

EROSION SURVEY No. 15

# *Erosion* and RELATED LAND USE CONDITIONS

*in the*  
**Conestoga Area**  
*Pennsylvania*

by JAY A. BONSTEEL

Soil Scientist

and TURNER C. BASS

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Physical Surveys Division, Soil Conservation Service

UNITED STATES DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE • WASHINGTON • 1940

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Field Survey by T. C. Bass and Party

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SOIL CONSERVATION SERVICE • WASHINGTON, D. C.

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## Introduction

SOIL EROSION threatens the permanence of prosperous farming, even in the fertile valleys of southeastern Pennsylvania. These farms have produced good yields of crops for more than 200 years, and most of them are in a high state of productivity today. Here and there, however, are evidences of soil erosion. Increasing use of fertilizer without any general increase in average crop yields; sloping fields that show spots of exposed reddish or yellow subsoil, where the corn crop fails in dry weather; new accumulations of fertile soil along fences, in small drainageways, and on bottom lands; and, perhaps most of all, the increasing amount of soil that must be removed from river water before it can be pumped to consumers in cities like Lancaster—all these point to a more or less neglected but persistent progress of soil erosion.

The drainage basin of Conestoga Creek and the surrounding territory has been prominent in the agricultural and industrial history of the United States since early colonial days. Even before the coming of the white man it was occupied by a powerful tribe of Iroquoian stock, the Conestogas or Susquehannocks, whose English designation was given to the Susquehanna River. Later they fell into conflict with the English in Maryland and Virginia and were subdued by the Iroquois Confederation to the north and almost completely absorbed into the Five Nations. About the end of the seventeenth century some of them had returned to their old territory, and their chiefs took part in the treaty negotiations with William Penn, through which the proprietor of the Penn grant secured honorable title from the Indians to all the lands within the limits of his grant from the British Government.

The Conestogas were the chief native occupants of the area when the Mennonite immigrants from Switzerland and the Rhine Palatinate purchased about 6,000 acres of land from Penn and made the first permanent white settlement in Lancaster County in the vicinity of West Willow and Strasburg in 1710. Later the "Great Conestoga

Road" was laid through this tract, connecting Philadelphia with the Susquehanna River and the country to the west and southwest. Along it flowed the traffic of peace and war, over it rolled the Conestoga wagons, carrying farm products to the seaboard and providing transportation for settlers who continuously pushed the American frontier a little farther to the west.

In many ways the early settlers of the area contributed to the welfare of the new country. The early deeds to land included provision for the ownership, distribution, and use of water for flooding meadows and growing grass. Water power was developed for grist mills and sawmills. Iron furnaces and forges came later. New seeds and new crops were brought over from the Rhineland to add to the scanty list of staples grown in the New World. The early use of grass and clover for the seeding of upland meadows made possible the adoption of crop-rotation farming, which was a great improvement over the older system of crop and fallow or "infield and outfield" tillage so prevalent in other localities.

Livestock production was closely coupled with grain and grass farming. A distinct type of draft horse, the heavy Conestoga horse needed to draw the heavy Conestoga wagons over frontier roads, was bred up in the area. Substantial barns and outbuildings made possible the proper feeding and care of livestock and the accumulation of stable manure for use on the tilled fields.

A new chapter in agricultural enterprise and forethought is now being written through the establishment of a demonstration project and a camp work area of the Soil Conservation Service of the Department of Agriculture and through the formation of a voluntary soil conservation district that has been organized under the laws of Pennsylvania and is controlled and operated by the farmers themselves. Because the history of the area is so well known and the stages of its development and growth can be substantiated with such certainty, it has special interest for those concerned with former and present-day developments in Ameri-

can agriculture. The area has been, for more than two centuries, a proving ground and center of dispersion for progressive farming practices. This led to its selection for a detailed soil conservation survey.

Soil erosion was recognized by agricultural leaders in the State many years ago. In order to combat it, a program of research and action was formulated in 1934. A number of experiments were established at State College by the Soil Conservation Service in cooperation with the school of agriculture and experiment station of the Pennsylvania State College. This work has been continued as a research project.

A project for demonstration of erosion control and good land use on individual farms was established near Indiana, in the western part of the State, early in 1935. Later that year similar projects were established in the southern part of Lancaster County, in Franklin County near Waynesboro, and in Westmoreland County near Vandergrift. Another project was established near Kutztown in Berks County in 1937. All these projects were selected to demonstrate soil conservation in representative agricultural and soil areas in the State. Camps of the Civilian Conservation Corps, attached to the projects for administrative purposes but in many instances located some distance away, conduct similar demonstrations and thereby extend the work beyond the limits of the projects.

More recently, the organization of local, self-governed soil conservation districts has been going forward under a State law passed in 1937. These districts when organized and placed in operation are authorized to call upon the Soil Conservation Service and other branches of the Federal Government; upon the State college, Extension Service, Department of Forests and Waters; and on other local, State, or national organizations that can offer assistance in agricultural or conservation work. Four legally constituted soil conservation districts in Pennsylvania have been organized and are cooperating actively with the Department of Agri-

culture (October 1939). One of them covers part of the Conestoga area.

The demonstration project in Lancaster County includes all land draining into the West Branch of Octoraro Creek, an area of 30,635 acres, lying east and southeast of Quarryville. The attached Civilian Conservation Corps camp, located at Lancaster, covers as a work area a large part of the Conestoga and Pequea watersheds, now within the soil conservation district. As a result, 86 farms within the limits of the area covered by this report are already serving to demonstrate soil conservation methods under a wide variety of soil and slope conditions. Examples of the many different practices that are necessary to control erosion may be seen on these different farms.

This publication contains a description of the area and its agriculture, and discussions of the survey and of the significance of physical factors in planning land use and control of erosion. Maps of the entire survey have been prepared on a scale of 4 inches equals 1 mile; that is, 1 inch on the map equals 1,320 feet on the ground. The map of the entire survey is reproduced in 77 sheets. Each report contains an index map and a sample sheet in the envelope that is attached to the back cover. Complete sets of the maps have not been distributed widely but may be consulted in libraries and in the offices of the Soil Conservation Service.

## Description of the Area

THE AREA surveyed includes all the territory drained by Conestoga and Pequea Creeks and their tributaries (fig. 1), about 632 square miles. Both empty into the Susquehanna River in west-central Lancaster County in southeastern Pennsylvania, and their mouths are separated by a distance of less than 3 miles. From this locality the watersheds spread fanwise through central and northeastern Lancaster County to headwaters originating in southern Lebanon and southwestern Berks Counties, with some slight drainage from extreme northwestern Chester County. The total area of the two watersheds is 404,672 acres.

Data compiled from the United States census of 1930 indicate that approximately 133,300 people live within the area, a population of 211 persons per square mile, which makes it one of the most densely populated localities

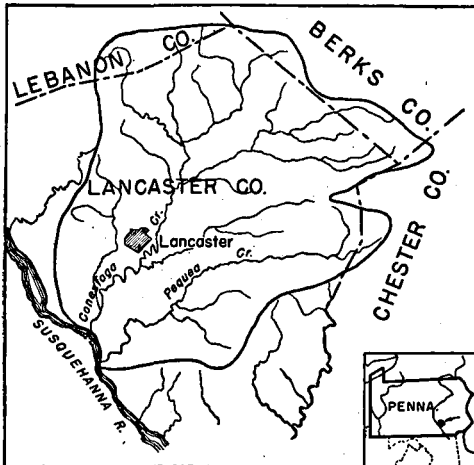


Figure 1.—Map showing location of Conestoga and Pequea watersheds, Pa.

in Pennsylvania outside of the strictly metropolitan areas. The rural population is approximately 64,000, or about 105 per square mile of rural area. Lancaster, the largest city, had a population of 59,949 in 1930.

### Topography

Conestoga and Pequea Creeks empty into the Susquehanna River at altitudes slightly less than 180 feet above sea level. The lower course of the Conestoga is deeply cut below the upland plain that rises from 200 to 300 feet above its bed. The highlands south of Pequea Creek attain an altitude of 700 feet on Mount Nebo. The southern divide of the area extends almost due east from this vicinity to a point southeast of Quarryville, thence northwest to the crest of Mine Ridge, where it has an elevation of about 800 feet, and eastward along that ridge past Gap across the western boundary of Chester County. It crosses and recrosses the boundary line between Lancaster and Chester Counties. Welsh Mountain projects into the eastern

side of the area, separating the limestone plain into two prongs.

The northern boundary closely follows the crest of South Mountain along the boundary between Lancaster and Lebanon Counties, but the northern tributaries of Cocalico Creek have their heads in the Lebanon Valley and flow southward through gaps in the ridge.

The western boundary of the area leaves the South Mountain ridge in the northern part of Penn Township and extends irregularly southward between Manheim and Lititz, swinging west of Landisville and Rohrerstown and thence sharply southwest to the mouth of Conestoga Creek near Safe Harbor.

The highest altitudes are along the eastern border in Welsh Mountain, where there are elevations in excess of 1,100 feet above sea level, and in the South Mountain ridge near Cornwall, with an elevation of 1,173 feet.

Numerous low ridges and hills rise above the undulating surface of the Lancaster plain, and a ridge, extending from the vicinity of Manheim past Ephrata, joins the higher lands to the east, separating the plain into two roughly parallel valleys.

Within the plains areas the elevations range from about 350 to 450 feet above sea level except where low ridges and hills rise above the 500-foot contour line. Below this gently rolling surface the major streams have cut their beds to depths ranging from 50 to 200 feet, the latter depths being reached only by Conestoga and Pequea Creeks near their mouths.

The surface is rough only along these deep-cut streamways and along the slopes of the mountain masses, chiefly to the east and north of the main body of the area.

### Drainage

Surface drainage of the land is well established, through Conestoga and Pequea Creeks and their many tributaries. Little Conestoga Creek drains the western part of the area. The Cocalico drains the north-central part, and its tributary, Hammer Creek, rising in Lebanon County, the north-western part. The southern and south-eastern parts drain into Pequea Creek.

There are also numerous sinkholes within the limestone area, and these carry away some of the surface waters as underground drainage.

In addition to the many small streams of the area, there are numerous springs, and many of them have been protected as a source of water for farm homes and for livestock.

The poorly drained areas of agricultural soil occur chiefly at the base of long slopes where seepage waters saturate the lower lying areas. Some small areas occur at streamheads and along the flood plains of the larger streams. There are no swampy areas of any size.

### Climate

The climate of the Conestoga area is temperate in all its essential elements. It is not subject to long periods of either extreme heat or cold. The winters are seldom severe enough to cause injury to winter grain crops or to fruit trees. The mean annual temperatures of 51.8° F. recorded by the United States Weather Bureau at Lancaster and that of 51.5° recorded at Lebanon are representative of conditions within the area.

The average annual rainfall is 41.86 inches at Ephrata, 40.83 inches at Lancaster, and 43.63 inches at Lebanon. This precipitation is so well distributed throughout the year that crops are

seldom injured either by drought or by excessive moisture. Crops grown on the small areas of excessively drained soils may be seriously affected by short periods of summer drought.

The frost-free season at Lancaster averages 160 days, with killing frosts occurring late in April and early in October. Killing frosts have occurred as late as May 27 and as early as September 11, but this is unusual.

Table 1 presents climatic data for the area compiled from the records of the Weather Bureau for the station at Lancaster.

### Vegetation

The earliest settlers in the area found a heavily forested country. Along stream bottoms there were small, marshy areas that formed natural meadows, and around each Indian settlement were small areas that had been cleared by girdling the trees and burning off the dead timber and the underbrush. There were some small glades or openings on the upland. With these exceptions the land was heavily forested by the numerous species of mixed hardwood trees of the lower altitudes of the Northeastern States. This was especially true of the limestone soils of the Lancaster plain, where a thick growth of oak, ash, elm, hickory, and black walnut all indicated to the early settlers the existence of

TABLE 1.—*Monthly, seasonal, and annual temperature and precipitation at Lancaster, Lancaster County, Pa.*

[Elevation 255 feet]

| Month          | Temperature (35-year record) |                               |                               | Precipitation (47-year record) |                    |                 |                                                  |                               |
|----------------|------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------|-----------------|--------------------------------------------------|-------------------------------|
|                | Mean                         | Absolute maximum <sup>1</sup> | Absolute minimum <sup>1</sup> | Mean                           | Greatest on record | Least on record | Average days with 0.01 inch or more <sup>2</sup> | Average snowfall <sup>3</sup> |
|                | °F.                          | °F.                           | °F.                           | Inches                         | Inches             | Inches          | Number                                           | Inches                        |
| January.....   | 30.3                         | 73                            | -27                           | 3.28                           | 5.92               | 1.57            | 8                                                | 8.6                           |
| February.....  | 30.7                         | 78                            | -18                           | 2.64                           | 5.66               | .58             | 8                                                | 8.5                           |
| March.....     | 38.6                         | 80                            | 0                             | 3.51                           | 6.61               | .50             | 8                                                | 6.7                           |
| April.....     | 48.1                         | 84                            | 11                            | 3.49                           | 6.64               | 1.20            | 9                                                | 2.3                           |
| May.....       | 60.2                         | 98                            | 28                            | 3.20                           | 7.04               | .74             | 8                                                | .0                            |
| June.....      | 70.1                         | 103                           | 33                            | 3.97                           | 8.41               | .92             | 9                                                | .0                            |
| July.....      | 74.0                         | 104                           | 42                            | 4.25                           | 9.17               | 1.18            | 10                                               | .0                            |
| August.....    | 72.1                         | 107                           | 39                            | 4.33                           | 13.94              | .92             | 9                                                | .0                            |
| September..... | 65.6                         | 99                            | 27                            | 3.38                           | 9.83               | .28             | 6                                                | .0                            |
| October.....   | 53.5                         | 93                            | 19                            | 3.16                           | 8.39               | .07             | 7                                                | .1                            |
| November.....  | 43.2                         | 81                            | 5                             | 2.55                           | 9.02               | .58             | 8                                                | .5                            |
| December.....  | 33.0                         | 73                            | -7                            | 3.07                           | 7.46               | .76             | 8                                                | 4.6                           |
| Year.....      | 51.8                         | 107                           | -27                           | 40.83                          | 56.22              | 26.37           | 96                                               | 31.3                          |

<sup>1</sup> 32-year record.

<sup>2</sup> 21-year record.

<sup>3</sup> 27-year record.

rich, productive soils. On the more stony ridges the growth was not so abundant, and a mixed growth of oaks and chestnut marked these localities.

An increasing agricultural population led to the clearing of lands for corn, oats, rye, barley, buckwheat, flax, and spelt. Rye was the chief winter grain in the early days. Flax was grown by the Scotch-Irish settlers, and linen and tow were manufactured.

The iron-smelting industry of southeastern Pennsylvania moved into the Lancaster County section early in the eighteenth century, after wood for making charcoal was exhausted in the vicinity of the iron furnaces in the Schuylkill Valley and iron was discovered in Mine Ridge and South Mountain along the boundary between Lancaster and Lebanon Counties. Large areas of timbered lands were reserved near each furnace, and hardwoods on the ridges were cut as a source of charcoal. This destructive use of woodland resources persisted until supplies of anthracite became available from the Wyoming Valley and Lehigh fields and means for utilizing this fuel in furnaces had been devised.

Consequently, the timbered areas in the valleys and the plain were cleared to provide agricultural land, and the rougher, more sloping hill and ridge lands were severely cut over to supply furnace fuel. This deforestation has left its record in progressive accelerated erosion on both the more level and the steeper lands.

The present trees on the timbered areas are species that have succeeded the original growth by several generations. Birch and cedar predominate in abandoned fields and old pastures in the north and northeast parts of the area, and the woodlands, chiefly on the Penn and Montalto soils, are dominated by oak. Oak and hickory, with some surviving chestnut, are the most common trees in the northwest. Alder, willow, and sycamore grow throughout the area along streams and on the colluvial and alluvial soils. In the south, locust, oak, and hickory are dominant. Within the forests is undergrowth of laurel, huckleberry, poison ivy, sumac, and briers. Maple, catal-

pa, and walnut have been planted in urban areas and around farm dwellings and grow along fence rows and highways throughout the limestone plain. There is a thick, dense growth of huckleberry and blueberry in the forests of the northeast part.

The most important grasses for grazing are Kentucky and Canada bluegrass and redbud. Alsike and wild white clover grow in association with them.

The common weeds and grasses growing in the hayfields and with the cultivated crops are broadleaf plantain, narrowleaf plantain, wild carrot, dandelion, yarrow, Canada thistle, ragweed, giant ragweed, crabgrass, little fescue, smartweed, and chicory.

### *Economic Development*

Before the first permanent agricultural settlement of the area, made in the watershed of Pequea Creek in 1710, traders had established posts as a basis for trade with the local and more western Indian tribes. They established the first commerce, an exchange with the Indians of iron implements, cloth, beads, and spirituous liquors for furs.

Swiss Mennonites migrating from their home through the Rhine Valley and the Netherlands, came to England, and there some of them bargained with William Penn, securing a grant of 10,000 acres of land for 500 pounds or about \$2,433. They came to Philadelphia and traveled westward. Nine families located on an area 2 miles wide and 10 miles long that stretches in a flat crescent from the vicinity of West Willow to that of Strasburg. They cleared land, prepared the soil, and sowed and planted crops. Others from the same general region and French Huguenots, Scotch-Irish, and Welsh settlers followed them, and in 1729, Lancaster County had sufficient population to be set off from Chester County as a separate governmental division.

The early settlers soon provided themselves with water mills for sawing lumber and grinding grain. Millwrights, blacksmiths, wagoners, and other craftsmen came to the region,

and a self-supporting community was created, based on agricultural production and the needs of farm families.

Indian trails and pack-horse routes were succeeded by roads over which the surplus products of the area could be hauled to the Philadelphia market in the Conestoga wagons. These wagons were designed and built for that purpose, and they later figured prominently in the military and civil transportation of regions far to the west and northwest. Skilled iron workers from Switzerland designed the small-bore long rifle, a weapon with great accuracy and minimum need for powder and lead, to meet the needs of the frontiersmen.

The need for the domestic manufacture of cloth led to the development of a linen and tow industry by the Scotch-Irish settlers and of the carding and weaving industries, which supplied both woolen clothing and blankets. Flour from rye and wheat was ground for sale in seaboard markets and later for export. Thus, agriculture, manufacturing, and commerce grew together.

Although log houses and rail fences were still common in the more remote sections as late as 1800, brick and limestone houses and substantial, large barns were being built on the longer settled limestone farms. Communication was still carried on over wagon roads, greatly improved since pioneer days. This land transportation was supplemented in the early part of the nineteenth century by the construction of canals. These waterways were supplemented and finally supplanted by the early steam railroads, beginning about 1834.

Iron smelting and working remained an important industry until 1870 or later. At one time 100 furnaces were reported in the section. Steel mills still operate in nearby localities, making use of fuel and ore shipped in from outside sources.

Lancaster County, within whose limits the greater part of the Conestoga and Pequea watersheds lies, possesses today approximately 400 different factories and smaller plants furnishing employment to 20,000 to 25,000 people. The

gross annual product is normally worth about \$95,000,000. Included in this number are 100 or more food-manufacturing and processing plants employing 1,500 to 2,000 people. These different industries furnish a labor outlet for surplus farm population and give an opportunity for employment to many young people from the farms during winter months. The manufacture of cigars and tobacco products from locally grown tobacco constitutes an important branch of industry.

Lancaster County agricultural products are extensively processed and manufactured near the locality of their production and within easy reach of adequate shipping facilities to outside markets.

There is still a large volume of direct sale of agricultural produce on market days at Lancaster and at Philadelphia and other industrial cities near the area.

Railroad facilities are unusually good. The area is crossed by the main line of the Pennsylvania Railroad between Philadelphia and Harrisburg, and branches reach Columbia and other points. The Philadelphia and Reading serves the northern part of the area. The main-line railroads have been electrified.

Improved highways radiate from Lancaster to the larger boroughs, and these points are served by numerous through and local bus lines. The busses furnish express and passenger service to the farmers along their routes. A large amount of local hauling is done by motortrucks. Until 1912 there were less than 150 miles of paved highway in the Conestoga area, and these were turnpike or toll roads. Since State and Federal authorities have assumed the ownership and construction of the roads, all the numerous tollgates have been discontinued. There are now between 1,500 and 2,000 miles of paved and macadam roads, and many miles of improved dirt roads lead to them from intervening territory.

Nearly all the farms within the area are reached by rural mail delivery. Telephones are in general use. Electric power and light are available to many of the farms, and some small communities have developed local water power



*Figure 2.—Typical farmsteads in Lancaster County, Pa.*

to generate electricity on a community basis.

Most of the rural homes are substantially built, well painted, and set in fenced and well-cared-for grounds with shade and ornamental trees and lawns (fig. 2). They compare favorably in beauty and comfort with the best city homes. They are generally equipped with modern appliances for comfort and convenience.

Both urban and rural parts of the area show the results of a well-balanced agricultural and industrial development.

## Agriculture

IN COMMON with other agricultural regions of the eastern United States, the Conestoga area passed by gradual transitions from a form of almost purely self-sustaining agriculture under pioneer conditions to the production of wheat and other grains for sale and to the growing of livestock for sale as meat animals. The cutting and sawing of timber constituted a part of the early farm work, and lumber, shingles, and barrel staves were the chief woodland products.

Wheat became a staple sale crop during colonial days and maintained a leading rank even after railroad transportation brought the wheatlands of southeastern Pennsylvania into compe-

tition with those of the more western States.

Beginning about 1840, the importance of wheat growing decreased and the feeding of livestock increased as a principal source of farm income. Woodland decreased in acreage, and pasture land increased. Tobacco had been introduced as a cash crop and increased in importance as a staple crop on the limestone lands.

By 1860 a well-balanced system of general farming for grain and hay production and cattle feeding had been established, and the Lancaster cattle market had become the most important selling point for beef cattle in the Eastern States.

The form of agriculture has since been modified by the growing importance of dairying because of an increasing demand for milk and cream in the urban areas. There has also been an increase in the production of vegetables, both for sale as fresh material and for canning at factories within and near the area.

The acreage devoted to wheat has varied considerably, depending on the cash return per acre received. Pasture land, especially on the limestone soils, has decreased to a very small area but has increased on some of the rougher and more sloping lands. Similarly woodland covers only small areas of the level, productive soils, whereas the

more stony and sloping soils are maintained in woodland.

In order to indicate the tendencies in farm-land occupation in the area, data for Lancaster County from the United States censuses for 1924, 1929, and 1934 are given in table 2. The acreages for the principal farm crops for 1909, 1919, 1924, 1929, and 1934 are given in table 3. While the statistics for the Conestoga area are not directly comparable with those for Lancaster County, yet the climatic, soil, transportation, and farming conditions are so similar that the changes experienced in the county indicate rather accurately what has occurred in the area surveyed.

TABLE 2.—Classes of land according to use in Lancaster County, Pa., in stated years <sup>1</sup>

| Class                        | 1924         | 1929         | 1934         |
|------------------------------|--------------|--------------|--------------|
|                              | <i>Acres</i> | <i>Acres</i> | <i>Acres</i> |
| Approximate land area.....   | 602,370      | 602,370      | 602,370      |
| Land in farms.....           | 520,764      | 517,373      | 519,282      |
| Cropland, total.....         | 393,653      | 380,536      | 372,917      |
| Harvested.....               | 380,684      | 363,729      | 344,680      |
| Crop failure.....            | 1,952        | 2,067        | 4,083        |
| Idle.....                    | 11,017       | 14,740       | 24,154       |
| Pasture land, total.....     | 62,698       | 76,769       | 73,712       |
| Plowable.....                | 16,150       | 29,928       | 24,238       |
| Woodland pasture.....        | 8,912        | 8,795        | 5,866        |
| Other pasture.....           | 27,636       | 38,046       | 43,608       |
| Woodland not in pasture..... | 81,544       | 32,624       | 43,471       |
| All other land in farms..... | 32,869       | 27,444       | 29,182       |

<sup>1</sup> U. S. censuses.

TABLE 3.—Acreage devoted to the principal crops in Lancaster County, Pa., in stated years <sup>1</sup>

| Crop                                | 1909         | 1919         | 1924         | 1929         | 1934         |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|
|                                     | <i>Acres</i> | <i>Acres</i> | <i>Acres</i> | <i>Acres</i> | <i>Acres</i> |
| Corn.....                           | 80,825       | 92,912       | 92,430       | 92,755       | 96,643       |
| Oats.....                           | 20,093       | 21,245       | 15,327       | 14,942       | 13,157       |
| Wheat.....                          | 115,568      | 116,067      | 101,640      | 90,785       | 85,404       |
| Rye.....                            | 8,583        | 2,427        | 966          | 531          | 946          |
| Hay.....                            | 109,843      | 105,762      | 110,868      | 97,641       | 96,162       |
| Timothy and timothy and clover..... | 104,594      | 97,346       | 102,012      | 88,200       | 80,149       |
| Alfalfa.....                        | 544          | 2,333        | 3,936        | 4,528        | 12,072       |
| Tobacco.....                        | 32,783       | 37,301       | 40,716       | 37,088       | 17,152       |
| Potatoes.....                       | 12,654       | 11,840       | 8,978        | 11,491       | 13,337       |

<sup>1</sup> U. S. censuses.

<sup>2</sup> Includes forage.

<sup>3</sup> Includes 429 acres of sweet potatoes.

The outstanding features of land use as indicated in table 2 are: (1) The area of land in farms is evidently stabilized at about 520,000 acres; (2) the area of cropland is decreasing slightly; (3) the area in pasture land has varied somewhat and there has

been an increase in plowable pasture, which possibly accounts for a part of the decrease in cropland; (4) the area in woodland, not pastured, is steadily increasing, whereas pastured woodland has slightly decreased.

Since the figures given in table 3 apply only to single years, they do not eliminate either favorable or unfavorable climatic conditions for any one crop for any year.

The steady increase in corn acreage is notable. The wheat acreage has decreased; as has oats, which are not well suited to the climate of the area. Rye has nearly disappeared as a staple crop. Although the total area devoted to hay has declined since 1924, the acreage of alfalfa has been notably increased, probably coincident with the increase of dairying as the main type of animal husbandry. The acreage of corn grown for silage has also increased. The acreage in tobacco has fluctuated markedly.

There has been an increase in the acreage given to the production of vegetables for sale as truck crops and for canning purposes, but that of potatoes remains about the same. Small areas of potatoes are grown on each farm chiefly for home consumption, with some small surplus for sale. According to information supplied by the local representative of the Extension Service, in 1938, 3,000 acres of tomatoes were grown for canning. There were also 600 acres of sweet corn for canning and for sale by count, and 575 acres of green peas. The acreage of these canning crops is increasing.

Some significant changes in the livestock population are indicated by the census statistics summarized in table 4. The increase in cattle is rather marked since 1910, showing the extension of the dairy industry. The decrease in number of horses is not offset by the increase in the number of mules, and it is evident that the tractor is furnishing an increasing amount of farm power. The number of sheep has been irregularly variable but seems to have increased slightly, whereas the number of swine has decreased markedly. It must be held in mind that the number of cattle on hand will vary with the

season of the year when data are secured and somewhat with different years, depending on the number of beef cattle being finished off or fed through the winter on the hay and forage by-products of the farms, as well as on the relative cost of feeders and the probable sale price in April or May.

TABLE 4.—*Number of the principal domestic animals in Lancaster County, Pa., in census years <sup>1</sup>*

| Year      | Cattle        | Horses        | Sheep         | Swine         | Mules         |
|-----------|---------------|---------------|---------------|---------------|---------------|
|           | <i>Number</i> | <i>Number</i> | <i>Number</i> | <i>Number</i> | <i>Number</i> |
| 1910..... | 66,516        | 24,441        | 5,882         | 47,259        | 7,777         |
| 1920..... | 87,692        | 22,175        | 5,245         | 72,094        | 8,476         |
| 1925..... | 78,979        | 19,103        | 3,396         | 43,282        | 8,831         |
| 1930..... | 79,495        | 16,800        | 9,642         | 34,825        | 9,546         |
| 1935..... | 91,892        | 14,391        | 7,273         | 28,775        | 9,476         |

<sup>1</sup> U. S. censuses.

The number of farms, their total and average size, and the values of land and buildings in the county are shown in table 5. It will be noted that the number of farms has decreased since 1910 but that the average size of the farms has increased. This would seem to indicate that some farms have passed to other than agricultural uses and the acreages of the farms remaining have been slightly increased. No significant evidence concerning land values is apparent because of broad changes in money values and of extraneous conditions. Values seem to have fluctuated in about the same direction and amounts as in other industries, with farm property probably representing the more stable investment. In relation to other regions, the changes are not marked and the farm values quoted for 1935 remain high.

TABLE 5.—*Land in farms, number and size of farms, and value of lands and buildings in Lancaster County, Pa., in census years <sup>1</sup>*

| Year      | All land in farms | Farms         | Average size of farms | Value of land and buildings |                |
|-----------|-------------------|---------------|-----------------------|-----------------------------|----------------|
|           |                   |               |                       | Average per acre            | Total          |
|           | <i>Acre</i>       | <i>Number</i> | <i>Acre</i>           | <i>Dollars</i>              | <i>Dollars</i> |
| 1910..... | 550,499           | 10,835        | 50.8                  | 129.49                      | 71,285,863     |
| 1920..... | 554,776           | 11,307        | 49.1                  | 168.31                      | 93,372,298     |
| 1925..... | 520,764           | 11,457        | 45.5                  | 174.97                      | 91,118,245     |
| 1930..... | 517,373           | 9,705         | 53.3                  | 169.79                      | 87,846,657     |
| 1935..... | 519,282           | 8,863         | 58.6                  | 115.76                      | 60,112,558     |

<sup>1</sup> U. S. censuses.

The average yields per acre for the staple crops of the section in 1934 (U. S. census) are given in the following tabulation.

|                                  |           |         |
|----------------------------------|-----------|---------|
| Winter wheat.....                | bushels.. | 23.9    |
| Oats.....                        | do.....   | 33.7    |
| Barley.....                      | do.....   | 35.3    |
| All hay, and sorghums for forage | tons..    | 1.6     |
| Alfalfa.....                     | do.....   | 2.2     |
| Corn harvested for grain.....    | bushels.. | 48.8    |
| Tobacco.....                     | pounds..  | 1,147.0 |
| Potatoes.....                    | bushels.. | 152.3   |

## The Conservation Survey

### Methods and Definitions

A CONSERVATION SURVEY is a physical inventory of the character of the soil, the dominant slope of the land, the extent to which soil erosion has affected the soils, and the existing cover of the land.

The survey of the watersheds of Conestoga and Pequea Creeks in southeastern Pennsylvania was made on aerial photographs at a scale of 1 inch equals approximately 1,320 feet and has been reproduced on maps that are made accurately on this scale.

The field survey party, using the required instruments, examined sections of the various soils to determine the character of the surface soil, the subsoil, and the underlying materials on which the soils had been developed by different processes of soil formation. The soils were classified into series, and also into individual soil types, reasonably similar in all their areas as far as permanent characteristics are concerned. The classification and nomenclature of the Division of Soil Survey of the Bureau of Plant Industry were used.

The different soil types were studied in wooded areas unchanged by cultivation or other human uses, if possible, in order to determine the depth of the surface soil and subsoil. This depth was used as a standard in estimating the degree to which soils on tilled or pasture areas had been affected by accelerated soil erosion during the years in which they have been used for agricultural production. The amount of soil erosion is shown on the map.

On some flat or low-lying lands, deposition had occurred through the transportation and deposition of upland material.

Since slope materially affects the activity of the water that brings about erosion, transportation, and deposition of soil, the dominant slope was also determined, by the use of the Abney hand level, and is shown on the map.

On the printed maps are shown all highways, railroads, occupied dwellings, villages and urban centers, streams, ponds, and other features commonly shown on maps. These serve as reference points to anyone attempting to locate a particular farm or soil area or timbered or cultivated tract or to anyone studying slopes and existing conditions of accelerated soil erosion. A section of the completed conservation-survey map is shown on cellophane in such form that it may be placed over the photograph from which it was prepared (pl. 1), and the relationship of the area to the mapping may be plainly seen. This sample area will aid in the reading of the entire map.

## SOILS

The conservation survey shows the areas of each individual type of soil. The survey disclosed 79 soils sufficiently different—in depth, coloration, structure, texture, surface and internal conditions of drainage, method of formation, or original materials on which they had been developed—to warrant considering them as essentially different types.

Soils closely related in all their characteristics except texture of the surface layer are considered together as a soil series, which is given a geographic name connected with the locality where the soils were first mapped. Each series is divided into soil types by characteristics of soil texture, that is, the relative proportions of sand, silt, clay, stone, or gravel in the surface soil and subsoil. Thus a soil having a dark-gray to grayish-brown surface soil and yellowish subsoil and derived through the weathering of the impure micaceous limestones would be called a Conestoga soil. It might be a silt loam or a grav-

elly silt loam in texture. But a soil formed on granite or gneiss that has been weathered to a great depth and has a brown surface soil and reddish-brown subsoil would be classed in the Chester series. That series would include several distinct soil types, such as Chester loam, silt loam, and stony loam.

Detailed descriptions of the 79 soil types in the area, their occupation for agricultural and other uses, their slopes, and the extent to which they have already been affected by soil erosion or deposition will be found in the appendix. Table 6 shows the acreage of each soil type and the individual soils that were combined into the groups discussed on pages 17 to 25.

TABLE 6.—Acreage and percentage of each soil group and type

| Group No., soil group, and type                                              | Area           |                  |
|------------------------------------------------------------------------------|----------------|------------------|
|                                                                              | <i>Acres</i>   | <i>Percent</i>   |
| <b>1. Well-drained upland soils from highly calcareous materials:</b>        |                |                  |
| (a) Complete (A-B-C) profile:                                                |                |                  |
| Conestoga gravelly silt loam.....                                            | 350            | 0.1              |
| Conestoga silt loam.....                                                     | 24,450         | 6.1              |
| Duffield gravelly silt loam.....                                             | 6,107          | 1.5              |
| Duffield silt loam.....                                                      | 106,143        | 26.4             |
| Duffield stony silt loam.....                                                | 130            | ( <sup>1</sup> ) |
| Dunmore gravelly silt loam.....                                              | 482            | .1               |
| Dunmore silt loam.....                                                       | 15,358         | 3.8              |
| Hagerstown gravelly silt loam.....                                           | 502            | .1               |
| Hagerstown silt loam.....                                                    | 3,393          | .9               |
| Letort silt loam.....                                                        | 13,766         | 3.4              |
| Strasburg silt loam.....                                                     | 7,549          | 1.9              |
| <b>Total.....</b>                                                            | <b>178,235</b> | <b>44.3</b>      |
| (b) Incomplete (A-C) profile:                                                |                |                  |
| Hollinger silt loam.....                                                     | 1,426          | .4               |
| Pequea gravelly silt loam.....                                               | 542            | .1               |
| Pequea silt loam.....                                                        | 6,990          | 1.8              |
| Pequea stony silt loam.....                                                  | 111            | ( <sup>1</sup> ) |
| <b>Total.....</b>                                                            | <b>9,069</b>   | <b>2.3</b>       |
| <b>2. Imperfectly drained upland soils from highly calcareous materials:</b> |                |                  |
| Conestoga silt loam, colluvial phase.....                                    | 874            | .2               |
| Duffield silt loam, colluvial phase.....                                     | 4,902          | 1.2              |
| Hagerstown silt loam, colluvial phase.....                                   | 194            | .1               |
| Lawrence silt loam.....                                                      | 73             | ( <sup>1</sup> ) |
| Pequea silt loam, colluvial phase.....                                       | 106            | ( <sup>1</sup> ) |
| <b>Total.....</b>                                                            | <b>6,149</b>   | <b>1.5</b>       |
| <b>3. Well-drained upland soils from gneiss and schist:</b>                  |                |                  |
| (a) Complete (A-B-C) profile:                                                |                |                  |
| Chester gravelly loam.....                                                   | 4,831          | 1.2              |
| Chester gravelly silt loam.....                                              | 8,791          | 2.2              |
| Chester loam.....                                                            | 6,850          | 1.7              |
| Chester silt loam.....                                                       | 9,100          | 2.2              |
| Chester stony loam.....                                                      | 1,115          | .3               |
| <b>Total.....</b>                                                            | <b>30,687</b>  | <b>7.6</b>       |
| (b) Incomplete profile:                                                      |                |                  |
| Manor gravelly loam.....                                                     | 5,198          | 1.3              |
| Manor gravelly silt loam.....                                                | 2,632          | .6               |

<sup>1</sup> Less than 0.1 percent.



**Aerial photograph of the area 2 miles southwest of Lititz. Scale: 1 inch equals 1,320 feet. This is the base map used to record the facts shown on the conservation-survey map overlay. Legend for the symbols used on the overlay is given on the maps accompanying this survey and on pages 15-16 in the text. Conservation-survey boundaries and symbols are in brown, land use in green, drainage in blue, and cultural features in black.**

**PLATE 1**

TABLE 6.—Acreage and percentage of each soil group and type—Continued

| Group No., soil group, and type                                                                 | Area   |                  |
|-------------------------------------------------------------------------------------------------|--------|------------------|
|                                                                                                 | Acres  | Percent          |
| 3. Well-drained upland soils from gneiss and schist—Continued.<br>(b) Incomplete profile—Contd. |        |                  |
| Manor loam.....                                                                                 | 5,112  | 1.3              |
| Manor silt loam.....                                                                            | 1,431  | .3               |
| Manor stony loam.....                                                                           | 3,973  | 1.0              |
| Manor stony silt loam.....                                                                      | 207    | .1               |
| Total.....                                                                                      | 10,723 | 4.6              |
| 4. Upland soils from quartzite:                                                                 |        |                  |
| Edgemont gravelly loam.....                                                                     | 7,003  | 1.7              |
| Edgemont gravelly silt loam.....                                                                | 4,546  | 1.1              |
| Edgemont loam.....                                                                              | 2,164  | .6               |
| Edgemont silt loam.....                                                                         | 1,917  | .5               |
| Edgemont stony loam.....                                                                        | 7,784  | 1.9              |
| Edgemont stony silt loam.....                                                                   | 2,164  | .6               |
| Total.....                                                                                      | 25,578 | 6.4              |
| 5. Upland soils from diabase or trap rock:                                                      |        |                  |
| Montalto gravelly silt loam.....                                                                | 1,900  | .5               |
| Montalto silt loam.....                                                                         | 1,693  | .4               |
| Montalto stony silt loam.....                                                                   | 4,496  | 1.1              |
| Total.....                                                                                      | 8,089  | 2.0              |
| 6. Upland soils from slate or argillaceous shale:                                               |        |                  |
| Berks shaly silt loam.....                                                                      | 1,711  | .4               |
| Berks shaly silt loam, brown phase.....                                                         | 16,960 | 4.2              |
| Berks silt loam.....                                                                            | 239    | .1               |
| Berks silt loam, brown phase.....                                                               | 1,627  | .4               |
| Cardiff silt loam.....                                                                          | 251    | .1               |
| Cardiff slaty silt loam.....                                                                    | 1,451  | .3               |
| Total.....                                                                                      | 22,239 | 5.5              |
| 7. Well-drained upland soils from Triassic sandstone and shale:                                 |        |                  |
| Lansdale gravelly loam.....                                                                     | 2,311  | .6               |
| Lansdale loam.....                                                                              | 2,766  | .7               |
| Lansdale stony loam.....                                                                        | 682    | .2               |
| Penn gravelly loam.....                                                                         | 17,173 | 4.3              |
| Penn gravelly silt loam.....                                                                    | 8,954  | 2.2              |
| Penn loam.....                                                                                  | 5,105  | 1.3              |
| Penn silt loam.....                                                                             | 6,306  | 1.6              |
| Penn stony loam.....                                                                            | 16,044 | 4.0              |
| Penn stony silt loam.....                                                                       | 8,680  | 2.1              |
| Penn-Lansdale gravelly loam.....                                                                | 784    | .2               |
| Penn-Lansdale loam.....                                                                         | 1,235  | .3               |
| Total.....                                                                                      | 70,040 | 17.4             |
| 8. Imperfectly or poorly drained upland soils from sandstone and shale:                         |        |                  |
| Berks silt loam, colluvial phase.....                                                           | 297    | .1               |
| Croton loam.....                                                                                | 1,435  | .3               |
| Croton silt loam.....                                                                           | 2,268  | .6               |
| Edgemont silt loam, colluvial phase.....                                                        | 267    | .1               |
| Glennville silt loam.....                                                                       | 467    | .1               |
| Penn silt loam, colluvial phase.....                                                            | 437    | .1               |
| Watchung-Lehigh silt loam.....                                                                  | 1,873  | .5               |
| Total.....                                                                                      | 7,059  | 1.8              |
| 9. Upland soils from metamorphosed sandstone and shale:                                         |        |                  |
| Brecknock gravelly silt loam.....                                                               | 3,281  | .8               |
| Brecknock silt loam.....                                                                        | 1,384  | .4               |
| Brecknock stony silt loam.....                                                                  | 2,040  | .5               |
| Total.....                                                                                      | 6,705  | 1.7              |
| 10. Terrace soils:                                                                              |        |                  |
| Birdsboro silt loam.....                                                                        | 280    | .1               |
| Elk gravelly silt loam.....                                                                     | 161    | ( <sup>1</sup> ) |
| Engleside loam.....                                                                             | 586    | .1               |
| Total.....                                                                                      | 1,027  | .2               |

<sup>1</sup> Less than 0.1 percent.

TABLE 6.—Acreage and percentage of each soil group and type—Continued

| Group No., soil group, and type                      | Area   |                  |
|------------------------------------------------------|--------|------------------|
|                                                      | Acres  | Percent          |
| 11. Well-drained flood-plain soils:                  |        |                  |
| Bermudian silt loam.....                             | 1,067  | .3               |
| Huntington silt loam.....                            | 3,785  | .9               |
| Total.....                                           | 4,852  | 1.2              |
| 12. Imperfectly or poorly drained flood-plain soils: |        |                  |
| Alluvial soils, undifferentiated.....                | 193    | ( <sup>1</sup> ) |
| Bowmansville silt loam.....                          | 3,447  | .9               |
| Codorus silt loam.....                               | 1,663  | .4               |
| Lindside silt loam.....                              | 5,661  | 1.4              |
| Melvin silt loam.....                                | 1,104  | .3               |
| Wehadkee silt loam.....                              | 780    | .2               |
| Wehadkee silty clay loam.....                        | 1,240  | .3               |
| Total.....                                           | 14,088 | 3.5              |
| Total.....                                           | 42,340 | 100.0            |

<sup>1</sup> Less than 0.1 percent.

<sup>2</sup> Water areas amounting to 1,131 acres and miscellaneous land areas totaling 1,201 acres are not included in this and the following tables.

## LAND USE

In determining the present uses of land, all land that actually was in use for crop production, or had been within the past year, was classed as cropland. Open land, showing no such use and not in pasture, was mapped as idle land. Land in use for pasture was so mapped. All land with 40 percent of its area covered by a spread of trees was mapped as woodland. Areas occupied by farm buildings and grounds, by schoolyards, churchyards, and cemeteries, or for other nonagricultural uses, and areas built up for urban residence were mapped by a special symbol and are referred to as farmyards and urban areas.

Woodland, pasture, and idle land are shown in green on the map by appropriate symbols. Cropland and farmyards and urban areas are left uncolored.

The areas of each soil group given to each land use are shown in table 7.

## SLOPES

In mapping the prevailing slopes of the land surface, it was necessary to divide the soil groups into two broad classes because of distinct differences in the erodibility of the soils. All the soils of the limestone plain, which in-

TABLE 7.—Distribution of the land use classes in each soil group

| Soil group       | Cropland |         | Idle land |         | Pasture |         | Woodland |         | Farmyards and urban areas |         | Total   |
|------------------|----------|---------|-----------|---------|---------|---------|----------|---------|---------------------------|---------|---------|
|                  | Acres    | Percent | Acres     | Percent | Acres   | Percent | Acres    | Percent | Acres                     | Percent |         |
| 1a.....          | 157,532  | 88.4    | 424       | 0.2     | 8,227   | 4.6     | 1,232    | 0.7     | 10,820                    | 6.1     | 178,235 |
| 1b.....          | 5,344    | 88.9    | 846       | 9.3     | 1,284   | 14.2    | 1,372    | 15.1    | 223                       | 2.5     | 9,069   |
| 2.....           | 4,204    | 68.4    | 24        | .4      | 1,855   | 30.1    | 54       | .9      | 12                        | .2      | 6,149   |
| 3a.....          | 22,134   | 72.1    | 861       | 2.8     | 1,561   | 5.1     | 5,650    | 18.4    | 481                       | 1.6     | 30,687  |
| 3b.....          | 7,561    | 40.8    | 1,336     | 7.2     | 1,227   | 6.6     | 8,153    | 43.9    | 276                       | 1.5     | 18,553  |
| 4.....           | 11,562   | 45.2    | 692       | 2.7     | 965     | 3.8     | 12,061   | 47.1    | 298                       | 1.2     | 25,578  |
| 5.....           | 2,744    | 34.0    | 459       | 5.7     | 322     | 4.0     | 4,502    | 55.9    | 32                        | .4      | 8,059   |
| 6.....           | 17,781   | 80.0    | 337       | 1.5     | 1,291   | 5.8     | 2,133    | 9.6     | 697                       | 3.1     | 22,239  |
| 7.....           | 35,788   | 51.1    | 2,906     | 4.1     | 1,947   | 2.8     | 28,475   | 40.7    | 924                       | 1.3     | 70,040  |
| 8.....           | 2,476    | 35.1    | 663       | 9.4     | 1,969   | 27.9    | 1,929    | 27.3    | 22                        | .3      | 7,059   |
| 9.....           | 3,470    | 51.7    | 131       | 2.0     | 189     | 2.8     | 2,840    | 42.4    | 76                        | 1.1     | 6,705   |
| 10.....          | 7,776    | 75.6    | 20        | 1.9     | 48      | 4.7     | 162      | 15.8    | 21                        | 2.0     | 1,027   |
| 11.....          | 1,013    | 20.9    | 83        | 1.7     | 3,326   | 68.5    | 408      | 8.4     | 22                        | .5      | 4,852   |
| 12.....          | 1,822    | 12.9    | 452       | 3.2     | 10,321  | 73.3    | 1,472    | 10.4    | 21                        | .2      | 14,088  |
| Entire area..... | 274,207  | 68.1    | 9,234     | 2.3     | 34,531  | 8.6     | 70,443   | 17.5    | 13,925                    | 3.5     | 402,340 |

cludes soils of the Conestoga, Duffield, Dunmore, Hagerstown, Hollinger, Lawrence, Letort, Pequea, and Strasburg series, the soils of the Chester and Glenville series in the Piedmont, the Birdsboro, Elk, and Engleside soils on the stream terraces, and all the flood-plain soils were grouped together. It is known that these soils are more easily eroded than the remainder of those in the Conestoga area. With these soils all surface slopes of less than 3 percent, that is, with a declivity of less than 3 feet in 100, were classed as A slopes, those of 3 to 6 as B, those of 6 to 12 as BB, those of 12 to 18 as C, and those of 18 percent and over as D.

For the remaining soils, those of the Manor, Berks, Penn, Lansdale, Edgemont, Brecknock, Montalto, Cardiff, Croton, Watchung, and Lehigh series, the slope classes have the following ranges: A, less than 3 percent; B, 3 to

8; BB, 8 to 15; C, 15 to 25; and D, 25 percent and over.

These classes indicate certain erosion risks and definite farm practices that should be employed to minimize or eliminate soil erosion.

A slopes include relatively flat areas on which there is slight soil erosion under ordinary conditions of cropping and tillage.

B slopes are so steep that erosion is likely to be active on all cultivated fields. Erosion-control measures can be employed without interfering with cultivated crops. Contour tillage, strip cropping, and terracing are the remedial measures needed.

BB slopes are so steep that, under the prevailing farm practices, such measures as strip cropping, contour tillage, and contour furrowing should be used in connection with the usual crop rotations. Serious soil erosion is

TABLE 8.—Distribution of the slope classes in each soil group

| Soil group       | A slopes |         | B slopes |         | BB slopes |         | C slopes |                  | D slopes |         | Total   |
|------------------|----------|---------|----------|---------|-----------|---------|----------|------------------|----------|---------|---------|
|                  | Acres    | Percent | Acres    | Percent | Acres     | Percent | Acres    | Percent          | Acres    | Percent |         |
| 1a.....          | 54,091   | 30.3    | 95,650   | 53.7    | 24,768    | 13.9    | 2,701    | 1.5              | 1,025    | 0.6     | 178,235 |
| 1b.....          | 60       | .7      | 648      | 7.1     | 2,249     | 24.8    | 2,975    | 32.8             | 3,137    | 34.6    | 9,069   |
| 2.....           | 5,973    | 97.2    | 122      | 2.0     | 27        | .4      | 27       | .4               | 0        | .....   | 6,149   |
| 3a.....          | 1,507    | 4.9     | 11,619   | 37.9    | 12,501    | 40.7    | 4,247    | 13.8             | 813      | 2.7     | 30,687  |
| 3b.....          | 40       | .2      | 841      | 4.5     | 3,842     | 20.7    | 6,839    | 36.9             | 6,991    | 37.7    | 18,553  |
| 4.....           | 2,785    | 10.9    | 10,322   | 40.3    | 8,291     | 32.4    | 2,964    | 11.6             | 1,216    | 4.8     | 25,578  |
| 5.....           | 635      | 7.9     | 3,311    | 41.1    | 2,248     | 27.9    | 1,143    | 14.2             | 722      | 8.9     | 8,059   |
| 6.....           | 1,765    | 8.0     | 9,101    | 40.9    | 5,322     | 23.9    | 4,334    | 19.5             | 1,717    | 7.7     | 22,239  |
| 7.....           | 4,689    | 6.7     | 27,460   | 39.2    | 18,732    | 26.7    | 11,950   | 17.1             | 7,209    | 10.3    | 70,040  |
| 8.....           | 3,593    | 50.9    | 3,031    | 42.9    | 403       | 5.7     | 27       | .4               | 5        | .1      | 7,059   |
| 9.....           | 378      | 5.6     | 3,290    | 49.1    | 2,396     | 35.7    | 539      | 8.1              | 102      | 1.5     | 6,705   |
| 10.....          | 345      | 33.6    | 451      | 43.9    | 195       | 19.0    | 12       | 1.2              | 24       | 2.3     | 1,027   |
| 11.....          | 4,773    | 98.4    | 15       | .3      | 32        | .6      | 13       | .3               | 19       | .4      | 4,852   |
| 12.....          | 13,880   | 98.5    | 146      | 1.1     | 43        | .3      | 3        | ( <sup>1</sup> ) | 16       | .1      | 14,088  |
| Entire area..... | 94,514   | 23.5    | 166,007  | 41.3    | 81,049    | 20.1    | 37,774   | 9.4              | 22,996   | 5.7     | 402,340 |

<sup>1</sup> Less than 0.1 percent.

TABLE 9.—Distribution of the land use classes in each slope class

| Land use                       | A slopes     |                | B slopes     |                | BB slopes    |                | C slopes     |                | D slopes     |                | Entire area  |                |
|--------------------------------|--------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|
|                                | <i>Acres</i> | <i>Percent</i> | <i>Acres</i> | <i>Percent</i> | <i>Acres</i> | <i>Percent</i> | <i>Acres</i> | <i>Percent</i> | <i>Acres</i> | <i>Percent</i> | <i>Acres</i> | <i>Percent</i> |
| Cropland.....                  | 68,328       | 72.3           | 133,700      | 80.6           | 53,152       | 65.7           | 16,098       | 42.6           | 2,929        | 12.7           | 274,207      | 68.1           |
| Idle land.....                 | 1,082        | 1.1            | 2,188        | 1.3            | 2,214        | 2.7            | 2,238        | 5.9            | 1,512        | 6.6            | 9,234        | 2.3            |
| Pasture.....                   | 19,430       | 20.6           | 7,191        | 4.3            | 3,727        | 4.6            | 2,466        | 6.5            | 1,727        | 7.5            | 34,531       | 8.6            |
| Woodland.....                  | 3,303        | 3.5            | 13,643       | 8.2            | 20,297       | 25.0           | 16,565       | 43.9           | 16,635       | 72.4           | 70,443       | 17.5           |
| Farmyards and urban areas..... | 2,371        | 2.5            | 9,295        | 5.6            | 1,659        | 2.0            | 407          | 1.1            | 193          | .8             | 13,925       | 3.5            |
| Total.....                     | 94,514       | 100.0          | 166,007      | 100.0          | 81,049       | 100.0          | 37,774       | 100.0          | 22,996       | 100.0          | 402,340      | 100.0          |

usually present on BB slopes that are not protected.

C slopes are too steep to permit economical control of accelerated erosion on fallow land or in clean-cultivated fields. Such areas should be limited to the production of close-growing crops like hay and pasture grasses. Pastures on these slopes need contour furrows for protection.

D slopes are too steep to permit economical control of accelerated erosion on cultivated areas. They should either be retired to permanent pasture and a good sod established or be planted to trees for the farm wood supply. Overgrazing should be avoided in the pastured areas.

The relationships between soil groups and slope classes are given in table 8.

The agriculture of the area has be-

come fairly well adjusted to the steepness of slope, but it is also influenced by other factors such as inadequate soil drainage and stoniness. The present relationships between land use and slope are shown in table 9.

### EROSION

The main purpose of the conservation survey was to determine the relationships of other physical factors to the existing conditions of soil erosion. Classes of erosion were set up, ranging from no apparent erosion or deposition of material to very severe erosion.

Sheet erosion is the removal of thin films of surface soil by successive rainstorms. It is usually accompanied by the formation of small channels by rills of running water. Commonly these are



Figure 3.—Sheet and rill erosion on a cornfield plowed up and down the hill.



**Figure 4.—Deep gullying on Penn shale loam.**

obliterated by the processes of plowing, harrowing, and cultivation. This form of erosion is shown in figure 3. When they become so deep that the ordinary operations of land management can no longer be carried across them, they are deemed to have become gullies (fig. 4). Sheet erosion is difficult to detect and is the greatest menace to the permanent productivity of soils in the Northeastern States. Although usually only a small amount of soil is lost at any one time, this extends across the greater part of the cultivated field, and the process is often repeated during a single cropping season. Gullies are confined in their area and are so easily seen that means are taken to remedy the conditions giving rise to them. In the Cone-stoga area experienced farmers are exercising some kind of gully control, but few of them realize the extent or seriousness of sheet erosion and consequently do not employ means to prevent it.

The following symbols were used in mapping sheet and gully erosion:

**Sheet erosion:**

2. Less than 25 percent of the original topsoil removed.
3. 25 to 50 percent of the original topsoil removed.

33. 50 to 75 percent of the original topsoil removed.

4. 75 percent or more of the original topsoil removed or all topsoil and some subsoil removed.
5. Topsoil and most or all of the subsoil removed; parent material may be exposed or eroded.

**Gully erosion:**

7. Occasional gullies: More than 100 feet apart.
8. Frequent gullies: Occurring less than 100 feet apart, but including less than 75 percent of the area delineated.
9. Very frequent or large gullies.
- . This symbol around a gully-erosion symbol indicates gullies too deep to be crossed with tillage implements.

**Miscellaneous:**

- +. Recent alluvial or colluvial deposits.
1. No apparent erosion.
- Θ. Undifferentiated erosion.

**Stabilized erosion:**

- △. Erosion partially stabilized, as 37.
- . Erosion completely stabilized, as 37.

Erosion classes were grouped as follows to indicate severity of erosion:

- Recent alluvial and colluvial deposits: +.  
 No apparent erosion: 1.  
 Slight erosion: 2, 27, Θ.  
 Moderate erosion: 3, 37.  
 Moderately severe erosion: 38, 33, 337.  
 Severe erosion: 338, 4, 47.  
 Very severe erosion: 48, 57, 9.

Fifteen different classes of erosion and one of deposition were mapped.

These have been combined into seven groups to indicate the severity of damage caused. The acreage and percentage of land in each erosion group and class are given in table 10.

TABLE 10.—Acreage and percentage of land in each erosion group and class

| Erosion group and class                           | Area    |                  |
|---------------------------------------------------|---------|------------------|
|                                                   | Acres   | Percent          |
| Recent alluvial and colluvial deposits:<br>+..... | 26,323  | 6.5              |
| No apparent erosion:<br>1.....                    | 872     | .1               |
| Slight erosion:<br>2.....                         | 61,928  | 15.4             |
| 27.....                                           | 4,052   | 1.0              |
| 6.....                                            | 13,724  | 3.4              |
| Total.....                                        | 79,704  | 19.8             |
| Moderate erosion:<br>3.....                       | 111,861 | 27.8             |
| 37.....                                           | 64,867  | 16.1             |
| Total.....                                        | 176,728 | 43.9             |
| Moderately severe erosion:<br>38.....             | 424     | .1               |
| 33.....                                           | 22,168  | 5.5              |
| 337.....                                          | 63,126  | 20.5             |
| Total.....                                        | 104,718 | 26.1             |
| Severe erosion:<br>338.....                       | 6,391   | 1.6              |
| 4.....                                            | 876     | .2               |
| 47.....                                           | 5,548   | 1.4              |
| Total.....                                        | 12,815  | 3.2              |
| Very severe erosion:<br>48.....                   | 1,654   | .4               |
| 57.....                                           | 4       | ( <sup>1</sup> ) |
| 9.....                                            | 22      | ( <sup>1</sup> ) |
| Total.....                                        | 1,680   | .4               |
| Total.....                                        | 402,340 | 100.0            |

<sup>1</sup> Less than 0.1 percent.

### Soil Groups

The upland part of the area includes all the soil groups except the low-lying alluvial soils and those lying on the well-drained terraces bordering the Susquehanna River and its larger tributaries and constitutes 95 percent of its total extent.

Detailed descriptions of the 79 soil types will be found in the appendix. For studying the relationships between soil material, slope, and the influence of present plant cover on soil erosion and conservation, it was possible to combine the 79 individual soils into 12 groups, within each of which the soils are closely related in most respects. Two of these groups were further divided into sub-

groups. Table 7 shows the acreage of each soil type and the individual soils that were combined into the respective groups.

### DEEP WELL-DRAINED SOILS FROM HIGHLY CALCAREOUS MATERIALS, GROUP 1a

Among the deep well-drained upland soils the most extensive are those derived from the various kinds of limestone or at least highly calcareous rocks that underlie the Lancaster plain. These have been placed in group 1a which consists of the soils of the Conestoga, Duffield, Dunmore, Hagerstown, Letort, and Strasburg series. They cover 178,235 acres, or 44.3 percent of the entire area. Prevalingly they are soft friable silt loams. Only 7,441 acres were classed as gravelly types and 130 acres as stony.

They are mature soils, possessing a complete soil section consisting of a surface soil with a depth of 10 inches or more, a subsoil 12 to 24 inches thick, and an underlying mass of weathered mineral matter, resting on the parent rock at depths from 3 feet to 15 feet in the extreme cases.

These soils are well drained, both across the surface and internally through the subsoil and the underlying material. They are prevalingly silt loams that absorb moisture moderately well and retain it tenaciously for the use of growing crops. They are well watered by numerous rapidly flowing brooks and creeks. On most of the farmsteads are never-failing springs that have been boxed and housed to provide a domestic water supply and even some refrigeration for household supplies.

The farmsteads, with substantial brick or limestone houses, substantially built barns and outbuildings, and stockyards near the barns, indicate that these soils are productive. It is no great distance to the improved highway, the school, the church, and the local market point.

As has been noted, the precipitation is adequate and well distributed, and the growing season is long enough to permit the production of all crops

suited to the mild, temperate, humid climate. Grains, grasses, legumes, vegetables, and fruits can be grown for home use and for sale. Nearly 98 percent of the surface of this soil group drops less than 12 feet in 100 feet of distance (A, B, and BB slopes); in fact, 84 percent has a slope of less than 6 feet to the hundred.

The land is almost as level as a prairie. The relief is characterized by low ridges of more resistant rock that rise above the plain and by deeply incised streamways near the Susquehanna River.

The appreciation of these facts by the inhabitants of this limestone land has led to its being cleared to such an extent that only 0.7 percent is still in woodland. The soil is too valuable for the growing of other crops to permit its use for timber production. Only 4.6 percent is used for pasture. This is no more than 3 acres on most farms. In fact the farmsteads, lanes, highways, schoolhouse lots, church lots, cemeteries, and other uses incident to intensive community development take up 6.1 percent of the area of the group, more than the woodland and pasture combined. Only 0.2 percent is idle. This leaves 88.4 percent of the total area of these well-drained upland limestone soils in cropland.

These soils have been brought to a high efficiency of production under the well-balanced system of general farming. Crops produced on the farm and the crop residues are fed to farm livestock, and the stable manure is carefully utilized on the cultivated fields. The equally well ordered economy of farm and household management has contributed to the continued prosperity of the farm population and to the reputation that this and related communities have gained for efficient agricultural development. During the 225 years of their use for agricultural purposes these soils have enabled their cultivators to maintain a recognized preeminence in the agriculture of the State and of the Eastern United States. This is the pleasing part of the picture.

The conservation survey made a careful inventory of the extent to

which these limestone soils are losing and have lost fertile surface soil through the long-continued action of accelerated soil erosion that was set in motion by the clearing of these lands.

Under natural conditions, soils had been formed and their surfaces clothed with vegetation. Geologic erosion, which had reduced the area to a plain trenched only by the more active streams, had brought about a stable condition under which soil formation approximately kept pace with soil removal. The abundant plant cover protected the surface of the land and contributed to the maintenance of soils. Human occupation disturbed this balance and brought about new conditions wherein the land was denuded of its forest cover; grasses were grown over only a small part of the area farmed, and small grains and intertilled crops occupied increasing areas.

The rains fell on extensive and periodically unprotected surfaces; plowing and cultivation disturbed the soil; stored organic matter in the surface layer was burned out by fire under pioneer methods of land clearing or was slowly oxidized by the atmosphere under conditions of cultivation. Water flowed more rapidly across the even, gently sloping fields of these limestone soils, and accelerated water erosion began to take its toll.

The conservation survey shows that 13 percent of the area of these limestone soils has been slightly eroded, nearly 60 percent moderately eroded, and approximately 27 percent has been more severely eroded. Most of the original topsoil has been carried away from 2 percent of these soils, the best soils in southeastern Pennsylvania.

Because of these losses crop yields have decreased in some small areas and expenditures for purchased fertilizing materials have increased rather generally. Figures from the United States censuses show that the farmers of Lancaster County were using twice as much purchased fertilizer in 1935 as in 1910. They are maintaining crop yields but at an expense that must be incurred annually and must be paid for by the crops grown and marketed each year.

#### SHALLOW WELL-DRAINED SOILS FROM HIGHLY CALCAREOUS MATERIALS, GROUP 1b

Associated physically with the soils of the limestone plain are those of group 1b, which are chiefly on the slopes leading down from the plain to the intersecting streams. On these slopes the soils have not been completely developed. The surface soil is not commonly separated by any distinct subsoil layer from the underlying partly weathered parent material on which it has been developed. Geologic erosion has here prevented the formation of a mature soil even under natural conditions.

Hollinger silt loam and Pequea silt loam occupy 8,416 acres out of a total area of 9,069 acres, and Pequea gravelly silt loam and stony silt loam, on even more sloping areas, make up the remainder.

The slopes of all these soil types are steep, 67.4 percent having an inclination of 12 or more feet in 100. This is reflected in the present uses of the land, about 59 percent being under cultivation, 14 in pasture, 15 in woods, and 12 in other uses.

In spite of the greater proportionate area in pasture and woodland, the steeper slopes in this group have led to the moderate or moderately severe erosion on a little over 70 percent of its area and the severe or very severe erosion on 24.5 percent more. In this case the relationship of slope to erosion, even with fairly good protection by vegetation, is clear.

#### IMPERFECTLY DRAINED SOILS FROM LIMESTONE, GROUP 2

Group 2 is made up of the imperfectly drained soils within this upland limestone area. They are chiefly on nearly flat or gently sloping areas where the accumulation of materials carried down from higher lying positions has given rise to colluvial soils. These include Lawrence silt loam and the colluvial phases of Conestoga, Duffield, Hagerstown, and Pequea silt loams. Of these the Conestoga and Duffield phases are most extensive, covering 5,776 acres

of the total area of 6,149 acres in the group.

Cropland occupies 4,204 acres, or 68.4 percent of the group, and pasture 30.1 percent more, leaving insignificant areas in woodland or other uses.

The slopes on more than 97 percent of their area are less than 3 percent and on more than 99 percent, less than 6 percent. This would be expected from their mode of formation—deposition of material eroded from higher-lying land.

These are colluvial soils, and 96.4 percent of their area consists of recently deposited material. Only 1.6 percent has been slightly eroded, and 123 acres have been more severely affected.

The slight concentration of pastured areas on these soils is significant of their ability to maintain a sod cover and of the fact that they cannot be worked for cropping to such good advantage as the surrounding well-drained upland soils.

#### WELL-DRAINED UPLAND SOILS FROM GNEISS AND SCHISTS, COMPLETE PRO- FILES, GROUP 3a

The soils of group 3a have been developed as residual soils on the rather highly crystalline rocks of the old Piedmont plateau. They occur chiefly in the southern and southeastern parts of the area and are classified as members of the Chester series.

The Chester soils are developed on the definitely crystalline rocks of the Piedmont plateau, chiefly gneisses and crystalline schists. They contain various amounts of mica and occur on undulating to hilly relief. They are well drained. The surface soils are yellowish brown to brown and the subsoils reddish brown to brown. They are important areally, since they cover 30,687 acres, or 7.6 percent of the entire area. About the same crops are grown on them as on the limestone soils, but yields are commonly not so high. About 72 percent of their area is in cropland, 18.4 percent is woodland, 5.1 percent is pastured, and the remainder is idle or in other uses.

The rolling character of their surface is shown by the fact that only 5 percent is classed as A slopes, 79 as B or BB, and 16 as C or D slopes.

Only 0.2 percent of the area of the Chester series is not eroded, 13.3 has been slightly eroded, 40.1 moderately eroded, and 41.5 has been affected by moderately severe erosion. Severe or very severe erosion has occurred on nearly 5 percent of the group. The prevalence of erosion is closely related to the rolling surface, to the large proportion of land under cultivation, and to the nature of the soil materials themselves.

#### WELL-DRAINED UPLAND SOILS FROM SCHIST, INCOMPLETE PROFILES, GROUP 3b

The soils of group 3b, the Manor series, occur on the more rolling and hilly parts of the area, which are chiefly along its southern and southwestern boundary. They have been developed on micaceous and chloritic schists and phyllites, and gneiss and contain numerous platy fragments of the original rock in both the surface soil and subsoil. They vary considerably in depth, and in some locations the broken rock directly underlies the surface soil. Geologic erosion has been active, and erosion under cultivation has been decidedly accelerated.

The surface soils of the Manor series are dark gray to grayish brown, and the subsoils are red to reddish brown and friable. Both are characterized by a high content of finely divided micaceous material, which gives them a greasy feel. The total depth of soil is commonly less than in the Chester soils.

The crops common to the region are grown on these soils, but yields, as reported, are decreasing rather sharply, probably owing to the effects of accelerated erosion.

The slope classes are clearly related to the prevailing land use. Less than 5 percent of the area of Manor soils has a slope of less than 8 percent, and 74.6 percent has a slope of 15 percent or more. Nearly 44 percent of their area is in woodland, almost 41 is in crops, 6.6 is in pasture, and 7.2 is idle. This is in sharp contrast with the soils of the Chester series and more so with those on the limestone lands.

The Manor soils have more accelerated erosion than either groups 1 or 2. Twenty-four percent of their area has been slightly eroded, and nearly 19 percent has been moderately eroded, but moderately severe, severe, or very severe erosion has occurred on 56.7 percent. Thus, in spite of the fact that a large part of the Manor soils has been left in woodland or used for pasture, erosion is very marked. All cropped lands are in need of protection, and measures need to be adopted to give greater protection to pastures and better management of woodland, including the exclusion of grazing from woodlands.

#### SOILS OF THE QUARTZITE RIDGES, GROUP 4

The soils of group 4, the Edgemont series, have been derived from the quartzites and quartz schists in the Welsh Mountains and along the north-eastern boundary of the limestone valleys and on some of the elevations in the southern part of the area. The surface soils are grayish yellow to yellow and the subsoils pale yellow to lemon yellow and decidedly friable. Surface and internal drainage are commonly good. Evidences of accelerated erosion are not so marked on the Edgemont soils as on those of the Manor or the Chester series.

Cropland occupies a little more than 45 percent of the Edgemont soils. Woodland covers 47 percent and pasture a little less than 4. Idle land and other uses account for the remaining 4 percent.

The slopes of 51 percent of this series are less than 8 percent and range from 8 to 15 on 32.4 percent. The soils of the series are gravelly or stony over 84 percent of their area, and this, rather than the existence of steep slopes, has prevented their complete use for crop production.

Over 38 percent of their area has been slightly eroded, a little over 41 percent has been moderately eroded, and in spite of the fact that nearly one-half of the area of the series is still in woodland, 20 percent has been more than moderately eroded.

## SOILS FROM DIABASE, GROUP 5

The soils of the Montalto series, group 5, have been developed by the weathering of the dark-colored igneous rocks associated with the shales of the Triassic basin or extending as long ridges through other formations. They occur principally in the northern and northeastern parts of the area, but a long, narrow area extends southeast from Mountville to Millersville. Their surface varies from gently rolling to hilly and ridged. Drainage is fairly well established in some areas, but there are large tracts in the northeastern part that are poorly drained.

The soils of the Montalto series are distinguished by the dark grayish brown to rusty-brown color of the surface soils and the dark yellowish red to dull-red stiff clay subsoils. Fragments of the parent material are common in the subsoil or even in the surface soil, and the deeper material contains large amounts of diabase in the form of either small gravel or larger stone and boulders.

Three types were recognized. The silt loam is a silty, almost stone-free type that occupies a total area of 1,693 acres. Throughout its soil section the gravelly silt loam contains small fragments of the diabase rock and the red and purple shales through which the rock has been intruded. These fragments are not large enough or numerous enough to interfere seriously with cultivation. The stony silt loam is the most extensive, covering an area of 4,466 acres, chiefly on rolling ridges.

On the group as a whole, cropland occupies 2,744 acres, or 34.0 percent of its area; 322 acres, or 4.0 percent, is in pasture; 4,502 acres, or 55.9 percent, is in woodland; 459 acres, or 5.7 percent, is idle; and the small remainder is in farmyards or other nonagricultural areas.

Forty-nine percent of the area, 3,946 acres, lies on A and B slopes, 2,248 acres on BB slopes, and the remaining 1,865 acres, or 23.1 percent, on C and D slopes.

Thirty-four acres of the series have not been eroded; 3,912 acres, or 48.6 percent, has been slightly eroded; 2,693 acres, or 33.4 percent, moderately

eroded; and 1,420 acres, or 17.6 percent, more seriously eroded. The most serious erosion has occurred chiefly on the more sloping areas of the cropland, although some of the woodland has been affected. Soils that are underlain by such stiff silt loam or clay loam subsoils do not absorb and retain water as readily as more open types, and the series is rather poorly drained internally.

## SOILS FROM SLATE OR ARGILLACEOUS SHALE, GROUP 6

The soils of group 6 have been formed by the weathering of various-colored thin-bedded shales and slates. They occur chiefly in the northern part of the area, where they occupy a series of low, rolling hills lying between the limestone plain and the Furnace Ridge of the South Mountain area. A long, low ridge of similar material, which gives rise to the same soils, extends from the vicinity of Manheim to that of Ephrata. It separates the northern portion of the limestone plain from the larger southern area. The group is made up of the Berks and Cardiff soils.

Since the shales are thin-bedded and fissile and break into small flakes, these soils are commonly referred to locally as gravel lands or slate lands.

The surface soils of the Berks series are dark gray to brownish yellow. The subsoils vary considerably in color but are prevailing reddish brown to yellow, usually silty loams. These grade down into broken rock fragments whose open spaces are filled with silty material. Both surface soil and subsoil contain some shale fragments.

By far the greatest area of this group—76 percent—is covered by a brown phase of Berks shaly silt loam, which differs from the typical Berks in that the subsoil is brown or reddish brown instead of gray or yellow. Berks silt loam and its brown phase contain noticeably fewer shaly fragments, even in the subsoil, than the shaly silt loam.

The soils of the Cardiff series are formed on slates. The surface soils are grayish or yellowish brown, and the subsoils are a dull yellowish gray. Cardiff slaty silt loam is the most ex-

tensive soil in the series. The soil and subsoil are filled with small fragments of slate, and the underlying material is a mass of partly disintegrated slate with little or no fine earth held in it.

The Berks and Cardiff soils occupy rolling hills and undulating uplands with smoothly rounded slopes. They have good natural drainage. Eighty percent of the group is occupied by crops, 5.8 percent is in pasture, and 9.6 percent is in woodland.

The slopes on these soils are moderate to rather steep—48.9 percent lies on A and B slopes, 23.9 percent on BB slopes, and 27.2 percent on C and D slopes.

Because the surface is rolling and most of the area is annually under cultivation, erosion has progressed rapidly on the Berks and Cardiff soils. The conservation survey shows that no area is entirely unaffected by erosion and that less than 10 percent of the area has been only slightly eroded. Moderate erosion has occurred on almost 45 percent, moderately severe erosion on nearly 42, and severe or very severe erosion on 3.6 percent.

The effects of erosion would be much more marked except for the rapidity with which the soft, claylike parent material of the underlying rocks is weathered into silty loam filled with shale chips. These are broken down by cultivation and disintegrated by frost and rain. It is probable that on many fields on the steeper slopes the original surface soil was long ago carried away and that new surface soil is being created, slowly, while the land is under cultivation.

Extra effort is required in handling these soil types in order to maintain a desirable amount of organic matter in the surface soil and extra use of chemical fertilizers is required to sustain crop yields. The group is one requiring the application of soil conservation measures over all its area—cropland, pasture, and woodland alike.

#### SOILS FROM TRIASSIC SANDSTONE AND SHALE, GROUP 7

The soils of group 7 occur extensively in the northern and northeastern parts of the area along the boundary lines

between Lancaster County and Lebanon and Berks Counties. They are developed on rocks of the Triassic age, which not only are of much more recent geologic origin than the other consolidated rocks of the area but contrast with them strongly. The igneous rocks, intruded through and between the dominant conglomerates, sandstones, and shales, give rise to the Montalto soils, already described. The sedimentary rocks, laid down in an old sea basin, range from coarse conglomerates, or "pebble stones," to sandstones and shales. They range in color from dark red to gray and yellow. These colors are original in the parent rock material, and they are inherited by the soils that overlie them.

The soils formed on the distinctly red sandstones and shales are classed as the Penn series. The surface soils are gray to grayish brown and are underlain by bright to dark-red subsoils. The disintegrated bedrock under the soil horizons varies from a pink color, where some admixture of white quartz sand or gravel modifies the deeper red, to the dark Indian red of the shales and sandy shales.

The soils formed on the lighter-colored shales and sandstones have dark-gray to grayish-brown surface soils and gray to brown subsoils. These are classed as the Lansdale series. These soils are relatively small in extent and differ from the Penn series chiefly in their color, although they have somewhat less slope and usually are not so stony.

Wherever the two series were so intimately intermingled that they could not be separated even on a map of the scale of 4 inches to the mile, the Penn-Lansdale soil complex was mapped.

Five types were mapped in the Penn series. Penn gravelly loam is most extensive and Penn stony loam is almost equal in area. The gravelly silt loam, the silt loam, and the stony silt loam occupy smaller areas.

Gravelly loam and loam types were mapped in both the Lansdale series and the Penn-Lansdale complex, and a small area of the Lansdale stony loam was recognized.

The smoother, less sloping areas of

these soils are farmed to the usual staple crops of the area and are good agricultural soils although not so productive as the soils derived from the limestones of the valley and plain.

They are commonly well drained internally but are very susceptible to soil erosion on steeper slopes kept in cultivation.

This group is second only to the limestone soils in area, occupying 70,040 acres, or 17.4 percent of the entire area.

The group is distinguished by 25,406 acres of stony types, more than 36 percent of its total area. On such areas the stones are large enough and numerous enough to constitute an obstruction to cultivation, and the areas are marked by the stone fences and the piles of stones in fields where they have been gathered to permit plowing and cropping. In addition, there were mapped 29,222 acres of gravelly types, where stone was present with the gravel but was not numerous or was smaller than 1 foot in diameter.

The conservation survey shows that 51.1 percent of the area of the group is in cultivated fields, 2.8 is pastured, and 40.7 is wooded, leaving 5.4 percent in other forms of use.

The survey also disclosed that 45.9 percent of the group has a slope of less than 8 percent, 26.7 percent has a slope of 8 to 15 percent, and 27.4 percent has slopes of 15 percent or greater. Ten percent of the area of the group has slopes of 25 percent and over, being surpassed in this respect only by the soils of groups 1b and 3b. A combination of stony condition and of rather steep slopes has resulted in the utilization of nearly 41 percent of the group for woodland. Only a little more than one-half of its area is in cultivated fields.

Almost all the area covered by these soils has been eroded to some degree. On 36.7 percent of their area slight erosion has occurred; on nearly 33 the erosion has been moderate; on a little over 30 it has been moderately severe to severe. It is a matter of field observation that cultivated fields are rather easily eroded, and, while some renewal of surface soil is taking place under good systems of crop rotation, there is a constant loss of soil from cultivated

lands on all except the most nearly level fields. The establishment of good pasture sod on a much larger proportion of these soils would be a good protective practice.

#### IMPERFECTLY OR POORLY DRAINED UPLAND SOILS FROM SANDSTONE AND SHALE, GROUP 8

As in the soils developed on limestones, there are areas of poorly drained soils scattered through the prevalent well-drained upland soils of the other upland groups. These make up group 8. Some of these areas are merely colluvial deposits derived from soil wash of closely related types, such as the colluvial phases of Berks silt loam, Edgemont silt loam, and Penn silt loam, and the Glenville silt loam, which occurs associated with the Chester soils. The imperfect to poor drainage of Croton loam and silt loam results from the formation of a hardpan or claypan at a depth of 14 to 20 inches below the surface. The Croton soils make up 3,698 acres, or more than 52 percent of these poorly drained upland soils associated with the soils of the crystalline and shale rock areas. They have grayish-brown to gray surface soils and yellow or mottled yellow and grayish or light-gray subsurface layers. The subsoils consist of a compact hardpan-like layer of chocolate red or mottled pink and yellow, often containing concretionary material. The underlying bedrock, either dark-colored argillite or a chocolate-red Triassic shale, lies at a depth of about 3 feet. The hardpan layer prevents good drainage and aeration and the complete oxidation of the soil material. The soils occur on rather flat, imperfectly drained plateau areas into which very few streams have cut to establish drainage.

Material has been deposited on 20.7 percent of this area, chiefly on the colluvial soils. Slight erosion has occurred on 34.4 percent, moderate erosion on a little over 40, and greater than moderate erosion on only 4 percent of the area.

Drainage seems to be as serious a problem on these soils as erosion prevention. A major cause for the poor

drainage of these soils is the fact that nearly 94 percent of their area lies on A and B slopes and only 0.5 percent on D slopes.

Over 35 percent of the area of these imperfectly drained upland soils is in crops, a little over 27 is wooded, nearly 28 is in pasture, and the remainder is either unused or in farmyards and other miscellaneous uses.

#### SOILS FROM METAMORPHOSED SANDSTONE AND SHALE, GROUP 9

Closely associated with the soils of the Lansdale and Penn series are those of the Brecknock series (group 9), developed on the baked and metamorphosed shales of the Triassic rocks. These occur chiefly on the ridges north of Churchtown, although there are other small areas in the northern part of the area. These soils are characterized by a dull-gray color in both surface soil and subsoil and by a bluish slaty material in the subsoil, which increases in proportion as the underlying parent material is approached. Some diabase is present with the baked shales. The relief ranges from gentle slopes to steeply sloping ridges and ridge crests. Internal drainage is usually good.

Fifty-four and seven-tenths percent of the area of the group occurs on A and B slopes, 35.7 on BB slopes, and only 9.6 percent on C and D slopes. Almost 44 percent of the series has been slightly eroded, 39.5 has been moderately eroded, and a little over 16 has been more seriously affected.

The farm crops common to the area are grown, and there is a small acreage of tobacco. Almost 52 percent of the series is under cultivation, a little over 42 is in woodland, only 2.8 is in pasture, and the remainder is in farmyards and other uses.

#### TERRACE SOILS, GROUP 10

At some former time the larger streams of the area have built terraces at isolated places along their courses, which are now above the level of stream overflow and of further deposition of materials. The soils on these terraces make up group 10.

Where the terrace material was derived from the reddish areas of the Triassic upland, these terrace soils have dark grayish brown surface soils and brownish-red to red subsoils. A thin gravelly layer commonly lies below the subsoils. Such terrace areas are mapped as Birdsboro silt loam.

Along Conestoga Creek similar terrace soils derived from the calcareous upland material have grayish-brown surface soils and light reddish brown to deep-red subsoils. They overlie a substratum of well-rounded water-worn gravels. They are mapped as Elk gravelly silt loam.

The somewhat similar terrace soils that are derived chiefly from the calcareous mica schist of the upland, are mapped as Engleside loam. They have dark-brown mellow loam surface soils and dull-brown friable heavy sandy loam subsoils. Below 34 inches this rests on a firm clay loam containing a noticeable amount of fine and medium sand.

With all these terrace soils the internal drainage is good, the surface is nearly level or gently sloping except at their edges, and they are productive enough to bring about the occupation of 75.6 percent of their area for crops. Nearly 16 percent is in woodland, 4.7 is in pasture, and only about 4 percent has other uses. Nearly 71 percent has been affected by moderate erosion, 14.2 by slight erosion, and nearly 13 by more severe washing. The more sloping fields under cultivation require some protection from soil erosion, especially since these soils are valuable for the production of all the staple field crops and for some of the specialized truck and canning crops.

#### WELL-DRAINED ALLUVIAL SOILS, GROUP 11

The soils that have been formed by more recent stream deposition, some of which are still subject to overflow, fall into two groups, depending on their present condition of drainage. The well-drained alluvial soils, Bermudian silt loam and Huntington silt loam, make up group 11.

Bermudian silt loam, along the

streams in the northern part of the area, has been laid down from materials derived from the red Triassic uplands. The surface soil is gray or reddish brown, the subsoil a dull red, rusty brown, or even mottled in the lower part.

Huntington silt loam consists of materials derived chiefly from the upland limestone soils. The surface soil is dark brown to grayish brown, and the subsoil is dark grayish brown.

Even though these soils are well drained, they are so closely associated with the poorly drained alluvial soils and lie in such small areas that they are not singled out for cultivation, and only 20.9 percent of their area is cropped. On the other hand, 68.5 percent is in pasture and 8.4 in woods. Nearly 99 percent of their area lies on A and B slopes, and 97.4 percent of their area has been subject to recent deposition of material. This group needs protection from overflow and from stream-bank erosion rather than from sheet and gully erosion.

#### IMPERFECTLY OR POORLY DRAINED ALLUVIAL SOILS, GROUP 12

Alluvial material deposited along streams, where it is subject to frequent overflow or occupies low positions, is imperfectly or poorly drained. The imperfectly or poorly drained alluvial soils make up group 12.

Materials from the wide variety of upland soils are being carried downstream and deposited as the force of floodwaters is checked. The character of these low-lying, imperfectly or poorly drained, recent soils depends to a large extent on the source of the upland material laid down. Thus, bottom lands where the wash is chiefly from the red soils of the Penn series have the reddish-brown surface soils of the Bowmansville series underlain by grayish-brown loam or silty clay loam subsoil that is mottled with red in places. Internal drainage of Bowmansville silt loam is poor, and the areas that it occupies are subject to periodic overflow.

In bottom lands where materials from the soils of the limestones have

contributed chiefly to the deposition, Lindside silt loam has been deposited. The surface soil is brown or grayish-brown silt loam, ranging from 10 to 18 inches in depth. The subsoil is gray or bluish-gray clay or silty clay. The deeper material is usually mottled. Some gravel and rock fragments occur at various depths. The internal drainage is imperfect.

The other alluvial soil types have relatively small areas. Their descriptions will be found in the appendix.

The surface of these flood-plain soils is almost flat, 98.5 percent having a slope of less than 3 feet in 100 (A slopes). Approximately 73 percent of their area is utilized for pastures, 10 percent for woodland, and only 13 percent for crops. There is almost no erosion on these soils, but deposition is taking place on 98.8 percent of their area, or 13,914 acres, and this accumulation distinctly represents even greater losses of well-drained upland soils since it does not account for similar material carried on downstream or deposited in reservoirs and ponds. It is convincing evidence of the losses sustained annually by upland farms.

#### *Analysis of Erosion Data*

The Conestoga area is probably as little affected by extreme conditions of soils, slope, and land use as any tract within the older agricultural areas of northeastern United States. Agriculture has been practiced for more than 200 years. Land uses and farm practices have become stabilized by the many generations who have farmed these lands, adapting their methods to the soil and climatic conditions and changing them gradually to meet improvements in agriculture and successive demands for different agricultural products.

Yet the soils of the area range in crop occupation from 88 percent on the well-drained upland limestone soils to 13 percent on the poorly drained soils of the alluvial bottom lands. Their slopes range from almost level on the alluvial and terrace soils to 15 percent or more on large areas of the Pequea, Manor, Berks, Penn, and Lansdale soils. The

soils range in texture from the soft silty loams that predominate on the limestone plains to the sandy, gravelly, and stony textures in the Montalto, Edgemont, and Penn series. Most of the soils are well drained internally, but the gently sloping colluvial soils of the upland and the flat soils of the overflowed flood plains are imperfectly to poorly drained.

It is difficult to determine the dominant factor in soil erosion. Running water is the chief agent wearing away the soil in the Conestoga area, and the form, intensity, and duration of precipitation largely determine the amount of running water. Rainfall, as well as other climatic conditions, is similar over this relatively small area, but three factors, mapped in the conservation survey, influence its effect.

The nature of the soil material itself exerts a great influence. Some soils are porous and absorb rainfall and water from melting snow whereas others are fine textured and dense and tend to shed water and turn it away as run-off.

The soils vary in texture, but most of the area has a soft silty surface soil. This "fine earth," even where gravel or stone is present, tends to seal the surface pores of the soil and interfere with the infiltration of surface water. It is also easily picked up and carried away by gently flowing water. Some erosion occurs even on the more gentle slopes unless they are fully protected by vegetation.

The relationships between the different soil groups and erosion are shown in table 11.

Slope exerts a strong influence on the speed of running water, and, other things being equal, speed determines the load of soil debris running water can carry. Doubling its speed increases its carrying capacity for suspended material manifold. Thus modification of the effects of slope by vegetative and engineering controls is essential in soil conservation.

The relationships between erosion and slopes are given in table 12.

The character of the vegetation also

TABLE 11.—Distribution of erosion in each soil group

| Soil group       | Recent alluvial and colluvial deposits |      | No apparent erosion |      | Slight erosion |      | Moderate erosion |      | Moderately severe erosion |      | Severe erosion |      | Very severe erosion |      | Total   |
|------------------|----------------------------------------|------|---------------------|------|----------------|------|------------------|------|---------------------------|------|----------------|------|---------------------|------|---------|
|                  | Acres                                  | Pct. | Acres               | Pct. | Acres          | Pct. | Acres            | Pct. | Acres                     | Pct. | Acres          | Pct. | Acres               | Pct. | Acres   |
| 1a.....          | 111                                    | 0.1  | 5                   | (1)  | 23,413         | 13.1 | 106,822          | 59.9 | 44,211                    | 24.8 | 3,479          | 2.0  | 194                 | 0.1  | 178,235 |
| 1b.....          | 16                                     | .2   | 0                   | ---  | 474            | 5.2  | 1,536            | 16.9 | 4,822                     | 53.2 | 2,093          | 23.1 | 123                 | 1.4  | 9,069   |
| 2.....           | 5,925                                  | 96.4 | 0                   | ---  | 101            | 1.6  | 67               | 1.1  | 43                        | .7   | 13             | .2   | 0                   | ---  | 6,149   |
| 3a.....          | 20                                     | .1   | 61                  | 0.2  | 4,068          | 13.3 | 12,305           | 40.1 | 12,745                    | 41.5 | 1,329          | 4.3  | 159                 | .5   | 30,687  |
| 3b.....          | 10                                     | .1   | 110                 | .6   | 4,457          | 24.0 | 3,445            | 18.6 | 7,934                     | 42.7 | 2,009          | 10.8 | 585                 | 3.2  | 18,553  |
| 4.....           | 10                                     | (1)  | 105                 | .4   | 9,798          | 38.3 | 10,556           | 41.3 | 4,427                     | 17.3 | 546            | 2.2  | 136                 | .5   | 25,578  |
| 5.....           | 0                                      | ---  | 34                  | .4   | 3,912          | 48.6 | 2,693            | 33.4 | 1,115                     | 13.8 | 300            | 3.7  | 5                   | .1   | 8,059   |
| 6.....           | 22                                     | .1   | 0                   | ---  | 2,119          | 9.5  | 9,978            | 44.9 | 9,322                     | 41.9 | 749            | 3.4  | 49                  | .2   | 22,239  |
| 7.....           | 45                                     | .1   | 22                  | (1)  | 25,704         | 36.7 | 23,050           | 32.9 | 18,668                    | 26.6 | 2,152          | 3.1  | 399                 | .6   | 70,040  |
| 8.....           | 1,464                                  | 20.7 | 34                  | .5   | 2,427          | 34.4 | 2,852            | 40.4 | 253                       | 3.6  | 29             | .4   | 0                   | ---  | 7,059   |
| 9.....           | 37                                     | .5   | 0                   | ---  | 2,943          | 43.9 | 2,647            | 39.5 | 973                       | 14.5 | 84             | 1.3  | 21                  | .3   | 6,705   |
| 10.....          | 24                                     | 2.3  | 0                   | ---  | 146            | 14.2 | 725              | 70.6 | 129                       | 12.6 | 3              | .3   | 0                   | ---  | 1,027   |
| 11.....          | 4,726                                  | 97.4 | 0                   | ---  | 50             | 1.0  | 14               | .3   | 37                        | .8   | 25             | .5   | 0                   | ---  | 4,852   |
| 12.....          | 13,914                                 | 98.8 | 0                   | ---  | 91             | .6   | 40               | .3   | 39                        | .3   | 4              | (1)  | 0                   | ---  | 14,088  |
| Entire area..... | 26,324                                 | 6.6  | 371                 | .1   | 79,703         | 19.8 | 176,730          | 43.9 | 104,718                   | 26.0 | 12,815         | 3.2  | 1,679               | .4   | 402,340 |

<sup>1</sup> Less than 0.1 percent.

TABLE 12.—Distribution of erosion in each slope class

| Erosion group                               | A slopes |       | B slopes |       | BB slopes |       | C slopes |       | D slopes |       | Entire area |       |
|---------------------------------------------|----------|-------|----------|-------|-----------|-------|----------|-------|----------|-------|-------------|-------|
|                                             | Acres    | Pct.  | Acres    | Pct.  | Acres     | Pct.  | Acres    | Pct.  | Acres    | Pct.  | Acres       | Pct.  |
| Recent alluvial and colluvial deposits..... | 25,984   | 27.6  | 333      | 0.2   | 0         | ---   | 6        | (1)   | 0        | ---   | 26,323      | 6.5   |
| No apparent erosion.....                    | 45       | (1)   | 84       | .1    | 137       | 0.2   | 80       | 0.2   | 26       | .1    | 372         | .1    |
| Slight erosion.....                         | 17,893   | 18.9  | 21,121   | 12.7  | 16,928    | 20.9  | 12,668   | 33.6  | 11,094   | 48.2  | 79,704      | 19.8  |
| Moderate erosion.....                       | 49,293   | 52.2  | 100,685  | 60.6  | 16,313    | 20.1  | 5,712    | 15.1  | 4,725    | 20.6  | 176,728     | 43.9  |
| Moderately severe erosion.....              | 1,272    | 1.3   | 42,271   | 25.5  | 42,072    | 51.9  | 14,559   | 38.5  | 4,544    | 19.8  | 104,718     | 26.1  |
| Severe erosion.....                         | 27       | (1)   | 1,430    | .9    | 5,131     | 6.3   | 3,875    | 10.3  | 2,352    | 10.2  | 12,815      | 3.2   |
| Very severe erosion.....                    | 0        | ---   | 83       | (1)   | 468       | .6    | 874      | 2.3   | 253      | 1.1   | 1,680       | .4    |
| Total.....                                  | 94,514   | 100.0 | 166,007  | 100.0 | 81,049    | 100.0 | 37,774   | 100.0 | 22,996   | 100.0 | 402,340     | 100.0 |

<sup>1</sup> Less than 0.1 percent.

strongly affects the absorption and retention of the moisture falling on the soil on any slope. First, a forest or grass cover or even the cover afforded by a strong-growing small-grain crop intercepts the impact of the rain and causes it to strike the land gently. The forest litter and undergrowth or the multitude of leaves and stems of a good grass sod or a thick-growing grain crop retard the flow of water across the surface. On the other hand lack of cover permits much more rapid run-off and normally gives rise to greater erosion damage. The presence of cover at critical periods of rainfall is also a factor.

The relationship between land use and soil erosion is shown in table 13.

All three factors—soil material, slope, and cover—may act together either to accelerate soil erosion or to retard it. Commonly there are such interactions that no one factor can be assigned as the single one that causes or prevents erosion. The actual degree of erosion is a resultant of the interaction of these three factors. The tabulation of the results of the conservation survey bring out certain relationships between soil erosion and soil materials, slope, and cover or land use.

#### EROSION ON GENTLE SLOPES

Four soil groups were least affected by soil erosion, the alluvial soils of the bottom lands (groups 11 and 12) and the colluvial soils of the upland (groups 2 and 8). All are recently transported soils to which soil-forming material is being added rather than removed. In relation to surrounding soils they oc-

cupy low-lying positions. Most of these areas have a slope of less than 6 percent. They vary considerably in land use or cover. Of the colluvial soils of the limestone upland, 68.4 percent of their area is cropped; about 30 percent is in pasture; less than 1 percent is wooded. This is in marked contrast with the well-drained alluvial soils, which have crops on only about 21 percent of their area, are pastured on 68.5, and support woodlands on about 8 percent. The colluvial limestone soils have been affected by only slight erosion or by actual deposition on 98.0 percent of their area; the well-drained alluvial soils on 98.4 percent of their area. That soil erosion is not a problem on either group is due to a combination of position and slope and is not the result of land use. The poorly drained alluvial soils have been even better protected by woodland and pasture cover and have been modified chiefly by the deposition of additional material rather than by erosion. The colluvial soils derived from the upland crystalline materials have been more seriously eroded, although they are fairly well protected—28 percent of their area is in pasture and 27 percent in woodland.

#### EROSION ON STEEP SLOPES

The other extreme of slope is represented by the soils of group 1b—the Hollinger and Pequea soils—and those of group 3b—the Manor soils. Over 67 percent of the Hollinger and Pequea soils and over 74 percent of the Manor soils are on C and D slopes. No other

TABLE 13.—*Distribution of erosion in each land use class*

| Erosion group                               | Cropland     |             | Idle land    |             | Pasture      |             | Woodland     |             | Farmyards and urban areas |             | Entire area  |             |
|---------------------------------------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|---------------------------|-------------|--------------|-------------|
|                                             | <i>Acres</i> | <i>Pct.</i> | <i>Acres</i> | <i>Pct.</i> | <i>Acres</i> | <i>Pct.</i> | <i>Acres</i> | <i>Pct.</i> | <i>Acres</i>              | <i>Pct.</i> | <i>Acres</i> | <i>Pct.</i> |
| Recent alluvial and colluvial deposits..... | 7,636        | 2.8         | 644          | 7.0         | 16,064       | 46.5        | 1,966        | 2.8         | 13                        | 0.1         | 26,323       | 6.5         |
| No apparent erosion.....                    | 0            |             | 0            |             | 6            | (1)         | 366          | .5          | 0                         |             | 372          | .1          |
| Slight erosion.....                         | 14,489       | 5.3         | 328          | 3.6         | 2,410        | 7.0         | 48,884       | 69.4        | 13,593                    | 97.5        | 79,704       | 19.8        |
| Moderate erosion.....                       | 148,750      | 54.3        | 1,953        | 21.2        | 9,463        | 27.4        | 16,300       | 23.1        | 262                       | 1.9         | 176,728      | 43.9        |
| Moderately severe erosion.....              | 92,661       | 33.8        | 3,761        | 40.6        | 5,600        | 16.2        | 2,646        | 3.8         | 50                        | .4          | 104,718      | 26.1        |
| Severe erosion.....                         | 9,723        | 3.5         | 2,000        | 21.7        | 825          | 2.4         | 260          | .4          | 7                         | .1          | 12,815       | 3.2         |
| Very severe erosion.....                    | 948          | .3          | 548          | 5.9         | 163          | .5          | 21           | (1)         | 0                         |             | 1,680        | .4          |
| Total.....                                  | 274,207      | 100.0       | 9,234        | 100.0       | 34,531       | 100.0       | 70,443       | 100.0       | 13,925                    | 100.0       | 402,340      | 100.0       |

<sup>1</sup> Less than 0.1 percent.

soil groups approach these two in the proportionate extent of steep slopes.

The Hollinger and Pequea soils have been affected by moderately severe, severe, or very severe erosion on 77.7 percent of their area, the Manor soils on but 56.7. Obviously some factor other than steepness of slope enters. The survey showed that nearly 59 percent of the area of the Hollinger and Pequea soils was in cropland, about 15 was wooded, about 14 was in pasture, and nearly 12 was idle or used for other purposes. By contrast, only about 41 percent of the area of the Manor group was in cropland, whereas about 44 was in woodland and 6.6 was pastured. The two groups were affected by about equal degrees of erosion on their wooded areas, but the Hollinger and Pequea soils were much more severely eroded on their cropped areas, which greatly exceeded those of the Manor soils in proportionate extent. Clearly, on these two groups, closely comparable in slope, the difference in land use has resulted in more severe erosion on the Hollinger and Pequea soils.

#### EROSION ON DOMINANTLY WOODED AREAS

On the Edgemont (group 4) and the Montalto (group 5) soils, another element enters to influence soil erosion. Both groups are characterized by moderate slopes and by a high proportionate area of woodland, nearly 56 percent of the Montalto and about 47 of the Edgemont. The woodland cover was retained on these soils because the surface is stony over large areas and is not suited to the use of farm machinery. This is particularly true of the "iron-stone ridges" of Montalto stony silt loam. The most useful comparison of erosion on the two groups is with differences in cover. The more completely wooded and less cultivated Montalto soils have been affected by more than slight erosion on 51.0 percent of their area as compared with 61.3 percent of the Edgemont soils. Less intensive cultivation of the Montalto soils, owing to the presence of more stones on the surface, is probably the chief cause of the difference in severity of erosion.

#### EROSION DIRECTLY RELATED TO SLOPE

Group 7, the Penn and Lansdale soils, and group 9, the Brecknock soils, give another enlightening comparison. On each group about 51 percent of the area is cropped, 2.8 percent of each is in pasture, and slightly more than 40 is wooded. The land use on the two groups is so nearly identical that this erosion-control factor is eliminated. This makes possible a direct comparison between slope and erosion, since the nature of the soils is not markedly different. A summary of the slope and erosion data on these two groups (table 14) permits direct comparison. It is obvious that under closely comparable conditions of land use, or cover, the more steeply sloping Penn and Lansdale soils have been much more severely eroded than the Brecknock soils.

TABLE 14.—*Summary of slopes and erosion conditions on soil groups 7 and 9*

| Erosion and slope          | Penn and Lansdale soils | Brecknock soils |
|----------------------------|-------------------------|-----------------|
| Slopes:                    | <i>Percent</i>          | <i>Percent</i>  |
| A and B.....               | 45.9                    | 54.7            |
| BB.....                    | 26.7                    | 35.7            |
| C and D.....               | 27.4                    | 9.6             |
| Erosion:                   |                         |                 |
| Slight.....                | 36.7                    | 43.9            |
| Moderate.....              | 32.9                    | 39.5            |
| Greater than moderate..... | 30.3                    | 16.1            |

#### SUMMARY OF THE RELATION OF EROSION TO SOIL, SLOPE, AND COVER

Summarizing this analysis, therefore, the nature of the cover exerts only a minor influence on erosion on areas having gentle slopes, such as the alluvial and colluvial soils. In fact, owing to their low-lying position, all these areas are the recipients of material eroded from higher areas. Aside from stream-bank erosion on some of the recent alluvial soils, removal of soil material is of minor significance. On those soil groups having steep slopes, the cover—woodland—clearly dominates the extent of erosion. With slopes that are comparable, cover exerts the strongest influence on soil erosion. Evidently, on all except nearly flat lands, cover is a very important factor in erosion control. With cover comparable (soil groups 7

and 9), the slope is the decisive factor in soil erosion.

Between groups 3a (Chester series) and 6 there seems to be an offset between the two influences of steepness of slope and adequacy of cover. The Chester soils have moderate to gentle slopes, and group 6 (predominately Berks soils) has more C and D slopes and a smaller area of BB slopes. Over 72 percent of the Chester soils is occupied by cropped lands; 80 percent of group 6 is cropped. The percentage of land affected by moderate or greater than moderate erosion is slightly greater on group 6. Small gullies on tilled fields are prevalent on both groups.

As has been pointed out, the well-drained limestone soils of the upland stand by themselves in most respects. Their total area of 178,235 acres comprises 44.3 percent of the entire survey area. The group is made up almost entirely of soft silty soils. Only 2.1 percent of their area lies on C and D slopes. Over 88 percent of their area is cropped; in fact, they carry 58 percent of all the cropland of the area and undoubtedly produce as much as two-thirds of all the crop yields.

Nearly 60 percent of their area has already been moderately eroded; that is, 25 to 50 percent of their topsoil has been removed. Almost 27 percent has been more severely eroded. Therefore, erosion prevention on these very valuable soils constitutes a major agricultural problem, not only in the Conestoga and Pequea watersheds but wherever they occur.

Since but 2 percent of the total area of these limestone soils is at all steep, it is not reasonable to recommend any extensive reforestation of slopes to prevent advancing soil erosion. The fact that only 4.6 percent of the limestone soils is occupied by permanent pasture shows that their area is in such great demand for crops that even pasture is being crowded off them. The problem of erosion prevention, then, becomes one that cannot be solved by changing land use to include greater areas of permanent, protective vegetation, such as forest and pasture. It resolves itself into the adoption of measures that will permit the most

complete possible use of the land for crop production with the least possible loss of soil through water erosion.

The same considerations bear on the uses of the soils of the Berks, Chester, Edgemont, and Penn series, making up the other extensively cropped soils of the area.

Soil-erosion prevention is thus decidedly soil conservation, and that is nothing more nor less than making such present use of each acre as to insure its continued future usefulness.

## Use of the Conservation Survey in Farm Planning

THE conservation survey is a record of the physical nature of the land. It is necessary for the planning of improved land use and control of soil erosion in full accord with the capability of each tract. Specific uses of the survey can best be discussed by referring to one of the farms for which erosion-control practices have been outlined in detail.

The Soil Conservation Service in 1935 established a project for the demonstration of the most effective measures for erosion control on farm lands in the watershed of the West Branch of Octoraro Creek, which is immediately to the southeast of the Conestoga area. In connection with this project, a camp of the Civilian Conservation Corps was located at Lancaster. Camp operations, demonstrating soil conservation methods, have been carried out on a number of farms scattered over the Conestoga area.

A farm owner or operator within the limits of the work area who believes that his land requires protection against soil erosion can make application to the Soil Conservation Service for an investigation of his problems. Since a soil conservation district has been organized, his application should be made to the district supervisors. A complete map of his farm is then prepared, showing the farm boundaries and the complete conservation survey, or physical inventory, of the land. This map shows the location of each field, its present use, the areas falling within the different classes of soil and slope, the

existing condition of soil erosion and deposition, and any special features such as gullied areas, large individual gullies, or rock outcrops.

Through discussion with the farmer, a soil conservation technician learns the economic requirements of the farm, and together they decide on the most desirable acreage for each farm crop, for pasture, and for woodland. It is then possible to draw up a complete

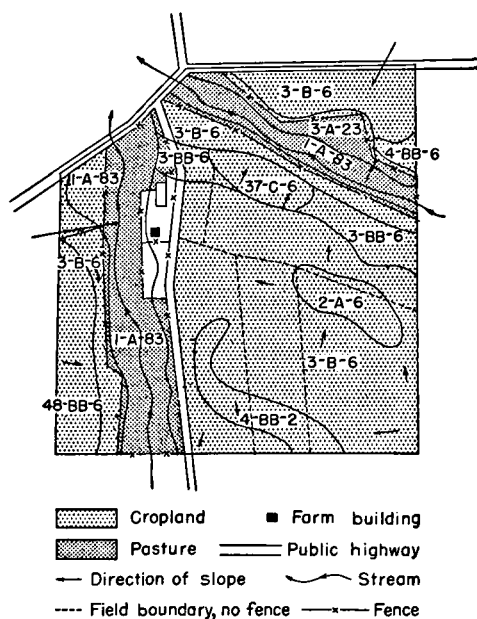


**Figure 5.**—Conservation-survey map of a 64-acre farm. Symbols show erosion—slope—soil type. Erosion legend: 1, No apparent erosion; 2, slight sheet erosion; 3, moderate sheet erosion; 37, moderate sheet erosion, occasional gullies; 4, severe sheet erosion, occasional gullies; 48, severe sheet erosion, frequent gullies. Slopes: A, less than 3 percent; B, 3–6; BB, 6–12; C, 12–18. Soils: 2, Conestoga silt loam; 6, Duffield silt loam; 23, Pequea stony silt loam; 83, Lindside silt loam.

plan for the farm, utilizing the best methods of soil conservation.

A cooperative agreement is prepared, which specifies in detail the practices that are to be followed over a period of years. Another map is made, showing in detail the necessary rearrangement of fields, any needed changes in crop areas and crop rotations, and all changes in the lay-out of field boundaries to fit physical conditions. All

details of contour strip cropping in rotation, sodding of waterways not yet developed into gullies but threatening such erosion, and water-diversion ditches that are required to conduct water harmlessly away from actual or potential gullies, are shown. All retirement of land particularly threatened with sheet or gully erosion to a cover of permanent hay or pasture is indicated, protection from grazing or any needed

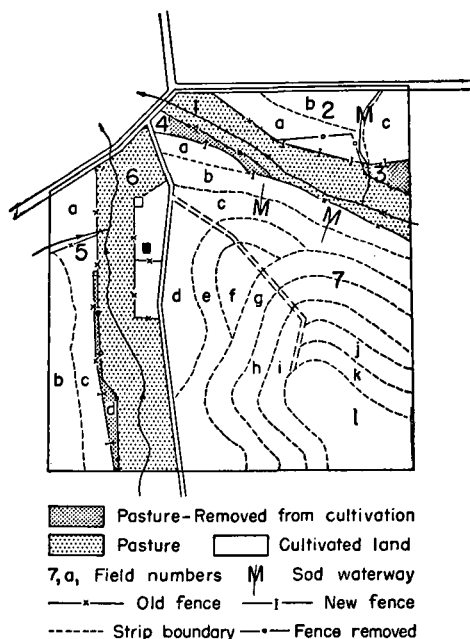


**Figure 6.**—Map of the farm shown in figure 5, showing reorganized land use. Erosion-control practices include strip cropping, contour tillage, retirement of eroded land, use of sod waterways, and improvement of permanent pastures.

improvement for wood lots is provided for, and the course of procedure is made a part of the farm plan.

In order to illustrate exactly the provisions of such a farm plan and the measures used by the farmer to establish erosion control, a typical set of maps is given (figs. 5 and 6), and the accompanying agreement is summarized.

The soil conservation survey map of this 64-acre farm is reproduced on a scale of 1 inch equals approximately 867 feet. It shows the farm boundaries, the field boundaries and fences

where these existed, the location of farm buildings and yards, the highways, and the stream courses through the farm. The direction of the slope is shown by arrows. The pasture and cultivated areas are shown by shading and the farmyard is left blank. The symbols inside the small irregular areas show the erosion conditions, the dominant slope, and the soil type.

It will be seen from the map that a small area of Conestoga silt loam (2) in the south-central part of the farm has a drop between 6 and 12 feet to 100 feet of distance (BB slope), and has lost 75 percent or more of the topsoil (class 4 erosion). All the remaining upland portion of the farm is covered by Duffield silt loam (6), which lies on slopes ranging from A slopes in the east-central part of the farm to C slopes where the upland breaks down to the streamway crossing the northern part of the farm. It is rather noticeable that the B slopes on this soil type have lost one-fourth to three-fourths of the original topsoil (class 3 erosion) over the greater part of their area, whereas one field along the southwestern boundary having a BB slope has lost three-fourths or more of the original topsoil and is becoming rather badly gullied (48 erosion). Along the courses of the two small streams that cross the northern and western parts of the farm are two areas of an alluvial soil, Lindsides silt loam (83). These areas have A slopes, and have been only slightly eroded except where water from higher lying land cuts across them, as in the northeastern part of the farm.

This is a compact, well-arranged farm located on some of the best soils of the area. The farmer was making good use of his imperfectly drained alluvial soil as permanent pasture and was practicing a customary crop rotation on his upland fields. The farm is thus representative of most of the farms located chiefly on Duffield silt loam.

The conservation-survey map (fig. 5) presents all the physical features of the farm. It does not show the farmer's economic needs to maintain the farm and the farm family. This information was secured and the new arrangement

of fields and crops was worked out by discussing present practices and desirable changes with the farmer.

It was found that a regular crop rotation consisting of 2 successive years in corn or other intertilled crop, 1 year in winter wheat, and 1 year in mixed hay could be adopted. This would provide for wheat and some corn as cash crops and enough corn, hay, and wheat straw to provide the forage and the bedding for the farm animals. In making the adjustments necessary for protection of the soil from erosion, it was found that this standard rotation could not be secured on all of the new cropland at once, and a rotation of 1 year of corn followed by wheat and then by hay was used on some fields. Field 5a (fig. 6) at the northwestern boundary receives periodic overflow, which interferes with production of both wheat and grass and makes the field one of the best on the farm for corn. In fact, it had been producing good yields of corn for the last 20 years. Provision was made for keeping this field in corn as much as necessary, since it lies on an A slope and is subject to soil deposition rather than soil erosion.

On all the upland fields, whether soil losses were slight or severe, a system of contour strip cropping was devised (fig. 7), so adjusted to soil conditions, slopes, and the need for a rather constant acreage of corn, wheat, and hay that a maximum amount of soil protection could be given.

Contour strip cropping (fig. 8) consists simply of so laying out the fields that they lie in long, rather narrow strips around the slopes and no plow furrows, harrow, or cultivator grooves, or rows of cultivated crops extend uphill and downhill. This arrangement checks run-off and causes it to sink into the soil instead of flowing immediately into streams. The strips are adjusted in width to meet the requirements of steep or gentle slopes and also to slow down erosion on certain soils that tend to lose surface soil rapidly when water runs across them. The succession of crops on each strip is shown on a cropping plan, which is made a part of the agreement.



**Figure 7.**—Plowing a contour strip around a hill. The diversion terrace above was established to prevent excess water from flowing down the long slope.



**Figure 8.**—Corn and grass growing in contour strips on a gentle slope.

On this particular farm it was possible to lay out the strips with a width of 90 to 100 feet and with a length of 600 to 1,200 feet.

The cropping plan was so arranged that each strip in a tilled crop would be protected by a close-growing crop lying above it (fig. 8). Where corn followed corn in the rotation, provision was made that rye should be seeded on the first-year corn ground after harvesting the crop to provide protection against the washing from fall and spring rains and from the run-off from melting snow. In the spring the winter crop of rye is to be turned under as a green manure for the succeeding corn crop. On the second year of corn, wheat is sown and a seeding to grass is made, as is the common practice in the area.

Contour strip cropping, carefully laid out in the first place and faithfully followed, together with the use of the winter cover crop (fig. 9) as needed, usually supplies excellent protection against erosion, since bare ground is exposed to rain wash during only a short time of the 4-year period of complete crop rotation.

On certain parts of this farm there

were shallow draws or run-off channels that were likely to become gullies unless they were protected from running water that becomes concentrated in these channels. Provision was made to seed down these channels to a thick-growing sod to be left as a permanent hay strip. The channels are seeded to a width of 7 to 8 feet. The strips can be crossed without damage by cultivators by simply raising the cultivator gangs when the sod strip is reached.

In order to secure better control of erosion and to line up field boundaries for the new cropping system, three small fields, each about one-half acre, were thrown into permanent pasture and an almost equal area of former pasture was included in the readjusted cropped fields. The new pastures were improved by the application of 1 ton of lime, 200 pounds of 4-12-4<sup>1</sup> fertilizer, and 15 pounds per acre of an approved seed mixture. The weeds and tall-growing grasses are to be mowed in June and in August or September of each year to give the nutritive grasses a better chance to grow, and the cattle droppings are to be spread so as to

<sup>1</sup> Percentages, respectively, of nitrogen, phosphoric acid, and potash.



Figure 9.—A cover crop of sweetclover sown in corn affords winter protection against erosion and provides organic manure to be plowed under.

prevent bunchy growth of pasture grasses. An improved pasture, thus treated, is shown in figure 10. Cattle are to be kept off the pastures in the spring until the grass has made a growth of 4 inches in height, and they are to be taken off early enough in the fall to permit an equal growth before winter. These simple changes in field boundaries, coupled with desirable methods of pasture management, serve to protect the slight slopes on the pastured areas and will eventually increase the carrying capacity of the 20 acres of pasture provided for the farm.

The completed plan for soil conservation on this farm includes a schedule of cropping for each field for a period of 5 years. It includes the map originally made to show the conditions existing at the beginning of the agreement and another to show what the system will be at the end of the 5-year period (fig. 6). Changes from the old to the new system are made gradually in order not to disturb crop acreages and field boundaries over the entire farm at one time. The completed plan becomes a matter of gradual growth and development. When it is accomplished, the farm will

be adequately protected from soil losses due to erosion.

This single example of an individual farm does not include all the erosion-prevention practices that are necessary in this area, especially on steeper slopes and on farms where erosion has become a serious problem through the formation of incipient or deep gullies. On such farms the simple remedies of contour strip cropping and the maintenance of waterways in sod are not enough. Engineering practices must be adopted to reinforce vegetation and to protect areas that are to remain permanently in cultivated crops.

Further gullyng can sometimes be prevented by the construction of diversion terraces (fig. 11) that will intercept water that has accumulated at higher levels and will carry it along gentle grades to some area where it can be spread out harmlessly on pasture land or can be conducted into a flowing stream. Such terraces are also used to conduct water away from gully heads.

The farm requirements on some farms necessitate the continued use for cropping of valuable cropland on the steeper slopes, and contour strip crop-



**Figure 10.**—A dairy herd grazing on an improved pasture. The tall growth in the foreground has been mowed.



**Figure 11.**—A diversion terrace breaking a long slope into two shorter ones. Water is carried away on a gentle grade. A grass strip above protects the terrace.

ping alone is not adequate protection. On the more gentle slopes broad-based terraces are constructed to break the length of slope and to prevent the accumulation of flowing water on any one strip of cultivated land. Such terraces supplement strip cropping, and the terraces can themselves be maintained in crops if proper provision is made to protect their upper margins by a strip of close-growing grass. The use of farm machinery in seeding such a terrace to barley is shown in figure 12.

Many farms still support areas of woodland. Some of these (fig. 13) are in such condition that the tree cover provides proper soil protection within the tract and delays run-off enough that lower-lying fields are not affected. This is not common, and it is frequently necessary to make a complete study of the wooded area and to devise a system of annual cutting that will, so far as possible, supply the needs of the farm and at the same time maintain tree growth for future cut-

tings. Wherever proper conditions for natural reproduction of tree growth must also be established, a long-term plan of woodland management is supplied, and provision is made for fencing off the wooded area against grazing. A grazed woodland is shown in figure 14.

Provision is also necessary for retiring to woodland certain steep or stony areas that are not suitable for cultivation or even for pasturing. Such areas are planted to trees, and species suitable for fence posts and for timber production are used as the site may indicate and the farm needs may require. Tree planting on a steep slope is shown in figure 15.

Where sizable gullies have already been formed, it is sometimes necessary to construct check dams to prevent them from cutting deeper, and also from extending headward into cropped fields or pasture land. The gullies are usually prepared for seeding to grasses in the channels and for planting



**Figure 12.**—Drilling barley on a field just terraced. Farm crops may be grown over all parts of a terraced field and power machinery used in all steps of preparing and planting the land and in harvesting.

to trees along their slopes. A temporary check dam is shown in figure 16.

Since no two farms present exactly the same problems in soil conservation, a specific plan for each farm must be prepared to meet its requirements and to provide complete protection for every acre of land.

The Civilian Conservation Corps camp was established at Lancaster in November 1935, and conservation agreements have been made with 86 co-operating farmers having farms within the Conestoga and Pequea Creek watersheds. Their farms comprise a total area of 7,790 acres. On these farms 210 acres have been planted to woodland, 110 acres of existing woodland have been fenced against grazing, and about 1,000 acres of pasture have been improved. One hundred acres, chiefly on the more sloping lands included in these pastures, have been protected from erosion by the plowing of properly spaced furrows on the exact level or the

contour. This prevents the rapid run-off of water; it retains the water on the pasture slopes for the use of the pasture grasses during subsequent drought periods.

Contour strip cropping has been laid out on about 4,000 acres of tilled land, or more than one-half of the total area of the farms under agreement. The width and arrangement of the strips has been fitted to the soils and slopes. The margins of the strips have been located by use of a level, and their courses, to be plowed out by the farmer as guide lines, have been marked by stakes.

In order to supplement these contour strips 13 miles of broad-based terraces, protecting 244 acres of land, and nearly 6 miles of diversion ditches, protecting 376 acres, were constructed.

Since the installation of these practices several very severe rainfalls have occurred. In no place where the installations had been completed was there an appreciable soil loss from



**Figure 13.—An improved woodland. The trees and undergrowth afford protection against erosion. Valuable timber is being produced.**

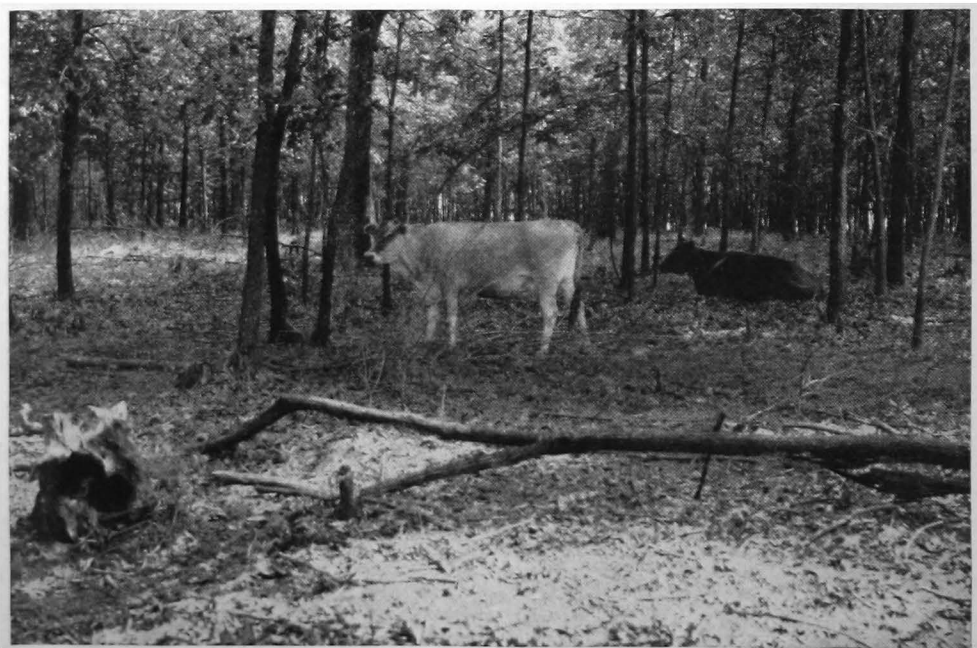


**Figure 14.—Pasturing wood lots results in poor pasture and poor woodland. There is no reproduction of trees and little protection against erosion.**



**Figure 15.**—Planting trees in contour furrows on a steep slope turns poor pasture into good woodland and prevents soil erosion.



**Figure 16.**—A temporary check dam in a formerly active gully. The banks are planted to locust; the bottom and sides are seeded to protective grasses. Water flows through the dam, but earth is held in place to fill the gully.

erosion. Fields and farms not thus protected and adjacent to those under agreement underwent severe soil erosion, especially in June 1938.

The results of 4 years of work along soil conservation lines on a wide variety of soils on very different slopes and with different farm lay-outs in relation to both soil and slope enable those in charge of the work in southeastern Pennsylvania to make certain very specific recommendations concerning the requirements for soil protection.

Practices desirable on A slopes need to be selected according to the length and position of the slope. On A slopes that receive no run-off from other areas, there is usually no erosion if a good rotation is followed. The rotation recommended by the Extension Service is a 4-year rotation with 2 years of cultivated crops, 1 of small grain, and 1 of hay. On those slopes that receive run-off from other areas, a vegetative means such as strip cropping or a mechanical one such as terracing should be used to control excess water.

On B and BB slopes, strip cropping should be used in addition to the crop rotation. Wherever terracing or diversion ditches can be used, these practices should be established to supplement strip cropping.

C slopes should be retired to permanent plant cover, either pasture, permanent hay, or trees. If, for economic reasons, it is necessary to farm these slopes, the cultivated strips should not exceed 80 feet in width. Mechanical control of water is usually not feasible on C slopes.

D slopes should be used for pasture, permanent hay, or trees and should be retired to trees if possible.

## Appendix

### *Description of Soil Types*

IN MAKING the field map and classifying the soils of the Conestoga area, the methods and system of classification and of soil nomenclature of the Division of Soil Survey of the Bureau of Plant Industry, United States Department of Agriculture, were followed. The conservation survey was made 22 years after the soil survey of Lancaster County, Pa., was completed in 1914. It was made on a

scale of 4 inches equals 1 mile, whereas the soil survey was made on a scale of 1 inch equals 1 mile. Consequently it was possible to map the soils and other physical factors in greater detail than in the former survey. Furthermore, many changes and refinements in soil classification and mapping had been adopted in the meantime. The broader subdivisions into soil groups correspond closely with the older survey, but certain soils, like the Hagerstown, have been subdivided, and numerous new types have been recognized.

The area lies within the great group of Gray-Brown Podzolic soils in the northeastern United States, where soils were developed on the underlying rock material in a humid, temperate climate under a dominantly deciduous forest cover. The resulting complete soil profile or section is marked on virgin areas by a thin leaf litter lying on 1 to 2 inches of dark grayish-brown granular mild humus, which grades into a grayish-brown leached horizon extending to a depth of 8 to 10 inches. This is the natural, undisturbed A horizon. The B horizon (the upper subsoil) ranges from yellowish brown to light reddish brown in color and is distinctly finer in texture than the A horizon. The underlying material (C horizon) is usually lighter colored down to the parent rock except in soils developed on limestone, where the C horizon may be of a deeper color than the B horizon and where in many soils there is a sharp contact between the deep material and the underlying, undissolved limestone rock.

The area is underlain by a wide variety of rock formations and on these a corresponding variety of different soils has been developed. Some of the upland soils have reached the stage of mature development in which all the soil horizons are represented. Others have undergone geologic and accelerated erosion to such an extent that the complete section is not present. The B horizon is the one commonly lacking.

In addition to the immature soils developed directly on parent rock, there are also immature soils whose materials have been transported relatively short distances. The alluvial soils have not become completely developed both because of their comparative youth and because new materials are being deposited within their areas either by annual or other overflows. On some upland areas the washing of soil materials downhill to positions of less slope causes deposits on lower slopes that are closely associated with the upland soils which contribute the greater part of their constituents. Drainage has not become completely established within these soils.

### GROUP 1.—WELL-DRAINED UPLAND SOILS FROM HIGHLY CALCAREOUS MATERIALS

Group 1 divides naturally into two subgroups: 1a, those soil types that possess a complete soil section of three horizons, and 1b, those that possess no distinct B horizon, the surface soil resting on the disintegrated

and partly decomposed parent material. Both subgroups are well drained across the surface and throughout the soil section, with the exception that internal drainage in the deep subsoils of some types is obstructed by heavy, somewhat compact silty clay or clay layers. The total extent of the group is 187,304 acres, or 46.6 percent of the entire area. Not only is it the most extensive group in the area but it is also agriculturally the most important.

#### SOILS WITH COMPLETE PROFILES

##### CONESTOGA

Conestoga silt loam covers 24,450 acres and Conestoga gravelly silt loam 350 acres. The surface soil of Conestoga silt loam is a dark-gray to grayish-brown silty loam having a depth of 8 to 10 inches. The upper part of the subsoil is a yellow to yellowish-brown mellow friable silty clay containing flakes of very finely divided mica and fragments of mica schist. The deep subsoil, down to about 3 feet, is a dark-brown to reddish-brown compact brittle silty clay loam containing fragments of the parent calcareous schist. It grades down into a yellowish-brown friable clay mixed with fragments of the parent rock and also a relatively large proportion of finely divided mica flakes. The gravelly silt loam contains a greater proportion of the broken fragments of the parent rock. The mica content gives a distinctly greasy feel to the surface soil and subsoil.

These soils, developed on limestone-schist, occur in the southern part of the limestone area, extending from Mountsville to a point east of Strasburg. They are distinctly darker in color than those developed on the more massive, purer limestones.

The Conestoga soils have a slightly undulating to rolling surface relief. They are well drained. They are subject to both sheet and gully erosion, since most of their area is cropped.

##### DUFFIELD

The Duffield soils are the most extensive series in the area. The gravelly silt loam covers 6,107 acres; the stony silt loam, 130 acres; and the silt loam, 106,143 acres, or 26.4 percent of the entire area.

The surface soil of Duffield silt loam is a grayish to yellowish-brown soft friable silt loam having a depth ranging from 8 to 12 inches. This is underlain by a subsoil of mellow friable silty clay loam of a yellow to brownish-yellow color, grading down into a yellowish-brown silty clay having a nutty or lumpy structure easily pulverized into a loose mellow mass. This grades at a depth of about 3 feet into a brown to reddish-yellow clay, which overlies the parent rock at depths of 4 to 10 feet or even more.

The Duffield soils are residual from thin-bedded platy limestone with some clay partings and from somewhat impure, more thickly bedded limestone. The rock outcrops at the surface of the stony silt loam. In

areas of the gravelly silt loam, fragments of quartz and of shaly and thin-bedded limestone occur in the surface soil and subsoil in amounts that increase with depth. These fragments grade down into a mingled mass of silty and stony material near the surface of the parent rock formations.

The surface is gently undulating to rolling, and there are few steep slopes. Drainage, both surface and internal, is good on all three types. They are recognized as the most productive soils in the area and give yields 50 percent or more above the average for the area. Yields of 80 bushels of corn and 35 bushels of wheat to the acre and tobacco yields up to 2,000 pounds per acre are not uncommon. Alfalfa can be established easily on these soils.

The Duffield soils, mapped as part of the Hagerstown in the older soil surveys in southeastern Pennsylvania, are of a distinctly lighter shade of yellow and brown than the Hagerstown and do not have its characteristic reddish color in the subsoil.

They are susceptible to active sheet erosion even on the more gentle slopes, and experience has shown that careful adjustment of crops to slopes, including contour strip cropping and contour cultivation, is needed for complete protection even on A slopes. On steeper slopes, terracing, the maintenance of grassed waterways, and contour strip cropping are decidedly necessary to preserve these very valuable soils in their full producing capacity. The evidences of active erosion, chiefly of the sheet and rill types, are seen where the yellowish or brown subsoil shows up as a rather clodded surface on knolls and on slopes in excess of 8 to 10 percent.

##### DUNMORE

The Dunmore soils are closely associated with those of the Duffield series. The silt loam covers an area of 15,358 acres, the gravelly silt loam only 482 acres.

The surface soils are brown to grayish-brown silty loams or silty clay loams. The subsoil is a yellowish to reddish-brown silty clay loam, grading into a brittle silty clay at a depth of about 2 feet. At this depth it may become slightly mottled and has a greasy feel. Small pieces of quartz may be present. The parent earthy material is a reddish-brown to reddish-yellow tough but brittle clay with dark-green, brown, and yellow specks and mottlings, overlying the limestone to a thickness of 20 inches to 2 feet. The gravelly silt loam differs from the silt loam in having numerous quartz fragments in both surface soil and subsoil.

The surface of the Dunmore series is rolling to sloping with some slopes in excess of 6 percent. The surface drainage is good, but the internal circulation of water in the subsoil is somewhat sluggish owing to the heavy silty clay texture and to the presence of the deep layer of rather impervious clay. These soils are largely under cultivation and rank high in productivity. Sheet erosion and some gullyng are evident over a large part of the

area, and measures for erosion prevention should be adopted.

#### HAGERSTOWN

Only 3,900 acres in the Conestoga area are mapped as Hagerstown soils, owing to the separation of the limestone soils into several series. Of this area Hagerstown silt loam covers 3,398 acres and Hagerstown gravelly silt loam 502 acres.

Hagerstown silt loam is characterized by a dark-brown mellow friable silt loam surface soil having a depth of 5 to 7 inches. It is underlain by a dark-red plastic silty clay or clay subsoil, granular in structure but liable to bake and clod when exposed at the surface. This grades at about 2 feet into a tough reddish-brown silty clay or clay having distinct yellow and reddish-brown streaks. This layer extends to a depth of about 56 inches, where it grades into brownish-yellow and red and yellow marbled plastic clay.

The surface of these soils is undulating to gently rolling, and surface drainage is good. Internal drainage is somewhat obstructed by the heavy, dense character of the subsoil. On almost all cultivated areas moderate or severe soil erosion is very obvious. Methods of erosion control need to be applied generally. The staple farm crops are grown, and moderate to high yields are obtained.

#### LETORT

Letort silt loam covers an area of 13,766 acres in the Conestoga area. The surface soil to depths ranging from 9 to 12 inches is a dark-brown mellow silt loam. The subsoil to 14 inches is a dark grayish-brown silty loam to silty clay loam. This is underlain by about 3 feet of dark grayish-brown to dark-gray friable clay containing finely divided mica and fragments of quartz and limestone. Beneath this is a dark-gray friable clay loam, somewhat less coherent. The parent material, encountered at a depth of 68 inches or more, is a disintegrated olive-green calcareous mica schist.

The greater part of the Letort silt loam is undulating to rolling, and a relatively small part has slopes of 15 percent or more. It is subject to slight sheet erosion on the more gentle slopes, but on the more rolling areas it has experienced severe sheet erosion and gullyng. On such areas protective measures should be adopted.

#### STRASBURG

Strasburg silt loam covers an area of 7,549 acres and is closely associated with the Conestoga soils in origin and geographic distribution. The surface soil to a depth of 9 inches or more is a dark-gray to grayish-brown silt loam, high in organic-matter content, and loose and mellow in structure. At a depth of from 9 to 12 inches this becomes more brown. This surface soil contains fine particles of a micaceous, lime-bearing schist, which are also present in the subsoil down to the parent material.

The immediate subsoil consists of a yellowish-brown to brown silty clay loam, extending to a depth of about 30 inches and underlain by a yellowish-brown compact silty clay loam or clay loam that is tough and plastic when wet. This rests upon partly disintegrated calciferous and micaceous schist.

The surface is slightly undulating to gently rolling; 89 percent of the type has a slope of less than 8 percent. Because the lower subsoil is compact the surface soil becomes saturated easily and is subject to sheet erosion and to some gullyng. This soil needs to be protected by adequate erosion-control methods.

#### SOILS WITH INCOMPLETE PROFILES

On the steeper slopes within the limestone and calcareous schist area are soil types that have not become fully developed. The surface soil rests directly on the partly weathered parent material without the intervention of any distinct B horizon. This is undoubtedly due to the fact that erosion has proceeded at so active a rate that the formation of a complete soil was impossible. These soils fall within a subgroup of those developed on strongly calcareous material.

#### HOLLINGER

Hollinger silt loam occupies an area of 1,426 acres on slopes from the upland to the deeper cut streamways. The surface soil is a dark grayish-brown mellow silt loam containing small chips of schist and mica flakes. It possesses a grayish-brown layer extending to a depth of 8 to 10 inches. This surface soil material rests on a brown friable silt loam material carrying a high percentage of schist chips and mica flakes. This grades down through a yellowish-brown, partly decomposed zone of micaceous limestone into the parent lime-bearing schist.

The surface is gently to steeply rolling, and drainage is good to excessive. Moderate and moderately severe erosion is pronounced even on the BB slopes. Gullyng is strongly in evidence on the steeper slopes. Cropped land has naturally been affected most severely, and the acreage in crops should be decreased wherever possible, with the adoption of larger areas of pasture and the reforestation of the steeper slopes. Even under natural conditions erosion was so severe as to prevent the formation of a complete, normal soil section, and accelerated erosion, the result of human occupation, has definitely increased this soil loss. Revegetation is the best remedy where it can be adopted.

#### PEQUEA

The Pequea soil series is represented by the silt loam, covering 6,990 acres, the gravelly silt loam, with an area of 542 acres, and the stony silt loam, covering 111 acres.

Pequea silt loam has a dark-gray mellow silt loam surface soil containing small pieces of black micaceous limestone with abundant mica flakes in its deeper portion. It has a

depth ranging from a few inches to 3 feet or more. It rests on dark-gray friable material containing a large amount of disintegrated black micaceous schist, which rests on partly disintegrated gray limestone and black micaceous schist. The entire section shows a high content of lime carbonate.

The surface is strongly rolling to steeply sloping. Drainage is excessive across the surface because of the steep slopes, and is also excessive within the soil section. Most of this soil (4,100 acres) is in cropland, and the remainder of its area is almost equally divided between pasture and woodland. Sheet erosion is very active under cultivation, and gullying is pronounced on all the steeper slopes. The area in cultivated crops needs to be greatly reduced and that in pasture and woodland increased in order to maintain this soil. All cultivated land requires protection by contour strip cropping, diversion terraces, and sodded waterways.

Pequea gravelly silt loam differs from the silt loam chiefly in having larger and more numerous fragments of the broken calcareous schist in both surface soil and subsoil and frequently, because of its shallower depth, in the parent material. The stony loam is marked by the presence of large rock fragments through the soil section.

## GROUP 2.—IMPERFECTLY DRAINED UPLAND SOILS FROM HIGHLY CALCAREOUS MATERIALS

Group 2 is made up largely of small areas and stringers of imperfectly drained material that are colluvial phases of well-drained upland limestone soils. They occur on nearly level areas at the foot of long, comparatively steep slopes and are covered by deposits from adjacent upland soil that have accumulated through the influence of gravity and local washing. The surface soils are prevailingly dark colored and deep. There is usually a larger proportion of organic material than in the upland types. At various depths the B horizon is encountered. It contains less organic matter and is not infrequently mottled. The material underlying the B horizon may have little resemblance to the surface soil and subsoil, since these have developed on material derived from the nearby uplands.

The colluvial phase of Duffield silt loam occupies an area of 4,902 acres; that of Conestoga silt loam covers 874 acres. The other imperfectly drained upland soils developed from calcareous material are relatively unimportant.

All these soils are used largely for pasture. Otherwise, they are cultivated to the same crops and by the same methods as the well-drained soils from which they are derived.

## GROUP 3.—WELL-DRAINED UPLAND SOILS FROM GNEISS AND SCHIST

The soils of group 3, which cover over 12 percent of the Conestoga area, are underlain by decidedly acid and highly crystalline

gneisses and schists, occurring chiefly in the southern part of the area. The gneisses contain feldspar, quartz, and mica; the schists are composed chiefly of mica and quartz with small amounts of secondary minerals. Differences in composition and structure of the rocks have given rise to somewhat different topographic forms as a result of weathering. This has necessitated the division of this group into two subgroups: 3a, soils with complete profiles, and 3b, soils with incomplete profiles.

### SOILS FROM GNEISS AND SCHIST (COMPLETE PROFILES)

#### CHESTER

The Chester soils are developed on the gneissic and schistose rocks. This series is marked by a completely developed soil profile, by rounded to rolling surface relief, by well-developed surface and internal drainage, and commonly by a deep C horizon consisting of disintegrated and partly decomposed parent rock. Stone fragments of various sizes from small chips or gravel to large residual boulders may be present in both surface soils and subsoils and in the C horizon. Rock outcrops are not common.

Chester silt loam covers 9,100 acres, and occurs chiefly in the southern and southeastern parts of the area. The surface soil in cultivated fields consists of a yellowish-brown to brown silty loam with some small mica flakes present. It extends to a depth of 8 inches or more and is underlain by a yellowish-brown friable silty clay containing a large amount of mica, which gives the material a greasy feel. Small weathered fragments of the parent rock material occur throughout the subsoil, which extends to depths ranging from 30 to 32 inches below the surface. The parent material, the C horizon, is a light yellowish brown highly weathered mass of mica schist. It is loose and friable, and the size of the mica particles increases with depth. Other crystalline rocks, chiefly micaceous gneisses, are associated with the mica schist, giving rise to the same soil section.

The surface is gently sloping to undulating, with only small areas of C and D slopes. Both surface and internal drainage are well established. Sheet erosion is evident even on some of the more gentle slopes, and gullying is present on BB and steeper slopes. Methods for the control of sheet and gully erosion need to be applied on all but A slopes, and terracing needs to be combined with contour strip cropping and the establishment of grassed waterways on much of the cultivated area. The soil is fertile and more than 80 percent of its area is cropped.

Chester gravelly silt loam covers 8,791 acres. The surface soil differs from that of Chester silt loam chiefly in the presence of 20 to 75 percent of broken rock material, referred to as gravel in this report, consisting chiefly of mica schist. The subsoil is a yellowish-brown to brown silty clay or silty clay loam containing enough finely divided mica

to give it a distinctly greasy feel. Small fragments of the parent rock occur throughout this horizon, which extends to a depth of 28 to 30 inches. The C horizon is a yellowish-brown to brown highly weathered mica schist, which crumbles when disturbed. It is encountered at various depths from 30 inches to 4 feet or more.

The surface of the gravelly silt loam is more rolling than that of the silt loam, nearly 28 percent of its area being found on slopes of 12 percent or greater. Greater than moderate sheet erosion and gully erosion have affected 39 percent of its total area. Erosion-prevention measures need to be adopted on most of its area.

Chester loam covers an area of 6,850 acres. The surface soil to a depth of about 8 inches consists of a dark grayish-brown mellow granular loam containing enough sand to give it a gritty feel. Small pieces of rock are present throughout the layer. The upper part of the subsoil is a dark-brown to reddish-brown friable clay loam containing a large amount of sand and scattered fragments of rock. It is porous and mellow. It is succeeded by a reddish-brown to dull-red brittle clay loam containing some mica flakes and fragments of the parent rock. This continues to a depth of about 30 inches, where it is underlain by a dull reddish-brown to brown loose friable mass of highly disintegrated schistose rock.

Chester loam lies chiefly on undulating to gently rolling surfaces; over 80 percent is on B and BB slopes. Consequently it is subject to moderate to severe sheet erosion and to some gully erosion on all cultivated areas on these or greater slopes. It is well drained and productive and most of it should receive erosion-prevention treatment.

Chester gravelly loam, which occupies 4,831 acres on undulating to rolling land surfaces, has good surface and internal drainage. It is distinguished from the loam chiefly by the presence of broken rock fragments throughout the surface soil and subsoil and by the prevalently darker brown to reddish-brown subsoil. The depth to bedrock is variable.

More than three-fourths of the type lies on B and BB slopes, and more than one-half has been affected by greater than moderate sheet erosion with pronounced gully erosion. Erosion-prevention measures are needed over nearly the entire area.

Chester stony loam occurs on 1,115 acres, and all but about 200 acres lies on BB or steeper slopes. Stones ranging in size from large gravel to boulders 2 feet or more in thickness are scattered over the surface and occur throughout the soil and subsoil, comprising 20 to 75 percent of the mass.

Because of the stony character of the land only one-fourth of its area is cropped, one-tenth is in pasture, and 63 percent of its area remains in woodland. It is probable that the 25 percent now cropped would be better used for pasture or woodland than for crops except where only small portions of a field that is otherwise suited to cultivation are occupied by this soil type.

#### SOILS FROM SCHIST (INCOMPLETE PROFILES)

Group 3b includes all soils developed on quartz-bearing mica schist and marked by the development of only the A and C horizons, although an accumulation of silt and clay at the top of the C horizon indicates the incipient formation of a discontinuous B horizon. The group consists of only one series, the Manor.

##### MANOR

The surface of the Manor soils is chiefly rolling to rather steeply sloping, with C and D slopes dominating all but one of the types. In most of the soil areas, fragments of the parent material ranging from rather coarse sand through gravel sizes to large stone, occur in varying proportions. Drainage across the surface is complete to excessive and good to excessive throughout the soil section, particularly in the C horizon. The series covers a total area of 18,553 acres, chiefly along the southern and southwestern boundaries of the area. It is probable that long-continued geologic erosion is chiefly responsible for the absence of a B horizon. Normal erosion is still in evidence on some of the steeper slopes, even when they are partly protected by woodland. Accelerated soil erosion is a serious problem on all cultivated areas, since less than 5 percent of the series has a slope of less than 8 percent. Only the rather open structure of the soils and of the underlying parent material prevents erosion from being decidedly severe. This structure and the fact that much of the area is wooded tend to reduce erosion to some extent.

Manor loam covers 5,112 acres. The surface soil to a depth of 6 to 7 inches consists of a dark grayish-brown friable loam. It contains small pieces of highly weathered mica schist, which give the soil a distinctly gritty feel. It is underlain by a brown to rusty-brown loam with numerous small pieces of mica schist. There is a partly developed zone of clay loam at the top of this division in some localities, which constitutes an incipient B horizon. The deep C horizon is a light grayish-brown to brown highly weathered material containing enough clay to give it some coherence. Usually, there is disintegrated bedrock at a depth of about 30 inches.

Sixty-nine percent of this soil lies on C and D slopes and 27 percent on BB slopes, leaving only 4 percent on A and B slopes. Fifty-three percent is in cultivated crops, and 74 percent of it has lost at least half of the original topsoil. Fifty-five percent of the land in crops lies on slopes of 15 percent or greater, and 91 percent of its surface has been damaged by gully erosion in addition to sheet erosion. Intensive and complete measures for erosion control are needed on almost every acre. Large areas of the steeper slopes can be permanently utilized only if returned to woodland.

The surface soil of Manor gravelly loam is a friable dark brownish-yellow to yellow loam containing numerous small and medium-

sized rock fragments. Sharp-edged sand grains make the loamy material distinctly gritty. At about 7 inches the brown to rusty-brown gritty loam subsoil is present. The clay content is hardly enough to give the material coherence. At a depth of about 2 feet the light grayish brown highly weathered parent material, containing unweathered rock fragments, occurs. The whole mass from the surface to a depth of 3 feet or more is open and porous. No distinct subsoil has been developed.

Manor gravelly loam occupies 5,198 acres, of which 71 percent is found on C and D slopes and 24 on BB slopes. Almost one-half of its area is in cultivated crops, and 69 percent has been more than moderately eroded. Every acre of cropland, amounting to 2,554 acres, has been moderately to very severely eroded, and 87 percent of the cropped area has been affected by gullying. Methods of erosion control need to be used on all cropped areas, and a large part should be in pasture or woodland.

Manor stony loam occurs on 3,973 acres, and 95 percent of its area has slopes of 15 percent or greater. Woodland occupies 3,743 acres, or 94 percent, and consequently only slightly more than 1 percent of the Manor stony loam has been severely eroded. Both the stony surface and the prevailing steep slopes have checked the clearing of this land, and it is consequently occupied for its best use—woodland. The soil section does not materially differ from that of Manor gravelly loam except that stone fragments ranging from a few inches to 2 feet or more in thickness occur throughout the entire section.

Manor silt loam covers 1,431 acres. It has a grayish-brown mellow silt loam surface layer with a depth of 6 to 7 inches underlain by a loose friable reddish-brown decomposed rock material. It contains little clay but a large amount of micaceous material, giving the loamy fine earth a greasy feel and a glistening sheen. It is marked by red streaks. The underlying material consists of large pieces of highly weathered mica schist interspersed with a grayish-brown friable mass of disintegrated rock. Bedrock lies at depths ranging from 3 to 8 feet below the surface. Forty-two percent has slopes of 15 percent or greater (C and D), 41 percent has BB slopes, and the remainder is more gently sloping.

Sixty-one percent of its area is in cropland, and 238 acres of the total of 875 acres of cropland lie on slopes of 15 percent or greater. This land is altogether too steep for continued cultivation, and wherever possible it should be turned into pasture or reforested. In fact, 68 percent of the soil type has already been affected by greater than moderate erosion, and all cultivated areas require some form of erosion-prevention treatment.

Manor gravelly silt loam closely resembles the silt loam except that from the surface downward there are numerous fragments of the broken mica schist, increasing in size with depth from the surface. Three-fourths of this soil lies on C and D slopes and 20 percent on BB slopes. In spite of this, more than half of its area is in cultivated crops, and only 34

percent is wooded. The survey disclosed that 443 acres of cultivated land lay on slopes less than 15 percent, while 915 acres were on steeper slopes (C and D). This is very poor land use and is reflected by the fact that 66 percent has been more than moderately eroded and that gullying is prevalent. It is inescapable that a large part of this cultivated land should be turned into pasture and some of it reforested in order to retain the soil. On all cultivated areas erosion-prevention measures should be adopted.

The fine earth of the Manor stony silt loam resembles that of the silt loam, but the entire soil mass is filled with large fragments and masses of the parent mica schist. Nearly all the area lies on C and D slopes. This fact and the stony nature of the material result in the presence of woodland on 203 of its 207 acres. Forest protection has prevented more than slight erosion over 74 percent of the area. Excessive thinning of the woodland stand has given rise to moderate and moderately severe sheet erosion and gullying on the remainder of the soil.

There is a close relationship between soil conditions, slopes, and land use in the Manor series as well as in the Hollinger, Pequea, and other soils lying on the steeper slopes. Both geologic erosion and, more recently, accelerated erosion have prevented the formation of a complete soil profile. The removal of material by erosion has been too rapid to permit the formation of a distinct B horizon through the percolation of water and deposition in the subsoil of the materials it carries, and complete weathering of parent material. That this shallow soil condition existed even before man's occupation is very probable, since areas still in woodland show the same lack of a well-developed B horizon. The present-day problem is so to use the land that the A horizon may be preserved against very active accelerated erosion. Over nearly its entire area some form of erosion-prevention measures should be adopted.

#### GROUP 4.—UPLAND SOILS FROM QUARTZITE

A little more than 6 percent of the Conestoga area is covered by the soils of group 4, which have been developed on the weathered Chickies quartzite and other formations containing large amounts of quartz. In addition, the metamorphosed sedimentary deposits contain sericite mica and a small amount of feldspar. There are also thin layers of interbedded black slate. This material has been resistant to geologic erosion. Consequently, it occupies ridges in the southern and southeastern parts of the area and on such conspicuous features as the Welsh Mountains along its eastern border.

##### EDGEMONT

The soils formed from the weathering of this material are classed as the Edgemont series. They cover 25,578 acres, or 6.4 percent, of the Conestoga area. Characteristically the soils of the Edgemont series have grayish-

yellow surface soils and pale-yellow to lemon-yellow subsoils. Both the surface and the internal drainage are good. Erosion is active on all of the steeper slopes in cultivated areas, on some of the pastured areas, and even on some of the more sparsely wooded ridges.

Edgemont stony loam and stony silt loam differ from each other chiefly in the larger amount of silt found in the subsoil of the latter. In other respects they are very similar. In each soil the surface is gently to steeply sloping, and cropping has been extended only over small parts. In fact the stony loam is forested over 7,381 acres out of its total 7,784 acres. Nearly 63 percent of the Edgemont stony silt loam is also in woodland. The cropped areas on both of these soil types have been severely affected by both sheet erosion and gullying because of the steep slopes.

Edgemont loam and silt loam show a similar textural difference—the silt loam has a somewhat more silty or claylike deep subsoil. Both types are marked by gentle slopes, only about 5 percent of either one exceeding 15 percent in slope. Seventy-seven percent of the loam and 80 of the silt loam are cultivated. Both have suffered moderately severe to severe erosion on a large part of the cropland, but in the woodland such erosion is negligible and is of moderate importance on the pastured areas. The crops common to the locality are grown with moderate success.

Edgemont gravelly loam and gravelly silt loam differ from other soils of the series in the fact that small broken fragments of the original rock are scattered throughout the entire section, increasing in quantity with depth toward the parent material. From 60 to 65 percent lies on A and B slopes, about 25 to 30 percent on BB slopes, and only 10 to 12 percent on the steeper C and D slopes. This fact and the stone-free nature of the surface soil lead to their very complete use for the production of the common field crops. Although both these types receive and absorb water rather freely, there is also a great deal of run-off across the surface. This has resulted in greater than moderate erosion on 27 percent of the gravelly loam and 32 percent of the gravelly silt loam. In both soils this takes place chiefly on the intermediate or B slopes.

Cropping practices have been well adjusted to the variations in slope and stone-free or stony surface conditions. Erosion-control practices need to be adopted on all cropland having slopes greater than 5 percent, and pasture improvement needs to be undertaken on a considerable part of the existing pasture. It is probable that all the stony loam areas should be reforested.

## GROUP 5.—UPLAND SOILS FROM DIABASE

### MONTALTO

Throughout the Triassic basin of the northern part of the area and even extending through other formations, there are areas of dark-colored traprock or diabase, usually

forming ridges. Soils developed on this material are classified in the Montalto series and are included in group 5. They are well drained to somewhat imperfectly drained on the more level areas. In the Conestoga area they cover 8,059 acres, 2 percent of the total area.

Montalto stony silt loam is the most extensive of these soils, covering an area of 4,466 acres. It is marked by a dark grayish-brown to brown friable silt loam surface soil containing a relatively high amount of organic matter. Rounded boulders from 1 to 6 feet in diameter are found on the surface and through the surface soil. They are a rusty-brown or dark-green color. The surface soil extends to a depth of about 7 inches and is underlain by a brown to dark-brown silty clay or clay. This becomes heavier and stiffer with depth, and reddish in color. There are large fragments of parent rock throughout this layer. At a depth of about 30 inches this grades into a yellowish-brown gritty claylike material mixed with highly disintegrated diabase rock and some mudstone, or slate. The parent rock is encountered at depths from 5 to 9 feet. About one-third of the area of this type lies on C and D slopes, about one-third on BB slopes, and about one-third on A and B slopes. Only 79 acres of this soil type are under cultivation, 143 acres are in pasture, and 4,179 acres are wooded. In consequence erosion is insignificant over the greater part of Montalto stony silt loam.

Montalto gravelly silt loam covers 1,900 acres in this area. It is characterized by a dark-brown to reddish-brown friable silt loam surface soil containing numerous small pieces of diabase rock and the baked shale associated with it. This surface soil is underlain at a depth of 6 to 7 inches by a dull reddish brown compact tough heavy clay or silty clay. This has a blocky structure and crumbles into granular particles. When wet, this subsoil is very stiff and plastic. At 28 to 30 inches it is underlain by a yellowish-brown highly weathered material consisting of yellowish-gray and brown plastic clay. Fragments of diabase and of the mudstone, or slate, are present in this C horizon. The surface of Montalto gravelly silt loam is gently sloping to somewhat rolling. Only 19 percent of the type lies on C and D slopes. Surface drainage is fairly good, but the internal drainage is decidedly interrupted by the presence of the stiff subsoil. Twelve hundred and fifty acres of the total area are under cultivation, 79 acres are in pasture, and 237 acres are in woodland. On the cultivated land, both sheet and gully erosion is fairly pronounced, greater than moderate erosion occurring on 46 percent of the cultivated area. On the pasture and woodland erosion is negligible. Much of this soil type has been used for building lots and particularly for recreation purposes in the vicinity of some of the larger towns.

Montalto silt loam covers an area of 1,693 acres, of which only 2 percent is on steep slopes and a little more than 81 percent is on A and B slopes. The surface soil is a grayish-brown

to yellowish-brown friable silt loam. It pulverizes easily into a granular structure and has a total depth of about 6 inches. It is underlain by a yellowish-brown to brown heavy silt loam or clay loam. Dark stains of organic matter are present in the upper 2 inches of this layer. Below is a dark-brown heavy tough clay. There are small fragments of purple slate in this layer. Almost 84 percent of the Montalto silt loam is under cultivation, 100 acres are in pasture, and 86 acres are wooded. Sheet erosion with some gullying has occurred over part of the cropland, but erosion is negligible on the woodland and the pastured areas, owing to the moderate slopes.

#### GROUP 6.—UPLAND SOILS FROM SLATE OR ARGILLACEOUS SHALE

The soils of group 6 have been developed on the thin-bedded shale and slate of various colors that lie between the limestone valley and the higher-lying soils derived from the Triassic sandstone and shale to the north. They occupy low, rolling hills and are marked by steep slopes only where main drainage lines have cut across the formation. These shales vary in color from yellow or brown to a reddish tint. They are thin-bedded and break up into small fragments, so that the soils derived from them are commonly referred to as gravel land or slate land.

##### BERKS

The principal soils derived from these shales, mapped as the Martinsburg shales by the United States Geological Survey and the Pennsylvania Geological Survey, are the soils of the Berks series. Of these, the brown phase of Berks shaly silt loam has by far the largest extent, amounting to 16,960 acres, or 81 percent of the series. The surface soil of this soil type to a depth of about 9 inches is a dark grayish-brown silt loam containing numerous flat shale fragments. This is underlain by a reddish-brown silt loam to silty clay that contains as high as 40 percent of the flat shale flakes. This usually grades at a depth of about 34 inches into the partly weathered parent material, which contains as high as 80 percent of the shale fragments held together by a small amount of reddish-brown or yellow heavy clay. Berks shaly silt loam differs from the brown phase chiefly in having a grayish-yellow to dark-yellow subsoil layer. The underlying parent material is chiefly a dull-gray to drab disintegrated shale, which lies at depths from 30 inches to 5 feet. In this material there is scarcely enough fine earth to fill the interstices between the shale fragments.

Over 78 percent of the brown phase of Berks shaly silt loam is under cultivation, and over half of this cropland has been more than moderately eroded. This is due to the nature of the material as well as to the fact that such a large proportion is under cultivation. Even half of the 970 acres in pasture has been

more than moderately eroded, and some of the woodland has also been seriously eroded.

Berks silt loam, brown phase, covers 1,627 acres. Eighty-nine percent of its surface lies on A and B slopes and only 7 percent on BB slopes. The normal Berks silt loam covers only 239 acres. The slopes are somewhat more pronounced on this type than on the brown phase, 24 percent of its area having BB slopes. These two soil types differ from Berks shaly silt loam chiefly in the fact that there is less finely divided shale in the surface soil. The amount increases with depth from the surface, and the parent material consists of broken fragments of the underlying shale.

##### CARDIFF

Associated with the soils of the Berks series are those of the Cardiff series, derived from a hard bluish-gray slate. Of these, Cardiff slaty silt loam, covering 1,451 acres, is the more extensive.

The surface soil of Cardiff slaty silt loam to a depth of 8 inches is a grayish-brown friable loam. This is underlain to a depth of 18 inches by a dull yellowish-brown friable heavy loam. The B horizon to a depth of about 30 inches consists of a dull grayish yellow to yellow friable silty clay. At 30 inches this grades into a greenish-gray mass of slate fragments having a small amount of claylike weathered material in the interstices. From the surface down to the parent material the entire section is filled with small fragments of slate making up from 15 to 40 percent of the total mass.

The Cardiff soils are developed on low ridges rising about 100 feet above the surface of adjacent territories. The surface of these ridges is usually smooth on the top, but the sides are rather strongly sloping. As a result, 72 percent of the Cardiff slaty silt loam and 86 percent of the silt loam lie on A and B slopes, whereas only 9 percent of the slaty silt loam and only 1 acre of the silt loam lie on the steeper C and D slopes.

Sheet erosion with gullying occurs on both of these types. This is due to the fact that 93 percent of their area is cropped, whereas only small areas are in pasture. Both the cropland and the pasture are rather severely eroded. The small areas in woodland are not seriously eroded.

#### GROUP 7.—WELL-DRAINED UPLAND SOILS FROM TRIASSIC SANDSTONE AND SHALE

Along the northern border of the Conestoga area the interbedded conglomerate, sandstone, and shale rocks of Triassic age form a broad belt. Prevalently these rocks are a deep Indian red in color, but interbedded with them are strata of gray or brownish shale and sandstone. This difference in color in the original parent rock gives rise to inherited color differences among the derived soils, which make up group 7. Those formed on red sandstone, shale, and conglomerate

are grouped in the Penn series, and those formed from the yellow, gray, or brown shales and sandstone fall in the Lansdale series. In certain locations the alternation from the red to the gray or yellow shales and the slope have given rise to an extremely complex pattern of soils, the color changing rapidly from gray or brown to reddish brown or even red. This material could not be separated even on the scale of 1 inch to 1,320 feet, and such areas were mapped as the Penn-Lansdale complex.

#### LANSDALE

Three types of the Lansdale series were mapped: Lansdale gravelly loam, covering 2,311 acres; Lansdale loam, covering 2,766 acres; and Lansdale stony loam, mapped only on 682 acres. In all respects except texture these soils are very similar, showing the same color succession from the surface to the parent material.

Lansdale gravelly loam is marked by a yellowish-brown to light-brown surface soil having a depth of 7 to 10 inches. This is underlain by a yellow to brownish-yellow silty clay loam subsoil that is compact but friable under normal moisture conditions and crumbles into a granular mass. This may be from 10 to more than 20 inches in thickness. It is underlain by a yellow silty clay loam or silty clay, which grades into disintegrated sandstone or shale parent material at various depths. Along its borders it shades toward the reddish coloring of the Penn series. Gravel is scattered throughout the complete section. A and B slopes cover nearly 75 percent of the gravelly loam, BB slopes 21 percent, and the steeper C and D slopes only 4. Eighty-nine percent is cultivated, and about one-third of the cultivated area has been affected by greater than moderate erosion. Only 92 acres are in pasture, but most of this has been moderately eroded, and even the 53 acres of woodland show some severe erosion.

Lansdale loam has the same color and texture sequence as Lansdale gravelly loam, but it does not possess the gravel. Eighty-seven percent of the Lansdale loam lies on the gentle A and B slopes, 8 percent on BB slopes, and 5 percent on C and D slopes. Three-fourths of its area is under cultivation, and most of the cultivated land has been affected by moderate or greater than moderate erosion. Twenty percent of the 121 acres in pasture has been more than moderately eroded.

Lansdale stony loam covers 682 acres. It is made up of material that is so stony from large and small blocks of conglomerate that little of it has been cleared for cultivation. It is also steeply sloping, 45 percent of its area lying on C and D slopes, 15 on BB slopes, and only 40 percent on the gentler A and B slopes. Less than 1 acre is under cultivation, 58 acres are in pasture, and 619 remain in woodland. This soil, because of its woodland cover, has been little affected by soil erosion.

The Lansdale soils where cultivated produce average yields of crops common to the area.

Drainage is good across the surface and internally, and only the rough condition of a part of the area, especially on the steeper slopes, prevents its more extensive use for cropping. Soil erosion constitutes a serious problem over the cultivated land and to some extent on the pasture.

#### PENN

Soils of the Penn series cover 62,262 acres, or 15.4 percent of the total area. They are exceeded in areal extent only by the soils of the Duffield series. Consequently they are of decided agricultural importance. These soils have been derived from underlying red or purplish-red sandstone, shale, and conglomerate of Triassic age. The purplish-red color of the soils themselves is inherited from the parent material. These soils are commonly acid in reaction.

The most extensive Penn soils are Penn gravelly loam, which covers 17,173 acres, and Penn stony loam, occupying an area of 16,044 acres. The gravelly silt loam covers 8,954 acres; the silt loam, 6,306; and the stony silt loam, 8,680 acres.

Penn gravelly loam has a surface soil that is grayish brown to yellowish brown in color and is a loose friable loam. It contains a large amount of small rock fragments and pieces of sandstone and conglomerate over the surface and throughout the soil layer. At a depth of about 6 to 7 inches the surface soil is underlain by a light-red loose friable gritty clay. This has enough pinkish gravel and red sandstone to give the subsoil a distinctly gravelly character. At a depth of about 30 inches this grades into dark Indian red highly weathered Triassic sandstone and conglomerate. Clay content is sufficient to give this material coherence. The parent material layer is very shallow, and the unaltered Triassic bedrock usually lies within 35 to 40 inches below the surface.

A and B slopes comprise 40 percent of the surface area; BB slopes, 36; and the steeper C and D slopes, 24 percent. Seventy-one percent, 12,122 acres, is used for cropland. The survey showed that greater than moderate erosion had occurred on 69 percent of this cropped area, on 52 percent of the 498 acres in pasture, and even on 8 percent of the 2,188 acres of woodland. In spite of the gravelly condition of the surface soil and subsoil and its fair receptivity for rain water, greater than moderate erosion has occurred on 61 percent of this soil.

Penn stony loam differs chiefly from Penn gravelly loam in that the stony material is of larger size and stone is scattered over the surface and throughout the surface soil and subsoil. It also differs from the gravelly loam in that only 103 acres are in cropland. Moderate or greater than moderate erosion has occurred on 99 acres of this and on 62 of the 69 acres in pasture. The 15,779 acres in woodland have been more than slightly eroded on only 11 percent of their area. Only 184 acres, slightly more than 1 percent of the soil type, has been affected by greater than moderate erosion. The remainder, because

of the woodland cover, has been fairly well protected.

Penn stony silt loam differs from the stony loam in the higher silt content of both the surface soil and the subsoil and in the rather stiff deeper claylike subsoil. Thirty-six percent of this soil lies on C and D slopes. Only 49 acres are in cropland and 111 in pasture. The 8,447 acres in woodland are fairly well protected, although 17 percent of the area has been affected by moderate or greater than moderate erosion.

Penn gravelly silt loam shows the characteristic grayish-brown to brownish-red surface soil of the series—in this soil a mellow friable silt loam containing a rather large amount of rounded gravel and pieces of red sandstone up to 6 inches in diameter. This material may comprise anywhere from 20 to 60 percent of the entire soil mass. The subsoil is a light Indian red, rather compact somewhat friable silty clay or clay. It contains specks and fragments of red shale throughout the layers. It also contains the same rounded stone fragments and small pieces of red sandstone in the surface soil. The C horizon begins at a depth of about 20 inches. It is a dark Indian red to maroon silty clay that is rather compact but can be crumbled under pressure. There are small pieces of sandstone, gravel, and some cobbles in this layer. At a depth of 65 to 70 inches this is succeeded by a dark-maroon layer, consisting chiefly of weathered Triassic rock mixed with tough Indian-red clay. The unaltered parent rock underlies this layer.

A and B slopes make up 62 percent of the area of Penn gravelly loam; the BB slopes, 32; and C and D slopes, only 6 percent. Cropland covers 7,457 acres, or 83 percent of the total. Eighty-two percent of this cropland has been seriously eroded, that is, has been affected by greater than moderate erosion. Nearly three-fourths of the 404 acres in pasture has also been seriously eroded, as well as one-fourth of the 586 acres in woodland. Consequently, 79 percent of the entire soil type shows serious erosion. This cannot be ascribed to extreme slopes, since only 6 percent of the area is on D slopes. It should rather be associated with the soft, silty nature of the surface soil and the fact that such a large proportion of the type is under cultivation.

The surface soil of Penn loam is a dark grayish-brown to yellowish-brown mellow friable loam. The reddish color is present at 4 to 6 inches in depth, and the surface soil grades into a bright Indian-red gritty sandy clay at a depth of 7 to 8 inches. This subsoil contains a relatively large amount of small rounded pebbles. At a depth of about 32 inches this subsoil gives way to a pale Indian-red sandy loam developed from the Triassic sandstone and conglomerate. Very little clay is present in this layer. Ninety percent of the surface of the Penn loam lies on A and B slopes, 9 percent on BB slopes, and only 1 percent on the steeper C and D slopes. Consequently, 4,626 acres of the total 5,105 is under cultivation. Fifty-five percent of this cultivated area has been seriously eroded,

while 33 percent of the 206 acres in pasture has also been affected by serious erosion. Only 28 acres are in woodland, but 42 percent of this area has been seriously eroded.

Penn silt loam, covering 6,306 acres, is marked by a dark Indian-red silt loam surface soil containing a noticeable amount of small particles of sand. It is friable and tends to crumble into small, irregularly shaped particles. It becomes heavier and firmer with depth. Small pieces of the parent rock are present in the surface soil. At 6 or 7 inches this grades down to a light Indian-red heavy compact silty clay or clay containing light-red specks. At about 20 inches this subsoil grades into a dark Indian-red brittle silty clay. Fine grains of sand are present in this layer, which extends to a depth of about 70 inches. It is underlain by a dark Indian-red partly weathered shale material. Eighty-five percent of Penn silt loam lies on gentle A and B slopes, 13 percent on BB slopes, and only 2 percent on C and D slopes. Ninety percent, 5,679 acres, is in crops. About 50 percent is seriously eroded, but only 67 percent of the 339 acres of pasture and none of the 69 acres of woodland have been seriously eroded.

It will be seen from this summary of the important soil types of the Penn series that the stony areas are principally in woodland and have very small cultivated areas. On the other hand, much of the gravelly loam, loam, and silt loam are cultivated, and serious erosion has occurred over a large part of the cultivated area.

#### PENN-LANSDALE

Along the boundary line where soils of the Penn and Lansdale series grade into each other and in localities where the parent material of these two series has become mixed, it was necessary to map a separation known as the Penn-Lansdale complex. Two distinct soil types were mapped under this designation.

Penn-Lansdale loam is distinguished by a dark grayish-brown to gray friable loam, which becomes a lighter brown with increasing depth. This surface soil extends to a depth of 8 to 9 inches. It contains some small rounded pebbles from the gray and red Triassic sandstone, but these are not present in sufficient quantity to give the soil a distinctly gravelly character. The subsoil is a pale-red or yellowish-brown friable loam or silty clay loam. Enough sand grains are present to give the soil a somewhat gritty feeling. Pebbles and some cobbles are present in the subsoil, which extends to a depth of 30 to 35 inches, and there are small pieces of the gray or dingy-red Triassic sandstone and conglomerate in the lower part. At a depth of about 3 feet the subsoil is underlain by a yellowish-brown or bright-red heavy claylike material that is mixed with highly disintegrated red and gray sandstone and conglomerate. This layer contains enough clay to make the material coherent. Small pieces of sandstone, pebbles, and cobbles are present in this layer. This soil appears to be a transitional type between Lansdale loam and Penn loam. Penn-Lans-

dale loam covers 1,235 acres, of which 1,037 are under cultivation. A and B slopes make up 78 percent of its area, BB slopes 20, and the steeper C and D slopes only 2 percent. Thirty percent of the cropland has been affected by greater than moderate erosion in spite of the gently sloping surface. Over two-thirds of the 37 acres in pasture has been similarly eroded. There has been no serious erosion on the 62 acres of woodland. This soil type seems to be peculiarly susceptible to accelerated soil erosion in cultivated fields.

Penn-Lansdale gravelly loam differs from the loam chiefly in the presence of a much higher percentage of gravel from the surface soil down to the parent material. This amounts frequently to as much as 60 percent of the entire soil mass. In consequence, surface soil and subsoil are rather crumbly and incoherent. Penn-Lansdale gravelly loam covers only 784 acres. Fifty-three percent lies on A and B slopes, 29 on BB slopes, and 18 on C slopes. Cultivated areas cover 579 acres, or nearly three-fourths of the soil type. Of this, 72 percent has been seriously eroded and some of the area badly gullied. Only 13 acres are in pasture, but this land has also been seriously eroded and gullied. On the 170 acres of woodland there has been little erosion.

It is noticeable that in spite of the rather moderate slopes of these two soil types and the fact that they are of medium to rather coarse texture and of open granular structure, they have been unable to absorb moisture with sufficient rapidity to prevent run-off across the surface and serious erosion on the cultivated and pastured fields. Erosion-prevention practices must be adopted on virtually every acre of this land.

#### GROUP 8.—IMPERFECTLY OR POORLY DRAINED UPLAND SOILS FROM SANDSTONE AND SHALE

Throughout the upland part of the area and outside of the limestone section, there are small areas where colluvial accumulations have been formed in association with the dominant, well-drained upland soils. There are other areas that, because of peculiarities of subsoil texture and structure, are not so well-drained internally as adjacent soil types with which they are associated. These areas make up group 8.

The colluvial phase of Berks silt loam covers only 297 acres. The surface soil to a depth of 9 inches or more is a dark-gray to grayish-brown silt loam that is mellow and easily pulverized. There is a relatively large amount of flat shale fragments in the surface soil. It is underlain by a gray to grayish-brown silt loam or silty clay, also well filled with small shale fragments. This material is lacking in coherence and readily crumbles. At a depth of about 36 inches a true subsoil is encountered, which is a grayish-brown mellow silt loam, also filled with shale fragments. It contains enough clay to give it coherence. At a depth of about 4 feet this is underlain by a dark-gray or grayish-brown silty clay or clay loam with about 65 percent of the mass consisting of

gray and yellow shale fragments. Ninety-two percent of the type lies on A and B slopes, and the remaining 8 percent on C and D slopes. Seventy-four acres are cultivated, and 10 percent of this is badly eroded. The chief use is for pasture, 179 acres. Only 5 acres of pasture have been eroded. Eleven acres in woodland have been slightly eroded.

The most extensive upland soils that are imperfectly drained fall into the Croton series, associated with the Penn series on the Triassic shale and sandstone upland. The two soils of this series have a grayish-brown to gray surface soil and yellow to mottled-yellow or light-gray subsurface layer extending to a depth of 14 to 20 inches. The deeper subsoil consists of a compact hardpanlike stratum of chocolate red or mottled bright red and yellow. It also frequently has a streak of yellowish brown and contains some dark-colored concretionary material. The underlying bedrock consists of dark-colored argillite or chocolate-red Triassic rock. The series has very poor aeration and oxidation. It lies on rather flat, imperfectly drained plateaus into which few streams reach, and these have but shallow channels. Thus the Croton soils have imperfect surface and internal drainage.

Croton loam covers a total area of 1,435 acres, of which 97 percent lies on A and B slopes and 3 percent on BB and C slopes. Little erosion occurs on the 524 acres under cultivation; 573 acres are in pasture. The woodland, covering 198 acres, has been affected by moderate or greater than moderate erosion on nearly one-third of its area. Of the entire type, about 2 percent has been affected by greater than moderate erosion.

Croton silt loam covers 2,283 acres, of which 893 are in cropland. Ninety-one percent lies on A and B slopes and 9 on BB slopes. It has the same color characteristics as Croton loam, and the claypan occurs at depths ranging from 30 inches down to the surface of the bedrock. Over one-third of the land in crops has been rather seriously eroded (greater than moderate erosion), sheet and gully erosion being prominent even on the B slopes. In the pasture land, only about 9 percent has been seriously eroded; on 13 percent of the 575 acres of woodland similar erosion has occurred.

The presence of the underlying claypan in these two soils, preventing the absorption and distribution of soil moisture, has been the dominant factor giving rise to surface saturation and erosion.

The colluvial phase of Edgemont silt loam covers only 267 acres. Most of this soil lies on A and B slopes, and only 4 acres have been seriously eroded. The surface soil to a depth of 14 to 15 inches is a dark grayish-brown to black friable silt loam. The upper subsoil down to about 30 inches is a yellow to yellowish-brown heavy plastic clay or silty clay. This is immediately underlain by a yellowish-brown to brown heavy plastic clay having a granular structure. Some small quartzite boulders are present in this layer. The underlying parent material is a yellowish-brown or gray highly weathered quartzite material.

Glenville silt loam occurs in association with the soils of the Chester series. The surface soil to a depth of nearly 30 inches is a grayish-brown to yellowish-brown micaceous silt loam having faint yellow and brown mottlings at the greater depths. Numerous small pieces of mica schist are present, washed down from surrounding hillsides. At about 30 inches the surface soil grades into a light brownish-yellow to yellow friable silty clay containing a relatively large amount of finely divided mica flakes and small fragments of mica schist. This changes at about 40 inches in depth to a weathered mica schist containing enough clay to give the mass coherence. This material is mottled grayish brown and yellow. This soil covers 467 acres, of which 245 are cultivated, 156 are in pasture, and 55 are wooded. It lies exclusively on A and B slopes, and 466 acres show deposition of material from higher levels. It presents no erosion problem, rather one of adequate drainage.

Penn silt loam, colluvial phase, has a dark reddish-brown mellow silt loam surface soil to a depth of about 20 inches. It is underlain by a dark brownish-red friable silty clay or clay loam subsoil that has a porous granular structure when dry but is tough and plastic when wet. The deeper subsoil has a similar coloring but contains sufficient sand grains to give it a gritty feel. The deep parent material is an Indian-red highly weathered mass of the parent Triassic rock containing enough clay to give it coherence. All the type lies on A and B slopes, and no serious erosion has occurred. Cropland covers 239 acres; pasture, 122; and woodland, 28.

Watchung-Lehigh silt loam, occurring on 1,873 acres, is developed on level or gently sloping areas in association with the Montalto series. The surface soil to a depth of about 7 inches is a dark-gray friable silt loam. The subsoil is a light-gray silty clay streaked with yellow, brown, and light green. Pieces of the parent rock are scattered through this layer. A tough silty clay or clay occurs at 30 to 32 inches, and this is mottled with red, blue, purple, and gray coloring. It contains a large amount of diabase rock and shale or slate. Below 32 inches this becomes a mass of highly weathered material apparently derived from both the diabase rock and the metamorphosed shales. A and B slopes comprise 92 percent of its area, all but 2 acres of the remainder lying on BB slopes. Only 359 acres are under cultivation, and 23 percent of this land has been seriously eroded. The 186 acres in pasture have largely escaped erosion, but 19 percent of the woodland, lying on B and BB slopes, has been moderately eroded. The total extent of the woodland is 1,045 acres. The tough, impervious subsoil gives rise to poor internal drainage and the rapid saturation of the surface soil under continued rains. The claypan thus contributes directly to erosion of the surface soil.

## GROUP 9.—UPLAND SOILS FROM METAMORPHOSED SANDSTONE AND SHALE

### BRECKNOCK

Where dikes and sheets of intruded basic igneous rock have come into contact with the shales and sandstones of the Triassic area, contact metamorphism has resulted and the rock has become baked to a statelike condition. Soils developed on these metamorphosed rocks, chiefly on the ridges north of Churchtown, are classed in the Brecknock series and make up group 9.

Brecknock silt loam has a gray to grayish-brown friable silt loam surface soil to a depth of about 8 inches, which contains small pieces of bluish slate. The upper subsoil to a depth of about 18 inches is a dark bluish-gray or steel-gray compact silty clay and also contains fragments of slate. The deeper subsoil is a dark-gray to bluish-gray slightly compact silty clay or clay. It has an irregular to blocky breakage and tends to crumble when dry. The underlying parent material at 30 inches is partly disintegrated blue slate. The soil covers 1,384 acres, with 80 percent occupying A and B slopes, 15 percent BB slopes, and only 5 percent C and D slopes. Cropland covers 1,014 acres, 61 are in pasture, and 244 are wooded. The cultivated area has been affected by moderate or greater than moderate erosion on 86 percent of its area in spite of the gentle to moderate slopes. All the pasture land has been moderately eroded, but only 35 acres of the woodland has been so eroded.

Brecknock gravelly silt loam has a dark slaty gray silt loam surface soil having a depth of about 8 inches. It contains a large amount of broken, partly disintegrated fragments of the parent material and is underlain by a dark-grayish friable clay loam upper subsoil. This is also well filled with broken fragments of the slate. It becomes heavier and lighter colored with depth and merges into a deep subsoil consisting of dark-gray or steel-gray slightly compact silty clay or clay. Fragments of the parent material make up 40 to 60 percent of the mass. It passes at a depth of about 40 inches into a gray slate.

Brecknock gravelly silt loam covers 3,281 acres, of which 59 percent lies on A and B slopes, 35 on BB slopes, and only 6 on steeper slopes. Nearly three-fourths of its area is in crops, and 61 percent of the cropland has been rather severely eroded. The 106 acres in pasture have been seriously eroded on 85 percent of their area, and 27 percent of the 642 acres in woodland has also been seriously eroded, chiefly on BB and C slopes.

Brecknock stony silt loam is developed on 2,040 acres. Nearly one-half of its area is covered with large flat pieces of slate, and these are found throughout the soil section. The surface soil is a slate-gray heavy silt

loam having a depth of about 8 inches. The subsoil is a bluish-gray, olive-drab, or yellowish-gray compact clay or silty clay. Large fragments of the baked shale and some of diabase are present in this layer, which reaches a depth of 38 inches. It is underlain by a mottled brown, blue, and reddish-brown gummy clay, mixed with disintegrated rock. It is tough and plastic and very sticky when wet.

Brecknock stony silt loam is more steeply sloping than the other soil types of the series, only 30 percent lies on A and B slopes, whereas 51 percent lies on BB slopes and 19 on C and D slopes. Only 52 acres are under cultivation, and 54 percent of this land has undergone greater than moderate erosion. Moderate or moderately severe erosion has occurred on all 20 acres of pasture, but only 1 percent of the 1,955 acres in woodland has been more than moderately eroded.

#### GROUP 10.—TERRACE SOILS

High-lying, well-drained terraces have been formed at some places along the larger streams draining the Conestoga and Pequea watersheds. The material built into the terraces was chiefly carried down from adjacent or nearby uplands and partakes of the nature of this parent material. Three distinct soil types of this class, group 10, were mapped, covering 1,027 acres. They are choice, well-drained, nearly level soils and 76 percent of their area is cultivated.

##### BIRDSBORO

Birdsboro silt loam has been developed on terrace materials that distinctly show their derivation from the red shales and sandstones of the upland. The surface soil to an average depth of about 6 inches is a brown silt loam. This is underlain by a dull reddish-brown friable gritty clay loam, which changes at a depth of 18 to 26 inches to an Indian-red brittle clay containing some quartz pebbles. Below 26 inches are some iron concretions. All but about 5 percent lies on A and B slopes, and 199 acres are under cultivation. About one-third of the cultivated land has been seriously eroded. There are 27 acres in pasture and 39 in woodland, only a small area of each being seriously eroded.

##### ELK

Elk gravelly silt loam, derived chiefly from the upland limestone soil material, is marked by a dark grayish-brown mellow silt loam surface soil having a depth of about 8 inches. This is underlain by a light-brown silty clay loam that is firm but friable. This extends to a depth of 18 to 20 inches and is underlain by a dark-brown clay loam. Both surface soil and subsoil contain large amounts of gravel and cobbles. The C horizon is a brownish-red clay, tough when dry and plastic when wet. Of the 161 acres of this soil, 131 acres are cultivated. Serious erosion has occurred on 24 acres of the cropland. The remainder

is chiefly in woodland, of which 4 acres have been seriously eroded.

##### ENGLESIDE

Engleside loam is the most extensive of the terrace soils, covering 586 acres, of which 446 acres are under cultivation. It is formed on materials derived chiefly from the calcareous mica schists of the upland or strongly influenced by admixtures of that material. The surface soil is a dark-brown mellow loam to a depth of 9 inches. This is underlain by a dull-brown friable heavy sandy loam, underlain in turn at 34 inches by a dark grayish-brown clay loam containing a noticeable amount of fine and medium sand. Texture variations are common in this terrace material at all horizons. A and B slopes make up 68 and BB slopes 31 percent of the soil. Of the 446 acres under cultivation 24 percent has been more than moderately eroded, and all the 96 acres in woodland have been moderately eroded. Erosion occurs chiefly on the B and BB slopes. This soil requires careful protection wherever cultivated.

#### GROUP 11.—WELL-DRAINED FLOOD-PLAIN SOILS

Material derived from various upland soils has been carried down into the stream courses of the area and deposited as more or less permanent soils, which are still in the process of formation and modification. These soils, group 11, do not have any distinct subdivisions into soil horizons, nor are they entirely uniform in texture and organic-matter content throughout the various types. Yet distinct soil types may be recognized in the alluvial bottom lands.

Two types exist under such topographic conditions that they are seldom subject to any prolonged overflow, and in both, internal drainage has become fairly well established.

Bermudian silt loam, formed from materials derived chiefly from the upland soils underlain by Triassic sandstones and shales, is characterized by a brown or reddish-brown silt loam surface layer that contains enough sand to give it a gritty feeling. At about 1 foot in depth this is underlain by a dull Indian-red friable silt loam with an increasing proportion of sand at greater depths. This grades into a loose friable Indian-red sandy loam showing distinct dark-red spots. Ground water may be present at depths below 30 inches. A slopes comprise 99 percent of the area. Only 6 acres are cropped, whereas 671 are pastured and 346 remain in woodland. Greater than moderate erosion has occurred on only 1.5 percent of the area.

Huntington silt loam to a depth of 8 or 10 inches is a dark-brown to grayish-brown mellow silt loam. This is underlain by a dark grayish-brown to gray friable silt loam or silty clay loam. There are red markings about 2 feet below the surface. Thence the deeper material consists of a drab-gray and yellowish-brown mottled silty clay. The

material forming this soil is derived chiefly but not exclusively from the limestone uplands. Huntington silt loam was mapped to the extent of 3,785 acres, of which 98 percent occurs on A slopes. Only 63 acres are more steeply sloping. The cultivated area amounts to 1,007, the woodland to 62, and the pasture to 2,656 acres.

#### GROUP 12.—IMPERFECTLY OR POORLY DRAINED FLOOD-PLAIN SOILS

The imperfectly and poorly drained alluvial soils occur at the lower levels in the stream bottoms and in positions where they are subject to annual or frequent overflow and make up the soils of group 12. Some of them have become well enough established to have individual characteristics warranting their recognition as soil types.

Bowmansville silt loam occupies poorly drained positions in the bottom lands and was mapped on 3,447 acres. The surface material to a depth of about 8 inches consists of a dark reddish-brown silt loam mottled with streaks of gray, brown, and yellow. It contains a large amount of organic matter in a high state of decomposition. This surface material is underlain by a dull grayish-brown to reddish-brown heavy silt loam or silty clay loam mottled with gray, yellow, and red. It is usually wet and sticky. This soil has been formed chiefly from materials from the red shale uplands. All but 24 acres lie on A slopes, only 48 acres show any erosion. Cultivated land covers 580 acres; pasture, 1,980; and woodland, 589. Drainage, rather than erosion, is the problem on Bowmansville silt loam.

Codorus silt loam, formed principally from materials derived from the Chester and Berks soils of the uplands, has a dark-gray to light purplish-brown friable micaceous silt loam surface layer containing a relatively high percentage of organic matter. It is about a foot thick and is underlain by a dark grayish-brown heavy micaceous silt loam. This extends to a depth of about 4 feet, where it becomes mottled with red or reddish-brown streaks. Water is usually present at this depth. The type covers 1,663 acres, of which 442 are under cultivation, 970 are pastured, and 231 are in woodland.

Lindside silt loam materials are derived chiefly from the calcareous upland areas. The surface material to a depth of about 9 inches is a dark-gray friable silt loam. This is succeeded by a grayish-brown to reddish-brown friable silt loam distinctly marked with dark-yellow and rusty-brown mottlings. Below 24 inches in depth there is a grayish-brown silt loam mottled with dark-gray and rusty-brown streaks. This layer is sticky and tough, and water is usually present at a depth of about 40 inches. This soil covers 5,661 acres, of which all but 9 lie on A slopes. Over 5,000 acres are occupied by pasture, 80 are in wood-

land, and 515 are cultivated. The cultivated land is not eroded, and only 13 acres of pasture show slight erosion.

Melvin silt loam occupies such low-lying positions that it is saturated with water during the greater part of the year. Of the 1,104 acres covered by this soil, all but 8 lie on A or B slopes. Pasture covers 952 acres, woodland 36, and 82 acres are cropped. Erosion is not a problem. The surface layer is a dull grayish-brown to dark-gray silt loam with distinct rusty-brown mottlings throughout. It is high in organic matter and either moist or saturated. At about 10 inches it is underlain by a mottled grayish-brown to rusty-brown silt loam, which is succeeded at about 20 inches by a drab-gray or bluish-gray sticky silt loam with faint red and yellow mottlings. The organic-matter content is high even at this depth. The layer is wet to saturated at all times.

Wehadkee silt loam consists of material derived principally from the Piedmont uplands but occupying poorly-drained bottom-land positions. The surface soil to a depth of about 5 inches is a grayish-brown to yellowish-brown silt loam mottled with red, brown, and gray streaks. It contains a large amount of organic matter. Immediately below this is a layer extending to a depth of 30 inches or more made up of grayish-brown to reddish-brown silt loam or clay loam, also mottled. At greater depths this is underlain by a dark bluish-gray heavy plastic silty clay loam mottled with rusty-brown and red streaks. The type is saturated at lower levels. It is nearly all on A slopes. No serious erosion has occurred on the 624 acres in pasture, and only deposition was mapped on the 82 acres of woodland.

Wehadkee silty clay loam has an area of 1,240 acres. It is formed chiefly from Penn and Lansdale material from the upland. The surface layer, about 10 inches deep, is a dark-gray to black silt loam showing rusty-brown streaks below 2 inches. This is underlain by a light-gray or drab heavy plastic silty clay or clay mottled with light-brown and yellow streaks. At a depth of 30 to 32 inches this changes abruptly to a loose red, gray, and yellow sand, which is usually saturated. All of this soil type lies on A and B slopes, and only 6 acres show any signs of erosion. Seven hundred acres are in pasture, 396 in woodland, and only 80 acres are cultivated.

An area of 193 acres of poorly-drained alluvial soils could not be separated into distinct types or was so subject to change with successive overflows that no distinctive characteristics have been established. This material was mapped as alluvial soils, undifferentiated. It lies almost entirely on A and B slopes and is about equally divided between woodland, cultivated land, and pasture. Seven acres of tilled land have been more than moderately eroded.