. Drainage is moderately well developed.

The chief use of this soil is for orchards, cash crops, and general farming. Yields of field crops are slightly more than on the shallow phase of the gravelly loam, and returns from the orchards are substantially greater. Peaches and cherries are grown with much greater success on this type.

Collamer silt loam.—This soil is closely associated with the Dunkirk, Hilton, and Berrien soils north of the escarpment and differs from Dunkirk silt loam mainly in the occurrence of a gray subsurface layer, indicating imperfect drainage. The normal cultivated surface layer is grayish-brown or dark grayish-brown granular silt loam, and in areas where it approaches silty clay loam there is a distinct tendency toward puddling if the soil is cultivated when too wet. The surface layer grades rather abruptly into yellowish-brown or light-gray firm silt loam mottled with brown and yellow. Between depths of 18 and 36 inches the subsoil is compact dull reddish-brown silty clay loam having a well-developed fragmental structure. Many streaks and nodules of segregated lime are present at the lower limits of this horizon. Below this the material is composed of brown to reddish-brown dense hard stratified clay and silt. In some places, it rests on unaltered bluish-gray glacial till at a depth of 50 to 60 inches, but normally the stratified silts and clays continue to an 8- to 10-foot depth.

In many areas near Lake Ontario and on some near the ridge small quantities of angular gravel and small stones are present, generally only in the surface soil but occasionally in a few places mixed with the upper 12-inch layer. Nowhere are gravel and stone abundant

enough to interfere with cultivation or to influence the agricultural characteristics of the soil. The gravelly areas are indicated by symbols on the map.

South of the Ridge Road and between Hartland and Johnson Creek, this soil differs from the typical in the absence of a pronounced gray subsurface layer. Here, the subsoil is not so heavy as elsewhere and the color is grayish rather than reddish brown. This area is in the flood plain of Johnson Creek, and includes some alluvial material.

With an aggregate area of 39.9 square miles, this is one of the more important soils of the county and is widely distributed throughout the northern part. Large bodies occur between the Ridge and the base of the escarpment, and there are a few areas northeast of Niagara Falls on the south side of the escarpment; otherwise the soil occurs only on the Ontario plain.

The flat or slightly depressed land accounts for the slow surface runoff. Internal drainage is imperfect, owing to the heavy compact nature of the subsoil and substratum. The gray layer below the surface soil has developed as a result of the slow drainage and indicates periodic waterlogging. It cannot be considered poorly drained, but removal of excess water is slow and in spring the water table remains high for extended periods. For continuous production of fruit it presents several problems. During seasons when rainfall is normal or slightly less, no ill effects result from excess water; but in wet seasons the yields are materially reduced.

This soil is used so extensively for orchards that it must be considered an important soil for fruit, chiefly apples, pears, and quinces, even though it is not so productive as other better drained soils (fig. 4). It is recognized by farmers as being too heavy for peaches and cherries. Since pears and quinces tolerate wetter soil conditions than apples, the yields of these fruits are not materially reduced by the slow drainage. Studies of the distribution of the roots of apple trees show a concentration in the upper layers and poor penetration into the subsoil.

A considerable acreage is planted to winter wheat, hay (principally timothy and clover), oats, and corn. Alfalfa does moderately well on areas where surface runoff can be made adequate. Cabbage, tomatoes, and peas for canning factories are also grown extensively. Wheat and alfalfa are sometimes injured by heaving, especially in depressions where the texture tends toward silty clay loam. The fairly heavy texture and the low organic-matter content make the preparation of mellow seedbeds rather difficult. If worked when wet, the soil tends to puddle and form clods. This is a serious disadvantage for peas or tomatoes.

Practically all of the land is under cultivation. Probably 20 percent is planted to apples, pears, and quinces; 25 percent to hay crops; 10 percent to winter wheat; 5 percent to cabbage, tomatoes, and peas; 10 percent to pasture; 15 percent to oats and corn; and 5 percent to grapes and miscellaneous vegetable crops. Idle land and wood lots account for the remaining 10 percent.

Average yields are 10 to 15 percent less than on Dunkirk silty clay loam under comparable systems of fertilization and management.

Collamer silty clay loam.—This heavy-textured member of the Collamer series is of small extent. The 6- to 8-inch surface layer is

dark grayish-brown light silty clay loam or heavy silt loam that is granular when sodded but lumpy and cloddy when cultivated. The subsurface layer is lighter gray firm silty clay loam highly mottled with gray, brown, and yellow. Below a depth of 18 inches the material is compact dense reddish-brown blocky clay, and at 36 inches it is strongly calcareous. The substratum is made up of stratified silt and clay and in places rests on compact till.

The larger areas of this soil (totaling 2.6 square miles) lie south of the escarpment (pl. 1, *B*) in the vicinity of Hartland. Other less ex-

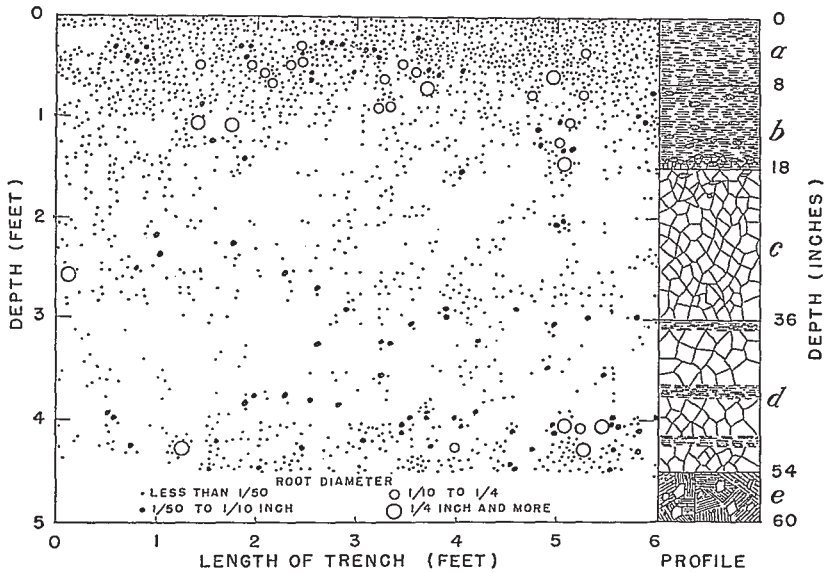

FIGURE 4.—Root distribution of a 75-year-old Baldwin apple tree growing on Collamar silt loam, as shown by trench. Soil profile description: *a*, Grayish-brown granular silt loam; *b*, light yellowish-brown mottled with brown and yellow silt loam; *c*, dull reddish-brown blocky silty clay; *d*, alternate layers of reddish-brown blocky silty clay and light-gray highly calcareous silt and fine sand; *e*, reddish-brown sandy glacial till. The subsoil and substratum are heavy-textured, but roots penetrate along cracks until they strike a structureless layer as in *e*.

tensive areas occur west of Lockport. The flat to slightly depressed surface accounts for the slow surface runoff. Owing to the heavy tight character of the subsoil and substratum, drainage through the soil also is slow.

Owing to poor drainage, this soil is used mainly for hay and pasture. Timothy and alsike, or red clover, are planted instead of alfalfa for hay, as the soil is not sufficiently well drained for the latter crop. Where it is possible to establish adequate drainage, however, the soil is fair for vegetables. Many of the small areas near the farmsteads are used for quinces. Apple orchards have been planted on this soil, but the yields are low and the trees are short-lived; only a few peach and pear trees are grown. Winter wheat is sometimes sown, but the soil is not well adapted to this crop as extensive damage from heaving usually occurs. The heavy texture makes tillage difficult, and the marked tendency to puddle and lump makes this a relatively poor soil for corn, tomatoes, and other intertilled crops.

Excellent pasture can be obtained, however, and the timothy meadows are good. Little commercial fertilizer other than phosphate is used, but manure is applied when available. Approximately 60 percent of the land is used for hay, 25 percent for pasture, 5 percent for woodland, and 10 percent for all other crops.

Colwood silt loam.—The Colwood series differs from the Granby in being silty instead of sandy but is similar in drainage, natural vegetation, and relief. This soil type has an 8-inch surface layer of dark-brown or nearly black silt loam, high in organic matter, and is abruptly underlain by a light-gray or nearly white smooth silt loam 4 to 6 inches thick. This layer grades into a reddish-brown sandy or gravelly loam mottled with yellow and brown. The lower subsoil layer and substratum may be either laminated silts and fine sand or glacial till; the color is always reddish brown or brownish red.

Occupying basins and depressions scattered widely across the northern part of the county, it is subject to prolonged waterlogging during parts of the year. Drainage has been improved in places by ditching, and the land is used for a variety of crops.

Undrained areas of this soil are swampy for many months of the year, but where improved by drainage, their high inherent fertility makes excellent crop yields possible. Natural conditions, as flatness of land, are a barrier to complete reclamation, and much of the total area of 4.2 square miles is still too wet for agriculture.

Dunkirk fine sandy loam.—The 8-inch brown or grayish-brown finely granular mellow sandy surface soil grades into lighter brown very fine sandy loam, which continues to a depth of 16 inches. This material is underlain to a depth of 24 inches by light reddish-brown moderately compact loam that shows considerable rusty-brown staining. Below this the material is light reddish-brown moderately compact silt loam underlain by stratified silt and fine sandy loam. East and north of Wrights Corners the soil differs somewhat from the typical in being sandy to a depth of 30 inches and in being underlain by light reddish-brown silt loam. The lower subsoil layer and substratum are similar to those of the typical soil.

The surface and subsurface layers are slightly to moderately acid, but the subsoil is calcareous at a depth of 30 to 40 inches. Drainage through the soil is good, and the moderately undulating surface allows adequate surface runoff. The principal bodies are in the northeastern corner of the county. The total area is 9.4 square miles.

Light texture and free drainage make this soil well suited to the production of cherries and peaches. Vegetable crops, wheat, corn, and hay also are grown. The farms are well managed and prosperous. Fertilization and crop rotation are about the same as on Dunkirk silt loam.

Dunkirk silt loam.—This is one of the most productive soils of the county (pl. 2). It is more nearly typical of the Dunkirk series than Dunkirk silty clay loam, which has a heavy reddish clayey subsoil layer. The silty subsoil probably makes it slightly superior for fruit, especially for peaches and cherries. The cultivated 6-inch surface soil consists of grayish-brown mellow finely granulated light silt loam underlain to a depth of 11 inches by light-brown slightly compact silt loam faintly marbled with rusty brown and yellow. This grades into firm rich-brown silt loam, 22 to 26 inches thick. This

layer has a well-developed fragmental structure. The fragments, ½ to 1 inch in diameter, show considerable iron-rust staining. To a depth of more than 40 inches the pinkish-brown stratified silt and very fine sandy subsoil have a moderately well-developed platy structure. Numerous streaks and nodules of free lime are present. The subsoil is moderately compact but does not hinder the penetration of roots.

Although an excellent soil, this silt loam occurs in a comparatively small area (0.8 square mile) in the northwestern corner of the town of Somerset along the shore of Lake Ontario and is used principally for orchard fruits, chiefly apples. Fertilization and management are essentially the same as for Dunkirk silty clay loam and fine sandy loam.

Dunkirk silty clay loam.[6]—This is the most extensive soil of the series. It has an 8-inch surface soil of yellowish-brown or grayish-brown mellow silt loam, which grades into slightly lighter yellowish-brown friable silt loam or silty clay loam. In many places below a depth of 14 inches there is a thin 2-inch layer of grayish-yellow silt loam having a platy structure and containing faint yellow and gray mottlings or stains. Between depths of 16 and 28 inches the material is light reddish-brown stiff heavy clay showing a pronounced fragmental structure. This is the layer of maximum compaction. Below a depth of 28 inches is light reddish-brown moderately compact silt loam with streaks and nodules of lime. Stratified layers of silt and fine sand generally lie at a depth of about 30 inches and continue to a considerable depth.

The first three layers are medium or slightly acid, whereas the fourth is approximately neutral. Free lime is present at a depth of 30 to 36 inches. The typical soil is free from stone and gravel, but in a few areas the surface and upper subsoil layers contain some sharp pieces of gravel or small stones. These areas, mainly along the lake shore, are indicated by symbol on the map.

In the broader areas the surface soil, on drying, has a grayish cast, and in places near the lake the subsoil has a deeper red tint than is typical. It occurs principally in a belt 2 to 3 miles wide along Lake Ontario. Fairly large areas also lie just north of the Barge Canal between Lockport and the county line on the east. A total of 34.8 square miles is mapped. The surface ranges from flat to strongly undulating. In some areas the soil occupies narrow ridges or small irregular bodies separated from each other by depressions occupied mainly by other soils. Part of the surface soil in places on the slopes has been removed by erosion. The absence of gravel and the silty texture of the soil make it very susceptible to soil washing.

Drainage in general is good, although percolation of ground water is rather slow in areas where the heavy clay layer in the subsoil is thick. Moreover, the level surface of some areas retards runoff.

Under proper moisture conditions, this soil, which is one of the most important in the agriculture of the area, offers little difficulty in obtaining a mellow seedbed, and is comparatively productive and suited to the wide range of crops for which it is used. The importance

[6] Strictly speaking, the profile characteristics of Dunkirk silty clay loam do not fit the accepted description of the Dunkirk series. Actually, the surface soil is silt loam and not silty clay loam, but the soil is developed on much heavier textured material than Dunkirk silt loam. It is retained in the series only because of precedent.

of fruit growing is due not only to the good quality of the soil, but also to the climatic protection offered by the lake. On some farms fruit growing is the principal source of income; on others a combination of fruit growing and production of cash crops, as cabbage and tomatoes for the canning factory, is practiced. Dairying supplements the income from the production of fruit on many farms.

Commercial orchards produce chiefly apples, but peaches, cherries, and pears also are grown. This silty clay loam is one of the best soils of the county for apples, and excavations show a good distribution of roots down to a 5- or 6-foot depth. Although peaches and cherries are grown in considerable quantity, the lighter textured soils are considered better suited to these fruits. As a rule, orchards are well managed. Clean cultivation is the predominant practice, but the trend seems to be toward the maintenance of a sod cover.

The principal grain crops are wheat, oats, corn, and barley. The acreage of alfalfa is small, but timothy and clover are grown extensively. Vegetable crops include tomatoes for canning, cabbage, sweet corn, and beans. Crop rotations usually consist of hay for 2 or 3 years followed by corn or some vegetable crop for 2 years, then back to hay. Depending on management practices and climatic conditions, hay yields 1 to 2½ tons an acre, oats 40 to 75 bushels, wheat 20 to 35 bushels, corn 30 to 50 bushels, silage 8 to 12 tons, cabbage 8 to 10 tons, tomatoes 5 to 12 tons, apples 90 to 225 bushels of packed fruit, peaches 80 to 100 bushels, and pears 50 to 150 bushels.

Most farmers use commercial fertilizers, both ready-mixed and separate materials. Complete fertilizers and superphosphate are applied to the grain and vegetable crops at the rate of 200 to 800 pounds an acre. Apple trees are fertilized only with separate materials, mainly nitrate of soda and ammonium sulfate in quantities of 2 to 8 pounds for each tree. In sodded orchards the application of fertilizer is materially increased (*7*). Spraying is necessary to produce fruit free of insect and disease injury. Niagara County is heavily infested with coddling moths; therefore, apple trees require heavy applications of insecticides 3 to 10 times a year. The successful production of salable apples depends to a considerable extent on a thorough spraying program (*8*).

Approximately 60 percent of the soil is in orchards and vineyards, 20 percent in hay, 10 percent in grain, 5 percent in vegetable crops, as tomatoes and cabbage, and 5 percent in woodland.

Dunkirk silty clay loam, rolling phase.—This phase differs from the typical soil on the basis of its strongly rolling to steep topography. It represents a geologically eroded area of materials laid down in still water. It is very susceptible to accelerated water erosion, owing to the silty nature of the surface and the clayey subsoil that prevents rapid infiltration of moisture. The surface soil is light reddish- or pinkish-brown heavy silt loam underlain by a heavy reddish silty clay loam subsoil.

This phase occurs only in the area between the Barge Canal and the escarpment east of Lockport and west of Gasport. The total area of 0.1 square mile is cultivated and planted mainly to apples, grapes, and pears.

Eel silt loam.—The 10- to 16-inch surface soil is medium-dark grayish-brown mellow smooth silt loam but varies from very fine

sandy loam to silty clay loam. The color also varies somewhat according to drainage conditions and the quantity of organic matter. The subsoil consists of brownish-yellow, light brownish-gray, or light-gray layers of silt loam, very fine sandy loam, and loam, mottled with yellow, gray, and rust brown. The surface layer has very little gravel, but the subsoil contains thin beds or layers of this material.

This soil occurs in the narrow valleys of small streams, totaling 6.2 square miles. Along the lower courses of the streams the deposits are deeper than along the headwaters. In general the land is flat, and natural drainage conditions are intermediate between those of the Hamlin and Wayland soils. Some of this bottom land is covered with growths of willow, basswood, maple, ash, elm, and shrubs; part is uncleared and remains idle, but the greater part has been cleared and is used for pasture or hay land.

Eel silt loam, colluvial phase.—In many parts of the area north of the escarpment are narrow belts or strips of soil that are low lying and imperfectly drained but without distinct drainageways. Many of these meander through areas of Dunkirk soils, but they are also associated with other soils. In addition to being imperfectly drained, these narrow belts receive wash from the adjacent slightly higher soils. Where these narrow strips extend across or into orchards, the trees along them are frequently missing or are in poor condition. These areas represent a condition rather than a distinct soil. An average area has a profile of 10 inches of dark grayish-brown to dark-gray heavy silt loam, underlain to a depth of 18 inches by grayish-brown heavy silt loam mottled with gray and yellowish-brown that grades into a brown less highly mottled silt loam. The lower subsoil material varies, but seems to exhibit characteristics similar to those of the surrounding soils.

The individual areas of this phase are so narrow that they have no distinct type of agriculture but are worked in conjunction with the soil they traverse. These areas are a hindrance and in places lower the value of the surrounding fields by dividing them into smaller areas. A total of 3.7 square miles is mapped.

Farmington stony loam.—This soil is associated with the shallow phase of Ontario silt loam at the crest of the escarpment where limestone bedrock of the Lockport formation is close to the surface. It has a grayish- or yellowish-brown gritty loam surface layer, 8 inches thick, underlain by yellowish-brown friable silt loam that rests on limestone bedrock at a depth of 15 inches. In some small areas limestone forms a complete pavement without a soil covering. Numerous boulders and outcrops are common on the other areas. A total of 1.8 square miles is mapped. On the northern edge of Lockport and 1 mile north of Gasport are several stony areas in which the rock material, mixed with the soil and underlying it at 8 to 24 inches, is composed of hard white and gray sandstone. These areas are included with Farmington stony loam because of their small extent and agricultural similarity.

Farmington stony loam is too shallow and too stony for crop use. All of it is either pasture land or wasteland. Pastures are poor because of the very small quantity of water held in the thin mantle of soil. Nearly all the grass dries up by early summer.

Farmington stony loam, steep phase.—The steep phase, totaling 2.5 square miles, occupies the front of the escarpment and ranges from

vertical 80-foot cliffs in the western part of the county to a rock ledge 5 to 10 feet high near the Orleans County line. All of it is wasteland, except the few less precipitous areas that are forested.

Fulton silty clay loam.—This soil occupies very flat areas having fair to poor natural drainage. It is more poorly drained than the Collamer and better drained than the Toledo soils. The 8-inch surface layer is dark-gray to grayish-brown silty clay loam or heavy silt loam, very granular where sodded, but in many places cloddy and lumpy when cultivated. It gives way sharply to brown or yellowish-brown dense tight mottled clay loam, with a well-developed irregular blocky structure. At a depth of 18 inches, this rests on tight tenacious clay highly mottled with gray, pink, and yellow. Structural aggregates in this layer are fairly large and resist crushing. The next lower layer, between depths of 30 and 40 inches, is a zone of lime segregation containing numerous nodules and streaks of lime. It consists of pinkish-brown very dense clay mottled with gray and brown. Compact calcareous till lies below.

The soil is uniformly free from gravel and stones, but the texture of the surface layer ranges from heavy silt loam to clay loam. In places the lower subsoil layer is made up of stratified silt and clay rather than heavy clay. A large area 3 miles northeast of Lewiston has a light reddish-brown subsoil somewhat less mottled than that of the typical soil. It is underlain by glacial till at a depth of 2½ to 8 feet.

The largest areas are northeast of Lewiston, and fairly large areas occur just south of the escarpment east of Gasport and between Lockport and Lewiston. The total area is 20.2 square miles. This soil occupies flat areas where loss of excess water by surface runoff is at a minimum and the heavy texture of the subsoil impedes the downward movement of water. The parent material consists of lacustrine sediments laid down in the former glacial lakes Iroquois and Lundy.

A few apple trees (fig. 5) are grown on the soil, but it is poor for orchards, production is low, and the trees are short-lived. A few pear orchards in the areas northeast of Lewiston do only moderately well. The soil is used mostly for pasture and hay crops. Native pasture grasses are mainly Canada bluegrass and bent grasses. Excellent pastures of Kentucky bluegrass and white clover are easily established and maintained. Corn and oats are produced on the better drained areas, and winter wheat can be grown where surplus water is removed by deep open ditches. Not much fertilizer is used, and yields are only moderate. Hay will produce 1 to 2½ tons an acre, wheat 20 to 25 bushels, oats about 40 bushels, and corn 20 to 40 bushels if adequately drained. Most of the land has been cleared, and the remaining woodlands support elm, silver maple (soft maple), basswood, hickory, and ash. Approximately 30 percent of the land is used for hay, 30 percent for pasture, 20 percent for woodland, and 20 percent for field crops.

Granby fine sandy loam.—The 7- to 11-inch surface layer consists of dark-gray sandy loam underlain by light-gray sand resting on mottled-gray sand overlying a reddish sandy clay substratum. An average profile has the following characteristics: An 8-inch surface soil of dark-gray to nearly black highly organic fine sandy loam; light-gray loose and open fine sandy loam to a depth of 15 inches; yellowish- or brownish-gray fine sandy loam, mottled with rusty brown

spots to a depth of 24 inches, grading into reddish-brown firm silt loam. The surface and subsurface soils are slightly acid, but free lime is present at a depth of 24 to 30 inches. On this soil there are many small mounds and low ridges of brown fine sand of insufficient area to be indicated on the map.

Large areas occur in the northeastern part of the county, and smaller areas in the western part, but the soil does not occur south of the escarpment. The total area is 8.2 square miles.

A large part of the soil is included in woodland of soft maple, elm, and ash. In undrained areas it is largely nonagricultural, but where

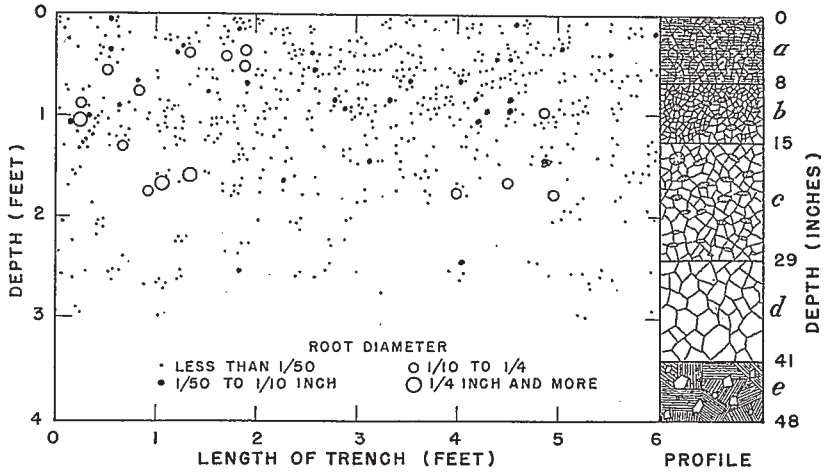

FIGURE 5.—Root distribution of a 65-year-old Baldwin apple tree growing on Fulton silty clay loam, as shown by trench. Soil profile description: *a*, Dark-gray coarsely granular silty clay loam; *b*, mottled yellowish-brown and dark-gray blocky firm clay loam; *c*, highly mottled gray and yellowish-brown compact blocky silty clay; *d*, pinkish-brown dense calcareous clay highly streaked with gray and yellow; *e*, compact highly calcareous gravelly clay loam till. Only a small volume of this poorly aerated, heavy soil is available to tree roots and the trees generally produce poorly or die.

adequate drainage can be established high yields of vegetables and hay are obtained.

Hamlin silt loam.—This is a well-drained first-bottom soil, much like the Genesee soils south of this area, the only distinction being in color, this one being reddish brown, and the Genesee soils brown.

The 8-inch surface soil is reddish-brown or brown mellow granular silt loam grading into light reddish-brown granular friable silt loam, which extends to a depth of about 22 inches. Below this material is reddish-brown heavy silt loam with an irregular blocky structure. In places some gravel may be scattered over the surface and in thin lenses or layers in the subsoil and substrata. The areas along Tonawanda Creek have brown or grayish-brown surface soil and brown subsoil that rests on heavy lacustrine clay at a depth of 10 to 12 feet. The total of 7.4 square miles mapped includes spots that are somewhat sandy in the immediate surface.

This silt loam consists of water-deposited sediments on flood plains that receive the wash from shale and sandstone materials. The sur-

face is flat, and the land lies 4 to 6 feet or more above the normal level of streams. The structure is conducive to good drainage between infrequent periods of flooding. The greater part of the land has been cleared, but narrow strips of willows and alders grow in places along the stream channels. Nearly all of this soil is used for pasture or hay land, but a few small areas are planted to corn or oats or are used for truck crops. The natural fertility level is high. Good yields are obtained without the use of heavy applications of fertilizer.

Hamlin silt loam, high-bottom phase.—The profile of the high-bottom phase does not show marked variation from the lower lying typical soil. The colors may be slightly more intense, and the soil materials are usually firmer. The 6-inch surface soil is dark-brown or dark reddish-brown friable fine granular silt loam underlain by a 4-inch layer of light grayish-brown firm silt loam that grades into dull reddish-brown rather compact silt loam with a thinly laminated structure. This layer continues to a depth of 26 inches and then changes to yellowish-brown friable fine sandy loam. From a depth of 30 to 50 inches the material consists of dull reddish-brown compact silt loam with well-developed cloddy structure. The surface soil is slightly acid or neutral, the subsoil alkaline or calcareous. Root penetration is good. The main variation is that of color, which ranges from yellowish brown to red.

This high-bottom phase is developed in fairly large areas on high benches along Eighteenmile Creek and its East Branch, which lie 10 to 20 feet above the normal level of the water. These high bottoms are seldom, if ever, overflowed. The total area is 3.2 square miles. The land is level to gently sloping, the gradient being sufficient to insure adequate surface runoff. Internal drainage is also well established.

This phase is well adapted to vegetables and field crops and gives good yields of peaches, cherries, and apples (fig. 6). It is easy to work, dries out fairly rapidly, and has good moisture-holding capacity. The main crops are peaches, cherries, apples, peas, and tomatoes for the canning factories, and cabbage, wheat, oats, and hay. The natural fertility level is high, and good yields are obtained with less fertilizer than is applied to many of the other well-drained soils. The approximate average yields of peaches are 125 bushels an acre, cherries 4,000 pounds, apples 200 bushels, tomatoes 7 to 10 tons, cabbage 7 to 10 tons, shelled peas, 1,000 pounds, wheat 30 bushels, oats 40 bushels, and hay 2 tons. All the high-bottom phase is cultivated; approximately 15 percent is in orchards, 20 percent in hay, 10 percent in pasture, 25 percent in wheat, oats, and corn, and 30 percent in vegetable crops.

Hilton gravelly fine sandy loam.—This soil is less uniform in its characteristics than the other members of the series. The 8-inch surface layer generally consists of light-brown or grayish-brown friable gravelly fine sandy loam underlain to a depth of 24 inches by light grayish-brown fine sandy loam, moderately compact and mottled with gray and brown, grading into very compact faintly mottled gritty loam. Below a depth of 30 inches is unaltered reddish-brown calcareous glacial till parent material.

This soil frequently occupies the crests of low ridges that have been modified by the deposition of wind-blown sand. It occupies a total area of 2.6 square miles. Drainage is somewhat better developed

than in the other members of the series. It is used for general farm crops and orchards. Considerable quantities of peaches and cherries are grown, but the yields are lower than on the gravelly loam.

Hilton gravelly loam.—The 8-inch surface layer is grayish-brown friable gravelly loam underlain abruptly by grayish-brown firm gravelly silt loam highly mottled with light gray and yellow. This layer, which is 6 to 10 inches thick, grades into reddish-brown hard compact gravelly clay loam that breaks into large irregular hard clods. Below a depth of 24 inches the material is light reddish-brown very gravelly calcareous loam, considerably more friable than the layer above.

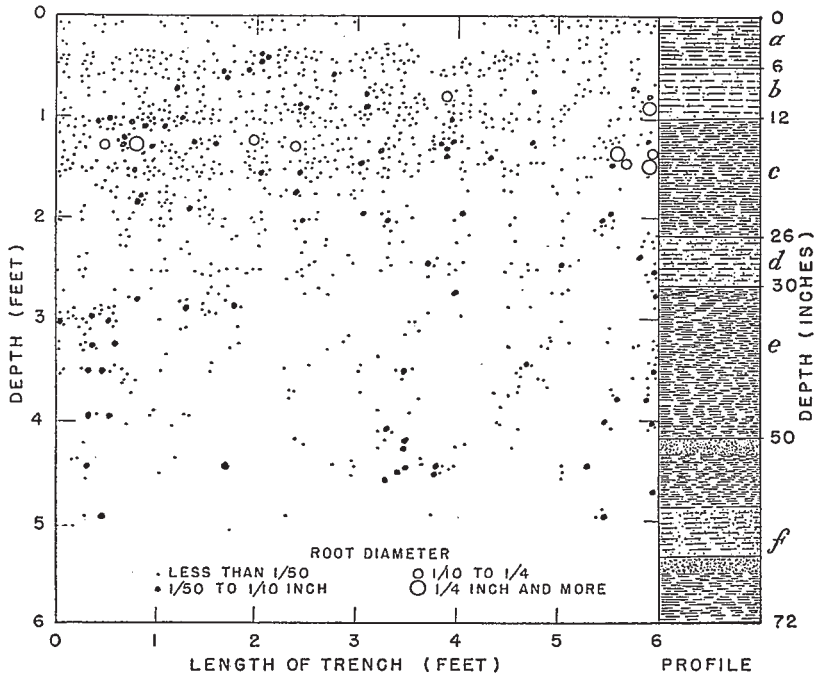

FIGURE 6.—Root distribution of a 60-year-old Rhode Island Greening apple tree growing on Hamlin silt loam, high-bottom phase, as shown by trench. Soil profile description: *a*, Dark grayish-brown friable silt loam; *b*, light grayish-brown friable silt loam; *c*, dull reddish-brown laminated slightly compact silt loam; *d*, bright yellowish-brown fine sandy loam; *e*, dull reddish-brown moderately compact silt loam; *f*, alternate layers of yellowish-brown fine sandy loam and dull reddish-brown silt loam. Fruit trees feed on a large volume of this young and very fertile well-drained soil lying above the flood level of streams.

The two upper layers are slightly acid, and free lime occurs at a depth of about 2 feet.

The soil is developed extensively north of the escarpment across the northern half of the county and occupies low broad ridges or level areas of considerable size. It has a total extent of 27.1 square miles. The parent material is glacial till derived from sandstone, limestone, and shale and laid down as ground moraine. In places the material shows evidence of washing by wave action, leaving the surface covered with considerable gravel and stones. Drainage is imperfectly developed. On low ridges the surface runoff is fairly good, but where

the land is fairly level the removal of excess surface water is hard to achieve. The hard compact subsoil greatly impedes internal water movement, which results in a high water table until late in the growing season. In common with other members of the series, it is a problem soil. During seasons of normal rainfall, the ill effects of slow drainage are not so apparent, but in years when precipitation is above normal, fruit trees do not thrive.

Many orchards of apples (fig. 7), pears, and plums are growing on this soil, even though it is not rated as good for fruit; pear and prune trees do better than other fruit trees. Winter wheat, tomatoes, cabbage, oats, hay, and corn are important crops. Agriculture consists

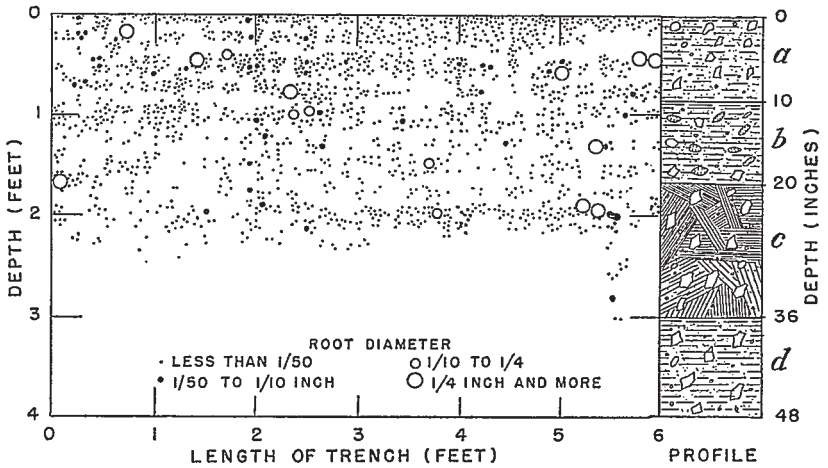

FIGURE 7.—Root distribution of an 85-year-old Rhode Island Greening apple tree growing on Hilton gravelly loam, as shown by trench. Soil profile description: *a*, Grayish-brown friable gravelly loam; *b*, pale grayish-yellow gravelly floury silt loam slightly mottled with brown; *c*, very compact slightly reddish-brown gravelly clay loam faintly mottled with yellowish brown; *d*, faintly reddish-brown moderately compact calcareous gravelly loam. Because of the compact layer this tree feeds almost entirely within the upper 2 feet of soil.

mainly of fruit and cash-crop production. Although considerable fertilizer is used, the response is less than on the better drained soils. The approximate normal yields are apples 100 to 150 bushels an acre, pears 90 bushels, wheat 25 bushels, oats 40 bushels, timothy and clover hay 2 tons, corn 40 bushels or 9 tons of silage, cabbage 8 tons, and tomatoes 6 to 8 tons. About 25 percent of the total acreage is planted to fruit trees, 25 percent to hay, 15 percent to pasture, 10 percent to wheat, 10 percent to oats, 10 percent to corn, and 5 percent to cabbage, tomatoes, peas, and other vegetable crops.

Hilton gravelly loam, compact subsoil phase.—Among the Hilton soils this phase ranks next to the gravelly loam in importance. While a mechanical analysis may not show any more clay and silt in the subsoil than is present in the typical soil, this phase is definitely less well drained and more compact in the subsoil. The areas are flatter, the soil darker, and the subsurface layer a more pronounced gray. The 6-inch surface layer is dark-gray or dark grayish-brown rather silty gravelly loam and rests on a gray or grayish-brown gravelly silt loam

highly mottled with brown and light gray. This layer is set off sharply from the surface soil, but grades into a reddish-brown very compact and hard gravelly silt loam faintly mottled with grayish pink and brown. Below a depth of 30 inches the subsoil is moderately friable very gravelly highly calcareous loam resting on unaltered glacial till at a depth of 40 to 48 inches. The compaction in the third layer is so great as almost to prohibit root penetration. The few roots that find their way below this layer do so by following worm burrows or the joint planes of the structural aggregates. A total of 23.9 square miles is mapped.

Drainage is not well developed. The very flat nature of the land makes artificial drainage a difficult problem. There are many open ditches along the roads that traverse the Hilton soils, but they are not always kept in a clean open condition.

The system of agriculture practiced on this soil does not differ greatly from that on the normal gravelly loam. The proportion used for fruit growing is about the same, but pears and plums are grown to a greater extent and apples to a less extent. Winter wheat, cabbage, and crops for the canning factories are of considerable importance. Yields probably average 5 to 10 percent less than on the gravelly loam.

Hilton silt loam.—This is a distinctly better soil than the compact subsoil phase of the gravelly loam. The surface is browner and drainage seems to be better developed. The typical soil has a light or grayish-brown granular silt loam surface layer 6 to 8 inches thick, overlying a grayish-brown silt loam mottled with gray and yellow, which grades, at a depth of 14 inches, into a reddish-brown gritty silt loam that is compact and hard in place. The subsoil is pinkish-brown friable gravelly calcareous loam.

Though associated with Lockport, Clarkson, and other members of the Hilton series in the northeastern part of the county, it is less extensive than the gravelly loam or the compact subsoil phase. The total area mapped is 5.4 square miles. Management, fertilization, and yields are substantially the same as on Hilton gravelly loam. Apples, pears, plums, winter wheat, cabbage, tomatoes, oats, hay, and corn are important crops.

Hilton silt loam, compact subsoil phase.—This phase occupies a lower and flatter position than the typical soil and has a darker surface layer, a more pronounced gray layer, and somewhat greater compaction in the subsoil. It has a more silty texture than the compact subsoil phase of the gravelly loam. The 8-inch surface soil is dark-gray somewhat granular silt loam with little or no gravel and changes sharply to light-gray or grayish-brown silt loam mottled with rusty-brown spots. Between 14 and 26 inches the upper subsoil layer is light reddish-brown silt loam mottled with gray and brown and is hard and compact in place. This material grades into dull reddish-brown silt loam with very little gravel and less compaction than the layer above. The substratum is reddish-brown calcareous till containing much fine and very fine sand. A total area of 7.4 square miles is mapped.

This compact subsoil phase has the same relief and drainage characteristics as gravelly loam, compact subsoil phase. Agricultural practices, management, crops, and yields are essentially the same.

Lake marsh.—Along Lake Ontario at the mouth of some of the small streams are areas of fresh-water marsh that are covered with water for the greater part of the year. In places the material is organic, and in others a thin layer of organic matter overlies alluvium. Vegetation consists of rushes, reeds, cattails, and swamp grasses. A total area of 0.2 square mile is mapped.

Lockport gravelly loam.—This soil is closely related to Clarkson gravelly loam. The profiles are somewhat similar, but shale bedrock is found closer to the surface in Lockport and drainage is not so well established. The 9-inch surface layer is dark grayish-brown gravelly loam giving way. abruptly to gray or light-gray gravelly loam mottled with rusty brown. At a depth of 27 inches this material grades into dull reddish-brown clay with a sharp cloddy structure. Partly weathered shale may be encountered at a depth of 30 to 36 inches. The surface of a few small areas in the vicinity of Johnson Creek is sandy and less gravelly than typical.

Lockport gravelly loam occupies an area of 1.6 square miles, most of which is about 4 miles southeast of Barker; other small areas are north of Lockport. Relief is flat and essentially like the silt loam. Drainage conditions also are similar. The parent material is largely glacial till. In a few places the soil has undoubtedly developed from a thin mantle of glacial till, which overlies the red shale bedrock at a depth of 30 to 40 inches.

This soil, though somewhat more productive than Lockport silt loam, is used in much the same way. It has a low value for agriculture. It is too wet for fruit growing, and the heavy texture makes tillage difficult. The principal use is for pasture land or for hay. Several pear orchards are on this soil, but the yields are only fair even on areas where the surface runoff is best. Canada bluegrass is the dominant pasture grass, and creeping bent grass is next in importance. Hay is made from timothy and medium-red or alsike clover. Yields are lower than on the compact subsoil phases of the Hilton soils. Approximately 5 percent of the soil is in woodland, 10 percent in pear, plum, and quince orchards, 30 percent in pasture land, 20 percent in hay, and 10 percent in wheat, oats, corn, cabbage, and tomatoes, and 25 percent is idle.

Lockport silt loam.—To a depth of 7 inches this soil is grayish-brown or dark-gray heavy silt loam, granular when in sod, but frequently lumpy and cloddy under cultivation. The subsurface to a depth of 13 inches consists of reddish-brown silty clay loam with a gray cast and mottled with gray and brown. It is dense in place and breaks out in hard irregular clods 1 to 2½ inches in diameter. This layer grades into brownish-red highly mottled dense tight clay with well-developed fragmental structure. Root penetration is along the cleavage planes and not through the clods (fig. 8). From a depth of 24 to 36 inches is red compact hard silty clay loam parent material, consisting of partly disintegrated shale. Below 36 inches are unweathered thin-bedded red and green shales of the Queenston formation. The surface soil is strongly acid, at a depth of 13 inches it is neutral, and at 30 inches the material is alkaline, and free lime may or may not be present.

The main variations consist in differences in surface texture. There are areas in the eastern part of the county where the surface is clay

loam. The surface texture of a few small areas about 2½ miles northeast of Lockport is light silt loam. There are also scattered areas having a slightly depressed relief, where the color is darker and drainage slower than typical.

This soil occurs extensively (11.2 square miles) throughout the Ontario plain. There are large continuous areas in the towns of Hartland and Somerset and another large area is just north of Lockport. Elongated bodies with a northeast-southwest trend are scattered between Eighteenmile Creek and Niagara River. The land is flat, with occasional broad depressed areas. In many places numerous crystalline rocks and boulders are scattered over the surface, indi-

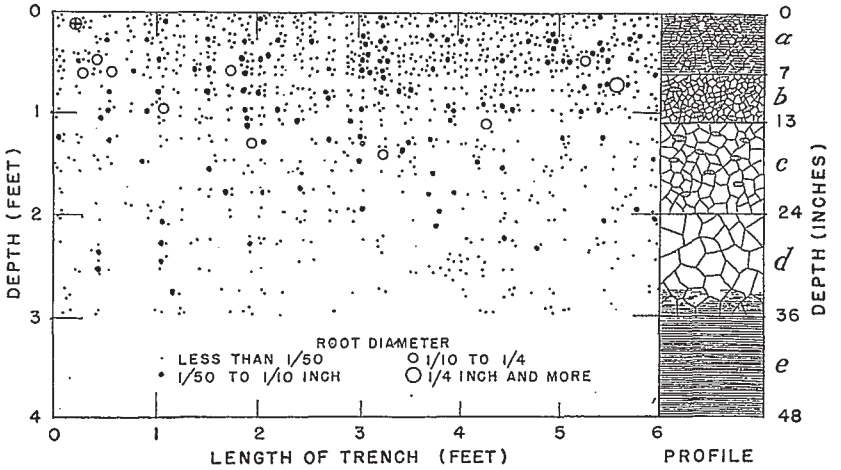

FIGURE 8.—Root distribution of a 75-year-old Rhode Island Greening apple tree growing on Lockport silt loam as shown by trench. Soil profile description: *a*, Grayish-brown granular silt loam; *b*, highly mottled brown, yellow, and gray clay loam; *c*, reddish-brown mottled with gray dense clay; *d*, compact hard reddish-brown silty clay containing some unweathered shale from bedrock; *e*, unweathered red thin-bedded shale. Imperfect drainage, heavy texture, and poor structure make this a poor soil for fruit, except where open ditches allow deeper rooting.

cating that a former mantle of glacial till may have been removed largely by wave action and geologic erosion.

This is a poorly drained soil, because surface runoff is inadequate and the downward movement of water through the soil is retarded by the heavy tight clayey subsoil and the impervious shale substratum. Open ditches are used but are not fully effective, because the extremely flat land offers no outlet for the drainage water.

Lockport silt loam, undulating phase.—The areas of Lockport silt loam having slightly rolling or sloping relief have been designated as the undulating phase. It is better drained and more productive than the level soil. The surface layer is dark reddish-brown heavy silt loam 8 inches thick, underlain to a depth of 20 inches by red blocky clay resting on partly disintegrated shale at a depth of 28 to 36 inches.

Though associated with the level soil, this phase is not nearly so extensive (1.5 square miles). The parent material includes less

glacial till than either of the two Lockport types, as it is almost entirely residual from the underlying shales. Drainage is fairly well established, and there is sufficient relief to allow adequate runoff. Where the Lockport soils can be rid of surplus water, as in the undulating phase, they make fairly productive soils for fruit, particularly pears and plums. Lockport soils are cloddy when worked if moisture is not right—a characteristic that makes them ill suited to cultivated crops.

This phase, is used mainly for hay, pasture, pears, and plums, and a rather small acreage for grain crops. Yields are 15 to 20 percent higher than on the other Lockport soils.

Lyons silt loam.—This silt loam is poorly drained, occupying sags and depressions in association with soils having calcareous glacial till parent material. It has a dark-gray or black granular silt loam surface layer 8 to 10 inches thick, which gives way abruptly to compact and hard silty clay loam highly mottled with gray, yellow, and brown. At a depth of 22 inches this grades into pinkish-gray less compact silt loam, mottled with gray, resting on moderately compact gravelly calcareous till. Where associated with Farmington soils or the shallow phase of Ontario silt loam, bedrock may occur at a depth of 30 to 36 inches. The areas surrounded by Brockport silt loam show a heavier textured subsurface layer and subsoil and contain less gravel than typical. If the total area were larger, the areas associated with the Brockport soils would be given another name. These areas are small and have the same agricultural use as Lyons silt loam and therefore were included in this type.

Most of this silt loam is found south of Gasport and Middleport in the east-central part of the county. A total area of 3.3 square miles is mapped. It is too wet for most crops and is used principally as pasture land. There are a few areas in which drainage is sufficient to allow winter wheat and hay to be grown.

Made land.—This land type represents areas that have been built up by dumping in materials of heterogeneous composition. It is found within and on the margins of the larger cities, in an area totaling 1.9 square miles.

Medina gravelly silt loam.—This is an inextensive soil type developed in a single area south of Hartland. It has an 8-inch surface soil of dark-gray to grayish-brown granular silt loam underlain to a depth of 20 inches by light grayish-brown hard compact silty clay loam mottled with rust brown. Between depths of 20 and 30 inches is gray or light-gray moderately compact smooth silt loam mottled with gray and rust brown. Mixed throughout the layer are numerous fragments of partly weathered shale fragments. Between depths of 30 and 40 inches is partly weathered soft greenish-gray or red calcareous shale.

This soil has a level to gently sloping relief and has developed from sediments laid down as a high terrace along the East Branch of Eighteenmile Creek. It has a total of 0.3 square mile. Drainage is imperfect, but good stands of wheat and hay are produced. Tomatoes and cabbage do well, but compact subsoil, shallow depth, and imperfect drainage make it a poor soil for fruit.

Newfane sandy loam.—This is considered the best soil in the county for peaches. The 8-inch surface layer is composed of grayish-

brown mellow sandy loam underlain to a depth of 15 inches by light-brown loose sandy loam, grading into brown loamy sand. Between depths of 24 and 30 to 36 inches the material is bright-brown or somewhat reddish-brown moderately compact sandy loam, containing a considerable quantity of fine material, which gives it a plastic consistence when moist. This layer grades into brown, yellowish-brown, or reddish-brown sandy loam or coarse sandy loam, generally a few feet thick but in places resting on coarse gravel at a depth of 40 inches or more. The occurrence of gravel is more common near the southern limits of the soil. In some places small quantities of fine gravel or pebbles are present in the soil or are scattered over the surface. The surface soil is rather low in organic matter, and organic residues are quickly oxidized when applied; nevertheless, this does not seem to be a serious drawback where tree fruits are the main crop. The surface soil is moderately acid, as also are the subsurface layers. At a depth of about 36 inches the subsoil is neutral, and some free lime is present at a 4-foot depth where gravel beds occur. To a depth of 48 inches or more the reaction of the several layers of sandy material is generally acid or neutral.

The parent material consists of lake-laid sands (*4*) that were deposited in shallow or sluggish water. In the vicinity of Olcott these sands overlie gravelly outwash material. Drainage is good. This soil is used principally for fruit growing, and the trees are able to draw on moisture from the deep subsoil, which the roots penetrate with ease (pl. 3, *A*).

The larger areas occur near Youngstown and along the lake shore in the vicinity of Olcott. Although the total area is only 5.6 square miles, it is an important soil in this part of the county. The surface is level to gently undulating, but there are a few gentle slopes along the shallow drainageways.

Peaches, cherries, and apples are the main crops, and tomatoes and cabbage are of considerable importance. Where more than enough of this soil is available for fruit and vegetables, wheat, oats, and hay also are grown (pl. 3, *B*). Management and fertilization practices are similar to those prevailing throughout the county. Owing to the sandy nature of the soil a greater quantity of fertilizer is used than on the heavier textured Dunkirk soils. The average acre yields of peaches are 135 bushels; apples, 150 to 200 bushels; sour cherries, 3,500 to 6,000 pounds; cabbage, 9 to 10 tons; and tomatoes, 9 to 10 tons.

All the land is under cultivation, except a narrow strip used for residential purposes along Lake Ontario. Probably 75 percent of the total area is planted to fruit; the rest is used for vegetables sold to canning factories and for field crops.

Ontario loam.—This soil occupies low rounded ridges some of which have imperfectly developed drumloid or cigar-shaped form. The 8-inch surface layer of dark-brown or grayish-brown friable granular, somewhat gravelly loam, is underlain at a depth of 16 to 20 inches by yellowish-brown gritty loam, friable in the upper part but slightly compact in the lower part. Numerous angular gravel and stone fragments are mixed with the finer material. This grades into reddish-brown or pinkish-brown moderately compact slightly plastic heavy silt loam, 10 or 15 inches thick, with fairly well-developed ir-

regular blocky structure. A lower content of gravel than in either the layer above or in that below characterizes this layer. Immediately below it there may or may not be a definitely compact layer, 6 to 8 inches thick, that grades into the pinkish-brown friable highly calcareous gravelly loam with well-developed fragmental structure that is typical of Ontario soils wherever they are found. Numerous angular stones and limestone boulders are mixed throughout the subsoil and substratum. The surface soil and upper subsoil layer are slightly to medium acid, and the lower subsoil layer is calcareous in most places below a depth of 30 inches. In a few places on the crests of the Ontario ridges the surface soil is gravelly fine sandy loam rather than loam.

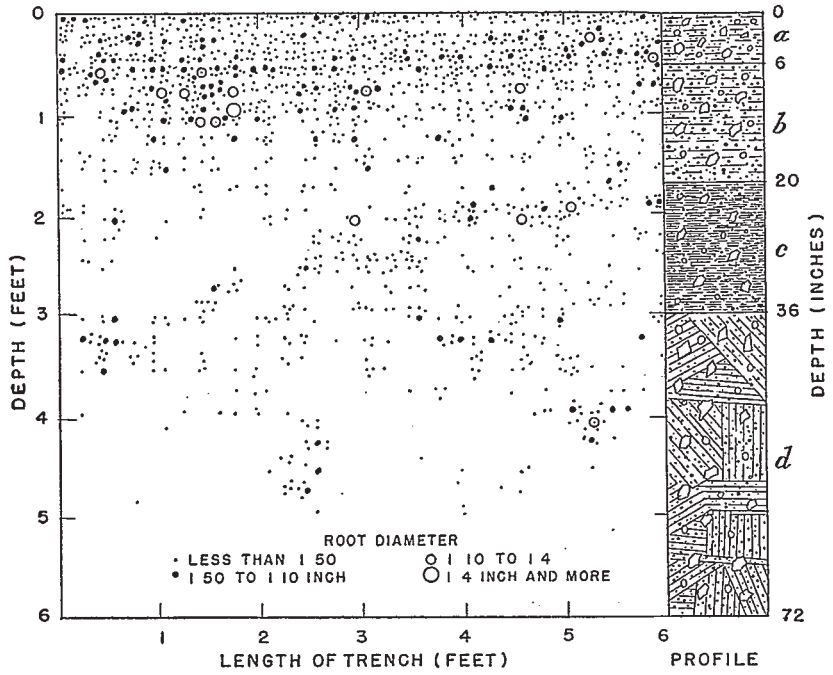

FIGURE 9.—Root distribution of a 27-year-old Baldwin apple tree growing on Ontario loam, as shown by trench. Soil profile description: *a*, Dark grayish-brown friable gravelly loam; *b*, yellowish brown gritty gravelly loam firm in place; *c*, brown firm slightly plastic gravelly silt loam; *d*, slightly pinkish brown moderately compact calcareous gravelly loam till. Although young, this tree has developed a good root system throughout the upper 4 feet of this open, well-aerated soil.

Continuous areas of this soil occur across the county at the base of and just south of the crest of the Niagara escarpment. Numerous other rather isolated areas are scattered through the southern part. The total area is 20.3 square miles. The parent material is glacial till derived from the local rock formations, with a preponderance of red Medina sandstone and limestone. Surface and subsoil drainage are good, but not excessive.

Good management and fairly heavy fertilization are commonly practiced on farms located on this soil, which is good for fruit growing (fig. 9) and field crops. It supports many productive orchards,

but south of the escarpment climatic hazards have limited the plantings. All fruits, including grapes, are grown successfully (pl. 1, *C*). Important field crops are wheat, oats, corn, hay, alfalfa, cabbage, and tomatoes for the canning factories. Sweet corn and peas also are grown. The approximate average yield of apples is 200 bushels an acre; peaches, 100 bushels; wheat, 30 bushels; oats, 40 bushels; corn, 40 bushels or 10 tons of silage; alfalfa, 2½ to 3½ tons; and cabbage, 9½ tons. The acid reaction of the surface and subsurface soils, makes applications of small quantities of lime desirable for growing alfalfa. After the plants are started they are able to reach the lime present in the subsoil, and the crop will maintain itself for many years.

Good tilth and favorable physical condition facilitate the preparation of the seedbed and contribute much to the excellence of the soil. All the land is cleared and under cultivation. Approximately 15 percent of the acreage is used for fruit growing, 20 percent for hay, 20 percent for pasture, 15 percent for wheat, 15 percent for oats, 10 percent for corn, and 5 percent for vegetable cash crops.

Ontario silt loam.—The 6-inch surface layer is light-brown or brown granular silt loam with a few angular stones scattered throughout. Between a depth of 6 and 14 inches is grayish-brown firm gritty silt loam with marbled or faintly mottled appearance, which grades into reddish-brown clay that breaks into rather hard irregular clods. Below a depth of 24 inches is reddish-brown friable gravelly calcareous glacial till of loam texture. The surface layer is medium to slightly acid, but free lime is present at a depth of 24 inches.

This soil is in close association with Ontario loam and occupies low rounded ridges and knolls with an east-west trend. In general the two soils are similar. The total area of 6.9 square miles is used for the same crops as the loam soil and has about the same yields. Heavier texture makes the silt loam slightly less easy to till, but in this area where heavy soils are common, it is not locally considered heavy.

Ontario silt loam, shallow phase.—The shallow phase is developed along the upper edge of the escarpment, where the heavy limestone beds of the Lockport formation are thinly covered by shallow glacial till. A short distance south of the escarpment the glacial deposits are deeper and the soils are typical of the Ontario series. The 8-inch granular silt loam surface layer is grayish-brown or slightly reddish-brown, becoming slightly redder with increasing depth. This material grades into reddish-brown heavy silt loam that breaks into small angular clods. Below a depth of 20 inches is reddish-brown silty clay loam that rests on bedrock at depths of 24 to 36 inches. In small included areas the bedrock may be exposed at the surface. The soil is slightly to medium acid to a depth of 20 inches. Below this it is approximately neutral but does not contain free lime even in the lower part.

The total area of 19.9 square miles is distributed as smaller individual areas in a belt 1 to 2 miles wide back from the crest of the escarpment. The largest areas are in the vicinity of Pekin and Sanborn and between these villages and Niagara Falls. The relief is level to slightly undulating and conforms closely to the surface of the underlying rock. The parent material is glacial till similar to

that from which the typical Ontario soils have developed. It is shallower, however, and practically all free lime has been leached from it.

Drainage is well established, as there is sufficient relief for adequate surface runoff and subsoil moisture can escape through the numerous cracks along the joint planes in the bedrock.

There are several orchards and vineyards on this phase, but it is not well suited for fruit production because of the shallow depth of the soil mantle and the consequent low moisture-storage capacity. When rainfall is above normal no difficulty is experienced, but in dry seasons trees suffer severely from lack of moisture. It is used principally for growing field crops, for shallow-rooted crops, as small grains, are not so subject to this limiting factor as fruit trees. Agriculture consists principally of general and cash-crop farming. Winter wheat, oats, barley, hay, corn, cabbage, and tomatoes and peas for canning are the main crops grown. The yields average 10 to 15 percent less than on Ontario loam.

Poygan clay.—The 6- to 8-inch surface layer is dark-gray or black clay, granular when in sod but very cloddy and lumpy when cultivated. The surface layer gives way abruptly to reddish-gray dense blocky clay highly mottled with yellow and gray, which grades into dark-red tight tenacious clay with well-developed prismatic structure at a depth of 12 inches. It is mottled with rusty brown and gray. Between depths of 24 and 40 inches is reddish-brown blocky calcareous clay with a less well-developed structure than in the layer above. Some dark-brown stains appear on structural surfaces, and nodules and streaks of lime are abundant at a depth of 30 inches. The substratum is composed of brown, reddish-brown, or yellow laminated silt and clay.

The only variations of importance are slight differences in surface texture, which in places may be silt loam, and in the color of the subsoil. Southeast of Lockport are large areas in which the subsoil is grayish brown rather than red. The gray material occurs in layers and is usually underlain by the heavy red clay typical of true Poygan soils.

It is closely associated with the Schoharie soils and is developed from the same kind of material in large continuous areas that form a belt completely across the southern part of the county. This soil is one of the most extensive in the county, comprising a total area of 41.0 square miles. On its flat and slightly depressed areas with poor natural drainage, open ditches are used to accelerate the removal of surplus surface water, very little of which percolates through the tight clay subsoil. Like the other soils of the Huron plain, parent materials are lake-laid sediments singularly free of stone and gravel.

The heavy texture and poor drainage make this soil rather low in agricultural value. It is difficult to work, puddles easily, and is generally in a poor physical state. When dry it shrinks markedly, and large deep cracks open. Its best use is for grass and timothy and clover hay, but some corn, oats, and wheat are grown. Native pastures are predominantly Canada bluegrass and creeping bent. The areas of this soil are usually large, and many farms have no other soil type. Much of the income of these farms is derived from the sale of dairy products. With considerable manure available, little fertilizer except superphosphate is used. Crop yields average 10 to 15 percent lower than on Schoharie silt loam.

A, An old orchard on Newfane sandy loam. *B*, Farmstead on Newfane sandy loam.

Quarries.—This land type, aggregating 0.4 square mile, includes gravel pits and numerous areas with rock pavement where stone has been quarried for commercial use. Numerous quarries are along the escarpment, and gravel pits are principally near Dickersonville and northeast of Lockport. Considerable limestone and sandstone were formerly quarried for building material. The only large quarry operating at present is just east of Gasport, where limestone is crushed for ballast.

Rimer fine sandy loam.—The 8-inch layer of brown fine sandy loam or loamy fine sand grades into yellowish-brown fine sandy loam mottled with rusty brown, which at a depth of 12 to 24 inches rests on heavy red clay like the corresponding layer of the Lockport soils. The land consists of low sand mounds and very small level areas of less well-drained gray sandy soils between. The sandy covering in these hollows is shallower and decidedly darker on the surface than that on the higher lying areas. This soil is mapped as a complex of these two conditions.

The total area is only 0.5 square mile. Owing to its lack of uniformity and to the rather poor drainage, it is classed as a poor soil. It is used mainly for pasture, hay, and corn, but it supports a few pear orchards, and some of the better drained areas are occasionally planted to cabbage and tomatoes. Average yields are low.

Along the Niagara-Orleans County line north of the Ridge Road, an area is mapped as this type but differs in having a reddish-brown gravelly or stony subsoil. This inclusion cannot be properly assigned to any other classification and is not sufficiently important to be given a new name.

Schoharie silty clay.—This soil differs from Schoharie silty clay loam principally in having a shallower silty surface layer. This material, only 3 inches deep, consists of grayish-brown silty clay, which grades into a dull-red clay subsoil that breaks into small sharp hard clods in the upper part and into large blocky clods in the lower part. For the most part, this type occupies low divides and slight ridges where part of the surface soil has been removed by erosion. In places in the western part of the county the deep subsoil layer is dark grayish-brown with a purplish tint. It is more difficult to work than the silty clay loam, but it is used in much the same way, possibly to greater extent for small grains and as grassland.

The immediate surface and subsurface layers are slightly acid, but the upper part of the subsoil becomes calcareous at a depth of about 30 inches. Alfalfa does well, and a considerably larger part of this soil is used for that crop than of the silty clay loam. The greatest difficulty of the Schoharie soils in general and the silty clay type in particular is the marked tendency to puddle if worked when moisture conditions are not optimum.

All the land is cleared and under cultivation, though less important than Schoharie silty clay loam. Its total area of 6.6 square miles is associated with Schoharie silty clay loam and with Poygan clay. Areas, some of which are isolated, are scattered across the southern part of the county from near the Niagara-Orleans County line to Niagara Falls.

Schoharie silty clay loam.—This type is in reality a complex of two soils developed from similar materials, one of which has good

drainage, the other imperfect, but the two are so closely intermingled that they cannot be accurately mapped separately. The better drained areas are slightly undulating, whereas those less well drained are flat or slightly depressed.

The 8-inch surface soil of the more nearly level areas is gray or dark-gray granular silty clay loam. This layer gives way abruptly to grayish-brown or ash-gray silty clay loam mottled with gray and yellow, which breaks into well-developed small clods. At a depth of about 16 inches this mottled or gray soil grades into reddish-brown or dull-red clay that is hard and dense in place, but has a large and well-developed prismatic breakage. This layer is calcareous in the lower part. Below a depth of 36 inches the material is light-red highly calcareous moderately dense silty clay loam having a less well-developed structure than the layer above. Typically the substratum shows stratification of the silt and clay, but in a few areas east of Niagara Falls red compact calcareous glacial till occurs at a depth of 2 to 3 feet.

The other soil represented in the complex differs in having a brown or reddish-brown surface layer and a somewhat yellow or pink silt loam subsurface soil in place of the gray mottled layer of the less well drained areas. The subsoil and substratum, however, are the same.

Schoharie silty clay loam occurs in large continuous areas throughout the southern part of the county from the Niagara-Orleans County line to the Niagara River. It does not extend north of the Niagara escarpment. The total area mapped is 48.7 square miles. The parent materials were laid down in glacial lake waters. The red color is inherited from fine fragments of red shale and sandstone and is not a developed characteristic.

Hay, winter wheat, oats, corn, canning peas, and pasture are grown on this soil. It is fair for orchards, but is not used extensively for this purpose as it does not occur in the climatic belt best suited to fruit. Agriculture consists of general and dairy farming, with a considerable acreage planted to cash grain crops. Less fertilizer is used by dairy and grain farmers on this soil than by vegetable and fruit growers; superphosphate is used more than complete fertilizer. Where more livestock is raised, as in the southern part of the county, considerable manure is available. The average yields of hay, principally timothy and clover, are 2 tons; wheat, 25 bushels; oats, 35 to 45 bushels; corn, 30 to 50 bushels; and silage, 8 to 10 tons. Pastures are generally good.

Probably 90 percent of the land is cleared; present forest trees on the woodland are elm, silver maple, ash, basswood, and hickory. Approximately 10 percent is idle, 35 percent is used for hay, 20 percent for pasture, 10 percent for wheat, 10 percent for oats, and 5 percent for corn and peas.

Drainage is a problem on this as well as on all the soils of the Huron plain. Open ditches are used, but, owing to the extremely flat terrain and impervious subsoils, they are not entirely effective.

Somerset gravelly fine sandy loam.—Differing from Somerset gravelly loam in the texture and quantity of gravel in the surface layer, this soil has an 8-inch dark-gray fine sandy loam surface soil, with some surface gravel, and is underlain abruptly by a light-gray or grayish-brown more or less gravelly fine sandy loam mottled with gray

and brown. From a depth of 20 to 30 inches the subsoil is gravelly clay and is underlain by mottled sand or by beds of sand and gravel. The heavy material may be moderately compact sandy clay or lenses of brown heavy sandy loam in compact masses. The substratum may be stratified layers of sand or a heterogeneous assortment of sand, silt, and clay.

Nearly all of this soil is in the towns of Cambria and Wilson, in association with Berrien, Allendale, and Collamer soils. A total of 2.1 square miles is mapped. The surface is flat or slightly undulating and drainage throughout is imperfect to poor. The surface layer is slightly acid, the upper subsoil neutral, and the subsoil alkaline or calcareous. The soil is used in the same way as Somerset gravelly loam, though it is possibly somewhat less productive, especially of hay and grain crops.

Somerset gravelly loam.—The 9-inch dark-gray very gravelly loam surface soil is underlain to a depth of 18 inches by gray, light-gray, or gray mottled with rust-brown light gravelly loam that grades into dull reddish-brown clay. This heavy layer varies in thickness, but normally continues to a depth of 24 inches and is underlain by brown loamy fine sand, mottled with lighter brown and gray, to a depth of 36 inches. Below 36 inches is reddish-brown loamy sand alternating with thin layers of reddish-brown clay. Just southwest of Olcott are areas of Somerset gravelly loam in which the drainage is better than in the broad areas scattered through the town of Hartland. In this particular area the soil material is like that of the Alton series, but compact clayey sand or gravel layers in the subsoil interfere with the percolation of water.

This type, aggregating 8.9 square miles, is developed principally in the towns of Hartland, Newfane, Wilson, and Cambria. For the most part the surface is smooth or undulating, but in a few places it occupies low broad ridges. The parent material is water-deposited sand, gravel, and clay. Surface drainage is not well established, owing to the usually level relief, and internal water movement is retarded by the heavy layers in the subsoil or substratum.

The soil is all in farms and is used for cabbage, tomatoes, wheat, corn, oats, timothy and clover hay, and pasture, and for plums, pears, quinces, and other fruits that tolerate imperfect drainage conditions. A few apple orchards on the higher lying areas do moderately well. With improved drainage, the yields of crops are about equal to those on Hilton gravelly loam. Complete fertilizers are usually applied to vegetables and complete fertilizer or phosphate to grains.

Toledo silty clay loam.—The 6-inch surface soil is a dark-gray to black silty clay loam, granular in the virgin state and in sod but usually lumpy and cloddy when cultivated. Beneath is an 8-inch layer of dull-gray heavy silty clay loam or clay containing rust-colored mottlings. This layer grades into heavy tight blocky clay, variously colored with shades of gray, dark gray, and rusty brown. The lower subsoil layer and substratum are dull brownish-yellow tight compact clay or silty clay loam mottled with gray and brown, but to a less extent than the layer above. In places bedded fine sand or silt may frequently be encountered in the subtratum.

This soil occupies poorly drained flats, swales, and depressions of the lowest positions, and in the northern part of the county is associ-

ated with Dunkirk and Fulton soils. Many areas occur as long narrow strips, and the largest and most typical areas are found scattered throughout the southern part of the county in association with Poygan, Schoharie, and Tonawanda soils. The soil receives drainage from adjacent lands, and sometimes the water remains on the surface and keeps it wet a long time. In some of the wetter areas a thin layer of organic matter covers the surface. Much of this type is in woodland of elm, maple, hickory, beech, ash, and oak. In its natural state this soil has a low agricultural value; it is inherently fertile but, because of poor drainage and heavy texture, is difficult to handle, and its best use is for grass and hay crops.

In the southeastern part of the county east of Wolcottsville an area is mapped in which the soil is of somewhat lighter texture, has a lighter subsoil underlain by fine sand, and as a whole is better drained. It is here used to a considerable extent for corn, clover, and small grains.

This soil covers an aggregate area of 9.5 square miles, 25 percent of which is forested, 30 percent is used for pasture, 25 percent for hay, 10 percent for various other crops, mainly oats, wheat, and corn, and 10 percent is idle. Crop yields average 10 percent less than on Fulton silty clay loam.

Tonawanda silt loam.—The 6-inch gray or yellowish-gray friable silt loam surface soil is underlain to a depth of 24 inches by light-gray and yellowish-brown highly mottled light silt loam. Below 24 inches the material is light-gray silt and very fine sandy loam in alternating layers. Mottling is less intense than in the layer above. Some areas near North Tonawanda in the western part of the county have red heavy clay subsoils.

This soil, in a total area of 24 square miles, occupies a narrow belt between Tonawanda Creek and areas of Tonawanda silty clay loam.

Drainage conditions and relief are similar to those of the heavier type. The lighter texture of the silt loam makes it easier to work and gives it a somewhat higher agricultural value. It is used for the same type of agriculture as Tonawanda silty clay loam, but the yields may average 5 percent greater.

Tonawanda silty clay loam.—The 6-inch surface layer is of gray or dark-gray silty clay loam frequently in a lumpy or cloddy condition. The 6- to 12-inch subsurface layer of yellowish-brown and gray highly mottled silty clay loam grades into dull-gray or yellowish-brown heavy plastic clay. From a depth of 18 to 36 inches the subsoil is made up of alternating layers of silt, fine sand, and clay mottled with light gray and yellowish brown. The surface is neutral to slightly acid, the subsoil calcareous. Cultivated fields frequently have a spotty appearance because of the mottled subsurface layer.

The parent material is largely lake-laid silts and clays deposited in the former glacial Lake Tonawanda. Nearly everywhere in the deep channel of Tonawanda Creek heavy red and gray clays are to be observed at depths of 5 to 8 feet.

This soil is extensively developed in a belt 1 to 2 miles wide along Tonawanda Creek, the southern boundary of the county. A considerable area extends northward along the Barge Canal to Lockport. A total of 28.9 square miles is mapped.

Between Bergholtz and North Tonawanda is a large area in which

the subsoil is red heavy clay similar to that of the Poygan soils; similar clay probably underlies the Tonawanda soils in the eastern part of the county, but at a much greater depth. Considerable variations in texture are apparent also in the type as mapped. In many places small areas of the surface soil are silt loam rather than silty clay loam.

The land is flat with a few narrow shallow drainageways too small to be indicated on the map. Surface drainage is very slow, and the heavy tight subsoil slows up the internal movement of water. Seedbeds are hard to prepare, owing to the heavy texture and the ease with which the soil puddles if worked when the moisture content is not optimum. Artificial drainage through the use of open ditches facilitates the removal of excess surface water.

The soil is best suited to hay and pasture, but considerable corn, oats, and wheat are grown. Dairying plays an important part in the agriculture practiced on the Tonawanda soils. Because considerable manure is available, the main fertilizer used is superphosphate, which is applied to the grain crops. The approximate average yields of crops grown on this soil are hay 1½ tons an acre, corn for silage 8 to 10 tons, oats 30 to 40 bushels, wheat 25 to 35 bushels, and corn for grain 35 to 45 bushels. Approximately 15 percent of this soil is idle, 10 percent in woodland, 30 percent in hay, 25 percent in pasture land, and the rest is in corn, oats, and wheat.

Wauseon fine sandy loam.—The 8-inch surface soil of dark-gray fine sandy loam is underlain to a depth of 15 inches by light-gray or grayish-yellow mellow fine sandy loam, resting on dull-red clay mottled with gray and brown. Some areas of the surface soil range from brown to dark gray, and the subsoil in places is red or gray clay. This soil occupies flat or depressed imperfectly drained areas in association with areas of Collamer silt loam or such sandy soils as those of the Berrien series.

This soil has a low agricultural value because of poor drainage. Where artificial drainage has been established and the soil is heavily fertilized, good to excellent yields of garden truck can be obtained. Only 1.9 square miles is mapped. The larger areas are north of Hartland, about 2 miles north of Johnson Creek, between Wrights Corners and Olcott, and south of Wilson.

Wayland silt loam.—The parent material of this soil is alluvial in origin. The 8- to 12-inch surface soil of dark-gray silt loam with rust-colored mottlings is underlain by gray silty clay mottled with yellow and brown and contains thin layers of fine gravel in places. At a depth of about 4 feet the soil rests on unassorted gravel and sand.

The total area of 1.2 square miles is along some of the smaller streams in association with Eel silt loam. The flat surface, drainage from adjacent upland areas, and sluggish flow of streams combine to keep this soil saturated for long periods. Some of this land has been cleared and used for pasture and the rest supports a growth of willows, reeds and rushes, and coarse grass. Unless artificially drained it is mainly wasteland.

Wolcottsburg silt loam.—The 8- to 10-inch surface layer is dark-gray or black mellow silt loam, below which a gray or yellowish-gray strongly mottled silt loam subsurface layer continues to a depth of 20

inches. The subsoil is pale-red or reddish-brown fine sandy loam similar to that in the Arkport soils. At a depth of 30 inches light-red compact calcareous glacial till is usually encountered. The surface soil varies from heavy silt loam to sandy loam, and the substratum may be composed of layers of light-red silt and fine sand instead of glacial till.

The principal areas are along the Genesee County line south of the escarpment. Considerable areas occur in the towns of Lockport and Pendleton, and it is also mapped in the town of Cambria along the ridge. The aggregate area is 4.3 square miles.

The land is flat or depressed, and natural drainage is poor, but a considerable acreage has been greatly improved through the use of open ditches. The undrained areas are used for hay and pasture; the drained ones for small grains and vegetable crops. The land for grains and vegetables receives an application of 200 to 1,000 pounds an acre of complete fertilizer, and the yields are correspondingly high. Approximately 20 percent of the soil is in woodland, 25 percent in hay, 25 percent in pasture, 20 percent in grains, and 10 percent in tomatoes, peas, cabbage, potatoes, and other vegetables.

PRODUCTIVITY RATINGS

The soils of Niagara County are listed alphabetically in table 6 and the estimated average acre yields for each of the principal crops are given under the prevailing farming practices. The principal type of farming, crops, or use made of each soil and the common fertilizer practices are given in the right-hand columns of the table.

The estimates in table 6 are based primarily on interviews with farmers, although they have been checked with the county agricultural agent, staff members of the State experiment station and college of agriculture, and others who have had experience in the agriculture of this county. They are presented as estimates of the average production over a period of years according to the prevailing type of farming. It is realized that they may not apply directly to specific tracts of land for any particular year, inasmuch as the soils as shown on the map vary somewhat, management practices differ, and climatic conditions fluctuate from year to year. On the other hand, these estimates appear to be as accurate information as can be obtained without further detailed and lengthy investigations, and they serve to bring out the relative productivity of the soils.

In order to compare directly the yields obtained in Niagara County with those in other parts of the country, yield figures have been converted in table 7 to indexes based on standard yields. The soils are listed in the approximate order of their general productivity for the principal crops under prevailing farming practices, the most productive soils at the head of the table.

The rating compares the productivity of each of the soils for each crop to a standard of 100. This standard index represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as the soil with the standard index. The standard yield for each crop shown in table 7 is given at the head of its column. Soils

given amendments, as lime and commercial fertilizers, or special practices, as irrigation, and unusually productive soils of small extent may have productivity indexes of more than 100 for some crops.

The principal factors affecting the productivity of land are climate, soil (this includes the many physical, chemical, and biological characteristics), slope, drainage, and management, including the use of amendments. No one of these factors operates separately from the others, although some one may dominate. The factors listed may be grouped simply as the soil factor and the management factor, since slope, drainage, and most of the aspects of climate may be considered as characteristics of a given soil type. Crop yields over a long period of years furnish the best available summation of the associated factors, and therefore, are used where available.

General productivity grade numbers are assigned in the column under that head. This grade is based on a weighted average of the indexes for the various crops, the weighting depending upon the relative acreage and value of the crops. If the weighted average is between 90 and 100 the soil type is given a grade of 1; if between 80 and 90, grade 2 is given, and so on.[7] In Niagara County no very precise mathematical procedures were followed in establishing the general productivity grade. The grade numbers are assigned arbitrarily by giving a percentage weighting to the indexes for apples, corn, wheat, and mixed timothy and red clover. For the soils on which apples are commonly grown, percentage weights of 60, 20, and 20, respectively, were given to the indexes for apples, corn, and wheat. For other soils not well suited to fruit, percentage weights of 30, 30, and 10, respectively, are given to the indexes for corn silage, wheat, and timothy and red clover hay. Because of the importance of fruit in the local agriculture, these soils are thereby given an arbitrary handicap. Other schemes of weighting can be selected to bring out further relations among the soils in respect to their suitability for given crops. Since it is difficult to measure mathematically, or otherwise, either the exact significance of a crop in the agriculture of an area or the importance of suitability of certain soils for particular crops, perhaps too much significance may be given to the order in which the soils are listed. On the other hand, the arrangement does give information as to the general productivity of the soils for some of the more important crops of the county.

The last column of table 7 gives for the soils of each group statements as to their general characteristics and physical suitability for use. A grouping of soils on the basis of general productivity will not necessarily coincide in all respects with a grouping on the basis of physical suitability for use, since characteristics other than productivity influence the general desirability of soils in respect to their use for crops. For example, slight differences in productivity may be overshadowed by differences in workability or the maintenance of productivity and the prevention of erosion. The statements given here for each productivity group are applicable to the group as a whole, but the arrangement or order of listing of the soils is based on general productivity as determined by a specific percentage weighting of crop indexes.

[7] The grade number 1+ is used for soils with a weighted average between 100 and 110.

TABLE 6.—*Estimated average acre yields of the principal crops on each soil in Niagara County, N. Y.*

Soil (type, phase, and drainage)	Corn (grain)	Corn (silage)	Wheat	Oats	Timothy and clover hay	Alfalfa	Cabbage	Tomatoes	Apples	Peaches	Pears	Cherries	Principal crops, use, or type of farming	Common fertilizer practices
	Bushels	*Tons*	*Bushels*	*Bushels*	*Tons*	*Tons*	*Tons*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Pounds*		
Allendale fine sandy loam:														
Drained	30	7		30	1								Vegetables, quinces	Moderate fertilization.
Undrained					1								Pasture, hay	Little fertilization.
Alluvial soils, undifferentiated.[1]														
Alton coarse sandy loam	30	6.5	15	25	1	2.5	7	8	225	135	100	6,000	Orchards, vegetables	5 to 10 pounds of nitrogen fertilizer per apple tree; 200 to 400 pounds of nitrogen fertilizer on peaches and cherries; 1,000 to 2,000 pounds of complete fertilizer on vegetables (5-10-5 or 4-12-8).
Alton gravelly fine sandy loam	30	6.5	18	25	1	2.5	8	9	225	135	100	6,000	do	Do.
Alton gravelly loam	30	6.5	18	25	1	2.5	7	8	225	135	100	6,000	do	Do.
Arkport very fine sandy loam.	25	7	15	30	1.6	2.8	6	7	200	90	100	4,000	do	Heavy fertilization on vegetables; rather similar practices to those on Newfane sandy loam and Dunkirk fine sandy loam.
Smooth phase	30	8	25	40	1.8	3	9	9	225	100	80	5,000	do	Nitrogen fertilizer on apples; nitrogen or manure on peaches and cherries.
Berrien fine sandy loam	30	8	17	40	1.2	2	7	8	200	100	75	5,000	Orchards, vegetables- general farming.	4 to 8 pounds per tree of nitrogen fertilizer; 200 to 400 pounds of 4-12-8 on vegetables; 300 to 500 pounds on tomatoes.
Berrien loamy fine sand	20	6	15	25	1	1.5	7	7	140	70	60	3,000	Peaches, cherries, vegetables; not so intensively used as the fine sandy loam.	Heavy fertilization. (Similar to Alton coarse sandy loam.)
Brockport silt loam	30	7	20	35	1.5	2	8	7	100	50	80	3,000	Hay, general farming	200 to 400 pounds of superphosphate on grain; manure on cornland.
Carlisle muck													Forest	No fertilization.
Shallow phase													do	Do.
Cazenovia silt loam	40	10	25	45	2	3	10	9	150	90	110	3,500	General farming	300 pounds of superphosphate on grain; manure on cornland.
Clarkson gravelly loam, shallow phase.	30	8.5	20	40	1.5	2.5	8.5	6	100	50	105	2,500	General farming, fruit, vegetables.	200 to 800 pounds of 5-10-5, or 4-16-4 on cabbage and tomatoes; phosphate on grain; nitrogen on fruit; manure on corn and hay.
Clarkson gravelly silt loam	40	8.5	25	45	1.8	2.5	9.5	9	175	110	120	4,000	Orchards, general farming, vegetables.	Do.

Collamer silt loam	30	8.5	25	40	1.8	2	9.5	8.5	150	65	120	3,000	General farming, fruit, vegetables.	Nitrogen on fruit trees, 2 to 5 pounds per tree; 200 to .660 pounds of 4-16-4 on vegetables; manure and phosphate on grain and corn.
Collamer silty clay loam	20	8	20	40	2	1.5	9	8	120	50	120	2,500	Hay, pasture, oats, pears	Do.
Colwood silt loam:														
Drained	30	8.5	15	35	1.8	1.8	10	7					Variety of crops, mainly vegetables.	No fertilization; very little has been drained effectively.
Undrained [2]														
Dunkirk fine sandy loam	40	9	20	40	1.6	2.5	8.5	9.5	225	130	120	5,500	Orchards, vegetables, small grains.	Essentially same as on the Arkport and Berrien soils.
Dunkirk silt loam	40	10	30	45	2	3	9.5	10	225	110	125	5,000	Orchards almost exclusively, vegetables, general farming.	200 to 800 pounds of complete fertilizer on vegetables and grains; 2 to 8 pounds of nitrate fertilizer per tree on fruit.
Dunkirk silty clay loam	40	10	30	50	2	3	9	9	200	90	125	4,000	Orchards, vegetables, dairying.	Do.
Rolling phase	35	8.5	20	40	1.8	3	9	8	175	80	90	3,500	Orchards, recreational, general farming.	Somewhat less fertilizer used than on the other Dunkirk soils.
Eel silt loam		8		30	1.5								Pasture, hay	Little fertilization.
Colluvial phase		8	15	30	1.5								General farming	Generally managed with soil types with which the areas are intimately associated.
Farmington stony loam													Pasture, idle	No fertilization.
Steep phase													Waste land, forest	Do.
Fulton silty clay loam:														
Better drained areas	25	6.5	22	40	2		5	5	80		70		Pasture, hay, general farming.	150 pounds of 4-16-4 on grain or 300 pounds of superphosphate plus manure.
Undrained					1.25								Pasture, hay.	
Granby fine sandy loam:														
Drainage by open ditches.					1.75		9	8					Vegetables, hay	Complete fertilization; drainage.
Undrained													Suitable for forest—nonagricultural.	No fertilization.
Hamlin silt loam	35	10	25	35	2	2.5	7.5	7					Pasture, hay, some corn and vegetables.	Little fertilization.
High-bottom phase	40	12	30	40	2	3.0	8	8	200	125	110	4,000	Vegetables, general farming, fruit.	Less fertilizer than on well-drained soils of the uplands.
Hilton gravelly fine sandy loam.	25	7	15	30	1.5	1	6	5	100	40	80	1,500	Mainly general farming, some peaches, cherries, vegetables.	Nitrogen on orchards; complete fertilizer on cabbage and tomatoes.
Hilton gravelly loam	40	9	25	40	2	2.5	8	7	125	60	90	4,000	General farming, fruits, vegetables.	2 to 8 pounds nitrogen per tree; complete fertilizer on cabbage and tomatoes; phosphate on grain; manure on orchards or meadows.
Compact subsoil phase	30	8	20	35	1.5	1.5	7	6	100	50	80	2,000	General farming, pears, prunes, cabbage, tomatoes.	Nitrogen on orchards; complete fertilizer on cabbage and tomatoes.
Hilton silt loam	40	9.5	25	40	2	2.5	8.5	8.5	150	60	100	3,500	do	Do.
Compact subsoil phase	30	8	20	35	1.5	1.5	7	6	100	50	80	2,000	do	Do.
Lake marsh [3]														

See footnotes at end of table.

TABLE 6.—*Estimated average acre yields of the principal crops on each soil in Niagara County, N. Y.*—Continued

Soil (type, phase, and drainage)	Corn (grain)	Corn (silage)	Wheat	Oats	Timothy and clover hay	Alfalfa	Cabbage	Tomatoes	Apples	Peaches	Pears	Cherries	Principal crops, use, or type of farming	Common fertilizer practices
	Bushels	*Tons*	*Bushels*	*Bushels*	*Tons*	*Tons*	*Tons*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Pounds*		
Lockport gravelly loam	30	7	18	35	1.5	1	7	5	90	------	25	--------	Pasture, hay, some wheat, pears, prunes.	Mostly manure; light application of complete fertilizer or 250 pounds superphosphate on wheat.
Lockport silt loam:														
Drainage by open ditches.	25	6	15	35	1.5	1	7	5	80	------	70	--------	do	Do.
Undrained	------	------	------	------	.75	------	------	------	------	------	------	--------	Pasture	Little, if any, fertilization.
Undulating phase	30	7	20	30	1.5	1.5	7	6	125	50	90	--------	Hay, pasture, pears, prunes	Mostly manure; light application of complete fertilizer or 250 pounds of superphosphate on wheat.
Lyons silt loam (undrained)	------	------	15	------	1.8	------	------	------	------	------	------	--------	Pasture; a few better drained areas used for hay and wheat.	Little, if any, fertilization.
Made land [4]	------	------	------	------	------	------	------	------	------	------	------	--------	------	------
Medina gravelly silt loam	30	7.0	20	35	1.5	2.5	8.5	7.5	120	50	100	2,000	General farming	Moderate fertilization.
Newfane sandy loam	35	8.5	22	40	1.5	3	9.5	9.5	180	135	125	5,500	Used intensively for orchards and vegetables.	Heavier fertilization than on the Dunkirk soils.
Ontario loam	40	10	30	40	2	3	9.5	9	200	100	130	4,500	General farming, orchards, vegetables.	Fairly heavy fertilization.
Ontario silt loam	40	10	30	40	2	3	9.5	9	200	100	130	4,500	do	Do.
Shallow phase	30	8	25	35	1.6	2.5	8	8	125	80	100	3,000	General farming, fruit, dairying.	Nitrogen on fruit; complete fertilizer or phosphorus on grains.
Poygan clay:														
Drainage by open ditches.	20	5	12	25	1.5	------	------	------	------	------	------	--------	Pasture, hay, general crops, dairying.	Manure and phosphate.
Undrained	------	------	------	------	1	------	------	------	------	------	------	--------	Pasture, woodland	Little or no fertilization.
Rimer fine sandy loam:														
Better drained areas	20	5	15	25	1	------	5	5	------	------	------	--------	Pasture, hay, corn	Manure and phosphate.
Less well-drained areas	------	------	------	------	1	------	------	------	------	------	------	--------	Pasture, hay	Little or no fertilization.

Schoharie silty clay:														
Better drained areas	30	7.5	20	35	1.5	1	5	5			70		General farming, dairying	Manure and superphosphate.
Undrained		5		25	1		3						do	Do.
Schoharie silty clay loam:														
Better drained areas	35	9	25	40	2	1.5	6	6	90	40	75		do	Do.
Undrained		6		30	2								Pasture, hay	Limited fertilization with superphosphate and manure.
Somerset gravelly fine sandy loam:														
With improved drainage.	40	9	20	35	1.8	2	8	7.5			90		Vegetables, general farming, peas, prunes.	Complete fertilizer for vegetables; phosphate for grain.
Undrained	20	7	15	25	1.5		7.5	7			90		do	Do.
Somerset gravelly loam:														
With improved drainage.	40	9	25	40	2	2.5	8	7	125	60	90	4,000	do	Do.
Undrained	25	8	18	30	1.5	2	7.5	7			90		do	Do.
Toledo silty clay loam:														
Better drained areas	20	7	15	30	1.5								Pasture, hay, woodland, small grains, corn	Manure and superphosphate.
Undrained													Pasture, woodland	Little or no fertilization.
Tonawanda silt loam:														
Drainage by open ditches.	45	9	25	35	1.5	1.5	7	6					General crops, hay, pasture, dairying.	Considerable manure on corn and phosphate on grain.
Undrained					1								Pasture, hay	Little or no fertilization.
Tonawanda silty clay loam:														
Drainage by open ditches.	40	9	30	35	1.5	.75	5						General crops, hay, and pasture; dairying.	Considerable manure on cornland and phosphate on grain.
Undrained					1								Pasture, hay	Little or no fertilization.
Wauseon fine sandy loam:														
Drainage by open ditches.	20	5	12	30	1.5		4	5			70		Vegetables, some pears, prunes.	Heavy fertilization; drainage.
Undrained					1								Pasture, hay	Little or no fertilization.
Wayland silt loam (undrained)													Waste land, pasture	Do.
Wolcottsburg silt loam:														
Drainage by open ditches.	40	10	30	35	2		8	6					Hay, grains, vegetables	About 200 pounds of complete fertilizer on grains and about 1,000 pounds on vegetables.
Undrained					1								Pasture, woodland, hay	Little or no fertilization.

[1] Occur only on Goat Island.
[2] Too wet for agriculture.
[3] Waste land.
[4] Largely within or adjacent to cities.

NOTE.—Blank spaces indicate that the crop is not commonly grown.

TABLE 7.—*Productivity ratings of soils in Niagara County, N. Y.*

Soil [1] (type, phase, and drainage)	Crop productivity index [2] for—												General productivity grade [4]	Physical suitability for use
	Corn (100=50 bu.)	Corn (silage) (100=12 tons)	Wheat (100=25 bu.)	Oats (100=50 bu.)	Timothy and clover hay (100=2 tons)	Alfalfa (100=4 tons)	Cabbage (100=12 tons)	Tomatoes (100=12 tons)	Apples (100=200 bu.) [3]	Peaches (100=125 bu.) [3]	Pears (100=125 bu.) [3]	Cherries (100=6,000 lb.) [3]		
Dunkirk silt loam	80	85	120	90	100	75	80	85	110	90	100	85	1+	Excellent to good land for orchard fruits. Some of the soils are also excellent for general farm crops. All are deep, well-drained, easy to work and warm comparatively early in spring.
Dunkirk silty clay loam	80	85	120	100	100	75	75	75	100	70	100	65	1	
Hamlin silty loam, high-bottom phase	80	100	120	80	100	75	65	65	100	100	90	65	1	
Ontario silt loam	80	85	120	80	100	75	80	75	100	80	105	75	1	
Ontario loam	80	85	120	80	100	75	80	75	100	80	105	75	1	
Dunkirk fine sandy loam	80	75	80	80	80	65	70	80	110	105	95	90	1	
Arkport very fine sandy loam, smooth phase	60	65	100	80	90	75	75	75	110	80	65	85	1	
Newfane sandy loam	70	70	90	80	75	75	80	80	90	110	100	90	1	
Alton gravelly fine sandy loam	60	55	72	50	50	65	65	75	110	110	80	100	1	
Alton gravelly loam	60	55	72	50	50	65	58	65	110	110	80	100	1	
Alton coarse sandy loam	60	55	60	50	50	65	58	65	110	110	80	100	1	
Clarkson gravelly silt loam	80	70	100	90	90	65	80	75	88	90	95	65	2	Good land for orchard fruits, but less productive and less suitable than the soils of the preceding group. Some of these soils are very good for general farm crops, although ordinarily neither so deep nor so well drained as those listed above.
Berrien fine sandy loam	60	65	68	80	60	50	58	65	100	80	60	85	2	
Dunkirk silty clay loam, rolling phase	70	70	80	80	90	75	75	65	88	65	70	60	2	
Arkport very fine sandy loam	50	58	60	60	80	70	50	58	100	70	80	65	2	
Cazenovia silt loam	80	85	100	90	100	75	85	75	75	70	90	60	2	
Hilton silt loam	80	80	100	80	100	65	70	70	75	50	80	60	2	
Collamer silt loam	60	70	100	80	90	50	80	70	75	50	95	50	3	
Hilton gravelly loam	80	75	100	80	100	65	65	58	65	50	70	65	3	
Somerset gravelly loam (with improved drainage).	80	75	100	80	100	65	65	58	65	50	70	65	3	
Ontario silt loam, shallow phase	60	65	100	70	80	65	65	65	65	65	80	50	3	
Lockport silt loam, undulating phase	60	58	80	60	75	40	58	50	65	40	70	------	4	Fair land for orchard fruits and good or fair for general farm crops. Various characteristics, as imperfect drainage, shallowness, and heavy subsoils limit the suitability of these soils for crops.
Medina gravelly silt loam	60	58	80	70	75	65	70	62	60	40	80	35	4	
Berrien loamy fine sand	40	50	60	50	50	40	58	58	70	55	50	50	4	
Schoharie silty clay loam (better drained areas).	70	75	100	80	100	40	50	50	45	32	60	------	4	
Collamer silty clay loam	40	65	80	80	100	40	75	65	60	40	95	40	4	
Clarkson gravelly loam, shallow phase	60	70	80	80	75	65	70	50	50	40	85	40	5	
Brockport silt loam	60	58	80	70	75	50	65	58	50	40	65	50	5	
Hilton gravelly loam, compact subsoil phase	60	65	80	70	75	40	58	50	50	40	65	35	5	
Hilton silt loam, compact subsoil phase	60	65	80	70	75	40	58	50	50	40	65	35	5	
Lockport gravelly loam	60	58	72	70	75	25	58	40	45	--------	20	------	5	
Hilton gravelly fine sandy loam	50	58	60	60	75	25	50	40	50	32	65	25	5	
Fulton silty clay loam (better drained areas)	50	55	88	80	100	------	40	40	40	--------	55	------	5	
Lockport silt loam (drainage by open ditches)	50	50	60	70	75	25	58	40	40	--------	55	------	6	
Wolcottsburg silt loam (drainage by open ditches).	80	85	120	70	100	------	65	50	------	--------	--------	------	3	
Tonawanda silty clay loam (drainage by open ditches).	80	75	120	70	75	20	40	--------	------	--------	--------	------	4	

Hamlin silt loam	70	85	100	70	100	65	62	58					4	Poorly suited to orchard fruits. The soils are either poorly or imperfectly drained, or are subject to flooding. If drainage is improved artificially, they generally give high or fair yields of general farm crops.
Tonawanda silt loam (drainage by open ditches).	90	75	100	70	75	40	58	50					4	
Somerset gravelly fine sandy loam (with improved drainage).	80	75	80	70	90	50	65	62			70		5	
Schoharie silty clay (better drained areas)	60	62	80	70	75	25	40	40			55		5	
Somerset gravelly loam (undrained)	50	65	72	60	75	50	62	58			70		6	
Colwood silt loam (drained)	60	70	60	70	90	45	85	58					6	
Eel silt loam, colluvial phase		65	60	60	75								6	
Somerset gravelly fine sandy loam (undrained)	40	58	60	50	75		62	58			70		6	
Toledo silty clay loam (better drained areas)	40	58	60	60	75								6	
Rimer fine sandy loam (better drained areas)	40	40	60	50	50		40	40					7	
Wauseon fine sandy loam (drainage by open ditches).	40	40	48	60	75		35	40			55		7	
Poygan clay (drainage by open ditches)	40	40	48	50	75								7	
Eel silt loam		65		60	75								8	Unsuited to orchard fruits. Generally moderately or highly productive of hay.
Schoharie silty clay loam (undrained)		50		60	100								8	
Allendale fine sandy loam (drained)	60	58		60	50								8	
Schoharie silty clay (undrained)		40		50	50		25						9	
Granby fine sandy loam (drainage by open ditches).					88		75	65					9	
Lyons silt loam (undrained)			60		90								9	
Fulton silty clay loam (undrained)					65								10	Unsuited to orchard fruits and poorly suited to general farm crops. Poor drainage or stoniness are the principal limiting characteristics.
Tonawanda silt loam (undrained)					50								10	
Tonawanda silty clay loam (undrained)					50								10	
Wolcottsburg silt loam (undrained)					50								10	
Wauseon fine sandy loam (undrained)					50								10	
Rimer fine sandy loam (less well-drained areas).					50								10	
Allendale fine sandy loam (undrained)					50								10	
Lockport silt loam (undrained)				40									10	
Farmington stony loam													10	
Alluvial soils, undifferentiated													10	
Wayland silt loam (undrained)													10	
Colwood silt loam (undrained)													10	
Toledo silty clay loam (undrained)													10	
Poygan clay (undrained)													10	
Granby fine sandy loam (undrained)													10	
Farmington stony loam, steep phase													10	
Carlisle muck													10	
Shallow phase													10	
Made land													10	
Lake marsh													10	

[1] The soils are listed in the approximate order of their general productivity under the prevailing practices of soil management, the most productive first. See table 6 for prevailing practices.

[2] The soils are given indexes that indicate the approximate average production of each crop in percentage of the standard of reference. The standard represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of regions of the United States in which the crop is most widely grown. The indexes are based on the estimated yields given in table 6. Absence of an index indicates that the crop is not commonly grown on the particular soil type.

[3] The standards used here for these crops have been selected largely on the basis of yields in New York, and they are not considered to be necessarily standards for all sections of the country.

[4] These numbers indicate the general productivity of the soils for the common crops. Refer to the descriptions of soil units in the text for further explanation.

Productivity tables do not present the relative roles that soil types, because of their extent and the pattern of their distribution, play in agriculture. The tables show the comparative productivity of individual soils under the more common practices of management. They cannot picture in a given county the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types planted to each of the specific crops.

Economic considerations have played no part in determining the individual crop productivity indexes. They cannot be interpreted, therefore, into land values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land. It is important to realize that productivity, as measured by yields, is not the only consideration that determines the relative worth of a soil for growing crops. The ease or difficulty of tillage and the ease or difficulty with which productivity is maintained, are examples of other considerations than productivity that influence the general desirability of a soil for agricultural use. In turn, steepness of slope, presence or absence of stone, the resistance to tillage offered by the soil because of its consistence or structure, and the size and shape of areas are characteristics that influence the relative ease with which soils can be tilled. Likewise, inherent fertility and susceptibility to erosion are characteristics that influence the ease of maintaining soil productivity at a given level. Productivity, as measured by yields, is influenced to some degree by all of these and other factors, such as moisture-holding capacity of the soil and its permeability to roots and water, and so these are not factors to be considered entirely separate from productivity. On the other hand, it seems that schemes of land classification designed to give the relative suitability of land for agricultural use must give some recognition to them.

LAND USE AND AGRICULTURAL METHODS

In Niagara County a higher percentage of the land in farms is cropped than in any other county of the State (*1*). About 64 percent of all the land in farms (1940 census) was planted to various crops in 1939. The total cropland harvested was 175,936 acres. Of this acreage 29 percent was in hay, 13 percent in wheat, 11 percent in oats, 11 percent in corn, and 7 percent in potatoes, sweet corn, cabbage, tomatoes, and other market vegetables. Agriculture is diversified and intensive, because of the excellent nearby markets and the favorable climatic conditions.

The high percentage of cropland per farm is possible because of the favorable relief. Except for the Niagara escarpment, which divides two distinct agricultural regions in the county, no areas are too rough for agricultural use. Practically all the orchards and most of the truck crops and vegetables are grown in the part north of the escarpment on the Ontario plain. The southern part, the Huron plain, has an agriculture based mainly on hay, pasture, and grain production.

Because of the tempering effect of Lake Ontario on the climate of the Ontario plain, fruit growing is concentrated along the lake. Practically all the soils south of the escarpment, with the exception of an area in the eastern part, are heavy and poorly drained and poorly suited to fruit or vegetables.

Formerly little attention was paid to the quality of soil in planting

orchards. The fact that the climate was favorable seemed to overbalance the soil factor. Some of the soils, however, were obviously too wet, but a large acreage of what has been recognized as Hilton and Collamer soils was set to orchards. In years of favorable climatic conditions, which would mean slightly less than normal spring precipitation, returns from these soils were fairly good, but during average or wet years the returns were considerably lower. Yields on these and soils of similar drainage conditions average about half of those on the best drained soils (*6*). In recent years more attention has been given to quality of soil in selecting sites for new orchards, but there are still many instances of new plantings on inferior soils.

Most of the orchards are cultivated (*5*), and the proportion of cultivated orchards is larger than in the counties to the east. The level topography, low rainfall, and generally minor erosion are the main reasons for clean cultivation. Orchards on the heavier soil types, as Dunkirk silty clay loam, Collamer silty clay loam, and the Hilton soils are more frequently left in sod than those on Newfane or Alton soils, because of the difficulty of cultivation.

In the Newfane-Olcott area, which comprises the town of Newfane, more than 25 percent of the trees are Baldwin, Rhode Island, Greening, McIntosh, Wealthy, and Oldenburg (Dutchess). New plantings since 1918 are largely of a few varieties. McIntosh, Rhode Island Greening, Baldwin, and Cortland account for 78 percent of all trees set from 1924 to 1933.

Spraying is an important factor in the production of marketable fruit. The injury from coddling moth is particularly severe, and to produce fruit free from insect and disease injury requires the application of large quantities of spray material. Unsprayed orchards in western New York produced an average of 43 bushels of marketable fruit an acre, compared with 131 bushels from orchards sprayed five times or more.

In spraying, the most important problems to be solved are control of apple scab, coddling moth, and rosy aphis (*2*). The number of times orchards are sprayed varies from none to six or more, with the largest number of growers spraying from three to five times. The number of spray materials that can be used to advantage in the average commercial orchard under normal local conditions is limited to a relatively few standard fungicides and insecticides. The most important of these are sulfur, lime-sulfur, wettable sulfur, lead arsenate, and nicotine sulfate for general use, and bordeaux mixture, dry-mix sulfur-lime, and oil preparations for special uses.

North of the escarpment the soils not suited to orchards, by reason of imperfect or poor drainage, are utilized to a considerable extent for grain, cabbage, and tomatoes. These crops will tolerate wetter soil conditions than apples and peaches; moreover, the returns per acre from cabbage and tomatoes for canning factories are relatively high. Several factories in different sections can both peas and tomatoes. No long hauls are necessary. During 1935, tomatoes were contracted for on the basis of $12 a ton field run, or $16 for firsts and $8 to $10 for culls.

Native pastures are only fair, as low rainfall in summer makes the grasses mature and dry up early. Predominant grasses on the heavy soils are Canada bluegrass and creeping bent. Considerable improvement is possible with the addition of phosphorus (*3*). On some of the poorer drained soils, moisture is not so frequently a limiting factor.

The southern part of the county, which produces little or no fruit, is used mainly for hay, wheat, oats, corn, and vegetables, as sweet corn and peas for canning factories. In order to facilitate drainage, the land is usually plowed in strips 5 to 10 rods wide; the dead furrows remain unfilled and greatly facilitate the removal of surface water. As plowing and cultivation are difficult, the land is left in meadows longer and more of it is utilized as pasture than in the section north of the escarpment. Probably the greatest improvements that could be brought about on these heavy soils would be to facilitate drainage through use of deeper and cleaner open ditches and to incorporate organic matter in the surface layer of the Tonawanda and Schoharie soils.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and development acting on materials deposited or accumulated by geologic agencies. Its characteristics at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the material has accumulated and 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 material. The climate, and its influence on soils 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.

Niagara County lies in the Eastern lake section of the Central Lowland physiographic province and comprises parts of the Huron and Ontario plains, which are separated by the Niagara escarpment. It is entirely within the region of Gray-Brown Podzolic soils. The well-developed, well-drained soils of the area occupy a relatively small area. Much of the area was originally poorly drained and swampy, but artificial drainage, mainly through open ditches, has improved surface runoff; heavy subsoil material, however, impedes the internal movement of moisture.

The soils of this county have developed principally from materials deposited through glacial action. Only in comparatively small areas have the underlying rocks been exposed to the forces of weathering.

Most of the surficial deposits are of the Quaternary period; they are almost wholly of the Pleistocene series and include glacial drift and associated lacustrine deposits. The drift deposits cover approximately half the surface, and lake-laid materials, recent alluvium, and residual materials the other half. The glacial deposits consist of till in various forms, chiefly of Wisconsin age, although they include a little pre-Wisconsin till and some stratified drift, in the forms of kames, eskers, and sheets of outwash sands and gravel. The lacustrine deposits were laid down on the bottoms and around the shores of lakes held back by the ice during its retreat across the area. With these deposits are associated beds of gravel and sand laid down in the channels of streams that flowed into the lakes. The most striking glacial feature north of the escarpment is the rounded gravel ridge extending across the county in an east-west direction which represents the shore line of the predecessor of Lake Ontario.

The underlying formations from which most of the soil-forming

materials were derived are wholly sedimentary and of Paleozoic age, ranging from Ordovician to late Silurian. The Ontario plain is occupied entirely by the Queenston shale, which consists of bright cherry-red shale intercalated with layers of green shale. The shale is friable and breaks down readily under atmospheric weathering to sticky red clays.

At the base of the Niagara escarpment Albion sandstone outcrops and forms an irregular terrace, which, in the vicinity of Lockport and Gasport, is bare of drift. It consists of acid gray, white, and red sandstone showing considerable crossbedding.

The Niagara group is represented by the Clinton formation and the Lockport dolomite. The former is composed of shale members at the top and base with limestone between, and extends as a narrow band along the slope of the escarpment. The limestone members in the middle of the formation are exposed on the intermediate terrace along the stretches where the escarpment is double. The lower shale member occupies the slope of the lower minor scarp and the upper shale member forms the slope of the upper minor scarp.

The Lockport dolomite occupies an east-west belt 5 to 7 miles wide extending across the county south of the Niagara escarpment, of which it nearly everywhere forms the crest. The lowest beds of the formation consist of bluish-gray fine-grained limestone, containing a large percentage of both magnesia and alumina. Although hard, it weathers rapidly on exposed surfaces into small irregular shaped fragments. The basal beds are overlain by light-gray coarse-grained semicrystalline pure limestone, which outcrops in a narrow belt along the brow of the escarpment at and east of Lockport. South of the escarpment these formations are everywhere covered with drift.

The southern part of the county is underlain by the Salina formation which is deeply buried everywhere by lacustrine and alluvial sediments.

A large part of the county is occupied by till or boulder clay of Wisconsin age. The till sheet also underlies the lake sediments nearly everywhere and practically the whole surface was originally covered by it. Its general effect is to reduce the relief and make the surface smoother, but its partial adaptation to the rock surface upon which it was deposited left it, in places, with low irregular undulations showing no particular form or arrangement except where it had been fashioned into drumlins or into elongated till ridges.

In a belt 3 to 5 miles wide extending from Lockport to the Niagara River and lying south of the escarpment, the ground moraine is most characteristic and has undergone less modification than elsewhere. It is also well displayed east and west of Lockport in the area between the escarpment and the beach, presumably formed by glacial Lake Iroquois. In large areas north of the ridge it has been extensively modified by submergence. The ground moraine in the area is rather thin, averaging 10 to 15 feet, with a maximum thickness of 50 feet.

The soils have developed from these materials under forest conditions in which maple, beech, oak, and ash predominated; and with a normal annual precipitation of about 31 inches, a mean temperature of 47.2° F., and a growing season of 164 days; these conditions are nearly uniform for the entire county.

The normal well-drained soils are light-colored and low in organic matter; the imperfectly drained soils are gray, and those with poor

571747—47——5

drainage are dark gray to nearly black. Lack of adequate drainage has been the most important factor in retarding normal development of the soils. The poor drainage is the result of flat surface relief and tight, fine-textured, or hard and compact subsoils.

The soils are relatively young and are still greatly influenced by the character of the parent material. Except where the soil-forming materials are sands and gravel, free lime is found at depths ranging from 12 to 36 inches. A characteristic of the heavy-textured soils developed from lacustrine deposits is the accumulation or segregation of calcium carbonate at a depth of 30 inches. Numerous white streaks, nodules, and lime concretions are encountered at this depth in many of the soils.

The soils that show normal development are those of the Ontario series. They have developed from parent material composed of glacial till deposited as low rounded ridges or imperfectly formed drumlins. Relief is undulating and drainage good. The soils of this series are among the best of the area and practically all are cultivated. The following description of a profile of Ontario loam was taken from an excavation made in a 27-year-old orchard with a sod cover:

0 to 6 inches, dark-brown mellow friable and granular loam.

6 to 20 inches, yellowish-brown gritty loam, friable in the upper part but firm at the bottom of the layer; vesicular and easily crushed; fragmental structure with aggregates ½ to 1 inch in diameter.

20 to 36 inches, reddish-brown slightly plastic heavy loam to silt loam; moderately firm and dense in place, but not to the extent that it interferes with water and root penetration; fragmental structure with definite cleavage planes.

36 to 66 inches, pinkish-brown highly calcareous friable gritty loam with a definite nut structure. Aggregates are ¼ to ¾ inch in diameter and are resistant to crushing. This is the parent material and contains numerous angular stones, gravel, and boulders, much of which is composed of limestone.

The Clarkson soils have profiles developed like the Ontario, but have a redder color, which is due to the larger quantity of the red Medina sandstone and Queenston shale in the parent material. Shallow phases of both series occur; in the Ontario series the bedrock is limestone, whereas that underlying the Clarkson is the red Queenston shale.

The Hilton soils are also developed from parent material deposited as glacial till. They occupy a much greater total acreage than the Ontario soils and are found entirely between the escarpment and the lake, whereas the Ontario soils are at the base of the escarpment and south of it. The Hilton soils lie on nearly flat land without adequate runoff and have a hard compact subsoil layer that impedes internal drainage. They are only of intermediate value, but are of considerable significance because of the large total acreage. A profile of Hilton gravelly loam, as observed in an old orchard one-quarter mile east of East Wilson, has the following characteristics:

0 to 8 inches, grayish-brown to gray granular loam.

8 to 20 inches, pale-yellow to grayish-yellow light silt loam mottled with gray and rusty brown, with a distinct line of demarcation between this layer and the surface soil. It is firm in place, but the structural aggregates are easily crushed.

20 to 36 inches, grayish-pink hard and very compact loam or silt loam, with numerous angular stones and gravel; faintly mottled in upper part with light gray and brown; imperfectly developed fragmental structure, with aggregates of ½ to 2 inches in diameter, vesicular and easy to crush when moist, but very hard and somewhat cemented when dry.

36 to 48 inches, pinkish or reddish-brown only moderately compact loam or fine sandy loam; highly calcareous and full of stones and gravel. This glacial till material is like that of the Ontario soils.

The compact subsoil phases of the Hilton soils are more poorly drained than the typical soil; they have darker surface soil and heavier more compact subsoil.

The Dunkirk soils have the best developed profiles of any of the series with heavy-textured lacustrine sediments as parent material. A profile of Dunkirk silt loam, as observed in an excavation 2 miles north and 1 mile east of the village of Appleton, is as follows:

0 to 6 inches, grayish-brown friable mellow silt loam with finely granular structure.

6 to 11 inches, slightly compact light-brown silt loam faintly mottled with gray and yellow; faintly developed platy structure.

11 to 22 inches, brown slightly compact silt loam with spots of dark-brown iron stains on the breakage surfaces.

22 to 40 inches, pinkish-brown stratified silt and very fine sand, firm but not compact; fairly well developed platy structure; numerous nodules and streaks of calcium carbonate. This zone of lime segregation is encountered at a depth of 36 inches in the silt loam and at a shallower depth in the silty clay loam.

40 to 55 inches, light-gray or olive-drab compact silt and fine sands. There is little uniformity in the substratum; the degree of stratification and quantity of silt, clay, and sand is variable from place to place. In this particular excavation a very dense layer of silt stopped root penetration at a depth of 50 inches.

The Arkport soils differ from the Dunkirk in that the parent material is composed mainly of very fine sand. The Collamer soils are imperfectly drained but are developed from the same kind of materials as the Dunkirk. Heavy clay subsoil slows up internal movement of water and causes the formation of a gray upper subsoil layer. The Schoharie soils are imperfectly drained and have developed from red lacustrine sediments.

Associated with Dunkirk, Collamer, and Hilton soils north of the escarpment are areas of Berrien fine sandy loam and loamy fine sand. The sandy materials have been deposited partly by wind and partly by water and usually overlie lacustrine sediments or glacial till. Berrien fine sandy loam, exposed in an excavation 2 miles west of East Wilson, has the following characteristics:

0 to 8 inches, grayish-brown friable loose finely granular or single-grained fine sandy loam.

8 to 25 inches, friable yellowish-brown sandy loam to loamy sand with no apparent structure.

25 to 38 inches, light yellow compact loamy medium sand, mottled with rusty-brown iron stains. Numerous hard iron concretions are scattered throughout this layer. Although hard and compact in place, when broken out the irregular lumps break down very easily.

38 to 50 inches, gray loose and open medium sand; faint mottling in upper part, but free from it at the lower limits.

50 to 60 inches, reddish-brown dense and compact laminated silt. The density of this layer is sufficient to stop root penetration.

60 to 70 inches, gray open and porous medium sand.

This soil is uniform throughout the first three layers, but considerable variation may occur in the composition of the subsoil material.

The Wauseon soils are poorly drained and consist of fine or medium sand over tight impervious lacustrine clay. The Rimer is a minor soil, variable in composition; typically it is sand on red residual clay.

The poorly drained heavy-textured soils developed from lacustrine

deposits are mainly south of the escarpment. A sample of Toledo silty clay loam representative of this group, as observed 1 mile east of Wolcottsville, has the following profile:

0 to 10 inches, coarsely granular, very dark-gray to nearly black silty clay loam. Under cultivation the surface is frequently in a badly puddled cloddy condition.
10 to 16 inches, dark-gray dense tight clay highly mottled with steel gray, yellow, and brown; fairly well developed prismatic structure.
16 to 30 inches, heavy plastic impervious clay loam mottled with gray and yellow on a light-gray base color.
30 to 40 inches, dense silt loam mottled with streaks of yellow and gray; calcareous.
40 to 60 inches, yellowish-brown only moderately compact very fine sand.

The Fulton soils are similar in composition to the Toledo, but drainage is better developed. The Poygan soils are similar to the Fulton in drainage characteristics but have a light-red subsoil. The Poygan soils are poorly drained associates of Schoharie soils and are developed from the same type of red lacustrine clays.

Colwood and Granby soils have developed under bog conditions and have a dark brownish-gray surface soil and a light-gray subsoil. The materials are calcareous at a depth of 30 inches, and the upper layers vary from slightly acid to neutral. The Wolcottsburg soils occupy poorly drained depressions and have medium textures and pink subsoils.

The Alton and Somerset soils have developed from stratified sands and gravel, the former having good drainage and the latter imperfect drainage, in part due to flat relief and to the presence of impervious layers in the substratum.

The Lockport, Farmington, and Brockport soils have developed in part from materials accumulated through disintegration of the underlying rocks in place. Lockport soils, developed from soft red Queenston shales, are heavy, sticky, shallow, and poorly drained. Farmington soils are well drained and are underlain by limestone. Brockport soils are well drained and developed from gray soft calcareous shale.

Soils developed from recent alluvium include members of the Hamlin, Tonawanda, Eel, and Wayland series. The Hamlin soils are well drained, with little profile development, but are excellent agricultural soils, especially the high-bottom phase. The Tonawanda and Eel soils are imperfectly drained. The former are developed in large areas along Tonawanda Creek from alluvium laid down on lacustrine clays. The Eel soils comprise a minor series, found on small narrow flood plains and drainageways in the northern part of the county. The Wayland soils are very poorly drained and, in places, swampy.

Miscellaneous materials include typical Carlisle muck and the shallow phase, practically all too wet for agriculture. Small areas of lake marsh have been mapped along the lake shore. Alluvial soils, undifferentiated, made land, and quarries are also mapped.

LABORATORY STUDIES

Analytical data for certain soils of Niagara County are presented in table 8. These data were obtained from chemical analyses of individual soil profiles and do not represent a composite sample of each soil type.

TABLE 8.—*Chemical data on certain soils of Niagara County,*[1] *N. Y.*

Soil type and laboratory number	Depth	N[2]	$CaCO_3$+ exchangeable bases	pH[3]	Exchangeable H[4]	Exchangeable bases (Kappen)	Exchange base saturation capacity (Kappen)	Exchange base saturation (Kappen)	Exchangeable bases ($NH_4Ac.$)[5]	Exchange base saturation capacity ($NH_4Ac.$)[5]	Exchange base saturation ($NH_4Ac.$)[5]	Approximate $CaCO_3$	CO_2[6]	CO_2[6]	Calcium as $CaCO_3$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Toledo silty clay loam:	*Inches*	*Percent*	*me/100 gm.*		*me/100 gm.*	*me/100 gm.*	*me/100 gm.*	*Percent*	*me/100 gm.*	*me/100 gm.*	*Percent*	*Percent*	*me/100 gm.*	*Percent*	*Percent*
1	0–10	0.517	180	7.23								9.0	130.10	2.880	6.560
2	10–16	.134	40	7.46								2.0	3.43	.074	.171
3	16–30	.059	320	8.16								16.0	315.50	6.950	15.780
4	30–40	.052	380	8.17								19.0	369.30	8.130	18.470
5	40–60	.025	190	8.15								9.5	326.90	7.190	16.350
Hamlin silt loam, high-bottom phase:															
6	0– 6	.182		6.62	3.6	17.4	21.0	83	11.6	15.2	76				
7	6–10	.039		7.05	1.2	12.0	13.2	91	7.6	8.8	86		.96	.021	.048
8	10–26	.025	30	7.71								1.5	1.02	.022	.051
9	26–30	.027	40	8.05								2.0	15.17	.334	.759
10	30–60	.031	230	8.39								11.5	229.90	5.060	11.490
Poygan clay:															
11	0– 8	.496		6.74	2.9	37.9	40.8	93	29.3	32.2	91				
12	8–12	.107		6.85	3.6	18.0	21.6	83	15.2	18.8	81				
13	12–24	.046		7.22	.2	31.9	32.1	99	20.3	20.5	99		.74	.016	.037
14	24–45	.039	310	8.03								15.5	286.00	6.280	14.800
15	45–50	.035	290	8.02								14.5	282.30	6.220	14.110
Hilton gravelly loam:															
16	0–12	.182		6.78	2.9	15.8	18.7	84	11.2	14.1	79				
17	12–18	.036		7.35	.5	17.0	17.5	97	11.9	12.4	96		.48	.011	.024
18	18–36	.020	190	8.07								9.5	194.10	4.270	9.700
19	36–48	.013	240	8.38								12.0	242.20	5.330	12.110
Newfane sandy loam:															
20	0– 9	.079		6.60	2.7	11.0	13.7	80	6.8	9.5	72				
21	9–30	.036		6.68	1.5	9.0	10.5	86	2.8	4.3	65				
22	30–48	.019		6.74	1.1	6.0	7.1	85	2.1	3.2	66				
23	48–72	.013		6.89	1.2	11.0	12.2	90	2.8	4.0	70				
Arkport very fine sandy loam:															
24	0– 9	.195		6.50	3.7	12.0	15.7	76	9.8	13.5	73				
25	9–18	.090		6.65	2.5	13.0	15.5	84	4.8	7.3	66				
26	18–30	.036		6.07	1.5	4.0	5.5	73	1.3	2.8	46				
27	30–40	.015		5.40	1.2	8.0	9.2	87	.5	1.7	29				
28	40–48	.019		5.63	1.4	9.0	10.4	87	1.1	2.5	44				

See footnotes at end of table.

TABLE 8.—*Chemical data on certain soils of Niagara County,*[1] *N. Y.*—Continued

Soil type and laboratory number	Depth	N[2]	$CaCO_3$+ exchangeable bases	pH[3]	Exchangeable H[4]	Exchangeable bases (Kappen)	Exchange base saturation capacity (Kappen)	Exchange base saturation (Kappen)	Exchangeable bases ($NH_4Ac.$)[5]	Exchange base saturation capacity ($NH_4Ac.$)[5]	Exchange base saturation ($NH_4Ac.$)[5]	Approximate $CaCO_3$	CO_2[6]	CO_2[6]	Calcium as $CaCO_3$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
			me/100 gm.		*me/100 gm.*	*me/100 gm.*	*me/100 gm.*						*me/100 gm.*		
Lockport silt loam:	*Inches*	*Percent*						*Percent*	*me/100 gm*	*me/100 gm.*	*Percent*	*Percent*		*Percent*	*Percent*
29	0–7	.224		5.12	8.3	12.0	20.3	59	3.9	12.2	32				
30	7–13	.052		4.81	5.2	10.0	15.2	66	.3	5.5	5				
31	13–24	.049		5.61	2.4	20.0	22.4	89	10.2	12.6	81				
32	24–36	.031	60	8.12								3.0	13.48	.296	.674
33	36–44	.031	150	8.43								7.5	127.40	2.800	6.370
Alton coarse sandy loam:															
34	0–12	.150	30	7.78								1.5	7.32	.161	.366
35	12–24	.027	10	7.70								.5	.30	.007	.015
36	24–42	.020	10	7.54								.5	.44	.010	.022
37	42–60	.026	10	7.69								.5	.36	.008	.018
38	60–96	.020	220	8.65								11.0	238.80	5.270	11.940
Ontario loam:															
39	0–6	.224		6.67	2.7	21.0	23.7	89	13.3						
40	6–20	.064		5.89	2.6	9.0	11.6	78	3.4	6.0	57				
41	20–36	.044		6.96	1.1	17.0	18.1	94	10.1	11.2	62		2.44	.049	.122
42	36–40	.018	380	8.47								19.0	474.50	10.430	23.720
Hilton gravelly loam, compact subsoil phase:															
43	0–9	.304		6.22	3.6	21.0	24.6	85	15.3	18.9	81				
44	9–18	.055		6.15	1.5	14.0	15.5	90	6.1	7.6	80				
45	18–38	.021	280	8.35								14.0	277.70	6.110	13.890
46	38–45	.015	240	8.56								12.0	227.10	5.000	11.360
Dunkirk silty clay loam:															
47	0–4	.253		5.72	5.5	15.0	20.5	73	11.8	17.3	68				
48	4–12	.074		4.80	8.0	15.5	23.5	66	1.8	9.8	18				
49	12–20	.036		5.05	4.1	13.5	17.6	77	4.7	8.8	53				
50	20–60	.039	330	8.22								16.5	360.70	7.930	18.040
51	60–84	.034	310	8.42								15.5	317.70	6.980	15.890
Berrien loamy fine sand:															
52	0–8	.205		6.06	5.3	15.5	20.8	75	7.4	12.7	58				
53	8–24	.065		5.91	2.1	8.5	10.6	80	.9	3.0	30				
54	24–36	.043		5.92	.7	6.5	7.2	90	.2	.9	18				
55	36–50	.035		6.05	.5	5.5	6.0	92	.3	.8	37				
56	50–52	.023		6.05	.6	8.5	9.1	93	1.4	2.0	70				
57	52–60	.025		5.43	1.3	11.5	12.8	82	2.9	4.2	69				
Collamer silt loam:															
58	0–8	.187		6.35	5.0	17.0	22.0	77	9.7	14.7	66				
59	8–18	.048		5.94	2.9	10.5	13.4	78	4.4	7.3	60				

60	18–36	.037		6.81	2.1	32.5	34.6	94	9.8	12.0	82		.44	.010	.022
61	36–60	.042	380	8.34								19.0	448.50	9.880	22.430
62	60–66	.013	160	8.43								8.0	152.00	3.340	7.600
Dunkirk fine sandy loam:															
63	0– 8	.136		6.15	4.1	9.5	13.6	70	7.2	11.3	64				
64	8–16	.066		6.07	3.8	7.6	11.4	67	4.2	8.0	52				
65	16–36	.030		6.12	1.5	6.0	7.5	80	1.6	3.1	52				
66	36–50	.020		6.05	.6	5.6	6.2	90	1.5	2.1	71				
Alton gravelly loam:															
67	0– 8	.158		5.90	4.4	11.2	15.6	72	7.2	11.6	62				
68	8–15	.060		5.22	2.8	8.8	11.6	76	5.2	8.0	65				
69	15–40	.044		7.01	.2	12.8	13.0	98	7.0	7.2	97		.32	.007	.016
70	40–50	.041		6.82	.2	11.2	11.4	98	5.1	5.3	96				.018
Dunkirk silt loam:															
71	0– 6	.152		5.96	2.7	12.0	14.7	82	8.6	11.3	76				
72	6–11	.030		7.07	.7	8.4	9.1	92	5.1	5.8	88		.24	.005	.012
73	11–22	.031		7.15	.2	12.8	13.0	98	9.2	9.4	98		.64	.014	.032
74	22–40	.024	310	8.20								15.5	310.20	6.820	15.510
75	40–55	.044	370	8.07								18.5	380.50	8.370	19.030
Fulton silty clay loam:															
76	0– 8	.194		5.98	5.0	20.0	25.0	80	21.0	26.0	81				
77	8–15	.049		6.67	1.7	34.4	36.1	95	25.7	27.4	94				
78	15–29	.041	220	8.17								11.0	198.40	4.380	9.920
79	29–41	.039	420	8.30								21.0	471.50	10.380	23.580
Tonawanda silty clay loam:															
80	0– 6	.330		6.57	4.8	25.6	30.4	84	21.2	26.0	82				
81	6–24	.084		6.92	1.6	20.4	22.0	93	15.0	16.6	90		.60	.013	.030
82	24–36	.042	360	8.19								18.0	392.70	8.630	19.640
83	36–50	.030	340	8.26								17.0		8.620	19.600
84	50–65	.015	310	8.26								15.5	297.00	6.530	14.850
Berrien fine sandy loam															
85	0–10	.170		5.88	5.0	11.2	16.2	69	7.0	12.0	58				
86	10–25	.071		6.47	2.4	7.6	10.0	76	2.2	4.6	48				
87	25–38	.015		6.67	.8	7.6	8.4	90	1.4	2.2	64		.32	.007	.016
88	38–50	.016		7.11	.0	8.0	8.0	100	1.5	1.5	100		.24	.005	.012
89	50–60	.017	220	8.26								11.0	219.80	4.840	10.990

[1] Analytical data from Cornell University Agricultural Experiment Station.

[2] Percentage of nitrogen determined on duplicate 10 gm. samples. They were digested with 30 cc. of concentrated H_2SO_4 in presence of K_2SO_4 and $CuSO_4$. The NH_3 was distilled from sample after being diluted and made alkaline with concentrated NaOH (Kjeldahl method). The NH_3 was collected in standard acid and the excess acid titrated with standard CO_2-free NaOH.

[3] The pH was determined on a 25:1 water-soil suspension of the air-dry material by means of a glass electrode.

[4] Exchangeable hydrogen per 100 gm. air-dry soil determined by titrating, potentiometrically, to the pH (7.00) of the original normal $Ba(Ac.)_2$ treating solution, the first 3 combined successive treatments of 10 gm. of air-dry soil with 75 cc. of solution. A fourth treatment was separately checked to make sure that no further hydrogen ions were exchangeable with a neutral cation.

[5] Exchangeable bases per 100 gm. air-dry soil determined by evaporating to dryness, igniting, and titrating the bases removed from 10 gr. of the soil by leaching with 500 cc. of normal NH_4Ac. The sum of columns 6 and 10 gives the values in column 11 (the total exchange capacity). Fractions of the exchangeable bases of these totals expressed in percentage are given in column 12.

[6] The CO_2 was determined by the method of Schollenberger, the CO_2 being reflux distilled from a suitable-sized sample (in the presence of $FeCl_2$ and HCl) under vacuo into standard $Ba(OH)_2$, the excess $Ba(OH)_2$ being titrated with standard acid. Column 14 gives the millequivalents of CO_2 per 100 gm. air-dry soil, column 15 the percentage of CO_2 and column 16 the percentage of calcium as $CaCO_3$.

NOTE.—Exchangeable H and bases expressed in millequivalents per 100 gm. soil.

Table 9 gives the mechanical analyses of a number of soils in Niagara County.

TABLE 9.—*Mechanical analyses of several soils in Niagara County, N. Y.*[1]

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Hilton gravelly loam:								
165101	0–12	1.3	4.1	4.3	10.6	19.5	47.7	12.5
165102	12–18	3.3	9.5	5.8	12.2	19.2	38.3	11.7
165103	18–36	3.3	5.0	4.4	12.7	19.5	49.3	5.8
165104	36–40	4.4	5.0	5.0	13.8	19.0	50.1	2.7
Berrien fine sandy loam:								
165105	0–10	1.5	3.0	4.7	43.8	23.5	17.4	6.1
165106	10–25	1.9	2.7	4.9	55.0	24.4	10.8	.3
165107	25–38	.2	.6	2.0	65.0	21.6	7.7	2.9
165108	38–50	.6	3.0	4.3	67.0	12.4	12.2	.5
165109	50–60	.4	.8	1.1	14.8	21.9	54.8	6.2
Collamer silt loam:								
165110	0– 8	.8	2.8	4.0	9.2	9.5	57.6	16.1
165111	8–18	.6	1.8	1.9	4.9	10.9	62.4	17.5
165112	18–36	.2	.9	1.0	3.7	3.8	55.9	34.5
165113	36–54	.5	.9	.5	.8	1.3	37.5	58.5
165114	54–60	2.6	5.9	7.3	18.2	23.0	38.0	5.0
Fulton silty clay loam:								
165120	0– 8	.4	.7	1.0	3.5	5.8	54.5	34.1
165121	8–15	.1	.4	.6	2.7	4.2	46.0	46.0
165122	15–29	.7	1.4	1.8	5.2	6.0	47.4	37.5
165124	29–41	.8	1.1	1.1	3.3	4.2	48.1	41.4
Hamlin silt loam, high-bottom phase:								
165125	0– 6	.2	.5	.4	4.3	11.7	68.4	14.5
165126	6–10	.2	.4	.4	4.2	13.0	67.0	14.8
165127	10–26	.0	.3	.3	1.1	11.0	76.8	10.5
165128	26–30	.5	.6	.4	3.1	18.7	69.3	7.4
165129	30–60	.9	1.2	.4	.4	3.1	86.5	7.5
Allendale fine sandy loam:								
165130	0– 8	.9	.4	1.2	55.2	20.6	16.3	5.4
165131	8–20	.3	.7	1.6	67.0	10.6	18.2	1.6
165132	20–48	.1	.5	.8	4.4	13.0	71.6	9.6
165133	48–60	.0	.4	.7	53.0	9.4	32.8	3.7
Hilton gravelly loam, compact subsoil phase:								
165134	0– 9	.6	3.4	4.2	9.7	27.6	41.8	12.7
165135	9–18	1.1	4.1	4.7	10.1	24.3	40.1	15.6
165136	18–38	2.8	4.3	3.6	10.6	21.7	48.6	8.4
165137	38–48	3.3	4.3	3.7	10.4	19.5	51.5	7.3
Berrien loamy fine sand:								
165143	0– 8	.0	.7	2.4	52.7	26.4	12.1	5.7
165144	8–24	.0	.5	2.3	62.8	27.2	7.2	0.0
165145	24–36	.1	.2	1.5	58.7	32.9	5.7	.9
165146	36–50	1.0	1.3	15.6	64.2	8.4	7.9	1.6
165147	50–60	1.0	2.7	2.5	7.5	20.9	58.8	6.6
Lockport silt loam:								
165148	0– 7	3.5	3.7	2.2	11.3	13.5	50.7	15.1
165149	7–13	.5	1.4	.9	2.9	6.9	55.0	32.4
165150	13–24	.7	2.0	1.1	1.8	7.5	60.3	26.6
165151	24–36	.4	1.9	1.4	2.8	8.6	67.9	17.0
165152	36–44	.4	2.0	2.0	3.8	10.3	69.1	12.4
Newfane sandy loam:								
165157	0– 9	2.4	13.3	22.1	17.4	15.7	23.4	5.7
165158	9–30	3.5	16.3	25.0	16.3	14.1	19.4	5.4
165159	30–48	2.9	16.3	24.1	16.7	15.3	20.1	4.6
165160	48–72	1.3	35.6	34.0	14.6	3.6	7.8	3.1
Dunkirk silty clay loam:								
165161	0– 4	.4	.9	.7	5.0	13.3	64.4	15.3
165162	4–12	.2	.8	.7	3.0	20.7	57.2	17.4
165163	12–20	.2	.9	.8	2.4	19.7	54.8	21.2
165164	20–60	.1	.3	.5	1.6	6.1	54.9	36.5
165165	60–84	.8	1.1	1.1	3.1	5.6	53.0	35.3
Somerset gravelly fine sandy loam:								
165166	0– 8	.9	1.9	4.1	17.5	40.9	27.0	7.7
165167	8–14	.7	1.7	4.9	19.8	48.1	21.7	3.1
165168	14–20	9.1	1.7	2.3	18.0	44.3	20.4	4.2
165169	20–60	.1	.4	1.0	4.2	14.8	60.0	19.5
165170	60–84	.0	.2	.8	14.2	53.1	31.3	.4
Ontario loam:								
165171	0– 6	4.2	4.5	4.5	13.0	18.4	45.4	10.0
165172	6–20	3.9	5.2	5.6	14.9	18.6	42.9	8.9
165173	20–36	2.9	3.9	3.7	11.6	18.0	41.7	18.2
165174	36–66	4.2	5.6	4.6	12.5	17.3	45.9	9.9

See footnote at end of table.

TABLE 9.—*Mechanical analyses of several soils in Niagara County, N. Y.*[1]—Con.

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Toledo silty clay loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
165179	0–10	.1	.3	.4	4.7	12.7	53.2	28.6
165180	10–16	.0	.0	.0	.3	2.7	60.3	36.7
165181	16–30	.0	.0	.1	1.0	12.0	65.5	21.4
Tonawanda silty clay loam:								
165188	0– 6	.1	.1	.2	.8	1.2	58.3	39.3
165189	6–24	.3	.4	.2	.5	1.1	64.0	33.5
165190	24–36	.2	.4	.3	2.2	15.4	65.7	15.8
165191	36–50	.3	.5	.4	17.9	40.7	31.3	8.9
165192	50–65	.0	.1	.4	27.2	55.5	14.1	2.7
Arkport very fine sandy loam:								
1651130	0– 9	.3	.6	.7	6.6	37.0	49.7	5.1
1651131	9–18	.3	.3	.5	6.7	41.1	45.5	5.6
1651132	18–30	.1	.2	.2	6.9	46.9	42.4	3.3
1651133	30–40	.0	.1	.2	8.8	47.0	42.1	1.8
1651134	40–48	.1	.1	.2	8.5	45.3	43.8	2.0
Poygan clay:								
1651135	0– 8	.0	.6	.4	1.0	1.1	40.6	56.3
1651136	8–12	.2	.4	.5	1.7	2.3	56.8	38.1
1651137	12–24	.4	.8	.7	2.0	2.5	36.3	57.3
1651138	24–45	.0	.2	.3	.8	1.0	55.8	41.9
1651139	45–50	.1	.2	.2	.4	.7	60.2	38.2
Dunkirk silt loam:								
1651165	0– 6	.2	1.2	5.0	15.1	19.9	49.3	9.3
1651166	6–11	.2	.7	2.2	6.3	20.2	61.2	9.2
1651167	11–22	.0	.1	.5	1.4	8.0	80.4	9.6
1651168	22–40	.7	.7	.7	2.9	5.1	82.8	7.1
1651169	40–55	.1	.2	.3	1.3	14.5	53.3	30.3
Cazenovia silt loam:								
1651170	0– 4	1.9	2.5	2.2	6.9	10.0	56.0	20.5
1651171	4–12	.2	1.0	1.4	5.1	8.6	42.5	41.2
1651172	12–25	1.5	2.8	2.6	7.5	10.8	49.3	25.5
1651173	25–37	1.8	3.2	2.6	7.8	11.5	49.8	23.3
1651174	37–48	1.1	1.7	1.9	6.0	10.4	38.9	40.0

[1] Analyses made by T. M. Shaw and E. F. Miles, Division of Soil and Fertilizer Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering.

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