

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.
IN COOPERATION WITH THE PENNSYLVANIA STATE COLLEGE SCHOOL
OF AGRICULTURE AND EXPERIMENT STATION,
THOMAS F. HUNT, DEAN AND DIRECTOR.

A RECONNOISSANCE SOIL SURVEY OF NORTHEASTERN PENNSYLVANIA.

BY

CHARLES F. SHAW, OF THE U. S. DEPARTMENT OF AGRICULTURE,
AND J. M. MCKEE AND W. G. ROSS,
OF THE PENNSYLVANIA STATE COLLEGE.

[Advance Sheets—Field Operations of the Bureau of Soils, 1911.]



LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 15, 1913.

SIR: In continuation of the soil survey work in Pennsylvania a reconnoissance survey of the northeastern part of the State was made during the field season of 1911. The work was done in co-operation with the State College of Agriculture and Experiment Station and the selection of this area was made after conference with the State officials.

I have the honor to recommend that the accompanying manuscript report and map covering this survey be published as advance sheets of Field Operations of the Bureau of Soils for 1911, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, reconnaissance survey, northeastern Pennsylvania sheet.

A RECONNOISSANCE SOIL SURVEY OF NORTHEASTERN PENNSYLVANIA.

By CHARLES F. SHAW, of the U. S. Department of Agriculture, and J. M. McKEE and W. G. ROSS, of the Pennsylvania State College.

GENERAL DESCRIPTION OF THE AREA.

The area surveyed embraces the 10 counties of northern and northeastern Pennsylvania, namely, Clinton, Lycoming, Tioga, Bradford, Sullivan, Wyoming, Lackawanna, Susquehanna, Wayne, and Pike, with a combined area of 7,848 square miles, or 5,022,720 acres. The Bradford County section was reduced from the detailed map which was completed during the summer.

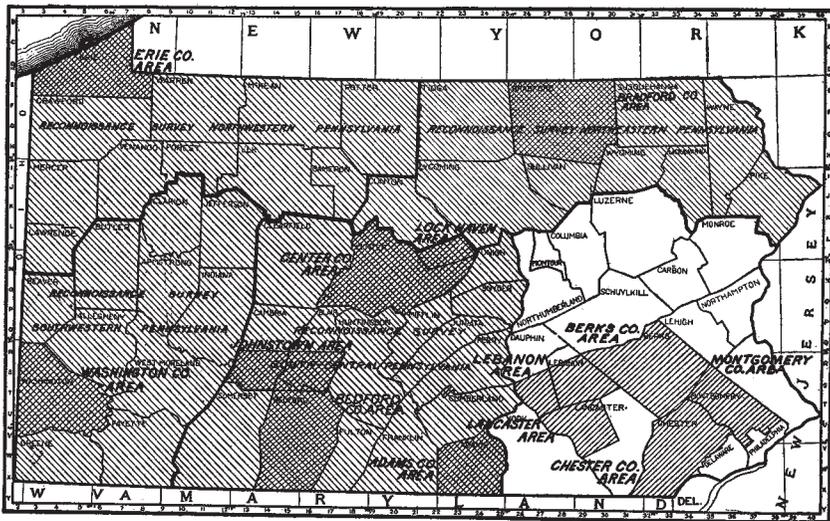


FIG. 1.—Sketch map showing areas surveyed in Pennsylvania.

On the west the area joins the Northwestern Pennsylvania Reconnaissance Soil Survey, which was completed in 1908, the boundary being the eastern line of Cameron and Potter Counties. On the north the area is bounded by New York State, on the east the Delaware River separates it from New York and New Jersey, while the southern limit of the area is marked by the northern boundary lines of

Monroe, Luzerne, Columbia, Montour, Northumberland, Union, and Center Counties.

The larger part of this area has been glaciated. The terminal moraine marking the southern limit of the ice sheet crosses the southwestern part of Tioga County and extends through Lycoming County, leaving the latter near its eastern extremity.

Topographically the area includes parts of both the Allegheny Plateau and the Appalachian ridges, about nine-tenths of it lying in the former and one-tenth in the latter. The Appalachian ridge belt occurs in the southern part of the area in southern Lycoming and Clinton Counties only. The ridges surrounding the Wyoming coal basin in Lackawanna County may be considered as outliers of the ridge belt occurring in the midst of the plateau. On the other hand, since the plateau is not simply a flat plain with valleys cut into it, but includes broad lowland belts alternating with high belts or ridges, the Wyoming ridges may be considered as extreme phases of these broader ridges, which are normal plateau features.

These alternating ridges and lowlands in the plateau are more abundant in Bradford, southeastern Tioga, and Luzerne Counties than elsewhere. Wherever they occur the broad lowland belts, although in practically all cases hilly, are mainly covered with farms. The ridges both in the plateau and in the Appalachian belt are usually uncultivated, though the broader, flat-topped plateau ridges may have farms on their tops.

In the eastern and western parts of the area mapped the plateau is more typical, although deeply and thoroughly dissected and containing a relatively small area of tillable land. The lowlands of the ridge belt have a smooth to rolling topography and are covered with farms. The Allegheny escarpment or front forms the steep south slope of the plateau, where it drops to the most northerly of the lowland belts in the ridge region.

DRAINAGE.

The drainage of this area is through two river systems, the Delaware and the Susquehanna. The Delaware River drains nearly all of Wayne and Pike Counties, with the Lackawaxen and Wallenpaupack as its largest tributaries. The Lehigh River, another Delaware tributary, drains a small part of southern Lackawanna County.

The North Branch of the Susquehanna River enters the area in the northeastern corner of Susquehanna County, only 13 miles west of the Delaware River, and swings south, west, and then north in the "Great Bend," leaving the area 7 miles west of the point where it entered. The river flows west through southern New York, again entering Pennsylvania near Athens, in Bradford County, where it

receives the waters of the Chemung River. This stream, although its main valley lies almost wholly within the State of New York, drains a large part of Tioga and Bradford Counties through the Cowanesque and Tioga Rivers and other smaller tributaries. From Athens the Susquehanna flows generally southeast to Wilkes-Barre, receiving the drainage waters of Bradford, Susquehanna, Wyoming, and Lackawanna Counties through many tributaries, the largest of which are Sugar, Towanda, Mehoopany, and Bowman Creeks on the west, and Wyalusing, Meshoppen, and Tunkhannock Creeks and Lackawanna River on the east.

The West Branch of the Susquehanna, entering the area in the extreme southwest corner of Clinton County, flows irregularly east and receives the drainage of Clinton County through Sinnemahoning, Kettle, Bald Eagle, and Fishing Creeks, while the waters from southern Tioga, Lycoming, and Sullivan Counties are received through Pine, Lycoming, Loyalsock, and Muncy Creeks and smaller tributaries. North of Muncy the West Branch changes its direction, flowing generally south, joining the North Branch at Northumberland, a few miles beyond the southern boundary of the area.

The character of two of the larger tributaries of the West Branch is somewhat striking. Pine Creek finds its source in the glaciated region of western Tioga County, draining a portion of one of the lowland belts lying in this part of the plateau region. Its course, however, is transverse to the lowland belt, so that it soon leaves it and enters a deep, narrow gorge which has been cut through the southernmost high belt of the plateau. It emerges from this gorge to join the Susquehanna at Jersey Shore. Loyalsock and Lycoming Creeks act in exactly the same manner, the former heading in the lowland belt in northern Sullivan and southern Bradford Counties, the latter in another belt lying in southwestern Bradford and southeastern Tioga Counties. They both flow southward through an adjacent broad, high belt, in which they have been able to do nothing more than excavate narrow gorges, and join the West Branch of the Susquehanna.

The general drainage of the area is ample to care for all the water that falls. In most regions the surface run-off is severe, and causes disastrous erosion. The removal of the forests in the mountainous regions has served to hasten the run-off in those sections, and as a result the streams are subject to periods of very high water during the spring thaws and wet seasons and to periods of very low water during dry months. The floods cause considerable damage to land and property and are a serious factor in the development along the river.

POPULATION.

The population of this area, according to the Thirteenth Census, is 571,100, an increase of 55,654, or 10.8 per cent, over the figures for 1900. The table below shows the figures by counties:

Population of counties included in northeastern reconnaissance survey.

County.	Population.		Per cent increase (+) or decrease (-).	Rural population.		Per cent increase (+) or decrease (-).
	1910	1900		1910	1900	
Bradford.....	54,526	59,403	- 8.2	40,023	45,748	-12.5
Clinton.....	31,545	29,197	+ 8.0	19,152	17,905	+ 7.0
Lackawanna.....	259,570	193,831	+33.9	23,092	23,634	- 2.3
Lycoming.....	80,813	75,663	+ 6.8	39,838	40,508	- 1.7
Pike.....	8,033	8,766	- 8.4	8,033	8,766	- 8.4
Sullivan.....	11,293	12,134	- 6.9	11,293	12,134	- 6.9
Susquehanna.....	37,746	40,043	- 5.7	28,519	31,951	-10.7
Tioga.....	42,829	49,086	-12.7	39,646	46,132	-14.1
Wayne.....	29,236	30,171	- 3.1	26,291	27,307	- 3.7
Wyoming.....	15,509	17,152	- 9.6	15,509	17,152	- 9.6
Whole area.....	571,100	515,446	+10.8	251,396	271,237	- 7.3

During these 10 years the rural population¹ has decreased 19,841, or 7.3 per cent, while the urban population has increased 75,493, or 30.9 per cent. The total population decreased in all except three counties—Clinton, Lackawanna, and Lycoming—and the rural population decreased in every county except one—Clinton. In 1910 the total population per square mile was 73.2, while the rural population was 32.2 per square mile.

About one-third of the total population are engaged in agriculture, nearly one-third in mining, and the rest in transportation, commerce, and other pursuits. The larger part of the mining population is foreign, and considerably over one-third of the total population is probably foreign. The rural population is largely native born, of mixed nationalities, with the Scotch-Irish and English strains predominating.

Scranton is the largest city in the area, with a population of 129,867 in 1910. Wilkes-Barre, on the border of the area, has 67,105 inhabitants, while Carbondale, east of Scranton, has 17,040. Between these cities are several boroughs that have populations of 2,000 to 5,000 each. Williamsport, with 31,860 inhabitants, is the largest city in the western part of the area. Lock Haven, with 7,772, Sayre, with 6,000, and Jersey Shore, with 5,381, are the other large towns. Binghamton and Elmira are not far north of the area, in New York State, while Sunbury is located a short distance to the south.

¹ Population outside of incorporated places having 2,500 or more inhabitants.

TRANSPORTATION.

On the whole the transportation facilities are good, although some of the mountainous districts are rather far from the railroads. The main line of the Erie Railroad follows the Delaware along the east boundary of Pike and Wayne Counties and passes through part of northern Susquehanna County. Two branch lines cross these counties to the anthracite coal fields and another branch taps the soft-coal district in Tioga County. The main line of the Lackawanna runs south across Susquehanna and Lackawanna Counties, while the main line of the Lehigh Valley follows the Susquehanna River from Sayre southeast across Bradford and Wyoming Counties to Wilkes-Barre. These three roads run express milk trains to New York City, carrying milk from southern New York and from the region they traverse in Pennsylvania and New Jersey. The Delaware & Hudson and New York, Ontario & Western Railroads have lines from the anthracite region north across Susquehanna and Wayne Counties into New York State.

The Pennsylvania system is represented in the area, with the Northern Central running south from Elmira through Williamsport, and the Philadelphia & Erie, which follows the Susquehanna through Clinton County to Williamsport and southward. The Reading system has a line to Jersey Shore, where it joins the Beech Creek division and the Pennsylvania division of the New York Central, the latter division running north from Jersey Shore through Tioga County into New York. The Buffalo & Susquehanna crosses northern Tioga County, and the New York & Susquehanna, Susquehanna & North Branch, and Central of Pennsylvania are smaller lines that serve other sections of the area. The numerous railroads give the area efficient freight and express transportation to all of the larger cities of the East, putting the farms in close touch with the large markets.

Trolley lines are not well developed outside of the anthracite region. There are excellent lines between Wilkes-Barre, Scranton, Carbon-dale, and adjacent towns, and a line north from Scranton to Factoryville is now being extended to Binghamton. The only other trolley lines outside of the cities are between Lock Haven and Mill Hall, Williamsport and Montoursville, and Athens and Waverly, and do not open territory not well served by steam lines.

The public roads are fair in the farming sections, but are very rough in the mountainous regions. There are a few stretches of macadamized roads, generally leading from the cities and shipping points for 2 to 4 miles into the country. Some of the country roads have been surfaced with limestone or gravel, but most of them are dirt roads and are generally good, though dusty in summer and very

muddy in the spring and fall. Owing to the broken topography the roads are very hilly, in some counties being merely a succession of rather steep ascents and descents. Road improvement is one of the great needs of the area.

HISTORY AND SETTLEMENT.

In 1769 a large part of the territory included in this area was purchased from the Six Nations, and between 1765 and 1770 the first settlers began to establish permanent homes in the area. Soon after this trouble developed between the Connecticut and Pennsylvania colonies, growing out of the fact that King Charles granted the area to Connecticut in 1667 and again to Pennsylvania in 1681. The quarrel over the title became acute at one time and resulted in what is known as the Pennamite wars. This trouble was adjusted about 1800.

The steady increase in the number of settlers, who occupied much of the best land, led to Indian uprisings, and several massacres resulted. After the Revolutionary War Indian troubles became less frequent and the real development of the region began. The first settlements were practically self-supporting, most of the trade being in furs and skins. Corn, rye, vegetables, and tobacco made up the farm crops. As the amount of farmed land increased the demands for a marketable product led to the establishment of numerous stills, and whisky became one of the most important products. Gristmills were established and some flour was marketed.

The early transportation lines followed the rivers, and canoes or rafts were used in carrying freight. Between the rivers pack trains served to transport goods over the divides. The necessity for communication between New York and the West led to the early opening of roads across the northeastern counties, and later roads were constructed connecting the area with Tulpehocking (now Reading) and Philadelphia.

With the discovery of coal in the Wyoming Valley came the necessity for better transportation. The first coal mined between Scranton and Wilkes-Barre was floated down the Susquehanna River in flatboats and barges. There was no way to reach the eastern markets except by wagon, and about 1820 a proposal was made for constructing a line of gravity railroad from Scranton to Hawley and a canal along the Lackawaxen River to the Delaware River. In 1823 the Delaware & Hudson Canal Co. was authorized to build a canal from the Delaware River to the Hudson River. About 6,000 tons of coal was mined and sent to the Atlantic seaboard in that year.

Railroads were proposed at an early date. The Lehigh Railroad was begun in 1839, and was opened from the Wyoming Valley to Easton in 1867. The Delaware, Lackawanna & Western Railroad

is the result of the union of two lines which were opened in 1851 and 1853 to connect Great Bend, in Susquehanna County, with the Delaware River at Water Gap. From this time railroad development progressed rapidly.

The presence of coal in the Wyoming Valley in northern Sullivan County and in southern Tioga County has had a great influence on the agricultural development of the region by encouraging the construction of railroads and the establishment of excellent local markets for farm products at the mining towns. The large number of people employed in the mines, on the railroads, and in other industries afford an excellent local market for food products. Potatoes, vegetables, fruits, etc., find a ready sale, while there is always an active demand for hay and grain at the mines and mills. The excellent transportation lines to New York and Philadelphia afford a means of marketing the dairy products.

One of the most important natural resources of the area was its lumber. In the eastern counties this was burned in clearing the lands, but in the mountain districts the timber was cut and marketed as lumber. The city of Williamsport grew with the development of the lumbering industries in Lycoming and Clinton Counties. At the present time a greater part of the timber supply is exhausted and most of the large mills have been removed or abandoned. Some of the small sawmills that remain are cutting timber which was left as worthless by the first lumbermen, and others are cutting the second-growth forests.

The tanning industry flourished for a time, but most of the tanneries have now been closed. Those that still run are dependent to a large extent on the tan bark shipped in from other sections.

Large paper mills in and near the area are using great quantities of the smaller timber, and in Sullivan County a large wood-alcohol plant is being operated.

Wasteful methods of lumbering and the devastation caused by forest fires have caused great losses in the forested regions. Some of the rough mountain regions excellently adapted to forest growth, but of no agricultural value, now exist as broad stretches of desolate, rocky country covered with a sparse growth of scrubby brush and marked by blackened stubs and burned tree trunks. Only by careful reforestation can these mountain regions be again made of economic value. The State has acquired considerable tracts of this land which it plans to reforest. In Pike County there are extensive private holdings in game and forest reserves.

Other natural products are brick clay and agricultural lime, but the production of each is very limited.

CLIMATE.

Climatic conditions over the area vary greatly with elevation, which ranges from 450 to 2,500 feet above sea level. Montrose, in Susquehanna County, has an elevation of 1,658 feet; Scranton, in Lackawanna County, 805 feet; and Williamsport, in Lycoming County, 530 feet. At Port Jervis, N. Y., just to the east of the area, the elevation is 470 feet. The larger part of the area occupies a plateau lying between 1,000 and 2,000 feet above sea level, and has a lower mean temperature and a lower rainfall than the counties to the south. The average rainfall over the area varies from 35 to 40 inches. The following table gives the normal temperature and rainfall at some of the principal stations:

Normal monthly and annual temperature and precipitation.

Month.	Montrose.		Scranton.		Williamsport.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.	° F.	Inches.
January.....	21.8	3.21	25.5	2.80	27.1	2.80
February.....	17.2	4.17	26.9	2.52	25.9	2.47
March.....	31.7	3.08	34.9	3.12	36.2	3.58
April.....	42.3	2.81	47.1	2.65	47.7	2.81
May.....	55.4	3.26	58.8	3.44	60.6	2.72
June.....	63.2	5.08	67.2	3.57	69	3.72
July.....	68.1	4.34	71.8	3.83	73.1	3.80
August.....	66.5	3.43	69.3	4.25	70.2	4.06
September.....	61.6	3.44	62.2	2.86	64	3.21
October.....	48.4	3.98	51.4	2.91	51.7	3.45
November.....	35.2	2.20	39.6	2.29	40.3	2.28
December.....	24.9	2.74	29.8	2.61	30.3	2.97
Year.....	44.7	32.58	48.7	37.05	49.7	38.07

PRESENT AGRICULTURAL CONDITIONS.

The general condition of agriculture over the area surveyed is poor. In some sections the farms and farm practices are good, but over much larger areas the land is not well farmed and yields are low. Owing to the wide range in soils, topography, market facilities, etc., it is almost impossible to give a good general idea of the conditions, and it is necessary to treat each section separately.

In the three limestone valleys (Nittany Valley and Sugar Valley in Clinton County and Nippenose Valley in Lycoming County) the farms are well cared for and in good condition. The soils are naturally fertile and by careful farming have been made quite productive. The general rotation consists of corn, oats, wheat, and grass, the latter being grown for two years. Wheat is one of the

money crops of these valleys. Corn, oats, and hay are usually fed on the farm, the manure thus made being an important factor in keeping up the productivity of these soils. Lime is needed on practically all of these limestone soils and is in common use. Better results would probably be obtained by the application of smaller quantities at more frequent intervals.

Dairying is the principal farm industry. The building of a large milk-condensing plant at Mill Hall has caused a decided increase in the number of milch cows in the Nittany Valley. The milk is collected by wagons or auto trucks and hauled to the nearest shipping point or to the condensing plant. Butter is the leading dairy product of Sugar Valley, while both milk and butter are important in Nippenose Valley.

Farm buildings and fences are in good condition and the land is valued at \$40 to \$60 an acre.

The soils of the river bottoms and terraces from Beech Creek to Montgomery are generally quite productive. The bottom lands along the river from Lock Haven to Jersey Shore are probably the most productive soils in the area. They are subject to overflow during periods of high water, and for this reason the farm buildings, while large and substantial, are not in the best condition. The barns are often built so high that the water rarely rises above the floor, but it is not uncommon to have the first floor of the houses flooded with muddy water. The soils of these bottoms belong in the Huntington series, and in this region they are extensively devoted to the production of tobacco. This crop does not occupy a regular place in the rotation. Corn, oats, wheat, and grass are the regular crops, while potatoes are grown to some extent. Tobacco, wheat, and corn are the money crops, and considerable hay is sold from some farms.

In this section the land is valued at from \$100 to \$200 an acre. Where tobacco is not the principal money crop land values rarely exceed \$100 an acre and are usually below that figure. Over such lands dairy products, wheat, and potatoes are depended on for cash returns. Some gardening is carried on near the cities, especially near Williamsport. East of Williamsport general farm crops are usually grown with excellent results, although on the terraces the depletion of the organic matter has reduced the moisture-holding capacity of the soil and crops suffer from drought. Alfalfa does well on these soils, and an increase in the acreage of alfalfa, clover, and potatoes, if well cared for, would materially add to the returns from the farms.

On the belt of shaly Dekalb and Upshur soils lying between the Susquehanna River and the Allegheny Mountains farming is not in such good condition. The soils are shallow and occupy rather steep slopes. Erosion is active on all the slopes, and if cultivated care

must be taken to prevent severe washing. Corn, oats, wheat, and grass are the general farm crops, with a small acreage of potatoes. Dairying is generally practiced on a small scale. The condensing plant at Mill Hall has served to stimulate the dairy industry in the region between Lock Haven and Beech Creek. In some sections the land is kept in good condition, with clean fields and well-tilled farms, but on the whole its condition is not good. Values range from \$15 an acre for the more hilly and remote farms to \$50 or \$60 an acre for some of the best areas. The soils are in need of organic matter and better tillage.

In the mountain regions of Clinton and Lycoming Counties there are a few areas of farmed lands, but these are not productive and in many cases are scarcely self-supporting. In most instances the areas were cleared and farming begun when the sawmills and lumber camps afforded ready local markets, and with the passing of the lumber industry the farmers have been left without a market for their farm products or for their farm lands.

Over all of the glaciated region dairying is the leading farm industry, and the crop rotations have been modified to fit the dairyman's needs. Wheat has been dropped from the rotation, the area in wheat in 1909 in the 8 glaciated counties being 2,193 acres, according to the Tenth Census, as compared with 31,561 acres in Clinton and Lycoming Counties. The area in rye in the glaciated region was 7,814 acres with 7,171 acres in the two residual counties. The elimination of winter grain has reduced the rotation to corn, oats, and grass. Buckwheat is an important crop, but has no definite place in the rotation. It is generally sown whenever any other crop fails, and is usually the first crop on any newly cleared fields. It is so often used as a catch crop where other crops have failed that the average yield is low, but when sown at the proper season good yields are obtained. In places it is one of the important money crops, especially in Bradford and Tioga Counties. In 1909 there were 70,446 acres of buckwheat grown in the glaciated area. Considerable buckwheat is grown in Clinton and Lycoming Counties, outside the area of glaciated soils.

Grass is usually seeded with oats, though buckwheat is often used as a nurse crop. As both these crops occupy the land throughout most of the summer and have a rather dense growth, shading the ground, they do not prove good nurse crops and farmers often fail to get a satisfactory stand of grass. The grass plants are generally weak and soft, and are often killed by the sun after the nurse crop is harvested. Some farmers seed their land to grass or clover without a nurse crop. This practice gives good results where the land has been well prepared. The yields of grass are low, the average for 1909 being 1.21 tons per acre. Over most of the area grass lands are

mowed as long as they give any returns, and often are pastured for several years after they cease to yield enough grass for hay.

The soils of this region are well suited to the growth of grasses, timothy doing very well and the clovers giving excellent yields on the well-tilled farms. The grass lands would become much more productive if shorter rotation periods were established, leaving the land in grass for only two or three years and taking care to maintain the lime content of the soil.

All of the tame grasses have disappeared from many of the meadows, and only Canada bluegrass, redbud, the fescues, and other grasses of even less value are being mowed for hay. Much of the hay is cut weeks after it is in the proper condition. During the season of 1911 farmers were cutting grass for hay as late as September. The grass was ripe and the stems were dry and hard. The feeding value, low at any time, was probably not half what it would have been had the grass been cut early in July when in bloom. In contrast with this general condition of the grass crops there were some well-kept farms on which timothy and clover yielded over 2 tons per acre of a very high grade hay. Alfalfa is grown to some extent in these counties, and on well-drained, thoroughly limed soils is giving good returns.

Silos are found on nearly all of the farms, most of the corn grown in the area being used for silage, though the flint varieties and the shorter-season grades of dent corn will generally mature. As a rule the corn is planted in rows 3 feet or more apart and yields good crops when matured. It is often sown very thick and few ears form. This is especially true on farms that do not have silos, but where the corn is cut and used as dry fodder.

Oats are the only small-grain crop on many farms and are grown for feed and for the straw which is used for bedding. In the greater part of the area there is a ready market for the grain, which is shipped to the mines for feed for the horses and mules.

Potatoes are grown throughout the region and should be one of the important crops. The soils are well adapted to the crop, and on the better farms yields of 200 bushels per acre and over are not uncommon. The average yield in 1909 in the eight glaciated counties, according to the Thirteenth Census, was 94.5 bushels per acre. Two factors serve to keep the yields low. One is that the crop does not receive the thorough tillage necessary for successful yields, being "laid by" early in July and no cultivation being given after that; the other is the injury to crops by blight and the ravages of the Colorado beetle or potato bug.

Dairying is the principal farm industry over the eight counties under consideration. In the sections near the Erie, Lackawanna, and Lehigh Railroads the milk is sold at local receiving stations and

shipped by refrigerator express trains to New York City. In the eastern counties a large part of this trade is in the hands of a condensed milk company. This company maintains a staff of inspectors and veterinarians, who inspect the barns and herds and insist on a certain standard of cleanliness and care in producing and handling the milk. This supervision has had a very beneficial effect on the dairy business in the sections where the company operates. In sections too far from the railroads to permit sending whole milk, skimming stations receive the milk, separate it, and transport the cream to the shipping points.

In western Bradford County, in Tioga County, and in those sections of the other counties at some distance from the railroads creameries and cheese factories are common. Most of the milk produced is delivered to these creameries, and the butter and cheese products are shipped to the city markets. Some butter is made on the farms, but most of this is disposed of at local markets.

On the whole the cattle are well bred, herds of pure-bred cattle being quite numerous and high-bred grades being common. The Holstein and Guernsey are the most common breeds, the former in the milk-shipping sections, the latter in the butter-producing districts. The use of full-blood sires is steadily improving the character of the dairy herds. Weeding out the unprofitable cows, or "boarders," from the herds by weighing and testing the milk produced by each cow is increasing the dairyman's returns.

Barnyard manure is in general use over the area. It is applied to the corn soils and plowed under, and in some sections it is used as a top dressing on grass lands. It is applied in quantities varying from 8 to 20 tons per acre. Little care is taken of the manure and heavy losses of plant food result from the leaching that takes place in the barnyards and from the piles when it is stored in the fields.

Practically all the soils in the area are in need of lime, and over most of the area it is in use, though rather sparingly. In many sections where clover could once be successfully grown it can not now be grown at all. This is usually because of a lack of lime, and on supplying that element good crops of clover can be obtained. The farmers are interested in liming at present and its use is becoming more common.

Commercial fertilizers are in general use over the area, being applied to the oat, buckwheat, and potato crops. They are usually bought by the brand name, without reference to composition, and the brands selling for \$18 to \$25 are most popular. The usual application of fertilizers is 150 to 200 pounds per acre, and even with these small quantities appreciable increases in crop yields are obtained.

The soils over the entire area are deficient in organic matter and as a result have a low water-holding capacity, tend to bake and clod,

and are hard to till. The long rotation practiced on most farms tends to accentuate this trouble, and the organic-matter content of the soil is decreasing. Shorter rotations, the addition of barnyard manure, and the plowing under of clover or other green manuring crops will materially benefit the soils.

Many of the areas of Volusia soils and some of the Lackawanna areas are in need of drainage. Those areas of silt loam that have a stiff clay subsoil locally known as hardpan are usually in need of drainage. The excess of water in the soil makes it very slow to warm up in the spring, materially shortening the growing season. Tile drainage is quite expensive, and it is probable that in many fields it would not pay. In most cases, however, drainage will materially increase the crop returns and prove a profitable investment. Many sloping fields with good surface drainage should be tile-drained, because of the seepage waters that work down from higher areas or that come to the surface along the outcropping of more impervious layers of rock. Many fields were noticed that were materially damaged by these seepage areas, or "wet weather springs."

On many farms the steep slopes of the fields permit a very rapid run-off and severe erosion results. Precautions against erosion are rarely observed, except the closing of gullies and washes that have been formed. Contour farming, plowing and planting around the hill, leaving strips of sod at intervals on the steeper slopes, will reduce erosion, and shorter rotations and the increase of humus will decrease the run-off and consequent losses by making the soil looser and more able to absorb moisture.

The condition of farm improvements over the area varies greatly. In some sections buildings are substantial and kept in good repair, while in others they are poor and in bad condition. Fences vary with buildings. The care taken of the farms generally is reflected in the condition of the buildings and fences.

Farm machinery is generally up to date and plentiful, but in many sections it is not well cared for. In Wayne County the amount and character of the farm machinery is exceptionally high, but as a rule the implements are neglected, being left in the fields without shelter from the time last used one season until needed the next year. Manure spreaders, sulky plows, and corn and grain binders are in general use and gasoline engines are quite common. Greater care in prolonging the usefulness, and thus reducing the cost, of farm machinery, and especially keeping it under cover when not in use, constitutes a reform whose need is too obvious to warrant discussion. Many thousands of dollars are annually lost to the farmers of this area by deterioration of machinery that could easily be prevented by proper care and housing.

The labor question is one of the most serious problems confronting the farmers. The railroads, shops, mills, and mines offer more attractive fields for labor than the farms, and in the regions near the industrial centers it is very hard to secure any farm help. Wages are low over most of the area, and it is possible that if better wages were uniformly paid the class of farm labor, as well as the supply of laborers, would materially improve. The hours of labor on the farm are long and there is no opportunity for advancement except where the laborer saves enough money to start out for himself as a tenant or owner. With better-planned farm rotations and practices, labor can be directed to better advantage and the hours of work made shorter. This, together with improved living conditions, will help to solve the labor question. This problem will always be the hardest one for the farmer to solve, however, and should warrant the most careful study and attention.

Most of the farms in this region are conducted by the owners. In the table below are given some figures from the Thirteenth Census bearing on land tenure. Under the head of "Farms operated by owners" is included the farms rented by men who also own and operate their own farms. The proportion of the farms in the area operated by owners is 81.6 per cent, and 34.1 per cent of these are encumbered with mortgages. No reports were made of the mortgages on farms operated by tenants or managers.

Number of farms, character of tenure, and mortgage indebtedness.

County.	Total.	Operated by owners.	Per cent.	Operated by tenants.	Per cent.	Operated by managers.	Number of mortgages.
Bradford.....	5,824	4,703	80.8	1,090	18.7	31	1,671
Clinton.....	1,268	884	60.7	353	27.8	31	197
Lackawanna.....	1,692	1,336	79.0	301	17.8	55	355
Lycoming.....	3,689	2,973	80.6	648	17.6	68	841
Pike.....	871	750	86.1	94	10.8	27	207
Sullivan.....	958	910	92.4	73	7.4	2	279
Susquehanna.....	4,239	3,458	81.6	715	16.9	66	1,220
Tioga.....	4,436	3,614	81.5	798	18.0	24	1,484
Wayne.....	3,449	3,069	89.0	354	10.3	26	1,137
Wyoming.....	1,756	1,408	80.2	330	18.8	18	494
Whole area.....	28,282	23,105	81.6	4,756	16.8	348	7,885

Tenants operate 16.8 per cent of the farms in the area. Of these, about one-half are share tenants and the remainder pay cash rentals. The system of renting varies in the different counties. In Lycoming, Clinton, and Tioga the share rental is customary, while in Lackawanna, Wayne, and Susquehanna the farms are usually rented for cash. The percentage of the farms operated by managers is 1.2,

The present condition of the land with respect to area in farms, area improved, size of farms, and value is shown in the following table:

Classification and value of farming lands.

County.	Area in farms.	Per cent of total.	Area improved.	Per cent improved.	Average acres.		Average value per acre.
					Per farm.	Im-proved.	
	<i>Acres.</i>		<i>Acres.</i>				
Bradford.....	623,303	85.1	458,637	73.6	107.0	78.7	\$15.27
Clinton.....	120,619	21.5	67,542	56.0	95.1	53.3	21.48
Lackawanna.....	134,160	46.5	58,760	43.8	79.3	34.7	33.68
Lycoming.....	358,209	45.9	206,547	51.7	97.1	56.0	22.21
Pike.....	173,481	49.8	26,407	15.2	199.2	30.3	13.57
Sullivan.....	96,216	32.8	39,068	40.6	97.7	39.7	11.57
Susquehanna.....	472,428	89.6	296,057	62.7	111.4	69.8	13.15
Tioga.....	475,471	65.1	293,011	61.6	107.2	66.1	16.63
Wayne.....	375,557	79.4	123,486	32.9	108.9	35.8	11.54
Wyoming.....	169,031	66.5	107,423	63.6	96.3	61.2	16.83
Total.....	2,998,475	60.0	1,676,938	55.9	106.0	59.2	16.45

This table shows that 60 per cent of the total area is in farms and that 55.9 per cent of this area, or 33.6 per cent of the total, is improved. The figures show a decrease from those of the Twelfth Census. The average size of farms is 106 acres, over 20 acres above the average for the State, but the average improved area is only 1.4 acres above the State average.

During the last 10 years the land values in 4 counties—Clinton, Lackawanna, Lycoming, and Pike—have increased, while the other 6 show decreases. The average value of \$16.45 an acre is 70 cents below the average of 10 years ago. The decrease in the total area in farms has been brought about by the abandonment of the poorer farms near the sites of the old logging camps. Some of these have been untenanted for several years and are growing up to brush and scrub trees.

SUGGESTIONS FOR IMPROVEMENT OF FARM PRACTICES.

An important improvement over the present methods of handling the land would be an increase in the depth of plowing. With deeper and more thorough plowing the soil would become looser and more open and a larger part of the rain would soak into the soil instead of running off the surface. The incorporation of organic matter by plowing under green crops or applying manure would increase the water-holding capacity. Harrowing immediately after plowing will break up any lumps that might be formed and make a surface mulch that will retain more moisture in the soil.

The corn and potato crops are reduced over 10 per cent each year by a lack of water during the time of the greatest development. It is the general custom over the area to "lay by" the cultivated crops after the third cultivation, or about the 4th of July. From this time on nothing is done to check the evaporation of moisture, the soil crusts over, and serious losses occur. Shallow cultivation every week or ten days would maintain a surface mulch that would prevent the excessive loss of water and enable the plants to make a much better growth. This should be continued until the plants are so large that they are in danger of being broken by further tillage.

Severe crop losses are suffered, particularly through injury by blight, which is common over the whole area, and through the damage to potato vines by the Colorado beetle or potato bug, frequently causing the loss of almost an entire crop. The blight can be successfully controlled by spraying with Bordeaux mixture, and the potato bugs can be exterminated by the use of Paris green or some other arsenical poison. Before this region can become prominent as a potato-growing district the farmers must take up the practice of spraying to control blight and bugs.

A more extensive use of lime will work a decided benefit for the farmers. Nearly all of the soils are deficient in this element and its use would correct acidity and make it possible to grow clovers and alfalfa profitably. Wherever the lime must be hauled any distance from a railway the lump lime is the cheapest form. One ton of lump or fresh-burned lime is equal to 2 tons of raw ground lime rock, or to $1\frac{1}{2}$ tons of hydrated lime. When freight is included it will be found that the lump lime is usually cheapest, particularly where it is necessary to haul the material for some distance from a shipping point. The lime should be applied at the rate of about 1 ton of lump lime per acre once in each rotation. After some years of use this quantity could probably be reduced.

The use of commercial fertilizers is general over the whole area, but they are usually purchased by brands, with little reference to their composition. The returns from their use would be increased by studying their composition and purchasing the brands that contain the quantity of nitrogen, phosphoric acid, and potash required. The bulletins which give the results of the analyses of the brands of fertilizers sold in the State should be in every farmer's hands.

Serious losses of fertilizing material are suffered through the exposure of manure to leaching and washing. Manure is the most important by-product of the farm and should be carefully protected to prevent loss. Greater care is required in storing the manure. It should be kept under cover and protected from leaching. Investigations at the Pennsylvania and New York experiment stations have shown that, measured by increased crop yields, manure is worth

about \$2 per ton. Other experiments have shown that when manure is exposed to the elements for 6 months it loses about one-half its bulk and the remaining material is poorer in fertilizing elements. From this one can see the decided losses suffered on those farms where the manure is thrown in heaps outside the barn, exposed to rain, and often catching all the water that runs from the eaves.

The area is developing rapidly, and with increasing care for its valuable grass land and dairy herds, it is destined to become one of the greatest milk-producing sections in the State.

SOILS.

Thirteen series of soils were mapped in the area. Three of these, the Dekalb, Upshur, and Hagerstown, are upland residual; two, the Volusia and Lackawanna, are upland glacial; three, the Wheeling, Holston, and Chenango, are terrace soils; four, the Huntington, Genesee, Moshannon, and Barbour, are bottom soils; and the remaining area is made up of the combined areas of Muck and Swamp. The residual soils are closely related to the geological structure of the region, and a clearer understanding of their formation necessitates the description of the structural geology and the effect of glaciation given below.

Nearly all of this region occupies the Allegheny Plateau. The Allegheny Escarpment, the steep southern wall of the plateau, enters the area on the western boundary of Clinton County, running across the county in an almost straight line, entering Lycoming County at Harbor Mills, and swinging in a broad curve north of Salladasburg, Warrensville, and Huntersville. It is cut through by Muncy Valley in Sullivan County, and leaves the area at the southwest corner of that county. From the top of the escarpment the general level of the country gradually rises to the west and north, with several ridges and basins varying the general elevation. The crest of the escarpment is of Pocono sandstone, which makes up the surface rock of most of Clinton County, southern Sullivan County, northern Lycoming County, and the mountains of Tioga and Bradford Counties. This formation also forms the mountain that lies between Lackawanna and Wayne Counties. In the northern and eastern parts of the area the Pocono has been largely removed and the Catskill group of sandstones and shales form the local rocks. On some of the anticlinal folds erosion has removed the Catskill, exposing the rocks of the Chemung group. In several shallow synclinal folds fragments of the productive Coal Measures have escaped erosion, and in southern Tioga and northern Sullivan Counties some important coal fields have been developed. Smaller fields occur in Lycoming and Bradford Counties. In all these regions the coal is bituminous, though some of the Sullivan County coals are quite hard.

A very deep synclinal fold has preserved the Coal Measures in Lackawanna County, in the famous Wyoming Valley or northern anthracite field. The Coal Measures are of the same formation as those in the bituminous fields, but the great heat and pressure produced by metamorphic processes that have operated in eastern Pennsylvania have hardened the coal in this part of the State and converted it into anthracite or hard coal. The development of this field, bringing in railroads and building up local markets, has had a profound effect on the history and development of this region.

In front of the escarpment the country is very similar to the areas to the south, described in the report of the South-Central Pennsylvania Reconnaissance Survey, made in 1910. On the slopes and at the foot of the escarpment the Catskill rocks outcrop as a continuous band of varying width occupying steep slopes or ridged valleys. This outcrop is shown on the map by the continuous band of Upshur soils extending across the area north of the Susquehanna River. The outcropping of the Chemung group¹ forms a series of narrow, steep-sided ridges and rounded hills covered with shaly soils, extending from the Catskill belt to the river, and in the eastern part of Lycoming County forming a broad area of steeply rolling country. The outcrops of the Lower Helderberg limestone are buried by river deposits, except near Montoursville, Pennsdale, and Elimsport. At each place the limestone is being quarried and burned for agricultural uses.

The Nittany Valley extends for a short distance into the area at its southwestern corner. Nippenose Valley lies a few miles northeast of this and may be considered as an outlier of the Nittany Valley, while the long, narrow Sugar Valley, with similar rocks and soils, lies a short distance east of the former and south of the latter. These are limestone valleys and contain Hagerstown soils. They are inclosed by the steep, rocky mountain ridges of the Medina-Oneida formation. These mountains extend in a broad curve from the western part of the area south of Beech Creek to a rugged knob northwest of Muncy, then to the southwest around the White Deer Hole Valley, passing out of the area as the south boundary of Lycoming County. Where the upward bends of the great fold occur, jumbled masses of Medina-Oneida rock formations are encountered. These occupy nearly all of the region of southern Clinton County outside of the limestone valleys, and form the great mountain masses south of Williamsport, in Lycoming County.

In this region of residual soils three series are developed. The Hagerstown soils are derived from the limestones and are the most productive upland soils in the area. The Upshur soils are derived

¹ No. VIII, Second Pa. Geol. Survey.

from the red Catskill rocks, and, occupying rather hilly positions, are generally shallow. In the Cogan Valley region the soils are quite productive. All of the other geological formations give rise to the Dekalb soils. Most of the Pocono area is made up of land too rough and stony for agricultural purposes and is in forest or cut-over land. The character of the soils from the other formations depends largely on the position and hardness of the rocks. The soils as they occur in each county are described further on in the report.

All of the area except the southwestern section has been glaciated. The great ice sheet which at one time covered a large part of North America moved southward across a part of this area. The southern limit of its movement, marked by the terminal moraine, enters the area near Mott, in eastern Lycoming County, extends west and northwest, crossing Muncy Creek at Tivoli, thence following the foot of the Allegheny Mountains to a point west of Warrensville, where it turns northward, crosses the mountains, and continues north to Marsh Hill; thence it turns west across the rough mountainous upland to a point near Oregon Hill, where it turns northwest through Lloyd, in Tioga County, leaving the area west of Gaines.

All of the country north of this line was overridden by the great mass of the glacial ice. The great thickness of this ice sheet is evidenced by the fact that in its advance from the north it was not stopped by the Allegheny Mountains, but rode over them, the terminal moraine lying at the south foot of the mountains from Mott to Warrensville. This ice sheet carried on its surface and within the ice itself large quantities of rock fragments of all sizes, from the finest clay to great rock masses weighing many tons each. When the recession of the ice front by melting became greater than the advance by the southward movement and the front of the ice sheet began to move back or "retreat," the load of débris carried in the ice was dropped and left on the surface of the land as a deposit of varying form and thickness.

The most extensive of these deposits is the sheet of till that forms the surface of nearly all of the glaciated region. This till sheet is made up of clay and silt containing varying quantities of angular stones and rock fragments. The till sheet in this area is generally thin and filled with fragments of the native rocks. It is not stratified, though in places it may show the effect of water action. This till sheet, mixed with the native rocks, gives rise to the extensive areas of Volusia and Lackawanna soils, the latter being those with a red color, while the former are gray and yellow.

Where the glacier front remained stationary for any length of time, as at the southern limit of glaciation and at some other places where its retreat was checked for a time, deposits of gravels and stones, mixed with sands and some clays, were formed. These occur as low,

irregular ridges and are called moraines. One of their striking features is the fact that their location bears no relation to the present topography, but that they extend across valleys, up slopes, or over mountains, depending solely on the position of the glacier front.

Eskers, kame, and kettle deposits are another type of glacial deposit found in the area. These are made up of more or less stratified and water-worked deposits of gravels and sands and occur as low, sinuous ridges and as masses of dimpled, gravelly hills. The soils from these deposits fall into the series already named, forming the sandy and gravelly soils of those series.

The deposits of glacial material in many cases obstructed drainage channels and formed many lakes and ponds. Some of the shallower ponds have become filled with vegetable deposits and are now swamps, but many beautiful lakes are to be found over the glaciated region. Some of the swamp lands have been cleared and drained and are very productive.

During the glacial epoch, and especially toward its close, the melting ice supplied a volume of water much greater than has been carried by the streams since that time. These waters were heavily laden with the sediment from the ice and very extensive alluvial deposits were made along the streams that flowed out from the glacial area. These streams have since cut through the deposits thus formed, leaving remnants of them as high terraces considerably above the present stream level. The terraces are composed of stratified gravels, sands, and silts and make up two important series of soils. In the glaciated region, where the terraces are composed wholly of reworked glacial material, the soils are known as the Chenango. South of the glacial region, along streams that flow out of the glaciated region, where the terrace materials are a mixture of glacial débris and material from the residual uplands, the soils are known as Wheeling.

The glacial action in this area has not altered the general topography, but it has had a modifying effect on local topography, making the hills less abrupt, filling some valleys and deepening others, and, in forming lakes and ponds and reversing drainage systems, has markedly affected the country conditions.

The Volusia soils of the glaciated area are in a general way related to the Dekalb of the residual area and in some ways are similar to them. The Lackawanna and Upshur soils are in a like way related. The relations of the terrace soils have already been shown, and on the present stream bottoms the Barbour, in the glaciated region, and the Moshannon, in the nonglaciated regions, are both red bottom soils, similar in many respects, while the Genesee, in the glaciated region, is a light-colored bottom soil comparable to the Huntington in the region of no glaciation.

The following table gives the name and extent of each of the soils series mapped in this survey:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Volusia soils.....	2,977,920	59.3	Hagerstown soils.....	19,008	0.4
Dekalb soils.....	988,416	19.7	Barbour soils.....	18,432	.4
Lackawanna soils.....	649,152	12.9	Moshannon soils.....	13,248	.3
Upshur soils.....	116,928	2.3	Muck and Swamp.....	10,368	.2
Chenango soils.....	77,184	1.5	Holston soils.....	9,792	.2
Genesee soils.....	65,088	1.3			
Wheeling soils.....	40,896	.8	Total.....	5,022,720	-----
Huntington soils.....	36,288	.7			

UPLAND RESIDUAL SOILS.

DEKALB SOILS.

The Dekalb series is made up of residual soils derived from the weathering of sandstones and shales. The surface soils are generally gray to brown in color, depending largely on their organic-matter content, and are rarely more than 8 inches deep. The subsoils are light yellow, yellowish brown, or mottled gray, yellow, and drab. They are heavier in texture than the surface soils, and grade at depths ranging from 1 to 5 feet into broken rock, which in turn grades into the unchanged bedrock from which the soil is derived.

In this area the Dekalb series are the most extensively developed of the residual soils, covering about five-sixths of Clinton County, three-fourths of Lycoming, the southwest corner of Tioga County, and a small area of Sullivan County. These areas form the northeastern extension of this series, which covers a large part of the regions to the west, mapped in the survey of 1908 in the Northwestern Pennsylvania area and in the survey of 1910 in the South-central Pennsylvania area.

The Dekalb soils in this area occupy two general topographic positions, the tops and flanks of the mountains and the hilly foot slopes and valleys. The soils in the mountainous regions are derived from the Pottsville conglomerate, the Coal Measures, and the Pocono sandstone, and from the Medina-Oneida formation. This formation is the source of the soil material in southern Clinton County south of the Bald Eagle Valley and in Lycoming County south and west of the Susquehanna River, consisting mainly of the rough and stony land on Bald Eagle, Nittany, Brush, and White Deer Mountains. There is but little farming land in this section, the region consisting principally of steep-sided, narrow mountain ridges, covered with loose, angular rock fragments to such an extent as to preclude cultivation.

North of the Allegheny escarpment, which extends across Clinton County just west of the Bald Eagle Valley, then northeast and east across Lycoming County, the Dekalb soils are derived from the Pocono sandstone and Coal Measures, and in some areas from the Pottsville conglomerate. The topography is that of a deeply dissected plateau, the drainage lines of the Susquehanna River and its tributaries, the Sinnemahoning Creek, Kettle Creek, Pine Creek, and Lycoming Creek having cut deep, narrow valleys, which, with their tributary valleys and ravines, have reduced the plateau form to a complicated series of narrow, steep-sided ridges and hills, with a few sections of rolling plateau at the divides.

There is practically no farming land in this region, the land soils being so steep and stony that it can not be cultivated, and with the exception of a few clearings the whole region is in the brush-and-stump conditions of cut-over forest land.

Where soil material is derived from the Pottsville conglomerate it is generally sandy and contains large quantities of rocks. The stony sand, stony sandy loam, and Rough stony land are the types found. The soils from the Pocono sandstone and Coal Measures, where not classed as Rough stony land, constitute the loam, stony loam, and some of the silt loam types.

In front of the Allegheny escarpment, extending across Clinton and Lycoming Counties, is a belt of Dekalb soils derived from the weathering of the Chemung, Portage, Hamilton, and other shales.¹ These soils occupy steep-sided, rounded hills and narrow, intervening valleys, though in southeastern Lycoming County the topography is better described as steeply rolling than as hilly. The shales from which the soils are derived are hard and thin bedded and the soils are generally shallow, the shale loam type being most extensively developed. Erosion is very active on these slopes, and the removal of the soil material takes place almost as fast as it is formed. The broken shale rock usually lies within 12 to 18 inches of the surface, giving a very loose, shallow soil mass. Drainage is excessive and crops are subject to damage from droughts. The control of erosion and the increase of the water-retaining capacity of the soil mass are the most urgent needs on these soils.

In the Dekalb series seven types, including Rough stony land, have been recognized in the area. Of these the Rough stony land, stony loam, and shale loam types are most extensive.

The Rough stony land, making up over 75 per cent of the total area of Dekalb soils, consists of those soils which because of the presence of large quantities of stone and rock fragments or of their position on steep and stony slopes are nonarable, but are suitable only for forest growth and to a small extent for pasture.

¹ Formation VIII of the Second Pennsylvania Geological Survey.

The Dekalb stony loam consists of 6 to 8 inches of a gray, grayish-brown, or, rarely, a brown loam or heavy sandy loam, underlain by a yellowish, compact clay loam or clay, sometimes somewhat sandy and occasionally mottled. Both soil and subsoil contain a high percentage of angular stone fragments of considerable size.

The surface soil of the Dekalb stony sandy loam consists of 6 to 8 inches of a loose gray or yellowish-gray sandy loam and rests on a grayish-yellow or dark-gray sticky sandy loam. Both soil and subsoil contain a large percentage of angular stone fragments.

The Dekalb stony sand is a grayish sand, 4 to 8 inches in depth, resting on a subsoil of similar character, which is often yellowish in color and becomes heavier and somewhat sticky with depth. Both soil and subsoil contain a high percentage of stone fragments.

The surface soil of the Dekalb shale loam consists of 4 to 8 inches of a yellowish or grayish-brown silty loam, containing from 20 to 60 per cent of small, flat shale fragments. This is underlain by a yellowish or grayish-yellow silty loam. The shale content increases with depth, until broken shale is reached at depths rarely exceeding 18 inches.

The Dekalb silt loam is a dark grayish brown silt loam, 6 to 8 inches deep, with a yellow or mottled plastic silty clay subsoil. Considerable quantities of shale fragments occur in both soil and subsoil.

The Dekalb loam consists of 6 to 8 inches of a fine brown or grayish-brown loam, underlain by a yellowish heavy loam, which grades into clay loam with increasing depth.

Between 75 and 80 per cent of the Dekalb soils are so rough and stony as to be unfit for cultivation. These areas were formerly covered with a magnificent timber growth, but this has all been removed, and, owing to recurring forest fires, a normal second growth of merchantable timber has not developed; but instead the soil is covered with scrub oaks and other bushes, making a dense thicket which affords excellent fuel for the fires. In Lycoming and Clinton Counties there are thousands of acres covered with this growth, affording a most desolate and depressing illustration of the effect of the destructive lumbering operations of the past.

In the regions where the Dekalb soils are farmed they are devoted to corn, oats, wheat, and grass, and in some sections to potato growing on a commercial scale. In the shale regions yields are fairly good, though the crops suffer from drought. Corn produces from 50 to 80 bushels, with occasional yields of over 100 bushels; wheat yields from 15 to 25 bushels, and potatoes from 75 to 150 bushels per acre. Clover yields well, but does not last over one season, and timothy also has a tendency to "run out." The soils are too droughty to maintain grass crops for any length of time, and the short rotations give best returns.

In the mountainous regions the same crops are grown, but the yields are usually indifferent. Buckwheat is grown to some extent and the yields vary greatly.

The Dekalb soils have a wide range in value. Cut-over lands, not cleared, can be purchased at from \$2 to \$10 an acre, while the farmed lands in the shale regions range from \$25 to \$50 an acre, depending on location with reference to markets and transportation facilities and on the nature of the soil and the farm improvements.

Fruit growing is being developed on the Dekalb soils, the shale loam being considered most desirable for this purpose. Orchards of apples and peaches seem to do well, though there are few extensive plantings that have reached a bearing age. It is believed that these soils will prove to be well adapted to fruit.

In tilling the Dekalb soils maintenance of the organic-matter content is an important factor. The soils are loose and friable, and unless organic matter is incorporated by plowing under clover and other crops or by the addition of barnyard manure their water-retaining capacity and productivity will fall to a low point. Maintaining the organic-matter content also helps to check erosion, which is a serious problem over these soils.

Clinton County.—In Clinton County the Dekalb series constitutes over 80 per cent of the soils, and over 75 per cent of this is Rough stony land. The Allegheny escarpment extends across the county about 3 miles west of Bald Eagle Creek, and from the escarpment west there is little farming land. The soils are derived largely from Pocono sandstone. The county has been so dissected by the Susquehanna River and its tributaries that there are few areas of level or rolling land left, and those are generally so strewn with rocks as to make cultivation impossible. This region is mostly cut-over forest land, covered with stumps and a growth of scrub oak. Small local sawmills are cutting what little good timber still exists.

In the vicinity of Caldwell, in Gallagher Township, there is an area of hilly land that has been cleared and farmed. Here the loam and stony loam types are most extensive, with some areas of sandy loam. Land values are low and crop yields are not high.

South of Bald Eagle Valley most of the Dekalb soils lie on the sides and tops of the narrow mountain ranges, Bald Eagle, Nittany, and Brush Mountains and their extensions, except on the lower slopes and in one area about Rosecrans, in Greene and Crawford Townships. This area is also Rough stony land. Near Rosecrans the soils are loam, sandy loam, and stony loam, and are fairly productive. Land values are low, as the area is a long distance from markets or transportation lines.

Between Bald Eagle Creek and the Allegheny escarpment lies the most valuable band of the Dekalb soils, derived from the Chemung,

Portage, and Hamilton formations. The shale loam and silt loam are the prevailing types. This belt of soil, from $2\frac{1}{2}$ to 3 miles wide, constitutes the best area of Dekalb soils in the county. About two-thirds of the land is cleared and farmed, though much of it is extremely steep and the soils very shallow. Corn, wheat, grass, potatoes, and fruit are grown, with fair yields. Farm practices are not as good as they should be, not enough attention being given to cultivation, to the control of erosion, or to the maintenance of organic matter. The land is valued at from \$25 to \$45 an acre, and by proper tillage and cultural methods it can be made quite productive. These soils seem well adapted to the growing of fruit and will undoubtedly be more generally devoted to apples and peaches in the future. Many of the old orchards bear well, though the trees show the effects of lack of nourishment. In order to be successful with fruit or any other line of farming considerable manure and other fertilizer will have to be used, together with consistent and thorough tillage.

Lycoming County.—The Dekalb soils cover fully 75 per cent of the area of Lycoming County, and of this over 50 per cent is Rough stony land. With the exception of some small areas in Pine and McHenry Townships, the whole of the county north of the Allegheny escarpment, which lies just north of the belt of Upshur soils that extends across the county from Tombs Run to Huntersville, consists of stump and cut-over lands that are unfit for agricultural use. The soils are derived from Pocono sandstone, with small areas from the Coal Measures and Pottsville conglomerate. In the past their heavy growth of forest trees constituted one of the county's greatest sources of wealth, but at the present time practically all the timber is gone.

In Gamble and Plunketts Creek Townships, on either side of Loyalsock Creek, an area of Dekalb rough stony land occurs within the glaciated province. No traces of glacial till were observed in this region, however, the soils apparently being wholly residual. For this reason they were included with the Dekalb. One or two small clearings of 100 to 200 acres of the stony loam are being farmed. The rest of the area is too rough and stony for cultivation.

An extension of this area into Hills Grove and Shrewsbury Townships comprises the only Dekalb soils found in Sullivan County. They are wholly Rough stony land and Rock outcrop and are not farmed.

Another area of Dekalb soils, made up almost wholly of Rough stony land, occurs south and west of the Susquehanna, in Lycoming County. In Bastress, Limestone, and Armstrong Townships the loam, silt loam, and sandy loam types are found, and are farmed with good results. Potatoes do especially well.

The belt of Dekalb soils, derived from the thin-bedded shale rocks, that extends across Clinton County, continues across Lycoming

County north of the Susquehanna River, and swings around to form a large area of valuable soils in the southeastern part of the county. Throughout this region the shale loam and silt loam are the most extensive types. The soils occupy an area of steep, rounded hills and ridges, with narrow intervening valleys and basins. The silt loam occurs in the depressions, while the shale loam occupies the slopes and hilltops. The land, with the exception of the steepest slopes, is cleared and in farms, and is of high agricultural value.

Corn, oats, wheat, potatoes, buckwheat, grass, and fruit are grown. The yields vary widely, depending on the thoroughness of cultivation and the use of manure or other fertilizers. Corn yields from 40 to 60 bushels; oats, 20 to 40 bushels; wheat, 15 to 20 bushels; potatoes, 75 to 150 bushels; and buckwheat, from 10 to 30 bushels. The best farms produce still greater yields, while some of the poorer farms fall below the minimum yields given. Buckwheat yields are variable, depending largely on the season and the time of sowing.

Some extensive plantings of apples and peaches are being put out on these soils, and with proper care they should prove profitable. Too much stress can not be laid on the importance of maintaining the supply of organic matter, the control of erosion, and proper tillage to conserve the water supply. The latter is especially important, as the water supply most often determines the crop yields. The soils also seem to be deficient in lime, and are benefited by the application of this material.

The soils bring from \$15 to \$50 an acre, depending largely on location.

Tioga County.—The Dekalb soils occupy the southwest corner of Tioga County and consist almost wholly of Rough stony land occupying mountain tops and ridges. They are mostly in stump and cut-over lands and have no agricultural value. They are essentially similar to the rough land in northwestern Clinton and Lycoming Counties.

UPSHUR SOILS.

The surface soils of the Upshur series vary in color from yellowish-red to brown, but are typically Indian red. The subsoils are generally dark red and usually heavier in texture than the surface soils.

In this area the Upshur soils are most extensively developed in Lycoming County, where they form some of the most valuable soils north of the Susquehanna. In Clinton County they are found in a narrow band at the foot of the Allegheny escarpment and in a small area in the northwest corner of the county. There are three small areas in southwestern Tioga County. They also occur throughout the north-central section of Pennsylvania and are shown in the survey of 1910. They are nowhere largely developed.

The Upshur soils in this area are residual and derived wholly from one formation, the red sandstones and shales of the Catskill formation. They occupy rolling to hilly areas, with some mountainous sections where the Catskill rocks outcrop on the steep flanks of the mountains. The most normal occurrence is as a series of rolling hills or rather steep ridges at the front of the mountains or in an intermontane valley.

These soils as a whole are well drained, and because of their topographic position and the loose nature of the rock are subject to severe damage by erosion. In some cases they are very shallow, the soil material being removed by erosion about as rapidly as it is formed by the weathering agents. There is usually considerable clay in the soil mass, and the water-holding capacity is such that whenever the soil is of sufficient depth crops do not suffer from short droughts, and with proper tillage could be carried through all but the most severe dry seasons.

Four types were recognized in the area surveyed—the shale loam, loam, silt loam, and fine sandy loam—the first named being most extensive.

The surface soil of the Upshur shale loam consists of a yellowish-red to dark reddish-brown fine silty loam, 4 to 8 inches deep, resting on a subsoil of Indian-red color and silty clay loam to clay texture. The soil contains from 30 to 60 per cent of flat, red shale or sandstone fragments. The percentage of shale increases in the subsoil, grading to broken rock at from 12 to 30 inches.

The Upshur silt loam is an Indian-red or brownish-red silty loam to a depth of 8 to 10 inches, with a subsoil of heavier, dark-red silty clay loam, grading into dark-red clay at about 30 inches. Shale fragments are numerous in the deeper subsoil.

The surface soil of the Upshur loam consists of an Indian-red, sometimes yellowish-red, mellow loam. It is underlain by a heavier subsoil of dark-red color, which grades into a clay loam at 30 to 36 inches.

The Upshur fine sandy loam is a yellowish-red or reddish-brown fine sandy loam, from 8 to 10 inches deep, resting on a subsoil which grows heavier in texture and darker in color with increasing depth. Both soil and subsoil contain a small quantity of angular, platy sandstone fragments.

Where properly cultivated the Upshur soils give good yields of corn, oats, wheat, buckwheat, potatoes, grass, and fruit. Corn yields from 50 to 75 bushels, oats 40 to 50 bushels, wheat 15 to 20 bushels, buckwheat 20 to 30 bushels, and potatoes 100 to 150 bushels. Hay yields from one-third ton to 3 tons per acre, depending on age of seed and seasonal conditions. The Upshur soils are locally known as "red-shell lands."

These soils vary widely in agricultural value, owing to range in topography and distance from markets. Cleared and fenced land, in fair condition, is valued at from \$40 to \$50 an acre, while uncleared or rougher land can be bought at \$2 to \$10 an acre. As not much over one-half the land of most farms is cleared, farm values run from \$20 to \$35 an acre.

The series as a whole seems deficient in lime, applications of which materially increase the yields. The use of lime, however, should always be accompanied by an increase in the organic matter in the soil, either by plowing down clover or other cover crops or by the addition of barnyard manure. The soils tend to lose their organic matter rapidly, and when this becomes low crop yields decrease and erosion becomes more severe.

Fruits, especially peaches, seem to do well on the Upshur series, and the few commercial orchards on these soils are proving financially successful. In further development of the fruit industry considerable thought must be paid to the means of transportation, as most of the Upshur soils lie at some distance from the railroads.

Clinton County.—The Upshur soils are not extensively developed in this county. In Leidy Township there are two areas, one lying largely on the steep-sided walls of the Kettle Creek Valley, the other on a hilly upland. The loam, shale loam, and fine sandy loam types are encountered. The soils are farmed to some extent. Owing to distance from markets the land is of low value, though fairly good crop yields are obtained.

The Upshur soils occur also in a narrow band along the front slope of the Allegheny escarpment and extend entirely across the county from Beech Creek Valley to Pine Creek Valley. This band varies from one-fourth mile to a mile in width and is made up largely of shale loam. The land is nearly all cleared and in farms, and good crop yields are obtained. This area includes steep, hilly slopes, and the soils suffer severely from erosion. Values range from \$15 to \$35 an acre, depending on location, topography, and character of improvements. In Woodward and Dunstable Townships some excellent farms are found on this series.

Tioga County.—In Tioga County the Upshur soils occur in three detached areas on outcrops of Catskill sandstone, and all occupy steep, rocky topography. They are not cleared or farmed, but are cut-over forest lands of little agricultural value.

Lycoming County.—In Lycoming County these soils are quite extensively developed. The narrow band that crosses Clinton County and the other counties to the south here widens out to about 5 miles across and extends in a rather irregular belt across the county to Muncy Creek. Glacial action has altered the soils in the eastern end, forming the Lackawanna soils, but an unglaciated area in Jordan

Township represents the easternmost occurrence of the Upshur soils. Other outcrops of the Catskill rocks give areas of the Upshur along the steep-sided valleys of Pine, Little Pine, and Lycoming Creeks, in Cogan Valley, and in the unglaciated portion of Rose Valley.

Along the crest of the mountain at Essick Heights and again on the flanks of the Loyalsock and Wallis Run Valleys, in Gamble Township, areas of Upshur soils occur within the glacial limit. The till sheet is entirely absent, however, and as the soil masses are obviously residual in origin, they were mapped as Upshur. In both these areas the shale loam is the only type. The Upshur soils along Pine, Little Pine, and Lycoming Creeks occupy steep hill-sides, while the other areas of the series have a rolling to hilly topography. In all cases the shale loam is the most extensively developed type, though in Cogan Valley the loam and fine sandy loam are encountered, and in the larger band across the county the silt loam has some prominence.

Taking the series as a whole, about 50 per cent of the land is cleared and in farms, though in some sections as high as 90 per cent is cleared and in farm land.

The value of the land varies from \$10 to \$50 an acre, but most farms can be purchased at from \$20 to \$35 an acre, owing to the areas of uncleared or rough land included within their bounds. In Cogan Valley the land is well farmed and held at good prices, although it is cut off from the railroads by surrounding mountains.

General farming is practiced, and while considerable cattle are kept, they are pastured as long as possible and not much manure is made. The land is rather deficient in organic matter. Lime is extensively used, being hauled from Montoursville. In the broad band mentioned the soils are well farmed and good results are obtained. A more general use of lime and greater effort in maintaining the organic-matter content of the soil would materially increase the crop yields. The losses of soil fertility and of actual soil through erosion are not appreciated by the farmers, and not enough care is exercised in preventing or reducing erosion.

Corn, oats, wheat, and grass constitute the standard rotation. Some farmers are growing potatoes on a commercial scale, with good results. The distance from shipping points and markets restricts the development of potato and fruit growing. The soils seem well adapted to the production of peaches and apples, and where other conditions are favorable excellent returns are obtained. Along the Northern Central Railway peaches are grown quite extensively, and the orchards at Trout Run are commercially successful.

The development of these soils along specialized lines, especially the growing of fruit and potatoes, offers good opportunities.

HAGERSTOWN SOILS.

The Hagerstown series includes yellow and reddish-yellow surface soils with yellowish-red or red subsoils. The material is derived from the weathering of massive limestones. These soils are found only in Clinton and Lycoming Counties, and while not extensive in area they constitute one of the most important soil series in these counties because of their productivity.

With the exception of two very small areas in eastern Lycoming County, the Hagerstown soils are derived wholly from one geological formation, the Trenton limestones. The small areas mentioned occupy the slopes of a ridge of Lower Helderberg limestone.

The Trenton limestones outcrop in three anticlinal valleys. Nippenose and Sugar Valleys are completely within the area and entirely surrounded by mountains, while Nittany Valley, in Clinton County, is the upper end of the great Nittany Valley that extends across Center County.

In the weathering of the limestone rocks to form these soils solution has played a very important part. The Trenton limestones are quite pure, and the waters, carrying small amounts of organic and other acids derived from decaying organic matter, have dissolved and carried away the larger part of the calcium and magnesium carbonates that made up from 75 to 90 per cent of the rock. The sink holes mark the openings into the underground channels through which a large part of the drainage waters escape, and these underground streams, where they come to the surface, form the great springs that are found in the limestone valleys.

The Hagerstown soils, though formed from limestone, are generally deficient in lime, as that material has been removed by solution in the process of soil formation. The application of lime gives very beneficial results and is quite generally practiced throughout the whole region.

Drainage is good over the whole area, and, except on a few steep slopes, erosion is not severe. The soils have some tendency to clod if tilled when wet, though they are normally loose and friable.

Five types were recognized in this area, the clay, stony clay, clay loam, silt loam, and loam.

The surface soil of the Hagerstown stony clay consists of from 2 to 6 inches of a dark-red or brown heavy clay loam, resting on a subsoil of stiff red clay. The soil and subsoil contain from 30 to 60 per cent of angular limestone and chert fragments. Limestone rock is usually encountered at depths of less than 3 feet.

The Hagerstown clay includes a surface soil of dark-red or reddish-brown heavy clay loam, 2 to 6 inches in depth, resting on a stiff red clay subsoil. In some places the surface soil consists of 2 to 4 inches of a light silt loam or loam over the stiff clay subsoil.

The Hagerstown clay loam consists of 8 to 10 inches of a brown or yellowish-brown loam or silty loam underlain by a yellowish, heavy silty clay loam which grades into stiff red clay at from 20 to 30 inches.

The surface soil of the Hagerstown silt loam consists of from 10 to 12 inches of a dark-yellow or brown silt loam. The subsoil to a depth of 24 inches is a yellowish silt loam overlying a reddish-yellow silty clay loam or clay.

The surface soil of the Hagerstown loam is a brown or yellowish-brown, rather silty loam, 8 to 10 inches deep, resting on an immediate subsoil of a light-yellow, heavy silty loam, or silty clay loam, which becomes heavier with depth until a heavy red clay is reached. The soil is loose and friable.

In this area these soils are almost wholly devoted to the growing of corn, oats, wheat, and grass. Dairying is carried on to a considerable extent, and the new condensery at Mill Hall has caused a marked increase in the number of cattle in Nittany Valley. Alfalfa is grown to some extent, with excellent results.

Crop yields are high and the farms are well kept. The character of farm improvements is better on the Hagerstown soils than on any other soils in the whole area surveyed.

Clinton County.—The Hagerstown soils in Clinton County occupy the west end of the Nittany Valley, in Porter and Lamar Townships, and the long, narrow Sugar Valley, in Logan and Greene Townships. The western development of the Hagerstown soils of Nippenose Valley extends across the county line into Crawford Township. Throughout the two former valleys the clay loam and silt loam are the most extensive types, while in Nippenose Valley the loam predominates.

The soils have a rolling topography in the valleys, though in Porter Township there are some very steeply sloping hillsides, especially along the streams on the north side of the valley.

Practically all the land is in farms, with the farm woodlots as the only uncleared portions. Land values range from \$40 to \$100 an acre, depending on the soil, location, and character of improvements.

Crop yields are good, corn giving 70 to 100 bushels, wheat 20 to 25 bushels, oats 20 to 30 bushels, and hay 1 to 2 tons. Few potatoes are grown, and but little fruit is produced on these soils. Dairying is the principal industry, every farmer having a herd of a fairly good class of grade cattle. The soils are all in need of lime, and this is being added on most farms. Lime and manure materially increase the crop yields.

Lycoming County.—The only large area of Hagerstown soils found in Lycoming County is in Nippenose Valley, where the loam is the most extensively developed type. The crops and yields are about the same as in Clinton County, though in Nippenose Valley

dairying is not so important an industry. The farms are in excellent condition, with well-kept buildings and fences and well-tilled fields. Land values are about the same as in Clinton County.

The two small areas of Hagerstown soils in Washington and Muncy Townships occupy the tops and sides of the limestone ridges, marking the outcrops of the Lower Helderburg limestones. Another similar outcrop occurs just west of Montoursville, in Loyalsock Township. The soils in these areas are usually stony clays and are of little agricultural value, owing to their shallowness and steep topography. The outcrops are valuable, however, as a source of lime for the near-by country.

UPLAND GLACIAL SOILS.

VOLUSIA SOILS.

The Volusia is the most extensively developed series of soils in this area, occurring in every county except Clinton and occupying practically all of Susquehanna, Lackawanna, and Pike Counties.

The Volusia soils are derived from the feeble glaciation of the sandstones and shales that form the bedrock of the region. The soil mass is made up partly of residual material weathered from the underlying rock, but mainly of material derived from that rock by being picked up, mixed, ground fine, and redeposited by the ice as a thin till sheet. Where the till deposit is thick the soil mass is composed wholly of that material, but where it is thin, as is usually the case, the action of frost, rains, and other weathering agents has thoroughly mixed the residual material and the till to form the typical Volusia soil mass. The soils derived from this material are usually fine-textured loams, silt loams, and clays, and the fine clayey subsoil, locally known as "hardpan," is usually compact and impervious, especially in the silt loam and clay loam types.

In mapping the Volusia soils no attempt has been made to differentiate the ice-laid from the water-laid material. All upland soil derived from glacial material is mapped as Volusia, regardless of whether it is ice laid or water laid.

It is known that a few small areas of water-laid material occur in the area, but they were not differentiated from the rest on account of their relative unimportance. They can be mapped in detailed work only. Probably much less than 0.05 per cent of the Volusia soils of the area are derived from water-laid drift.

In contrast with this Volusia material is the sandy and gravelly material that was piled up as moraines before the ice sheet whenever the glacier front remained stationary for any period. The moraines have a varied topography, being marked by ridges, hills, and hummocks of sand and gravel. In places these are made up of steeply sloping, pitlike depressions and rounded, inclosing ridges that are

known as the "kame and kettle" deposits. This accumulated material gives rise to the lighter types in the Volusia series, the sands, gravels, and sandy and gravelly loams.

The Volusia soils derived from the thin till sheet are gray or grayish brown in the surface section, with grayish-yellow, gray, or mottled heavy subsoils, while those derived from the morainic deposits have grayish-yellow to brown surface soils, and yellow or grayish-yellow subsoils. The former soils are normally rather poorly drained, while in the latter the drainage is good.

The topography of the Volusia series varies considerably over the area. The hummocky ridges of the terminal moraine and the "moraines of recession," which have been described, form but a small part of the total area of the series. Throughout Bradford, Susquehanna, and the larger part of Wayne and Lackawanna Counties the Volusia soils occupy a series of rounded, flat-topped hills and uplands, separated by deep V-shaped, steep-sided stream valleys. Viewed from any prominent elevation, the country appears as a rolling plateau, but on driving over the area the roads, except those that wind along the valleys, are found to be a succession of steep climbs over the seemingly endless succession of hills and ridges. The bedrock over this general region is largely of the Catskill formation, with smaller areas of the Chemung-Portage-Hamilton formation, both of which are made up of rather soft shales and sandstones. These, under the influence of preglacial erosion and the effect of the ice itself, have been worn to the topographic forms described.

South and west of this region a stretch of rougher country occurs, where the bedrock is made up of Pocono sandstone and the harder sandstone layers of the upper Catskill formation. In this region the Volusia soils occupy the sides and plateau tops of the mountain ridges. While the underlying rock enters very largely into the composition of the soil mass, the effect of the ice action is very evident and the soils are distinctly glaciated. Where the Pocono sandstone is the parent rock the soils are very rough, Rough stony land being almost the only type. In such areas the soil consists of a mass of glacially worn and scratched stones and boulders of all sizes, with a small quantity of sandy or silty interstitial soil. In one place an outcropping ledge of Pocono sandstone proved to be the parent rock from which the glacier removed the boulders and stones that are distributed along a course to the southwest for over a mile, showing the direction of the ice movement and the ability of the ice to break loose and transport large masses of rock. Glacial till of considerable depth is occasionally found on these elevated plateaus, and in many cases the till and morainic deposits have filled drainage lines and formed ponds and lakes, some of considerable size.

The heavier types of the Volusia series are not well drained. The impervious nature of the subsoil prevents the free movement of water, holding it in the soil mass and making the soils cold and wet. This is true not only on the more level uplands, but also on the sloping Volusia hillsides, where the trouble is even more severe because of the seepage from the higher levels. The seepage waters come to the surface as springs and in wet, marshy areas along the lower slopes. This stiff, impervious clay subsoil is locally known as "hardpan," although no true hardpan was seen in the area. With drainage and careful tillage the hardpan can be broken up and its ill effects eliminated.

When the land was first cleared the drainage problem was not prominent. The openings formed by the passage of tree roots through the soil into the underlying shales afforded efficient drainage channels. These channels gradually filled up, and as the organic matter in the soil became depleted by continued tillage the soils became more compact, wet, and cold. Artificial drainage is now necessary before satisfactory crop yields can be obtained, and a system of farming that will increase the organic matter in the soil must be practiced in order to make the soil loose, mellow, and capable of producing its best yields.

The supply of lime in these soils is practically exhausted, and maximum yields can not be obtained without this amendment. On many farms it is almost impossible to grow clover. With the increasing sourness of the soil the farmers change from red to mammoth clover, then to alsike, and finally abandon clover altogether. Other crops do not show the need of lime with such clearness, but its use gives marked increases in yields. There are no supplies of limestone in the glaciated country, and all the lime must be shipped in from some distance. This makes the material expensive, and it is not being extensively used. The Volusia soils will not reach their full productivity unless the lime requirements of the soil are supplied.

Erosion is active over the whole area of the Volusia soils, but is nowhere recognized as a serious problem. The removal of the soil material proceeds slowly, and gullies and washes are not often seen. On the steeper-lying farms more attention should be paid to the control of erosion, especially in the cultivated fields.

Eight types, including Rough stony land, were recognized in the area. Of these only the silt loam, Rough stony land, and loam are extensively developed. A brief description of each type follows:

The surface soil of the Volusia clay loam consists of 6 to 8 inches of a grayish-brown silty clay loam, and rests on a drab, yellow, or mottled clay loam subsoil.

The Volusia silt loam consists of 6 to 8 inches of a gray or brownish-gray silt loam, overlying a subsoil of gray or yellow silty clay loam which grades into a mottled silty clay.

The Volusia stony silt loam is essentially similar to the silt loam, except that over the surface and throughout the soil mass there occurs from 30 to 60 per cent of flat shale and sandstone fragments of varying sizes.

The surface soil of the Volusia loam is a grayish-brown to dark-brown rather silty loam from 6 to 8 inches in depth, underlain by a subsoil of yellowish or mottled clay loam, which grades into a mass of broken rock at 30 to 36 inches.

The Volusia stony loam consists of 6 to 8 inches of a dark-colored, heavy loam, underlain by a yellow or mottled silty clay loam subsoil. The soil and subsoil contain 40 to 60 per cent of flat shale fragments of varying sizes.

The surface soil of the Volusia sandy loam is a gray to brown sandy loam, extending to a depth of 6 to 8 inches and resting on a brownish-red to yellowish, coarse sandy clay loam subsoil. In places the stone content is sufficient to make the type a stony sandy loam.

The surface soil of the Volusia gravelly loam consists of 6 to 8 inches of a light-brown loam, often somewhat sandy. The subsoil is a brown to grayish-brown loam to sandy loam. Both soil and subsoil contain a large percentage of rounded gravel and some angular shale and sandstone fragments.

The Volusia rough stony land is distinctly derived from glacial material, and includes all the rough, rocky areas within the glaciated region having the typical gray or yellowish soil material.

Dairy farming is the leading agricultural pursuit on the Volusia soils, and the crop rotations and farm practices are planned with a view to obtaining feed for the dairy cattle. Wheat is rarely grown, most of the grass seed being sown with the oat crop. Where any rotation at all is followed it usually consists of corn, oats, and grass, the latter for three to five years. The corn is usually cut for silage, though the short-season varieties mature the grain and give good yields. Some of the oats is cut for fodder, but the general practice is to grow the crop primarily for the grain, using the straw for bedding, and when hay is scarce for a supplemental fodder.

Rye is grown in some sections, with fair yields. Some spring rye also is grown. The acreage of rye, however, is very small.

Buckwheat is grown on almost every farm, and constitutes one of the important money crops. It has no definite place in the rotations, however, being sown wherever for any reason other crops may fail. When meadows run out or become unprofitable they may be plowed up and sown to buckwheat, to be followed by oats or corn, as the

preference of the farmer or the working of the rotations demand. When, because of wet weather or other circumstances, the corn fails to come up and it seems too late to replant the ground, it is harrowed and sown to buckwheat. On some farms buckwheat has a more or less regular place, coming in after corn and before oats, making a corn-buckwheat-oats-grass rotation.

Potatoes are grown on most farms in small quantities, usually only for home consumption, but a few farmers are growing the crop on a commercial scale. On these latter farms potatoes usually follow corn in the rotation, being followed by oats. The potatoes as a rule are not carefully handled, little spraying being done and cultivation not being thorough. The crop suffers severely from blight almost every season.

The grass crop is the most important, both from the standpoint of acreage and from its bearing on the leading farm industry, dairying, although it is a poor crop throughout this area of soils. The Volusia soils are naturally adapted to grass, and where well handled and cared for large yields of a very fine quality of clover or timothy can be obtained. The depletion of the lime supply and the poor drainage have made clover growing impossible, however, over much of the area, and the tendency to keep the meadows too long in grass has reduced the acreage of timothy. On these cold, sour soils the finer-stemmed grasses, such as Canada bluegrass, redbtop, and the fescues, soon crowd out and replace the timothy. The hay from these grasses is much less valuable than timothy hay and the yields are very much lower. By following shorter rotations, not leaving fields in grass over three years, and by using lime the yields of hay can be materially increased.

Crop yields over the Volusia series vary considerably, depending on local farming methods and on soil conditions. Oats yield from 20 to 40 bushels, averaging about 35 bushels; buckwheat yields from 10 to 40 bushels, with about 25 bushels as a fair average; potato yields range from 50 to 200 bushels, with an average of about 125 bushels; corn yields from 12 to 15 tons of silage, or from 40 to 100 bushels of ears, the average being about 60 bushels; hay gives from one-half to 2 tons, with an average of 1 ton per acre, owing to the large area of poor meadow that is annually mowed.

Apples do well on the Volusia soils, though there are few commercial orchards in the area. The farm orchards bear well, although the trees are generally in poor condition and the fruit wormy and of poor quality because of neglect. It is believed that apples would prove a profitable crop on the better-drained areas of Volusia soils. Land values vary from \$10 to \$60 an acre, the average value lying between \$20 and \$30 for the ordinary farm soils.

Tioga County.—In Tioga County the Volusia series comprises about 60 per cent of the total land area. The best Volusia soils lie

in the northern part of the county and from Wellsboro east, past Mansfield, to the county line. The southern and southwestern sections of the county are hilly and even mountainous, and rough stony land is the prominent type. The chief types in the county are the loam, silt loam, and stony loam. About one-half of the Volusia soils is in farms, the balance being about evenly divided between forest, mountain, and rough, broken land.

Land values vary, the poorer and rougher soils being very low in value, while the well-located areas of loam and silt loam bring from \$25 to \$50 an acre.

Crop yields vary widely, depending on character of soil and the ability and industry of the farmer. Much of the Volusia series in this county needs drainage and practically all of it needs lime. With drainage and the application of lime, clover can be profitably grown and the yield of all crops increased. Dairying is the principal industry, milk being sold to the condenseries and to creameries and cheese factories. Farm conditions are fair. Buildings and fences are fair to poor.

Lycoming County.—Practically all of the Volusia soils in this county lie on the mountains and are Rough stony land. Some areas along the Tioga County line are farmed, and in Penn and Mill Creek Townships there are some areas of fairly good soil. These are all, however, of very small extent.

Sullivan County.—Fully two-thirds of the area of Sullivan County is composed of Volusia soils, but as practically 75 per cent of this is Rough stony land, the series is not agriculturally important. In Fox, Cherry, and Colley Townships there are some good farming areas, but over the remainder of the region few farms are to be found. The greater part of the series consists of cut-over lands which support a second growth of beech, birch, maple, and chestnut, while many areas are covered with bracken and a low growth of scrub brush. In Fox and Colley Townships the farmed areas are decreasing, many fields being used only as pasture and allowed to grow up to brush.

Although crop yields are fairly good on these soils, land values are low, \$5 to \$15 an acre being the general range. Oats yield 20 to 30 bushels, potatoes 60 to 150 bushels, buckwheat 20 to 35 bushels, while the yield of hay is fair to poor. The land is in poor condition and buildings and fences are not good.

Bradford County.—In Bradford County the Volusia soils occupy over two-thirds of the land area. With the exception of a mountainous section in the southwestern part, the soils have a rolling to hilly topography. The silt loam is the most extensive type, with considerable areas of loam and some gravelly loam. In places the loam and silt loam types are quite stony, especially on the steeper slopes.

Most of the series is in farms, although there is considerable waste land that is devoted to poor and unprofitable pasture or meadow.

Land values vary greatly, depending on location and character of improvements. In the poorer sections values are as low as \$5 to \$10 an acre, while the better farms will bring over \$50 an acre. The average value is between \$20 and \$35 an acre.

Crop yields are fair. Corn produces 40 to 60 bushels, oats 30 to 40 bushels, buckwheat 20 to 30 bushels, potatoes 75 to 150 bushels, and hay one-half to 1½ tons per acre. Dairying is practically the only type of farming. In the western part of the county the milk goes to creameries and condenseries, while in the Lehigh Railroad shipping district most of it is shipped by fast milk trains to New York City. In the creamery sections Guernseys and Jerseys are the leading breeds, while in the milk-shipping districts Holsteins are most common.

Bradford County soils are uniformly in need of lime and a large part of the heavier types need drainage badly, while the organic-matter content of the soils has been depleted. These three factors bring about the cold, sour condition on these naturally heavy soils that shortens the growing season and causes low yields.

Susquehanna County.—The Volusia series covers practically the entire area of Susquehanna County, there being only a few small, scattered areas of Lackawanna soils and small areas of bottoms and terraces. The topography is typically rolling to hilly, with some very steep hills along the Susquehanna in the northeastern townships. The silt loam type is most extensive, with the loam, stony loam, and shale loam as practically the only other types. With the exception of considerable areas in the northern tier of townships, practically all the series is in farms. In the section named there are some extensive areas of forested and cut-over lands.

Land values vary from \$15 to \$30 an acre, depending largely on location and improvements. The best agricultural conditions and highest land values prevail in Harford, Brooklyn, Dimock, Springville, and Auburn Townships. In the rougher and more remote regions there are many vacant, so-called abandoned farms, some of which can be purchased for less than the buildings are worth.

Dairying is the principal industry, most of the milk being shipped to the cities via the Lackawanna and Lehigh Railroads. In the sections more remote from the railroads the milk or cream is sold to creameries and made into butter and cheese. The Holstein is the most popular breed in the county, though there are some excellent herds of Guernseys and some Jerseys.

Crop yields vary considerably over the county. Corn, oats, buckwheat, and grass are the principal crops. Corn is usually grown for

fodder or ensilage, although it will mature the grain in ordinary seasons. Oats yield 25 to 50 bushels, buckwheat 25 to 35 bushels, and potatoes 75 to 150 bushels. Hay yields from one-third to $1\frac{1}{2}$ tons, depending largely on the length of time the meadow has been in grass.

The soils all need lime and organic matter, and over much of the county they need drainage as well. Farm practices are not up to date, and, as a rule, tillage is not thorough. The soils are capable of producing much higher yields than are now secured.

Wayne County.—The Volusia series occupies over two-thirds of Wayne County, covering all of the northern and southern sections and most of the central and western portions of the county. Except for the Moosic Mountain ridge along the western boundary line, the topography is normally steeply rolling to hilly, with few if any level areas.

Only a small percentage of these soils is cleared and in farms. The greater portion is too stony for farming and is now covered with a growth of birch, beech, and maple. The stones have been largely removed by hand from the fields in cleared areas, but the soil auger is usually stopped by stones at less than 36 inches. The stony loam and stony phases of the loam and silt loam types predominate over the farmed areas. Near the boundaries between the Volusia and Lackawanna the soil mass becomes more reddish in color, the change from one series to the other being very gradual.

Corn for ensilage, oats, buckwheat, potatoes, and hay are the crops grown. Oats average from 28 to 30 bushels, buckwheat 20 to 25 bushels, potatoes 75 to 100 bushels, and hay one-half to 1 ton per acre.

Farm values are low, the best farms being held at \$20 to \$40 an acre. The soils are low in organic matter and wash rather badly. They respond well to the use of lime. The soils over the whole county are overrun with weeds.

Wyoming County.—In this county the Volusia soils cover about two-thirds of the land area. The southwestern corner of the county, west of Bowman Creek, is practically all Rough stony land, having a mountainous topography, while between Bowman Creek and the river the country is rolling to hilly, with a rather sandy loam and a stony loam as prevailing types. Drainage is good in this region. The farms are poor and little live stock is kept. Apples are being planted in this region and some large orchards have been set out.

Land values range from \$10 to \$40 an acre.

Practically all the Volusia soils north and east of the river are of the heavy types—loams, silt loams, and clay loams. More live stock is kept here, dairying being the principal industry, and the

farms are in fairly good condition. The soils are in need of lime and are low in organic matter, though on some farms enough manure is made to maintain the organic-matter supply in the soil. Some areas of the heavier soils need drainage, being cold and wet. Land values are higher than they are west of the river, \$30 to \$60 being the ruling prices. Over the whole county considerable interest is being taken in fruit growing and numerous plantings have been made. Some orchards have proven very successful.

Lackawanna County.—The Volusia soils cover all but a very small part of Lackawanna County. All of the southern, eastern, and central sections of the county, however, are either mountainous or very rugged, and of little agricultural importance. Most of the soils are Rough stony land, and support a scant growth of maple, beech, and birch. The northern and western parts of the county are mainly cleared and in farms. In these sections the loam and silt loam are the predominant soil types. Dairying is the principal industry, and the main object is to keep the land in grass. Corn, oats, potatoes, and buckwheat are the cultivated crops. No regular rotation is followed. Grass lands are planted to corn, or corn and potatoes, then to oats, and then to grass again. Buckwheat may replace the corn or it may come in before oats. More ear corn is grown than in the surrounding counties. Corn averages 50 bushels, oats 35 bushels, buckwheat 25 bushels, potatoes 100 bushels, and hay about 1 ton per acre.

Land values range from \$20 to \$50, averaging about \$25 an acre. The soils are deficient in lime and organic matter, and are often in need of drainage. Some orchards are being set out in the northern part of the county.

Pike County.—Fully 95 per cent of Pike County is occupied by the Volusia series, and of this area not over 5 per cent is cleared and in farms. The remainder consists of second-growth forest of beech, birch, maple, chestnut, and oak, largely held as State forest reserve or as private game reserves. The greater part of the county is a roughly rolling elevated plateau, with Rough stony land and stony loam as the prevailing soils. In the clearings over this upland the loam and a heavy phase of the sandy loam are farmed with low yields.

Land values range from \$1 to \$10 an acre.

Along the Delaware River a belt of Volusia soils from 1 to 3 miles wide, underlain by the Chemung-Portage formation, is farmed to a considerable extent. The topography here is rolling to hilly, and the loam and silt loam are the most extensive types. Corn, oats, grass, buckwheat, and potatoes are grown, with low yields. Corn produces 30 to 50 bushels, oats 15 to 25 bushels, and grass one-half to 1 ton per acre. Land values in this region range from \$5 to \$20 an acre. Farm houses are all in good condition.

LACKAWANNA SOILS.

The Lackawanna series includes those soils having pinkish-red to dark Indian-red surface soils and reddish-brown to dark-red subsoils, derived from the feeble glaciation of red shales and sandstones. The series occurs in every county in the area except Clinton, but only in Tioga, Bradford, Sullivan, Wyoming, and Wayne Counties is it widely enough developed to be important in agriculture.

The Lackawanna series occupies about the same topographic position as the Volusia, being developed over steeply rolling to hilly country, with some mountainous areas in Tioga and Wayne Counties. The soils are made up of a mixture of glacial till and residual material from the underlying rocks. Both the till and residual material are so largely derived from red shales and sandstones that the red color predominates. In the more extensive areas the color is generally dark red, and the greater part of the soil is composed of glacial material, but in many of the small, isolated spots of Lackawanna soil the material is largely residual, with an admixture of small quantities of glacial material. The soils are locally known as "red shell" land.

The soils of the Lackawanna series, like those of the Volusia, are derived from ice-laid material with or without admixture of residual material. There are, however, probably small areas of water-laid material which have not been differentiated from the rest. The larger part of the glaciated portion of this area is underlain by the Catskill formation, made up largely of red sandstones and shales, and on the steep slopes and hillsides, in areas mapped as Volusia, there are many places where narrow strips of red soils are found, formed by the intermingling of the outcropping soft red shale layers with the glacial till. On a large scale map these could be shown as Lackawanna soils, but on the scale used they could rarely be shown.

On the hilltops where the red shales outcrop erosion has removed much of the soil material, leaving a mass of red shaly soil, with some glacial débris, to form areas of red soils that might be classed either as Lackawanna, on the basis of their having been glaciated, or as Upshur, because of the large quantity of residual material present. These areas were all shown as Lackawanna, as all those of sufficient extent to be shown on a map of the scale used were sufficiently glaciated to warrant including them in that series.

As a whole the Lackawanna series is much better drained than the Volusia series, though in the clay loam and silt loam soils there are some areas which are in need of artificial drainage. Some of the lighter types are excessively drained, and all except the heaviest soils

are subject to rather severe erosion. The hilltops and slopes described suffer severely from erosion, the soil being thin and stony, with bedrock close to the surface.

Seven types were recognized over the area surveyed.

The surface soil of the Lackawanna clay loam consists of 6 to 8 inches of a reddish-brown to dark-red heavy silty clay loam. The subsoil is a dark-red heavy silty clay to clay.

The Lackawanna silt loam consists of 8 to 10 inches of a pinkish-red to dark-red silt loam, underlain by a subsoil of heavy red silt loam to silty clay loam.

The soil mass of the Lackawanna stony silt loam is very similar to that of the silt loam. It differs from the latter mainly in the presence of from 40 to 60 per cent of flat, somewhat worn stone fragments.

The surface soil of the Lackawanna loam consists of a pinkish-red to red, somewhat sandy loam, 6 to 8 inches in depth, resting on a dark-red sandy, heavy loam to clay loam subsoil.

The soil of the Lackawanna shale loam consists of a light-red silty loam, containing from 40 to 70 per cent of small shale fragments, underlain at 6 to 10 inches by a red shaly subsoil which grades into broken shale rock at 10 to 20 inches.

The surface soil of the Lackawanna gravelly loam is a reddish-brown loam, 6 to 8 inches deep, containing a high percentage of rounded gravel and waterworn shale fragments. The subsoil is of very similar character. The type occupies the occasional areas of red morainic deposits and is not extensive.

The Lackawanna rough stony land includes all the areas that are too steep, rough, and stony to be suitable for any use except forestry or, in rare cases, pasture. Large areas of this type are indicated on the map by the usual Rough stony land symbol in the Lackawanna color.

The farm practices and cropping systems on these soils are essentially the same as those of the Volusia series. Dairying is the leading industry, and corn, oats, buckwheat, and grass are the principal crops. Potatoes and fruit are grown to some extent.

Crop rotations and methods of handling the soil are practically the same as those on the Volusia soils, but yields from the Lackawanna soils average somewhat higher. Corn produces from 50 to 75 bushels per acre; oats, 30 to 40 bushels; buckwheat, 20 to 30 bushels; potatoes, 100 to 150 bushels; and hay, three-fourths to 1 ton. The Lackawanna soils are generally considered better potato and grain soils, while the Volusia are better for grass.

Land prices vary greatly, depending on location of the land. In the more remote sections the land is held at from \$10 to \$20 an acre, while well-located farms will bring from \$40 to \$50 an acre. The

soils are deficient in lime and organic matter, and unless these are supplied full crop yields can not be expected. While these deficiencies seem to be the limiting factors in the yields of most crops, on the majority of farms more thorough tillage will materially increase yields. Crops on these soils are subject to drought, and more thorough tillage during the growing season would conserve the moisture and enable crops to develop and yield better.

Tioga County.—In Tioga County the Lackawanna soils occur as a continuous band extending from Tiadaghton northeast past Covington and Sullivan into Bradford County. Scattered areas occur in the central and northeastern townships and a broad belt is found in Liberty and Union Townships, in the southeastern corner of the county. This belt and the northern areas are steeply rolling to hilly, but include some good farming sections. The best area of Lackawanna soil in the county occurs in Liberty Township. Here the topography is rolling, and crop yields are high. Corn produces 75 bushels and oats 50 bushels per acre. Wheat yields 25 bushels, though very little is grown. Lime is used quite generally, being hauled in from Roaring Branch. Land values in these areas range from \$30 to \$60 an acre. Throughout part of the county the land brings from \$15 to \$30 an acre, and crop yields are correspondingly lower. Dairying is the chief farm industry in the county.

Lycoming County.—The Lackawanna soils occur in several scattered areas in Lycoming County. The body of these soils, in Liberty Township, Tioga County, extends into Jackson Township, but in its southern extension is rougher and less productive than in Tioga County. There is an extensive body of these soils in Gamble Township, between Rose Valley and Proctor. Here the loam and silt loam are the leading types. The soils are devoted to the general crops, with fair yields, dairying being the leading industry.

Along the foot of the mountain from Warrensville, east to the county line and extending northeast up the valley of Muncy Creek into Sullivan County, lies a body of rolling to hilly Lackawanna soils, made up mainly of loam, shale loam, silt loam, and stony silt loam. The greater part of this area is cleared and in farms, and in the southern part of Sullivan County it is the only farmed land. Corn, oats, grass, and buckwheat, with some potatoes, are grown, with fairly good yields. Several orchards of good size are located on these soils. Land prices range from \$5 to \$10 an acre for the rougher and more remote farms and from \$25 to \$30 an acre for those more favorably located. There are some excellent farms in this district.

Sullivan County.—In addition to the Lackawanna soils just described as occurring in the Muncy Valley, there is a broad extent of these soils over the larger part of the northern tier of townships

in Sullivan County. This area has a gently rolling to hilly topography. The loam, silt loam, and clay loam types make up the greater part of the area. About 60 per cent of these soils is cleared and in farms, the balance being in forest and pasture. The soils are good, but because of the lack of transportation facilities prices are low, ranging from \$10 to \$40 an acre. Little lime is used, though the soils need it very much, and in general they are deficient in organic matter. Corn yields 40 to 75 bushels, oats 30 bushels, wheat, of which little is grown, 20 bushels, and potatoes 75 to 100 bushels per acre. With better transportation facilities these soils could be developed into a valuable section of the State.

Bradford County.—With the exception of Barclay Mountain, the Lackawanna soils occupy the entire southern part of Bradford County. They also occur in a triangular area between Columbia Cross Roads, East Troy, and Canton. The silt loam, clay loam, gravelly loam, and stony silt loam types predominate, but only the first two are extensively developed. The soils have a rolling to hilly topography, with some mountainous sections in the southwestern townships. They are fairly well drained and produce good yields of staple crops. They give better yields of corn and potatoes than do the corresponding types of the Volusia series, and seem to be better suited to apples and small fruits, probably because of their better natural drainage. Crop yields are good, corn averaging 75 bushels, oats 30 bushels, potatoes 150 bushels, buckwheat 20 bushels, and hay one-half to 1 ton per acre. Land values range from \$20 to \$50 an acre. The soils are all deficient in lime and organic matter. The application of lime causes marked increases in the yields of all crops.

Wyoming County.—The body of Lackawanna soils that occurs in southern Bradford and northern Sullivan Counties extends eastward into Wyoming County as a belt of rolling to hilly, red soils. Loam, silt loam, and clay loam are the prevailing types, with the silt loam best developed. About 60 per cent of the region is farmed, the remainder being rough and in pasture or forest. Soil conditions are much the same as those in the two preceding counties. Interest is being shown in apple culture and some orchards are being set out. Land prices are higher than in Sullivan County, ranging from \$20 to \$50 an acre; the soils near the towns bringing the highest prices.

Wayne County.—The Lackawanna soils occupy a large area in the eastern and central parts of Wayne County, and also occur as a long band along the east flank of the Moosic Mountain, in the western part of the county. In addition to these, there are many small, irregular spots of Lackawanna soils scattered over the county, most of which are too small to be shown on the map. Along the Delaware, in the northern part of the county, is a long, rough, irregular belt of

Lackawanna soils which was too narrow to be mapped. The Moosic Mountain area is all Rough stony land, while the other bodies occupy steeply rolling to hilly topography, with the loam and silt loam as the prominent types. About one-half of the soils are cleared and in farms, the best agricultural section lying in southern Damascus Township. The better types seem to be somewhat more productive than the corresponding Volusia soils. The average yields are not high. Oats average 30 bushels; buckwheat, 25 bushels; potatoes, 100 bushels; and hay, three-fourths to 1 ton per acre. The farmed lands have a value of \$20 to \$40 an acre.

Pike County.—The Lackawanna series is comparatively unimportant in Pike County. There is one large area near Blooming Grove and several smaller, scattered areas. The soils are only partly cleared, and are rather rough and somewhat sandy. There are few farms on these soils.

Lackawanna County.—The Lackawanna soils occur in two rough, stony bands along Moosic Mountain and in a number of small, scattered areas in the northeastern part of the county. Except in Fell Township, these areas are seldom large enough to constitute an entire farm. The shale loam and stony silt loam types are most common. Crop yields are below those of the Volusia soils.

Susquehanna County.—The Lackawanna soils occur in small, scattered areas throughout this county, occupying the tops or flanks of rounded hills and ridges. There are no extensive bodies of these soils, the largest area lying in Auburn Township. The shale loam and silt loam are the leading types, and because of their position the soils are shallow and droughty and suffer from severe erosion. These are considered somewhat better than the Volusia soils for potatoes and corn, but poor for grass and small grains. Crop yields vary greatly and no fair averages could be given. The land could probably be bought for \$12 to \$20 an acre. There are many smaller strips and spots of Lackawanna soils scattered over the county, which, because of their small size, could not be shown on the map.

TERRACE SOILS.

WHEELING SOILS.

The Wheeling series of soils is found on the terraces along the Susquehanna River and its tributaries. The surface soils are brown to yellowish brown in color, and the subsoils are generally of about the same texture as the surface soils, but somewhat lighter in color.

These soils are found only in Clinton and Lycoming Counties and occupy a level or sloping position on the benches. The lower terrace, just above the bottom land, is usually made up of rather heavy soils, silt loam predominating, while the soils on the second and third terraces and, where it occurs, on the fourth terrace, are sandy and gravelly.

In places the soil is a thin layer of water-deposited material, with shales or sandstones lying within 3 or 4 feet of the surface. Usually, however, the soil mass is deep, some cuts showing the water-deposited gravels to extend to depths of 30 to 50 feet. The soil material is composed largely of material brought down the river and deposited during the glacial period, when the volume of water was very much greater than at present. In the southern part of Lycoming County, in Clinton, Brady, and Washington Townships, there is a large body of terrace soils lying in a valley not occupied by any large stream, but which may once have been the valley of the Susquehanna. The soil deposits may have been the result of an ice dam or jam lower down the river, confining the waters in a temporary lake.

The Wheeling soils normally have good drainage, though on the silt loam there are a few wet areas. They are strong soils and give good yields of the staple crops.

The soils vary greatly in texture, but as a whole they are prevalently sandy. Four types are extensively developed—the silt loam, gravelly loam, sandy loam, and fine sandy loam—while some small areas of clay loam and loam occur. A brief description of the important types follows:

The surface soil of the Wheeling silt loam to a depth of 6 to 8 inches consists of a brown, mellow silt loam. The subsoil is a yellowish-brown, sometimes mottled, heavier silt loam, grading into clay loam with depth.

The surface soil of the Wheeling gravelly loam is a yellowish-brown gravelly loam, with silt loam or sandy loam fine material. The subsoil is a yellowish-brown gravelly loam.

The Wheeling sandy loam consists of 6 to 10 inches of a light-brown sandy loam, in places rather silty, resting on a sandy loam subsoil, which becomes somewhat heavier with depth.

The surface soil of the Wheeling fine sandy loam consists of a brown fine sandy loam, 6 to 10 inches in depth, grading into a lighter brown, more compact fine sandy loam subsoil.

Most of the towns along the Susquehanna are located on Wheeling terraces and for this reason land prices vary greatly. The terrace soils, where not affected by city valuations, will bring from \$75 to \$100 an acre. They give good yields of wheat and corn, and are excellent potato soils. Truck and fruit, especially small fruits, do very well on these soils. The upper terraces are somewhat droughty but with thorough tillage and the addition of organic matter this tendency can be largely overcome.

Clinton County.—Only a small area of Wheeling soils occurs in Clinton County, on account of its location with respect to the glacial boundary. All the streams flowing through it drain unglaciated territory. The extreme southeastern corner of the county, however, in-

cludes the west half of the ancient terrace fan of Pine Creek. Since this stream heads within the glaciated area the soils on this fan are correlated with the Wheeling. They are mainly sandy loam and fine sandy loam and are excellent soils.

Lycoming County.—There are two extensive areas of Wheeling soil in Lycoming County. The area along the Susquehanna east of Williamsport has a rolling topography, the terrace having been cut and eroded by the local drainage channels. The soils are generally sandy, and are excellent for farming, especially for corn, wheat, and potatoes. In Clinton, Brady, and Washington Townships the soils occupy rolling areas, cut by local drainage lines, and vary from sandy to silty in texture. In places considerable stone is present. The soils give good results with general farm crops and with fruit. At Antes Fort and Goldenrod Level the soils on the terraces are mainly fine sandy loam, highly productive, and excellent for general or specialized farming. At Jersey Shore the terraces are all within the city or held by real estate dealers and not farmed to any extent.

HOLSTON SOILS.

Holston soils are derived from the weathering of terrace material deposited by streams which drain unglaciated territory. In this area they occur in Clinton County only, along the West Branch of the Susquehanna and its tributaries. The surface soils are brown to yellowish brown in color and rest on subsoils of much the same texture and lighter color. Their agricultural value is about the same as that of the Wheeling soils of corresponding types. The terraces are narrow and the soils vary in value due to the wide variation in type and topography, though the sandy loam and fine sandy loam types predominate. At Beech Creek the soil is heavy and most of it lies within the borough limits. At Lock Haven the terrace lies within the city limits and the larger part of the soil consists of sandy loam and gravelly loam. At McElhattan the terrace has been altered by a fan delta formed by materials brought down by McElhattan Creek and most of the soil is rather poor stony sandy loam.

CHENANGO SOILS.

The Chenango series comprises light-brown to reddish-brown surface soils, with yellowish-brown to brown subsoils. The soils of this series occupy the benches and terraces along the streams in the glaciated region. They usually occur as level or gently sloping terraces, though in places subsequent erosion has reduced the terraces to a series of rounded and sloping shoulders and benches. The soils are made up of sands, silts, and gravels carried by the streams and deposited when the water levels were much higher than at present.

Much of the material is of glacial origin, but on some of the terraces along the smaller streams the soil material is largely derived from local rocks.

The soils are normally well drained and usually are not subject to erosion. The lighter types are excessively drained, often having gravelly subsoils, and during droughts crops on all these would suffer severely from lack of moisture.

The Chenango and Genesee are the most productive soils in the glaciated region.

Five types were encountered, the loam, silt loam, gravelly loam, fine sandy loam, and sandy loam.

The surface soil of the Chenango loam consists of a mellow, rather silty yellowish-brown or reddish-brown loam, underlain at 6 to 10 inches by a lighter-colored subsoil, which grows heavier with depth.

The Chenango silt loam consists of 6 to 8 inches of a light-brown to yellowish-brown or reddish-brown soft silt loam, resting on a subsoil of a brown or yellowish-brown color, and varying from a rather sandy silt loam to a heavy silt loam.

The Chenango gravelly loam is a light-brown to brown sandy loam, resting at a depth of 6 to 10 inches on a yellowish-brown to light-brown sandy loam subsoil. The soil and subsoil contain 20 to 60 per cent of rounded gravel of varying sizes. The gravel content frequently increases with depth.

The surface soil of the Chenango fine sandy loam is a light-brown fine sandy loam from 8 to 10 inches deep. The subsoil is light brown and of similar texture.

The soil of the Chenango sandy loam to a depth of 6 to 12 inches consists of a light-brown sandy loam. This is underlain by a reddish-brown or yellowish-brown sandy loam subsoil. Some gravel is usually present in both soil and subsoil.

The Chenango series is well adapted to corn, potatoes, and fruit, and gives good yields of grain and grass crops. The standard crop rotations are followed and good results are obtained. The soils are well adapted to truck crops and considerable trucking and gardening are carried on near the cities. Fruit trees are being set out on the upper terraces, and several large orchards were seen. The bearing orchards on this series are doing very well.

The soils vary much in price, those best located bringing \$75 to \$100 an acre, while other land, more distant from market, may be bought for \$35 to \$50. Most of the cities and larger towns are situated on the Chenango terraces, usually at the junction of two streams, where the development of this series is most extensive, and some of the best of the soils are thus rendered unavailable for agricultural purposes.

Tioga County.—The Chenango soils in Tioga County are most extensively developed along the Cowanesque Valley, Tioga River, and Pine Creek west of Ansonia. The soils in the Cowanesque Valley are well handled, and give good yields of potatoes, truck, grass, and grain. The greater part of the Chenango soils are farmed, though some are in permanent pasture or timber. Land values range from \$15 to \$60 an acre, but where well located the sandy loam type is held at \$45 to \$60. The sandy loam and gravelly loam are the prevailing types in the county.

Bradford County.—The most extensive development of the series in Bradford County is along the Susquehanna River, although there are some areas along the smaller streams and one large area near Canton. The soils occupy high terraces, the silt loam, fine sandy loam, and gravelly loam types being present. They are productive, and are considered, with the Genesee, the best lands in the county. Corn, oats, wheat, grass, rye, potatoes, and tobacco are produced, with good yields. A great deal of buckwheat and some cabbage are grown.

Land values range from \$40 to \$100 an acre, depending on soil, location, and improvements.

Sullivan County.—There is only one area of the Chenango soils in Sullivan County, practically all of which lies within the limits of Forksville Borough.

Susquehanna County.—The only extensive areas of the Chenango series in this county lie along the Susquehanna River and Starrucca Creek. The terraces along the latter stream are mostly gravelly and are not as productive as the normal Chenango soils. They are largely in grass and pasture. The best terraces along the Susquehanna River are occupied by towns and are not available for agriculture. The sandy loam is the most extensive type, and where farmed this soil gives good yields.

The land values range from \$20 to \$50 and upward an acre, depending on location and improvements. Good yields of the staple crops and of potatoes and truck are obtained. The soils here are normally low in organic matter and are droughty.

Pike County.—The Chenango soils are found along the Delaware River in Pike County. The sandy loam and gravelly loam types are encountered, the former being the most extensive and most productive. The series is wholly in farms and gives good yields of corn, wheat, potatoes, and truck. Land values range from \$25 to \$50 an acre. Farm improvements are usually good. Some good dairy farms are located on these soils.

Wayne County.—In Wayne County the Chenango soils are found as narrow bands along the Delaware River and Dyberry and Lacka-

waxen Creeks. The areas are all small and the types generally sandy and gravelly. The soils are relatively unimportant.

Lackawanna County.—In Lackawanna County these soils lie almost wholly along the Lackawanna River as high, eroded terraces, cut through by the tributary streams. They occur as level table lands, irregular benches, or as knolls of sands and gravel, and are not important agriculturally, being almost entirely occupied by the cities and mining towns of the valley.

Wyoming County.—The Chenango soils in this county are developed mainly along the Susquehanna River as level or sloping benches or as rounded knolls that have been cut and eroded by subsequent drainage lines. They vary in texture, but are generally sandy. Where well farmed, good yields of the staple crops are obtained, potatoes doing exceptionally well. These soils are well adapted to fruit growing, and extensive plantings are being made. Bearing orchards on the terraces, where well kept, are giving excellent returns.

The soils vary from \$30 to \$100 an acre in value, depending on location and soil condition. They are naturally well drained and have a tendency to be droughty. They are low in organic-matter content.

BOTTOM-LAND SOILS.

HUNTINGTON SOILS.

The surface soils of the Huntington series are brown or yellowish brown, with subsoils of lighter color and generally growing heavier in texture with increasing depth. The soil mass consists of the reworked and stream-deposited material derived from the sandstones and shales of the Dekalb region. The soils occupy the first bottom and overflow lands along the streams in the residual portion of the area. The series is developed along the Susquehanna River and its larger tributaries in Clinton and Lycoming Counties, occupying a level or gently sloping position. Along the larger streams the soils are normally well drained, while those along the smaller streams and adjoining the upland along the Susquehanna are frequently wet and in need of drainage. These soils are subject to overflow, and areas along the swifter streams suffer from erosion when flooded. In some places stream channels have been cut, and in others silt and sand have been deposited. The damage from erosion is sometimes great. On the other hand, the fields are often benefited by the deposits of silt and other material.

Four types were recognized in the area—clay loam, silt loam, fine sandy loam, and fine sand—of which the fine sandy loam is most extensive.

The surface soil of the Huntington clay loam is 6 to 8 inches deep, and consists of a dark-brown, drab, or grayish-brown heavy silty loam. This is underlain by a mottled, silty clay subsoil. The type is poorly drained.

The Huntington silt loam is a yellowish-brown to brown silt loam, 8 to 12 inches deep, resting on a brownish, heavier silt loam, sometimes growing lighter in color with increasing depth.

The soil of the Huntington fine sandy loam is a soft, mellow, brown fine sandy loam, grading imperceptibly at 8 to 10 inches into a lighter colored sandy loam, which becomes somewhat heavier with depth.

The surface soil of the Huntington fine sand consists of 6 to 10 inches of a light-brown loamy fine sand, and is underlain by a yellowish-brown, light, stratified fine sand subsoil.

The Huntington soils are exceptionally fertile and are among the most valuable soils in the area. They are devoted to the standard crops of the region, corn, oats, wheat, and grass, and also to potatoes, truck, and tobacco. Yields are uniformly good over most of the series. Corn yields from 75 to 100 bushels per acre; wheat, 20 to 30 bushels; oats, 25 to 50 bushels; hay, $1\frac{1}{2}$ to 2 tons; tobacco, 1,000 to 2,000 pounds, depending on the grade grown; and potatoes, from 150 to 200 bushels. Practically all of the farming land is well situated for truck gardening, being near to markets and transportation lines. Considerable cabbage, tomatoes, and other truck crops are grown, with good returns. Alfalfa seems to do well where the water does not stand on the land for any length of time. Three cuttings are normally obtained, yielding 4 to 5 tons per season.

Land values are high. Near the towns the land is held at \$200 to \$300 an acre, and from that values grade down to a normal of about \$100 to \$150 an acre for good soils almost anywhere along the Susquehanna. Along the smaller streams, where the soils are generally less productive, prices range from \$60 to \$100 an acre.

Although the land is subject to floods, the houses and barns are located on the bottoms, the inhabitants moving to the upper stories in times of flood. Since the cellars on the bottom lands can not be used for storage on account of flood waters, each farm usually has a "cave" or cellar for this purpose located on the hill slopes along the edge of the upland. When particularly severe the floods do considerable damage to fences and buildings. This is especially true along the Susquehanna. Many of the farmsteads are located on the small sandy ridges occurring here and there over the bottom lands.

Clinton County.—In Clinton County the Huntington soils are developed mainly along Bald Eagle Creek and the Susquehanna River. Along the river the fine sandy loam and silt loam are the

most extensive types and the land is very productive. Most of the tobacco produced in the area is grown just east of Lock Haven, on the fine sandy loam and the silt loam. The soils are badly infested with weeds, the seeds of which are brought in by the flood waters, but crops yields are high. Along Bald Eagle Creek the soils are heavier, the clay loam and a wet, heavy phase of the silt loam being the prevailing types. The soils need drainage. They are best adapted to grass and grain and are largely used for pasturage and hay. The soils along Fishing Creek are normally wet and heavy, though there are some good fields on the better-drained areas.

Lycoming County.—In Lycoming County the series is most extensively developed along the Susquehanna River. The fine sandy loam predominates, with the silt loam next in importance. General farming, with some trucking, is practiced, and excellent returns are obtained. The narrow belt of land below Williamsport, lying between the old canal and the river, is largely fine sand and is not extensively farmed.

Along the Muncy Creek the soils are good where well drained, but there are some large areas of wet soils that are suited only to pasture and grass production. Along the Little Muncy Creek most of the land can be used only for pasture and small grains, while in Washington Township, near Elimsport, the soils must be drained to be farmed to the standard crops. They are now best adapted to grass and pasture.

GENESEE SOILS.

The Genesee series comprises the first bottom and overflow lands in the glaciated regions, having brown to dark-brown surface soils, with subsoils of slightly lighter color. The soils have a flat or level topography and, being made up of "recent" alluvium, their formation is still in progress. The series occurs throughout the glacial region, along all the streams which have developed bottom lands along their valleys, and these areas are indicated where sufficiently wide to be shown on a map of the scale used. The Genesee soils are found in every county except Clinton, though the total area of these soils is not large.

Since they occupy the low first bottoms, the Genesee soils are generally not well drained, and artificial drainage, especially of the heavier members, is necessary in order to get satisfactory returns. Along the swifter streams the flood waters occasionally damage soils by erosion, resulting in the removal of the fine material, or by deposits of silt and sand on the surface. The Genesee soils along practically all of the smaller streams are usually wet, because of seepage and the presence of spring waters, and are adapted only to pasturage or to grass. Along such streams the silt loam and silty clay loam are the prevailing types.

The series embraces a wide range of textural variations, ranging from sands to clays, but only three types were found to be developed to any great extent. Their description follows:

The Genesee sandy loam is a yellowish-brown to dark-brown rather fine sandy loam, grading at 8 to 12 inches into a somewhat coarser sandy loam of lighter brown color.

The Genesee silt loam consists of 8 to 12 inches of a dark-brown friable silt loam, grading into a brown or light-brown heavy silt loam.

The surface soil of the Genesee silty clay loam is a grayish-drab to light grayish-brown silty clay loam, from 4 to 8 inches in depth, resting on a gray, drab, or mottled silty clay loam to silty clay subsoil.

The soils, with the exception of the silty clay loam, are mellow and easily worked, and where well drained they produce good yields of the staple crops. The silty clay loam is adapted mainly to pasture and grass crops. The sand and silt loam, where well located, are valued at \$50 to \$100 an acre and are in demand. Corn yields from 75 to 110 bushels, oats 40 to 60 bushels, wheat 20 to 30 bushels, hay $1\frac{1}{2}$ to 2 tons, and potatoes from 100 to 250 bushels per acre.

Tioga County.—The most extensive development of the Genesee soils in Tioga County is along the Cowanesque and Tioga Rivers, though there are some large areas along Crooked and Marsh Creeks. The sandy loam and silt loam are the prevailing types and are extensively farmed. With the exception of a few wet areas, all the bottoms are cultivated. Along the Cowanesque considerable tobacco is grown, a rotation of corn, tobacco, wheat, and grass being practiced. Excellent crop yields are obtained, corn producing 75 to 100 bushels and wheat 20 to 30 bushels per acre. The best of these soils are valued at \$50 to \$100 an acre. The more poorly drained areas are held at much lower figures.

Bradford County.—The principal areas of Genesee soils in this county occur along the Susquehanna River, with narrow Genesee bottoms along many of the smaller streams. The silt loam and sandy loam are the prevailing types, the former being most extensive. Practically all the land along the river is farmed, though along the smaller streams much of it is wet and adapted only to grass and pasture. Near Athens, Sayre, and Towanda the land is valued at \$75 to \$100 an acre, while at a greater distance from markets it ranges from \$50 to \$75 an acre for the well-drained lands and much lower for the narrow bottoms along the smaller streams.

On the well-drained and well-farmed areas corn yields 75 to 125 bushels, oats 40 to 60 bushels, wheat 20 to 30 bushels, and hay $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. These soils are also well adapted to truck and garden crops.

Lycoming County.—In Lycoming County this series occurs only along Lycoming Creek as narrow, channel-cut, rather stony bottom land of little value.

Sullivan County.—In Sullivan County it occurs along both the East and West Branches of Fishing Creek. The soils are stony, cut by flood channels, and of little value except for rough pasture.

Susquehanna County.—In Susquehanna County there are few extensive areas of the Genesee soils. The series usually occurs as narrow wet bottom lands, valuable only as pasture or grass lands. Along the Susquehanna River near Great Bend and north from Lanesboro to the State line are some good areas of sandy loam and silt loam. These are well farmed and give high yields of the staple crops. The soils vary as to drainage, but in the areas mentioned are fairly well drained. Values for the well-drained land near towns range from \$75 to \$100 an acre, while the bottoms along some of the streams, when included in farms extending over the uplands, will bring from \$15 to \$35. The entire series is in need of artificial drainage.

Pike County.—The only important development of the Genesee soils in Pike County is along the Delaware River, where they, with the Chenango soils, form the most valuable soils in the county. The sandy loam is the prevailing type, and where well drained this soil gives excellent returns. Corn yields 75 to 100 bushels, oats 30 to 50 bushels, potatoes 75 to 150 bushels, and hay 1½ to 2 tons per acre. Some trucking is practiced near the larger towns and summer hotels with good results. Commercial fertilizers, lime, and manure are being used in large quantities to the great benefit of the soil. Land values range from \$25 to \$75 an acre, depending largely on location and improvements.

Wayne County.—The Genesee soils are not important in Wayne County. They occur only as narrow bands along the streams and are devoted largely to grass and pasture. Along the Wallenpaupack Creek, south of Hawley, in both Wayne and Pike Counties, there is a large area of Genesee soils.

Lackawanna and Wyoming Counties.—Small areas of Genesee soils occur in these counties, along the Susquehanna and Lackawanna Rivers and their tributaries, where they are subject to periodical overflow. Near the towns these soils are devoted to some extent to trucking and gardening with good results. Usually they are farmed to the general crops of the region, while the wet areas are left in grass or pasture. They constitute valuable parts of the farms in which they occur, but are not extensive enough to be of relative importance among the soils of the counties.

MOSHANNON SOILS.

The Moshannon series includes dark Indian-red soils, with dark-red subsoils, derived from the reworking of material from the Upshur soils. They occupy the narrow bottom lands along streams that flow through or from Upshur regions and are generally subject to overflow. The most extensive developments occur in Lycoming County, though some Moshannon soil is found in Clinton County.

Three types were found, the fine sandy loam, loam, and silt loam.

The surface soil of the Moshannon fine sandy loam consists of 8 to 10 inches of a yellowish-red to dark Indian-red fine sandy loam, overlying a red to dark-red fine sandy loam which becomes heavier with depth.

The Moshannon loam consists of a brown or Indian-red fine loam to a depth of 6 to 10 inches, resting on a dark-red, silty clay loam subsoil.

The surface soil of the Moshannon silt loam is a dark Indian-red, rather heavy silt loam from 8 to 10 inches deep. The subsoil is an Indian-red silty clay loam, growing heavier with depth.

The soils are very productive and where farmed give high yields of the staple crops. Corn, oats, wheat, and grass are the crops most extensively grown. The better located areas are devoted to truck and garden crops. Some tobacco is also grown on these soils.

As few farms lie exclusively on the Moshannon soils, it is hard to give an estimate of crop yields and values, but in the remote sections \$30 to \$60 an acre and in the better located regions \$60 to \$100 an acre seem to be the general valuations.

The soils are normally subject to annual spring overflows, but since the forests have been removed from the headwaters of most of the streams overflows occasionally occur during the growing season, often ruining the crops.

Clinton County.—There are two areas of the Moshannon soils in Clinton County, one along Kettle Creek, near Hammersley Fork in Leidy Township, the other on Pine Creek, in Pine Creek Township. Neither is at all extensive or important.

Lycoming County.—In Lycoming County the series is developed along several of the larger creeks, the soil condition varying with the character of the stream valley and stream flow.

The soils are most extensive along Pine Creek. The area at Cammal is narrow, and but little of it is farmed. The long, narrow bottoms between Ramsey Station and Jersey Shore are farmed over more than half their area. The sandy loam is the dominant type, though the loam is quite extensively developed. Near Jersey Shore these soils are very productive and of high value.

The bottoms along Little Pine Creek were formerly very productive, but the disastrous flood of 1889 washed away soil, buildings, and even orchards, and most of the bottoms are now rough and stony, with occasional narrow strips and patches of good sandy loam.

The bottoms along Larry Creek, below Salladasburg, are generally productive, consisting largely of loam and sandy loam, with some poorly drained areas of silt loam. Above Salladasburg the bottoms are narrow and of little value.

Along Lycoming and Loyalsock Creeks the bottoms are very productive, though some areas occur which are wet and unfit for agriculture. Along both these creeks the sandy loam type is most extensive, with the silt loam occurring in the wet areas. The soils near Williamsport are used for truck and garden crops, excellent results being obtained.

The bottoms along Carpenter Creek and Hoagland Run are narrow, wet, and of little value except for pasture.

The Moshannon series as a whole is in excellent physical condition, but the silt loam often needs draining, and where any of the types have been farmed for a long time the use of lime and manure increases crop yields.

BARBOUR SOILS.

The Barbour series includes those soils having red, yellowish-red or pinkish surface soils and light-red to Indian-red subsoils and occupying the first bottoms and overflow lands along the streams that flow through or from an area of Lackawanna soils. The series occupies the same position among the bottom soils of the glaciated regions that the Moshannon soils occupy in the residual regions. The soils are not extensively developed in this area, and, occurring as long, narrow strips along the stream courses, are not of great importance from an agricultural viewpoint.

The Barbour soils are encountered in Lycoming, Bradford, Sullivan, Wayne, and Pike Counties. Their greatest development lies along Loyalsock Creek, in Sullivan and Lycoming Counties, though there is a considerable strip along Muncy Creek, in the same counties, and along Lackawaxen Creek, in Wayne County.

The soils are subject to overflow and are dissected by old stream channels, some of which are wet and marshy. Drainage is generally good, though the narrow bottoms along the smaller streams are in many places saturated by seepage waters from the higher lands.

Only two types were extensively developed, though small areas of other types occur.

The Barbour fine sandy loam consists of 6 to 8 inches of a red, yellowish-red or salmon-pink fine sandy loam, resting on a light-red to dark-red fine sandy loam subsoil.

The surface soil of the Barbour silt loam is a pinkish-red to dark-red mellow silt loam extending to a depth of 6 to 8 inches, where it is underlain by a dark-red or Indian-red silty clay loam subsoil, which becomes heavier with increasing depth.

The soils are well adapted to the general farm crops and give good yields of corn, oats, wheat, buckwheat, potatoes, and grass. Only a few farms are located exclusively on this series, except along the Loyalsock. Such farms are small and distant from markets. Land values range from \$15 to \$35 an acre, depending largely on location. The sandy loam is the most desirable type.

MUCK AND SWAMP.

Small bodies of swampy land occur throughout the glaciated area, some of which include accumulations of muck of considerable depth. Most of these have been formed where the glacial deposits have obstructed drainage lines, forming wet, swampy areas, though some are the result of the filling of old lake beds by the accumulation of organic matter. Most of these areas are too small to be indicated on a map of the scale used, and many are too small to be shown even on the "mile to the inch" scale of the detailed surveys.

Few of the areas have been cleared and drained, though where the muck deposit is over 18 inches thick they prove excellent soils for celery, cabbage, onions, and such crops.

Between Marsh Creek and Stokesdale Junction, in Tioga County, extensive areas of Muck have been drained and celery growing has developed into an important industry. Some areas along the Northern Central Railway, in Bradford County, and a few areas in Wayne County are also drained and devoted to celery culture, with excellent results. The total area of Muck and Swamp lands in the survey is very small and land values vary. Near Stokesdale the Muck, where drained and in good condition for farming, is valued at \$150 to \$200 an acre.

SUMMARY.

Ten counties of northeastern Pennsylvania, with a total area of 7,848 square miles or 5,022,720 acres, were surveyed.

The area occupies an elevated plateau, and, with the exception of the two southwestern counties, the entire region has been glaciated.

Thirteen series of soils were mapped, five being upland soils and eight terrace or bottom soils.

The upland residual soils comprise three series—the Dekalb, Upshur, and Hagerstown.

The Dekalb soils are derived from the weathering of sandstones and shales. Most of these soils are rough and stony and are in forests or pastures. The surface soil is generally gray to brown

in color, with light-yellow, yellowish-brown, or mottled subsoils. The Dekalb soils in this area are the most extensively developed of the residual types.

The Upshur series is derived from the red sandstones and shales of the Catskill formation. The surface soil ranges from yellowish to brown, but is typically Indian red. The subsoils are dark red. The series as a whole suffers from severe erosion. The soils are shallow, but are fairly productive.

The Hagerstown soils are derived from limestones and are the most productive in the area. The surface soils are yellow and reddish yellow, with yellowish-red or red subsoils.

The upland glacial soils include the Volusia and Lackawanna series.

The Volusia is the most extensive series in the area. The soils are derived from the glaciation of sandstone and shale rock. The surface soils are grayish brown or grayish yellow, and the subsoils yellow, grayish yellow, gray, or mottled. Crop production is subordinate to and is planned to support the dairying industry, and crop yields vary widely.

The Lackawanna soils are derived from red shales and sandstones. They are pinkish red to dark Indian-red in the surface section, with reddish-brown to dark-red subsoils. The crop practices and adaptations correspond with those of the Volusia soils. Dairying is the principal industry.

The terrace soils include the Wheeling, Holston, and Chenango series.

The Wheeling soils are brown to yellowish brown, with lighter colored subsoils. They produce good yields of the staple crops.

The Holston soils are essentially similar to the Wheeling.

The Chenango soils are largely of glacial origin. The surface soils are light brown to reddish brown, and the subsoils yellowish brown to brown. These, with the Genesee series, constitute the most productive soils in the glaciated part of the area.

The bottom-land soils comprise the Huntington, Genesee, Moshannon, and Barbour series.

The Huntington soils are brown or yellowish brown, with lighter colored subsoils. The series is subject to overflow and consequent erosion. The soils are exceptionally fertile and produce good yields of the standard crops. They are excellent trucking soils, and land values are high.

The Genesee series includes brown to dark-brown soils, underlain by subsoils of slightly lighter color. The soils occupy the low first bottoms. Where well drained good crop yields are obtained.

The Moshannon series comprises types with dark Indian-red soils, underlain by dark-red subsoils. The soils are productive, but are subject to overflow.

The Barbour soils are red, yellowish red, or pinkish, with light-red to Indian-red subsoils. They are inextensive and of little agricultural importance.

Small areas of Swamp occur throughout the glaciated region, many of which are too small to map. They contain deep accumulations of Muck, which when drained is valuable for the production of such truck crops as celery, cabbage, and onions.

All of the upland and terrace soils in the area are deficient in organic matter and lime.

Dairying is the principal agricultural industry.

The most important crops are hay, corn for ensilage and grain, buckwheat, and oats.

Throughout the area agriculture can be greatly improved by the introduction of better rotations and more systematic management generally.

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