BULLETIN 55—PART B

Geologic Series

The Peats of New Jersey And Their Utilization

by

SELMAN A. WAKSMAN, H. SCHULHOFF, C. A. HICKMAN,
T. C. CORDON and S. C. STEVENS

DEPARTMENT OF
CONSERVATION AND DEVELOPMENT
STATE OF NEW JERSEY

IN COOPERATION WITH

NEW JERSEY AGRICULTURAL
EXPERIMENT STATION, RUTGERS UNIVERSITY

Trenton, N. J.

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LETTER OF TRANSMITTAL

April 10, 1943.

MR. CHARLES P. WILBER, *Director,*
Department of Conservation and Development,
Trenton, N. J.

SIR:

As stated in Part A, Bulletin 55, the peat deposits of New Jersey constitute an important natural resource which is being developed on an increasing scale to replace the peat formerly imported from Germany and Scandinavia. It is hoped that this comprehensive report on the quality and quantity of our deposits will therefore be of timely aid in this development and will point the way to their wise utilization.

It is a pleasure again to acknowledge the generous cooperation of the New Jersey Agricultural Experiment Station in making this report available for publication as a bulletin in the Geologic Series of this Department's publications.

Respectfully yours,

MEREDITH E. JOHNSON,
State Geologist.

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Part B

ABSTRACT

Part B comprises a survey of the peat bogs of New Jersey. These peats are considered from the point of view of their distribution, botanical and chemical nature, surface area and depth, and utilization for agricultural and other purposes. The peat areas of the State are divided into three broad regions, namely (a) the Northern, which are predominantly of the sedge and reed types; (b) the coastal plain, predominantly of the forest type, and (c) the salt marshes and the alluvial peats. No true sphagnum peat is found in New Jersey, although growing sphagnum is found very extensively over the bogs. Among the forest peats, the "cedar swamps" are particularly characteristic.

The State is divided into 21 regions, on the basis of drainage basins which vary greatly in size and in the nature of the peats. A total of 364,671 acres, or 70 per cent of the total area, formerly classified as bogs, swamps, and marshes has been surveyed. Sixty per cent of this surveyed area was found to comprise true peat and 40 per cent comprised only mineral soil or soil material with less than 50 per cent organic matter (dry basis), or contained less than 12 inches of peat. Many of the bogs present great variation in the nature of the peat throughout the depth of the bog profile.

INTRODUCTION

Peat has played an important part in the geological surveys of the State, as in its agricultural and industrial development. That interest in peat was evident a century or more ago, is brought out in the final report on the geology of New Jersey by Henry D. Rogers in 1840 (81).[1] However, it was Dr. George H. Cook (24, 25, 26) as director of the New Jersey Agricultural Experiment Station, who first devoted considerable attention to the subject of peat.

Cook emphasized the great potentialities of the peatlands of the State and in his reports stated that the reclamation of the meadows and marshes had been thoroughly studied and effectually practiced in western New Jersey from the earliest settlement of the country. In Salem County, for example, attempts to bank Alloway Creek were made as early as 1700. Information concerning the peats of the State and their utilization has been given in various geological, soil and Experiment Station reports, the last comprehensive study being a report on the peat resources of northern New Jersey which was prepared by Parmelee and McCourt (73) and inserted in the Annual Report of the State Geologist for 1905.

[1]All bibliographic references are given at end of report.

The extensive areas of peatlands in the State fully justify this continued interest. It is sufficient to cite here the results of one of the geological and one of the soil surveys.

In the final report of the State Geologist for 1895 (volume IV), the distribution of peat in relation to the total area of New Jersey is summarized as follows:

	Acres
Total area of State	5,263,641
Land surface	4,809,218
Water surface	454,423
Upland soil, including fresh-water swamps	4,494,567
Tidal marsh	296,289

Of the tidal marsh, 34,304 acres were said to be embanked and more or less improved.

The report of the Soil Survey, prepared by Lee (56), estimated that about half a million acres of the surface area of the State are occupied by peatlands. These were classified as follows:

	Acres
Peat or "swamp"	215,104
Tidal "marsh"	215,040
"Muck" lands, cultivated and uncultivated	42,369

These figures do not distinguish between types of peat, their respective depths, their nature and chemical composition, or their possible usefulness. The depth of peat in these areas may range from 1 to more than 30 feet, and in many cases the surface organic layer may be so shallow that the area could hardly be considered as a peat bog.

According to these data, the peatlands of the State comprise 8 per cent of the total surface area and about 20 per cent of the undeveloped regions. Since part of this can be made productive if required for agricultural purposes or for exploitation of the peat for use in soil improvement, it may well be considered as occupying a prominent place in any system of recovery of marginal land in the State. Because of the increasing density of the population and the close proximity of many of the bogs to large centers of population, the reclamation of many of the bogs deserves careful consideration on the part of both the conservationist and the agricultural economist. This was well recognized nearly eight decades ago by Cook, who wrote in his preface to the "Geology of New Jersey":

> In the agriculture of our state, can the great body of tide-meadows be profitably reclaimed and their inexhaustible stores of fertility be made available? Will the continued agitation of this subject, and the publication of facts showing its advantages finally bring capitalists to undertake it? How shall the state best prepare for this improvement which is sure to come?

Various systems of classifying the peatlands of the State have been proposed, depending largely on the special interest in those lands. Some of the systems were agricultural, others geographical or geological.

From an agricultural point of view, they were classified into three groups: first, those that are permanently wet and can never be made fit for cultivation; second, those that afford good pasturage for livestock; and third, those that can easily be drained and developed. Another common classification divided these lands into: first, areas that in their natural condition are subject to periodical overflow by streams; and, second, lands that produce profitable crops during seasons of light or medium rainfall but that are unproductive during seasons of greater than normal rainfall (37).

Since the present survey stressed the occurrence, abundance, and especially the nature of the peat types, the latter are classified primarily on the basis of their botanical and chemical composition. Wherever possible, emphasis is also laid on the utilization of the peat or peatlands. It is the sincere hope of those who labored in obtaining and making this information available that it will help to stimulate interest both in the peatlands of the State, and in their better utilization.

METHODS USED IN SURVEY

In November, 1938, a project of the Work Projects Administration was set up to make a comprehensive survey of the peatlands of New Jersey. This survey was sponsored by the Department of Soil Microbiology of the New Jersey Agricultural Experiment Station, Rutgers University. The object was to determine the abundance, distribution, and nature of the different types of peat in the State, with a view to their possible utilization for agricultural and industrial purposes.

The organization of the project was as follows: The W.P.A. personnel consisted of three state and four district supervisors. There were, at various times, 15 to 25 field crews or units, five men each, working in different sections of the State. The office staff comprised clerks, draftsmen, typists, and one artist. Several chemists, laboratory assistants, and laborers made up the laboratory staff. The district supervisors directed the work of the field units in their particular areas. They planned the work, supervised operations, and made reports to the central office. They also checked all the field work, samples, and reports, before they were transmitted to headquarters.

The soil maps prepared by the Bureau of Chemistry and Soils, U. S. Department of Agriculture in cooperation with the State Department of Conservation and Development were used as a basis for locating the peat areas to be surveyed in the State. All the areas designated as swamp, tidal marsh, meadow, and muck were selected, and, in addition, other areas that appeared to contain peat were examined. Peat was actually found in areas not so designated on the soil maps, such as in Papakating silt loam; and on the other hand, a great many areas designated on the maps as swamps were found to contain little or no peat. In preparing the field work-maps for the crews, the rectangles formed by the lines showing latitude and longitude on the State maps were enlarged five times and the areas supposed to contain peat were plotted thereon. Roads, towns, and other landmarks were included in order to facilitate locating the bogs. Each of these field maps bore a number determined from the intersection of the latitudinal and longitudinal lines at the lower left hand corner. A map bearing the number 74.30–41.02, for instance, designates the area bound by latitude 41°02′–41°04′ N, and longitude 74°28′–74°30′ W. Different peat bogs within each quadrangle were numbered consecutively, as Area 1, Area 2, Area 3, etc.

In addition to these maps, the field crews were supplied with mimeographed forms—"face" and "profile" sheets—on which field observations were recorded. On the "face" sheets were recorded the map number; condition of the bog; name of owner; local designation of bog; location with respect to towns, railroad stations, and highways; acreage; average depth; drainage; surface vegetation; utilization of bog; and description of surrounding terrain. The "profile" sheets were used to record the location of the profile submitted to the laboratory; nature, color, texture and structure of the samples in the profile; and the presence or absence of free water and gas.

In preparing for a field survey a map was issued to a unit, the location of the area to be surveyed being indicated by crossroads, railroad track, and other markings. When it was definitely determined that the location was correct, a plane table was set up and the area was traversed with a compass. Borings were made at intervals of 50 to 300 yards, depending on the size and general characteristics of the area. Care was taken to determine the edges of the bogs and that no unusual changes in the bottom contour were missed. A specially designed peat sampler was used to make the borings and samples were obtained of every foot of peat down to the underlying

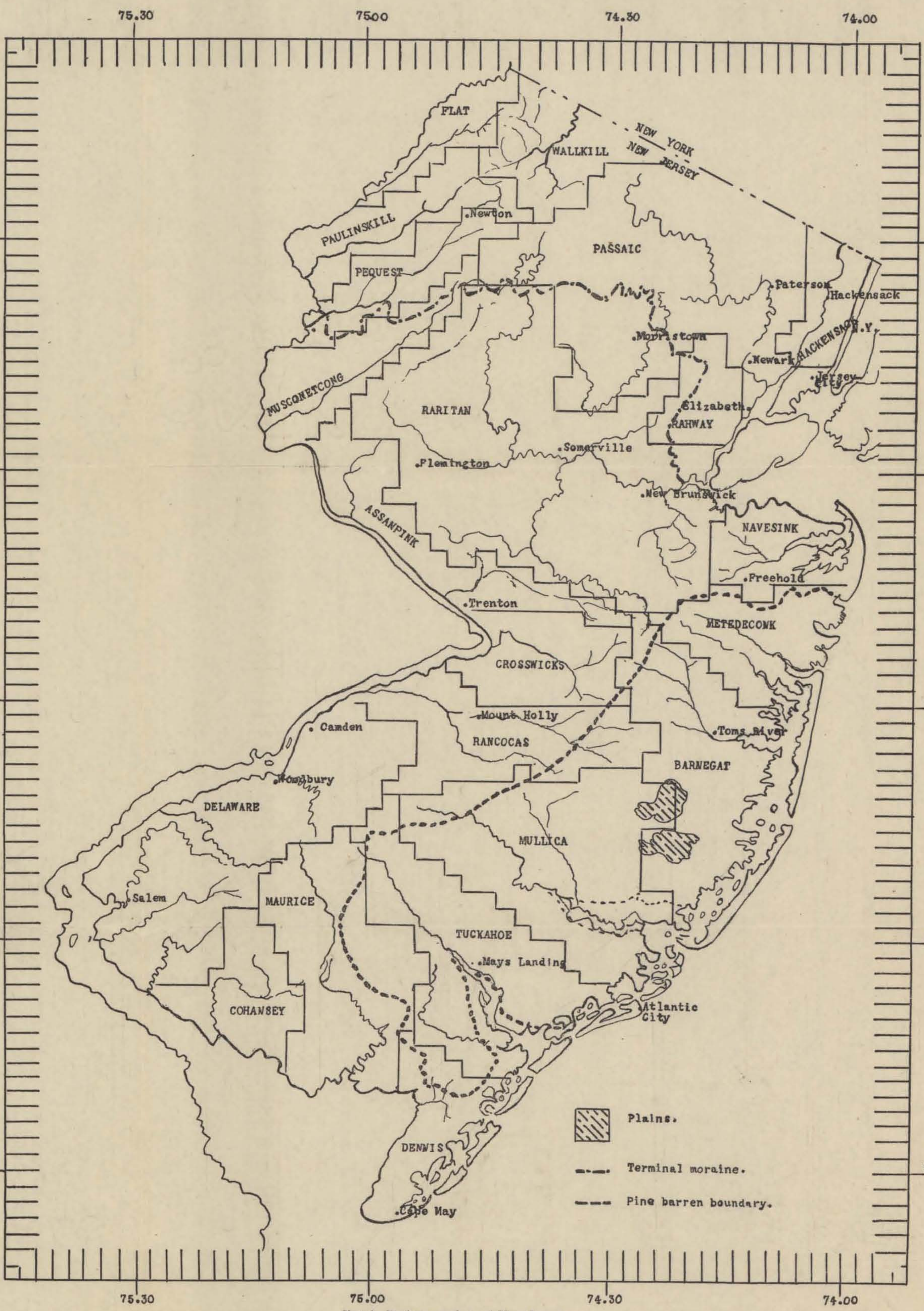


FIG. 1. Drainage regions of New Jersey.

mineral soil. The samples were examined as to their nature, structure, and texture, and the information was recorded on the "profile" sheets. After an area was completed the "face" sheet was filled out, giving the information indicated above. A representative profile was next selected, and samples for each foot were taken and placed in jars. A sketch of the bottom contour was prepared on the basis of the depth of the profiles and soundings and a plan of the bog was made using dimensions obtained from the pacings.

On arrival at the laboratory the samples were examined and observations recorded (with naked eye, and often by the use of microscope). Each sample of peat was carefully mixed and analyzed for moisture, ash, total nitrogen, and pH value.* On the basis of the field reports and the chemical, microscopic, and other data, a cross section was made of each area showing the peat horizons, the contour of the bottom of the bog, and the nature of the surface vegetation.

To facilitate handling the large accumulation of data the State was divided into 21 regions on the basis of the drainage systems. (Figure 1). Lines separating the drainage regions were drawn to follow the latitude and longitude. Many parts of the State, especially along the Atlantic Coast and Delaware Bay, are drained not by large, well-defined rivers, but by numerous small streams; hence the regions were given the name of the largest river where a well-defined system was present, but in other cases numerous small streams were combined into one region and named for one of the larger streams.

The survey lasted a little over three years and at one time more than 150 persons were employed. Before it was ended about 70 per cent of the peat areas of the State were examined; however, since these areas are distributed through the State and are characteristic of the other areas that have not been surveyed, the data obtained are sufficient to justify generalizations concerning the peat resources of the State as a whole.

ACKNOWLEDGMENTS

In addition to those listed as co-authors there were many collaborators who contributed toward the success of this project, and it is sufficient to mention Mr. E. B. Wilson, Mr. L. C. Steffener and Mr. W. J. Jamieson, who served as District Supervisors, Miss A. Sadtler, the artist, Mr. E. P. Gambarova and Mr. L. F. Capers, statisticians.

* pH = hydrogen ion concentration. Neutral water has a value of 7; lesser figures indicate acid waters; greater figures, alkaline waters.

The authors wish to acknowledge their indebtedness to Mrs. Herminie B. Kitchen for the careful editing of this manuscript, to Dr. J. P. Martin for assistance in taking some of the photographs, to Dr. A. P. Dachnowski-Stokes of the Bureau of Plant Industry, U.S.D.A., for assistance in training some of the personnel, and to Mr. Meredith E. Johnson for the critical examination of the manuscript and for assisting in the publication of the results of this survey.

The authors have drawn freely and extensively upon the information supplied by the geological and soil surveys of the State, as well as upon the various contributions dealing with the vegetation of peat-bearing areas. Particular acknowledgment is made here of the use of "The Glacial Geology of New Jersey", by R. D. Salisbury, whose work proved extremely helpful; also of "The Geology of New Jersey", by J. V. Lewis and H. B. Kümmel; the State Geologist's Report for 1888, Vol. 1, entitled "Topography, Magnetism and Climate"; and J. W. Harshberger's "The Vegetation of the New Jersey Pine Barrens."

CHAPTER I

GEOGRAPHICAL, GEOLOGICAL, AND OTHER CONDITIONS CONTROLLING PEAT FORMATION IN NEW JERSEY

EARLIER CONCEPTS

The early concepts of New Jersey peats were limited to their occurrence, agricultural utilization, or to geological factors governing their formation. In this connection it is sufficient to examine the early geological reports of the State in which peats and peat bogs received considerable attention. Very often peat was considered quite incidentally as illustrated by the description of peat bogs given in connection with the occurrence of marl by an early geologist, Kitchell (52), in 1854.

On the other hand the tidal marshes, which are so prominent in the State, were treated largely from the point of view of relation to surface vegetation and the contribution of such vegetation to the formation of the peat. This can best be illustrated by citing a typical description of a marsh by Cook (25-27) in his "Geological Survey of New Jersey":

> Tide meadows along the Delaware Bay and River, and those along the Hackensack, Passaic and Raritan Rivers, and the salt marshes along the sea shore, are attracting much attention. Some of them have formerly been swamps, and covered with a heavy growth of timber, and are, to a considerable depth, made up of muck or black earth, formed from the decay of leaves, twigs, branches and trunks of trees. Others have been formed by the fibrous roots of sedges and coarse grasses, which grow in wet ground and shallow water, and have finally accumulated in sufficient quantity to form a complete network of roots, which holds water like a sponge. Near the banks of water courses, where muddy water is constantly passing and repassing with every change of tide, the network of roots become filled with mud, quite solid, and a little higher than the marshes farther from the streams, but where only clear water comes, the substance of the marsh contains scarcely anything except the fibrous roots of coarse grasses. Water, at high tide, runs over and fills these marshes, and is held in their fibrous or peaty substance just as in a sponge, so that their upper surface is kept at high water-mark.

It is evident from the above description that cognizance was taken of the existence of different types of peat and that marked distinctions were made between them. The term "swamp" for example, was applied in the above characterizations to forest peat formation; "peat" and "muck" designate lowmoor or sedge and reed peat; and "meadow" was used in an all-inclusive manner for peat bogs. The forest peats found in the eastern part of the State received particular attention.

It is unfortunate that the terminology employed in the early literature was often confused because of an insufficient understanding of the nature and origin of different types of peat. The banked meadows of Salem and Cumberland Counties, for example, were said to consist on the surface of a fine mud, known as "black mud" or "grey mud". This was usually 2 to 4 feet in depth and rested on a "black peaty mass" known as "horse dung muck" or "turf", which in turn was often several feet in depth. In some places this order of superposition was reversed, the peat covering the mud and being 1 to 2 feet deep. This type of peat formation was said to make an inferior meadow.

The early students of peat in the State did not limit themselves, however, to mere descriptions. Attempts also were made to characterize these peats chemically, or at least to analyze them. These early chemical analyses were limited largely to inorganic constituents (table 1). It was established that the New Jersey peats were relatively high in ash and had a fairly high lime content. However, there was considerable variation in this respect. In subsequent analyses, the high nitrogen content of many of the New Jersey peats began to receive consideration (table 2). There appeared to be no correlation between the total nitrogen and the ash.

Since these early studies, considerable progress has been made in our understanding of the origin of different types of peat, their chemical composition, physical properties, and practical utilization, as brought out in Part I of this Report (104). This information led to a sound appreciation of the nature of New Jersey peats and made possible a more detailed study.

GEOGRAPHY

Detailed descriptions of the geography, geology, and topography of New Jersey are found in the works of Cook (26), Salisbury (83), McCourt (63), Vermeule (100), Smock (91), and Lewis and Kümmel (61). Only a brief summary is presented here.

The State of New Jersey is part of the Atlantic slope of North America and lies within two geographic and geologic regions: namely, the Coastal Plain and the Appalachian Province. The latter is usually further subdivided into the Piedmont Plateau, the Appalachian Mountains or New Jersey Highlands, and the Appalachian Valley (plate I).

The *Coastal Plain* includes the southern part of the State from the southern tip to a line running diagonally across the State through Trenton and New Brunswick. It constitutes about three-fifths of

TABLE 1

Early chemical analyses of New Jersey peats (Cook, 1868)

(On basis of air-dried material)

Locality	Organic matter	Moisture	Fe_2O_3+ Al_2O_3	CaO	MgO	K_2O	P_2O_5	SO_3	CO_2	SiO_2
Black Brook Meadows, Morris County	65.6	16.2	3.19	3.86	.37	.31	.93	.89	.09	8.64
Columbia, Morris County	66.9	15.2	3.97	3.17	.39	.27	.10	2.46	...	7.63
Allendale, Bergen County	83.8	11.7	0.42	1.46	.17	.08	.05	.74	.04	1.07
Beavertown, Morris County	69.8	16.8	2.92	3.34	.27	.02	.19	.76	.43	5.36

TABLE 2

Early analyses of a number of New Jersey peats (66)

(On basis of air-dried material)

Locality	Ash	Nitrogen
Allendale	5.04	2.17
Sussex	7.27	2.10
Stockholm	5.75	2.10
Dunker Pond	6.24	2.11
Mount Hope	5.14	1.27
Ironia	9.34	1.17
Bog and Vly	7.28	2.16
Southtown	6.54	1.62
Westwood	7.30	2.11
Kerr's Corner	8.01	2.35
Danville	8.62	2.45
Franklin Lake	8.34	2.03
East Newton	10.34	2.24
Lafayette	10.45	2.83
Sussex	11.38	2.34
Van Sickle	13.04	2.25
Rockport	11.36	2.02
Vernon	14.40	2.73
Ironia	14.26	1.30
Rockaway	10.54	2.11
Black Meadows	12.43	2.05
Great Meadows	10.84	1.88
Great Swamp	13.86	2.07
Troy Meadows	10.60	1.46
Pequannock	12.69	1.61
Danville	11.04	1.98
Southtown	13.42	2.52
Woodbridge	10.40	2.62
Buttsville	10.41	2.65
Pompton Plains	13.64	2.11

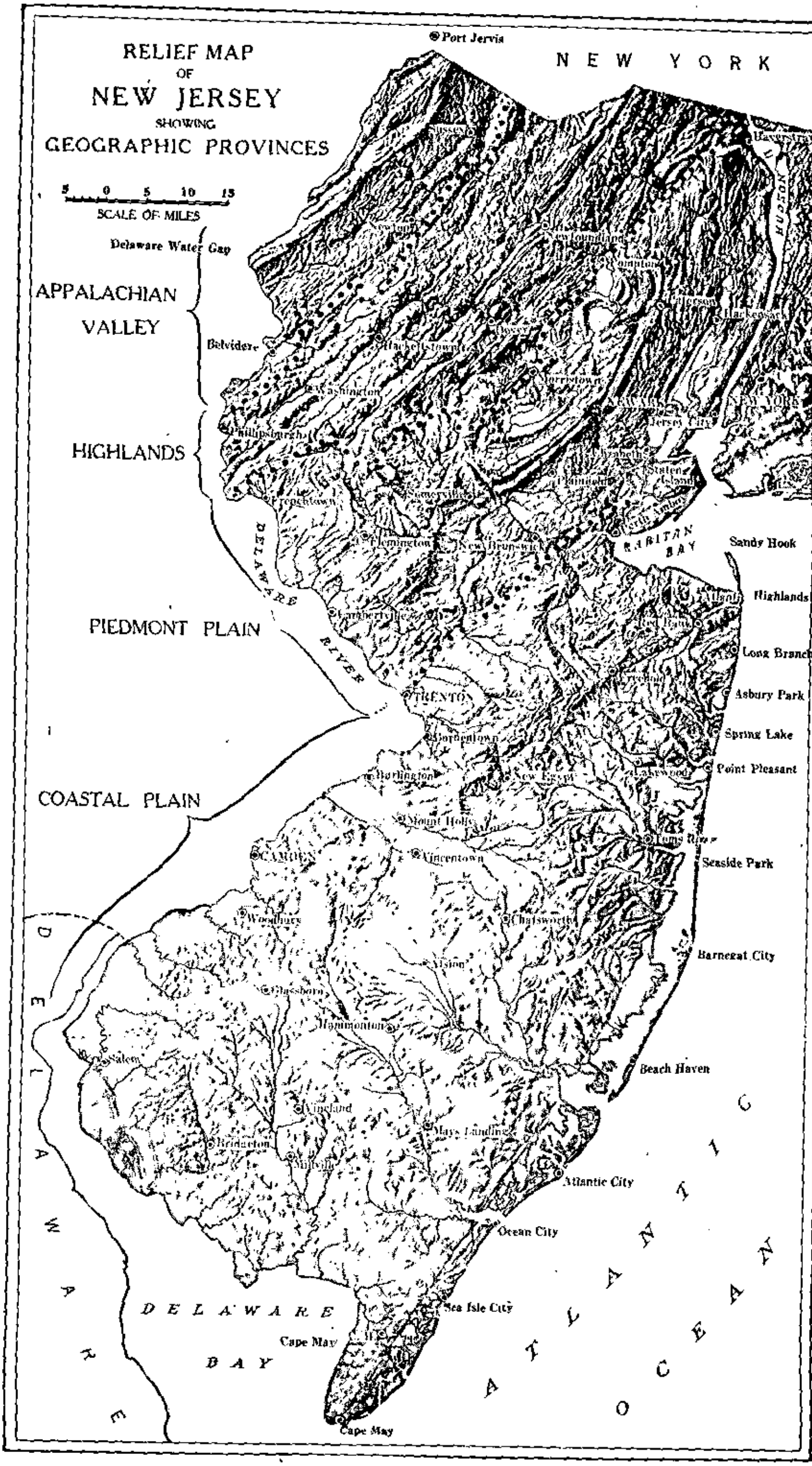


Plate I. Geographic provinces of New Jersey (after Lewis and Kümmel).

the entire area of the State and comprises the counties of Cape May, Atlantic, Salem, Gloucester, Camden, Burlington, Ocean and Monmouth, together with the southern parts of Mercer and Middlesex.

The *Piedmont Plateau* is bounded in New Jersey by Hudson River in the east, by the Coastal Plain in the south, by Delaware River in the west, and by the Highlands in the northwest. The latter boundary extends from Delaware River, between Frenchtown and Phillipsburg, irregularly northeast through Morristown, and more directly, through Pompton and Haverstraw to New York. The Piedmont Plateau occupies Union, Essex, Hudson, and Bergen Counties, together with large parts of Hunterdon, Morris, Passaic, Mercer, Somerset, and Middlesex. The area involved is approximately one-fifth of the entire State.

The *Highlands* of New Jersey are bounded on the northeast by New York State, on the south by the Piedmont Plateau, on the southwest by Delaware River and on the northwest by the irregular line of the Appalachian Valley, running north of Phillipsburg through points south of Newton and Sussex. Parts of Hunterdon, Morris, Passaic, Warren, and Sussex Counties are included in this division. This region occupies about one-tenth of the entire area of the State.

The remaining portion of the State, north of the Highlands, is also approximately one-tenth of the total area and comprises the Appalachian Valley. The western part is occupied by the narrow Delaware Valley and the eastern part by Kittatinny Valley, these parallel valleys being separated by the Kittatinny Mountains. This mountain range must be considered as one of the subordinate ridges of the Appalachian Valley although it reaches a greater elevation than the Highlands.

TOPOGRAPHY

The Coastal Plain slopes gently to the southeast, this slope usually not exceeding 5 or 6 feet to the mile. Since the greatest elevation in this area is only 400 feet and the mean elevation less than half this figure, the relief is only slight. Of the 4,400 square miles occupied by this area only about 25 per cent rises above 200 feet. A depression adjacent to the Piedmont Plateau, and running from Raritan Bay to Delaware River at Trenton, has a mean elevation of less than 100 feet above sea level. This depression continues down the Lower Delaware Valley, which is at tide level. Thus the Coastal Plane falls to sea level everywhere except where it abuts against the Piedmont Plateau in the northern extremity, and here it is less than 100 feet above tide.

From the Highlands of the Navesink (269 feet), a series of hills runs in a westerly direction to the vicinity of Morganville. This continues as a flat ridge to Freehold, with a mean elevation of 200 feet. A group of gravel hills continues to Whitings and Woodmansie, the greatest height being Pine Hill, near Manalapan, with an elevation of 372 feet. The watershed divide gradually falls, continuing in a southerly direction until, between the Rancocas, which flows northwest, and the Mullica, which flows southeast, the elevation is less than 100 feet.

Continuing south, the land rises, a maximum elevation of 208 feet occurring at Shamong Station. From high ground at Berlin, the watershed divide runs southwest to Glassboro and Shiloh.

Most of the streams of the Coastal Plain flow from the divide either southeast to the ocean or northwest to the Delaware. The valleys of the streams of the two slopes are, however, quite dissimilar; those of the western slope being deep, narrow, and steep-banked, whereas the eastern valleys are broad and shallow. This difference is caused by the dip to the southeast of the alternating strata of sand, gravel, clay and marl (plate II). The beds outcrop on the northwest slope and the streams running northwest cut across them; the resistance encountered results in relatively deep, narrow valleys. Streams flowing down the southeastern slope of the divide do not encounter these resistant layers and therefore form shallow valleys. For the most part, the divide between the two slopes lies within 15 miles of the Delaware River, making the streams flowing to the northwest considerably shorter than those flowing to the southeast. The one exception is Rancocas River, which heads within 15 miles of Barnegat Bay.

The red sandstone Piedmont Plateau is a region of gently rolling hills, studded with trap ridges. The two most notable trap ridges, namely, First and Second Mountains, attain maximum elevations of 665 and 691 feet, respectively, above sea level. These parallel ridges rise from the plain in the vicinity of Pompton, at the foot of the Highlands, in the northern part of the State, and, following the form of a very broad horseshoe, culminate again at the foot of the Highlands in the vicinity of Pluckemin and Basking Ridge. Smaller trap ridges are enclosed within the huge bulge of First and Second Mountains and the Highlands.

This part of the Piedmont Plateau, enclosed by the trap ridges and the Highlands, is 41 miles in length and varies from 7 to 12 miles in width. During part of the period of the Wisconsin glaciation, this region was covered by the glacial Lake Passaic, and remnants of this body of water remain as a series of bogs, the members of which follow

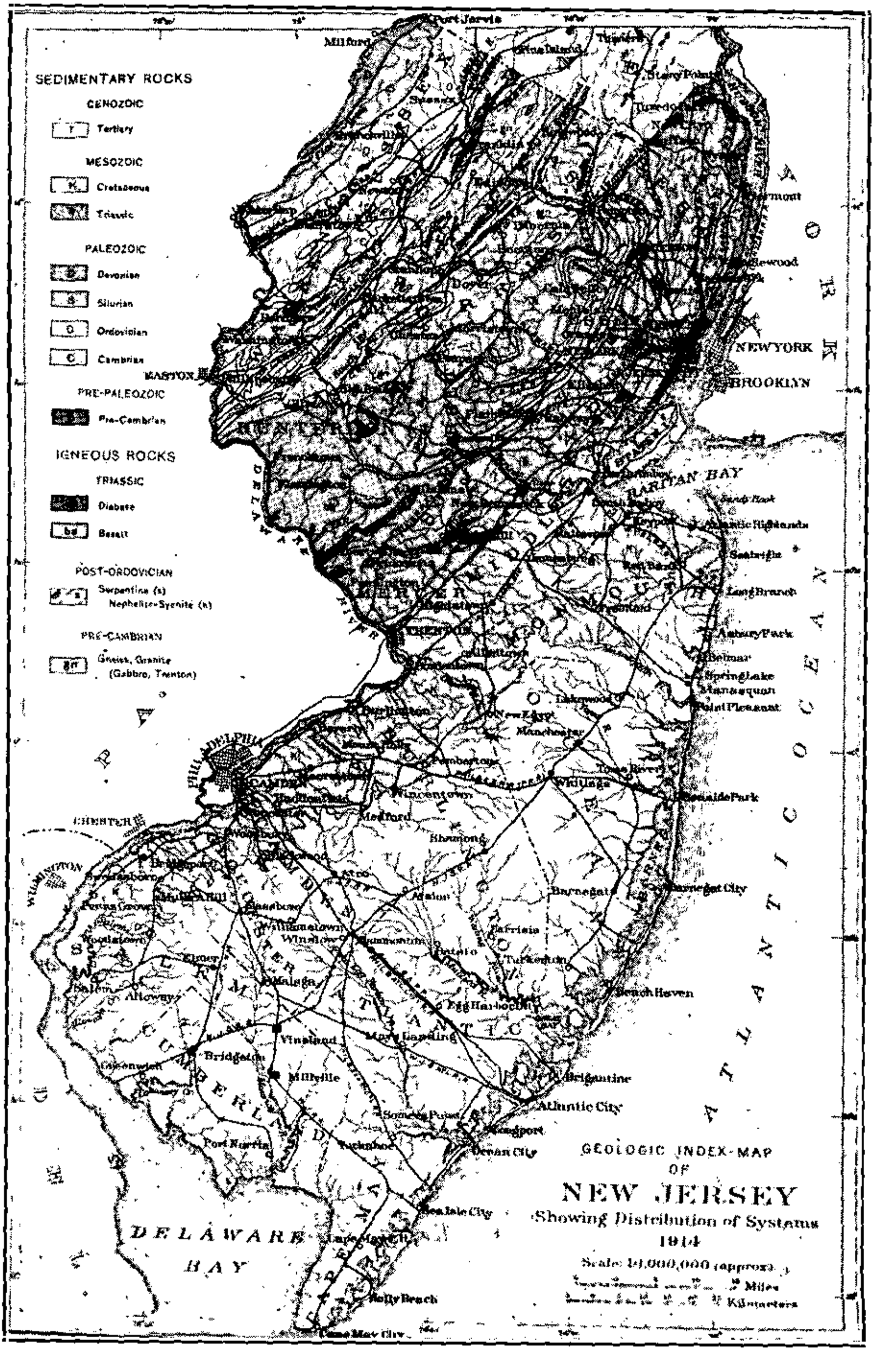


PLATE II. The geologic index-map of New Jersey (after Lewis and Kümmel).

a definite pattern. This series of bogs, as well as the events which caused their formation, will be discussed later.

A third trap ridge, forming the Palisades, follows the west bank of Hudson River and towards its northern end hooks westward to the base of the Highlands. There is considerable evidence to show that toward the end of the last period of glaciation, much of the enclosure formed by the Palisades on the east, the Highlands on the northwest First and Second Mountains on the west, and the terminal moraine on the south, was covered at times by fresh-water lakes.

The Highlands of New Jersey occupy an area of over 800 square miles. The height varies from 600 to 1500 feet above sea level, the maximum elevation occurring in the northwest and the minimum in the southeast. The general trend of the ridges is from northeast to southwest. This mountain system may be resolved into a series of four parallel ranges, namely, the Hudson range (Ramapo Mountain), the Passaic range, the Central Highland Plateau, and the Allamuchy-Pohatcong range. These ranges are separated by valleys, namely, the Wanaque, the German-Longwood, the Sparta-Musconetcong, and the Pohatcong. There are, in addition, a certain number of other peaks and valleys of secondary importance.

Near the northern boundary of the State the Hudson range has a maximum elevation of 1171 feet, and is 4 to 5 miles wide. Its southern end is at Pompton, 10 miles from the State line. This range is extremely rugged, and is in a wild condition save for scattered poor mountain farms and resort camps. It contains a large number of glacial kettles, some of which are still in the form of lakes, whereas others are peat-filled; these are found between the subordinate ridges.

West of the Hudson range is the Wanaque Valley, which extends also into New York State. This valley has an elevation of some 500 feet at the State line, but falls to 200 feet at Pompton, where it emerges from the Highlands. There are various peat deposits in this rather narrow valley, but neither their number nor their extent is impressive.

The Passaic range on the west side of Wanaque Valley also extends into New York State and attains an elevation of 1200 feet and a breadth of 4 miles at the State line. It is in turn bounded on the west by the German-Longwood Valley. The Pequannock River flows out of Oak Ridge reservoir at the north end of this valley and, after flowing east to Newfoundland, cuts through the entire Passaic range. The cleft through the range is 400 to 500 feet deep, 7 miles long, and is a natural topographic dividing line. Green Pond and Copperas Mountains, separated by the cleft from the northern Passaic range, form level, crested, and parallel ridges, extending southwest to Rockaway River, some 12 miles distant. These mountains range from 1200 to 1300 feet above sea level. Green Pond is situated between them. Southeast of these ridges, as far as Splitrock Pond, is a belt of irregular hills, similar in form to those of the north, where another region of ridges is encountered. The southern limits of the Passaic range lie at Mendham, Ironia, and High Bridge. Mine Mountain, near Peapack, is isolated by a subvalley from the main mountain range, but is similar to it physically.

The German-Longwood Valley (including in this designation the valley extending northeast from Newfoundland) is the most important one in the Highlands, both because of its continuity and because it separates the Highlands into two parts, which in some structural details are noticeably different. The valley is occupied by Greenwood Lake and its tributary bogs, from the New York State line to a point near West Milford. Some 3 miles southwest, drainage of the valley changes from northeast to southwest and the Pequannock watershed is entered. At Milton, Longwood Valley widens out to more than 2 miles, but below that small community and as far southwest as Berkshire valley, the valley contracts markedly. Two miles to the south the Rockaway River turns east, but relatively low ground continues to the southwest past Kenvil, Flanders and Long Valley. The latter community was long known as German Valley, and hence the name German-Longwood applied to this valley and its continuation to the northeast.

Black River has its source near Kenvil and its valley parallels German Valley from Succasunna Plain to Chester. For some six miles above Chester it flows through boggy ground.

The Central Highland Plateau is the largest mountain mass in the State, and contains the most important peat deposits to be found in the New Jersey mountains. The maximum elevation in the range is 1500 feet, with ridge structure marked, especially in the northeast. The range lies west of the German-Longwood Valley and extends from New York State into Pennsylvania. The width of the plateau is 5 miles at the New York State line, broadening to more than 7 miles between Wawayanda Lake and Canistear reservoir. Nowhere in the State has the work of the Wisconsin ice sheet been more marked and nowhere, with the possible exception of parts of Kittatinny Mountain, is there more rugged, inaccessible terrain. Bogs and lakes, which owe their origins to the work of the ice sheet, are found in numbers between the ridges of the main mountain masses.

Certain valleys and mountains must be given special mention, because of their relation to peat formations.

The famous "Drowned Lands" of the Walkill River, extending from New Jersey into New York State, are in the valley of that river whose origin is half a mile south of the upper end of Lake Mohawk and whose waters flow northeast through Sparta and beyond, entering Kittatinny Valley near Franklin. Lake Mohawk is man-made and was formerly a bog.

Musconetcong Valley heads in Lake Hopatcong and runs southwest. This valley is drained by Lubbers Run, an important tributary of Musconetcong River which arises on Sparta Mountain less than a mile southeast of Lake Mohawk and flows southwest for some nine miles to the vicinity of Stanhope where it joins Musconetcong River. Many peat areas are in the valley of this river.

Pochuck Mountain lies between the valleys of Wallkill River and Pochuck Creek. Several peat deposits are found on this mountain.

The Allamuchy-Pohatcong range rises from the Kittatinny Valley at Franklin, and attains a maximum elevation of some 1300 feet above sea level. Allamuchy Mountain extends from Franklin to the vicinity of Hackettstown, with many deposits of peat between its ridges. The Pimple Hills, or that part of the range directly southwest of Franklin, contains kettles of glacial origin. Pohatcong Mountain lies mostly south of the terminal moraine and therefore contains only a very few peat deposits, all of which are north of the moraine.

Jenny Jump Mountain is an isolated mass lying northwest of Pohatcong Mountain and paralleling it. A few bogs are found in places where the mountain is wide enough to permit basin formation.

Scotts Mountain is connected with the Allamuchy-Pohatcong range by a discontinuous ridge which extends for about 10 miles, with a width of some 4 miles. The only bog worthy of note on this mountain is that found at Oxford Furnace.

In New Jersey the Kittatinny Valley is some 40 miles long and from 10 to 13 miles wide, lying between the Highlands on the east and Delaware River on the west. Two subvalleys traverse Kittatinny Valley longitudinally. One heads at Augusta and drains both to the northeast through Papakating Creek and Wallkill River, and also to the southwest through the Paulinskill. The valley thus drains to both the Delaware and Hudson Rivers. The Paulinskill rises in an important bog and has much peatland along its course. The second important drainage subvalley is that of Pequest River which rises in a large bog between Springdale and Huntsburg, and flows through much peatland in its northern reaches including the great area of cultivated peat north of Great Meadows. The Pequest Valley separates Jenny Jump Mountain from the Highlands.

Kittatinny Mountain, bounding Kittatinny Valley on the northwest, enters New Jersey from New York State only three miles southeast of Port Jervis and extends southwest to Delaware Water Gap. This mountain attains an elevation of 1800 feet at High Point, the highest elevation in New Jersey. Within the State the only low point in this ridge is at Culvers Gap where the elevation is 915 feet. Large sections of this mountain were inaccessible for the survey. Many bogs, some of considerable size, lie between the crests of the mountain where they are multiple, as well as between the subordinate ridges of the top. The mountain mass ranges in width from 8 miles, opposite Montague, to less than 1½ at some points south of Culvers Gap. The greatest number of bogs occur in the regions of greatest width, but some peat deposits are found even in the narrower portions.

GEOLOGY

The Coastal Plain (see plate II, p. 25) consists chiefly of beds of clay, sand, gravel, and other unconsolidated rocks of Cretaceous, Tertiary, and Quaternary age. A broad belt of Cretaceous formations runs diagonally across the State directly south of the Piedmont Plateau. These formations comprise various sands and clays, both glauconitic and nonglauconitic. Gravels and sands are abundant. Yellow limestone and calcareous (oceanic) marl deposits are present in restricted regions but apparently have not influenced the course of fresh-water peat formation in the vicinity.

The Piedmont Plateau is underlain by Triassic strata, with which are associated volcanic and intrusive igneous rocks. The Palisades are composed of diabase or coarse-grained trap rock which was intruded into the pre-existing sandstone and shale but did not reach the former land surface.

The similar but fine-grained trap rock composing First and Second Mountains and the smaller ridges associated with the evanescent glacial Lake Passaic were extruded on the former land surface as extensive flows. The ridges between First Mountain and the Palisades are made of sandstone, conglomerate and shale. West and south of Bound Brook are other ridges of diabase or basalt. Massive beds of conglomerate are found principally along the base of the Highlands. In the vicinity of Flemington and Hopewell are beds of the Lockatong formation, consisting of shale, argillite, flagstone, and occasional thin, impure limestone beds. The remainder of the Piedmont area is underlain, for the most part, by the Brunswick formation and is composed of soft red shale with a little interbedded sandstone.

The Appalachian Mountains in the Highlands province consist mostly of highly metamorphosed rocks of pre-Cambrian age, namely, gneisses and schists, with some marble or crystalline limestone, and intrusive igneous rocks, mostly granite gneiss. Paleozoic limestone and shale are found infolded with the pre-Cambrian crystalline rocks, chiefly in the narrow valleys separating the ridges.

In the same region are Green Pond, Copperas, Bowling Green and Bearfort Mountains, all of which are composed of quartzite and conglomerate. Limestone valleys are found below the terminal moraine in the Highlands, but since only two peat deposits are located in them, they need not be discussed further.

The lower parts of the Appalachian Valley and the intermontane valleys previously mentioned are chiefly on the Kittatinny limestone, and the great majority of peat deposits found in these valleys are entirely different from those found elsewhere in the State. These peats have been markedly affected by the type of substrata on which they rest. The ridges which traverse the great valley are mainly composed of Martinsburg shale, which is mostly black slaty shale.

Kittatinny Mountain is composed in the eastern part of Shawangunk conglomerate, and in the western part, of the High Falls formation, red shale and hard red sandstone. The ridges adjacent to Delaware River are composed of sandstone. Silurian and Devonian strata are represented in the valleys.

GLACIAL GEOLOGY

The geological changes due to the last or Wisconsin glaciation are presented here only in broad outline. Their effect upon peat formation will be discussed in connection with the individual deposits.

The Wisconsin glaciation is the most recent of a series of four glacial epochs recognized in the Mississippi basin and this last great ice sheet is estimated to have retreated some 20,000 to 25,000 years ago. Since changes in drainage and topography caused by ice sheets of greater age than the Wisconsin have largely been eradicated as a result of the Wisconsin glaciation and later erosion, only the Wisconsin glacial deposits will be discussed here.

The Wisconsin ice sheet extended farthest south in southern Indiana and Illinois. New Jersey was covered from its northern borders south to a highly irregular line running from Perth Amboy to Plainfield and Summit, thence to Union Village and back through

Chatham, Morristown, and Denville, finally to Budd Lake, Townsbury, and Belvidere. In this glaciated area, the State is covered discontinuously with glacial drift composed of boulders, gravel, sand and clay, transported by the ice and melt-waters. Along the line of the southernmost extension of the ice, the drift is designated as the "terminal moraine", this part being ordinarily thicker than other parts of the drift.

The ground moraine or till, that is, the debris deposited by the glacier and overridden by it, is as widely distributed as was the glacier, but on steep slopes and narrow ridges it is present only in small amounts. In most localities the ground moraine is not sufficiently thick to alter the pre-existing rock topography.

The terminal moraine has a maximum thickness of more than 300 feet, but averages about 100 feet. It varies from half a mile to more than 2 miles in width and is most conspicuous where rock relief is slight as in areas between Perth Amboy and Morristown. In the Highlands it is for the most part dwarfed by the great relief of the region.

In many places the terminal moraine is characterized by a network of interlacing ridges and troughs, often without outlet for drainage, the result being the formation of large numbers of bogs containing peat. The moraine is pitted in places with kettles, depressions resulting from the melting of ice blocks. Lack of drainage usually resulted in clusters of peat bogs. The largest cluster is encountered in the vicinity of Dover and numbers over 50 bogs in a square mile of moraine.

Both the terminal moraine and the ground moraine caused the formation of many lakes and bogs by alteration of existing drainage lines. A survey of the mountain ranges in the glaciated and nonglaciated parts of the State reveals the presence of hundreds of lakes and bogs in the mountains north of the terminal moraine and virtually none to the south. The topography is fundamentally the same, except for the deposition of the moraine. Within and north of the terminal moraine, steep-sloped ravines or valleys have been partly filled with boulders, sand, and clay, and in many cases have been dammed, thus retarding drainage; south of the moraine, bogs and lakes are virtually nonexistent.

Many glacial deposits in New Jersey have been produced as a result of the liberation of immense quantities of water during the disintegration of the ice sheet. The glacial streams carried much sediment; this was deposited in stratified formations designated as kames, kame terraces, valley trains, outwash plains, deltas, and eskers.

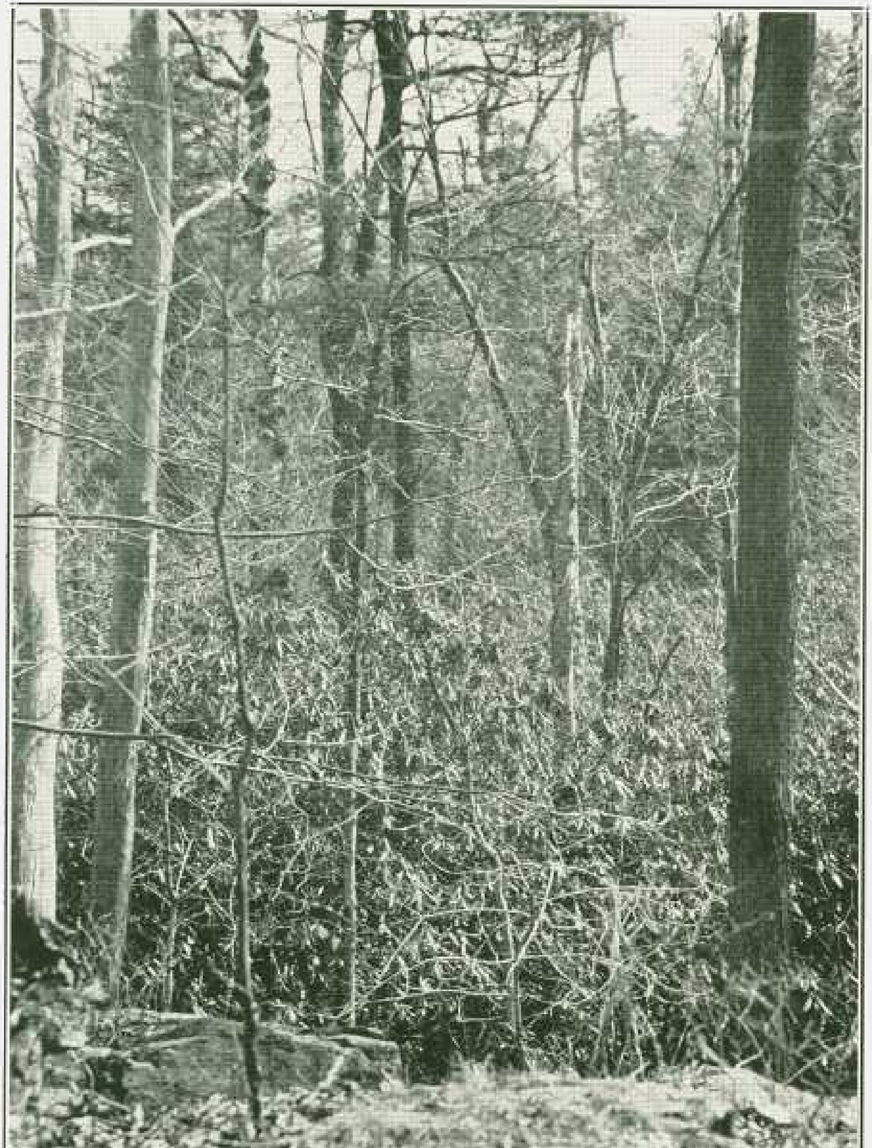


PLATE III. Mountain bog near Upper Greenwood Lake.

Kames are numerous in New Jersey and often occur in groups termed "kame moraines", the topography of which is similar to that of the terminal moraine. In many cases these contain bogs in the troughs between the kames. Other bogs occur in some of the "kettles" or undrained depressions in the outwash plains.

VEGETATION FACTORS IN PEAT FORMATION

The vegetation of the State in relation to bog formation has been the subject of many botanical studies. No attempt will be made here to review or even to list the numerous papers dealing with the sedges and reeds, which are important in the formation of sedge and reed peats, or the shrubs and trees that are equally important in the formation of forest peats. Attention is merely directed here to several contributions of particular interest. Among these, the work of Harshberger (41-45) is most important. The studies of Chrysler (21) and Chapman (19-20) also have a bearing upon this problem.

After the recession of the last glacier and the renewal of milder climate, the vegetation gradually spread northward. The bog vegetation was the first to take the place of the barren ground left by the retreating ice. These bog plants soon became firmly established, especially in the smaller glacial depressions where absence of wave action favored littoral vegetation. These bog societies were typical of the colder parts of North America and were closely related to those of Europe and Asia. They showed an optimum region of dispersal having a moist climate, subject to great temperature extremes (99). One such typical bog is illustrated in plate III.

Considerable light on the past history of the vegetation of New Jersey can be gained from an examination of the pollen diagrams from peat bogs. Typical diagrams of some of the northern bogs are presented in figures 2-4. Dr. J. E. Potzger, of Butler University, who made these analyses and also made these data available, submits the following interpretation of the results.[1]

All bogs except Squires Corner show a period of importance for spruce-fir, or a period of boreal climate. Pine was the next most important genus but hemlock and oak soon made their prominence felt. Oak represents, perhaps, a warmer-dry climate. The oak and pine seem to have shared the forest cover for a long period of time, and the striking thing is the two periods when hemlock increased (fairly well accentuated in all but the small Ramsey bog). This means that N. J. had two periods of increased moisture during which hemlock was able to crowd pine and oak. Hemlock, apparently, belongs to the broad-leaved element of the forest complex, rather than, as so frequently assumed, to the pine complex. The lower portion of the pollen spectrum is missing in the Squires Corner bog (77).

[1] Personal communication

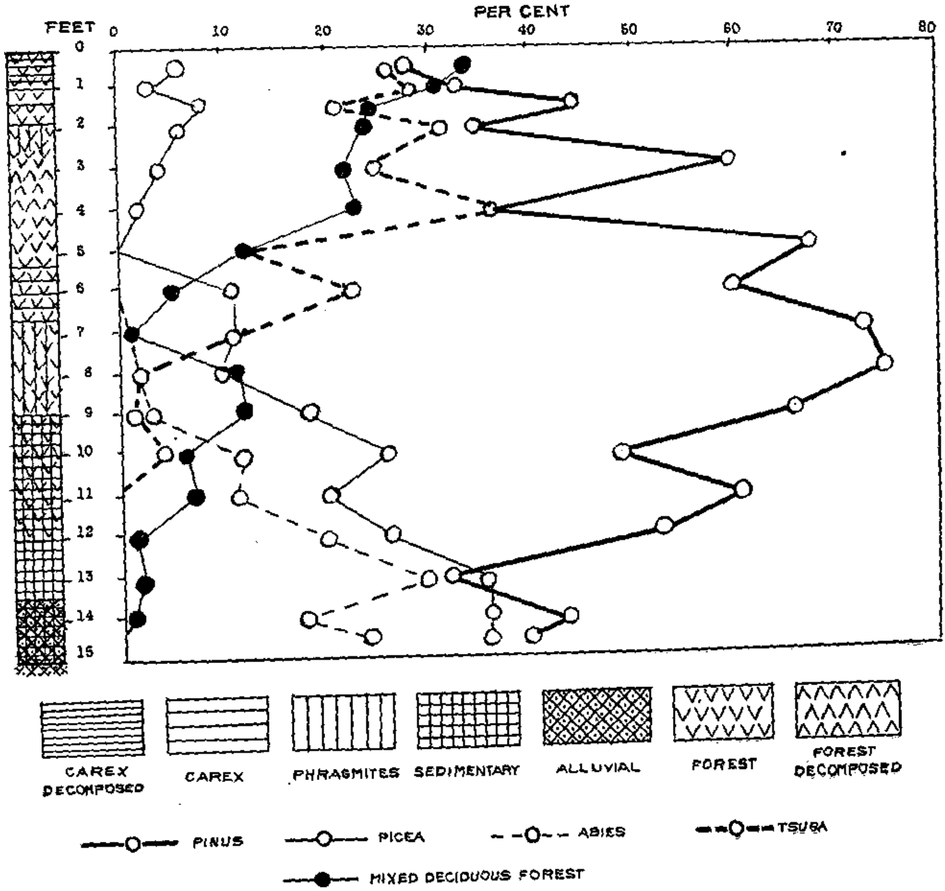


FIG. 2. Pollen diagram of Culver Lake margin bog on Kittatinny Mountain.

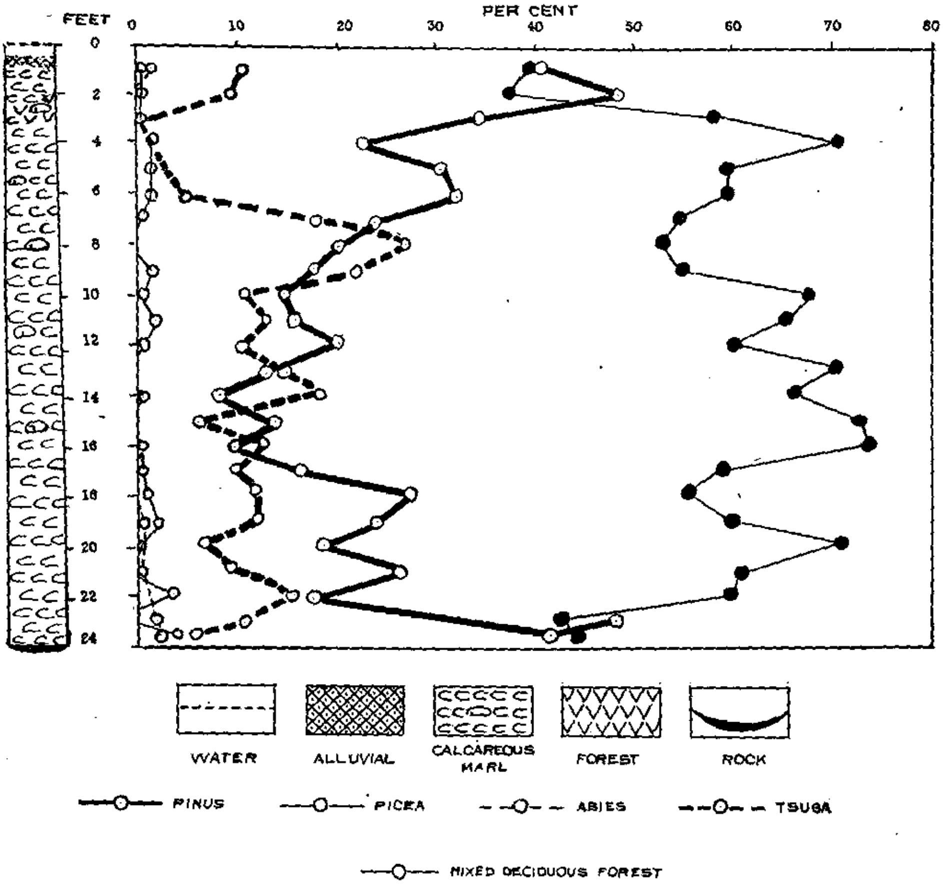


Fig. 3. Pollen diagram of bog surrounding White Lake, Squires Corners, in a limestone valley.

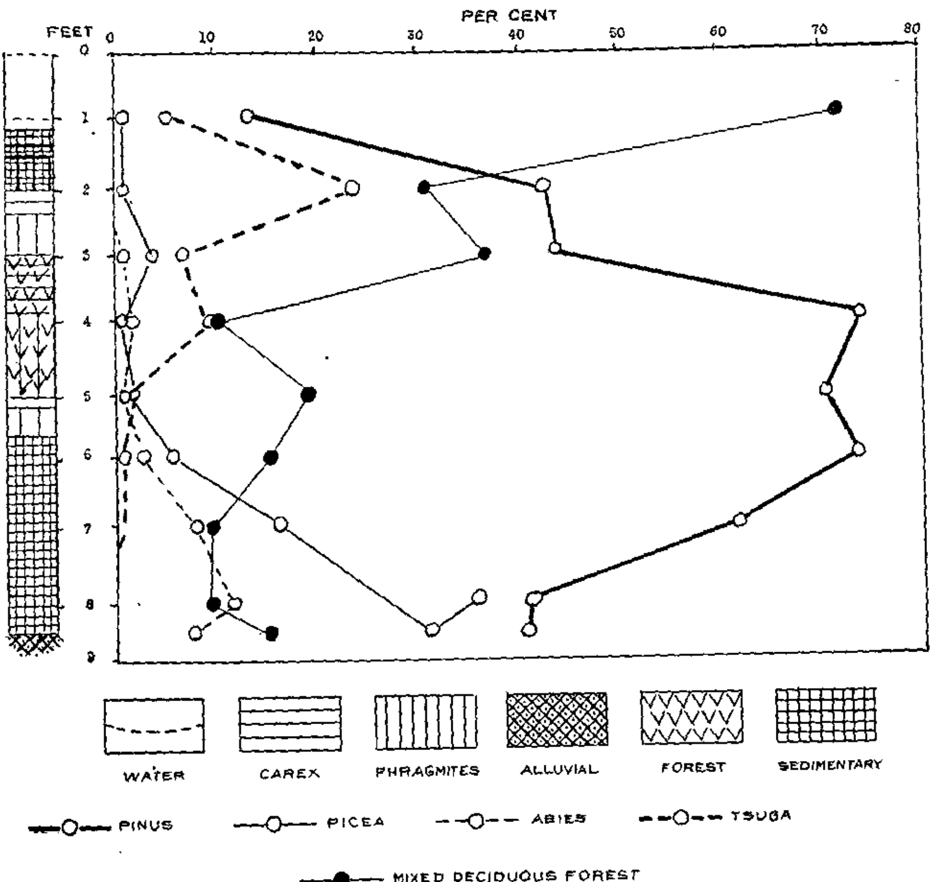


FIG. 4. Pollen diagram of a bog near Ramsey, Bergen County, in the Triassic plain.

MARL DEPOSITS IN NEW JERSEY BOGS

This brief survey of the various factors controlling peat formations in New Jersey would not be complete without an examination of a type of bottom material characteristic of the underlying mineral strata of some of the sedge and reed peats in the northern sections of the State; namely, calcareous marl. The formation of this material is a highly important phase of biological activity. Marl deposits are always found to be associated with calcareous regions. Marl consists principally of calcium carbonate with an admixture of other inorganic and organic substances. It is usually white or slightly cream-colored and granular to powdery. On treating marl with acids, the carbonate is dissolved and the organic matter is left in the form of flakes and other particles. The process of marl formation is described in detail by Davis (36).

Some deposits of marl may be produced largely or partly by mollusks and other invertebrate shells. Most deposits, however, do not contain recognizable shell fragments in any abundance. The calcium carbonate is deposited in the form of small crystals; by their aggregation, an incrustation is produced on plants. Very often beds several feet thick are encountered which are covered by layers of peat. In explanation, Davis suggested that conditions unfavorable to the growth of *Chara* were favorable to other plants, until a depth of water was reached at which *Chara* was able to occupy the bog, covering it from the bottom up, and holding the steep slope of the peat in place by mechanically binding it. When *Chara* occupied the bog, the amount of organic matter left decreased and calcareous deposition increased, until the latter predominated.

The association of marl with peat formations in New Jersey was observed by the first students of the geology of the State, just a little over a century ago. Kitchell (52) reported that the formation and accumulation of marl (calcareous tufa, travertine) and shell marl are the result of deposition of lime from solution in water. Water saturated with carbon dioxide (CO_2) dissolves the calcium carbonate ($CaCO_3$) in passing through limestone rocks; the carbonate is carried to lakes and bogs and is deposited, after CO_2 is liberated, as a white calcareous powder. It may also be absorbed there by testaceous animals, who use it in their protective shells. In the presence of high concentrations of carbonate, there is abundant animal growth, which results in large deposits of shell marl. An excess of carbonate will bring about the precipitation of more marl, aside from the shells. The marl may thus give rise to the lower or sedimentary layer of the pond, upon which peat is formed. The marl bed, of varying thickness, may rest upon a bed of clay, sand, or gravel, and is superimposed by a series of layers of peat, also varying greatly in thickness. Kitchell believed that the testacea continue to grow while the peat layer is being formed, living forms occurring at the juncture of marl and peat and often in the layer of the peat itself. In support of his belief he cited a deposit covering an area of 75 to 100 acres in Montague Township, Sussex County, where the total depth of the material was 18 feet, the lowest 11 feet consisting of decomposed shells, the next 4 feet of mixed marl and peat containing testaceans, and the top 3 feet of peat. In other places, the peat was much deeper. One area gave 5 to 6 feet of peat, and 6 to 8 feet of marl, underlain by a bed of sand and gravel.

The utilization of this marl attracted the attention of early American students of peat. Leavitt (55) wrote, in 1867:

> It is well known that numerous shell-marl-beds or pits are exclusively and profitably worked for fertilizing purposes. These marl-beds are usually found to rest upon a bed of clay, sand, or gravel, and are succeeded by peat or muck, the depth of the peaty deposits varying, according to the statements we have seen, from three to twenty feet.

CHAPTER II

PEATS IN NEW JERSEY, TYPES AND DISTRIBUTION

NATURE OF PEAT TYPES FOUND IN NEW JERSEY

The status of peat nomenclature is highly unsatisfactory, as elucidated in Part A of this report (104). This is chiefly the reason why such confusing terms as "muck", "humus", and "turf" are not used in the report of this survey. Four types of peat have been recognized and are used here as the basis for classification:

1. *Sphagnum or moss peat.* With the exception of certain shallow layers found in a few bogs, no true sphagnum peats exist in New Jersey. However, growing sphagnum moss is found on the surface of many bogs, especially in the forest peat areas throughout the central and southern parts of the State.

2. *Sedge and reed peats.* This type is often referred to as "low-moor peat". It is usually dark brown to black, powdery when dry, and contains varying amounts of fibrous material. Wood particles are commonly present. The reaction is between pH 4.5 and 6.8. On a dry basis, the total nitrogen is 2.0 to 3.5 per cent, and the organic content ranges between 70 and 95 per cent.

3. *Forest peat.* This type of peat is also known as "forest litter", "forest mold", "oak leaf mold", "tree mold", and "peat mold". It is brown to dark brown, fluffy, and somewhat fibrous. Its reaction is between pH 3.8 and 5.5. The total nitrogen ranges between 1.0 and 2.5 per cent on a dry basis, and the ash content between 3 and 20 per cent.

4. *Alluvial or sedimentary peats.* The organic content of these peats varies from 20 to 60 per cent (dry basis). The nitrogen also varies considerably, usually between 0.2 and 1.5 per cent. This group of peats is well represented in the State by an important subgroup, which can be designated as the *salt-marsh peats.* These usually contain coarse fibrous material, together with large amounts of mineral sediment. Woody layers are frequently present. The reaction, as well as the chemical composition, is extremely variable.

Among the fresh-water peat bogs found in New Jersey, the most common and probably the most important are the sedge and reed peats, most of which originated in lakes and ponds in the northern part of the State. The growth of water plants retarded the movement of such waters, and in time the entire surface became covered with vegetation. This surface growth was accompanied by vertical growth of plants, like water lilies, ferns, grasses, and shrubs, which took root in the dead plant residues and constantly added to the accumulation of plant material. Peat was thus produced. It continued to accumulate as larger plants and even trees appeared, thereby adding to the growing vegetation and to the decomposing plant material. The lake or pond eventually became entirely filled with a mass of vegetable matter (peat), with plants growing on the surface. The fibrous stratum, in turn, rested upon either macerated or colloidal peat, or upon calcareous marl, in which fiber is present only to a very limited extent (figure 5).

The formation of coastal forest peats, frequently designated as "cedar swamps", is characteristic of the central and especially the southern parts of the State. Because of the subsidence, elevation, and resubsidence of the land areas in glacial times, the forests grew, became submerged, and grew again. This resulted in the growth of superimposed forests, one above the other, in some cases as many as five. These peat bogs range in depth from 2 to 30 feet. They are characterized by a forest type of vegetation, commonly rich in white-cedar trees (figures 6 and 7).

Peat bogs were also formed along rivers, on terraces and in flood plains, where, during times of high water, water plants grew and accumulated to form a deposit of peat accompanied by a considerable amount of silt, clay, and even sand.

The marine marshes were formed along the coast, in bays and in protected harbors; and large ones border the coast of New Jersey. These are covered with marsh grasses which gradually decompose and accumulate to form a fine mud rich in organic matter. The resulting deposit is not usually considered to be a very good type of peat. Many deposits of the salt-marsh type or of fresh-water origin are found in drowned valleys where the coast has subsided and landlocked lagoons or deltas have been formed, and in the flat, imperfectly drained areas farther inland (plates IVA and V). In many places, salt-marsh peat overlies peat of fresh-water origin, indicating coastal subsidence (63).

Differences between tidal marsh situated east of the coastal plain divide and the marshes west of it, are extreme. Large tidal marshes are not encountered along Delaware River until Delaware Bay is reached; these marshes continue, with some interruptions, to the southern tip of the State.

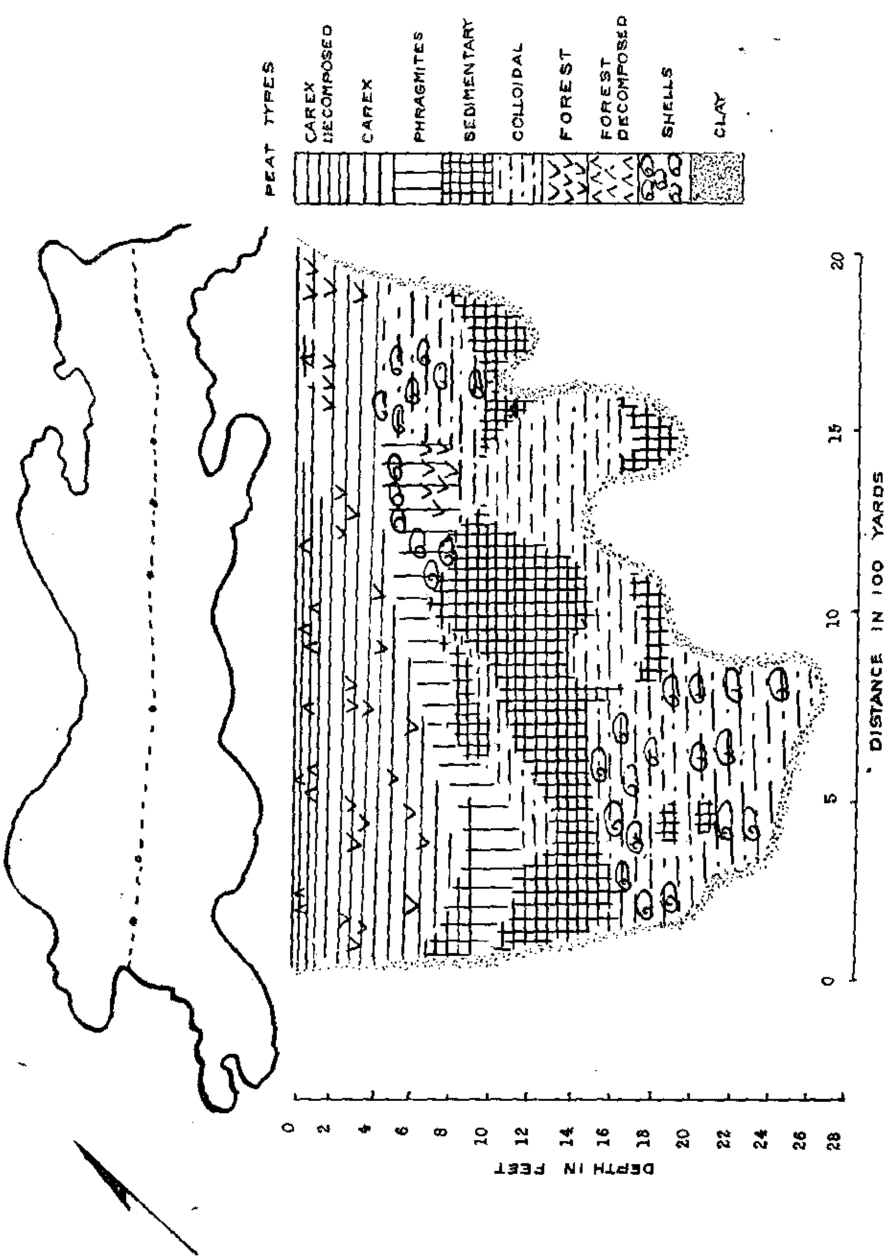


FIG. 5. Cross section of the source bog of Paulinskill River.

FIG. 6. Great Cedar Swamp and associated tidal marsh (Dennis Creek drainage region).

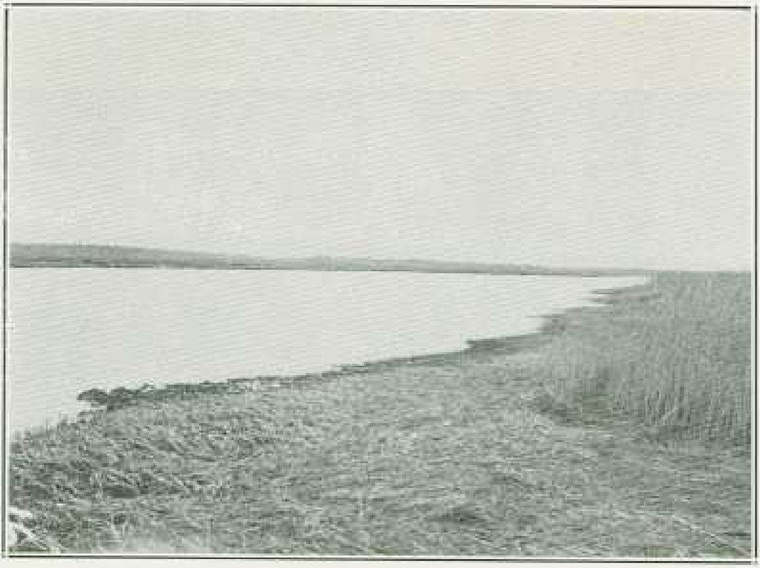


PLATE IV.A. Tidal marsh on Great Egg Harbor River.

PLATE IV.B. Hackensack basin tidal marsh, Lyndhurst, N. J.

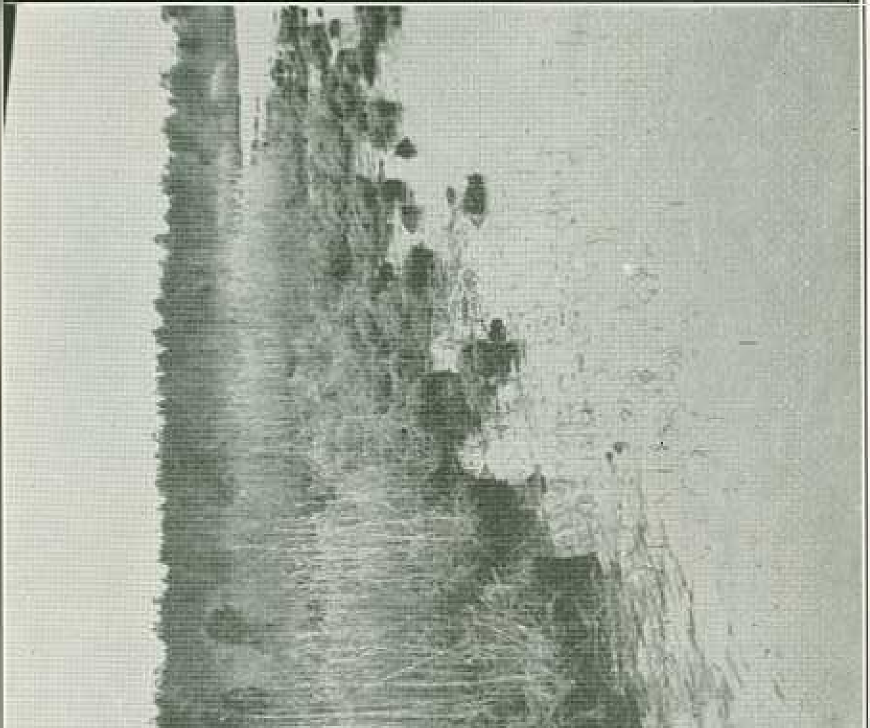


PLATE V. Tidal marsh and cedar forest at Green Bank on Mullica River.

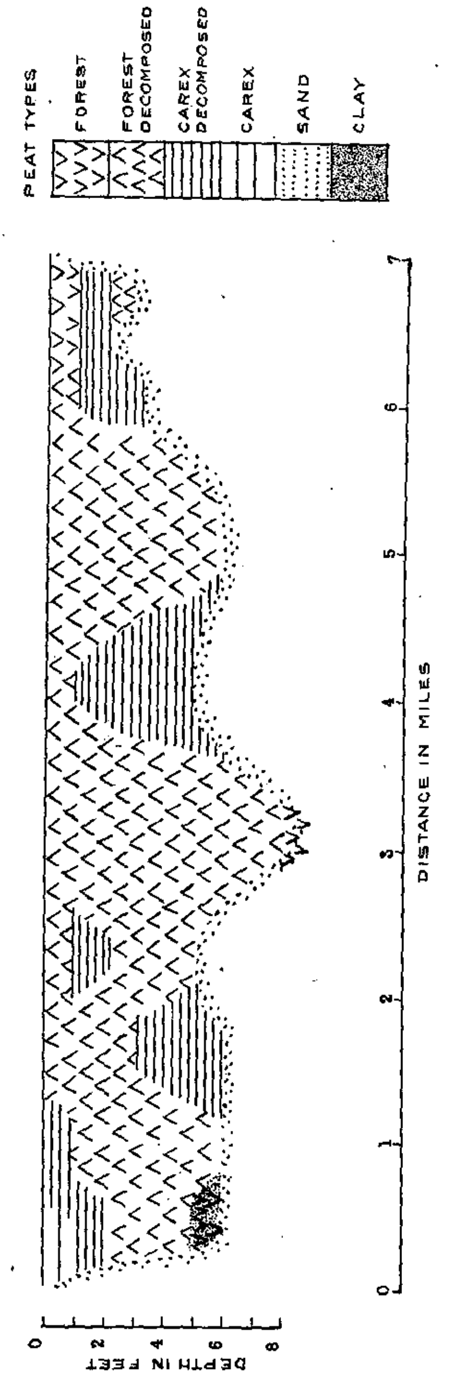


FIG. 7. Cross section of Great Cedar Swamp.

Few large fresh-water bogs are found west of the coastal plain divide. The streams, except Rancocas River, are short. Many of the stream flood plains are of a boggy nature, but little true peat is found in them. A large stream in a narrow flood plain results almost invariably in a deposit of mineral materials rather than in peat formation; and except for Rancocas River, such mineral deposits have accumulated along the streams west of the divide. Rancocas River has cut so far to the east that it follows the pattern of the streams flowing to the south and southeast.

The most striking feature of the bogs of the Coastal Plain, particularly the drainage regions to the south and east of the divide, is their extent. Great Cedar Swamp, extending northeast from Dennisville, is about 6 miles long and 2 miles in greatest width. The tidal marsh along Great Egg Harbor and Tuckahoe Rivers is some 13 miles long and about 6 miles wide. This flat topography accounts for the relative shallowness of the peat deposits.

Most of the bogs in the Piedmont Plateau closely resemble one another; there is also a close resemblance to those in the dry bed of glacial Lake Passaic. South of the terminal moraine, bogs are few and peat of high quality is virtually nonexistent. Great Swamp, part of the old Lake Passaic, is the only notable exception.

The central Highland Region, north of the terminal moraine, contains great numbers of lakes and bogs; these show remarkable similarity to one another, both in the nature of the peats encountered and the surface vegetation. This similarity extends to most of the mountain ranges in the northern part of New Jersey. Bearfort Mountain, which forms the northeastern escarpment of the plateau, is the most interesting in the State, since on it are found many remarkable peat deposits. To the southwest, Bowling Green Mountain, contains many bogs but has little true peat. Budd Lake, in western Morris County, is of special interest, since it contains a bog marginal to the terminal moraine which is, in part, a floating mat composed largely of sphagnum moss. Sparta Mountain, north of Schooleys Mountain, contains some remarkable peat deposits, as do Hamburg and Wawayanda Mountains. The largest peat areas are found in the broad rough plateau region between the higher ridges and knolls.

DISTRIBUTION OF PEAT TYPES IN NEW JERSEY

Varying physical conditions have resulted in the predominance of different peat types in different sections of the State. Sedge and reed peat is most common in Kittatinny Valley where it may or may not be underlain by deposits of calcareous marl. Save in very few instances, calcareous marl has not been found outside the Great Valley in New Jersey. In some cases there is considerable admixture of forest peat in the reed and sedge deposits. The salt-marsh peat is invariably found in regions of brackish water. In the coastal plain, many of the bogs found inland contain alluvial deposits, but the great majority of true peat deposits in the fresh-water bogs are of the forest type.

The mountain regions almost invariably give rise to forest peat, usually containing reeds and sedges. Alluvial peats are common. The Piedmont Plateau has given rise to a sedge and reed peat containing forest remnants and in most cases, alluvial deposits.

The peat areas of the State may be classified according to the drainage regions into 21 groups (figure 1, p. 13). These are listed in alphabetical order as follows:

Assanpink	Hackensack	Paulinskill
Barnegat	Maurice	Pequest
Cohansey	Metedeconk	Rahway
Crosswicks	Mullica	Rancocas
Delaware	Musconetcong	Raritan
Dennis	Navesink	Tuckahoe
Flat	Passaic	Wallkill

The total areas covered by this survey in each drainage region are given in table 3. In addition to the peat areas, the purely mineral areas, believed to be peat in accordance with the Soil Survey maps, are also listed. Each drainage region may now be described in detail with particular reference to the types of peat and the nature of the bogs. The area, depth, organic matter and nitrogen content, and reaction of a series of bogs are given in table 4. These results emphasize the wide variation in nature and composition of these peats, and therefore, differences in their practical utilization.

TABLE 3

Summary of peat survey as of January 15, 1942

Region	Per cent of region surveyed*	Total areas surveyed	Peat areas surveyed	Peat-free areas surveyed	Size of peat areas	Size of peat-free areas
					acres	*acres*
Assanpink	95.65	44	19	25	602	3,584
Barnegat	59.05	170	122	48	23,551	9,769
Cohansey	65.11	64	42	22	12,190	4,137
Crosswicks	56.25	72	22	50	1,169	3,800
Delaware	86.70	263	105	158	9,119	26,447
Dennis	66.10	54	52	2	16,591	3,732
Flat	92.30	122	37	85	678	2,330
Hackensack	63.41	86	39	47	10,487	5,166
Maurice	49.57	83	56	27	12,200	6,397
Metedeconk	56.25	127	95	32	5,493	3,384
Mullica	53.89	231	147	84	35,711	18,671
Musconetcong	100.00	25	21	4	241	110
Navesink	48.07	157	30	127	1,701	4,717
Passaic	76.16	654	306	348	15,259	16,292
Paulinskill	95.55	210	72	138	2,686	3,703
Pequest	100.00	127	60	67	3,545	2,615
Rahway	86.66	22	9	13	1,009	814
Rancocas	92.30	174	80	94	7,216	17,980
Raritan	82.05	251	126	125	8,370	11,994
Tuckahoe	61.29	140	106	34	32,590	10,304
Wallkill	84.90	248	104	144	5,423	2,892
Total		3,324	1,650	1,674	205,831	158,838

* Based upon the areas supposed to contain peat.

TABLE 4

Size, depth, and organic content of a series of typical New Jersey peat bogs

Name of bog	Area	Total depth	Organic matter, dry basis: 0–1 ft. depth	Organic matter, dry basis: At greater depth		Nitrogen, dry basis 0–1 ft.	Reaction of peat: 0–1 ft.	Reaction of peat: greater depth	
	acres	*feet*	*per cent*	*feet*	*per cent*	*per cent*	*pH*	*feet*	*pH*
Swartswood Lake (1)	26	19	65.0	8–9	60.1	2.2	5.7	8–9	5.6
Swartswood Lake (2)	25	7	60.9	3–4	82.6	1.9	5.3	3–4	5.3
Swartswood Lake (3)	60	22	56.9	10–11	28.7	2.5	4.6	10–11	6.4
Wallpack	5	22	85.9	9–10	90.4	3.0	5.4	9–10	5.7
Kittatinny Lake	10	10	63.4	4–5	67.3	2.5	4.3	4–5	5.1
Branchville (Culver's Lake)	78	19	72.4	9–10	43.1	2.7	5.7	9–10	6.6
Budd Lake (1a)	347	10	65.9	4–5	94.5	2.6	5.5	4–5	6.0
Budd Lake (1b)	347	3	85.7	1.3–1.4	30.7	1.1	4.9	1–2	5.7
Glovers Pond	5	9	87.5	3–4	75.5	3.0	6.7	3–4	6.5
Greendell	239	22	86.3	10–11	94.6	3.7[1]	6.4	10–11	6.7
Laurel Pond	23	18	64.9	9–10	75.5	1.8[2]	5.5	9–10	6.4
Beariens	7	17	83.4	7–8	91.8	3.1	5.6	7–8	5.8
Culvers Lake Swamp	73	4	29.0	2–3	93.9	0.8	6.3	2–3	5.6
Pine Swamp	102	17	94.6	8–9	96.2	2.0	5.0	8–9	5.1
Pine Swamp	38	18	94.5	8–9	94.4	1.8	4.2	8–9	5.0
Burnt Fly Swamp	235	7	73.8	2–3	37.3	1.1	4.5	2–3	4.1
Lakewood area (1)	520	6	87.8	2–3	91.8	1.6[3]	4.5	2–3	4.3
Lake Carasaljo	9	6	87.9	2–3	92.4	1.7	4.5	2–3	5.0
Lakewood area (3)	26	3	90.4	1–2	74.9	1.7	4.1	1–2	4.1
Hope	17	25	82.0	12–13	52.6	3.1	6.3	12–13	8.3
Andover	21	8	83.5	3–4	90.5	2.8	6.5	3–4	6.2
Lake Passaic (Troy Meadows)	100	7	64.5	4–5	71.7	...	...	4–5	6.0
Columbia Meadows	538	5	47.2	2–3	69.2	1.7	5.3	2–3	5.5
(Black Meadow)	...	11	76.1	5–6	47.5	2.7	5.6	5–6	6.0
Bridgeton	475	5	29.7	2–3	17.8	...	4.8	2–3	4.8
Springdale	8	15	78.5	7–8	89.0	3.4	6.5	7–8	7.6
Silver Lake	1	21	70.0	8–9	20.4	2.6	6.2	8–9	8.2

[1] 2–3 feet.
[2] 4–6 feet.
[3] 1–2 feet.

Assanpink drainage region

The region designated as the Assanpink includes the territory along Delaware River from Trenton north to Frenchtown. Besides Assanpink Creek, which flows north and west and empties into the Delaware at Trenton, the region includes several others such as Jacobs, Moores, Wickecheoke, and Nishisakawick Creeks. Of the 4,186 acres surveyed in this region, fewer than 15 per cent, or 602 acres, were found to contain peat. The remaining 3,584 acres may be classified as mineral soil.

The peat deposits found in this region are all east of 74°46′ longitude and are almost exclusively of the fresh-water alluvial type. These are found along Assanpink Creek and its tributaries. They have been subjected to frequent flooding and the flood waters have deposited a great deal of mineral sediment. Because of their alluvial nature they are characterized by a concentration of mineral matter, especially in the surface layers. The organic matter of these peats is always so well macerated that it is often difficult to determine the nature of the plants from which the peat has originated. Some woody material, however, can be recognized, as can a certain amount of fibrous sedge and reed peat. The deposits are shallow, having average depths of 1 to 3 feet and maximum depths of 2 to 4 feet. The organic matter in the surface foot ranges between 20 and 56 per cent, the greatest concentration at any depth ranging between 20 and 84 per cent. The total nitrogen values in the surface foot vary between 0.58 and 1.81 per cent. The pH values are low, ranging between 4.2 and 5.8. The pH does not seem to change consistently with a change in depth.

The remainder of the peat deposits in this region are of the forest type.

Barnegat drainage region

The territory included in this region extends along the Atlantic Coast from Silverton south to Great Bay. Many streams drain the region, including Toms River, the largest, and Cedar Creek, Forked River, Oyster Creek, and Mill Creek. The total area of the region is about 283,000 acres. Of the 33,320 acres surveyed, 23,551 contain peat. A good deal of the peat in this region is of the salt-marsh type, located along the bays and the tidal part of the streams. The fresh-water peats are found along the streams and in the shallow flooded basins. The peats of this region so far surveyed are distributed as follows: sedge and reed peat, 2,747 acres; forest peat, 7,488 acres; fresh-water alluvial peat, 3,352 acres; salt-marsh peat, 9,964 acres.

The sedge and reed peats are along the streams and shallow basins. The deposits are rather shallow, having average depths of 1 to 3 feet and maximum depths of 3 to 9 feet. In the surface layers, the organic content ranges from 71.3 to 95.6 per cent, the highest concentrations being 81.8 to 95.6 per cent on a dry basis. The total nitrogen content of the surface material varies between 0.81 and 2.25 per cent, and the pH values range from 3.7 to 6.7. There is no general tendency for an increase or decrease of pH with depth. All the sedge and reed bogs contain some woody material.

The forest peats differ from the sedge and reed peats mainly in the proportions of wood and fibrous material. Sixty per cent of the forest peat areas contain some fibrous material. The bogs are relatively shallow, having average depths of 1 to 4 feet and maximum depths of 4 to 8 feet. In the surface layer, the organic content ranges between 77.2 and 93.2 per cent, whereas the highest organic values at any depth fall between 79.4 and 96.6 per cent. The nitrogen content of the surface material varies between 1.35 and 2.28 per cent, and the pH values between 3.8 and 5.3. There is no definite change of pH with depth.

The salt marshes are found along the bays and tidal portions of the rivers and streams. Wood is often found at depths considerably below the surface. Since the trees did not grow in saline water and since they must have been autochthonous in nature, or have grown in places where they are now found, it must be assumed that the coast line has sunk since the forest grew or that the water level of the ocean has been raised.

A considerable range of peat depths is found in the salt marshes. The averages are from 2 to 23 feet, and the maximum is 34 feet. The surface layers have organic contents of 9.9 to 87.2 per cent. The nitrogen values in the surface material range between 0.26 and 1.57 per cent, and the pH values between 3.2 and 7.1.

Cohansey drainage region

Cohansey Creek is in the southwestern part of the State. Its headwaters lie near Friesburg and it flows south to Fairton, then due west for about 6 miles, and finally southwest to Delaware Bay. It is tidal as far north as Bridgeton. Other streams such as Black Cedar and Nantuxent Creek are found in this region, all south and east of Cohansey. The tidal area comprises about 104,000 acres. Of the 16,327 acres surveyed, 12,190 contain peat.

The peat-survey areas in this region are divided as follows: sedge and reed peat, 90 acres; forest peat, 395 acres; fresh-water alluvial peat, 235 acres; salt-marsh peat, 11,470 acres. Almost all of the salt-marsh deposits contain both sedge and reed material, as well as wood. There must have been a difference of 20 or more feet in the relative levels of land and water between the time the peats were formed and the present. These deposits have average depths of 2 to 11 feet with maxima of 5 to 30 feet. The concentrations of organic matter in the deposits vary greatly, ranging in the surface layers between 17.7 and 91.4 per cent. The total nitrogen ranges between 0.80 and 1.82 per cent, and the pH values in the surface layers range between 2.6 and 6.5.

Crosswicks drainage region

The drainage region designated as Crosswicks includes all the streams between Trenton and Burlington that drain into Delaware River. The largest of these is Crosswicks Creek. Among the others are Black Creek and Assiscunk Creek. An area of about 156,000 acres, entirely within the Coastal Plain, is drained by the above streams. Peat deposits are found along the flood plains of the streams and at their mouths where the water becomes tidal. The survey covered 4,969 acres of which 1,169 contained peat.

The peat in this region is almost entirely alluvial, in part fresh-water and in part tidal. As in other regions of the Coastal Plain, the drainage is poor and mineral sediments from the land are deposited in depressions where peat is formed, thus giving rise to a material with a high ash content. The organic matter in these deposits originates from sedges and reeds and frequently from trees and shrubs. Because of fluctuating water levels, the material is usually well decomposed and macerated.

The fresh-water alluvial peats occur along the flood plains of the streams. Reed and sedge material was found in about half of the bogs, and woody material in the other half. The bogs are relatively shallow, having average depths of 2 to 5 feet and maximum depths of 3 to 15 feet. As would be expected, the organic content is low, the average in the surface layer being 21.5 to 62.2 per cent, with maxima up to 84.2 per cent. The total nitrogen values in the surface foot range between 0.11 and 1.85 per cent, and the pH values between 3.7 and 5.7. There is no consistent change of pH with depth.

The tidal marshes in this region are at the mouths of the streams. The water is not excessively saline but only brackish. The marshes, however, are flooded at high tide and are covered with salt-marsh vegetation. The deposits average 3 to 7 feet in depth, and have maximum depths of 8 to 12 feet. The organic matter ranges between 31.1 and 62.2 per cent in the surface layer and the maximum at any depth is between 34.1 and 93.1 per cent. The nitrogen varies from 0.46 to 1.32 per cent, and the pH values range between 3.1 and 5.1.

Delaware drainage region

The territory included in the Delaware drainage region extends from Pensauken Creek south to Stowe Creek. It is drained by numerous streams, the chief of which are Pensauken, Timber, Mantua, Raccoon, Oldmans, Salem, Alloway, and Stowe Creeks and Cooper River. These streams all flow into Delaware River and all are tidal at their months. A considerable amount of tidal marsh along this section of the Delaware and along the above streams was once diked and reclaimed, but in recent years storms have washed out the dikes leaving the land under water and making it inaccessible for surveying. This region comprises about 440,000 acres. The survey has so far covered only 35,566 acres including 9,119 acres of peat. The peat in this region is mostly of the tidal marsh type. The fresh-water streams flow through narrow valleys and the flood plains are not extensive. The deposits so far surveyed are distributed as follows: sedge and reed peat, 387 acres; forest peat, 631 acres; fresh-water alluvial peat, 2,484 acres; salt-marsh peat, 5,617 acres.

The salt-marsh peats are found along Delaware River and the tidal portions of the drainage streams of the region. Their average depths range from 2 to 18 feet and their maximum depths reach 25 feet. In the surface foot, the organic content varies widely, from 7.4 to 93.2 per cent, and the total nitrogen ranges from 0.59 to 2.83 per cent. The pH values range from 3.3 to 6.3 in the surface foot.

The fresh-water alluvial peat deposits are shallow, having average depths of 1 to 4 feet and maximum depths of 2 to 8 feet. The organic matter in the surface layers ranges from 15.6 to 61.5 per cent, and the nitrogen from 0.50 to 1.49 per cent. The pH values in the upper foot range between 4.4 and 5.7.

The sedge and reed peats have average depths of 2 to 13 feet. The organic matter in the surface layers ranges between 61.3 and 81.0 per cent and the total nitrogen values between 1.19 and 2.54 per cent. The pH values in the surface materials fall between 3.7 and 5.0. The bog 4 miles from Penns Grove is an example of this type. It has an average depth of 13 feet and a maximum of 16 feet. With the exception of the surface 2 feet, the peat contains a great deal of mineral sediment.

Dennis drainage region

The Dennis region includes most of Cape May County. It is drained by numerous small streams, among which are West, East and Dennis Creeks. Almost the entire tip of the State is surrounded by tidal marsh and, in addition, there are numerous other bogs, several of which are extensive. The total area of the region is about 137,800 acres. A total of 20,323 acres has so far been covered of which 16,591 acres contain peat. The deposits include 103 acres of sedge and reed peat and 13,562 acres of forest peat.

The forest peat areas are all shallow. They have average depths of 2 to 3 feet and maximum depths of 4 to 7 feet. The peat is not uniform in depth but occurs in pockets in low, uneven wet lands. The organic matter in the surface layers of these bogs ranges between 75.6 and 90.7 per cent, and the total nitrogen between 1.46 and 2.98 per cent. The pH in the surface layers varies between 3.7 and 5.8.

The salt marshes are similar to those found in other regions. They average 2 to 13 feet in depth, with a maximum depth of 22 feet. The presence of wood in some places in the deeper layers indicates that the coast line has become submerged; this condition is similar to that found in other regions. The organic content of the surface layers varies widely, between 18.6 and 73.0 per cent, and the pH values range between 2.8 and 6.7. A representative peat of the salt-marsh type occurs 3 miles from Cape May Court House. It is mostly clay with some fibrous plant material.

Flat drainage region

Flat Brook and its tributaries drain the northwestern slope of Kittatinny Mountain, an area of about 68,000 acres. Of the 3,008 acres surveyed, 678 contain peat. It is of interest to note that comparatively little peat is found in Delaware Valley, into which Flat Blook flows. Perhaps the movement of water and of ice during the peat-forming periods kept the valley denuded of vegetation. The peat deposits so far investigated are, without exception, found in kettles, small lakes and ponds, and along the flood plains of some of the smaller streams. Many of the areas are high in the mountains and can be located only with difficulty. None of the peatlands in this region are under cultivation, and only about 30 acres are used for pasture.

The peat found in this region is largely of the sedge and reed type with an admixture of wood. In almost every bog the bottom layer consists of aquatic or sedimentary peat. This fact attests to the lacustrine origin of the bogs. Only four bogs were found with a shell-marl layer. Two of the areas in this region may be classed as alluvial (figure 8). The organic matter in the surface foot was found to range between 63.4 and 95.5 per cent and the nitrogen between 1.55 and 3.69 per cent. The pH varies between 4.0 and 6.5 at the surface, and almost always increases with depth. Only three bogs show a decrease in pH with depth, and in a similar number the pH remains about constant.

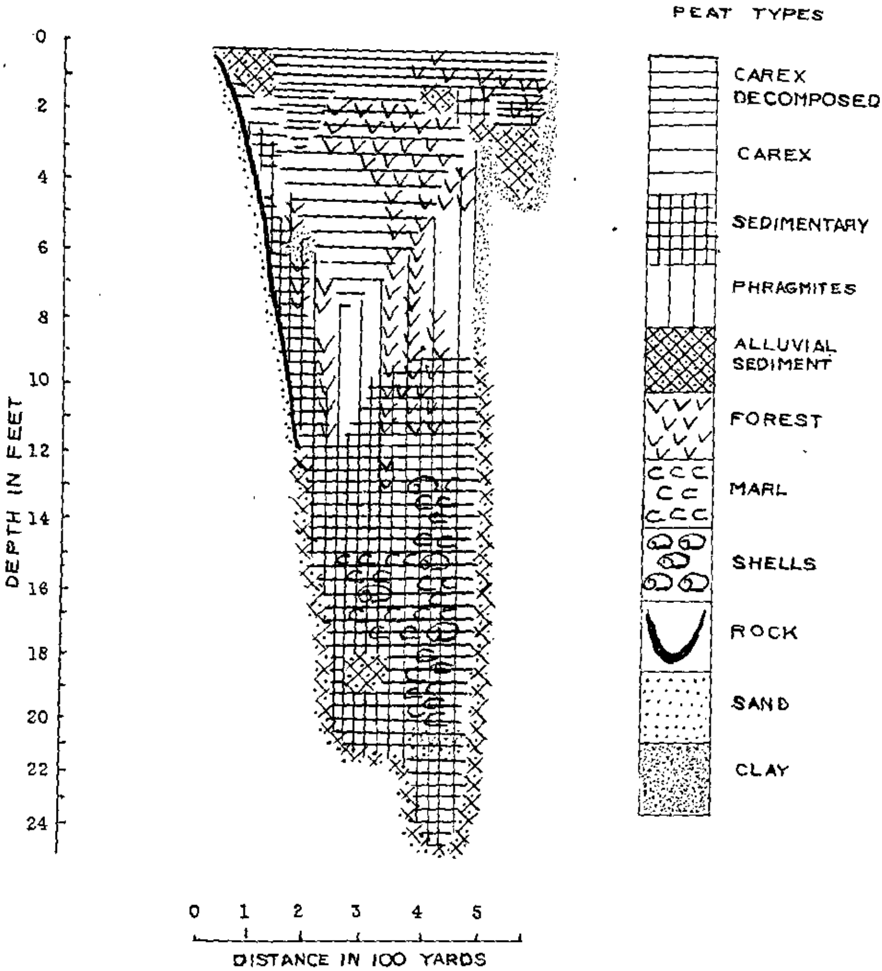


FIG. 8. Cross section of bog on upper Little Flat Brook.

Hackensack drainage region

Hackensack River has its origin in bogs and lakes in New York State. In New Jersey, it drains the region between the range of the Palisades on the east, and the Passaic drainage region on the west. It flows in a southerly direction and empties into Newark Bay. For several miles north of the mouth of the river the valley is at present almost at sea level and is flooded by tidal or brackish water (plate IV, B p. 45). The peats of the northern part of the region consist of sedge and reed or alluvial-sedge-and-reed deposits. There is good evidence that at one time the southern end of the valley was considerably higher with respect to sea level than it is now. At least two buried cedar forests occur in the part of the valley now covered by tidewater and these forests undoubtedly grew in an area saturated with fresh water. Within the memory of living men cedar forests grew in certain parts of this valley, and stumps and roots of trees still protude from the ground in those places. Some of these forests were cut for timber and others died from such causes as: (a) subsidence of the forest due to more or less general land sudsidence; the entrance or exclusion of salt water depending on the level and the volume of fresh water entering the swamp, the degree of subsidence relative to tide levels, the amount of subsidence of barrier dunes, and other factors; (b) influx of salt water caused by storms; (c) influx of salt water due to deepening, widening, and increasing the number of the streams or ditches; (d) influx of oil and other wastes from industry and shipping (mentioned by old residents, but of doubtful significance); (e) lowering in level of the fresh ground-water of the bog, due to drought over a comparatively long period or diversion of fresh-water streams, thus permitting salt water to permeate the bog; and (f) industrial wastes in the fresh-water streams entering the bog.

The region is entirely within the Piedmont Plain and was covered by the last glacier. Geologists who have examined the area believe that part of the valley was once occupied by a lake as evidenced by widespread alluvial deposits similar to those found in the bed of Lake Passaic. These include the large beds of varved clay found from Newark Bay almost to the New York State line.

The region contains about 93,000 acres of which 15,653 acres with 10,487 acres of peat has been surveyed. With minor exceptions the salt-marsh or tidal peats contain woody material which emphasizes the fresh-water origin of some strata. Sedge and reed peat and alluvial sediment are commonly present; some of the marsh contains recognizable aquatic peat. The average depths of the deposits vary between 2 and 16 feet. The organic matter in the surface foot ranges widely, between 19.5 and 91.4 per cent. This is no doubt due to the uneven deposition of the mineral sediments washed down by flood waters. As would be expected, the nitrogen contents of the deposits are relatively low and also extremely variable. In the surface foot, the nitrogen ranges between 0.55 and 3.24 per cent, with only four values above 2.0 per cent. The pH values in the surface foot also vary, the figures falling between pH 3.3 and 6.9. In about half the deposits the pH values increase with depth.

Maurice drainage region

Maurice River drains the region between Port Norris and Glassboro, a distance greater than 30 miles. The river flows into Delaware Bay and skirts the western flank of the Pine Barrens north of Millville. Several tributaries, such as Manumuskin River, Manantico Creek, and Blackwater Branch penetrate deeply into the Pine Barrens. In many respects the bogs and tidal marshes found in the valley of Maurice River make the region one of the most interesting in southern New Jersey.

This region comprises about 294,000 acres. Of the 18,597 acres surveyed, 12,200 contain peat. The latter is divided as follows: sedge and reed peat, 581 acres; forest peat, 2,066 acres; fresh-water alluvial peats, 1,359 acres; and salt marsh, 8,194 acres. The peat deposits are found along the stream flood plains (figure 9).

Considerable tidal marsh occurs along the bay shore and in the lower parts of the rivers and streams. There is good evidence that the tidal marsh was once above sea level. At one place near Port Norris as many as five separate forests are buried one on top of the other, and all are now covered by recent tidal deposits. There must have been, therefore, a difference of about 27 feet in the levels of the present surface and the surface of the land when the first forest grew.

The sedge and reed deposits are shallow, having average depths of 2 to 3 feet and maximum depths of 3 to 6 feet. They all contain woody material. In the surface layers, the organic matter varies from 63.2 to 84.6 per cent. Two representative total nitrogen values are 1.96 and 2.55 per cent. The pH values in the surface layers range between 4.2 and 5.7.

The forest peats have average depths of from 1 to 3 feet and maximum depths of 4 to 10 feet. Five of the eleven areas have a depth of 4 feet. One area has a maximum depth of 10 feet. In the

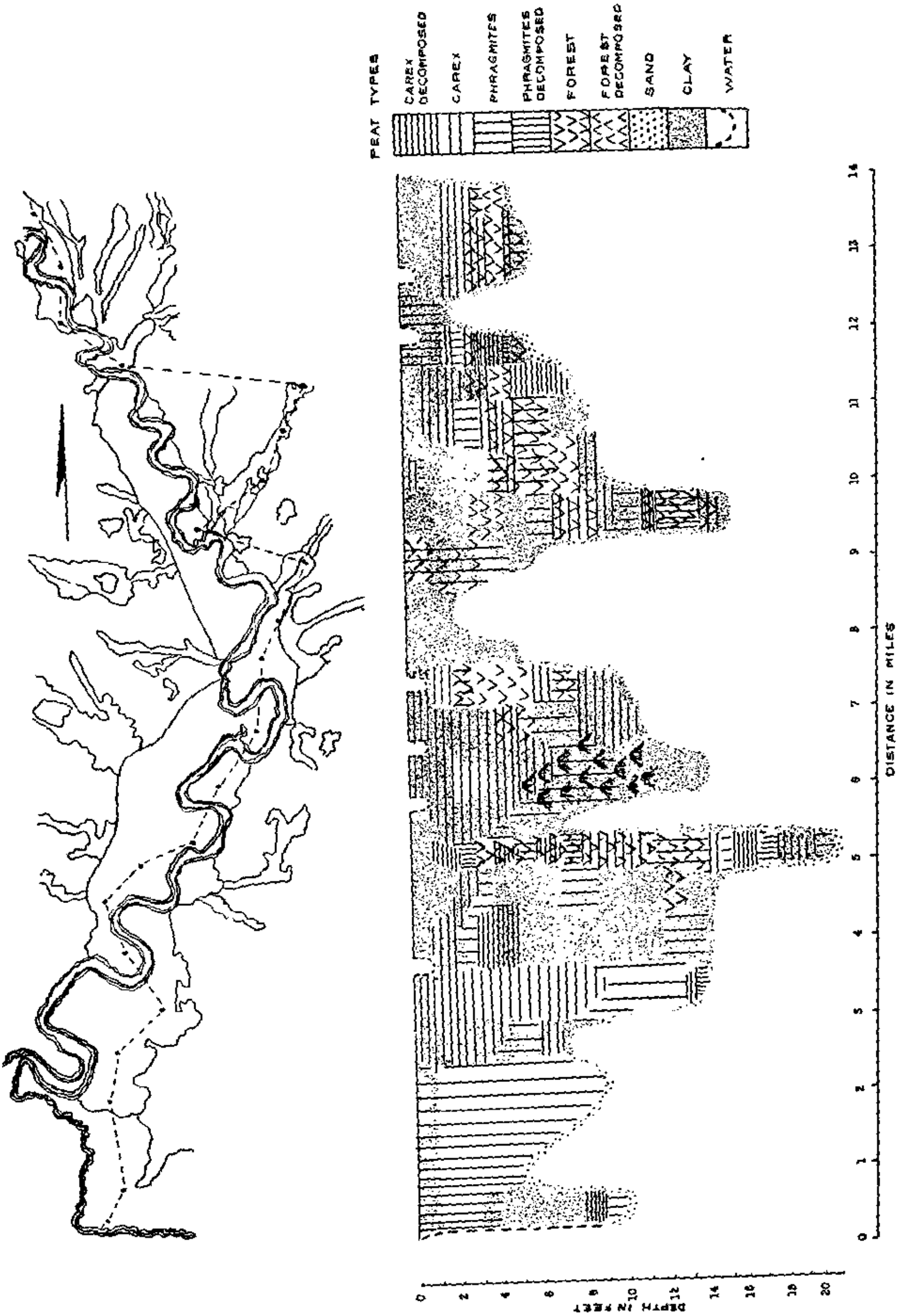


FIG. 9. Cross section of the Maurice River tidal marsh.

surface layers, the organic contents vary from 65.9 to 90.4 per cent. The greatest organic values in any stratum fall between 65.9 and 90.4 per cent. Total nitrogen values in the surface layers range between 1.37 and 1.85 per cent, and the pH values between 3.6 and 5.2. These peats are mostly well macerated and contain more or less fibrous material.

Most of the areas so far surveyed in this region are of the salt-marsh type. Almost all of these peats have woody layers, and well-preserved logs are found in several places. In about half of the bogs fibrous material is abundant. These deposits have average depths of 4 to 24 feet and maximum depths of 7 to 39 feet. The organic matter in the bogs is also variable, ranging in the surface layers from 8.6 to 83.4 per cent. At greater depths the highest values recorded are between 32.7 and 91.4 per cent. Total nitrogen ranges from 0.53 to 2.27 per cent, and the pH values in the surface layers from 3.5 to 6.3. The alluvial peats differ from the forest or sedge and reed peats only in the amount of mineral sediments. The bogs are shallow, averaging 2 to 3 feet deep and having maximum depths of 3 to 4 feet. In the surface layers the organic matter falls between 27.3 and 34.2 per cent, with maxima of 33.6 to 59.4 per cent. Total nitrogen values vary between 0.79 and 0.91 per cent, and the pH values at the surface between 4.1 and 5.5.

Metedeconk drainage region

The territory included in the Metedeconk region extends from Elberon on the Atlantic Coast south to Mantoloking. It is drained mainly by two rivers and their tributaries; the Metedeconk, with headwaters near Clarksburg and Smithburg, flowing in a southeasterly direction and emptying into Barnegat Bay; and the Manasquan, with headquarters near Jerseyville and Smithburg, flowing in a south-easterly direction and emptying into the Atlantic Ocean. Shark River and Deal Creek are smaller streams included in the region. The total area is about 264,000 acres. Of the 8,877 acres surveyed, 5,493 contain peat. The peat deposits have been classified as follows: sedge and reed, 1,216 acres; forest, 1,504 acres; fresh-water alluvial, 1,194 acres; and salt-marsh, 1,579 acres.

Peat is found, as in all the coastal plain regions, along the stream flood plains. The southern part of the region is within the Pine Barrens and many of the peat deposits are of woody origin. Some of the bogs have a surface growth of cedar trees, but buried cedar forests are infrequent. The region also contains considerable tidal marsh, of which only a small part has been surveyed.

The sedge and reed peats of this region almost always contain more or less woody material. In one bog, well-decomposed, submerged logs were found. The peat is usually well macerated and frequently contains mineral sediments. The bogs are relatively shallow, having average depths of 1 to 5 feet and maximum depths of 3 to 9 feet. The organic matter in the surface material ranges from 58.5 to 92.7 per cent, the total nitrogen from 1.06 to 2.64 per cent, and the pH from 3.6 to 7.2. Only one pH value, however, was above 6.0.

The forest peats in this region are located chiefly in the southern part of the region, that is, in the Pine Barrens. Most of the deposits contain more or less reed and sedge material. They are rather shallow, having average depths of 1 to 4 feet and maximum depths of 3 to 8 feet. In the surface foot, the organic matter varies between 50.4 and 90.4 per cent. The highest percentages of organic matter found in any depth, range between 66.7 and 96.4 per cent. The nitrogen in the upper foot varies between 1.32 and 3.83 per cent, and the pH between 3.5 and 5.8. The change of pH with depth is very erratic; in some deposits it increases, in others it decreases, and in some it is extremely variable.

The fresh-water alluvial peats are characterized by their high ash content. The organic fraction consists of very well macerated reed and sedge peat, or wood, or mixtures of both. The bogs have average depths of 1 to 7 feet and maximum depths of 2 to 10 feet. In the surface layers, the organic matter ranges from 6.8 to 46.2 per cent. The total nitrogen in the surface layers varies between 0.36 and 1.75 per cent, and the pH between 3.4 and 6.1.

Mullica drainage region

The Mullica region is drained almost entirely by the Mullica River and its tributaries. Some of the larger tributaries comprise the Wading, Bass, Oswego, and Batsto Rivers. The system drains territory as far west as Berlin and as far north as Butlers Place. The southwest border of the region is on a line through Hammonton and Egg Harbor City. The entire region includes about 392,500 acres. A total of 54,382 acres have so far been surveyed and of this total 35,711 acres contain peat. The peat deposits are divided as follows: sedge and reed, 3,507 acres; forest, 13,778 acres; fresh-water alluvial, 6,780 acres; and salt marsh, 11,646 acres.

With very few exceptions, the sedge and reed peats in this region contain woody material. The bogs are shallow, having average depths of 1 to 4 feet and maximum depths of 2 to 9 feet. In the surface layers, the organic matter ranges between 57.4 and 91.1 per cent, and the total nitrogen between 1.19 and 2.23 per cent. The pH values range between 2.8 and 5.6.

The forest peats of this region occur usually in large bogs but the depths are not great, the averages ranging from 1 to 4 feet and the maximum from 2 to 8 feet. The peat is predominately of the forest type, and logs and stumps are common. About half of the bogs contain fibrous material, and in all the bogs the material is more or less macerated. In the surface layers, the organic matter ranges from 55.2 to 93.1 per cent, the total nitrogen from 0.90 to 2.18 per cent, and the pH from 2.9 to 5.6.

The alluvial deposits are shallow and are subject to frequent flooding by surface water which carries mineral sediments. The average thickness is 1 to 4 feet, with maximum depths of 2 to 6 feet. The organic matter in the surface layers ranges between 3.2 and 55.3 per cent, with maxima of 14.6 to 78.1 per cent. Total nitrogen ranges between 0.34 and 1.22, and the reaction between pH 3.4 and 5.1.

The tidal marshes lie along the seacoast and the lower reaches of the rivers. The subsidence of the coast line is very graphically demonstrated some 4 or 5 miles up Wading River where the remnants of a forest, with logs and stumps 2 to 3 feet in diameter, can be seen at low tide. As one passes down the river, this dead forest gradually disappears from view; however, the stumps and logs are present below the surface of the river bed and banks. Farther down the river, the stumps are buried deeper and deeper, until near the coast line they are 20 to 22 feet below the surface. Considerable wood is found buried throughout this entire section of the tidal marsh. The marshes vary greatly in depth, the average of each ranging from 6 to 23 feet, with maxima of 16 to 32 feet. The organic matter varies between 10.2 and 59.7 per cent in the surface layers, and between 10.4 and 90.0 per cent at other depths. Total nitrogen ranges between 0.88 and 1.42 per cent, and the pH between 2.3 and 5.9.

Musconetcong drainage region

Musconetcong River has its origin in Lake Hopatcong and flows in a southwesterly direction to Delaware River at Riegelsville. The Musconetcong drainage region also includes Pohatcong Creek, which is north of the Musconetcong and runs about parallel to it. Except for its northern tip this region lies south of the terminal moraine of the Wisconsin ice sheet and entirely within the Highlands geographic province. It is of interest to note that the only peat deposits occur in the small part that was covered by the ice sheet (figure 10).

Sedge and reed, forest, and alluvial peats are represented in this region. The sedge and reed peats (150 acres) are characteristic of those commonly found in the glaciated section. The organic matter in the upper foot varies between 87.7 and 91.3 per cent. In one area, the surface 2 to 3 feet has an abnormally high ash content, which may be due to extensive decomposition caused by drainage and cultivation. The nitrogen values of the peat, on a dry basis, fall between 1.2 and 2.8 per cent, and the pH between 4.7 and 6.1. In most bogs the pH increases with depth and these bogs also contain aquatic peat. Calcareous marl is found on the limestone in this region.

Navesink drainage region

The Navesink region comprises the territory drained by the Navesink and Shrewsbury Rivers, which flow into Sandy Hook Bay, as well as several small streams which flow into Raritan Bay. The coastal part extends from Cliffwood on Raritan Bay to below Long Branch on the Atlantic Coast. The total area of the region comprises about 120,000 acres.

Only 6,418 acres have been surveyed in this region, 1,701 of which contained peat. The peat deposits are divided as follows: sedge and reed, 4 acres; forest, 12 acres; fresh-water alluvial, 362 acres; salt marsh, 1,323 acres. The peat bogs are located along the streams; tidal marshes are found along the coast and for a considerable distance up the Navesink and Shrewsbury Rivers.

Passaic drainage region

The Passaic River is one of the largest in the State, draining an area of about 565,000 acres. Some of the larger tributaries include the Saddle, Ramapo, Wanaque, Pequannock, Rockaway and Whippany Rivers. Except for the area south of Morristown, the entire region was covered by the last ice sheet. The area not covered by the ice, notably Great Swamp, was also greatly affected by the glacier which closed the present and former outlets of Passaic River at Paterson and Summit, thus causing the formation of the glacial Lake Passaic. After the gap at Paterson was opened by melting of the ice, the lake was largely drained, but swampy conditions persisted in large areas in which peat accumulated. The largest, known as Great Swamp, was in the southern part of the basin. Other large peat deposits, namely Troy Meadows, Black or Columbia Meadows (plate VI), Bog and Vly Meadows, and Great Piece Meadows were formed in the northern part of the lake bed.

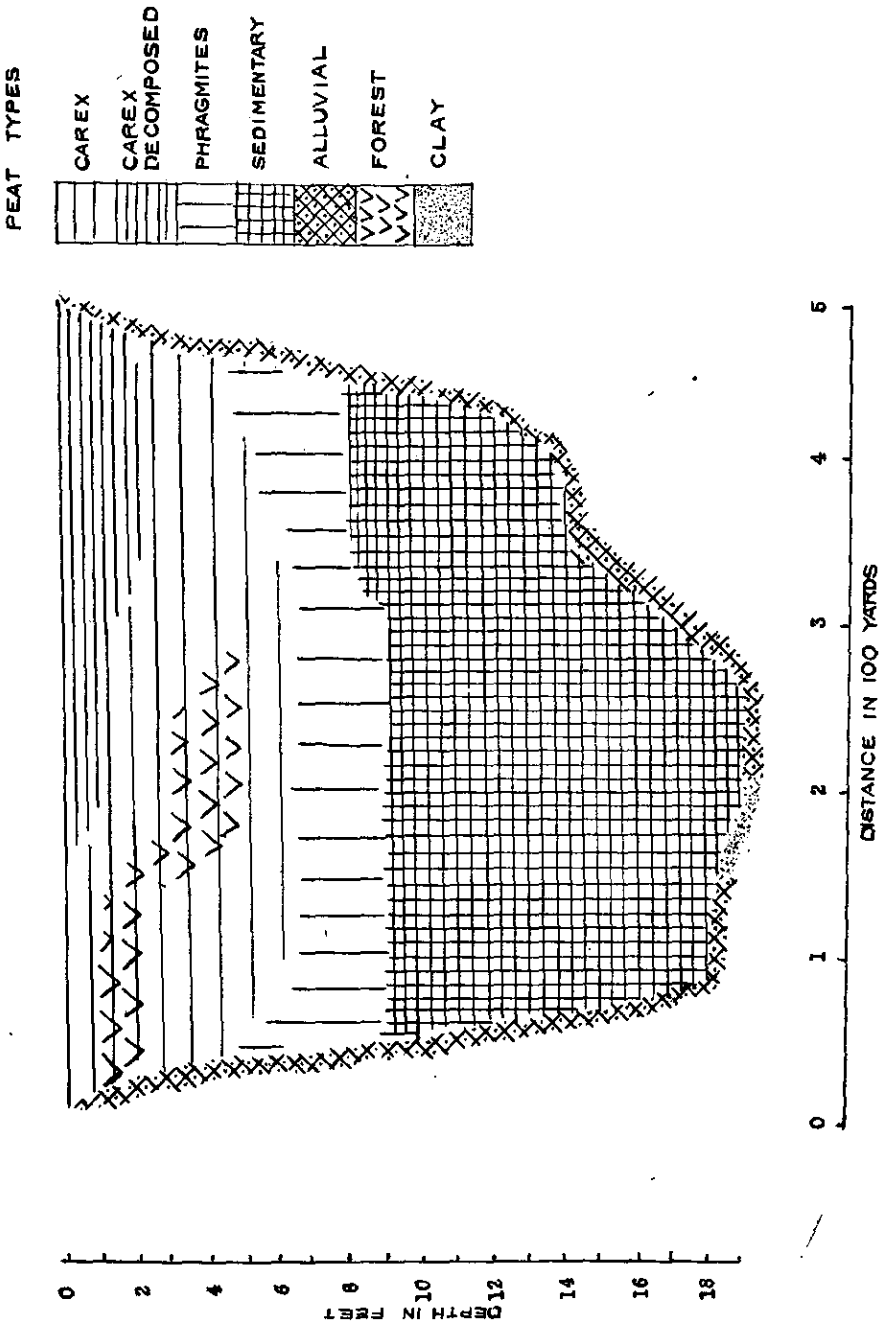


FIG. 10. Cross section of Allamuchy Mountain bog.

In addition, the Passaic region contains numerous deposits of peat formed in the kettles characteristic of glaciated terrain. Peat is also found along the many streams covering this region. Many of the flat areas along the streams were designated as "meadows" by the Soil Survey. Some of these meadows contain only mineral soil; many others, however, contain extensive peat deposits. Of the 31,551 acres surveyed to date, 15,259 are peat.

In addition to the fresh-water peat areas of this region, considerable salt-marsh peat is found along the lower Passaic Valley and at the mouth of the river where it enters Newark Bay. The Passaic and Hackensack Rivers enter the bay at almost the same place, thus rendering difficult the separation of these two regions at this point. The division made is shown on figure 1, p. 13.

The fresh-water peat belongs mainly to the sedge and reed type, with a small amount of alluvial peat and still less forest peat. As in other north Jersey regions, most of the sedge and reed peats usually contain varying amounts of wood and, conversely, the forest peats usually contain considerable reed and sedge material. With very few exceptions, the fresh-water peat deposits have layers of aquatic peat. Few areas in the entire region contain calcareous marl. This lack of marl, in contrast to the other north Jersey regions, is explained by the difference in the underlying geologic formations.

The sedge and reed peat bogs in this region range in depth to 33 feet. There can be no doubt as to the lacustrine origin of most of these bogs. Only four areas contain shell marl. The organic matter in the first foot varies between 60 and 98 per cent. In some of the bogs, mainly in the Triassic plain, the organic content of the first foot was found to be below 60 per cent. This is due to extensive decomposition resulting from cultivation or to washed-in mineral soil. The nitrogen content of the surface foot of the sedge and reed types of peat falls between 1.5 and 3.0 per cent for 92 per cent of the cases, with 5 per cent above the higher figure and about 3 per cent below the lower figure. The acidity range of these peats is very wide, namely, between pH 3.5 and 7.2. Most of the peats, however, fall between pH 4.5 and 6.5.

One deposit of considerable interest in this region is the area designated as "Black or Columbia Meadows" (figure 11). Though it comprises about 2,000 acres it is actually the smallest of the three large deposits formed in the bed of the glacial Lake Passaic. Great Swamp is roughly twice as large, and Troy Meadows is slightly larger. Columbia Meadows lie about 3 miles east of Morristown. The peat area surveyed has an average depth of 4 feet and a maximum

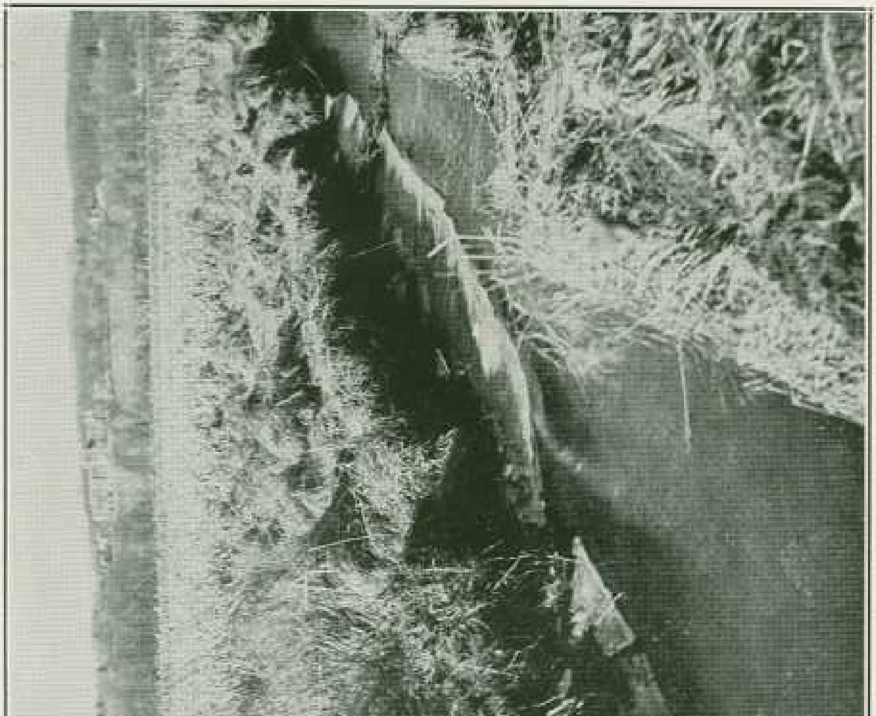


PLATE VI. Columbia meadows; bed of Lake Passaic.

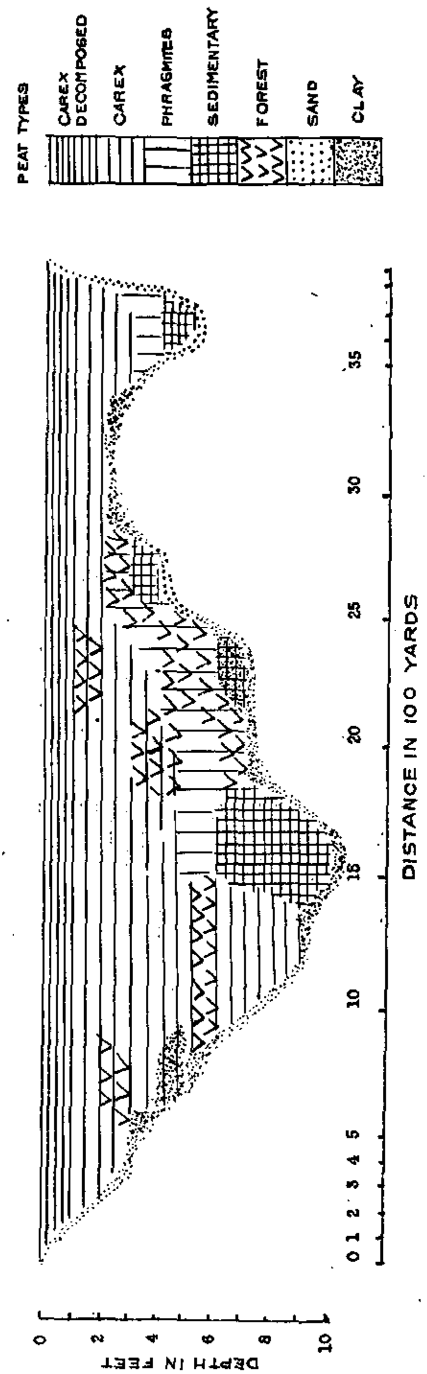


FIG. 11. Cross section of Black Meadows.

depth of 11 feet. Attempts at cultivation have been unsuccessful because of insufficient drainage and flooding during wet seasons.

The forest peat bogs range in depth up to 39 feet. The organic content in the surface foot varies between 65 and 90 per cent, with a few cultivated areas showing as little as 55 per cent. The highest percentage of organic matter recorded for any depth is 97.0 per cent. The nitrogen values vary between 0.44 and 3.13 per cent, though most of them fall between 1.6 and 2.3 per cent. The pH values range between 3.7 and 7.2, and chiefly between pH 5.0 and 6.1 (figure 12).

About 15 per cent of the areas in this region are of the fresh-water alluvial type. Most of these peats contain both wood and sedge, and half of them contain aquatic peat. These areas have average depths of 2 to 7 feet, with maxima up to 38 feet. The organic matter in the surface foot varies greatly, from 20 to 95 per cent, and the

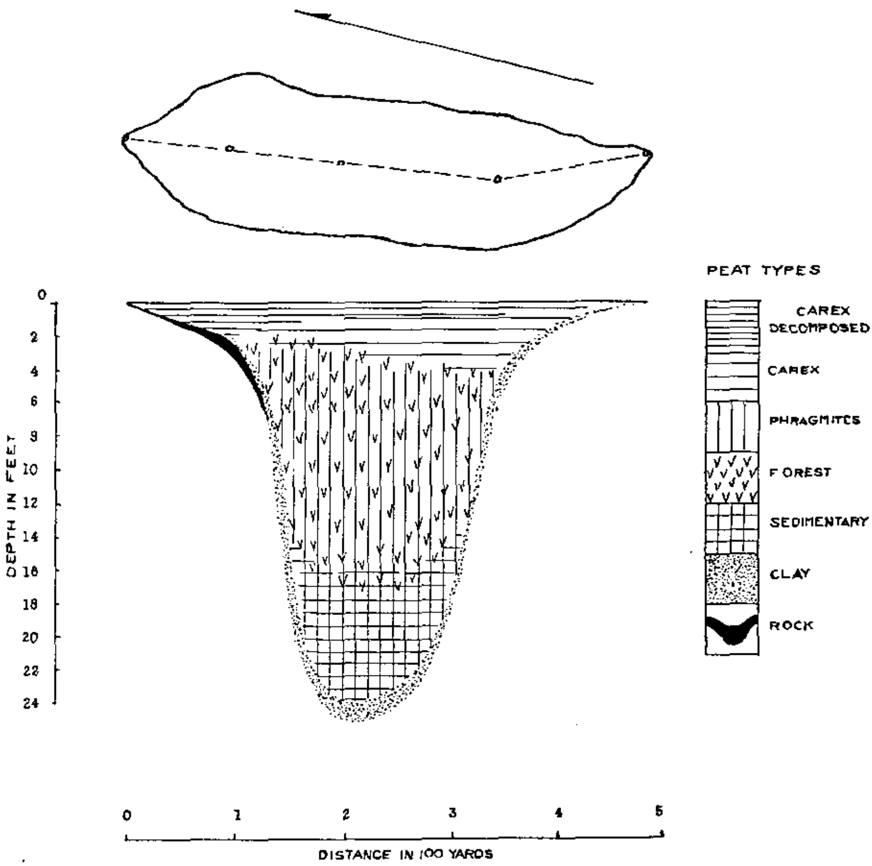


FIG. 12. Cross section of kettle near Fox Hill Lakes.

nitrogen from 0.56 to 2.76 per cent. The pH values are comparatively constant, ranging between 4.0 and 6.0.

The tidal marsh areas in this region are at the mouth of the Passaic River and also along Newark Bay. Approximately 5,000 acres are included. A considerable part of the marshes has been filled and is now used for industrial plants. The average depths of the marshes are from 5 to 10 feet, with a maximum of 16 feet. The peat is of the reed and sedge type with considerable admixture of clay which in many places predominates. In virtually all tidal marshes the amount of clay varies greatly. In one profile, for example, the material may consist largely of reed and sedge with very little clay, and a few feet away the profile may show the reverse condition. The explanation of this is probably to be found in the location and movement of the inland waters, which carry and deposit the mineral material. In one place on the Kearny Meadows, a considerable amount of wood and many submerged stumps were found. These, of course, indicate a historical change in the land level with respect to the sea. The organic matter in the surface foot of these marshes ranges between 8 and 90 per cent, and the nitrogen between 1.15 and 2.28 per cent; the pH varies from 3.6 and 7.0. A large part of the Newark Meadows has been filled by dredgings from Newark Bay. The peat is typical of a tidal marsh, has an average depth of 9 feet and a maximum depth of 12 feet. The surface 2 feet comprises pure clay; from 3 to 5 feet the ash content is 52.1 to 41.6. The pH rises from 3.6 at 3 to 4 feet, to 4.2, at 5 to 6 feet.

Paulinskill drainage region

Paulinskill River, just south of Kittatinny Mountain, drains an area of about 122,000 acres, including the southeastern slopes of the mountain. This region is entirely within the Appalachian Valley and was completely covered by the Wisconsin ice sheet. The river descends rapidly from its source east of Newton to the Delaware at Columbia, and as a result no considerable flood plain has been formed, except in the headwaters. Most of the peat deposits are found in small basins, glacial kettles, and lakes. The total area so far surveyed comprises 6,389 acres, of which 2,686 acres were peat.

As in most of the drainage regions of northern New Jersey, the peat consists of sedge and reed, forest, and alluvial types, the first being by far the predominating type. Most of the bogs also contain some material of forest origin. The depth of peat in this region varies from 1 to 34 feet. Most of the peatland is unused, but a small amount is under cultivation or is used for pasture.

The sedge and reed peat in this region is characterized by the almost universal presence of woody material and by strata of aquatic peat. About one-third of the areas contain calcareous marl. In the surface foot, the organic matter ranges between 63.1 and 93.7 per cent. The surface of many areas contains a relatively high ash content, due either to more extensive decomposition or to the presence of alluvial sediments. The nitrogen ranges from 1.19 to 4.02 per cent, the great majority of the samples containing 2.0 to 3.5 per cent. The pH values range from 4.4 to 6.7, and are mostly between 5.0 and 6.5. In about 80 per cent of the bogs, the pH increases with depth, though a few show a decrease with depth.

Except on the higher hills the forest peats in this region are few in number. They have an organic content of 61 to 96 per cent, a nitrogen content of 1.69 to 2.57 per cent, and a pH between 4.2 and 5.3. All the bogs have aquatic peat layers on the bottom, and half of them contain sedge peat. Calcareous marl is absent from the forest peats.

Few alluvial bogs are found in this region. They are characterized by a high ash and low nitrogen content. The organic matter ranges from 21.8 to 93.9 per cent; the nitrogen from 0.79 to 2.14 per cent, and the pH from 6.0 to 7.4.

Pequest drainage region

The Pequest River is in the northwestern part of the State. Its headwaters are near Newton and it flows in a southwesterly direction and empties into Delaware River near Belvidere. The total area of the region drained by Pequest River is about 125,000 acres. Part was covered by the Wisconsin glacier and the peat deposits are mostly located in this part. There is no peat in the entire southwestern part of the region.

Of 6,160 acres surveyed, 3,545 acres contain peat and it is almost exclusively of the sedge and reed type. Few forest peat or alluvial peat bogs have been found. Some of the sedge and reed bogs contain layers of alluvial sediment (figure 13).

The great majority of the bogs in this region contain material of woody origin and have an underlying layer of aquatic peat. Over half of the bogs have a layer of calcareous marl. In many bogs the sedimentary peat on the bottom is covered by a layer of calcareous marl, and on the top, by sedge and reed peat mixed with more or

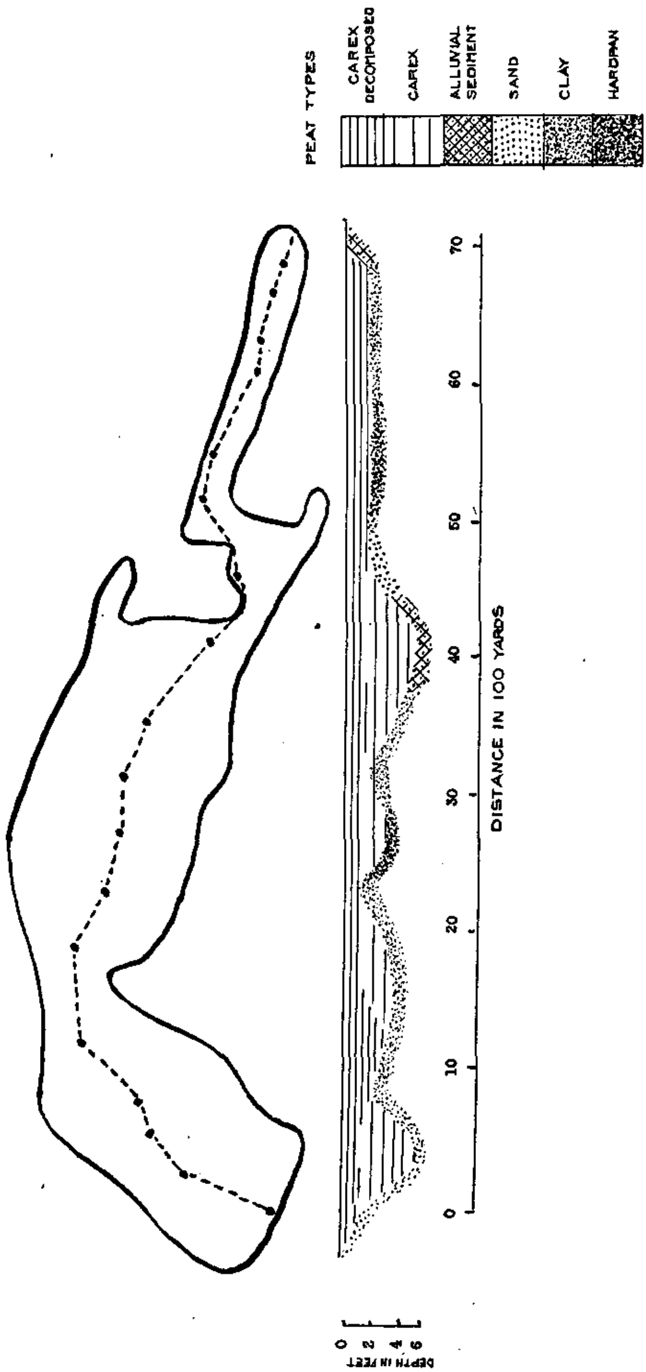


FIG. 13. Cross section of Great Meadows.

less material of woody origin. In some bogs, however, the shell marl and the aquatic peat may be reversed and in others, shells lie between layers of aquatic peat. In still others, either one or both layers may be absent altogether. Occasionally woody material is found in the aquatic or in the shell strata (figure 14).

The depths of the bogs in this region vary between 2 and 34 feet. Exclusive of those having surface alluvial layers in which the ash content is high, the organic content of the surface foot usually varies between 60 and 92 per cent. The greatest organic content found in any of these bogs is 96.8 per cent. The total nitrogen values, on a dry basis, range between 1.42 and 4.13 per cent, by far the great majority falling between 2.5 and 3.5 per cent. The pH values are between 4.7 and 6.1, with the majority between 5.5 and 6.5. In most cases the pH increases with depth, but in about one-third of the bogs it remains almost constant, and in a very few it even decreases (plate VII).

Rahway drainage region

The Rahway drainage region includes the territory drained by Rahway River and several other streams which drain into the Arthur Kill between Elizabeth and South Carteret. It is a small region of about 78,000 acres which contains comparatively little peat. A total of 1,823 acres have been surveyed of which 1,009 acres contain peat.

With the exception of a few areas of forest and alluvial peat, all the deposits are of the salt-marsh variety. The peats found in this region contain, therefore, considerable mineral sediment together with some reed and sedge material. A few areas contain some woody material. The average depth of the peat is 8 to 10 feet; maximum depths are 11 to 16 feet. The organic content in the surface foot ranges from 30.9 to 55.1 per cent, the total nitrogen from 1.13 to 1.29 per cent, and the pH values from 5.2 to 6.1.

Rancocas drainage region

Rancocas Creek heads near Whitings and South Park; from there it flows in a northwesterly direction and empties into Delaware River near Riverside. The total area of the region drained by Rancocas Creek, its tributaries, and a few other small streams, comprises about 236,600 acres. The peat deposits are located along the streams.

Of the 25,196 acres surveyed, 7,216 acres contain peat which in this region consists of several types, namely: sedge and reed, forest,

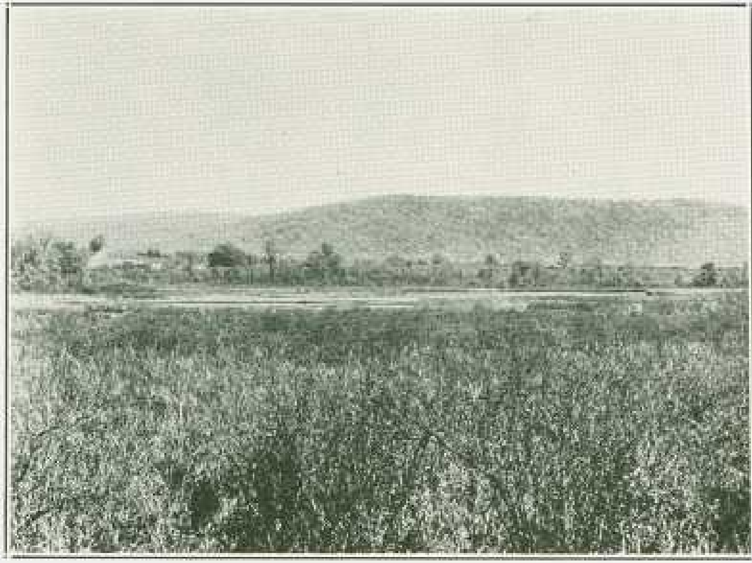


PLATE VII. Glacial lake being filled by peat. (Beaver Brook in the Appalachian Valley).

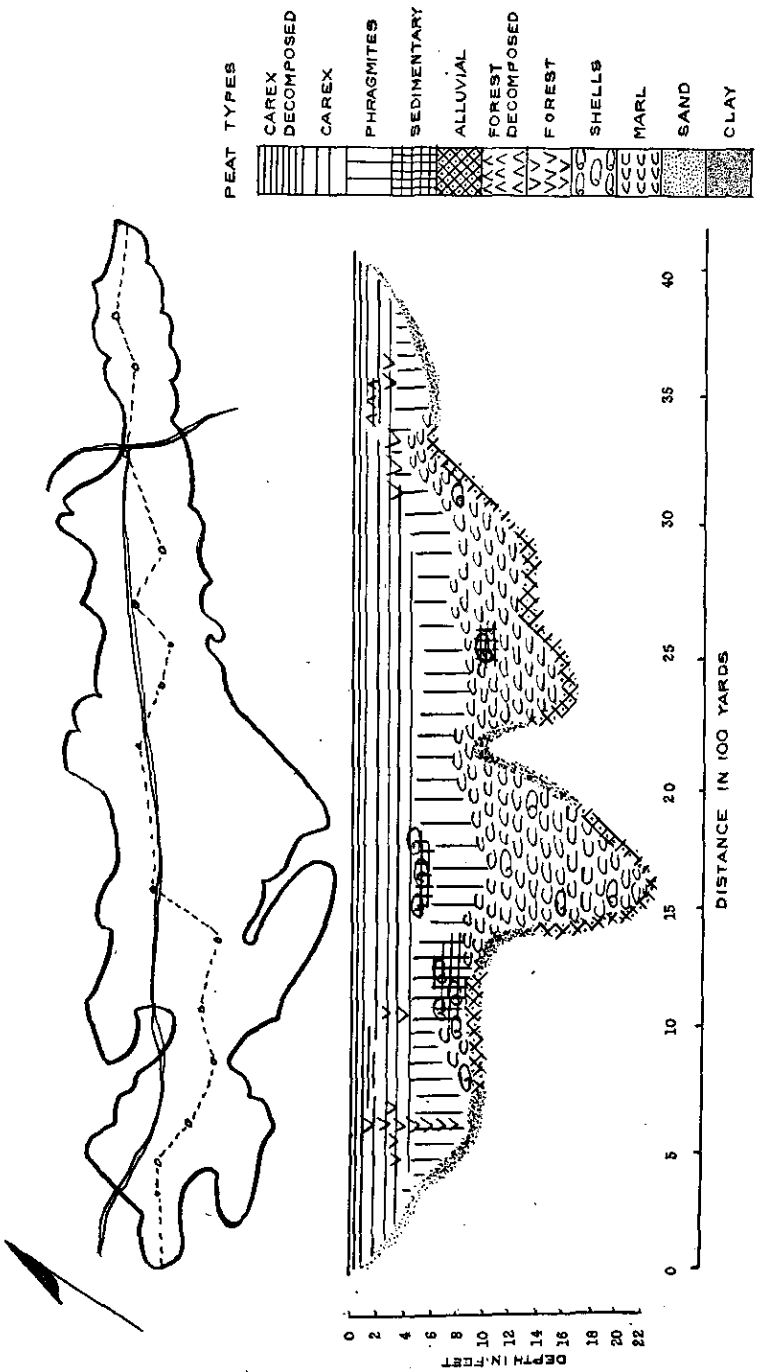


FIG. 14. Cross section of source bog of the Pequest River.

alluvial, and salt-marsh. Cedar forests are found in that part of Rancocas Valley within the Pine Barrens.

In this region 805 acres of reed and sedge peat have been surveyed. This is usually found to be well macerated, indicating fluctuating water levels with consequent extensive decomposition. Woody material is usually present. The deposits have average depths of 1 to 3 feet and maximum depths of 3 to 6 feet. The organic content is high and constant, ranging in the surface foot from 72.7 to 87.2 per cent. Total nitrogen ranges between 1.25 and 3.30 per cent and the pH values are between 4.0 and 5.9.

The forest peat deposits which have been surveyed comprise about 4,230 acres. Like the sedge and reed peats, they also are mixtures, many of the deposits containing reed and sedge material. Many of the forest peats are so well macerated as to be colloidal in nature. Many of the bogs also contain considerable mineral sediment. The average depth is from 1 to 4 feet with maximum depths of 2 to 6 feet. Organic matter in the surface layers ranges between 59.0 and 92.6 per cent; the total nitrogen between 0.88 and 2.34 per cent; and the pH values between 3.7 and 5.8.

About 1,406 acres of fresh-water alluvial peats have been surveyed. These peats are typical of alluvial deposits; they have a high ash content and a small amount of well-macerated organic matter, usually reed and sedge or woody peat. The bogs are shallow, having average depths of only 1 to 2 feet and a maximum depth of 4 feet. The surface layers contain between 24.2 and 79.7 per cent organic matter, and the pH values vary between 3.2 and 4.7.

Tidal marshes are located at the mouths of the streams and in the case of Rancocas Creek, extend for a considerable distance inland. The depths of peat in some of the marshes average between 2 and 12 feet, with maxima ranging from 4 to 21 feet. The organic contents are variable, ranging between 12.4 and 81.0 per cent at the surface and between 18.1 and 90.0 per cent at greater depths. The nitrogen in the surface foot ranges between 0.50 and 1.59 per cent, and the pH values between 4.2 and 5.6.

Raritan drainage region

The Raritan River and its tributaries drain about 725,000 acres, more territory than any other drainage system in the State. Among the larger tributaries are South and Millstone Rivers, which flow from south to north, the North and South Branches and the Black River (plate VIII) which flow from north to south. The South Branch

PLATE VIII. Black River bog at Chester.

has its origin in Budd Lake, which is three miles southwest of Netcong and just south of the terminal moraine of the last ice sheet. With the exception of this small area in the northern tip of the region and a few other isolated bogs, all the peat deposits within this region lie south of a line bisecting the State through Lambertville and New Brunswick. These deposits are distributed as follows: sedge and reed, 2,339 acres; alluvial, 3,102 acres; forest, 868 acres; and salt marsh, 2,060 acres.

A considerable portion of the Triassic plain occurs south of the Wisconsin terminal moraine. Where the terrain is hilly or mountainous, as in Hunterdon County, part of Somerset County, and in the Raritan drainage region, peat deposits are virtually nonexistent. In Hunterdon County, for example, only one peat bog, situated in a depression of Musconetcong Mountain west of Glen Gardner, is known. For the most part drainage conditions are such that it has been impossible for standing water to accumulate and consequently peat has not formed.

In this region the sedge and reed peats north of the terminal moraine are somewhat different from those in the southern section. In the first place, almost all of the northern bogs have an aquatic layer, this mark of lacustrine origin being universally absent in the southern section. The sedge and reed peats of the northern section have less ash, more nitrogen, and are slightly less acid. The following summary illustrates these points:

Organic matter in first foot	Nitrogen in first foot	pH of first foot	Change of pH with depth	Aquatic layer
Northern section of Raritan region				
per cent	*per cent*			
67.6–95.5	1.05–3.8	3.3–6.1	mostly increase	present in all areas
Southern section of Raritan region				
56.0–92.5	1.14–2.25	3.3–6.3	some constant some decrease	none

The average depths of the sedge and reed peats range between 1 and 10 feet, and the maximum depths between 2 and 34 feet; most of the bogs contain woody material. The organic matter in the surface foot varies between 56.0 and 95.5 per cent. Two bogs have 13.0 and 26.5 per cent ash as a result of cultivation. The pH values of the surface foot range between 3.3 and 6.3.

Fresh-water alluvial peats are found mostly in the southern section of the region. The deposits vary in size from 2 to 250 acres, in average depth between 1 and 7 feet, and in maximum depth from 2 to 14 feet. The organic matter in the surface foot varies between 15.7 and 81.0 per cent, the nitrogen between 0.47 and 3.34 per cent, and the pH between 3.5 and 5.8.

The tidal marsh in this region is located on the tidal flood plain of the Raritan River. This peat contains alluvial sediment throughout, together with sedge and reed and some woody material. The average depth of the deposits is between 2 and 12 feet and the maximum between 6 and 16 feet. The percentage of organic matter in the surface foot ranges between 11.0 and 58.0, the nitrogen between 0.66 and 1.56 per cent, and the pH between 3.5 and 6.4.

Tuckahoe drainage region

The Tuckahoe region is drained by two rivers, the Great Egg Harbor and the Tuckahoe. The former extends from Great Egg Harbor northwest to near Berlin; it is tidal to Mays Landing, a distance of about 15 miles. Tuckahoe River also empties into Great Egg Harbor and drains the southwest part of the region. The total area of this region is about 302,500 acres. The survey covered 42,894 acres of which 32,590 contained peat.

The peat types are distributed as follows: sedge and reed, 1,909 acres; forest, 11,707 acres; fresh-water alluvial, 3,436 acres; salt marshes, 15,538 acres.

The sedge and reed peats occupy the shallow stream basins and have average depths of 1 to 5 feet and maximum depths of 3 to 8 feet. All these peats contain well-macerated woody material in addition to the predominant sedge and reed. The organic matter in the surface layers ranges from 57.5 to 90.1 per cent, the total nitrogen from 1.23 to 2.84 per cent, and the pH from 3.9 to 5.8.

The forest peats are found along the streams and in gullies and basins. These bogs are also shallow, having average depths of 1 to 5 feet and maximum depths of 3 to 10 feet. About half of the bogs contain sedge and reed material. Although these peats are essentially of forest origin, well-preserved buried cedar logs or stumps are not numerous. The surface layers contain organic matter in amounts ranging between 49.7 and 95.1 per cent, total nitrogen between 1.36 and 2.33 per cent, and a pH between 3.7 and 5.4.

The fresh-water alluvial peats are in part composed of sedge and reed or woody material, but they also contain a large amount of mineral sediment. These deposits average from 1 to 4 feet in depth

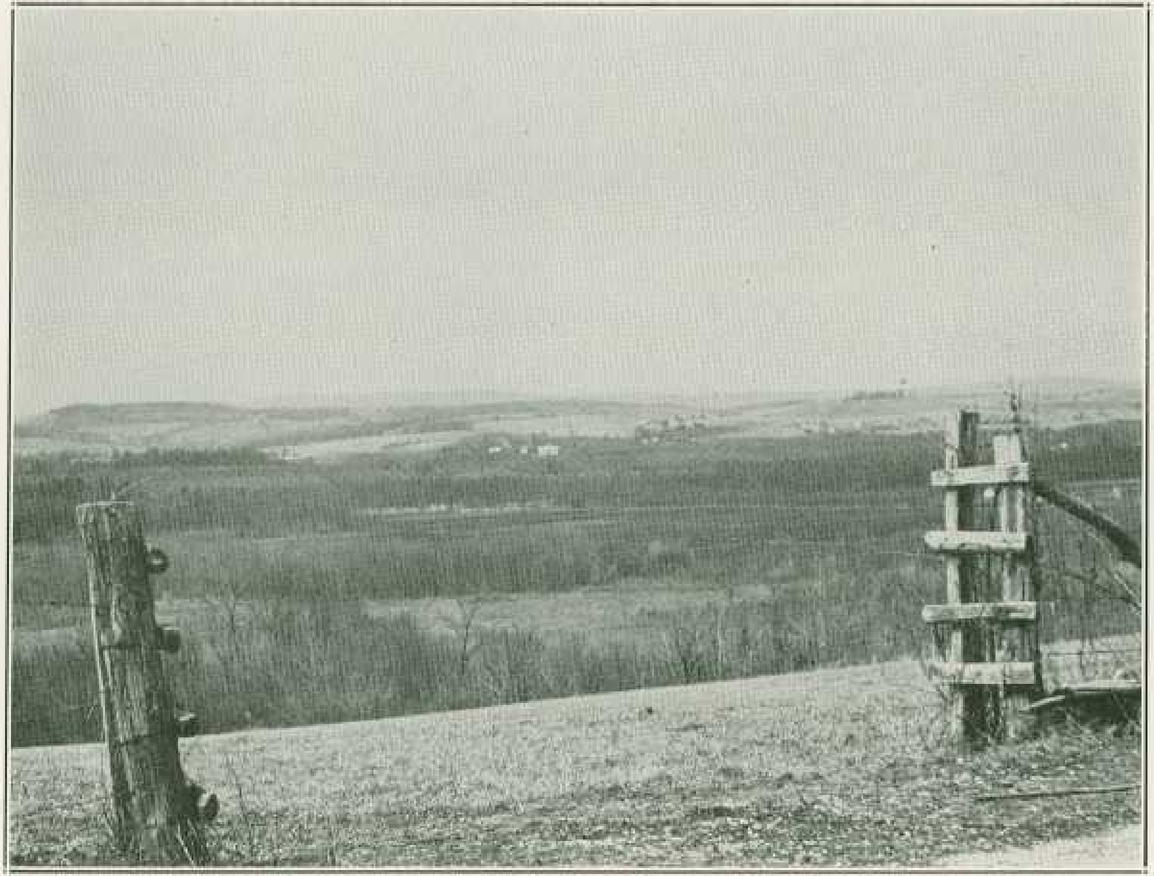


PLATE IX. "Drowned lands" of the Wallkill in New Jersey; river in the background.

and have maximum depths of 3 to 6 feet. One deposit was found to have a depth of 14 feet, but this was possibly due to underlying tidal marsh. The organic matter in the surface layers of these bogs ranges from 13.8 to 73.1 per cent, the total nitrogen from 0.32 to 1.58 per cent, and the pH from 3.1 to 5.9.

The salt-marsh deposits are found along the shores of Great Egg Harbor and the associated rivers. They have average depths of 2 to 13 feet and maximum depths of 5 to 24 feet. Wood is found in several of the deposits at considerable depths. Organic matter in the surface layers ranges between 15.8 and 90.7 per cent, total nitrogen between 0.65 and 1.99 per cent, and the pH between 2.0 and 6.0.

Wallkill drainage region

Wallkill River, in the extreme northern part of the State, drains an area of approximately 130,000 acres. It rises in a former bog southwest of Sparta, now the artificial Lake Mohawk, and flows in a northerly direction, finally emptying into Hudson River in New York State. The New York part of Wallkill Valley includes the famous Orange County onion section and contains thousands of acres of peatland of great agricultural value.

This drainage region lies in both the Appalachian Valley and in the Highlands. The entire region was covered by the last ice sheet, which made conditions suitable for peat formation. The large flow of ice gouged out large amounts of rock and soil, leaving ponds; it also deposited a great deal of drift across some of the valleys, creating lakes. Other ponds and small lakes were formed by the melting of stagnant ice in the drift-filled valleys, these undrained depressions, or "kettles", being common in the area between Woodruffs Gap and Hamburg.

Wherever bodies of water exist over long periods of time and the climate and soil are suitable for plant growth, peat will be formed. In this region, peat was deposited in the valleys of the rivers and streams, in kettles, in small ponds and lakes, and, in fact, in every place where a water-saturated condition existed for many years (plate IX and figure 15).

A total of 8,315 acres have been surveyed, of which 5,423 contain peat. Classified according to predominance in the upper 3 to 4 feet, the peat falls into three types: sedge and reed, forest, and fresh-water alluvial. The former are by far the most abundant, followed by a considerable amount of alluvial peat, and a small amount of forest peat. Almost all the sedge and reed peats have an admixture

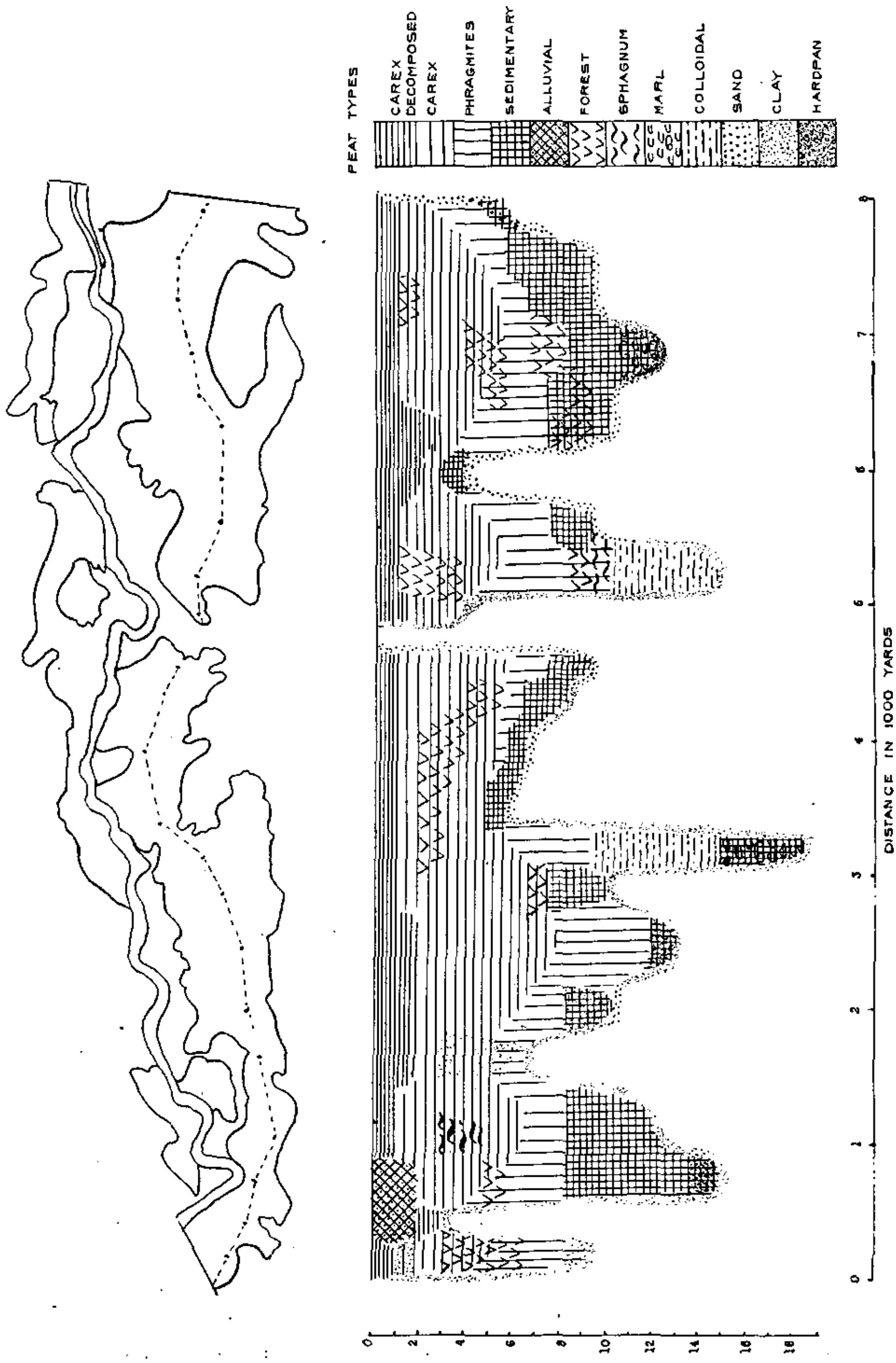


FIG. 15. Cross section of Wallkill bog.

of woody material, and the forest peats contain considerable sedge and reed. Most of the peat bogs in this area contain sedimentary or aquatic peat, and many also have strata of calcareous marl.

The sedge and reed peats range in depth from 1 to 39 feet. Some of the small bogs are very deep, and some of the larger ones are relativly shallow, there being no correlation between size and depth. The organic matter ranges between 60 and 96 per cent (dry basis). The relatively high ash content of some of the sedge and reed peats is due to the deposition of alluvial sediments. Also, the surface foot of most of these bogs has a higher ash content than the lower layers. This may be due to the recent deposition of mineral material, to the greater decomposition of the plant material as a result of drainage and aeration, or to both factors. Total nitrogen in the surface foot of these deposits ranges between 1.3 and 3.8 per cent (dry basis). If the values were calculated on an ash-free basis, however, they would fall within much narrower limits. The majority of these peats contain between 2.0 and 3.5 per cent nitrogen. In the surface foot, the pH values vary from 3.6 to 7.5, most of the values falling between 5.0 and 6.5. The change in acidity with depth of deposit is fairly predictable since the pH increases with depth in the great majority of cases. In a few, the pH decreases. About one-third of the sedge and reed peats in this region contain shell marl and when it is present in a bog in considerable quantity the pH remains approximately constant or increases with depth. The distribution of the calcareous marl is erratic and though it may be present in one bog, another nearby will contain none.

Typical forest peats in this region are comparatively few, and even these are not pure forest types, having large admixtures of sedge and reed. All but two of these bogs are in the Lake Wawayanda section of this drainage region. Their depths range between 1 and 28 feet. The organic matter in the surface foot varies between 60 and 97 per cent. The nitrogen content lies within the limits of 1.78 and 2.94 per cent. The pH values range from 3.8 to 5.9. Some of these values increase with depth, some decrease, and some remain constant; none of the forest peat deposits have layers of shells.

The alluvial peats are located for the most part along the flats of the Wallkill and its tributaries (figure 16 and plate X). In some places sedge peat of low ash content is covered with mineral soil to a depth of 6 to 7 feet. About 22 per cent of the areas are classified as alluvial. These areas vary in depth between 1 and 22 feet, and the organic matter ranges from 16.4 to 93.5 per cent. The nitrogen values in the first foot vary widely between 0.21 and 2.15 per cent,

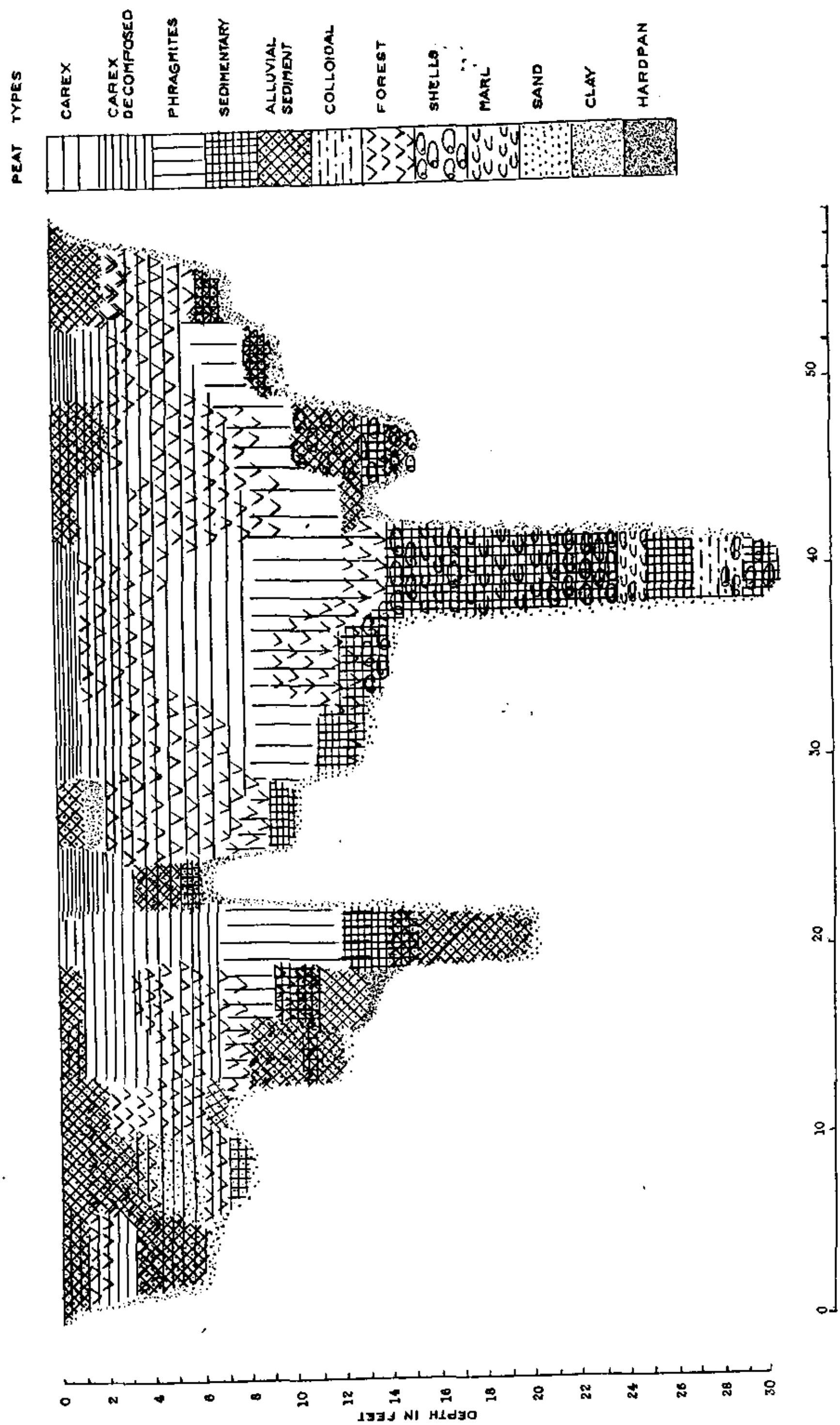


FIG. 16. Cross section of Pochuck Creek bog, south of Warwick Creek in northeastern Sussex County.

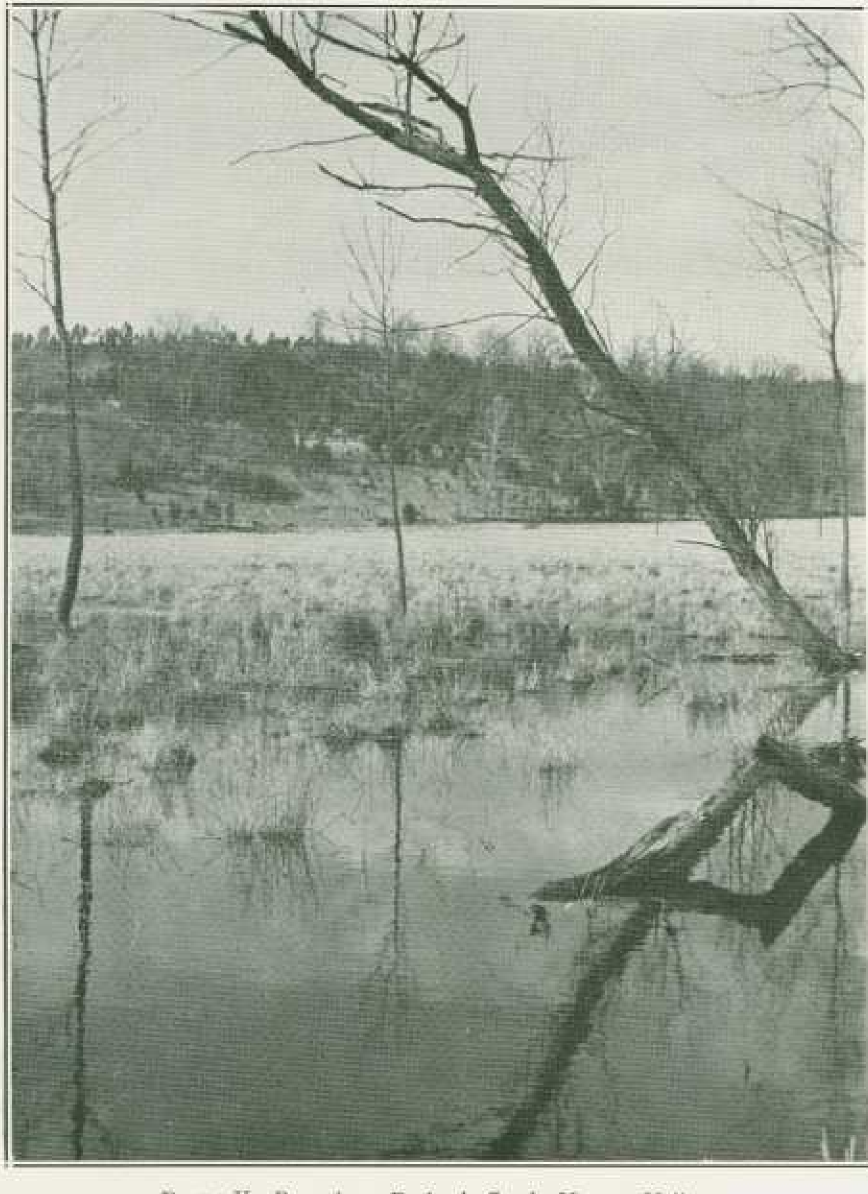


PLATE X. Bog along Pochuck Creek, Vernon Valley.

and the pH between 4.9 and 6.6. Only 4 out of 18 bogs contain shell marl.

All drainage regions

In all the drainage regions of the State, 364,671 acres, or 70 per cent of the total, have been surveyed; of these, 205,831 acres, or nearly 60 per cent, were found to contain peat. The other 40 per cent (158,838 acres) comprised mineral soil, including in that classification areas that had less than 50 per cent organic matter on a dry basis, or had an organic layer less than 12 inches deep.

SOME IMPORTANT PROPERTIES OF THE PEAT TYPES OF NEW JERSEY

It is impossible to consider peat of any given bog as pure in type. A bog containing predominantly sedge and reed peat ordinarily contains also woody material, or even forest strata; the presence of this material will, therefore, be shown in the various analyses. In the following mathematical analysis, bogs in all parts of the State were carefully selected for dominant type, but all extraneous and subordinate strata were included in the proper averages; thus, an alluvial sedge and reed stratum, occurring in a forest bog, was averaged with the forest stratum, in order to indicate the actual condition of the bog. In many instances, throughout the State, the layer forming the present surface of the bog contains large amounts of alluvial material although peat of excellent quality may occur beneath it. In other cases, alluvial strata are found sandwiched between fibrous or woody peats. In a single bog, great variation may also be found in the pH and in the nitrogen values. A core obtained from a buried tree trunk, for example, may, in a bog predominantly of the sedge and reed type, result in analytical values indicative of the forest peats.

In figure 17, data from a large number of peat areas representative of the different peat types found in the State have been summarized. The data for depth, ash content, nitrogen content, and pH values were averaged. The major types selected were as follows: sedge and reed peat, forest peat, fresh-water alluvial peat, and tidal marsh peat. Further subdivisions of these peat types were based on the presence of submerged forest peat in tidal areas; combinations of two or more of the above main peat types; the presence of a dominant type in different geographic regions of the State—namely in the north and in the south—and the presence or absence of calcareous

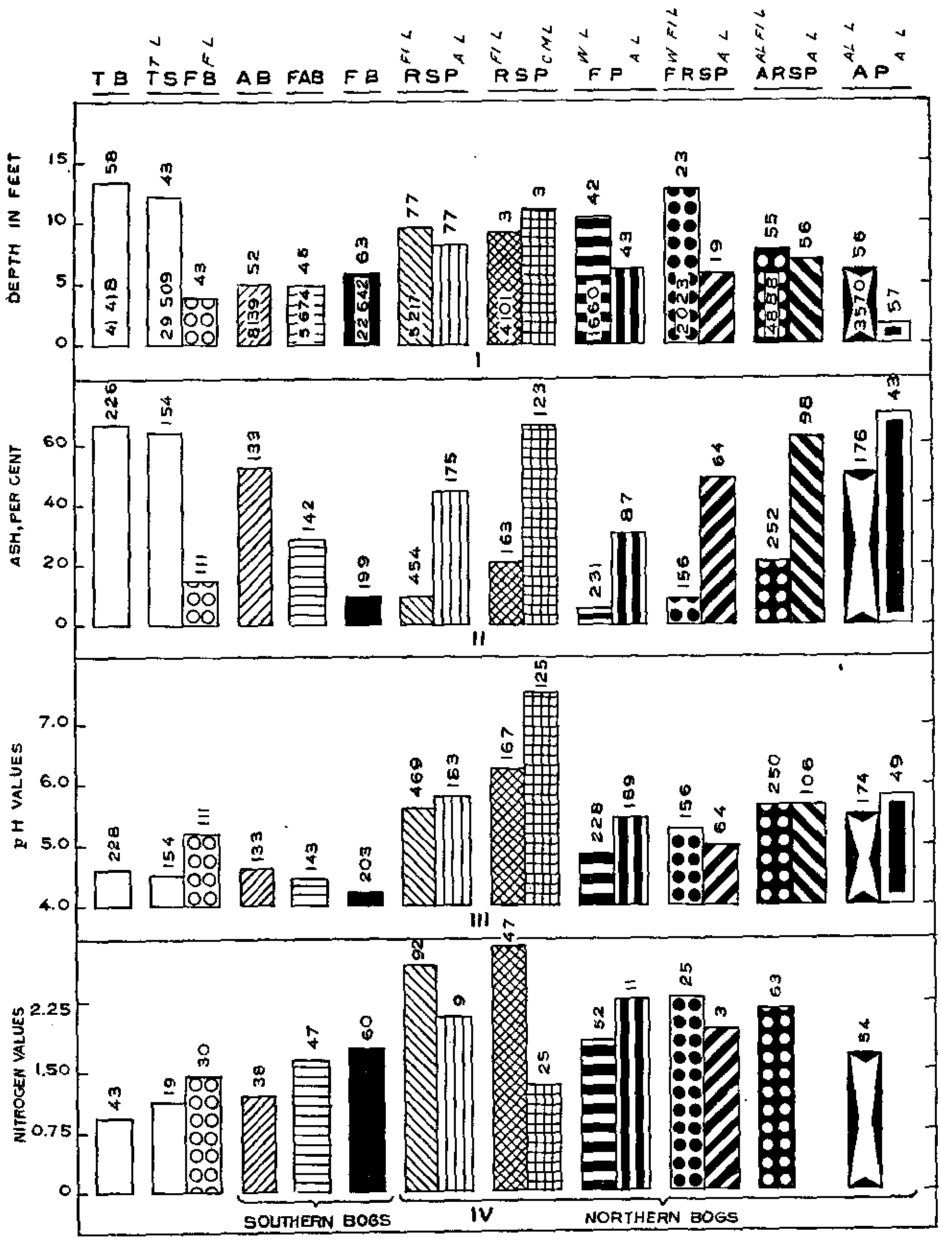


FIG. 17. Average composition of New Jersey peat types.

marl in the peat profile. In averaging the data, a considerable number of samples were used. In the case of the tidal peats, for example, 58 areas comprising 41,418 acres and located in all parts of the tidal regions of the State, were selected. In these 58 tidal areas, the following number of analyses were available for preparing the average: 226 for ash, 228 for pH, and 43 for nitrogen. For the northern reed and sedge peats, 77 areas totalled only 5,217 acres; but 454 analyses of ash values were available for the fibrous strata and 175 for the sedimentary strata. For these two strata, 652 pH determinations were made, and 101 nitrogen analyses. Insufficient determinations of certain nitrogen values were available to permit proper averages.

CHAPTER III

THE NORTHERN PEATS OF PREDOMINANTLY SEDGE AND REED TYPE

Of the various types of peat occurring in the bogs in New Jersey, sedge and reed has received the greatest consideration since this type has found extensive utilization in the growth of agricultural crops and as a source of humus for improving soils low in organic matter. New Jersey peats of this type are very similar in organic content and chemical composition to the typical lowmoors of Europe, especially to the sedge (*Carex*) and the reed (*Phragmites*) types. The sedge and reed peat bogs in New Jersey average only 5 to 8 feet in depth, although some reach a depth of 30 to 35 feet. Many of these bogs are formed almost entirely by sedges and reeds, whereas many others have an admixture of forest material. Some are underlain by clay, others by greensand marl or by calcareous marl. Some have a deep aquatic layer, others have a shallow aquatic layer or none at all. Some are overlain with an alluvial layer, which may range in depth from a few inches to several feet; whereas others have no surface alluvial layer at all. These bogs usually can be drained readily and result in excellent soils for the growth of truck crops. The peat is not very acid in reaction, usually pH 4.5 to 6.8, and hence requires no addition of lime for crop growth. Since many of these peats are underlain by calcareous marl, the pH may go up to 7.5 or even 8.0. Former State Geologist Kümmel, in commenting on the findings of Cook made in 1877, pointed out that the shell-marl deposits in Sussex and Warren Counties may contain up to 99.94 per cent $CaCO_3$. These marl deposits are usually covered by layers of sedge and reed peat.

Most of the bogs are in a wild condition, but a number are under cultivation. The wild bogs are usually covered with a mixed vegetation of deciduous trees and shrubs, such as birch, maple, elder, huckleberry, heath bush, and pussywillow, as well as sedges, reeds, mosses, and ferns. Wild bogs of forest peat which occur in the mountains are covered with a tangle of pine, cedar, rhododendron, laurel, and tamarack. Glacial kettles containing sedge and reed peat are abundant throughout the northern glaciated area.

EFFECT OF DRAINAGE CHANGES UPON PEAT FORMATION

The topographical changes produced by glaciation have resulted in the formation of vast numbers of lakes and bogs. Salisbury (83) presents a detailed discussion of these drainage changes, as follows:

As the continental ice sheet invaded a region, its valleys were filled with ice, and drainage was thereby deranged. Different streams were affected in different ways. When the entire basin was filled with ice, the streams of that basin were, for the time being, obliterated. Where basins were but partially filled, several distinct cases arose: (1) Where the ice covered the upper part of a valley or river basin, but not the lower, the lower portion was flooded, and though the river held its position it assumed a new phase of activity. (2) Where the ice occupied the lower portion of a valley, or river basin, but not the upper, the ice blocked the drainage, giving rise to a lake. (3) Where the ice occupied the middle part of a stream's valley first, a lake was likely to be formed above, while the part below was flooded. (4) Where the stream flowed parallel to the edge of the advancing ice, it was sometimes shifted in the direction in which the ice was moving, its new course often remaining parallel to the front of the ice.

The lake and pond basins of the glaciated part of the State belong to several distinct classes. There are (1) limestone sinks; (2) rock basins, produced by glacial erosion; (3) basins produced by the obstruction of river valleys by means of the drift; (4) depressions in the surface of the drift itself; (5) basins produced by a combination of two or more of the foregoing. The fourth class, as specified above, may be subdivided into (a) depressions in the surface of the terminal moraine; (b) depressions in the surface of the ground moraine, and (c) depressions in the surface of the stratified drift. Since the stratified drift in which the lakes of this last subclass lie is largely in valleys, it would not be altogether inappropriate to class them with group (3) specified above.

Salisbury has shown that Wallkill and Black River Valleys represent two types of ice-jammed river valleys. Both of these valleys contain extensive peat deposits which were markedly affected by postglacial changes, the former after the period of peat formation, the latter during the period of peat formation.

During the course of the survey of Wallkill Valley, a part of the flood plain on the west bank of the river north of Sussex was found to be covered by 1 or 2 feet of alluvial material, although small areas contained peat at the surface. Peat, where present, was about 12 feet deep. The alluvial areas differed in physical surface characteristics from the surrounding peat areas in only one way, that is, in having surface elevations 1 to 2 feet greater than the Wallkill River. This led to the belief that the greater part of the river terrace might contain peat overlain by mineral soil of varying depth. This conclusion was further substantiated by the fact that, along a 2-mile stretch of the Wallkill River in this area, peat could ordinarily be found at the river's edge where the velocity of the current had prevented settlement of the mineral soil. Removal of the heavy soil to a depth of 6 feet, revealed peat along the 2-mile stretch to depths as great as 18 feet where the surface was flat, save at sites of previous hills or points where sand and gravel had been deposited in old river bends.

Wallkill River is notorious for floods, periodically backing up to the hills. Hence the mechanism by which such heavy layers of mineral soil were deposited is readily understood.

The Black River bog extends from Succasunna to the vicinity of Hacklebarney Park in Chester Township. The area lies on both sides of the river, which flows down a valley between two mountain ridges. The ridges in most places are not more than 0.5 mile apart. The area consists mainly of mineral soil, but here and there pockets of peat are found. These pockets are usually shallow, the deepest being 11 feet.

Many other examples of bogs formed in river valleys that were once dammed by ice might be mentioned; it should be said, however, that in most instances, peat was formed in the more permanent lakes held in place by glacial deposits, rather than in the larger ice-held lakes. The bogs found in the beds of the large ice-dammed lakes have certain characteristics which differentiate them from the usual northern peat deposits. Most of them are relatively shallow because of the short life of the lakes and the deposition of large quantities of water-carried materials. In most cases these alluvial materials have filled the irregular bottoms of the old valleys and the bogs are remarkably constant in depth. Aquatic peat may be lacking or may be masked by the alluvial materials deposited during the peat-forming period. All strata of peat may be high in mineral content. Since these bogs are found in the large valleys, they commonly represent the sedge and reed type, combined with forest remnants and alluvium.

Probably the most typical limestone sinks to which Salisbury refers, are located near Squires Corners, near Blairstown, Warren County. Mud Pond, in this vicinity, may be an example of a flooded depression due to solution of the limestone, although the filling of the depression with water to form the pond is, in part at least, due to damming by glacial drift. The entire pond is fringed by a bog, and, as would be expected, the major part of the deposit consists of calcareous marl.

Salisbury considered that only one lake in New Jersey, Sand Pond on Hamburg Mountain, was definitely proved to have been formed as the result of glacial erosion. It appears probable, however, that many of the small bogs and lakes at the northern end of Bearfort Mountain were also a result of rock plucking by the glacier.

Drift or moraine-damned valley basins have resulted in the formation of the majority of the larger bogs in northern New Jersey. One may mention the bog at Newton, which was caused by the Balesville recessional moraine, or that at Lafayette, retained by the same formation, or the many lake-margin bogs of Culvers Lake, Green Pond, Budd Lake, and others.

Great numbers of small bogs are found either in the terminal moraine or in the stratified deposits associated with it. Many bogs are also found in the recessional moraines and in the stratified drift over a wide area. The bogs that owe their origins to the influence of stagnant ice are ordinarily of relatively great depth. This is also true of the limestone sinks.

PEAT DEPOSITS ALONG POCHUCK CREEK

The physical conditions encountered on Pochuck Creek resulted, during the peat-forming period, in the accumulation of two radically different types of deposit. Peat of good quality, though overlain with sedge and reed peat containing considerable quantities of alluvial material, is encountered in Vernon Valley between McAfee and Maple Grange. Between Sand Hills and the State line north of Glenwood, that part of the plain not occupied by glacial deposits is filled by alluvial sediments, with pockets of peat occurring in what were either the deeper portions of the original valley or the sites of stagnant ice blocks.

In Wallkill Valley, the peat is found to improve in quality with increased width of the valley and with distance from the issuance of the river from the mineral uplands. In Vernon Valley exactly the reverse situation obtains. Were Pochuck Creek the only stream in Vernon Valley, it would be difficult to suggest a logical explanation; but a stream, Warwick Creek, draining a large region mainly in the Great Valley in New York State, enters Pochuck Creek at Maple Grange, and the character of the deposits in the Pochuck flood plain alter remarkably below the point of confluence of the two streams. It appears reasonable to conclude that alluvium was carried by Warwick Creek in sufficient quantities to largely fill Vernon Valley. If this assumption is correct, one finds here a remarkable instance of the power of a stream to modify the course of peat production.

The bog lying between McAfee and Maple Grange is almost 3 miles long and has a maximum width of over half a mile. It constricts markedly at Sand Hills to a width of some 50 or 100 yards. South of Sand Hills the bog contains sedge and reed peat, liberally admixed with alluvium. As shown in table 5 the southern end of the bog contains peat of excellent quality, once the surface stratum is penetrated. Calcareous marl is absent in this part of the bog, although to judge from the pH values of the 15 to 20-foot stratum, much lime must be present in the sedimentary deposits. The high nitrogen contents of the various strata are noteworthy. In the surface stratum, with more than one-third of the dry matter mineral in nature, the nitrogen content is 2.88 per cent. It increases to 3.94 per cent in the second foot, and to 3.10 per cent in the tenth foot.

In the southern part of the wide sector of the bog north of Sand Hills, the surface stratum of reed, sedge, and alluvial peat contains 25.4 per cent ash and 3.38 per cent nitrogen and has a pH value of 6.0. Between the first and the eleventh foot, below which sedimentary material is encountered, the ash content varies between 6 and 17 per cent and the pH between 6.2 and 4.4, the lower value occurring in the eleventh foot. The nitrogen content of the dry matter of the fourth foot is 3.56 per cent. Sedimentary peat with a pH reaction of 4.4 replaces calcareous marl in the lowest stratum, the fifteenth foot, which has a pH of 7.7. The larger part of the bog north of Sand Hills contains peat with the same high nitrogen values as the other portions. Calcareous marl is present in considerable quantities.

TABLE 5

Typical profile of southern end of Pochuck Creek bog south of Sand Hills

Area 3, Field map 74.32–41.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0-1	Dark brown sticky reed, sedge, and alluvial peat	73.3	34.2	2.88	5.7
1-10	Brown granulated and crumbly or fibrous reed and sedge peat	87.1	8.2	3.94	5.8
10-12	Brown reed and sedge peat containing sedimentary peat	85.6	14.8	3.10	5.3
12-15	Brown sedimentary peat	73.0	63.5	....	5.0
15-20	Grayish brown sedimentary material	46.0	87.8	....	7.4
20-21	Gray sand	29.0	88.3	....	7.2

PEATS OF THE APPALACHIAN VALLEY

Peat deposits of the Appalachian Valley that occur on limestone bottoms are generally of the sedge and reed or lowmoor type, with calcareous marl as the underlying stratum. In bogs situated in the higher parts of the valley, on slate and sandstone bottoms, the peat generally contains more wood, and the marl layer is scanty or absent altogether.

One of the most important bogs in New Jersey, the Hyper-Humus, extends from Newton to Branchville Junction, occupying an area of about 1,400 acres (tables 6, 7). This peat deposit is on limestone in the great valley that extends across New Jersey from Delaware River to the boundary line with New York State. Paulinskill River, draining to the Delaware, rises in this bog. The geology of the surrounding rocks is of considerable interest. Slate ridges form, for the most part, the sides of the long axis of the area, which, like the limestone valley, trend northeast. Limestone knolls bound the bog to the southwest, and at the northeast is found a part of the Balesville recessional moraine, which was formed when the ice was in retreat and which has a maximum width of three-quarters of a mile. The moraine, laid down in the vicinity of Warbasse, dammed the waters of this part of the valley giving rise to a fairly deep lake, which, with the passage of time, became converted into a peat bog.

TABLE 6

Profile of the source bog of the Paulinskill

Area 1, Field map 74.44–41.04

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0-1	Dark brown, granulated and crumbly, well-decomposed material	86.7	10.1	5.8
1-3[1]	Brown, fibrous and matted reed and sedge peat	87.8	7.0	5.9
3-7	Dark brown reed and sedge peat containing wood	89.5	7.9	6.0
7-8	Dark brown sedimentary peat with few shells	92.4	15.7	6.6
8-14	Gray shell gyttja	79.5	75.3	6.9
14-17	Gray-brown liver peat	87.7	52.2	6.8
17-18	Gray clay gyttja	66.5	85.5	6.8
18-19	Gray clay	....	....	...

[1] Nitrogen content 2.40 per cent.

TABLE 7

Profile of the source bog of the Paulinskill

Area 7, Field map 74.44–41.02

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0-1	Black, granulated, crumbly, well-decomposed material	86.0	8.0	3.29	5.1
1-9	Dark brown, coarse, fibrous and matted reed and sedge peat	89.8	6.9	2.63	6.2
9-10	Brown, fibrous and matted reed and sedge peat	91.9	12.2	3.37	6.8
11-13	Gray mixture of sedimentary peat, shells, and calcareous marl	83.4	62.0	1.22	7.6
16-17	Gray-brown liver peat with shells	83.6	62.6	1.43	8.0
18-19	Chocolate-brown liver peat	89.4	39.1	2.43	7.9
19-20	Gray-brown liver peat	85.3	58.9	1.48	7.8
20-21	Brown liver peat	89.2	42.7	2.31	7.8
21-22	Chocolate-brown liver peat with a few shells	90.0	30.8	2.78	7.9
24-25	Gray clay	44.6	94.8	0.18	8.0

The bog has lately been ditched and as a result the bed of the Paulinskill is considerably lower than formerly.

Much of the bog is thickly covered with tall deciduous trees, beneath which grow shrubs and ferns; conifers are found in some sections, and reeds and sedges form the dominant growth in some of the wetter parts. Where drainage is most efficient and the forest has been removed, upland vegetation such as blackberry growth has encroached. The average depth of peat in this deposit is some 14 feet, the greatest depth being 30 feet. It is of the typical sedge and reed lowmoor type, although there is some admixture of forest material. The surface foot, except along the main ditch (the Paulinskill, where alluvial deposits are found), consists of well-decomposed material, black in color. The next lower succeeding layer consists mainly of brown sedge and reed peat, although sunken logs are frequently encountered, some layers being definitely woody. Beneath this is an aquatic layer, which consists largely of liver peat, both containing and alternating with, shell layers.

Considerable woody peat is found in some parts of the bog. The pH values rise from 5.8 in the surface foot to 6.5 in the 8 to 11-foot layer; thereafter, the presence of lime, in the form of shells, produces its effect, the pH rising suddenly to 7.6 and remaining virtually constant at that value throughout the remaining depth of the bog. The nitrogen content, on a dry basis, ranges from 2.46 per cent, in the 3 to 7-foot layer, to 3.14 per cent in the 17 to 19-foot layer. The ash content is high in the surface layer, decreasing from 31 per cent to 3 per cent in the seventh foot, then increasing to 8 per cent in the 8 to 11-foot stratum, and rising in the shell layer to 81 per cent. The ash content of the stratum of light-brown liver peat is 26 per cent and increases to 67 per cent in the stratum of greenish-brown liver peat. The high surface ash content is due to an admixture of alluvial material, which covers part of the southern section of the bog to considerable depths.

In the northern end of the bog, fibrous sedge and reed peat of excellent quality is found to a depth of 10 feet. The ash content decreases from 8 per cent at the surface to 6.5 per cent in the sixth foot, and increases again to 12.2 per cent in the ninth foot. The nitrogen content decreases from 3.3 per cent at the surface to an average of 2.6 per cent, but when the ninth foot is reached it increases to 3.4 per cent. The pH value increases from 5.1 at the surface to 6.8 in the ninth foot. From the tenth foot downward a sudden marked decrease in organic matter occurs. The presence of calcareous marl is responsible for the increase with depth of pH value and ash content, accompanied by a corresponding decrease in nitrogen content. In other parts of the bog alternating layers of shell gyttja and liver peat are found with strata of clay gyttja occurring near the clay substratum.

The relationship between the geologic formation on which the peat deposit occurs and the types of peat produced in the deposit is clearly demonstrated in the bog extending south from Balesville. This bog is situated in the sandstone and shale hills rising above the Hyper-Humus tract to the west, and is only 1½ miles from the latter area. The difference in elevation between these two areas is slight; the Hyper-Humus bog is 554 feet above tide, whereas the Balesville bog is 600 feet above sea level. Both bogs owe their origin to the damming effect of the Balesville recessional moraine: in the first case, a limestone valley was damned, and, in the second, a slate and sandstone valley.

Part of the Balesville bog is utilized as pasture, but the major part is wild. The entire central part is thickly covered by deciduous trees beneath which are found shrubs and ferns, with some reeds and sedges. For the most part, the margins of the bog are devoid of trees and shrubs. Where the bog has been cleared for pasture, grasses predominate, and where the high water-table or other factors prevent the growth of trees, virtually the only vegetation consists of reeds and wild sedges. The aquatic layers vary from green to brown and consist either of sedimentary or true liver peats; no shells or calcareous deposits are present. The aquatic peat strata are overlain by reed, sedge, and woody peat, which, at the surface, has undergone considerable decomposition. The pH values range between the narrow limits of 5.5 and 6.0, thereby differing markedly from the Newton bog and indicating absence of an excess of lime.

TABLE 8

Profile in Crooked Swamp, devoid of calcareous marl

Area 1, Field map 74.42–41.04

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0-1	Black, well-decomposed, granulated material; some alluvial deposit	80.6	13.2	4.16	5.8
1-6	Dark brown, crumbly reed and sedge peat with some wood	86.8	8.6	4.20	5.9
6-10	Brown mixture of reed, sedge, and aquatic peat	90.1	6.4	....	6.1
10-11	Brown sedimentary peat with some reeds and sedges	89.9	10.9	....	6.1
11-12	Brown sedimentary peat with some reeds and sedges	90.1	21.8	2.76	6.1
12-13	Gray clay	...	....	....	...

A bog of special interest lies northeast of the Balesville recessional moraine, and is known locally as "Crooked Swamp" (table 8). (See also plate XI and figure 18.) This peat deposit is 1½ miles from the Hyper-Humus tract, and lies in almost a direct line with it to the northeast of Lafayette, between slate ridges. The difference in elevation between these two bogs is about 30 feet, the Lafayette bog having an elevation of 524 feet. Calcareous marl is found in part of the bog and since the area is on a large slate "island", its discovery was unexpected. In seeking an explanation it was noted that virtually all of the surface drainage into the area takes place at the northeastern extremity, where a stream flowing out of a smaller bog enters

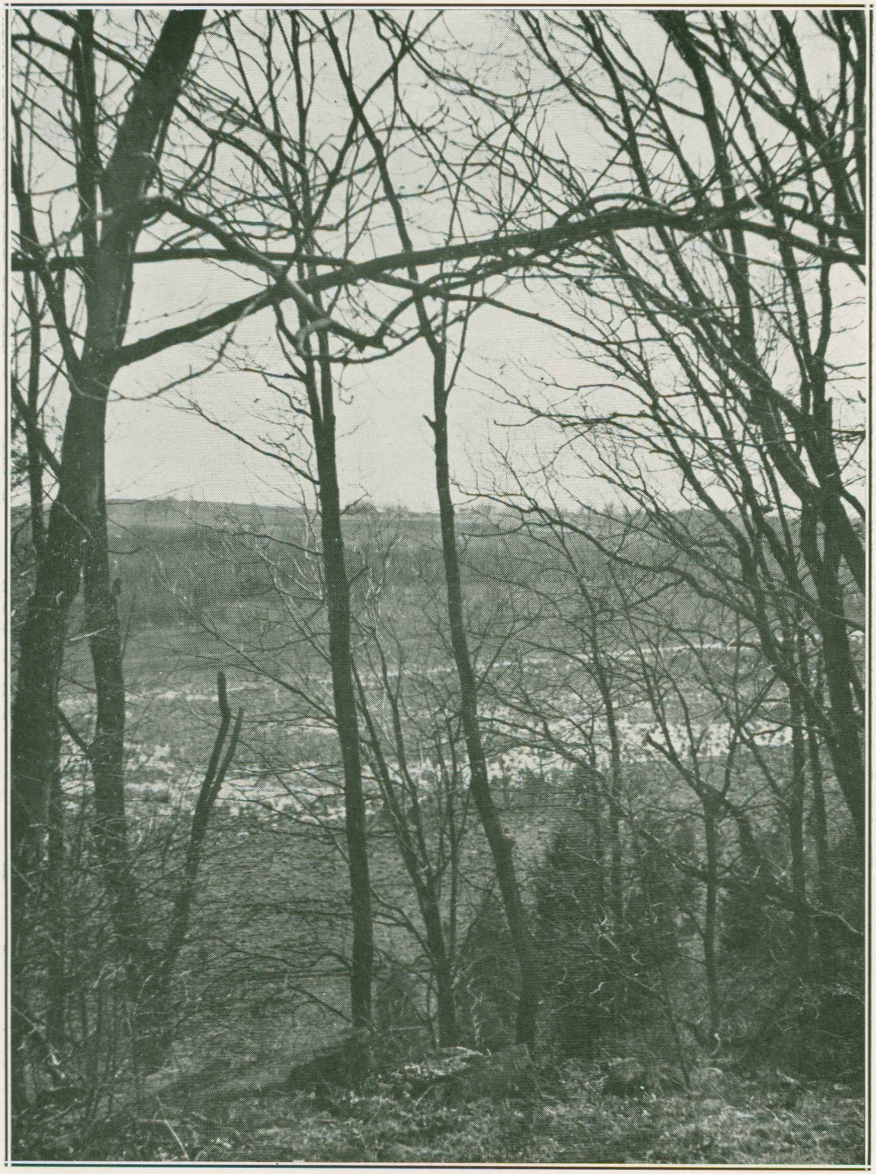


PLATE XI. "Crooked Swamp" near Lafayette.

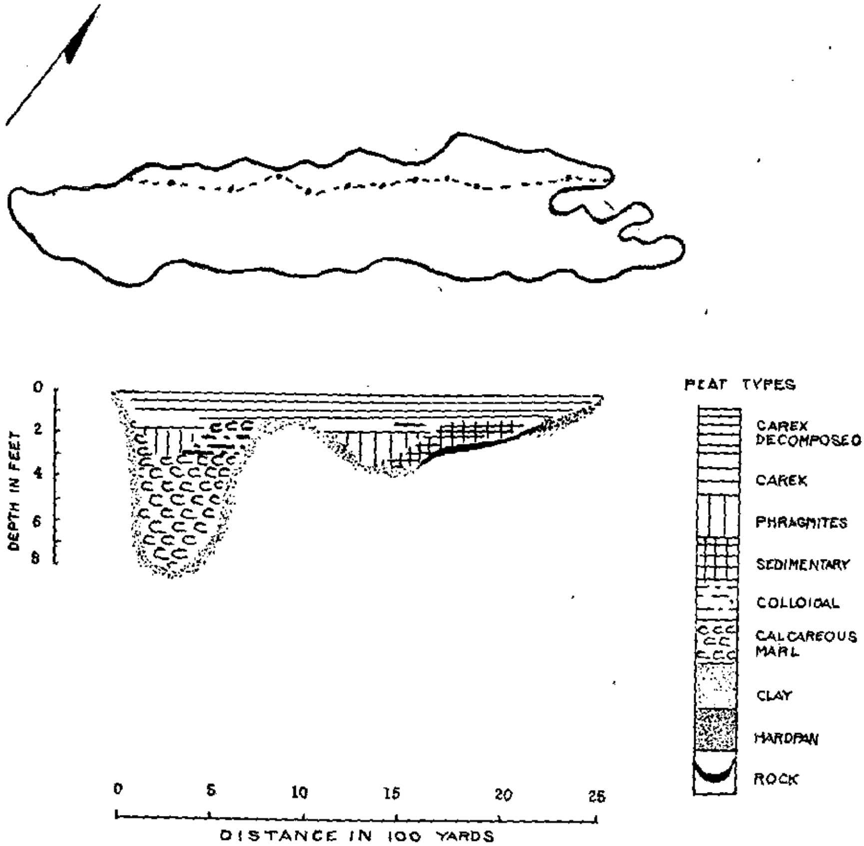


FIG. 18. Cross section of Crooked Swamp showing deposit of calcareous marl.

this one. A second stream enters the bog midway on the eastern side, its flow being considerably less than that of the first. The entire southwestern part of the bog is spring-fed, and calcareous marl is found only in this section. This latter circumstance points directly to the higher ground separating this bog from the Hyper-Humus bog as the source of the lime-bearing spring-water, since there are a number of sink-holes there which unquestionably were caused by the solution of limestone, and the difference in elevation is sufficient to cause the flow noted.

A large ditch is required to drain the southern part of the bog, the ditch and streams merging near the center of the western boundary, where a single large stream flows into the limestone valley below.

This bog has been largely cleared in order to utilize the land. Most of the cleared portions are used as pasture, although the extreme southern tip of the bog is planted to truck crops and corn. The virgin portions of the bog contain large deciduous trees intermingled with shrubs, ferns, moss, and sedges. The vegetation of the pasture-land is typically upland, and consists of grasses, nettles, and the like. Where pasture has been abandoned, much of the secondary growth consists of birch trees.

The peat found in the deposit is a typical sedge and reed with some admixture of wood. Calcareous marl has been deposited in a limited portion of the area, this deposit being one of the most interesting encountered. The bog is over 2 miles long and has an average width of one-quarter mile. In the southern part and extending northward for about 800 yards, with an average width of some 150 yards and in an average 3-foot stratum of peat, is found a ribbon-like deposit of lime. The southern limit of this deposit is about 300 yards from the southern extremity of the bog; the ribbon is not found within 75 yards of the western side or within a greater distance of the eastern side. It extends in the direction of the outlet stream and parallels the present stream draining the southern part. The ribbon does not invariably extend downward to the clay or rock subsoil; in part, it has below it gray colloidal clay or other sedimentary deposits.

It appears quite probable that this interesting marl ribbon represents the flow of a great lime-rich spring. The surface water in the southern part of the bog has a pH value of 7.3; the stream coming in from the north has a pH value of 7.7; and the pH value of the outlet stream is 8.3. Since the outlet stream contains the waters from both the southern and northern sections and since the pH of this stream is higher than either of the streams taken separately, it is apparent that some water richer in lime has been added. This enrichment may be due to the passage of spring water through the present marl deposit, or it may be due to passage through limestone.

In that part of the bog from which calcareous marl is absent, the presence of a small amount of alluvial material in the surface stratum has resulted in a somewhat higher mineral content than in lower strata. The surface foot has 13.2 per cent ash, which decreases gradually to 6 per cent in the eighth foot; the tenth and eleventh feet show an increase in ash, possibly due to the presence of clay. The nitrogen content of the sedge and reed and of the woody strata is 4.2 per cent; the pH values vary within the narrow limits of 5.8 to 6.1.

Another profile was taken about 100 yards distant from that shown in figure 19 in a part of the bog containing calcareous marl (table 9). The presence of aquatic peat and calcareous marl in the top 3 feet probably indicates the action of spring water in the mixing of bottom and top materials. The extremes in pH values, 5.3 to 6.7, are much wider in this than in the previous profile; the effect of the calcareous marl is clearly shown in the surface foot stratum, and in the 14 to 16-foot stratum. In this profile, the ash concentration is consistently higher than in the preceding one, probably because of the presence of marl and other inorganic sediments distributed by ground waters. The nitrogen content is correspondingly lower.

TABLE 9

Profile in Crooked Swamp, containing calcareous marl

Area 1, Field map 74.42–41.04

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0-1	Black, crumbly, well-decomposed material with some calcareous marl	80.5	17.6	3.76	6.6
1-2	Dark brown reed and sedge peat with wood and some calcareous marl	84.8	13.4	....	5.9
2-4	Dark brown reed and sedge peat with some aquatic peat	87.4	8.0	....	6.0
4-8	Brown reed, sedge, and woody peat	89.0	8.5	....	5.3
8-10	Brown fibrous reed and sedge peat	98.7	10.9	2.75	5.5
10-12	Brown reed, sedge and woody peat	88.2	13.1	....	5.5
12-13	Brown mixture of sedimentary, reed, sedge, and woody peat ..	91.6	7.7	....	5.7
13-14	Olive-green sedimentary peat with some calcareous marl	88.4	25.1	....	5.6
14-15	Olive-green sedimentary peat with some calcareous marl	80.7	61.1	....	6.2
15-16	Olive-green sedimentary peat with some calcareous marl	68.6	76.4	0.63	6.7
16-17	Gray clay	....	....	....	...

A mile and a quarter to the east, measured from the northern tip of Crooked Swamp, lies the village of Monroe. Between Monroe and North Church, 1¾ miles distant to the northeast, the limestone valley is almost entirely filled with a bog which is a remnant of the glacial Lake North Church. This lake was formed as the result of an ice blockade behind the North Church delta which dammed normal drainage. With the melting of the ice, this lake did not disappear entirely. The delta blocked the narrow valley and this resulted in the persistence of a smaller lake for a much greater period of time. Peat accumulated in this lake (table 10).

TABLE 10

Profile of bog in bed of glacial Lake North Church

Area 6, Field map 74.38–41.06

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark, crumbly, well-decomposed material with alluvial deposit	80.0	20.5	5.7
1–3	Dark brown fibrous reed and sedge peat ...	85.8	11.1	5.9
3–5	Dark brown fibrous reed and sedge peat with a few shells	87.6	10.1	5.9
5–7	Gray-brown sedimentary peat with shells and calcareous marl	....	....	...
7–12	Gray-brown calcareous marl and sedimentary peat	67.2	53.7	8.2
15–16	Gray clay with a few shells	....	....	...

[1] Nitrogen content, 3.37 per cent on dry basis.

The bog is about 1¾ miles long and has a maximum width of 500 yards. It is remarkable for the amount of calcareous marl deposited, the irregularity of its cross section, and the shallow depth at which calcareous marl is found, in some places only 1 foot from the surface. The depth of peat and marl ranges from 1 foot to more than 28 feet. The peat deposit is a typical sedge and reed, underlain by abundant calcareous marl. In many places woody materials are found. Due to the deposition of alluvial material the ash content of the surface stratum has a high value of 20.5 per cent. It falls to 11 per cent in the third foot and to 10 per cent in the fifth foot. Where calcareous marl is encountered, as in the eighth foot, the ash content increases to 53.5 per cent and remains virtually constant thereafter at greater depths. The nitrogen content is 3.37 per cent at the surface. The pH value remains constant at 5.9 until the marl stratum is reached, when it becomes 8.2. The water of the bog has a pH value of 7.7.

The shallow part of this bog is toward the northern end where it is cultivated. The peat is so shallow that ordinary plowing has turned up the calcareous marl and clay layer and mixed it with the well-decomposed sedge and reed stratum. In the wild parts of the bog, large deciduous trees tower above shrubs, ferns, sedges and moss; in the wetter parts, reeds predominate.

The stream draining this bog flows into Wallkill River at Franklin. The Wallkill is famous agriculturally, because along its banks and the banks of the largest of its tributary streams, Pochuck Creek, is a large acreage of cultivated peatland, planted mainly to onions. This farmland is probably as valuable as any in the entire country.

The peatlands of the Wallkill occur intermittently along its course from a point near its source at Sparta, but only a limited amount of peat is found until a point is reached 1 mile north of Independence Corner and 2 miles east of Sussex. From here north to the New York State line, the bog is 5½ miles long, and near the state line it is almost 2 miles wide. The portion of the Wallkill Drowned Lands found in New Jersey constitutes only a fraction of the whole area which extends into New York State, almost to Goshen. The whole bog is almost 20 miles long and attains a maximum width of 5 miles.

The Wallkill-Pochuck bog series represents part of the bed of glacial Lake Wallkill. In the preglacial period, the limestone valleys of the Wallkill and the Pochuck drained to the north into Hudson River. The glacial ice advancing to the south acted as a dam, the impounded waters extending southwest almost to Augusta in the valley of Papakating Creek, a tributary of the Wallkill, as well as to Hamburg or beyond in the valleys of Pochuck Creek and the Wallkill. As the ice advanced, the lake became smaller, for the glacier progressively covered greater portions of the valleys. Eventually the entire area was covered with ice. When the glacier receded, the lake again appeared. It became progressively larger with the retreat of the ice, until the outlet of the valley system was uncovered. The main body of water then disappeared, but smaller bodies of water, comprising a series of lakes, were impounded by glacial deposits across the valleys.

As previously mentioned, the Wallkill now rises in Lake Mohawk. Between this former bog and the town of Sussex, many interesting and important formations resulted from the Wisconsin ice sheet. This region, however, need not be considered at this time, since no peat deposits of importance occur in the valley until North Church is reached.

The banks of Papakating Creek are in many places boggy, but peat is not found in any of the wet areas, which consist of the silt loam named after the creek. The same type of flood plain is encountered along the Wallkill from a point a mile north of Sussex and extending far to the south. Some of the bogs are of considerable extent, but they consist entirely of water-deposited mineral material. This alluvial soil extends over the surface of the peat, north of Sussex. In some parts of the area, as much as 10 feet of silt and clay were encountered before peat was reached. This situation prevails everywhere for a short distance (100 yards) from the Wallkill, even in the wider parts of the bog where the peat deposit is of excellent quality at a greater distance from the stream. The same condition is found along Pochuck Creek. In the stream-bed and for a short distance from its banks, pebbles of various sizes are found as well as sand and finer mineral constituents. As the distance from the stream increases the alluvial deposits become less and of smaller particle size, whereas the peat beds increase.

The vegetation covering the Wallkill-Pochuck bog series varies considerably. Along the Wallkill, large tracts in the north are cleared and in pasture. Continuing south, huge deciduous forest areas are encountered, alternating with pastureland and land devoted to the culture of onions. In the higher, shallower areas, corn and other crops are grown. Almost all of the bog in the vicinity of the New York-New Jersey State boundary is cleared and planted to onions.

The Pochuck Creek lands are cleared and utilized as pasture in the drier portions; the remainder is covered with deciduous forest. The wettest lands, in both bogs, are covered with reeds (see plate X, p. 89).

The Wallkill flood plain north of Sussex is narrow and is subject to repeated floods by the Wallkill, which is joined by Papakating Creek just south of this point. Both streams, previous to entering the bog, flow through meadows composed of Papakating silt loam for many miles, and in consequence carry much mineral matter when in flood. The peat in this section is overlain by a foot of clay, deposited by the flood waters of the river. Under the clay, the peat is of poor quality, varying from 20 to 41 per cent in ash content. The pH values range from 4.4 to 5.0, showing an unusual acidity for a limestone valley. The river flood plain is much wider on the east bank of the Wallkill, the peat being of better quality away from the river. The upper strata of peat contain considerable mineral matter, and, in some instances, as at the southern end, the peat is overlain by clay and silt, in spots to depths of over 6 feet; for the most part, however, the upper strata consist of peat of low quality. This section floods several times each year but since the mineral deposits have a larger flood plain upon which to deposit their sediments; the layers laid down are thinner than on the west bank.

TABLE 11

Profile of an east bank Walkill peat area

Area 3, Field map 74.34–41.12

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, crumbly, well-decomposed peat and alluvial deposit	68.7	33.9	5.6
1–2	Dark brown, crumbly, well-decomposed peat and alluvial deposit	80.2	20.6	...
2–3	Brown macerated reed and sedge peat	84.8	15.8	...
3–6	Brown fibrous reed and sedge peat	88.7	7.3	5.7
6–8	Gray-brown macerated reed and sedge peat	89.9	12.8	6.0
8–9	Dark brown fibrous reed and sedge peat ..	88.5	15.7	5.9
9–10	Gray-brown mixture of clay and reed and sedge peat	82.2	65.8	5.4
10–11	Clay	....	....	5.3

[1] Nitrogen content, 2.59 per cent on dry basis.

Physical and chemical characteristics of the peat deposit on the east bank of the river are presented in table 11. The effects of flooding induced, in part at least, by the filling of the basin with peat can be readily demonstrated by the ash content of the various strata. Beginning with the oldest and deepest layers, the peat is found to consist of sedge and reed, heavily admixed with clay, as shown by the high ash content of 65.8 per cent. The ninth foot contains only 15.7 per cent ash and progressing upward in the order of deposition, the ash is reduced to only 6.0 per cent in the fifth foot. Because of admixture with clay it then increases, however, as shown by the 15.8 per cent ash content in the third foot, 20.6 per cent in the second, and 33.9 per cent in the top foot.

More than one major factor is believed to be involved in the deposition of silt and clay over the peat. It may be generally assumed that with the filling of a depression with peat, the incidental increase in elevation of the stream progresses at a higher rate than in other parts of the bog. This assumption is based on the fact that the coarser mineral sediments are invariably deposited close to the stream, thus forming a mineral dyke in which the stream flows. As the stream bed is confined and elevated, the quantity of water necessary to cause flooding of the surrounding lowland is diminished, and floods are of more frequent occurrence. Confinement produces, likewise, an increase in the rate of flow; and since more rapidly moving waters possess the ability to carry greater quantities of mineral matter, the effects of flooding may be expected to become of increasing magnitude.

Dredging has been practiced for many years along the Wallkill because of the great value of the land for agriculture. Drainage of peatlands invariably results in subsidence and since the mineral content of the peat varies directly with proximity to the stream, it may be assumed that subsistence would be least nearest the stream, thus causing deeper floods when the banks are topped. Deposition of silt and clay is greatest near the entry of the stream into the bog, for this portion acts as a shallow settling basin for the remainder of the area.

As one proceeds northward along the Wallkill, the bog widens and

TABLE 12

Excellent peat at some distance from the Wallkill

Area 1, Field map 74.34–41.14

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black crumbly reed and sedge peat	77.9	10.0	5.2
1–11	Brown, fibrous, matted reed and sedge peat	88.2	8.3	6.1
11–12	Brown macerated reed and sedge and sedimentary peat	89.7	8.7	5.9
12–14	Brown, sticky, sedimentary peat	90.2	15.8	5.2
14–15	Brown liver peat	83.5	57.0	5.2
15–16	Gray-green liver peat	79.9	71.1	7.2
16–19	Gray-green sedimentary peat alternating with calcareous marl	69.6	79.6	7.1
19–21	Green sedimentary peat and clay	....	....	...
21–22	Clay	....	....	...

[1] Nitrogen content, 2.67 per cent on dry basis.

the quality of the peat improves. With the appearance of more efficient lateral ditches, a larger proportion of the area is found to be in use either as pasture or for the growth of truck crops. A profile taken 900 yards from the main stream shows peat of excellent quality (table 12). The peat is a typical sedge and reed type with little, if any, woody material. The top stratum of 11 feet consists of highly fibrous peat with an ash content ranging between 6.5 and 11.6 per cent. The nitrogen content of the surface stratum is 2.67 per cent. The pH values range from 5.2 to 7.2. The aquatic layers consist of alternating strata of colloidal and noncolloidal material, the lowest layer (16-21 feet) containing narrow bands of calcareous marl. Gray clay underlies this part of the bog.

A profile taken in proximity to the river showed that the surface foot of peat had a high ash content of 23.6 per cent, which is more than double that of the second foot. The ash content of the third foot had a high ash value of 45.0 per cent, which decreased in the fourth foot to 10.9 per cent. One finds here the history of periods of great precipitation, alternating with periods of drought. The presence of calcareous marl has affected the ash contents and the pH values of the lower strata of the deposit at this location. Calcareous marl does not occur everywhere in the bog and in most places, it does not form a stratum of any great thickness.

Two and one-half miles northwest of the northern extremity of the Wallkill bog in New Jersey is a bog of some 200 acres, which is locally known as the "Wolf Pit". This bog occurs in a depression in a region of slate and sandstone, the waters draining into a small stream which flows into the Wallkill at a point near the state line. As outlined by Salisbury it is obvious that the Wolf Pit bog was formed as a result of the damming of drainage by the stratified drift laid down by the Wisconsin glacier.

Large areas of the Wolf Pit bog are cleared and utilized as pasture; the remainder is covered with deciduous forest, and in the wetter parts, with reeds. Sphagnum moss grows beneath the trees. This bog represents an anomaly. It is situated on slate and sandstone and is elevated some 200 feet above the limestone valley of the Wallkill, which is at a distance to the east. It should contain peat of a sedge and reed or of a forest type, without calcareous marl. This, however, is not always the case; for although in some parts of the bog the aquatic strata contain no calcareous marl or shells, in other parts considerable marl is deposited. The surface sedge and reed layer contains considerable amounts of alluvium, below which the quality of the peat improves with large amounts of wood in many places.

TABLE 13

A Wolf Pit bog profile without calcareous layer

Area 3, Field map 74.36–41.16

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, sticky, well-decomposed peat and alluvial deposit	82.1	36.4	6.6
1–2	Dark brown, crumbly reed, sedge, and woody peat	....	....	...
2–4	Dark brown, lumpy, woody peat	83.2	27.1	5.6
4–8	Brown, lumpy reed, sedge, and woody peat	88.5	19.1	5.0
8–15	Brown, fibrous and matted or sticky reed, sedge, and moss peat containing wood ..	90.6	11.5	5.1
15–16	Brown, sticky sedimentary peat	91.7	10.6	4.7
16–18	Olive-green, sticky sedimentary peat	90.9	15.7	4.7
18–22	Olive-green, sticky sedimentary peat	73.4	72.3	5.0

[1] Nitrogen content, 2.25 per cent.

Table 13 gives the physical and chemical data for the profile of this area. Calcareous marl is absent and the peat is of a forest type admixed with reeds and sedges. The upper stratum contains much alluvium. The ash varies from 36.4 per cent at the surface to 10.4 per cent in the tenth foot. The material is acid in reaction throughout the profile, ranging between pH 6.6 at the surface and pH 4.7 near the bottom. The cross section of the bog shows (figure 19) that for a distance of some 700 yards along a line extending from the south-western extremity toward the northeast, it is devoid of calcareous marl. Near the northern extremity a stream flows out of an alluvial bog the deposits of which are rich in calcareous marl, enters the Wolf Pit bog, flows to the center, and thence to the east. Everywhere along its present course and probably through its past courses, calcareous marl was deposited. This marl appears to have been carried in solution.

West of the Wolf Pit bog, there is rolling country of increasing elevation for 3 miles to the almost vertical eastern face of Kittatinny Mountain, which at this point is several miles broad. Not more than three-quarters of a mile west of the foot of the western flank of

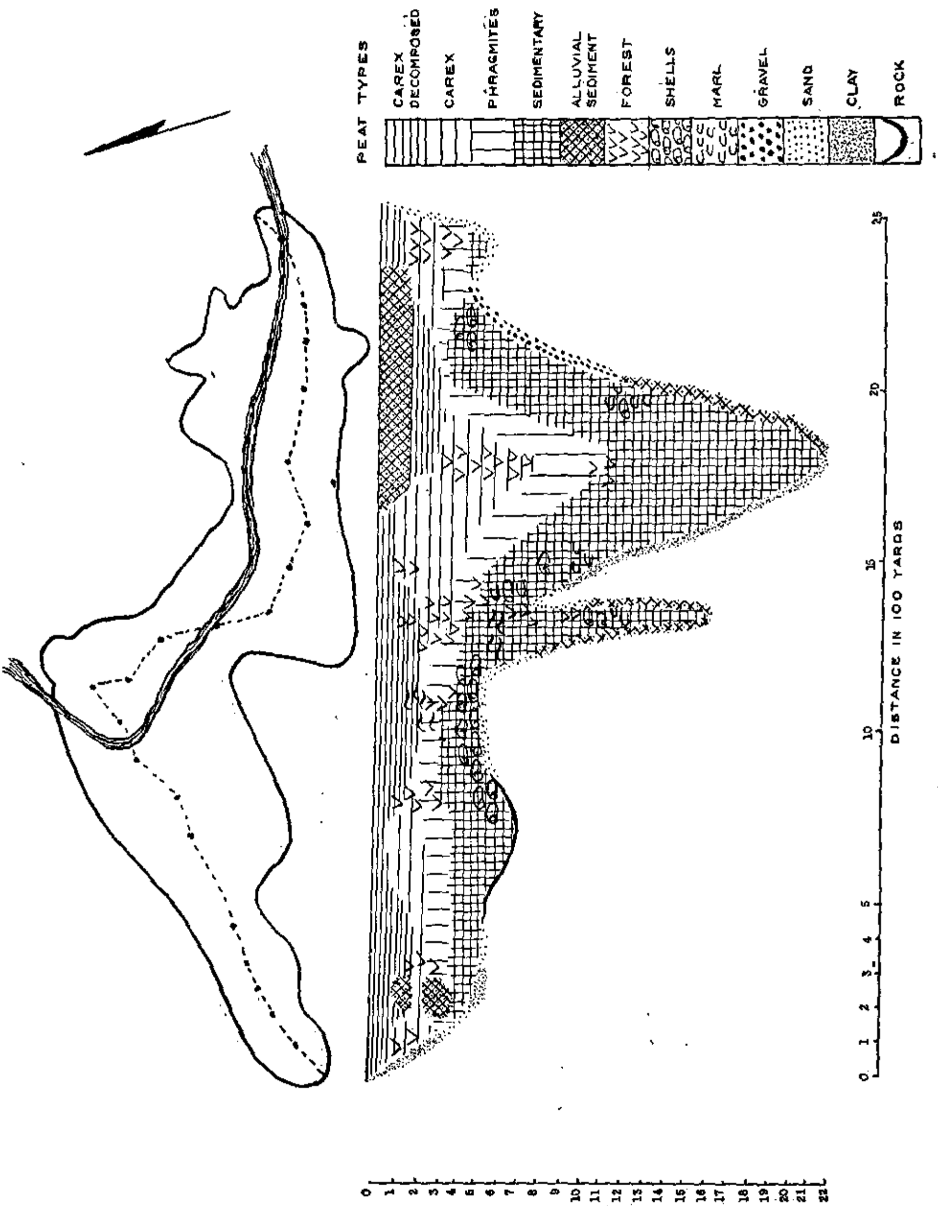


FIG. 19. Cross section of Wolf Pit bog.

the mountin lie several bogs. These are separated from one another by short distances and from Delaware River, near Montague, by the ridge which crosses the State line from the north near Port Jervis and parallels the river to Wallpack Bend.

The only bogs requiring discussion are situated in the narrow limestone valley that lies between Kittatinny Mountain and the aforementioned ridge, and at the headwaters of Mill Brook and a short unnamed stream that enters the Delaware at Millville, opposite Milford, Pa.

The history of the geological changes produced by the Wisconsin glacier along Little Flat Brook and in and around the divide between it and Mill Brook is of considerable interest and bears directly on the peat deposits of the region. It is well described by Salisbury:

At Hainesville the brook (Little Flat) meanders in a wide alluvial plain which in places is interrupted by swamps. The stream has here an elevation of about 620 feet. Above the alluvial plain rise low mounds and terraces of gravel, many of which have an elevation of less than 640 feet, though in places the sand and gravel extend up to about 670 feet. The best marked terraces are on the east side of the brook, near the Hainesville cemetery. About two and a half miles northeast of Hainesville, a . . . recessional moraine crosses the valley. This moraine, to be correlated with that near Montague . . . records a . . . halt in retreat of the ice, during which time the bulk of gravel . . . was deposited. Much of the way between Hainesville and the moraine above the brook flows through swamps, which appear to mark the former sites of stagnant ice-blocks. They are surrounded by stratified deposits, and their outlines are those of the buried ice-blocks and are extremely irregular. . . . North of the moraine is a large swamp, formerly a pond, in which were accumulated considerable beds of shell marl. At the southwest end of the swamp is a group of large kames, whose maximum elevation is over 660 feet. They are separated from the moraine area by a limestone hill nearly free from drift. . . . A wide kame terrace limits the swamp on the north. A mass of stratified drift, with kame topography, forms the divide between the swamp, drained by a stream flowing into the Delaware and the swamp in which the Clove Brook heads. Along much of its course, Clove Brook flows through a wide and somewhat swampy alluvial plain, above which there are more or less discontinuous kame terraces sixty to one hundred forty feet above the stream. They are best developed about the source of the brook and are continuous with the kame area described above.

It should be noted that Clove Brook is now known as "Mill Brook" and should not be confused with Clove River which heads on the east face of Kittatinny Mountain and empties eventually into the Wallkill. The bog in which Mill Brook heads need not be discussed at length, since, as is the case with all bogs in the flood plain of that stream, the deposit is chiefly alluvial.

One mile southwest, and on the opposite slope of the divide, is found a peat deposit of considerable interest. A short stream, previously referred to, rises in this 84-acre bog and flows directly into Delaware River. This bog contains peat of the sedge and reed type, underlain by calcareous marl, and it is typical of peat deposits found on limestone. Physical and chemical analyses are presented in table 14. The presence of alluvial material in the surface stratum

TABLE 14

Profile of bog situated on divide between Mill and Little Flat Brooks, with marl layers

Area 4, Field map 74.48–41.18

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, granulated, well-decomposed reed and sedge peat	82.6	17.3	3.76	4.7
1–2	Black, granulated, well-decomposed reed and sedge peat, with wood	81.4	14.4	....	6.0
2–7	Brown, fibrous and matted reed and sedge peat	89.3	10.4	....	6.2
7–8	Gray calcareous marl	81.5	58.5	....	7.6
8–9	Pinkish gray calcareous marl ..	....	....	....	...
9–13	Cream calcareous marl	68.5	83.3	....	7.9
13–15	Cream sedimentary peat and calcareous marl	78.2	61.8	1.14	7.8
15–21	Tan calcareous marl	68.8	83.9	....	7.8
21–24	Tan sedimentary peat and calcareous marl	71.7	65.7	....	7.7
24–26	Green liver peat	83.1	63.2	1.64	7.2
26–27	Sedimentary deposit	....	....	....	...

should be noted; also the immediate rise in pH in the presence of calcareous marl. Colloidal aquatic (liver) peat is found between the mineral layers and the calcareous marl. The bog is covered with a heavy stand of large deciduous trees which rise above deciduous shrubs, laurel and rhododendron, ferns, sedges, and sphagnum moss. A few conifers are also present.

A quarter of a mile northeast, and at the same elevation, lies another peat deposit in which calcareous marl is virtually absent. This 30-acre deposit is of the sedge and reed type, containing mostly aquatic peat of the noncolloidal type, although liver peats and calcareous marl occurring in narrow bands are found in a few places. Alluvial material has been deposited in the surface stratum. The general absence of calcareous marl is shown by low pH and low ash values in the sedimentary layers. A thick, matted stand of deciduous and coniferous trees and shrubs cover the bog, and heath bushes, ferns, and sphagnum moss are also found.

One and one-half miles from the above areas, at the southern end of the small divide and near the headwaters of Little Flat Brook, is found an interesting bog with a calcareous marl bottom. This bog embraces 94 acres and contains a considerable amount of alluvial material in the upper stratum.

Half a mile south of the outlet of the last-mentioned bog, Little Flat Brook enters a 34-acre bog containing peat very similar in type and with vegetation similar to that found on similar bogs in the vicinity. Large trees, mainly deciduous, but in part coniferous, tower above heath bushes and other shrubs; laurel and rhododendron are common, and ferns, reeds, sedges, and sphagnum moss are abundant.

At Wallpack, a dozen miles down the valley past the junction of Little Flat Brook with Flat Brook and considerably above Flat Brook Valley, there is a typical lowmoor bog with a calcareous marl bottom. Previously in cultivation, this was recently abandoned. It was formed as a result of the consolidation of gravel and sand deposits around an irregular block of ice. The gravel terraces along Flat Brook are well known, and the adjacent hills are in many instances covered by a considerable mantle of till. This bog represents a kettle situated in the drift of a limestone valley. The bog covers an area of some 15 acres.

Reference has already been made to Pequest River, which occupies one of the larger valleys of northern New Jersey. It has its source near Huntsburg in southwestern Sussex County where a fairly large bog, underlain by limestone, and extending to Springdale, 3 miles south of Newton, is drained by a small stream which takes a northeasterly course through it, then reverses and flows southwesterly. Pequest River is notable for the peat deposits along its flood plains, which culminate in Great Meadows, just north of the terminal moraine.

The glacial deposits of this region (which have a direct bearing on the occurrence of peat) are discussed at length by Salisbury:

A little more than a mile east of Hunt's Mills (Huntsburg) are extensive kame terraces, at the southwestern extremity of the swamp which stretches northeast to Springdale. These terraces, although continuous with those along Bear Creek,* are now drained by another tributary of the Pequest which flows to the northeast, but the glacial stream which deposited the drift probably flowed to the southwest. For much of the distance along the margin of this swamp, stratified deposits are wanting, but towards its northern end there are kame terraces about the same height as those near Hunt's Mills. From this point they extend northeastward to Newton. . . . Still nearer Newton, the gravel forms narrow terraces against the sides of the hills, and flat-topped winding ridges of about the same elevation. Inclosed by the terraces and ridges are irregular depressions and sinks. These sinks often have a linear arrangement, and are separated from one another by ridges of gravel, somewhat lower than the bordering terraces. In the southern part of Newton, the topography of the gravel deposits is kame-like, hillocks and kettles having a relief of twenty-five feet following each other in rapid succession, without apparent tendency to approach a common level.

* A tributary to the Pequest south of Johnsonburg, into which flow the waters of a notable bog which will be discussed later.

The Huntsburg-Springdale bog is representative of the sedge and reed type found in a limestone region. The fibrous sedge and reed strata contain woody material and are underlain by calcareous deposits. Part of the surface stratum contains alluvial deposits laid down by flood waters. Springs abound in the bog, adding greatly to the volume of the river, and in many places are so numerous that access is impossible, since even in the coldest weather the surface does not freeze. Large deciduous trees cover much of the bog, together with deciduous shrubs, rhododendron, ferns, and mosses. Reeds are abundant in the wetter areas and in some of the dry sections upland vegetation, such as blackberry vines, is found. Coniferous trees grow in places.

TABLE 15

Profile from southern part of Huntsburg-Springdale bog, near entrance of Pequest River

Area 3, Field map 74.50–40.58

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, granulated, well-decomposed reed and sedge peat	80.4	55.3	6.2
1–4	Dark brown, fibrous reed and sedge peat with wood and alluvial deposit	83.2	25.7	6.1
4–7	Dark brown, fibrous reed and sedge peat with wood	86.9	12.8	6.0
7–8	Brown sedimentary peat with wood	84.1	42.2	5.6
8–9	Brown sedimentary peat	81.7	46.9	5.9
9–10	Tan sedimentary peat and calcareous marl	....	....	...
10–14	Tan calcareous marl	57.7	86.4	8.2
14–15	Brown liver peat	....	....	...
15–16	Tan liver peat with shells	78.5	70.7	7.5
16–17	Tan calcareous marl	....	....	...
17–18	Gray sedimentary deposit	....	....	...

[1] Nitrogen content, 1.75 per cent.

Analytical results of a profile obtained from the southern part of the bog are presented in table 15. The abnormally high ash content of the upper 4-foot stratum is notable and is due to flooding by the stream which enters the bog from the south and deposits the bulk of its load there. This condition is similar to that shown for the Wallkill where the surface peat distant from the stream entering from the hills is of much better quality than that near it. An improvement in quality of peat is also found adjacent to the stream when sufficiently distant from the southern end of the bog.

Half a mile northeast of the north end of the Huntsburg-Springdale bog lies Muckshaw Pond. The outline of the pond and bog is remarkably irregular even for this limestone region, and is due, at least in part, to vertical limestone cliffs protruding into the bog. The depth of peat at the edge of the cliffs is extraordinary. In one boring for example, 4 feet of fibrous and matted sedge and reed peat was underlain by 14 feet of sedimentary peat and that in turn, to a depth in excess of 30 feet (for technical reasons bottom was not reached) was underlain by sedimentary peat containing many shells. Great depths of peat have been encountered directly adjacent to cliffs in other bogs in the limestone region.

The bog is covered largely with reeds and sedges, together with low-growing shrubs. Trees, mainly deciduous, are found on the shallow areas adjacent to the edges, or in the narrow coves. The

TABLE 16

Profile of bog draining into Pequest River south of Springdale

Area 1, Field map 74.48–40.58

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Dark brown well-decomposed reed and sedge peat with wood	83.4	13.7	6.4
1–8[1]	Dark brown fibrous reed and sedge peat ..	88.4	8.2	6.5
8–11	Dark brown, fine, fibrous, and matted reed and sedge peat	90.8	5.6	6.7
11–13	Dark brown fibrous reed and sedge peat ...	91.6	5.9	6.8
13–18	Pinkish tan calcareous marl	76.0	80.6	7.3
18–21	Tan calcareous marl	72.1	83.3	7.3
21–22	Olive-green liver peat	74.0	78.8	7.5
22–23	Gray sedimentary deposit	....	....	...

[1] Nitrogen content, on dry basis, 3.7 per cent.

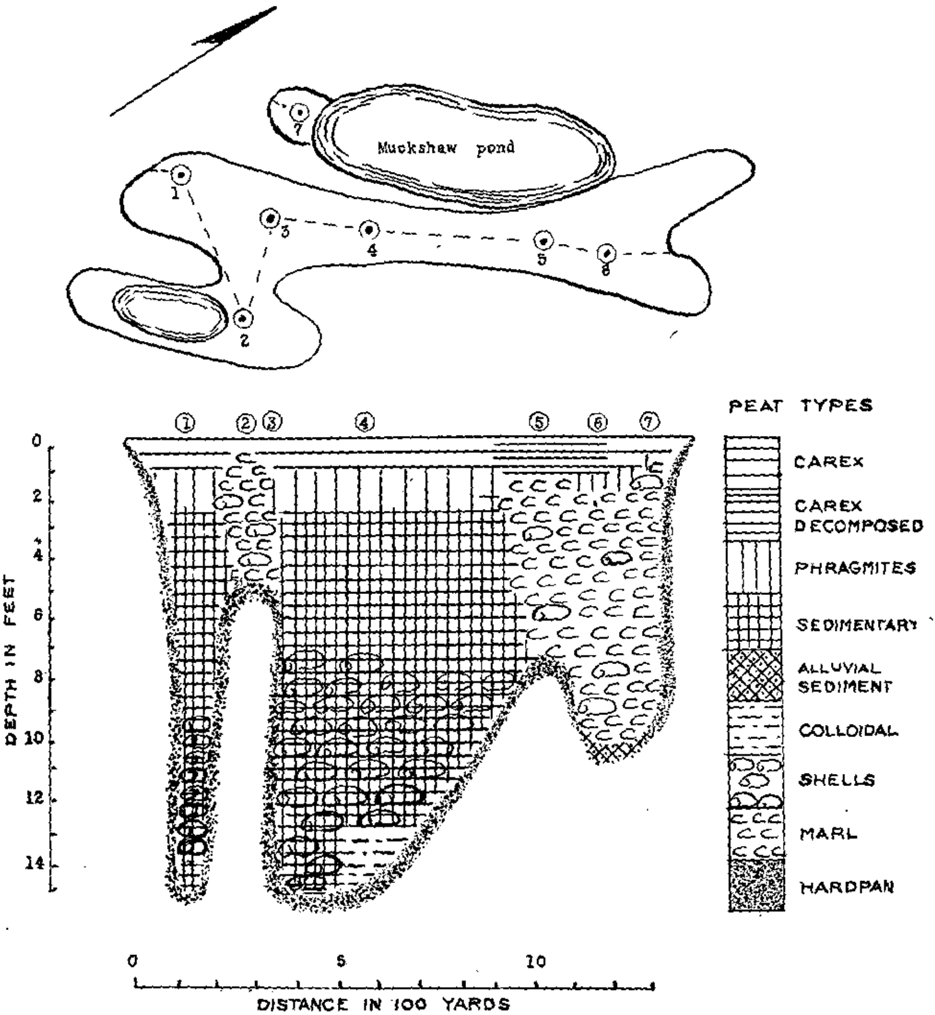


FIG. 20. Cross section of Muckshaw Pond bog.

bog and pond cover some 73 acres. Peat has been partly removed from the southeastern end of the bog with the resultant formation of an additional shallow pond. A cross-section of the bog is given in figure 20. The upper stratum of the profile contains large quantities of alluvial material in some locations, as shown by high ash values. In other parts of the bog, the sedge and reed peat is of better quality.

Half a mile east of the Huntsburg-Springdale bog, and separated from it by a limestone ridge, lies a bog noteworthy for the extreme irregularity of its shore line and for the coloring of the aquatic peats it contains. The bog is enclosed between precipitous limestone hills and, in turn, almost encloses another limestone hill. It drains in an easterly direction to Pequest River, through the stratified drift which formerly retained a glacial lake within the tortuous limestone valley. This bog has been largely cleared for pasture, the predominating vegetation consisting of grasses with some reeds. A few shrubs are found, as well as small coniferous and deciduous trees.

The profile analysis of this area is shown in table 16. The fibrous sedge and reed stratum is of good quality. Much of the calcareous marl in this location is remarkable for its pinkish color. In other areas, reddish-cream, gray, cream, brownish-pink, and pinkish-cream calcareous marl has been noted.

Bear Creek, draining Hunt's Pond, is joined south of Johnsonburg, Warren County, by a stream rising in a notable bog. This bog is under cultivation in the southern or outlet end. In its wild interior, there is a remarkable multiplicity of jagged, precipitous limestone islands and the bog has an extremely irregular shape. In some parts

TABLE 17

Profile of bog on tributary to Bear Creek

Area 1, Field map 74.56–40.56

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, crumbly, well-decomposed reed and sedge peat with wood	66.6	19.8	6.3
1–3	Dark brown, crumbly, well-decomposed reed and sedge peat with wood	81.6	15.0	6.4
3–5	Dark brown fibrous reed sedge peat with some wood	....	....	...
5–6	Dark brown fibrous reed and sedge peat with wood and moss	89.5	6.4	6.3
6–7	Brown reed and sedge peat with some wood and shells	....	....	...
7–11	Yellow liver peat with shells	66.6	61.5	7.8
11–14	Brown sedimentary peat with shells	84.3	60.8	5.2
14–18	Brown liver peat with shells	89.9	42.9	7.9
18–21	Brown liver peat with shells	75.3	87.2	6.1
21–22	Sedimentary deposit	....	....	...

[1] Nitrogen content, 3.30 per cent.

the peat is 20 feet deep, but in a horizontal distance of only a few yards the depth may decrease to only 2 feet. Thus the borings have shown that the cliffs of the islands and of some of the surrounding hills are continued under the surface of the bog. Large deciduous trees, together with some conifers, and shrubs, heath bushes, mosses and ferns are found in the uncultivated part of the bog. The comparatively high ash of the surface material may be due to decomposition and to stream flooding and deposition (table 17).

Beaver Brook is a tributary of the Pequest which it joins above Belvidere. Along its course lies Silver Lake, which offers an excellent example of a glacial kettle lake in the process of obliteration. Following its formation by the melting of stagnant ice in stratified drift and till, Silver Lake probably consisted of two ponds connected

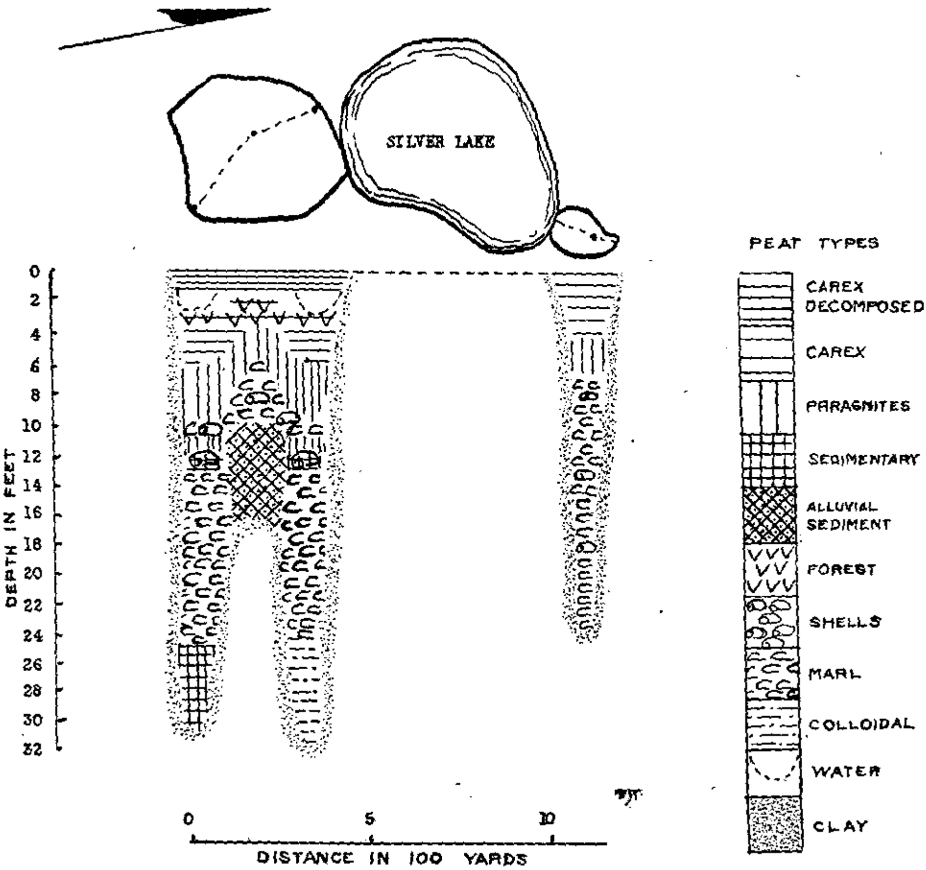


FIG. 21. Cross section of Silver Lake bogs.

by means of a deep, narrow waterway. Since then the smaller lake has been largely filled with peat and marl deposits and the larger lake has been reduced in size by the 17-acre bog at the northern extremity; the waterway connecting the two lakes has been reduced in depth to 6 feet, and in width to a fraction of its former size (figure 21); and only the flow of the stream between the lakes has kept a channel open. The bogs apparently overlie both limestone and shale.

The surface growth of the bogs of Silver Lake follows the lake margin pattern. At the lake edge reeds alone find favorable conditions. A short distance from the edge of the water, sedge tussocks appear, with low shrubs growing on the tussocks. Farther away, deciduous trees put in an appearance.

Pequest River crosses the terminal moraine at Danville. Extending north from this point for almost 4 miles along the course of the stream and for a mile on each side of it, are the famous Pequest Meadows. These meadows have been drained and are largely in cultivation. They consist, not of one great expanse of peatland, but rather of stretches of alluvium, such as Papakating silt loam, running into shallow deposits of true peat. Similar deposits occur in the main valley of the Pequest as far north as Quaker Church. Moraine islands, some of which may have rock cores, are found in the area.

Although the peat deposits of Pequest Meadows occupy a large part of the valley, and a much larger region would necessarily have to be included were the alluvial deposits to be considered, the peat is so remarkably similar in all portions of the meadow that samples from only one boring will be discussed (table 18). The peat is everywhere comparatively shallow, and nowhere is aquatic peat, unmasked by other sediments, present. This is evidence that the extinct Lake Pequest was in existence for a short time only. In most places the peat varies in depth from only a few inches to 3 feet, and rarely is the depth as great as in the profile under discussion. Over much of the area, the surface stratum is sandy, as shown by the high ash values. The quality of the peat beneath the cultivated upper stratum is considerably better.

The peat deposits, isolated from one another by silt loam and sand plains, are remarkably similar. Situated in a limestone valley and laid down in a large shallow lake of short duration, they are similar to deposits in other geological regions, such as in the Piedmont plain, as will be shown later. The particular spot in which the profile was taken is underlain by clay; this clay is no doubt in turn underlain by sand, since most of this area has a sand bottom.

TABLE 18

Typical profile of Pequest Meadows

Field map 74.56–40.52

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, granulated, well-decomposed reed and sedge peat and sand	51.4	59.6	1.42	5.1
1–2	Dark brown fibrous reed and sedge peat	77.3	27.0	2.42	4.6
2–3	Brown fibrous and matted reed and sedge peat	81.6	15.7	3.02	6.0
3–6	Light brown fibrous and matted reed and sedge peat	87.7	10.6	2.08	6.0
6–7	Light brown crumbly reed and sedge peat	87.9	17.1	2.45	6.4
7–8	Brown clay	50.3	89.7	0.32	7.6

All of Great Meadows was at one time under cultivation but some portions are now abandoned. Since drainage is excellent for much of the year, the vegetation that has encroached is largely upland in nature.

Three miles southwest of Danville, at the foot of Jenny Jump Mountain, lies Mountain Lake. Following the Wisconsin glaciation, there were two lakes separated by a narrow ridge only a few feet higher than the lakes. The more southerly lake is now entirely filled with calcareous marl and sedge and reed peat, whereas the upper lake is deep enough to be widely used for recreation. Prior to the Wisconsin glaciation, the limestone valley in which Mountain Lake occurs was probably an arm of the Pequest River valley. The terminal moraine, deposited across the mouth of the subvalley, provided the dam that blocked the valley drainage and formed the lakes. The ridge between the extinct lake and Mountain Lake is probably a kame formation.

The bog is thickly covered with exceptionally large deciduous trees; conifers, shrubs, heath bushes, ferns, mosses, and rhododendron are also present. In some places a calcareous stratum extends to only a foot beneath the surface. This is possibly due to the action of springs in raising the marl above the level at which it was first deposited. The lighter sedge peat may have been washed away, leaving the heavier calcareous deposit. Such a churning action of springs is known to take place. Some areas could not be surveyed for several days following heavy rains, since the whole mass of the bog became semifluid and the material could not be brought to the surface in the sampler. In bogs where calcareous marl is present the sedge and reed stratum may be very shallow or even absent. At least one bog is known in which the calcareous deposit is some 20 feet deep; the sedge layer, however, is in no place over 1 foot thick.

One of the most interesting collections of kettles and sinks in New Jersey is in the vicinity of Squire's Corner, two miles northeast of Blairstown. Here is found White Pond, with a depth of marl reputed to be approximately a hundred feet, and known definitely to be in excess of 27 feet in the narrow, comparatively shallow, and completely filled bays of the lake. This pond lies in the limestone valley of the Paulinskill at an elevation of 452 feet above tide level or some 50 feet above and 1 mile north of that stream. Only half a mile farther north, and also underlain by limestone but at the edge of the slate and sandstone foothills of Kittatinny Mountain, lies a bog which contains a true forest type of peat. The difference in elevation between these widely removed peat types is of no consequence, being only about 20 feet. It appears logical to attribute the differences in the types of deposit in these two areas to the waters feeding them.

TABLE 19

Profile of the White Pond bog

Area 2, Field map 74.56–41.00

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2[1]	Dark brown, well-decomposed reed and sedge peat and alluvial deposit	80.0	26.5	6.6
2–7	Brown fibrous reed and sedge peat	88.7	8.9	6.7
7–8	Brown reed and sedge peat and calcareous marl	82.3	42.4	6.7
18–27[2]	Tan calcareous marl	63.2	92.8	6.6

[1] Nitrogen content, 3.05 per cent.
[2] Bottom not reached.

The analysis of a sample profile of one of the bogs situated on the margins of White Pond is presented in table 19. The mineral bottom was not reached in this location, although the filled-in arm of the lake is barely 50 yards wide. Mud Pond may be an example of a flooded sinkhole due to solution of the limestone, although the filling of the depression with water to form the pond is, in part at least, due to kame damming. The lime contents of the deposits of this pond are probably not so great as those of White Pond, since sedimentary and liver peats are present. The mineral bottom was not reached at 27 feet, a considerable depth in view of the small size of the pond (some 400 yards long). It is probable that much underground and some surface water from the slate and sandstone region, immediately north, finds its way into the pond and bog. This pond is entirely surrounded by a narrow bog, with an extension on the southeastern extremity. It is a classic example of the "inclosed irregular depressions", of which Salisbury writes.

Two other bogs are found between the kames adjacent to the above bog. In neither case does calcareous marl occur. The outlet stream of the above marl bog flows through a shallow cut in the gravel and enters the kettle bog, which may be classified as a forest peat deposit. Not only is calcareous marl entirely lacking, but much of the peat is markedly woody in character. In one of the deeper parts of the bog 8 feet of forest peat were shown to cover a 9-foot stratum of highly matted sedge and reed peat containing much wood. This is underlain by a bottom stratum of green sedimentary or liver peat more than 11 feet thick, the mineral bottom not being reached in several instances. The waters feeding this bog were evidently deficient in lime, although originally they had a high content of that mineral. This bog occurs above limestone but is probably separated from it by glacial deposits.

The sizeable stream from this bog flows southeast for a short distance to a cleft in a large kame, where it disappears in the gravel.

TABLE 20

Profile of forest bog at Squire's Corners

Area 4, Field map 74.56–41.00

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–4[1]	Dark brown, lumpy, woody peat	85.4	9.0	5.2
4–8	Dark brown, lumpy, woody peat	89.2	7.2	5.7
8–15	Green sedimentary peat	90.3	13.1	5.7
15–18	Green sedimentary peat with wood	....	....	...
18–19	Gray sedimentary deposit	....	....	...

[1] Nitrogen content, 2.71 per cent.

It seems certain that, after flowing underground for a third of a mile, the stream reappears at the northern end of a deposit of forest peat. This area has been designated on the maps of the Soil Survey as containing silt loam. Although this is true as far as the southern extremity of the bog is concerned, the northern end at one place contains 18 feet of peat with an 8-foot layer of forest peat over 10 feet of sedimentary peat containing logs (table 20). The pH values in this bog are lower than those in the calcareous deposits in this vicinity. All members of this bog series have surface vegetation consisting of large deciduous trees, together with some conifers, shrubs, ferns, and mosses. In the wetter areas only reeds and sedges are found.

KITTATINNY MOUNTAIN BOGS

Kittatinny Mountain, as was previously pointed out, should be considered geographically as a high ridge of the Appalachian Valley. The peat deposits found thereon, although conforming in type with the bogs of the Highlands rather than of the valley, will therefore be discussed in conjunction with those of the valley. Alluvial deposits are of common occurrence on Kittatinny Mountain, but where true peat is found it is universally of the forest type, without any calcareous marl substrata. The present vegetation of the bogs consists principally of coniferous trees, such as spruce, cedar, hemlock, and pine, rather than deciduous trees; laurel and rhododendron are very common, as are ferns on some bogs.

Cedar Swamp (figure 22), situated less than a mile northeast of Lake Marcia and within a few hundred yards of the New Jersey-New York boundary line, is the northernmost bog in New Jersey, and is elevated some 1500 feet above tide—an elevation as great as that of any bog in the State. The bog drains down the mountain into New York State, the water eventually finding its way into the Wallkill. Glacial till and stratified drift are found on this part of Kittatinny Mountain, which is approximately 1½ miles wide between the steep eastern and western slopes. Cedar Swamp lies in a ravine at the head of a steep slope to the north, and it appears certain that glacial till blocked the ravine, resulting in the formation of a 30-acre lake. The presence of a certain amount of stratified drift is indicated by the sand found beneath a part of the bog (table 21).

The bog vegetation is typically that of a northern mountain cedar bog; cedars, rhododendron, and laurel form a tangled mass, together with ferns, heath bushes and certain deciduous trees. Reeds and

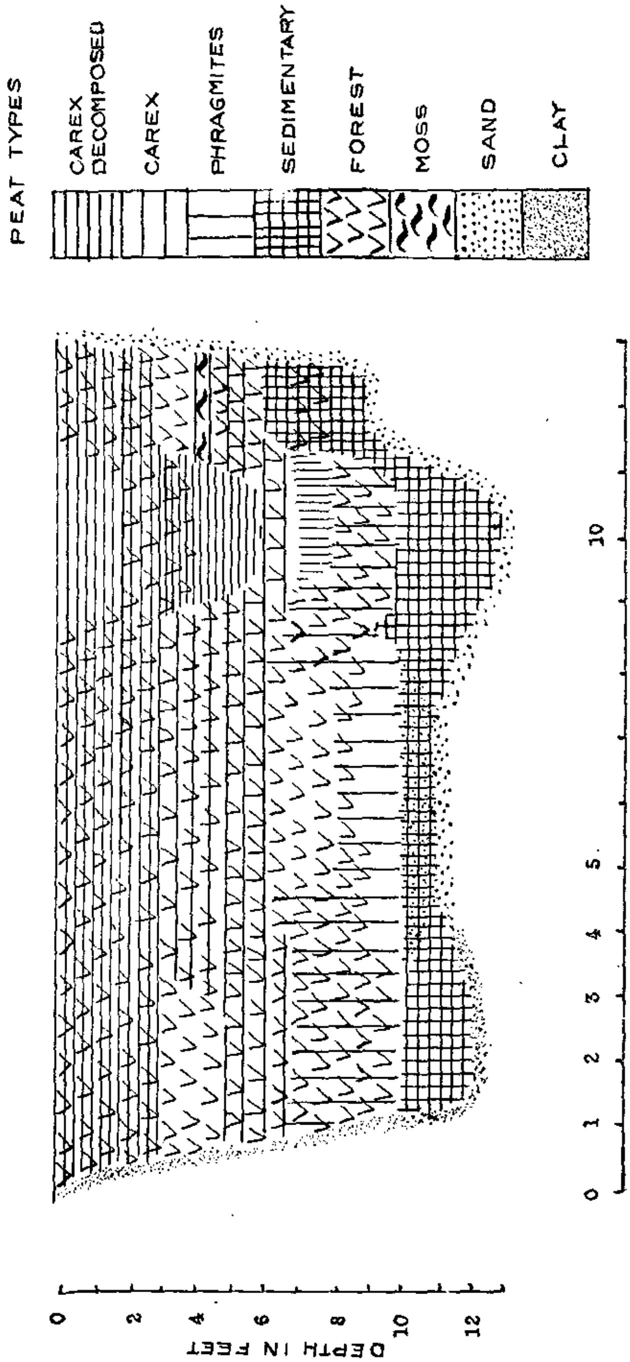


FIG. 22. Cross section of "Cedar Swamp", Kittatinny Mountain.

TABLE 21

Profile of Cedar Swamp on Kittatinny Mountain

Area 6, Field map 74.40–41.18

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–4[1]	Brown, well-decomposed forest peat	81.0	5.7	4.2
4–7	Brown forest and reed and sedge peat	90.8	2.3	5.5
7–9	Brown forest peat	90.7	2.3	6.1
9–10	Brown reed and sedge peat	90.3	31.4	6.2
10–11	Green sedimentary peat and sand	....	....	...
11–12	Gray sand	....	....	...

[1] Nitrogen content, 1.65 per cent.

sedges are not abundant. The growth is almost impenetrable in certain sections.

This bog contains a typical forest peat which is characterized by low ash values below the surface stratum and by a low nitrogen content: namely, 1.65 per cent. The pH values vary from 4.2 to 6.2. It should be noted here that the forest peats of northern New Jersey do not normally attain the low pH values of similar bogs in the southern part of the State.

Three miles southwest of Cedar Swamp, at an elevation of some 1160 feet above tide, are three bogs. The most northerly is covered with a thick growth of deciduous shrubs and trees. Some conifers are present, reeds and sedges are prevalent in certain sections, and sphagnum moss covers much of the bog. The surrounding hillsides are extremely stony. Parts of the bog, however, are underlain with clay and sand, and water-deposited materials may have played a role in the formation of a lake in times past. The bog contains considerable alluvial material and represents a combination of forest and alluvial types. In some sections of the bog, particularly in proximity to the stream, true peat is probably absent, the deposit consisting largely of mineral alluvium. The outlet stream from this bog flows into a companion bog to the south, the second of this series, before emerging on the western slope of the mountain. The second bog is similar in every respect to the first. The third bog lies 300 yards to the southeast, and is a typical kettle, for the most part filled with forest peat. The outlet stream of this bog forms one of the sources of Big Flat Brook. It appears probable that these three bogs were formed in kettles resulting from the melting of stagnant ice. Very possibly they lie in the Montague-Libertyville recessional moraine.

Two miles southwest, at an elevation of 1195 feet is Pine Swamp, one of the most interesting bogs in New Jersey. This bog, a mile and a quarter long, was formed as a result of the deposition of glacial drift across a mountain valley. If Pine Swamp and possibly the three more northern bogs previously discussed were not formed by morainic deposition, they unquestionably owe their origins to the mantle of drift left by the glaciers. Pine Swamp is thickly covered with pines, cedars, laurel, and rhododendron. Reeds and sedges are prevalent about the shores of "Lost Pond", a body of water within Pine Swamp, small at the surface, but enlarging with depth—which is relatively great—to make a huge bottle of water, the neck contracted by the floating surface growth of sphagnum moss, reeds, sedges, and low shrubs. Sphagnum moss grows profusely in the bog, as does the cinnamon fern. Pine Swamp has a maximum width of 600 yards. Figure 23, a section through "Lost Pond", shows two great bottles of water under the surface. The bog in the vicinity of the surface pond is highly dangerous and the floating mat of vegetation offers extremely insecure footing.

TABLE 22

Profile of Pine Swamp, Kittatinny Mountain

Area 5, Field map 74.44–41.16

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–5	Brown, granulated, well-decomposed reed, sedge, and forest peat	84.6	5.1	1.83	4.6
5–10	Brown, fibrous, and matted reed, sedge, and forest peat	93.4	5.6	....	5.0
10–11	Gray-brown sedimentary peat with reeds and sedges	....	....	....	...
11–20	Olive-green sedimentary peat	91.6	23.6	3.45	5.4
20–21	Gray clay	....	....	....	...

The peats (table 22) found in Pine Swamp are typical of the forest bogs of mountainous northern New Jersey. The top foot consists of forest material admixed with remnants of reeds and sedges. The ash and nitrogen values are comparatively low. The underlying stratum to the eleventh foot consists of sedge and reed peat with

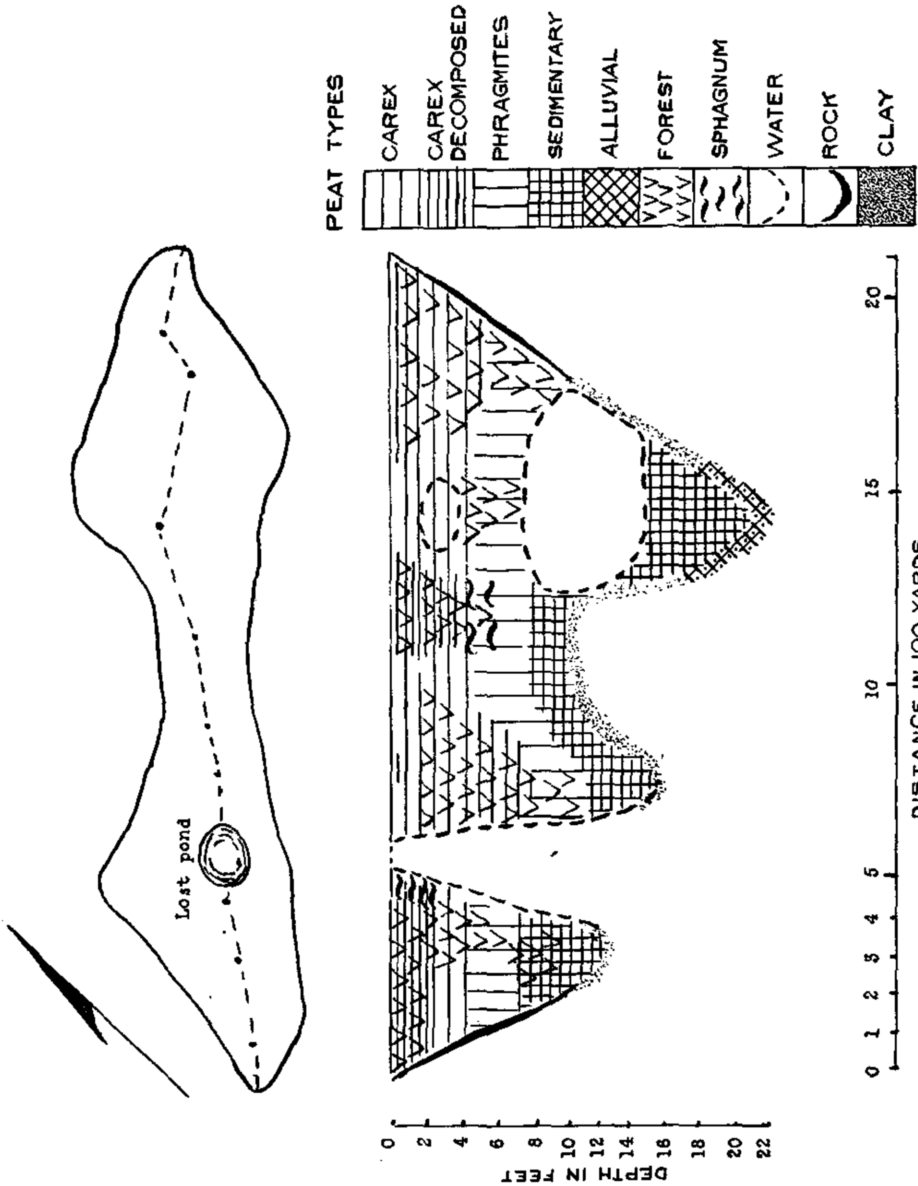


FIG. 23. Cross section of Pine Swamp, Kittatinny Mountain.

much woody material, and is generally very fibrous. Here again, the organic content is very high. Below this stratum is found sedimentary peat, considerably higher in ash and nitrogen. The pH values vary from 4.2 to 5.6, the sedimentary layers having the lower acidity.

Less than a mile southeast of Pine Swamp, which is an example of a large lake now almost entirely filled by vegetation, lies a lake of similar origin which has been filled only to a rather limited extent. This body of water is Mashipacong Pond. The peat deposit at the northern end is of the same general type: namely, a floating, largely living mat with free water underneath. The bog occurs in a former cove, which is markedly constricted at the entrance to the main body of water. The vegetation is almost an exact duplicate of that occurring on Pine Swamp in the vicinity of Lost Pond. On firmer ground near the shore, coniferous and deciduous trees rise above laurel and rhododendron; but as the water's edge is approached, the trees and shrubs become smaller and less numerous, and the floating mat is composed of reeds, sedges, sphagnum moss, and scattered shrubs, with an occasional stunted tree. The surface stratum contains a considerable amount of alluvial material, since the ash value is nearly 19 per cent. The nitrogen content is 2.54 per cent at the surface and falls to 1.92 per cent in the seventh foot. This lower stratum has an ash value of only 5.4 per cent. The pH varies between 5.3 and 5.7. The peat is of the forest type, but has an admixture of reeds and sedges, as well as some alluvial material.

Kittatinny Mountain loses its plateau-like character south of Culvers Gap, 7 miles south of Mashipacong Pond. Between Culvers Gap and the New Jersey-New York State boundary, the plateau is bounded by narrow, rugged, and precipitous ridges between which are found many small bogs containing peat of good quality. Other bogs occur on the plateau proper, but south of Pine Swamp, none is of particular importance until Culvers Gap is passed.

Southwest of Culvers Gap, the precipitous, ridge-like part of Kittatinny Mountain widens, and at Quick Pond it is over a mile in breadth. This ridge constitutes the western face of a plateau-like shale region,* which extends southwest to Delaware River and contains such lakes as Culvers, Owassa, and Fairview, as well as several important peat deposits. One of the most interesting of these, and probably the most important, is the bog called Bear Swamp, the northern extremity of which has not yet been filled with peat and which constitutes Lake Owassa, extensively used as a resort lake. Bear Swamp is about 860 feet above tide. Its waters drain partly through Lake Owassa into the western end of Culvers Lake, and partly through the opposite end of the bog and into the outlet stream from Culvers Lake at Mt. Pisgah, and thence to the Paulinskill at Augusta.

* This region may be considered as the foothill of Kittatinny Mountain, and the bogs will be treated with those on the mountain proper.

The Balesville moraine, as well as isolated deposits of stratified drift and unassorted till, are probably responsible for the formation of the lakes and bogs in this vicinity.

Culvers Lake has a shallow alluvial-forest type of deposit at the northeastern extremity and an extremely deep forest type of peat deposit at the southwestern end. Kittatinny Lake, just west of Culvers Gap, which was previously a forest-type peat bog, was artificially converted into a lake. Lake Owassa and Bear Swamp are situated just south of the moraine. Two other forest peat deposits are found west of Lake Owassa and a series of contiguous bogs occupy the narrow ravine between that lake and Culvers Lake. Quick Pond is almost 50 per cent filled with forest peat. The long bog system east of Round Pond (at present called Harding Lake) adjoins the escarpment of Kittatinny Mountain and receives its drainage waters. Many other unnamed bogs and wet alluvial meadows also occur in this region.

Bear Swamp is over 2 miles long and has a maximum width of more than three-quarters of a mile. It is very heavily forested and contains both deciduous and coniferous trees, as well as a tangled growth of rhododendron. Ferns are abundant and sphagnum moss grows everywhere.

Pools of methane gas, some of which cover many acres, occur under the surface of the bog. In places the gas is retained under sufficient pressure to blow the water from the hole left by the sampling instrument fully 6 feet into the air after the sampler is removed. The upper limit of these pockets is usually 5 to 10 feet below the surface of the bog and the gas is retained by the fibrous layer of forest peat which occurs throughout the bog.

TABLE 23

Bear Swamp (Lake Owassa) profile

Area 6, Field map 74.50–41.06

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, well-decomposed forest and reed and sedge peat and alluvial deposit	78.9	16.6	4.8
1–2	Black fibrous forest peat with reeds and sedges	....	....	...
2–8	Brown forest peat with reeds and sedges..	90.2	8.9	5.3
8–11	Olive-green sedimentary peat	88.9	40.2	4.2
11–12	Sedimentary deposit and blue gravel	49.7	90.0	3.4

[1] Nitrogen content, 2.57 per cent.

Bear Swamp is in all respects typical of the mountain forest peats. The present vegetation is that normally found on acidic peat deposits. The peat itself is largely of the forest type, mixed with sedge and reed, and underlain by sedimentary peat. Table 23 shows the analysis of a profile taken in the southern part of the bog. The pH values vary from 3.4 to 5.3. The ash content is low over much of the area, although in the southern end alluvial deposits are present in the surface stratum.

One and a half miles west of the southern end of Bear Swamp is found the northern tip of a series of bogs and meadows which lie at the foot of the Kittatinny escarpment and extend southwest for some 5 miles. Two streams flow from this series of bogs: Trout Brook, which empties into the Paulinskill in the vicinity of Middleville, and an unnamed stream which empties into the northern extremity of Swartswood Lake. Much of the lowlands do not contain peat, but some interesting deposits are found in the long valley. It is highly probable that these peat bogs were formed in temporary lakes brought into being by glacial deposition across the narrow valley in the vicinity of Wintermutes Foundry and southeast of Mud Pond. Kames, some of considerable magnitude, occur in the vicinity. The stream emptying

TABLE 24

Composition of peat in bog near Quick Pond

Area 1, Field map 74.52–41.06

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, well-decomposed reed and sedge peat	81.6	10.9	4.6
1–2	Dark brown, fine fibrous and matted reed and sedge peat	87.0	7.7	5.0
2–3	Black sedge peat, fibrous and matted	86.6	8.7	4.9
3–4	Dark brown reed and sedge peat	88.3	16.1	5.8
4–5	Black reed and sedge peat	....	....	...
5–8	Dark brown, fine fibrous and matted reed and sedge peat	88.5	13.6	5.5
8–11	Brown reed, sedge, and sedimentary peat	88.4	23.2	5.7
11–15	Olive-green sedimentary peat	85.0	47.3	5.5
15–16	Sedimentary deposit	75.3	77.6	4.7

[1] Nitrogen content, 2.80 per cent.

into Swartswood Lake has its source in the peat deposit filling the northernmost bog of the series. The surface growth of this bog consists of a thick stand of deciduous trees and shrubs, with ferns, mosses, reeds and sedges. The peat is of good quality and, surprisingly, contains few woody remnants. The pH values are higher than those of Bear Swamp, ranging from 4.6 to 5.8. Alluvial material has been deposited in some of the strata, indicating periods of high precipitation (table 24).

On a somewhat higher level, some 500 yards from the southern extremity of the bog just discussed, lies Mud Pond, a kettle lake now approximately three-fourths filled. The stream flowing from Mud Pond enters the stream flowing into Swartswood Lake a short distance south of the bog previously discussed. The plant life covering this bog is of interest. Deciduous trees are found at the southwestern end, together with shrubs and reeds and sedges, but the predominating plant cover consists of the cinnamon fern, which forms almost a pure

TABLE 25

Mud Pond bog

Area 1, Field map 74.54–41.06

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, granulated, well-decomposed reed and sedge peat	82.2	9.9	5.4
1–2	Dark brown, fine fibrous and matted reed and sedge peat	89.5	6.5	5.4
2–4	Water pocket	....	....	...
4–6	Dark brown, fine fibrous and matted reed and sedge peat	89.6	3.6	5.4
6–7	Dark brown, fibrous and matted sedge peat containing wood	89.0	4.2	5.3
7–11	Dark brown, fine fibrous matted reed and sedge peat	89.2	3.9	5.3
11–12	Dark brown reed and sedge peat containing much wood	89.9	3.0	5.5
12–16	Dark brown, fibrous, matted reed and sedge peat	91.0	4.0	5.5
16–23	Green sedimentary peat	88.1	48.0	5.3
23–24	Sedimentary deposit	....	....	...

[1] Nitrogen content, 2.54 per cent.

stand over much of the bog. The roots of the fern have been cut and removed for many years from this as well as other bogs of the region, this cutting appearing to aid in the development of the aerial part of the plant. The fibrous root masses are the "peat" of the orchid grower although it does not in any sense constitute a true peat.

The analyses of peat samples from Mud Pond are given in table 25. Since the nonaquatic stratum is composed primarily of remnants of sedges and reeds with smaller amounts of woody material than is usual for a mountain bog in New Jersey, and the ash values are lower than usual, the peat must be considered as of unusually good quality. The nitrogen content was found in some cases to be as high as 3.91 per cent of the dry matter. It is interesting to note that the remains of ferns are not found in large quantity in the peat deposit. It is obvious that the ferns represent a recent growth and did not predominate at the time the peat was formed.

One and two-fifths miles southwest of the northernmost bog of this series lies the bog that is the main source of Trout Brook. Much of this 65-acre bog is covered with a pure stand of cinnamon fern,

TABLE 26

Trout Brook bog

Area 2, Field map 74.54–41.06

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, well-decomposed reed and sedge peat and alluvial deposit	85.3	17.4	3.29	5.2
1–6	Dark brown, fine fibrous and matted reed and sedge peat ...	90.6	8.9	....	5.1
6–7	Dark brown, fine fibrous and matted reed and sedge peat containing wood	89.9	3.8	....	5.3
7–14	Dark brown forest peat containing reeds and sedges	83.3	10.3	2.29	5.5
14–15	Dark brown reed, sedge, and sedimentary peat containing wood	87.6	30.1	....	5.4
15–16	Green sedimentary peat containing wood	85.6	39.8	....	5.2
16–24	Green sedimentary peat	89.9	41.7	....	4.9
24–25	Sedimentary deposit	86.6	43.4	1.77	4.2

cutting of which has been systematic and prolonged. On that part of the bog which has not been cut for "orchid peat", large deciduous trees and shrubs, as well as rhododendron, heath bushes, reeds, sedges, and mosses grow on the surface. The profile is given in table 26. Although most of the peat is of excellent quality, the surface stratum contains considerable alluvial material deposited by the stream in flood. Considerable quantities of wood are found in the bog, but the pH values do not reach limits as low as do some of the mountain deposits. The sedge and reed stratum contains 3.29 per cent nitrogen, whereas the forest stratum contains only 2.29 per cent, although the ash values vary in an inverse ratio.

From the southern extremity of Stokes Forest, 3½ miles northeast of Round Pond (Harding Lake), to Delaware River at the Water Gap, both the eastern and western escarpments of Kittatinny Mountain are steep and access to the mountain top from either side is difficult. In fact, large parts of the mountain can be reached only with extreme difficulty. In the entire 20-mile section of mountain only two roads cross it: those between Fairview Lake and Flatbrookville, and between Franklin Grove and Millbrook. The mountain nowhere exceeds 2 miles in width, but many streams rise in the subvalleys between the crests, and in many cases the headwaters of these streams flow from bogs, some of which contain peat with some alluvium. Most of these deposits fail to appear on the map of the Soil Survey and are located with difficulty. However, none of the bogs so far investigated is large and only one typical bog need be discussed at this time. This is a deposit of forest peat situated near the Franklin Grove-Millbrook road which embraces some 22 acres and is covered with mountain bog vegetation. Laurel and rhododendron grow in rank profusion beneath coniferous and deciduous trees, and ferns and mosses are abundant. Much of the bog is underlain by springs and is dangerous. The peat is of excellent quality, the pH values and nitrogen falling within the normal limits of northern forest peats.

PEAT DEPOSITS OF THE HIGHLANDS

The Central Highland Plateau is flanked on the western side by the following discontinuous mountain masses: (a) Pochuck Mountain, completely isolated by the Wallkill and Vernon Valleys; (b) the Pimple Hills, paralleling Wallkill Valley west of Sparta; and (c) Jenny Jump Mountain, which lies west of Great Meadows. These mountains are comparatively small and the bogs between them and the main mountain mass are unimportant.

PEAT DEPOSITS OF POCHUCK MOUNTAIN

The only bogs on Pochuck Mountain which require comment consist of a series of four glacial kettles which occupy different levels of a steep, narrow ravine approximately 2 miles northeast of Hamburg. The stream flowing through the three southernmost bogs enters the Wallkill at Hamburg, draining the ravine to the southwest. The northernmost bog drains into Pochuck Creek, flowing to the northeast. The glacial drift deposited between the two northern bogs constitutes a low divide.

The bog of lowest elevation consists at the surface of a black, granulated and crumbly, well-decomposed sedge and reed peat containing considerable clay. Beneath this is a dark brown and fibrous sedge and reed layer, some 2 feet deep, also containing some clay. This is underlain by a 2-foot reddish-brown stratum consisting of forest peat with an admixture of reeds and sedges. Sedimentary peat, either green or greenish-brown, fills the basin to a depth of about 9 or 10 feet. This bog is cleared and is utilized as pasture.

The next two bogs to the north contain the same peat types, with a maximum observed depth of 12 feet. These bogs are covered with a moderately thick growth of deciduous trees and shrubs, together with ferns, reeds, sedges, and mosses. Only part of the most northerly bog contains peat and this is only 2 feet deep.

PEAT DEPOSITS OF THE PIMPLE HILLS

Many of the wet meadows and bogs in the Pimple Hills consist of alluvial deposits containing little organic matter. This is probably due to the steep slopes surrounding the depressions, with consequent rapid run-off. In bogs that contain peat, the mineral content is usually high.

A representative bog occurs at an elevation of more than 800 feet. Curiously enough, the aquatic deposits in one part of the bog contain calcareous marl, although the bog is some 300 feet above the adjacent Wallkill Valley. This bog had previously been cleared but has been allowed to run wild. The surface growth consists of sedges, deciduous shrubs, trees, and upland vegetation. Aquatic peat is lacking in certain profiles, although it occurs in some parts of the bog and consists of sedimentary peat with wood or moss, or both. The peat contains much alluvial material.

PEAT DEPOSITS OF JENNY JUMP MOUNTAIN

The peat deposits of Jenny Jump Mountain are comparatively few in number and are limited in extent. These deposits range in character from alluvial sediments to peat of fair quality, although in most instances a considerable quantity of alluvium is present. Several of the bogs on this narrow ridge are not shown on the maps of the Soil Survey, probably because of their limited extent. A few were surveyed and sampled, but most were not included because of their small size and lack of time.

TABLE 27

A characteristic profile of a bog on Jenny Jump Mountain

Area 2, Field map 75.00–40.52

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, granulated, well-decomposed reed and sedge peat, with alluvial material ..	79.4	47.2	6.0
1–3	Brown, fibrous and matted reed and sedge peat, containing some wood	87.3	9.6	3.8
3–5	Brown, fine fibrous and matted reed and sedge peat	89.3	12.2	4.5
5–10	Brown sedimentary peat with wood	79.1	54.0	5.6
10–12	Olive-green sedimentary peat	79.1	58.4	7.2
12–13	Gray clay	....	....	...

[1] Nitrogen content, 3.37 per cent.

A representative bog (figure 24, table 27), 17 acres in extent, is found on the eastern slope of the mountain at an elevation of approximately 600 feet, or 200 feet higher than Mountain Lake, which lies to the south. Part of the bog has been cleared, ditched, and is under cultivation. The surface vegetation of the wild part consists of deciduous shrubs and trees, reeds, and sedges. The surface stratum contains much alluvium but the quality of the sedge and reed peat improves markedly with depth. The pH values vary greatly, ranging from distinctly acid to neutral. Calcareous marl was absent in part of the bog, as would be expected because of its location, but elsewhere shells were found in conjunction with sedimentary peat.

PEAT DEPOSITS OF THE CENTRAL HIGHLAND PLATEAU

As was previously mentioned, the Central Highland Plateau consists of a high, ridged tableland, containing some of the largest and potentially most valuable peat deposits in the northern part of

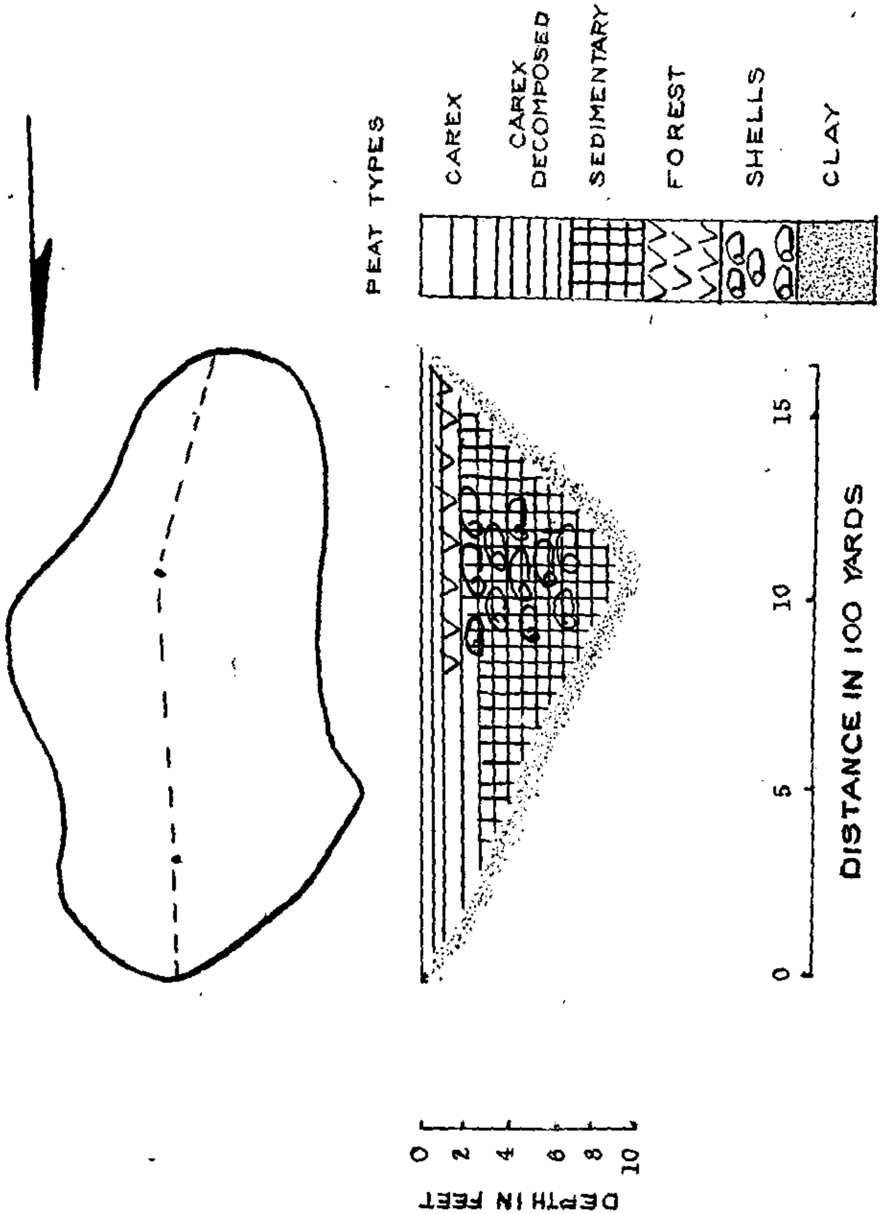


FIG. 24. Cross section of bog on Jenny Jump Mountain.

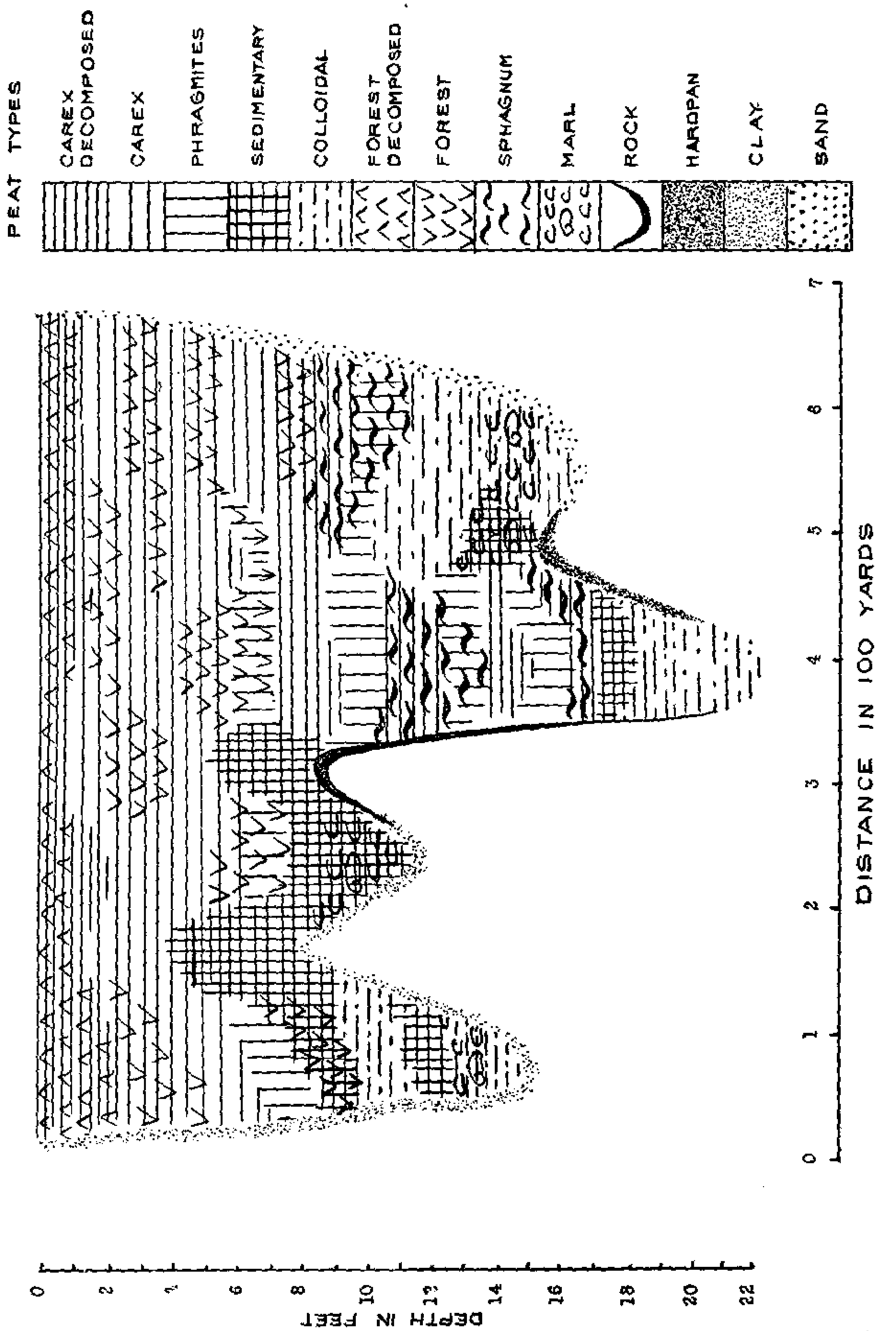


FIG. 25. Cross section of combined forest and sedge and reed bog on Wawayanda Mountain.

the State. Various mountain ranges form the eastern and western escarpments, the crests often rising above the level of the interior.

PEAT DEPOSITS OF WAWAYANDA MOUNTAIN

There are many small glacial kettles between the ridges of Wawayanda Mountain. None of the bogs are large, but they may be over 20 feet deep and the region is of particular interest because of the peat types found in these. The glacial till on the mountain is probably nowhere very thick, but sufficient material was deposited to account for the numerous bogs that were formed. The geology has been described in detail by Salisbury.

The highest point of land in the New Jersey Highlands is found on Wawayanda Mountain half a mile west of the southern extremity of Highland Lake, which, previous to the installation of a dam, formed a peat deposit 1¾ miles long. Half a mile north and only 240 feet below the summit is a typical kettle which contains some calcareous marl. Seven other kettles are found in a rough circle around the summit. Many of these kettles contain shells or calcareous marl or both. In one instance, where marl is absent, the pH range of the peat lies between 3.9 and 4.8. In two other cases where marl is absent, the pH values range from 5.2 to 6.1. Marl is present in the remaining bogs, with pH values of 5.5 to 7.5. In all but the one

TABLE 28

A characteristic profile of a bog on Wawayanda Mountain

Area 2, Field map 74.30–41.08

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, well-decomposed reed, sedge, and forest peat	91.5	10.8	6.3
1–3	Dark brown, well-decomposed reed, sedge, and forest peat	86.6	9.6	5.7
3–9	Brown fibrous and matted reed and sedge peat with wood	90.8	62.3	6.3
9–10	Gray-brown sedimentary peat	91.5	20.7	6.5
10–12	Greenish sedimentary peat with shells	83.8	61.5	7.0
12–14	Greenish liver peat with shells	....	....	...
14–15	Gray clay	....	....	...

[1] Nitrogen content, 2.62 per cent.

acid bog, the pH averages are closer to neutrality than could be anticipated for the reason inasmuch as limestone strata do not occur here. The presence of marl in the majority of the bogs may be explained, however, by the abundant limestone boulders in the glacial till. In the vicinity of Lake Wanda, where till has been exposed in road construction, many cobbles partly covered with hard lime are present. This was leached from higher strata and redeposited.

The southern extremity of the bog situated due north of Wawayanda summit (figure 25, table 28) is covered with reeds and sedges. Farther north these are dominated by deciduous shrubs and trees. As shown by the illustration, calcareous marl does not occur throughout the bog and the nonaquatic deposits contain much woody material and, in some strata, even moss. A noncalcareous deposit occurs half a mile north of this kettle. In this the peat layers, exclusive of the calcareous marl and associated colloidal peats, are similar to the one just described. The pH range is narrow, the limits being 5.7 and 7.0. The bog is covered for the most part with deciduous shrubs and trees.

A meadow one and a quarter miles long is situated east of Wawayanda summit and its long axis extends from northeast to southwest. This meadow is wet over most of its length, peat being found only in two kettles, one at each end of the depression. A few shells were found in the aquatic deposits in the northern bog, but for the most part calcareous marl is absent. The pH values of the material in this deposit range between the narrow limits of 6.0 and 6.2, and the vegetation consists principally of deciduous shrubs.

The shallow bog at the southern end of the meadow has a considerable amount of calcareous marl (figure 26) and is connected by a stream with the more northerly bog. The vegetation consists principally of deciduous shrubs and trees and the peat is of poor quality, being identical with that observed in alluvial deposits in the Great Valley. The pH values range from 6.5 to 7.5.

In an exceptionally acid bog situated on the divide between Canistear Reservoir and Highland Lake, the peat layers are similar to other noncalcareous deposits, the ash content of the upper stratum being 5.9 per cent. Moss is present in some layers. It is similar in type to the bogs east and west of this narrow valley.

Three other bogs in this locality are similar to those previously discussed. Shells are encountered in two and are absent in one; the pH values range between 5.2 and 6.1; and the greatest depth exceeds 22 feet. Moss is found in some of the lower layers.

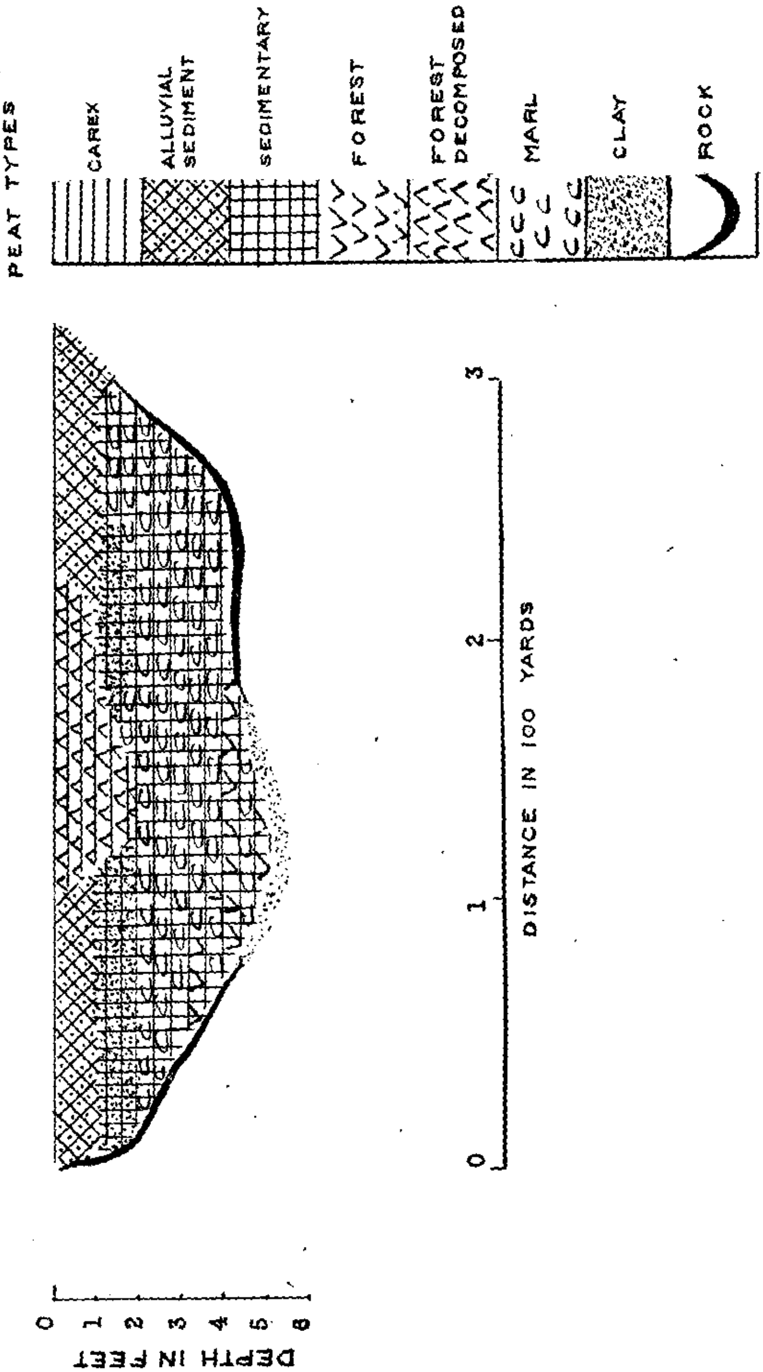


FIG. 26. Cross section of Wawayanda Mountain alluvial bog.

Several small peat deposits are found in the discontinuous valley extending from Stockholm to Vernon and separating Hamburg and Wawayanda Mountains, but they are of no particular interest or importance. It is sufficient to point out that whereas wet meadows fill much of the southern part of the valley (the part draining toward the north being too precipitous to retain water), peat is rare and occurs chiefly in the deeper depressions.

PEAT DEPOSITS IN THE STOCKHOLM-NEW MILFORD VALLEY

East of Wawayanda Mountain there is another discontinuous valley, the Stockholm-New Milford. In this valley 2 miles north of Stockholm is the Canistear Reservoir, and 2 miles farther north the present Highland Lake. Northeast from Highland Lake is a whole series of wet meadows, some of which, like that of Wanda Lake, have been dammed and converted into lakes. The remaining boggy land either contains peat of low quality or consists only of mineral soil.

One deposit of peat is found west of Wawayanda Lake and drains into its northern extremity. The depression consists of a double hollow, the two parts being separated by an outcrop of rock. A small alluvial plain slopes down to and covers part of the smaller bog. The surface of the latter, except for the area occupied by a small pond, is thickly covered by deciduous forest; the larger bog is likewise forest-covered. Some of the alluvium covering part of the small bog has been transported by the connecting stream to the larger bog.

The other bogs of the vicinity contain peat of similar nature. In one instance shells were found in the sedimentary strata with a consequent rise in pH value to 7.8, but for the most part calcareous marl is absent.

PEAT DEPOSITS ON HAMBURG MOUNTAIN

Many glacial kettles and two peat bogs, one three-quarters and the other a mile and a quarter in length, are found on Hamburg Mountain. In some localities, such as northwest of Mud Pond, glacial deposition is marked and kettle and hummock formations are common.

The smaller bog situated on the mountain between Hardistonville and Stockholm, has its long axis due east and west. This is unusual since the mountain ridges and valleys generally have a northeasterly trend. The bog vegetation consists in the eastern part of reeds and sedges, grading westward into low deciduous shrubs and trees which become larger with distance from the stream. Although no analyses have been made, a representative section may be described as follows: The surface stratum consists of black, well-decomposed sedge and reed peat containing alluvium. This is underlain by a stratum 2 or more feet thick consisting of dark brown sedge and reed peat, fibrous in texture, and sticky or matted in structure. Below this, woody remnants are intermixed with the reeds and sedges and in many cases the brownish peat is definitely of forest type. The brown sedimentary peat begins at the ninth foot or lower and persists to the twelfth foot or deeper. The bottom consists of clay or other mineral deposits. It is possible that this section was obtained in one of the shallower parts of the bog and that much greater depths might have been encountered had the bog been more systematically surveyed.

The larger bog is northeast of Mud Pond and has the north-south orientation usual for the mountainous regions of New Jersey. This general area contains numerous bogs, separated from one another by rocky runs which, in some cases, are hundreds of yards long. The largest bog covers an area greater than all the others combined and is the only one of economic importance. The bogs are covered by mixed forest and shrubby vegetation, both coniferous and deciduous (table 29).

TABLE 29

Characteristic profile of bog northeast of Mud Pond on Hamburg Mountain

Area 1-E, Field map 74.32–41.08

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–9[1]	Brown, fibrous and matted reed, sedge, and forest peat	89.5	5.2	5.2
9–14[2]	Brown, fibrous and crumbly reed, sedge, and forest peat	91.3	14.6	5.5
14–17	Brown, crumbly reed, sedge, and sedimentary peat	90.7	31.2	5.3
17–26	Green sedimentary peat, containing plant material	90.8	43.1	4.7
26–31	Green sedimentary peat	85.4	66.5	4.6
31–34	Green sedimentary peat and sedimentary material	68.6	86.4	6.4
34–35	Black sedimentary material	78.1	71.8	5.3
35	Rock	....	....	...

[1] Nitrogen content, first foot, 2.75 per cent; sixth foot, 2.27 per cent.
[2] Nitrogen content, tenth foot, 2.72 per cent.

PEAT DEPOSITS OF SPARTA MOUNTAIN

Sparta Mountain contains as many peat deposits as any other mountain in the State. Dozens of glacial kettles not indicated on the maps of the Soil Survey have been located, and lakes and wet mineral-soil meadows are numerous.

Three miles east-southeast of Sparta is Pine Swamp, a mile-long forest bog which is three-quarters of a mile wide in one part and the most notable bog in the region. This occupies a roughly V-shaped valley and is some 1200 feet above tide. It is very heavily forested, mainly with conifers, and heath bushes form an almost impenetrable undergrowth. Sphagnum moss covers the surface of the bog and ferns are numerous.

Pine Swamp drains both east and west. A stratum of sedimentary peat is overlain by peat of the forest type, containing reeds and sedges, although some strata contain sedge and reed peat devoid of woody material. In many places bottom was not reached at 18 feet, and in three instances, the forest-reed-sedge stratum was 15 or more feet thick. Although some alluvium is present in most of the bog, the peat is of good quality. The pH is above the limits normally encountered in New Jersey forest peats, ranging between 5.2 and 6.3.

A striking example of the effect produced by the deposition of glacial drift across a narrow part of a steep-sided mountain valley is found 1 mile west of Hopewell at the junction of the road from Edison to Hopewell with the Sparta-Russia road. The glacial drift blocked the valley extending to the southwest, as well as the longer valley, and formed a clover-shaped lake each extension of which had a length of approximately 1 mile. Much of the old lake has since been filled, but the entire central part still persists. The arm extending to the east has been converted to a small lake by the construction of a dam but sufficient of the old meadow is left to show that it consisted of glacial till and alluvial deposits, true peat being absent.

The large bog that fills the valley toward the southwest was examined in only one place. It apparently contains a mixture of reed, sedge and woody peat and alluvial deposits, such as clay and sand. It is probable that peat of higher quality will be found in the interior of the bog. This bog is separated from the lake by the road which follows a kame formed along the glacial ice.

The third arm of the old lake, which extends from the present lake toward the northwest, is now filled with a forest bog containing peat of good quality. Low glacial deposits separate the bog (table 30) from the existing lake. Considerable alluvium has been deposited on the surface of the bog as the result of flooding in comparatively recent times. The bog vegetation consists mainly of deciduous shrubs and trees, but conifers are also found, as well as heath bushes and ferns. Reeds and sedges fill the wetter areas.

TABLE 30

Characteristic profile of bog on Sparta Mountain

Area 4, Field map 74.36-41.02

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0-1	Water	....	....	...
1-3[1]	Dark brown, well-decomposed reed and sedge peat, containing wood and alluvial deposit	90.6	16.1	5.4
3-9	Brown, fibrous, reed sedge and forest peat	89.4	6.9	5.4
9-12	Olive-green sedimentary peat, containing wood	89.8	37.2	5.7
12-13	Green sedimentary peat	....	....	...
13-14	Olive-green sedimentary deposit	....	....	...

[1] Nitrogen content, 2.38 per cent.

Situated southwest of Pine Swamp and some 2 miles from the most northerly arm of Lake Hopatcong at Woodport, is a cluster of bogs, some of which drain to the Wallkill River at Sparta; some to the Rockaway River; and the remainder to Lake Hopatcong. These bogs contain peat with varying amounts of sand, clay, and other alluvial deposits. The vegetation consists mainly of deciduous trees and shrubs, together with reeds and sedges, ferns and mosses, and heath bushes. Alluvium is present in the upper part of the peat as a result of stream flooding which persists to the present time. The pH values are remarkably constant in one bog, varying only between 5.2 and 5.5.

PEAT DEPOSITS OF LUBBERS RUN

Lubbers Run occupies a narrow valley, 10 miles long, extending from a point on Sparta Mountain southeast of Lake Mohawk, through Roseville to Cage Hill, where the stream enters Musconetcong River. The headwaters of Lubbers Run are approximately 1040 feet above tide, and it descends some 400 feet to Cage Hill. The bogs and lakes along the stream have been formed by stratified and unstratified deposits of glacial drift. These dammed the original valley in many places, and subsequent filling of the bogs and wet meadows produced a series of shelf-like plains.

One of the sources of Lubbers Run is a bog draining also to Wallkill River at Sparta, and to Lake Hopatcong at Woodport. The bog vegetation consists mainly of deciduous shrubs and trees, ferns, and mosses. In the lower, wetter sections there are reeds and sedges. Coniferous trees and heath bushes are also present. Considerable quantities of alluvium occur in this bog (table 31), the ash content decreasing with depth. The wider spreading of alluvium in a bog as the depression fills is well shown here. The surface stratum contains 36 per cent ash, and this rapidly diminishes with increasing depth until the sedimentary layers are reached, where the ash content again rises. The pH values approach neutrality, ranging between 6.1 and 6.3. The peat contains considerable quantities of wood.

TABLE 31

Characteristic profile of Lubbers Run bog

Area 11, Field map 74.38–41.00

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, well-decomposed reed and sedge peat containing wood	74.8	36.2	6.3
1–3	Dark brown, fibrous and crumbly reed and sedge peat containing wood	84.6	13.5	6.1
3–7	Brown, matted reed and sedge peat containing wood	89.7	6.6	6.2
7–8	Brown liver peat	89.5	24.6	6.2
8–12	Greenish-brown liver and sedimentary peat	....	....	...
12–13	Sedimentary deposit	....	....	...

[1] Nitrogen content, 2.65 per cent.

The various streams which merge near Sickle's Mine to form the main stream of Lubbers Run, contain no peat until a point is reached 2 miles below the last-mentioned bog. Here the valley divides around a central long hill of glacial drift. Unquestionably, stagnant ice played its role in the formation of the notable bog that surrounds this hill. Some parts of this contain peat of excellent quality; others contain peat that is largely sand, silt or clay. This has resulted from the network of streams in the area. In some parts of the bog, a dozen streams must be crossed in order to progress a hundred yards.

Under such conditions flooding occurs often, and much alluvial material is deposited. The bog is covered mainly with deciduous trees, shrubs, reeds, sedges, and ferns. Heath bushes and coniferous trees, as well as mosses, are also found.

The remainder of the valley of Lubbers Run, to its union with the Musconetcong Valley, contains little or no peat. Large boggy areas occur but they are made of alluvial material. The same condition prevails in the subvalley containing Wrights Pond, an old natural lake which has been raised by damming. Bogs have also been flooded to form artificial lakes.

ALLUVIAL DEPOSITS OF BOWLING GREEN MOUNTAIN

Only one peat deposit, and that of poor quality, has been found on Bowling Green Mountain. A number of sinuous, narrow valleys west of the mountain and 300 to 400 feet above Longwood Valley are filled, however, with alluvial material. The region in which they occur is extremely rough and is now entirely uninhabitated, although several abandoned farms are situated on the mountain top. During much of the year these wet meadows are flooded.

In the valley of Beaver Brook, which drains part of Bowling Green Mountain into a small lake (the overflow of which enters Lake Hopatcong) is a bog that was formed as a result of the persist-

TABLE 32

Characteristic profile of Beaver Brook bog on Bowling Green Mountain

Area 4, Field map 74.36–40.58

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Mineral soil	....	....	...
1–2[1]	Dark brown alluvial deposit and well-decomposed reed, sedge, and forest peat	67.5	78.0	5.4
2–5	Dark brown alluvial deposit and well-decomposed reed, sedge, and forest peat	81.6	48.5	5.5
5–9	Brown, fibrous reed, sedge, and forest peat, with some alluvial material	88.2	27.9	5.7
9–13	Dark brown forest peat with some reeds and sedges	90.4	12.0	5.7
13–19	Olive-green sedimentary peat	80.8	39.3	5.5
19–20	Hardpan	....	....	...

[1] Nitrogen content, 1.56 per cent.

ence of stagnant ice in the narrow valley. Following glaciation, the valley was devoid of deep depressions, save in the part occupied by the stagnant ice, half a mile above the lake. Alluvial material was carried down the valley by Beaver Brook and filled the shallower parts, but did not succeed in filling this deep kettle. The peat in it (table 32), liberally intermixed with alluvium, forms a striking example of kettle deposit in an alluvial plain, a type of formation discussed later under the section on Black River. The ash content is extremely high at the surface and decreases with depth. Reeds, sedges, and deciduous shrubs and trees, with some ferns and mosses, constitute the bog vegetation.

PEAT DEPOSITS OF ALLAMUCHY MOUNTAIN

Allamuchy Mountain rises from the Central Highland Plateau in the vicinity of Cranberry Lake and extends 6 or 7 miles southwest to where it joins Pohatcong Mountain, which continues in the same direction. Many interesting peat deposits are located on the mountain, which is crossed by the terminal moraine.

A typical bog (table 33) covering 8 acres, lies in a narrow valley opening into Cranberry Lake, 1½ miles to the east. It has an elevation of 800 feet above tide. It was formerly utilized for the growth of truck crops, but has been abandoned. The vegetation consists mainly of sedges and reeds. The nonaquatic peat is of good

TABLE 33

Representative profile of bog on Allamuchy Mountain

Area 2, Field map 74.48–40.56

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Dark brown, granulated and crumbly reed and sedge peat	....	....	...
1–2	Dark brown, fine fibrous and matted reed and sedge peat containing wood	84.5	11.2	5.0
2–9	Dark brown, fine fibrous, matted reed and sedge peat	90.6	4.8	5.5
9–12	Dark brown sedimentary peat	92.2	7.2	5.5
12–16	Olive-green sedimentary peat	88.5	40.0	5.5
16–18	Olive-green sedimentary peat	76.4	75.3	5.7
18–19	Gray clay	....	....	...

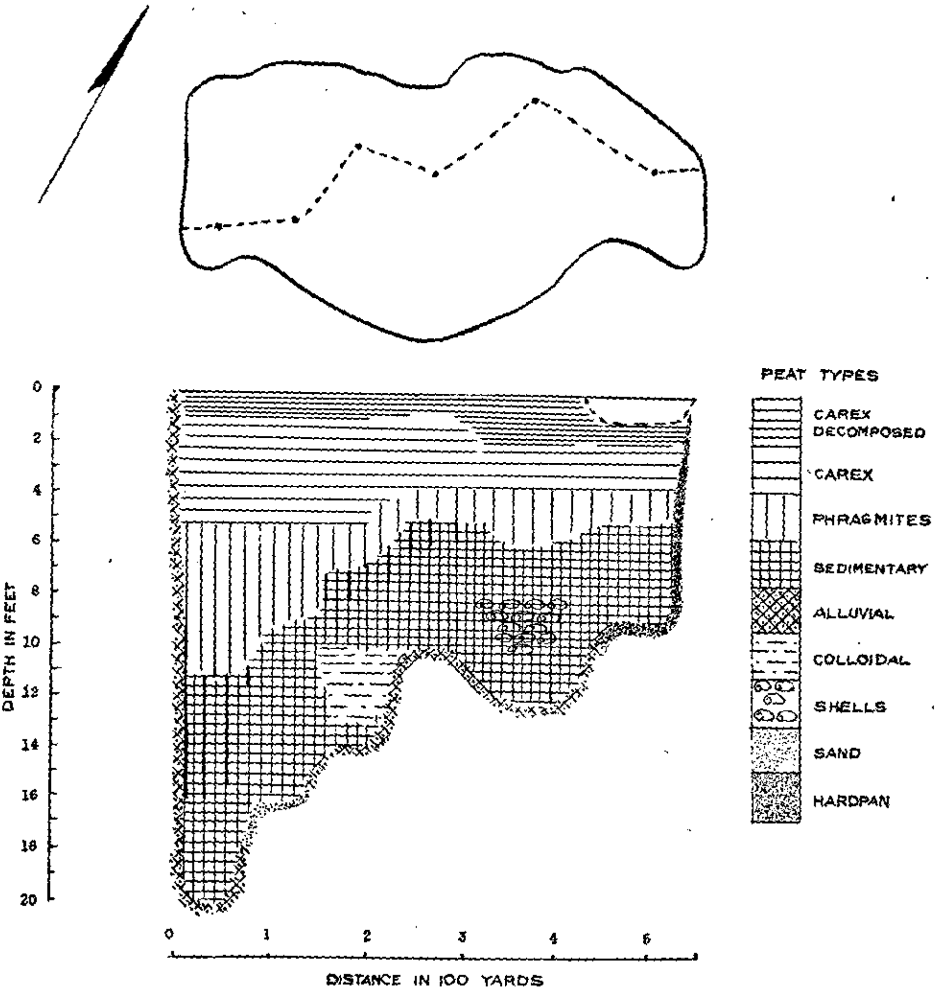


FIG. 27. Cross section of Allamuchy Mountain bog.

quality, the ash content varying between 4 and 11 per cent, and the pH between 5.0 and 5.7.

A second bog, comprising some 30 acres, is situated on the mountain three-quarters of a mile north of Waterloo. The bog vegetation consists of coniferous and deciduous trees, shrubs, and heath bushes, together with reeds, sedges, sphagnum moss, and ferns. Part of the bog was under water at the time of the survey. Save for minor differences, the peat is similar to that found in the bog last described.

The third and final bog to be considered in connection with Allamuchy Mountain is located 1½ miles north of the abandoned road connecting Allamuchy and French's Pond. This bog covers some 15 acres. It formerly was cultivated, but has been abandoned. The drainage is good, and the present vegetation consists primarily of upland plants such as white birches and blackberries. The bog owes its formation to the deposition of till across a narrow valley, and since the area occurs at the edge of a depression with a steep slope to the north, it could readily be drained by blasting should it be found desirable to remove the peat, which is of excellent quality (figure 27). The nitrogen content of the surface stratum is unusually high, particularly in view of the presence of some alluvial material. Calcareous marl is present in part of the area.

All of the bogs located on Allamuchy Mountain are thus of the sedge and reed type commonly found in nonlimestone regions. Some woody material is present, but the peats are essentially composed of reeds and sedges.

PEAT DEPOSITS OF POHATCONG MOUNTAIN

Two peat deposits occur in the terminal moraine which crosses Pohatcong Mountain. Both have been cultivated. The bog nearest Hackettstown is 1¾ miles west of that municipality at an elevation of approximately 800 feet, and its drainage flows east to the valley and then south to Musconetcong River. The type of peat found in this bog is alluvial sedge and reed. The depression originally was of slight relief and aquatic peat was not deposited.

The second bog, four-fifths of a mile to the southwest, is also of the sedge and reed type but does not contain so much alluvial material.

TABLE 34

Profile of Pohatcong Mountain cultivated bog

Area 2, Field map 74.54–40.50

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, granulated, well-decomposed reed and sedge peat	74.2	26.0	2.63	5.9
1–8	Brown, fibrous and matted reed and sedge peat containing wood	87.9	8.9	2.48	5.9
8–9	Brown, fibrous and matted reed and sedge peat containing clay	84.5	34.1	1.68	6.3
9–10	Gray clay	....	....	....	...

The mineral content of the surface, however, reaches the high value of 26 per cent (table 34). The bog drains to Pequest River, 1 mile south of Great Meadows.

PEAT DEPOSITS OF MUSCONETCONG VALLEY

Lake Hopatcong constitutes the source of Musconetcong River, which flows through Lake Musconetcong, descends to the limestone in the vicinity of Waterloo, and enters Delaware River at Riegelsville. No peat is found in the valley south of Hackettstown. Just north of that town, in the terminal moraine, there is a large cluster of small kettles which are sufficiently elevated above the limestone so that calcareous marl is virtually absent from the aquatic layers. The peat varies from alluvial to sedge and reed, including mixtures of the two. From one kettle peat is at present being removed for sale but the

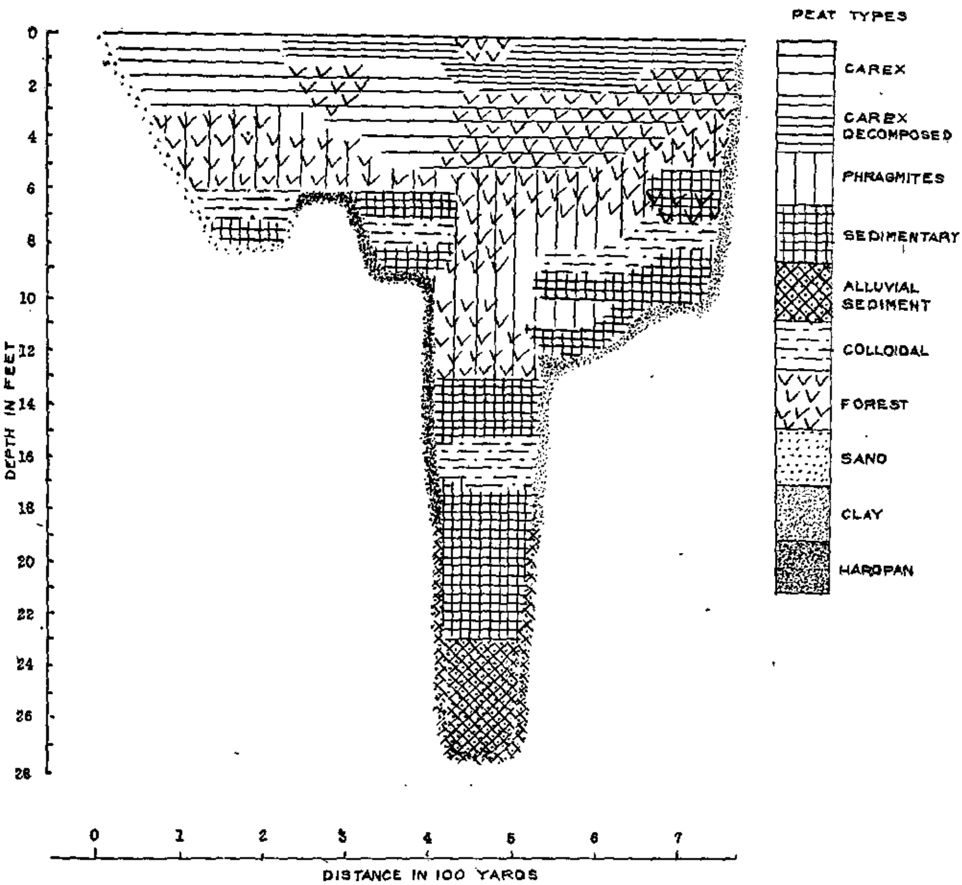


FIG. 28. Cross section of peat bog at Stanhope operated by Netcong Natural Products Company.

aggregate acreage of all the kettles is too slight to warrant further discussion.

Some 4½ miles up-stream from the kettle cluster a large depression is found at river level, probably representing a former eddy of the stream. This bog covers about 20 acres and is partly underlain with calcareous marl. The surface is thickly covered with deciduous trees and shrubs, as well as with ferns, mosses, reeds, and sedges. The nonaquatic layers, to a depth of 11 feet, vary in pH from 5.3 to 5.9; immediately under this stratum is a 3-foot sedimentary layer, very acid in reaction; beneath this is highly calcareous material in which the pH rises as high as 7.5. These wide variations in pH values illustrate the limited water movement in a bog, especially where springs are lacking.

Still farther up-stream, a subvalley extends to the northwest from the northern extremity of Lake Musconetcong. This subvalley is elevated above the lake which here fills the main valley. At this place there is an interesting peat deposit from which both peat and diatomaceous earth have been removed for sale. The peat is of the sedge and reed type with abundant wood. Calcareous marl is absent and the peat is definitely acid. The bog vegetation consists of deciduous trees and shrubs, ferns, mosses and upland plants, the area being well-drained (figure 28, table 35).

PEAT DEPOSITS OF BEARFORT MOUNTAIN

Bearfort Mountain crosses the New York-New Jersey boundary west of Greenwood Lake and extends southwest to Clinton Reservoir.

TABLE 35

Profile of bog at Stanhope, in Musconetcong Valley

Area 1, Field map 74.42–40.54

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2[1]	Dark brown, well-decomposed reed, sedge, and forest peat	82.1	7.4	4.3
2–13	Dark brown, fine fibrous and matted reed and sedge peat containing wood	90.3	7.2	5.6
13–15	Olive-green sedimentary peat	92.0	28.7	5.9
15–17	Olive-green liver peat	83.3	68.3	5.8
17–23	Olive-green sedimentary peat	87.8	62.8	4.8
23–28	Gray sedimentary deposit	....	....	...

[1] Nitrogen content, 2.34 per cent.

The eastern flank of the mountain is precipitous, rising more than 700 feet above Greenwood Lake in a distance of little more than half a mile. Observed from the west, the escarpment, though still ridge-like, has much less relief, for the high interior of the Central Highland Plateau lies to the west. The eastern part of the mountain is composed of Bellvale sandstone and Cornwall shale; the western part of Skunnemunk purplish conglomerate, boulders of which may be observed many miles to the south. The steep slopes of shale, sandstone and conglomerate make the mountain virtually the most rugged and inaccessible in the State. A large number of rock basins are found on the mountain, particularly in the northern section. Some of these basins are occupied by ponds ranging in size from 20 acres to a small fraction of an acre; others are completely or partly filled with peat.

The section of Bearfort Mountain in the vicinity of the New York-New Jersey boundary is notable for its deep rock basins, many of which contain peat. Of the dozens of such basins, many are too small for accurate representation on any published map, and many others are so inaccessible that the labor of locating them was discontinued.

At least two well-marked drainage depressions are found in this section. The first contains the body of water locally known as "Surprise Lake", which, with its bog to the north, extends nearly to the State line. The drainage from the lake, flowing to the southwest through a rocky ravine with occasional pockets of peat, swings to the southeast a mile from its source and enters Greenwood Lake. The second drainage depression lies one fifth of a mile or less to the west and is divided, in its upper reaches, by a precipitous narrow ridge. A series of bogs in the north drain into West Pond (figure 29, plate XII), which in turn drains down a rocky ravine containing several deposits of peat. The stream flows to the southwest for a distance of 2 miles; then turns southeast to join the stream from Surprise Lake.

The peat found on this part of the mountain is of either the forest or the alluvial type, or mixtures of the two. The forest peats are more nearly true to type here than elsewhere in northern New Jersey. The bog vegetation also differs in some degree from the usual flora of New Jersey's mountain bogs, for swamps are prevalent in most cases, replacing the cedar found at lower, less exposed altitudes, and wild cranberries are found in many of the wetter sections of the bogs where trees do not grow. The remainder of the flora consists of the usual northern mountain swamp plants such as rhododendron, laurel, cinnamon fern, and deciduous shrubs and trees. Sphagnum moss

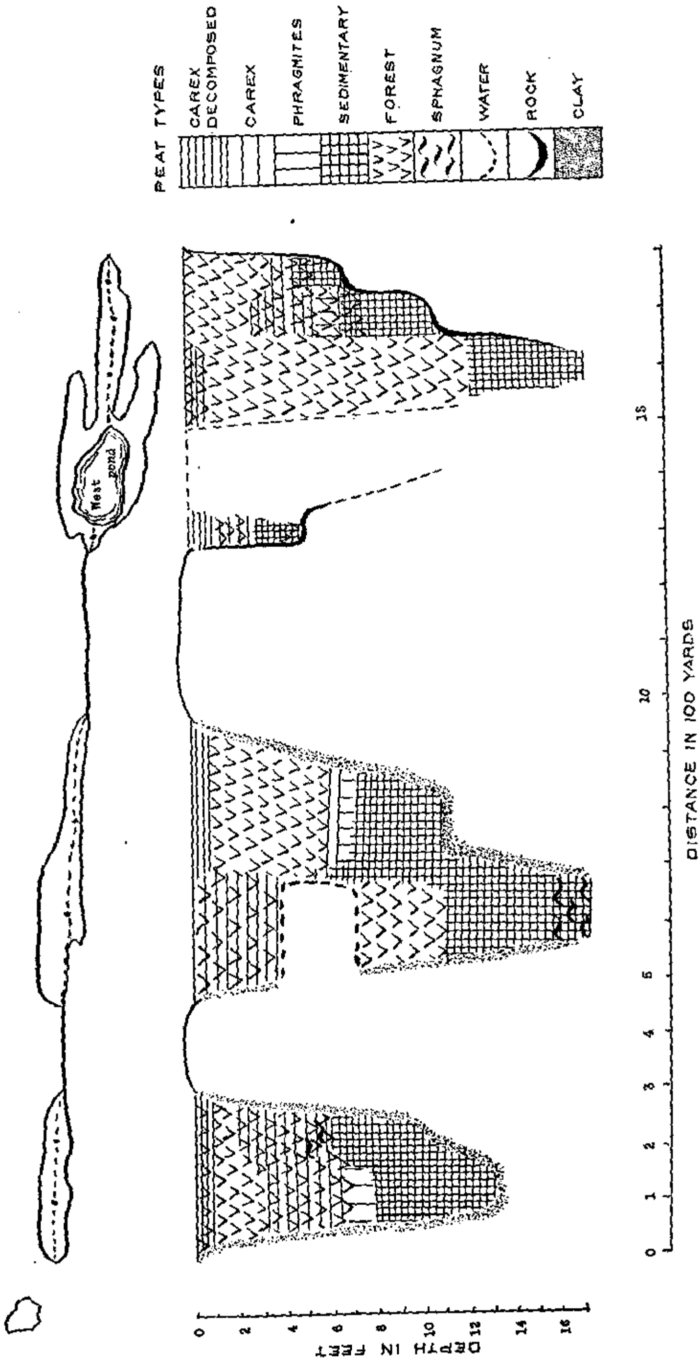


FIG. 29. Cross section of pond and bog series on Bearfort Mountain, northern sector.

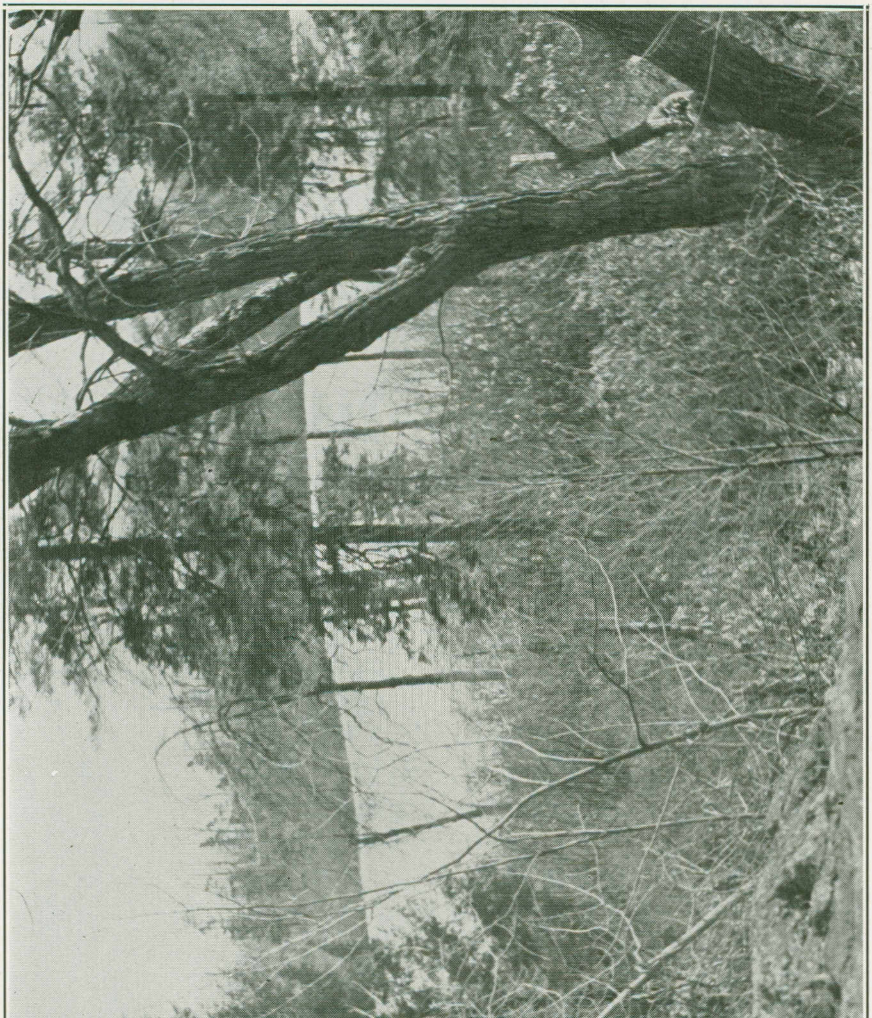


PLATE XII. West Pond, Bearfort Mountain, showing marginal bogs.

covers the hummocks and low stumps. The bogs are exposed to high wind velocities and low winter temperatures, and this condition is reflected in the vegetation. Some of the exposed ridges are so windswept that the upland pines reach heights of only 1 or 2 feet. Similar conditions are found only on the more exposed parts of Kittatinny Mountain.

The bog containing West Pond extends one-third of a mile to the northeast and borings have shown that alluvium occurs in most strata as shown by the ash values. The pH increases from 4.0 at the surface, to 5.5 in the fifth foot.

West Pond is entirely surrounded by finger-like marginal bogs, which fill the rock basin. The aggregate area of these bogs is less than 10 acres and the peat is similar throughout. A typical profile (table 36) shows little alluvium; a nitrogen content of 2.1 per cent, common for forest peat; and pH values ranging from 3.5 at the surface to 5.6 in the sedimentary stratum.

TABLE 36

Composition of peat in West Pond bog on Bearfort Mountain

Area 11, Field map 74.22–41.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Brown, granulated, well-decomposed forest peat	86.5	5.2	3.5
1–8	Brown, coarse, fibrous and matted forest peat and reed and sedge peat	88.2	4.2	4.6
8–9	Brown sedimentary peat containing plants	91.9	13.6	5.3
9–14	Brown sedimentary peat	81.2	61.3	5.6
14–15	Pink clay	....	....	...

[1] Nitrogen content, 2.10 per cent.

A long, narrow bog is found one-third of a mile southwest of West Pond, the stream from the pond passing through it. This is a 7-acre bog, containing forest peat with some alluvial material.

The section of Bearfort Mountain that lies south of the road connecting Greenwood and Upper Greenwood Lakes and a point one mile southwest of Terrace Pond was not systematically examined during the course of this survey. It is probable that peat deposits occur in this region.

The peat bogs found at or near Cedar Pond near the southern end of Bearfort Mountain, occupy wider valleys and most of them are more extensive than those in the northern section. They do not occur between the highest ridges, as do the bogs to the north, but are west and below the escarpment.

Cedar Pond has an elevation of 1115 feet and some of the small, nearby bogs have elevations 100 to 150 feet higher. All of the bogs drain into Cedar Pond, the waters of which, passing through Clinton reservoir, enter Pequannock River at Newfoundland.

A wet meadow is found at the southern end of Cedar Pond but it does not contain peat. At the northern end of the lake, however, three fingers of a peat bog emerge from the waters of the lake. The westerly bog is 700 yards long. The middle one has a length of 300 yards from the lake edge to a narrow ravine. Above this narrow place, the ravine widens to 200 yards and the bog continues to the north for an additional 500 yards. The easterly bog is similar to the middle bog, occurring in two sections of 200 and 300 yards length respectively, separated by a narrow, short, rocky gorge. Two high, narrow ridges separate the middle bog from the others except towards the north where the bogs are connected by wet meadowland containing clay and boulders.

Most of the bogs are thickly covered with deciduous and coniferous trees. Heath bushes and deciduous shrubs are abundant, as are ferns and mosses. The lower growth is found nearest the lake. The peat is primarily of the forest type and is of excellent quality, although the sedimentary peat is close to the surface in many places. Some mineral wash has occurred in the northern end of the combined bogs. In this series the analysis of samples from one area shows a low ash content down to the thirteenth foot. The pH range resembles the sedge and reed type of bog, rather than the forest type.

The most southern of a remarkable series of bogs which extends northeastward from Cedar Pond for 2 miles and which consists of 17 members, is situated 200 yards east of the pond. There may be as great a difference in elevation as 200 feet between the lowest and the highest members of the series, most of which occupy two valleys, the higher draining into the lower over a series of waterfalls aggregating 100 or more feet. The entire system drains into Cedar Pond.

The largest bog in this series is the lowest and its drainage passes through two other bogs before reaching Cedar Pond. Its greatest length is four-fifths of a mile and its greatest width one-fifth of a mile, although the average is much less. The peat found in this bog varies widely in different places. Alluvial material may be replaced within a distance of 100 yards by woody reed and sedge peat of excellent quality. Most of the peat consists of mixtures of reeds, sedges, and forest residues, the type as a whole being more nearly typical of forest than of sedge and reed peat (table 37). The ash values are low until the sedimentary stratum is reached. The pH values rise from 4.1, at the surface, to 5.7 in the twentieth foot. Calcareous marl is absent as would be expected from its location in the heart of a nonlimestone region. In some of the small bogs to the northeast, however, calcareous marl is found. These bogs are in

TABLE 37

Composition of peat in Bearfort Mountain bog, Cedar Pond section

Field map 74.22–41.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2	Dark brown, granulated, well-decomposed forest peat	86.2	7.3	4.1
2–10[1]	Brown, fine fibrous and matted reed, sedge, and forest peat	89.6	6.0	5.0
10–21	Brown, fibrous and spongy reed and sedge peat containing wood	92.6	5.4	5.7
21–34[2]	Light brown sedimentary peat containing plant material	93.2	33.7	5.7

[1] Nitrogen content, 2.39 per cent.
[2] Bottom not reached.

TABLE 38

Composition of peat in a small Bearfort Mountain bog, Cedar Pond Section

Field map 74.22–41.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, fibrous and woody reed, sedge, and forest peat	84.2	8.9	4.6
1–4	Brown alluvial deposit containing wood ..	....	....	...
4–5	Light brown, fine fibrous and spongy reed, sedge, and moss peat and alluvial material	92.6	39.3	5.3
5–6	Light brown, fibrous and spongy reed, sedge, moss, and sedimentary peat	92.4	36.7	5.2
6–10	Light brown sedimentary peat containing wood	87.5	40.1	5.5
10–11	Rock	....	....	...

[1] Nitrogen content, 2.18 per cent.

no case greater than 50 yards in diameter. In common with most of the bogs in this region, they probably represent the sites of stagnant ice. The limestone sources of the calcareous marl deposits probably consist of boulders and smaller stones in the glacial drift.

Analyses of samples from one of the small bogs higher in the same valley are presented in table 38. It will be observed that although the deposit is of the alluvial forest type, calcareous marl is absent and consequently the pH values are not greater than 5.5, as contrasted with 7.5 in the calcareous bogs. In the higher of the two valleys occupied by this series, the most important bog is situated 100 or more feet above the northern end of the largest bog in the lower valley. The waters drop from the former area to the latter in a horizontal distance of 100 yards or less.

PEAT DEPOSITS OF THE CENTRAL REGION OF THE CENTRAL HIGHLAND PLATEAU

The central region comprises all those portions of the Central Highland Plateau not included in the mountain masses previously discussed.

Long House Creek rises at the western foot of Bearfort Mountain, 5 miles from the State line, and flows northeastward through a complex meadow, bog, and lake system, before it leaves New Jersey. The present Upper Greenwood Lake (or Mt. Laurel Lake) occupies 2 miles of the valley and another mile of bog and flooded meadow extends north from the dam forming that lake to the State line. Upper Greenwood Lake was formerly a forest peat bog but at present is covered by 4 to more than 12 feet of water.

The former bog was surveyed through the ice in the winter of 1940. The primary purpose of the survey was to acquire information concerning the rate of deposition of peat, as well as the types of peat that are being deposited under present conditions. The peat in this lake could probably be removed by dredging, thus greatly improving the lake for recreational purposes. Moreover, the operation might prove a profitable one since the forest peat is of good quality.

The analyses of a profile obtained at a point 800 yards from the extreme southern tip of the lake are presented in table 39. This part of the former bog receives the drainage of the narrow valley extending to the south. The flooded valley is largely filled with alluvium, including considerable quantities of clay and silt. The ash content decreases below the eighth foot, then increases again, reaching 63 per cent in the thirteenth foot. It is possible that sedimentary material has increased the ash content of the peat in the surface foot of the

TABLE 39

Composition of peat in Upper Greenwood Lake, southern section
Area 3-A, Field map 74.24–41.08

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–7	Water	....	....	...
7–8	Black, granulated, well-decomposed reed and sedge peat and alluvial material	81.1	35.5	4.9
8–13[1]	Reddish-brown, fibrous and matted reed and sedge and forest peat	91.7	8.6	5.1
13–15	Light brown sedimentary peat containing wood	84.1	63.1	5.2
15–17	Olive-green sedimentary peat	....	....	...
17–20	Grayish-green sedimentary peat containing plant material and clay	....	....	...
20–21	Gray clay	....	....	...

[1] Nitrogen content, 2.70 per cent.

old bog, since the area has been flooded. It appears more probable, however, that the greater part of the mineral material was deposited prior to flooding. This is shown by the analytical results of a profile obtained from the bog at a point 1800 yards distant from the southern end of the lake. The ash content of the surface layer of the old bog is only 12 per cent, as contrasted with 36 per cent 1000 yards closer to the stream entering the lake. The peat was found to be of good quality to a depth of more than 35 feet below the surface of the water. Since 9 feet of water and ice were present at the time of sampling, at least 26 feet of nonaquatic peat lies beneath it. The bottom could not be reached at this point with the equipment available, but it is believed that the depth of peat must be much greater.

The vegetation covering the bog before the area was flooded consisted of cedars, rhododendron and laurel, deciduous trees and shrubs, mosses and ferns, with reeds and sedges in the wetter sections. This flora is typical of the large bogs in this north-central part of the plateau. Nowhere is growth more impenetrable than in these northern forest bogs. Vision is restricted to a few yards in any direction. During the course of the survey, lines were held almost entirely by sound rather than by sight. These considerations do not, of course, apply to the bog now covered by Upper Greenwood Lake. This bog, prior to flooding, was cleared. Open bog is found in only one small part of the area; here much of the former surface vegetation was killed by the rise of the lake water.

Almost midway between Upper Greenwood Lake and Wawayanda Lake to the west, lies the tangled and almost impenetrable forest bog known as "Big Cedar Swamp" (plate XIII). In many places the cedar or rhododendron thickets literally cannot be penetrated. The bog is somewhat less than 2 miles long and is from half a mile to 150 yards wide. It drains both east and west from the wide southern margin, but both streams eventually find their way to Wallkill River.

Most of the peat found in the southern end of the bog is of poor quality and is heavily admixed with alluvium. Calcareous marl is absent here although it is found in the northern end. Throughout much of the latter part of the bog, the peat is of excellent quality and extends to considerable depths (table 40). Virtually no alluvium has been deposited in this wide area of bog, and the ash content does not rise above 6 per cent until the underlying sedimentary stratum is reached. The presence of calcareous marl is of special interest. It appears probable that limestone, carried up into the highlands by the Wisconsin glacier, has, through leaching, provided this calcareous material.

TABLE 40

Representative profile of Big Cedar Swamp, northern section

Area 7, Field map 74.26–41.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–4[1]	Brown, granulated reed, sedge, and forest peat	87.0	4.6	4.7
4–7	Brown, macerated reed, sedge, and forest peat	90.2	4.1	5.5
7–14	Brown, fibrous and matted reed and sedge peat containing wood	89.4	5.4	5.8
14–22	Brown, fibrous and spongy reed and sedge peat	92.2	4.9	6.0
22–29[2]	Brown sedimentary peat containing plant residues and wood	91.0	42.9	5.4
29–37	Greenish-brown sedimentary peat and calcareous marl	78.2	69.2	6.1
37–38	Dark gray sedimentary peat and clay	....	....	...
38–39	Gray clay	....	....	...

[1] Nitrogen content, 1.51 per cent.
[2] Nitrogen content, 2.04 per cent.

PLATE XIII. "Big Cedar Swamp", near Upper Greenwood Lake.

The region surrounding this bog and extending for some miles to the south exhibits every indication of extraordinary glacial action. Huge boulders are commonly found perched upon the bare bedrock or upon other flattened boulders. In some instances, the individual boulders are of such size that a man could readily disappear in the spaces between them. Large expanses of the bedrock have apparently been cleared of soil by the action of the ice. Many indications of flooding are readily observable, not only in the lowlands, but over much of the plateau-like highlands. In fact, much of the interior portion of the Central Highland Plateau may have been flooded over a region which could have extended from the vicinity of the New York-New Jersey boundary as far south as Canistear and Rutherford mines. This temporary lake may have been held in place, to the north, by the ice and by the ridges, and by the drift or the ice over the remainder of the region. Although no single lake may have covered the entire region, there appears little doubt that much land in excess of the present bogs was once under water. Many of the peat deposits show, in whole or in part, evidence of having been formed under large shallow lake conditions. They are similar to bogs formed in the bed of the glacial Lake Passaic, in that the depths of peat are not great and in many places it is admixed with water-carried mineral sediments; they are dissimilar in that surface growth, because of climatic factors is, and has been largely of the northern forest type, leading to the formation of forest-alluvial deposits, rather than of sedge and reed alluvial deposits. The bogs in this northern region that have been discussed, namely, that now covered by Upper Greenwood Lake and that locally termed "Big Cedar Swamp", are exceptional in that they contain chiefly forest or forest sedge and reed peat of excellent quality. Many of the other deposits consist largely of silt or clay-covered lowland with peat, which may be of good quality, present only in the deeper parts of the original depressions. This situation is identical with that found along Black River, the flood plain of which will be discussed later.

Southward on the Central Highland Plateau, the character of the bogs is found to change. In the north, the most striking surface feature is the tangled, almost impenetrable jungle of cedars and rhododendron which grow so close together that the bogs are gloomy, even on a bright day. When the vicinity of Lake Hopatcong is reached, the bogs are mostly covered with deciduous shrubs and trees and often large areas of the bogs are devoid of trees and are covered only by reeds, sedges, shrubs, and ferns. In some bogs, the original vegetation may have been coniferous, but lumbering or some other cause has changed the dominant flora.

None of the bogs in the southern section compare in size with the large bogs in the north. In the vicinity of Lake Hopatcong there are numerous glacial kettles, occurring both in the terminal moraine, and in the stratified drift of the region. All the peat deposits around Lake Hopatcong are found near its southern end. Though kames are numerous around the north end of the lake, and glacial kettles are present, true peat is absent. It would appear that the run-off from the hills led, during the peat-forming period, to the deposition of alluvial sediments in such quantity that the depressions were filled.

An interesting group of 11 glacial kettles, ranging in size from less than half an acre to 17 acres lies southeast of Mt. Arlington. All these bogs drain into Lake Hopatcong, some by surface streams, others through the permeable drift. The analysis of a typical bog is presented in table 41. This 8-acre bog was cultivated at one time but has been abandoned for many years. Upland vegetation has encroached upon the drained surface and bush blackberries, white birch, and similar plants now form a thick cover. The surface peat stratum has a high ash content of 29 per cent. This may be partly due to cultivation during former years, but it is largely caused by the alluvium deposited by the stream. The surface layer is also high in ash in the majority of the other kettles. The lower strata in all the bogs contain peat of excellent quality, the lowest ash content encountered (in the fourteenth foot) being 4 per cent. The pH values range between 5.8 and 6.1.

TABLE 41

Characteristic profile of terminal moraine bog at Lake Hopatcong

Area 6, Field map 74.40–40.54

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2[1]	Black, well-decomposed reed and sedge peat containing alluvial material and wood	80.9	29.2	6.0
2–15	Dark brown, fibrous and spongy reed and sedge peat	89.8	6.1	5.9
15–29	Olive-green colloidal peat and sedimentary peat	93.1	21.1	5.8
29–30	Gray sedimentary deposit	....	....	...

[1] Nitrogen content, 2.56 per cent.

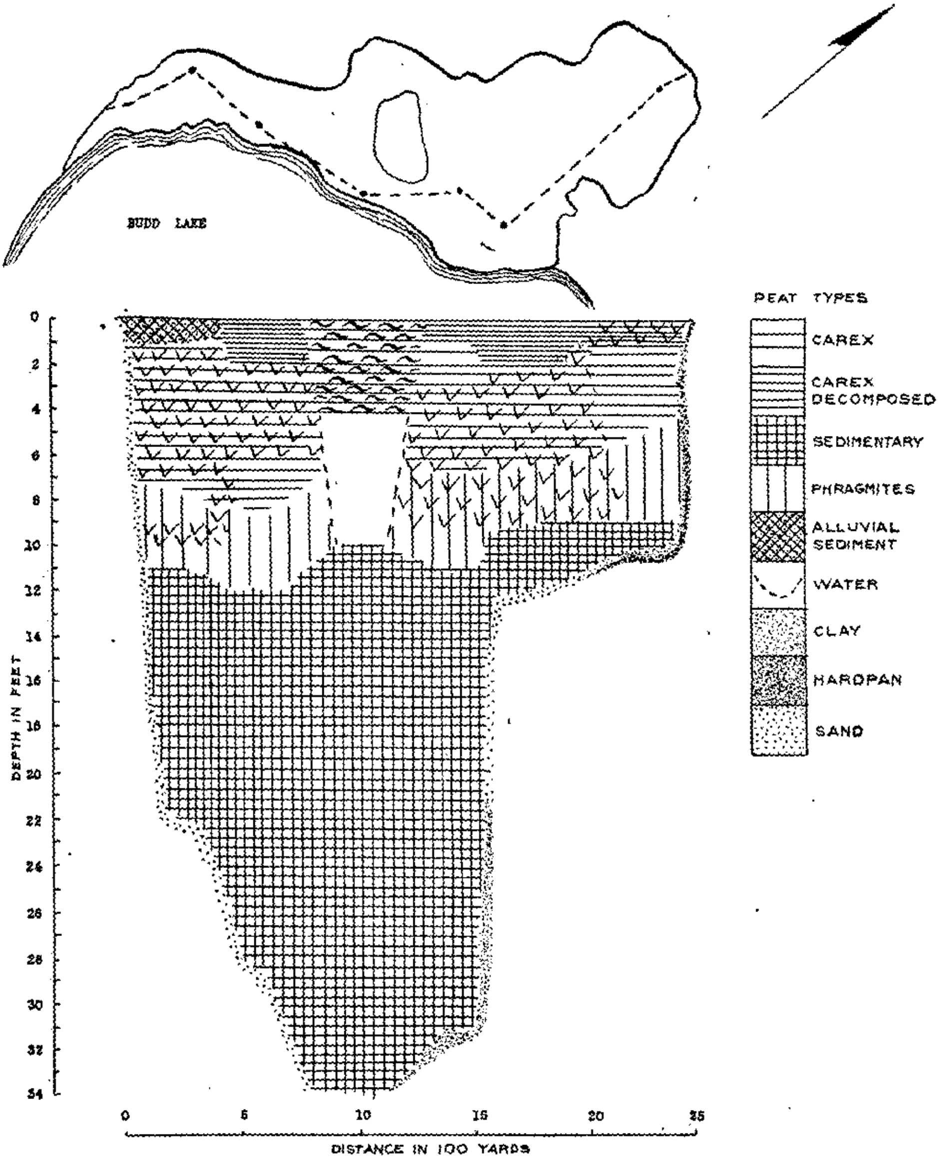


FIG. 30. Cross section of Budd Lake bog.

Budd Lake, 4½ miles southwest of the southern end of Lake Hopatcong, owes its origin to the terminal moraine which dammed the valley in which it lies to a level higher than the present outlet of the lake toward the south.

Much of the northern and western margins of Budd Lake consists of peatland (figure 30). Generally the nonaquatic peat consists of the remains of reeds and sedges admixed with woody material, but at least one part of the bog, floating on the surface of the lake, is formed by a mat of sphagnum moss peat admixed in the upper layer with an equal quantity of reed peat. The stratum over the open water is composed of pure sphagnum. Moss has been observed in many northern bogs, but this bog appears to contain the only pure sphagnum peat in the glaciated section of New Jersey. The floating mat, probably covering several acres of surface, supports vegetation that is typical of the sphagnum bogs. Sphagnum moss grows luxuriantly on the surface and the carnivorous pitcher plant abounds; clumps of one or two species of low shrubs and stunted trees are scattered throughout.

TABLE 42

Characteristic profile of Budd Lake bog, floating mat section

Area 1-B, Field map 74.46–40.52

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Brown, coarse fibrous and matted sphagnum and reed peat	91.6	14.3	4.9
1–4[1]	Light brown, coarse fibrous and spongy sphagnum peat containing few reeds ...	94.4	5.5	5.4
4–10	Water	....	....	...
10–34[2]	Olive-green sedimentary peat	83.8	71.5	6.3

[1] Nitrogen content, 1.05 per cent.
[2] Bottom not reached.

Analyses of samples from a boring through the floating bog are presented in table 42. The nitrogen content of the sphagnum stratum (little more than 1 per cent) is characteristic of this type of peat. The pH values are unusual, increasing from 4.9 at the surface, to 6.0 in the second foot. These values are probably affected by the pH of the lake water, which is 5.6, and by the sediments deposited by a stream entering from the stratified drift to the west which spreads its water over the bog in the vicinity of the boring. The high value of pH 7.2 in the sedimentary stratum, between the twenty-sixth and thirty-fourth foot (equipment was not available to permit sampling of greater depths), may denote high lime content in these deposits. The ash content, decreasing from the surface downward until the floating mat is left behind, is probably a result of flooding by the stream. This is substantiated by the analytical results obtained from a second boring in the same bog, taken within 200 yards of the shore. Here the ash content of the top foot of peat has a value of 34 per cent, which decreases in the fourth foot to 6 per cent (table 43). The difference between the nitrogen content of this sample, namely 2.63 per cent in the second foot, as compared with 1.05 per cent in the floating mat sample taken at the same depth, is most striking.

TABLE 43

Characteristic profile of Budd Lake bog

Area 1, Field map 74.46–40.52

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Black, granulated, well-decomposed reed and sedge peat containing wood and alluvial material	78.9	34.1	5.5
1–3[1]	Dark brown, coarse fibrous and matted reed and sedge peat and alluvial material	88.4	17.7	5.7
3–7[2]	Brown, coarse fibrous and matted reed and sedge peat	90.6	5.3	5.9
7–9	Brown, fibrous reed and sedge peat containing sedimentary material	89.4	12.9	6.0
9–10	Olive-green sedimentary peat	72.9	81.0	5.7
10–11	Sand and hardpan	....	....	...

[1] Nitrogen content, 2.63 per cent.
[2] Nitrogen content, 2.51 per cent.

In the moraine and stratified drift to the north and east of Budd Lake are many glacial kettles, some of which are filled with water-borne sediments, but the majority of which contain a fair to good grade of peat. These deposits do not differ greatly from the Budd Lake material, although in no case is true sphagnum peat present. The analysis of the floating mat, therefore, would not represent these bogs.

PEAT DEPOSITS OF THE LONGWOOD AND BLACK RIVER VALLEYS

The Longwood-German Valley bounds the Central Highland Plateau on the entire eastern flank. The only part of this valley that contains peat in sufficient amounts to justify detailed discussion is the region, 4 miles long by 2½ miles wide, containing the villages of Russia, Milton, Woodstock, and Petersburg. The deposition of much stratified drift in this wider stretch of the valley has resulted in the formation of many peat deposits and lakes.

An extremely interesting bog lies one mile northeast of Petersburg. At present in pasture, it was drained and utilized for truck farming about 75 years ago. The settling of the peat due to drainage and cultivation is extraordinary when the small size (40 acres) of the area is considered. The center of the bog is fully 5 feet lower than the edges, only 150 yards distant. The peat found in the depression is of good quality, the comparatively high ash content of the surface stratum being due either to alluvial material or to decomposition resulting from former cultivation, or to both.

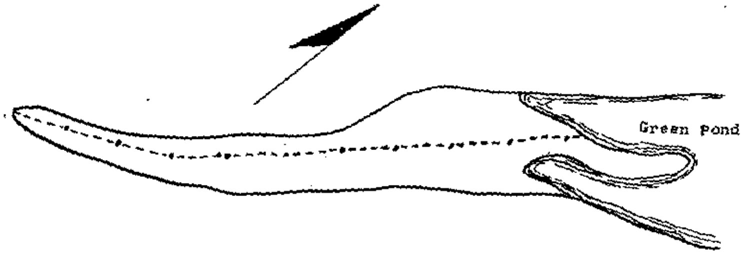
Approximately a mile distant is a 50-acre bog entirely surrounding a large kame. Although much of the surface is covered with deciduous forest and one arm supports many pine trees, the peat is of the sedge and reed type.

Mooseback Lake is three-quarters encircled by a bog. The lake is surrounded by large sand and gravel deposits, so well drained as to support almost desert vegetation. Considerable quantities of wood are present in the peat, which is of the forest type. Most of the bog is covered by deciduous forest, intermingled with pine trees.

PEAT DEPOSITS OF THE GREEN POND MOUNTAIN BELT

Green Pond occupies that part of the deep valley between Green Pond and Copperas Mountains which is southeast of Petersburg. Its elevation is 1046 feet above tide. The only noteworthy deposit of peat in this mountain belt is at the southern end of the pond. Though the valley was once drained to the northeast, it now drains to the southwest through a brook of the same name which joins Rockaway River at Wharton.

The lake-margin bogs of northern New Jersey are commonly found to have their greatest depths at the lake margins. This is not true of the Green Pond bog, as will be seen by inspection of the cross section presented in figure 31. The greatest depth (only 9 feet) is found approximately midway down the long axis of the bog, over half a mile from the lake. The deposit is of the sedge and reed forest type, commonly found in the New Jersey mountains. It is covered with deciduous shrubs and trees, heath bushes, and sphagnum moss. In the wetter sections, reeds and sedges predominate.



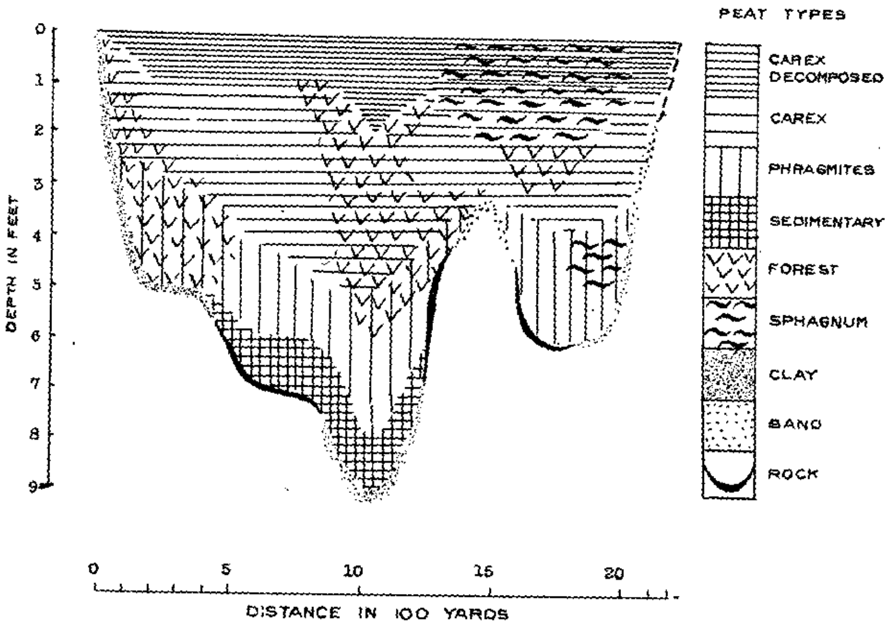


FIG. 31. Cross section of Green Pond bog.

PEAT DEPOSITS OF THE VALLEY OF BURNT MEADOW BROOK AND TIMBER BROOK

The valley east of Copperas Mountain is drained, in the northern part, by Timber Brook, which flows into Pequannock River at Charlottesburg, and in the southern part by Burnt Meadow Brook, which merges with Green Pond Brook at Denmark. This narrow valley is filled for much of its length and breadth with lakes and peat bogs, which, in many instances, attain considerable depths. Many of the bogs contain considerable quantities of alluvium in the surface stratum, and farther south in the large flood area near the confluence of Green Pond Brook with Rockaway River at Wharton, peat is nearly or entirely absent.

PEAT DEPOSITS OF THE PASSAIC RANGE

The Passaic range lies east of Greenwood Lake, Kanouse Mountain and the valleys of Timber Brook and Burnt Meadow Brook. It is separated from the Hudson range (Ramapo Mountain) by the Wanaque Valley, the Pequannock River cutting through the range between Newfoundland and Riverdale.

Extending from the vicinity of West Milford, south of Greenwood Lake, to the Pequannock River, is a diverging intricate system of drainage depressions which contain the most important peat deposits to be found within the limits of the range. The influence of stagnant ice, as well as the deposition of stratified and unstratified drift led to the formation of the bogs in these valleys. It appears probable that the greatest influence was exerted by water-deposited drift, although massive deposits of bouldery till are known. In one instance, large blocks of rock may be seen at the top edge and on the slope of the long axis of a steep-sided ravine; the position of the jagged fragments and the uniformity of surface level would lead to the belief that they were scraped into position by the ice.

The largest of the peat deposits in this area is found in the valley east of Kanouse Mountain, west of Upper Macopin, and directly north of Macopin Lake, into which the bog drains. Locally termed the "Pine Hammock", the deposit embraces some 250 acres.

Large deciduous trees cover much of the "Hammock". Beneath the trees are deciduous shrubs and heath bushes. Coniferous trees are also present, and in the open stretches—the bog being drained for the most part by ditches—upland vegetation, such as blackberry is abundant. A small part of the bog has been cleared and is devoted to the culture of onions. Small amounts of peat are removed from the bog for sale. Pine trees were probably more numerous in the past than at present, since lumbering has probably affected the dominant vegetation.

In some parts of the bog the peat contains considerable quantities of alluvium. This is not shown in the samples taken, for the areas of high ash content are limited in extent and occur in the vicinity of the natural streams or of the drainage ditches that have been cut into the beds of the natural streams. For the most part the peat is of excellent quality (table 44). A cross section of the bog is illustrated in figure 32. Many other bogs are found in the region around Upper Macopin, but these deposits are similar to the

"Hammock", save for varying quantities of alluvial material that has been deposited by the streams.

TABLE 44

Profile of the "Pine Hammock" bog

Area 9, Field map 74.24–41.04

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, woody, forest peat containing some alluvial deposit	82.4	11.2	4.5
1–15	Dark brown, fibrous and spongy reed and sedge peat	90.5	5.6	5.4
15–16	Brown sedimentary peat containing plant material	92.2	11.7	5.5
16–17	Brown colloidal peat containing plant material	92.2	23.4	5.5
17–20	Brown sedimentary peat	89.4	58.9	5.5
20–22	Gray sedimentary peat and clay	58.3	91.5	5.3
22–23	Gray clay	....	....	...

[1] Nitrogen content, 2.82 per cent.

South of Pequannock River and extending to the terminal moraine, the Passaic range presents the aspect of a tumbled mass of hills. Many large and small lakes and peat bogs are situated at the bottoms of the short, disconnected valleys. In most cases, the bogs represent filled glacial kettles, but some of the larger bogs owe their origin to valley-damming or to alluvial sediments deposited by streams.

In the vicinity of Splitrock Pond, southeast of Marcella, a number of bogs have been formed either by the deposition of drift across the valleys or by the melting of stagnant ice, or by combinations of the two factors. Splitrock Pond owes its origin to the deposition of stratified drift. The majority of bogs in this vicinity contain considerable amounts of alluvial deposit in the nonaquatic strata, as indicated by the ash values which range from 10 to 40 per cent. One bog, which lies along the abandoned road crossing the northeastern tip of Splitrock Pond, half a mile or less from the tip, forms an exception and contains highly fibrous peat of excellent quality. These bogs are heavily forested, but do not ordinarily contain coniferous trees.

A second notable group of glacial-kettle lakes and bogs formed by the flooding of drift-dammed valleys, is found in the vicinities of

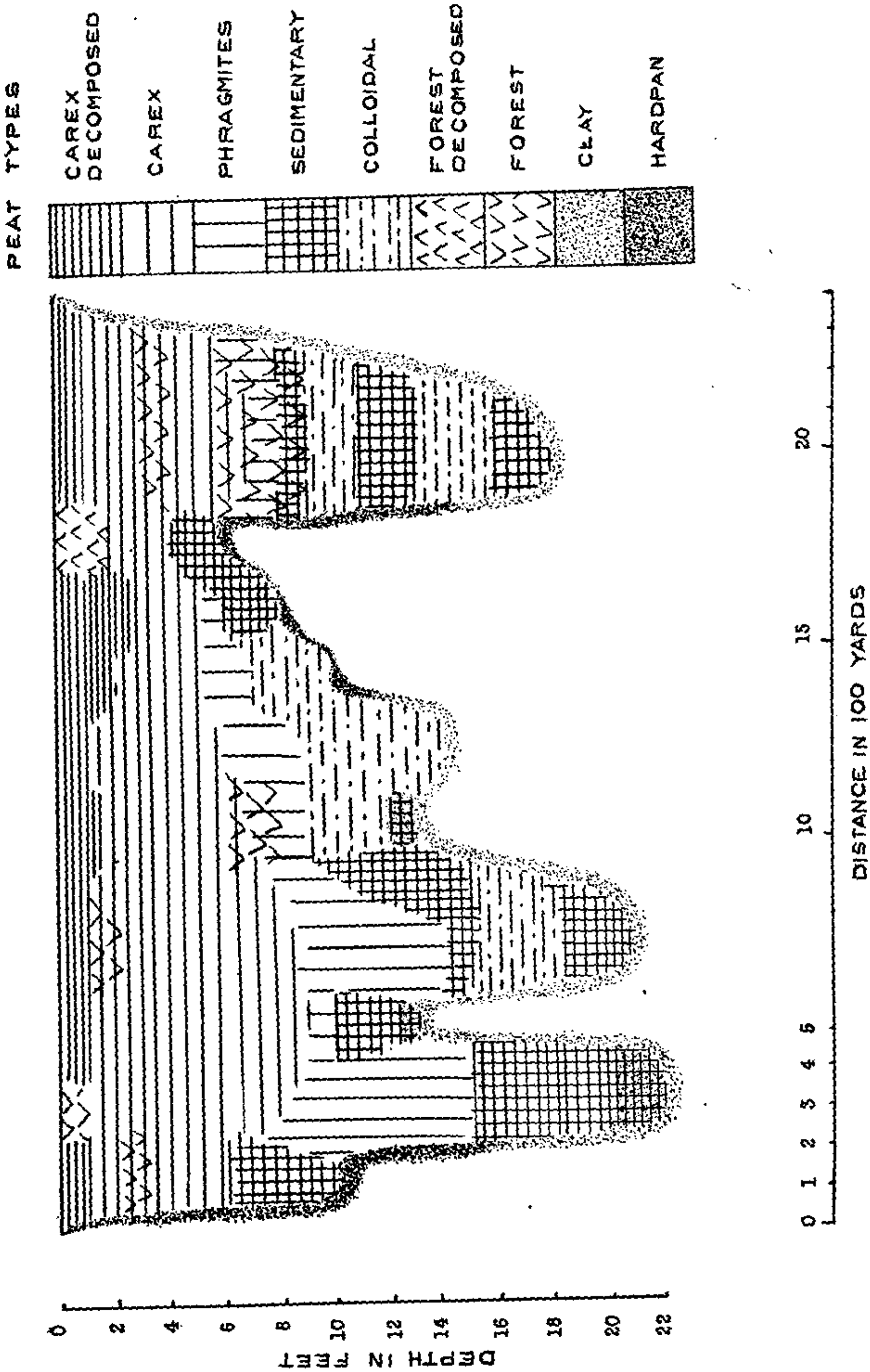


FIG. 32. Cross section of the "Pine Hammock" bog.

Mountain Lakes and Boonton. At Boonton there is a mile-long bog with a maximum depth of peat of 9 feet. In some parts of this and other bogs (table 45) much alluvial material has been deposited.

In contrast to the large bog at Boonton, the peat in a typical nearby kettle barely 400 yards long and 100 yards wide attains a maximum depth of 24 feet. The maximum depth of the nonaquatic peat in this bog is 16 feet. The ash content of the nonaquatic peat decreases from 7.5 per cent, in the surface stratum, to the extremely low value of 0.9 per cent in the sixteenth foot. The peat is of the forest type.

TABLE 45

Profile of bog north of Mountain Lakes

Area 1, Field map 74.28–40.52

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Black, well-decomposed reed and sedge peat and alluvial material	79.1	30.8	4.9
1–2	Dark brown, fibrous and matted reed and sedge peat and alluvial material	87.9	15.1	5.3
2–6	Dark brown, fibrous and matted reed and sedge peat	90.2	8.1	5.6
6–8	Dark brown, fibrous reed and sedge peat containing wood and alluvial material ..	85.4	32.4	5.5
8–9	Brown sedimentary peat containing wood..	81.0	54.4	5.7
9–10	Hardpan	....	....	...

[1] Nitrogen content, 2.34 per cent.

The most extraordinary cluster of kettles in the State of New Jersey is situated in the terminal moraine south of Mount Hope. The large bog east of Mount Hope has a maximum length of one mile and a maximum width of three-fifths of a mile. It was probably formed by the deposition of stratified drift, although stagnant ice may have played a part in this. South of this bog and occupying an area of approximately 2½ square miles, are at least 43 peat or water-filled kettles. These bogs have been surveyed, but many others known to be present were not examined. Drainage in this limited region is largely through the gravel, although some of the bogs are connected by streams. The large Mount Hope bog contains peat of good quality beneath the surface layer which contains considerable quantities of alluvium (table 46).

TABLE 46

Representative profile of Mount Hope bog

Area 6, Field map 74.32–40.54

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Dark brown, well-decomposed reed and sedge peat and alluvial material	85.5	28.5	4.6
1–11[1]	Dark brown, fibrous and matted reed and sedge peat containing wood	92.0	7.5	5.3
11–13	Brown, fibrous and matted reed and sedge peat	84.5	55.5	5.3
13–14	Brown or olive-green sedimentary peat ...	....	....	...
14–15	Gray clay containing plant residue	53.5	93.8	4.3
15–16	Gray sand and clay	....	....	...

[1] Nitrogen content, 2.36 per cent.

Much of the peat found in the kettles contains large quantities of wood, together with reeds, sedges, and alluvial material. In some cases, the peat may be considered to be of the sedge and reed type, whereas, in others, it is definitely alluvial. In virtually every case, however, the pH values of the peat are well below 6.0. In bogs containing some wood, the nitrogen values tend to approach the low values of the forest peats. The surface strata of some of the bogs unquestionably has been influenced by wash water from the mines in the vicinity, particularly from the grinding operations. In some instances, the entire bog has been covered with one or more feet of fine rock dust, which has hardened to such an extent as to be impenetrable to the sampling instrument. In one area (table 47), extremely low pH values were noted. A bog situated to the north receives such waters and has been filled by the solid material formerly in suspension; the clarified waters are then carried to the area under consideration.

The bogs containing large quantities of forest peat are similar to the large Mount Hope bog. The alluvial peats vary in ash content from 20 to 30 per cent. Many of the bogs are overlain with alluvial peat or even with mineral soil. Very few conifers grow on these bogs and the vegetation consists chiefly of deciduous trees and shrubs, together with reeds and sedges. On many of the bogs, where the water table is normally high, only reeds and sedges are found.

The South Branch of Raritan River occupies German Valley below the terminal moraine. Except at the headwaters on Succasunna Plain,

TABLE 47

Characteristic profile of glacial kettle in the terminal moraine south of Mount Hope

Area 8, Field map 74.34–40.54

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2[1]	Brown, well-decomposed reed and sedge peat	85.9	4.8	3.5
2–7	Brown, fine, fibrous and matted, reed and sedge peat	90.8	2.3	3.9
7–9	Brown, fibrous, reed, sedge, and sedimentary peat	89.5	17.4	4.1
9–10	Gray sedimentary peat and clay	....	....	...
10–11	Hardpan	....	....	...

[1] Nitrogen content, 1.64 per cent.

peat is absent in this valley until the Piedmont Plain is reached. Also heading in the Succasunna Plain is Black River, which merges eventually with the waters of the North Branch of Raritan River.

Black River parallels the South Branch on the northwest for about nine miles. Both streams flow southwest until Black River is joined by Tanners Brook and swings south to enter the cleft at Hacklebarney. The valley of Black River is filled, for 7½ miles of its length above Chester, by boggy meadows.

According to Salisbury,

> Apart from the Passaic system, the most obvious change in drainage within the glaciated area is that of the Black river, the present course of which is believed to be in some sense postglacial, for while the valley is pre-glacial, the drainage through a part of it has been reversed. The pre-glacial flow from the upper part of the valley was to the north, into the valley of the present Rockaway, somewhere near Kenvil. Just above the junction, the ice, and later its moraine, obstructed the drainage, and the waters were ponded above. They rose until they found escape over the low divide to the south. When the ice disappeared, the drift filling at the moraine and south of it had raised the surface there above the level of the channel leading south and the stream therefore continued to flow in that direction. . . . On Succasunna plains, in the upper part of the Black River basin, there are considerable deposits of stratified drift, which belong to the general class of overwash plains. The stratified drift here fronts the moraine interruptedly for about three miles and slopes off to the south, its material becoming notably finer in that direction. The plain is interrupted by various rock hills and ridges, which divide it into several parts. A small part lies west of the hill north of Drakesville, a larger part between this hill and the ridge northeast of Kenvil, and the largest extends from the moraine northeast of Kenvil, south to Ironia and beyond.

Peat is entirely absent from the boggy flood plain of Black River from its source until the plain widens between Ironia and south of

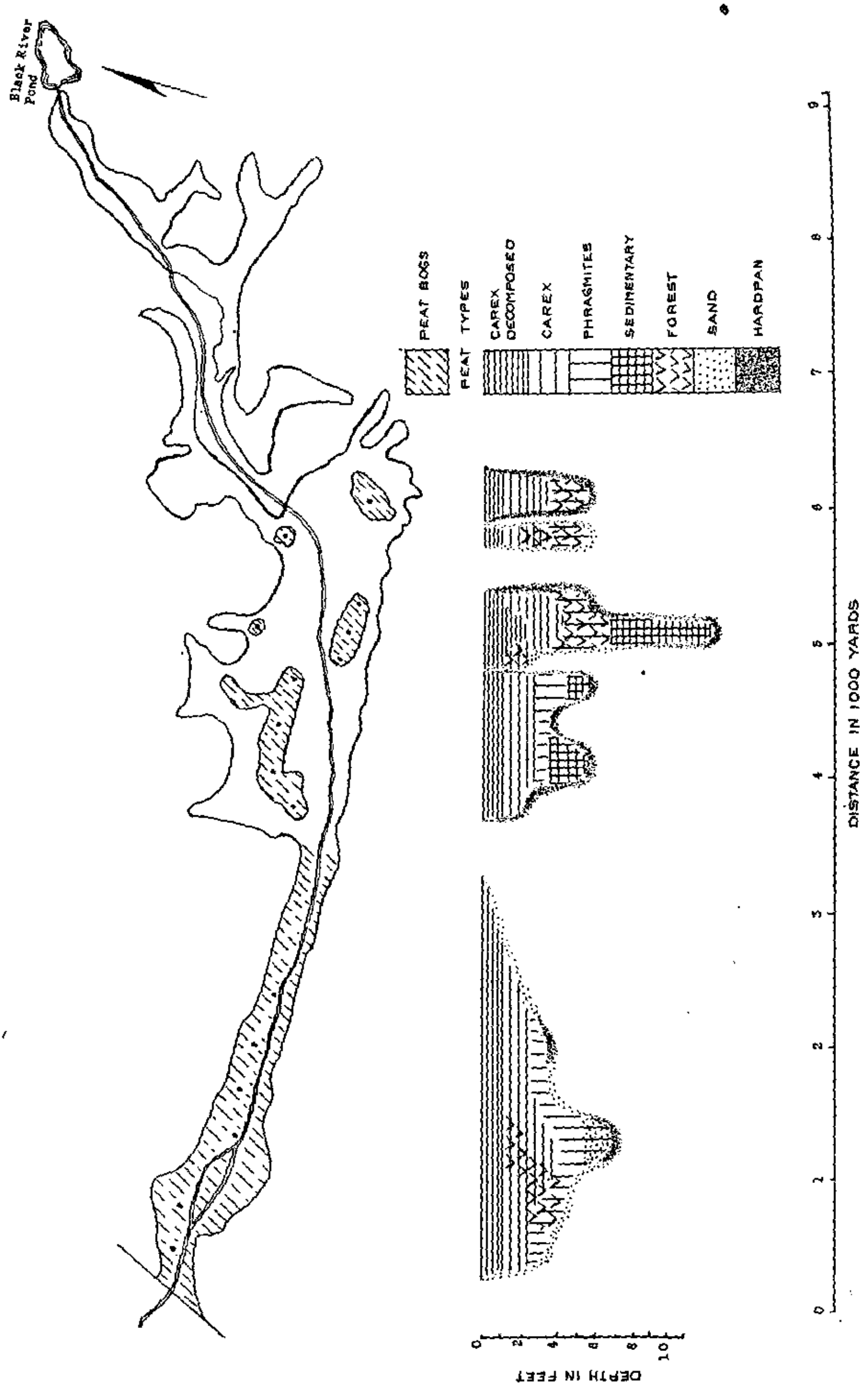


FIG. 33. Cross section of the flood plain of Black River between Succasunna Plain and Tanners Brook.

Horton's Station*. In this region the boggy land covers an area some 2 miles long and between three-fifths and four-fifths of a mile wide. Five peat pockets were found in this region, separated from one another by wide expanses of boggy, sandy soil. Below a point south of Horton's Station and extending nearly to Chester Station, the flood plain is filled with a shallow stratum of alluvial peat. Below Chester Station, to the point where the river bed becomes a narrow ravine, peat again is absent, although the flood plain widens in places to more than a quarter of a mile.

The peat deposits in the flood plain of Black River between Black River Pond and Tanners Brook, are shown in figure 33. Only isolated pockets of peat are found where the flood plain widens between Ironia and south of Horton's Station. The original valley was so completely filled by alluvium as to preclude peat formation except in its deeper portions. The flood plain, continuing to the southwest for about 2 miles is devoid of peat.

There appears to be little doubt that Black River, now flowing southwest, formerly flowed northeast. Tanners Brook, which formerly formed the headwaters of Black River, may indeed have filled the preglacial valley under discussion to nearly its present height, for, at present, the difference in elevation of the headwaters of Tanners Brook and the southwestern part of the Black River Valley is almost 200 feet; this difference was probably greater before glaciation. Much material must have been washed down by Tanners Brook and deposited in the wide, lower reaches, when drainage was to the north.

Parts of the Black River flood plain are covered with deciduous shrubby forests. The wetter areas contain reeds and sedges. The peat in the wide part of the plain is of considerably better quality than that in the narrow parts (table 48).

PEAT DEPOSITS OF WANAQUE VALLEY

Little peat is found in Wanaque Valley, most of which is narrow and rocky. Small kettles are common in the hills and in the small subvalleys set off from the main valleys, though even here drainage conditions have been such as to preclude the formation of peat in the majority of the wet areas.

Wanaque reservoir now fills much of the widest stretch of the Wanaque Valley and many small kettles are covered by this body of water. One such bog has barely escaped flooding and may be

* This and subsequently mentioned "Stations" were situated on a railroad that is now abandoned.

TABLE 48

Profile of northeastern part of Black River bog

Area 1, Field map 74.40–40.48

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2	Dark brown, well-decomposed reed and sedge peat	83.4	8.7	4.5
2–6[1]	Dark brown, fibrous and woody reed and sedge peat containing alluvial material..	83.5	32.3	4.3
6–11	Olive-green sedimentary peat containing plant residues	73.4	74.1	4.8
11–12	Hardpan	....	....	...

[1] Nitrogen content, 1.33 per cent.

considered typical of the whole valley (table 49). A characteristic decrease in ash content with distance below the surface is well shown in this bog. At least one bog has been found in which excellent subsurface peat is covered with mineral soil.

TABLE 49

Characteristic profile of a bog in Wanaque Valley

Area 3, Field map 74.20–41.02

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2[1]	Black, well-decomposed reed and sedge peat containing wood	86.4	13.3	5.5
2–14	Brown, fibrous and spongy reed and sedge peat	89.3	7.5	6.3
14–20	Dark brown or green, crumbly, reed and sedge peat containing wood	90.8	2.0	6.4
20–33	Olive-green sedimentary peat containing plant residues	82.2	72.9	6.3
33–34	Gray clay	....	....	...

[1] Nitrogen content, 2.95 per cent.

Conifers are found in limited numbers in some of the bogs in the valley, but for the most part deciduous trees predominate. Heath bushes are common. The pH values of the peats of the region range from 5.0 to near neutrality.

PEAT DEPOSITS OF THE HUDSON RANGE

The part of Ramapo Mountain in New Jersey forms a triangular mass 9 miles long and 4 miles wide at the State boundary, the apex of the triangle being at Pompton Station. The western slope is less precipitous than the eastern since the Wanaque Valley, which bounds the mountain on the west, is considerably higher than Ramapo Valley to the east. A complex system of rolling hills covers the top of the mountain and the comparatively slight amount of glacial drift that was deposited there sufficed to produce several small lakes and many peat deposits.

The majority of the peat bogs on Ramapo Mountain either are alluvial or have an alluvial stratum over sedge and reed and forest peat of good quality. Low hills separate the bogs which unquestionably were formed through the persistence of stagnant ice in glacial drift. Several groups of peat bogs are found on the mountain. The two larger members of one group were probably formed as a result of the damming of existing valleys by drift. The remainder of the bogs represent glacial kettles (figure 34).

The peat found in the larger bogs on Ramapo Mountain is of excellent quality as shown by analyses of samples from Bear Swamp (table 50) and the 35-acre bog situated in the same general region. The greatest depth in the latter bog is 33 feet, of which 17 feet is nonaquatic material. The pH values of the upper 17 feet of reed, sedge, and forest layers range between 4.4 and 5.9; the ash content between 2.2 and 6.3 per cent; and the nitrogen content from 1.91 per cent in the fourth foot to 2.34 per cent in the fourteenth foot.

TABLE 50

Characteristic profile of Bear Swamp, Ramapo Mountain
Field map 74.30–40.58

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–3[1]	Brown, woody, well-decomposed forest peat	88.5	10.0	5.2
3–14	Dark brown, fine fibrous reed, sedge, and forest peat	91.3	7.7	5.5
14–16	Brown sedimentary peat	89.8	6.8	5.6
16–18[2]	Olive-green sedimentary peat	89.8	44.8	5.2
18–22	Olive-green liver peat	....	....	...
22–23	Sedimentary deposit	....	....	...

[1] Nitrogen content, 1.96 per cent.
[2] Nitrogen content, 2.04 per cent.

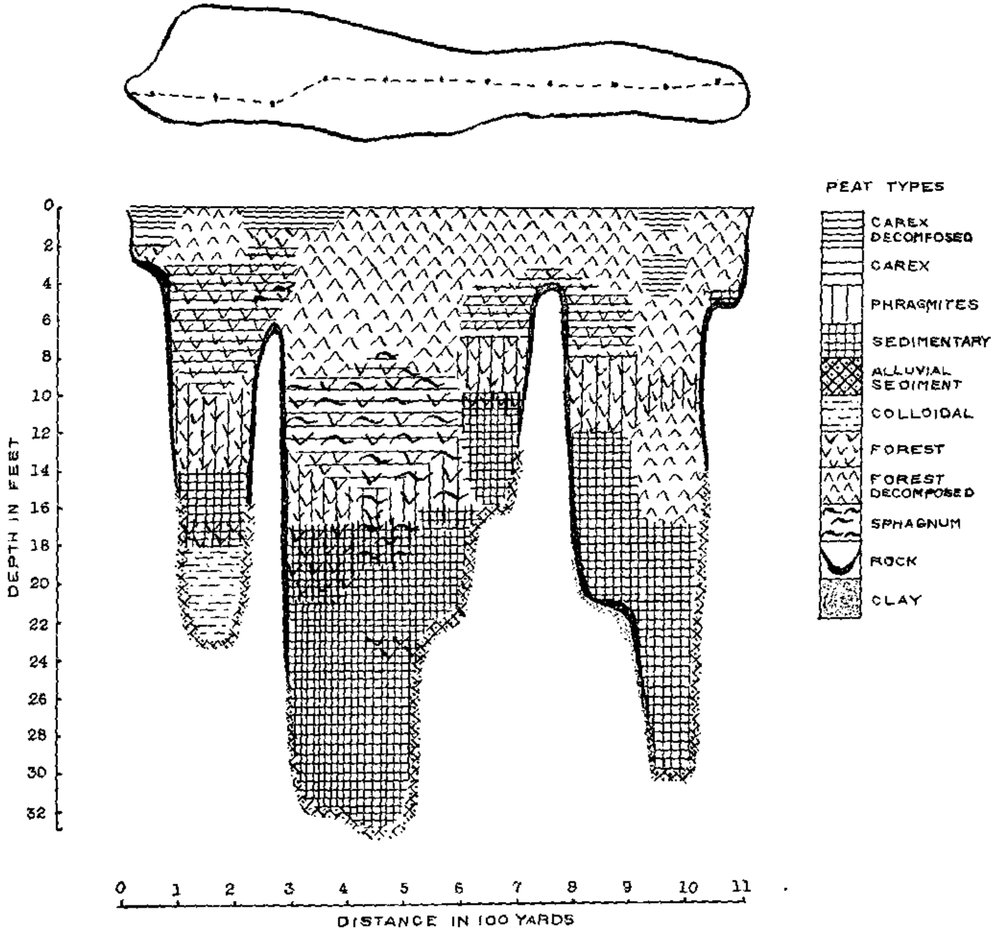


FIG. 34. Cross section of "Bear Swamp", Ramapo Mountain.

PEAT DEPOSITS OF THE PIEDMONT PLAIN

The geography of the Triassic Plain is described by Salisbury as follows:

The Piedmont plain is divisible into two parts, or sets of parts. The one is underlain by trap, the other by sandstone and shale. The subdivision is geographic as well as geologic, for the areas of trap are for the most part conspicuous ridges, often hundreds of feet above their surroundings of shale and sandstone. . . . The trap ridges are separated and surrounded by sedimentary rocks, the surface of which is in general much below that of the crests of the trap ridges. . . . The trend of the trap ridges is, in general north-northeast to south-southwest, with considerable departures from this direction north of the Passaic River. The greater relief features of the Triassic plain antedate the glacial period, or at least the last glacial period. The principal process in fashioning its topography was rain and river erosion. Under the influence of running water, the softer sedimentary beds were worn to lower levels, while the more resistant trap rock remained as conspicuous ridges. As a result of the pre-glacial erosion, the region between the moraine on the south, First Mountain on the west, and the Palisade ridge on the east, had been largely reduced to a lowland before the advent of the ice. The surface of this region was, however, by no means flat. The valleys were even lower than now, and the ridges probably higher, for the former were partly filled by glacial drift, and the latter were somewhat reduced by the erosion of the ice. Similarly a great area west of Second Mountain, the area now occupied by Great Swamp, and extending thence northeastward to the Passaic River and to Pompton, had been reduced to a low level by pre-glacial erosion. This lowland was shut in on the east, the north, and the south by trap ridges, and on the west by the Highlands.

The site of a former great glacial lake on the Triassic Plain, namely, Lake Passaic, is now largely filled by thousands of acres of peatlands. In its bed are four huge bogs, designated from south to north as "Great Swamp", "Black or Columbia Meadows", "Troy Meadows", and the "Bog and Vly Meadow". A fifth expanse of wet meadowland is called "Great Piece Meadow", but there is virtually no true peat within its limits. Large acreages of mineral flood-plain are also found in the vicinity of Great Swamp and between Second Mountain and the subordinate trap ridge to the north, as well as along the Passaic River generally.

It has previously been pointed out, in connection with other temporary glacial ice-dam lakes, such as Lake North Church, that even after the retreat of the ice, followed by drainage of the main body of water, smaller, shallower bodies of water were retained by glacial deposits for periods of time sufficiently long to permit peat to form. This also is true of Lake Passaic and the large peat bogs mentioned were formed in this same manner.

Great Swamp, including the associated smaller, isolated bogs, is contained in an area of some 20 square miles, bounded by Long Hill on the southeast, the municipalities of Chatham and Madison on the northeast, Green Village, Pleasantville and Madisonville on the northwest, and Lyons on the southwest. Low hills occur in this basin, and between half and two-thirds of the area consists not of peat, but of boggy, or even dry, water-deposited mineral soils. Only the eastern part of the basin contains peat, and this restricted area will be referred to in this report as "Great Swamp". This peat deposit has maximum dimensions of 4 miles from north to south, and of over 3 miles from east to west. Black Brook, which has been ditched, flows out of Great Swamp toward the southwest, joining Passaic River about 1½ miles north of Millington.

Great Swamp was formed in the remnant of Lake Passaic which, after the retreat of the ice beyond Little Falls, was retained by Long Hill on the south, by a system of hills on the west and north, and by the subaqueous outwash plain fronting the terminal moraine on the northeast. It is covered almost entirely by a forest of tall, dense, deciduous shrubs; only the wetter parts being devoid of trees. The entire bog is normally flooded at least once a year.

Stony material was deposited in and around Great Swamp, beyond the limits of the moraine, both by water and by floating ice. Consequently the peat of Great Swamp varies widely in quality. The depth of the bog is not great, ordinarily ranging between 1 and 12 feet to the clay or sandy-clay bottom. Table 51 gives the analyses

TABLE 51

Profile of southern part of Great Swamp, close to Long Hill

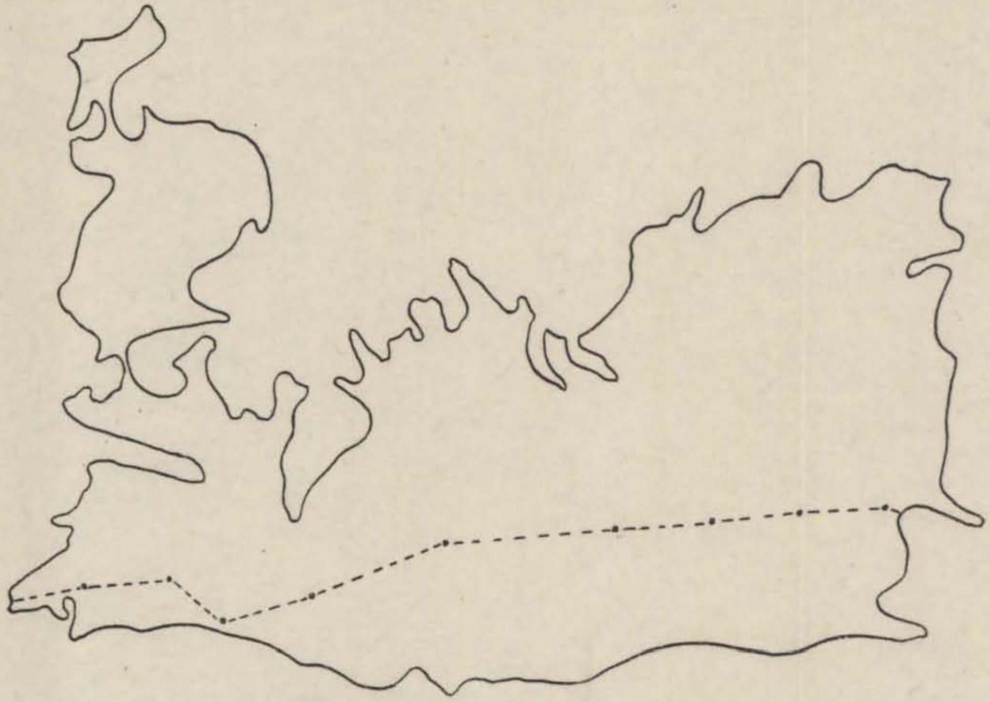
Area 1, Field map 74.28–40.40

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Black, crumbly, well-decomposed alluvium containing reeds and sedges	88.1	73.1	5.9
1–2[1]	Black, crumbly, well-decomposed reed and sedge peat	87.1	13.1	5.7
2–6	Brown, fibrous and matted reed and sedge peat	89.0	8.8	5.8
6–8	Brown, woody and fibrous reed, sedge, and woody peat	89.3	9.7	6.1
8–10	Brownish-green sedimentary peat containing wood	84.1	57.6	6.4
10–11	Olive-green sedimentary peat containing plant material	....	....	...
11–12	Green sedimentary peat containing plant residues and clay	....	....	...
12–13	Gray clay	....	....	...

[1] Nitrogen content, 2.82 per cent.

of samples taken at the extreme southern end of the bog. This part of the bog is close to Long Hill and it is probable that the surface wash from the steep slope is responsible for the very high mineral content noted in the top sample. However, since most of the basin is subject to heavy flooding, it is possible that this alluvial layer may have been formed during such flooding.

A second 300-acre portion of the bog projecting out into the silt-loam region of the basin is situated west of the main body of Great Swamp and is connected with it only by a narrow neck. It is



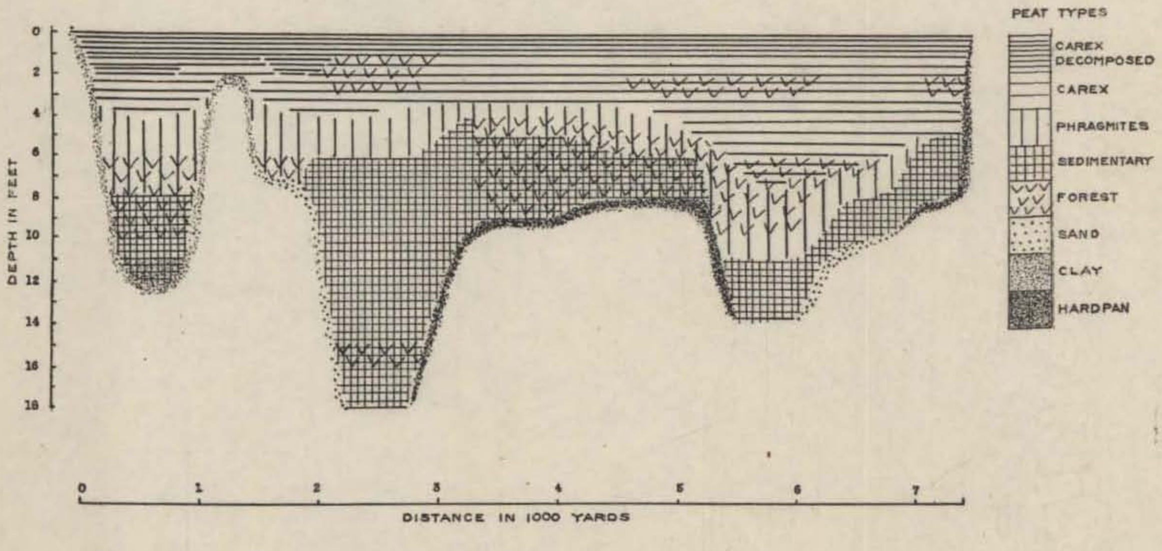


FIG. 35. Cross section of Great Swamp.

surrounded almost entirely by the silty plain and is subjected to repeated flooding. All peat strata in this shallow part of the bog are high in ash.

The northern end of Great Swamp receives the drainage (Loantaca Brook) of the region between Green Village and Morristown, 4 miles to the north. The peat in this part of the bog shows clearly the effects produced by the fluctuation of precipitation over long periods of time (table 52). As shown by the samples, the surface stratum

TABLE 52

Typical profile of part of Great Swamp receiving drainage of Loantaca Brook

Area 5, Field map 74.28–40.44

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Brown, crumbly, well-decomposed reed and sedge peat containing alluvium	80.8	39.9	5.6
1–2[1]	Brown, woody reed, sedge, and forest peat	89.3	6.2	5.4
2–5	Brown, macerated reed and sedge peat containing alluvium	89.3	16.0	5.6
5–6[2]	Brown, woody reed, sedge, and forest peat	87.7	7.0	5.6
6–7	Brown, fibrous reed and sedge peat	90.4	13.7	5.6
7–8	Brown sedimentary peat	87.2	45.8	5.7
8–11	Green, clayey reed and sedge peat	81.2	67.5	5.8
11–12	Gray clay containing plant material	48.3	92.3	4.5
12–13	Gray sandy clay	....	....	...

[1] Nitrogen content, 1.95 per cent.
[2] Nitrogen content, 1.62 per cent.

is high in alluvium, the first foot containing 40 per cent ash. The peat directly beneath it contains much wood and has an ash content of only 6 per cent. The ash then increases to 21 per cent in the third foot and decreases progressively in the succeeding strata until a content of 7 per cent is reached in the sixth foot, below which it again increases. It is interesting to note that the shallow aquatic peat stratum is underlain by reed and sedge peat containing much clay. The bog is deeper here than elsewhere, reaching a depth of 25 feet (figure 35).

Although depths of peat in excess of 18 feet are known to occur in the main body of the bog, the average is much less, approaching 5 feet. Great expanses of bog are known where scarcely 1 foot of alluvial peaty material covers the sandy clay subsoil. The surface stratum over most of the bog contains greater or lesser quantities of alluvial peat, the ash content of which ranges from 13 to more than 40 per cent. The more fibrous sedge and reed strata (all of which are likely to contain woody particles) contain between 6 and 20 per cent ash. The aquatic peat is everywhere mixed with clay, and in many cases is sandy as well.

The bog known as Black Meadows is north of the terminal moraine in the basin between Whippany, Florham Park and Hanover. Troy Meadows extend northeast from Black Meadows and lie between Whippany, Troy Hills, and Pine Brook. These two bogs persisted as a single or double lake, after Lake Passaic had been drained, mainly because of the stratified drift deposited between the natural hills of the region, thus blocking the drainage. Such drift extends along the eastern, the northern and at least part of the western borders of the bogs. Black Brook (not to be confused with Black Brook in Great Swamp) drains Black Meadows to the north where it joins Whippany River at the northeast corner of the bog. Whippany River there swings to the northeast, skirting the eastern edge of Troy Meadows and receiving its drainage. Troy Meadows end where the Whippany flows into Rockaway River at Rockaway Neck, only three-fifths of a mile west-southwest of the junction of this stream with Passaic River in Hatfield Swamp.

The peat areas of Troy and Black Meadows are separated by more than a mile of alluvial plain. It is considered almost certain that alluvium deposited by Whippany River is responsible for this separation. If this be true, then it would appear that originally, after Lake Passaic had been drained, one lake covered both Black and Troy Meadows and probably Hatfield Swamp and Great Piece Meadows also.

Black Meadows is 2 miles long and almost as broad. The peat found there is, on the whole, of poorer quality than that found in Great Swamp. The bog is not covered so uniformly by deciduous forest and large portions of it are devoid of trees, the vegetation consisting only of reeds and sedges, with a few scattered shrubs. The greatest depth of peat encountered in Black Meadows was 10 feet, the average being considerably less. The peat is of the sedge and reed type, containing varying quantities of alluvium. The section given in table 53 is typical of the whole bog. In common with many other shallow bogs of great expanse, aquatic peats are virtually absent.

Troy Meadows is 3 miles long and averages about a mile wide. The vegetation covering the bog is essentially similar to that found

TABLE 53

Characteristic profile of Black Meadows

Area 1, Field map 74.26–40.46

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, well-decomposed reed and sedge peat	68.7	23.9	2.71	5.6
1–2	Black, well-decomposed reed and sedge peat	80.6	17.6	3.84	5.6
2–3	Brown, fibrous reed and sedge peat containing wood	87.4	14.0	2.93	5.6
3–4	Light brown, fibrous reed and sedge peat	87.0	14.3	....	5.4
4–5	Light brown, crumbly reed and sedge peat	79.1	44.4	....	5.9
5–6	Light brown, fibrous reed and sedge peat	76.9	52.5	1.54	6.0
6–10	Light brown, granulated reed and sedge peat	74.7	62.3	....	5.7
10–11	Gray clay	56.8	86.0	....	6.0

on Black Meadows. The greatest depth of peat found in the area is 15 feet, but the average is of course much less. In some sections the sedge and reed peat is of good quality; in others, considerable quantities of alluvium are present. The profile taken in the southern section represents the best peat in the bog (table 54). A profile taken farther north shows that the peat contains more alluvium there.

Peat is virtually absent from Hatfield Swamp and Great Piece Meadows. The expansive river plain in Great Piece Meadows consists almost entirely of water-deposited mineral soil, though occasionally alluvial peat deposits are found. Such deposits are invariably present in long, narrow, tortuous basins, lower than the remainder of the plain, and undoubtedly represent obliterated meanders of the river, long cut off from the present stream.

The Bog and Vly Meadow, north of Lincoln Park, together with Great Piece and Hatfield, was possibly occupied by the same lake that covered Black and Troy Meadows. Peat of good quality is contained in the first-mentioned bog, and considerable acreage is devoted to truck farming. In many sections much alluvium is present, peat being virtually absent over a wide area.

TABLE 54

Representative profile of southern section of Troy Meadows

Area 1, Field map 74.24–40.48

Depth feet	Physical description	Moisture per cent	Ash per cent	pH
0–1	Brown, well-decomposed reed and sedge peat	86.4	....	6.3
1–7[1]	Brown, fine, fibrous and matted reed and sedge peat	89.8	10.3	5.9
7–8	Brown, coarse, fibrous and matted reed peat	91.0	5.4	5.9
8–9	Brown, coarse, fibrous and matted reed peat	88.5	45.5	6.2
9–11	Brown, gritty, sedimentary peat	85.0	62.5	6.2
11–12	Olive-green sedimentary peat	86.6	58.7	6.3
12–15	Olive-green sedimentary peat with plant material	84.1	68.5	6.3
15–16	Gray clay	....	....	...

[1] Nitrogen content, 2.36 per cent.

PEAT DEPOSITS OF THE HACKENSACK RIVER

Vermeule (101) presented the following description of the Hackensack and Newark Meadows, which, although written 45 years ago, is still essentially correct:

> The tide-marshes commonly known as the Hackensack and Newark meadows extend in a continuous belt about 18 miles long and with a general width of four miles, from Elizabeth northeastward to Hackensack and Englewood. The Newark meadows, lying between Elizabeth, Newark and Newark Bay, have an area of 7,289 acres, mostly within the limits of these two cities. The Hackensack marshes have a total area of 20,045 acres, of which 1,465 acres, lying between Hackensack and Wood Bridge is not tide-marsh, but fresh meadow. With this exception, the total of 27,334 acres is tide-marsh, lying at, or slightly above, the level of high tide. Occasionally an unusual high tide submerges the whole area, and it is always in a saturated condition. The marshes have a soil consisting, for the larger part, of blue mud or clay, but portions are the bottom of former cedar swamps, are of a peaty nature and contain many logs, roots and stumps. The depth of mud has been sounded by this survey. . . . By far the greater part shows a depth ranging between 10 and 15 feet, although there are considerable areas where the depth is only 4 to 8 feet, or even less, and also small areas showing over 20 feet. In its present condition practically all of this area is unproductive. It raises a luxuriant crop of coarse sedge and salt grass having little value.

Vermeule considered three methods for recovering this land, and to greater or lesser degree, all three methods have been used. These methods were: first, filling by dredging canals and utilizing the dredged material for fill; second, filling with city refuse; and third, diking. None of these methods has been used extensively, although the aggregate acreage of filled lands would be considerable. Filling with city refuse has been commonest practice. In many places the streams have been deepened by dredging, and the dredged material, as well as other fill, has been used to elevate the surface sufficiently to enable the construction of buildings. The dredged streams often provide water transportation to manufacturing plants.

When considerable organic matter is found in marshland, shrinkage follows embankment and drainage, but since there is little organic matter here, very little shrinkage occurs. Large areas are known which are diked marshland, but which do not have now the characteristics of such land. The slight amount of organic matter originally present has long since been decomposed by tillage.

These tidal meadows were unquestionably once partly covered by cedar forests. Evidence has also accumulated to indicate that the entire tidal region, with the exception of those parts that were in close proximity to, and subject to flooding by the saline tidal streams, may have constituted one or more cedar swamps. No part of the tidal marsh is entirely devoid of the reddish-brown woody peat characteristic of the cedar forest, although it would appear that in some instances, notably in the southern section, the groups of trees were separated by considerable expanses of marshland or by open water.

The basin of the lower Hackensack and Passaic Rivers is extremely well protected from the erosive action of the sea. It would appear that, following the melting of the Wisconsin glacier and the probable flooding of the region, the area containing the basin was uplifted to the point where cedar forests developed over a considerable part. Quantities of tidal-marsh peat may have been deposited over the clays of the last period of glaciation before the cedar swamps covered the region. Tidal marsh must have fringed the depression on the south, and it appears probable that over much of the Newark Meadows the stand of cedar was scant.

Subsidence must have followed for it is known that cedar forests are superimposed one upon another in several places, indicating flooding of the forest and subsequent regrowth of the same type of vegetation. Tidal-marsh peat is often found between the forest strata. It is to be expected that, if general subsidence of the land was responsible for fluctuating conditions observed in the peats of the depression, the last cedar forests to survive would be inland, removed from the immediate effect of the saline bay waters. This is found to be the case; for although living cedar forests are no longer found in the area, such forests were in existence around and north of Secaucus 40 or 50 years ago. The remnants of these forests are still to be found in the form of dead cedar trees, stumps and logs which cover the surface of the marsh.

There can be no doubt that the physical conditions of the region changed during the peat-forming period. In addition to the forest peat found in almost every section of the marsh, the surface strata are commonly higher in ash content than the lower strata. At first glance, this condition would appear to be exactly similar to that found in the upper reaches of the Wallkill, but there is a basic difference. Tidal-marsh peat is ordinarily high in clay; since this type of peat covers the surface of the deposit. In these tidal meadows, the underlying peat of a lower ash content often contains wood and in many cases consists of forest (cedar) peat. The peat types are quite unlike those of the Wallkill.

A study was made of one of the most recent of the cedar forests near Secaucus, a sketch and cross-section being given in figure 36. In the center of the area numerous stumps of southern white cedar are found on the surface, together with dead, standing swamp oak and living shrubs, briars, and vines. Surrounding this "island" is a second region on the surface of which are found numerous stumps, together with living small oaks, birches, and briars. This area is in turn surrounded by typical tidal marsh. On the surface, and 3 to 5 feet below, however, cedar stumps are found. The surrounding region is of tidal-marsh type, both in the living vegetation and in the deposit of peat, although occasional stumps are present.

Reconstructing the history of this area, it appears probable that the extinction of this cedar forest may have progressed as follows: whatever the adverse influence causing the death of the trees, the outer fringe was affected first as shown by the greater decomposition of the stumps (assuming the absence of stumps over a wide area can be attributed to this cause). Death of the trees progressed from the margins toward the center, the standing dead trees of the central zone being still alive half a century ago. It is apparent that a certain degree of recovery has recently occurred since the central zone now supports living shrubs and vines. Small oaks and birches are found in the surrounding zone, although living cedar is absent. This zone is in turn surrounded by tidal marsh reeds and sedges.

That the cedar forests stood over the lowlands for many years is indicated by the counts of the annual rings on certain cedar logs found in the vicinity of Kearny, some of which reached 200. The vegetation covering most of the marsh consists of reeds and sedges.

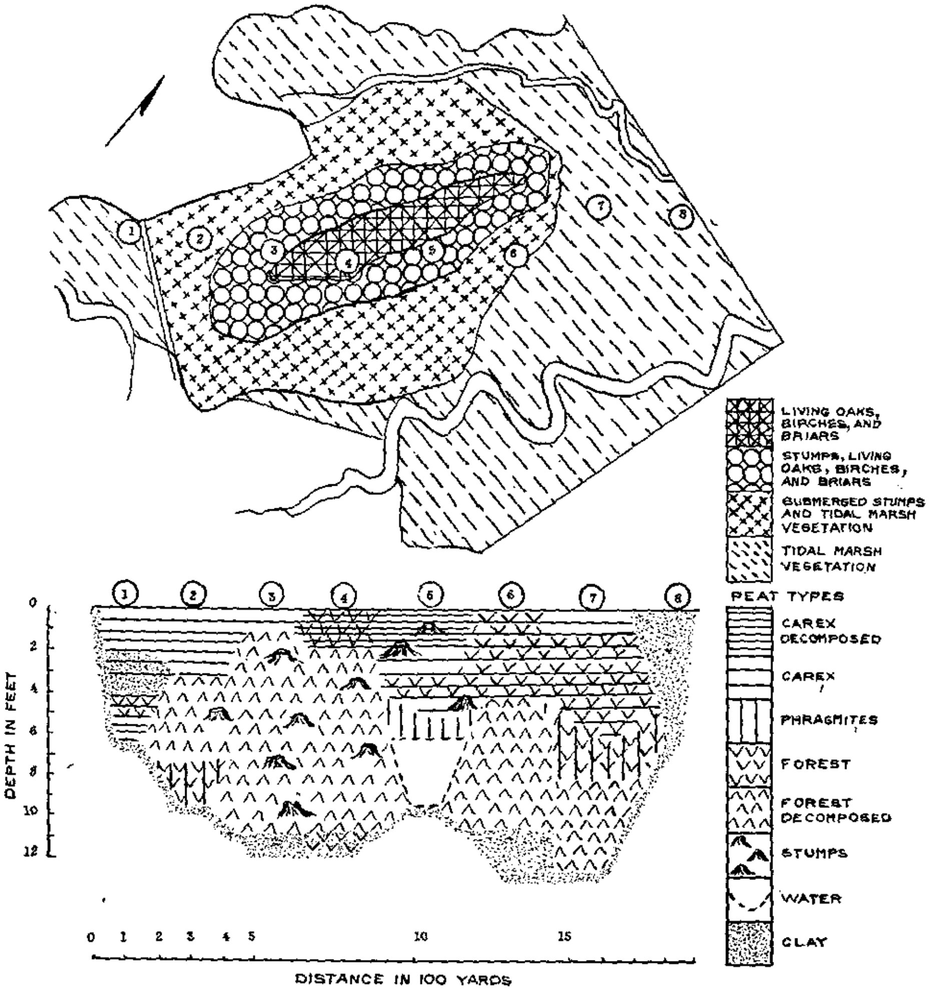


FIG. 36. Cross section of recent cedar swamp on the Hackensack Meadows.

Where diking has been resorted to and the land has been abandoned later, the high mineral areas, remaining above tide, have developed covers of upland vegetation. Two profiles obtained in different parts of the area bring out the degree of variation in the peat formations in this area as shown in tables 55 and 56.

The Piedmont Plain abounds in alluvial peats. A bog above Rochelle Park, north of the confluence of Sprout Brook and Saddle River, may be taken as a type. This deposit is part of a former lake which was 4½ miles long and 1 mile wide in the widest section. The alluvial part of the bog occupies 2¾ miles; the remainder, to the

TABLE 55

Composition of peat in the Hackensack Meadows west of Harrison

Area 1, Field map 74.08–40.44

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Brown, fine, fibrous reed and sedge peat containing wood	78.9	10.9	4.1
1–2	Brown, fibrous and matted reed and sedge peat containing wood	87.6	12.9	5.7
2–3	Light brown, macerated reed and sedge peat containing wood	90.5	14.7	4.5
3–4	Light brown reed and sedge peat containing wood and clay	76.2	63.0	4.9
4–5	Gray clay	....	....	...

TABLE 56

Peat profile in the Hackensack Meadows near Babbitt

Area 1, Field map 74.02–40.48

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, fibrous reed and sedge peat containing clay	80.6	50.0	4.9
1–2	Dark brown, fibrous reed and sedge peat containing wood	86.6	22.2	5.7
2–5	Red-brown, fibrous reed and sedge peat containing wood	90.3	16.2	6.4
5-6	Red-brown, macerated reed and sedge peat containing wood	91.3	15.7	6.5
6–7	Red-brown, macerated reed and sedge peat containing wood and sand	88.9	34.5	6.5
7–8	Gray sand	....	....	...

[1] Nitrogen content, 1.36 per cent.

north, is filled by the larger of the only two important peat deposits found on the Piedmont Plain. True peat is virtually absent from the alluvial part; although 10 acres of low-grade peat is found at the southern end. Alluvial material is present in all parts of the bog, which is nowhere over 4 feet deep. The peat may be described as a mixture of reed and sedge with wood and alluvial material. The ash content ranges from 20 to 70 per cent, and the pH values from 5.6 to 6.0.

The northern part of the depression, which forms the main source of Sprout Brook, is drained and cultivated, the principal crops being celery and spinach. This drained bog is probably the peat-filled site of stagnant glacial ice, the depression having sufficient depth after the melting of the ice to enable good peat to form (table 57, figure 37).

TABLE 57

Profile of cultivated bog near Ridgewood

Area 2, Field map 74.06–40.56

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Dark brown, granulated, well-decomposed reed and sedge peat containing wood	60.9	15.0	5.1
1–11[1]	Brown, fine fibrous and matted reed and sedge peat containing wood	89.9	5.4	5.5
11–13	Brown sedimentary peat	90.1	16.6	5.8
13–15	Olive-green colloidal peat	....	....	...
15–17	Olive-green sedimentary peat	....	....	...
17–18	Sedimentary deposit	....	....	...

[1] Nitrogen content, 3.22 per cent.

A second cultivated bog, 1 mile long and one-tenth of a mile wide, lies 5 miles to the northwest at Allendale, in a depression drained by a small tributary of Hohokus Creek. This bog is crossed by a glacial deposit that may be an esker. The peat is of excellent quality (table 58), and the same crops are raised as in the Ridgewood area.

Kettles filled by peat are numerous in some parts of the Triassic Plain, but in most cases the peat is of poor quality, the deposits comparing unfavorably in both quantity and quality with those in the Great Valley and in the mountains. The peats in the main drainage depressions of the plain are ordinarily of the sedge and reed type, liberally admixed with alluvium and containing some wood. In the higher parts of the plain, however, the bogs may be definitely of the forest type. Such peats are found in the vicinity of Franklin Lake, which lies between First and Second Mountains about 5 miles northwest of Paterson at an elevation of 417 feet above sea level. Even here, however, the upper strata, as well as some of the deeper material, may contain quantities of alluvium.

A bog a mile and a half long extends northwest from the southern end of Franklin Lake. It is bounded by the lake and high banks of

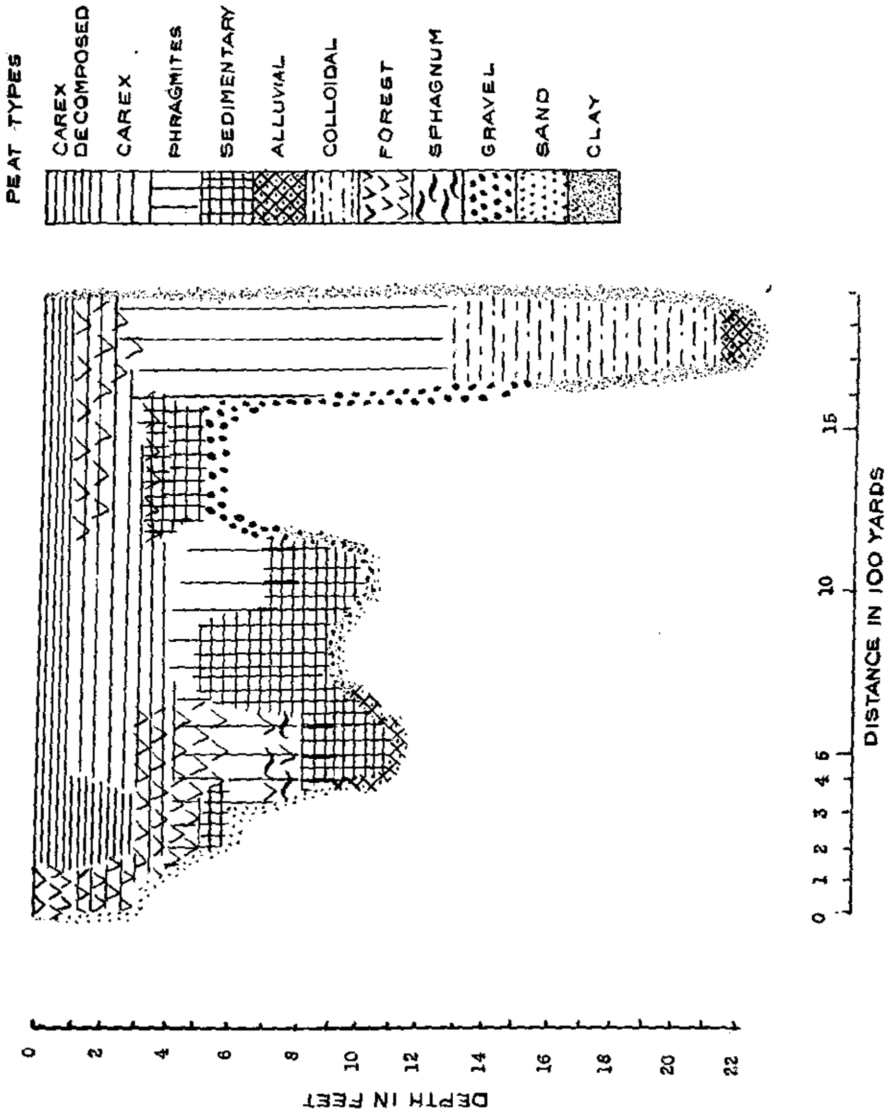


FIG. 37. Cross section of cultivated bog near Ridgewood.

stratified drift. The depths of peat encountered are impressive, considering that the maximum width is only one-fifth of a mile; and that in one borehole 39 feet of peat was found. The surface vegetation is similar to that of the northern mountain forest bogs, and the bog, being at lake level, is very wet and dangerous. The peat is mixed with alluvium in the upper few feet but improves markedly with depth until the sedimentary strata are reached. Large quantities

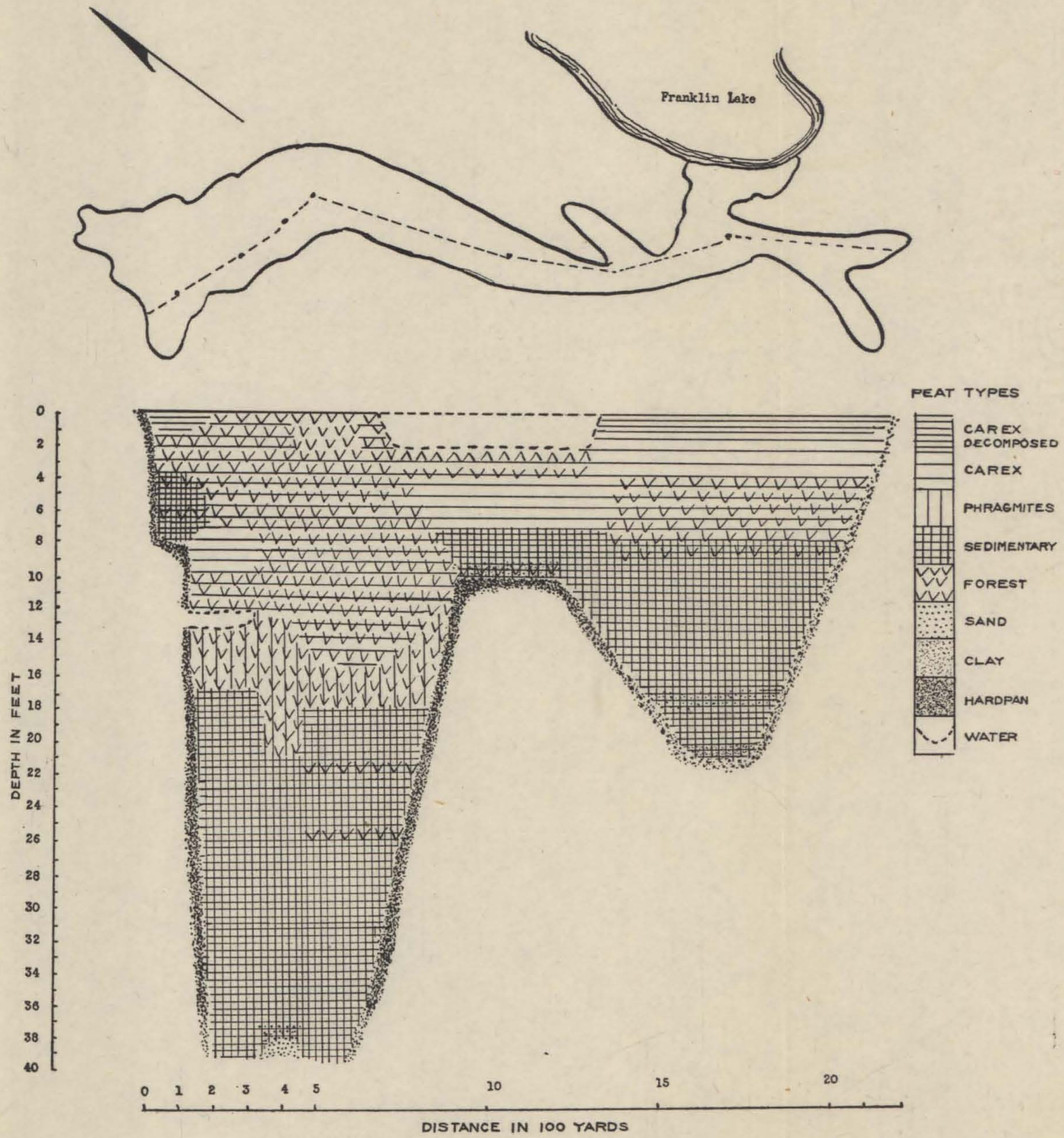


FIG. 38. Cross section of bog at Franklin Lake.

TABLE 58

Composition of peat in cultivated bog at Allendale, Bergen County

Area 1-A and 1-B, Field map 74.08–41.02

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Black, granulated, well-decomposed reed and sedge peat and alluvial material	79.1	28.5	....	6.1
1–5	Dark brown, coarse fibrous reed and sedge peat	89.7	8.3	2.70	5.7
5–10	Red-brown, woody forest peat ..	89.8	7.9	2.09	5.5
10–14	Brown, fibrous reed and sedge peat containing wood	91.0	11.5	3.25	5.4
14–16	Olive-green sedimentary peat ...	89.9	34.4	....	5.4
16–17	Chocolate colloidal peat	....	....	....	...
17–18	Olive-green sedimentary peat ...	....	....	....	...
18–21	Olive-green colloidal peat	87.4	43.3	....	3.6
21–23	Olive-green sedimentary peat ...	....	....	....	...
23–24	Olive-green sedimentary deposit	....	....	....	...

TABLE 59

Profile of bog at Franklin Lake

Area 1, Field map 74.16–40.58

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–2	Brown, macerated reed, sedge, wood, and alluvial material ..	90.1	34.5	2.15	5.3
2–7	Brown, fibrous reed, sedge, wood, and some alluvial material	95.2	13.8	....	5.3
7–18	Brown, spongy reed, sedge, and forest peat	93.4	6.1	2.55	5.3
18–19	Brown reed, sedge, forest, and sedimentary peat	93.3	13.2	....	5.6
19–26	Brown-green sedimentary peat containing plant material	91.0	34.3	....	4.8
26–35	Olive-green sedimentary peat ...	91.5	48.4	....	4.5
35–38	Olive-green sedimentary peat ...	77.6	78.3	....	3.7
38–39	Gray sand	....	....	....	...

of wood are present. The nitrogen content is typical of forest peats, as are the pH values which range from 5.3 at the surface to 3.7 in the 38 foot (table 59, figure 38).

Peat is virtually absent from the trap ridge of the Palisades. One exception is the 20-acre bog situated half a mile from the New York —New Jersey boundary and the same distance from Hudson River. Here the peat attains a maximum depth of 31 feet. The surface stratum is high in alluvium and has an ash content of 52.7 per cent and a nitrogen content of 1.69 per cent. Below this the peat is of fair quality, the ash ranging between 15 and 23 per cent, and the pH values from 5.3 to 6.0 and probably higher, since calcareous marl is found in some of the sedimentary strata.

CHAPTER IV

THE COASTAL PLAIN PEATS OF PREDOMINATELY FOREST TYPE

That part of New Jersey which lies south of a diagonal line extending from Trenton through New Brunswick and Woodbridge, is the Coastal Plain. This plain is drained by the southern tributaries of Raritan River which flow northward; Assanpink, Crosswick, and Rancocas Creeks, which flow westward; numerous streams towards the southwest in the Lower Delaware drainage region; Cohansey Creek, Maurice River, and Dennis Creek in the southern part of the plain; Tuckahoe and Great Egg Harbor Rivers, the Mullica River system, Toms River, and other streams in the Barnegat drainage region; and the Metedeconk and Navesink systems in the northeastern part of the plain.

PEAT FORMATION IN THE COASTAL PLAIN

Three major peat types are found in the Coastal Plain of New Jersey; namely, alluvial, forest, and tidal marsh peats. The tidal marshes fringe the coast, extending south from Hackensack to Cape May, then northward up the Delaware to the head of tide at Trenton. Most of the alluvial peats are found north and west of a line joining Asbury Park, Colts Neck, Farmingdale, Clarksburg, New Lisbon, Berlin, Malaga, Millville, Delmont, and South Dennis. The remainder of the plain constitutes the Pine Barrens in which most of the forest peats occur. Differences in fresh-water peats may be attributed in part to differences in topography. Except for Rancocas Creek, the streams flowing into the Delaware are short, and are contained within narrow valleys. On the other hand, those in the Pine Barrens occupy broad, shallow valleys, forming extensive bogs. The topographic differences are primarily due to the southeastward dip of the underlying strata.

Differences in peat type may also be caused by differences in the physical composition of the surface soils; the soils of the Pine Barrens containing relatively little clay, whereas the soils outside the barrens are heavier and contain much alluvial material.

Many of the differences between the bogs of the barrens and of the remainder of the Coastal Plain may be attributed to the preservation of the Pine Barrens, with its typical vegetation, as an island when the remainder of the Coastal Plain was submerged beneath the sea. The level, marginal plain that was developed as a result of the erosion of the Lafayette formation (the Beacon Hill of New Jersey) extended along the Atlantic Coast and became tenanted by a different flora of fairly uniform character from north to south. This flora has been described in detail by Harshberger (43).

The Metedeconk River and the subsidiary streams of the region flow wholly within the boundaries of the Pine Barrens, as do the streams composing the systems designated as Barnegat, Mullica, Tuckahoe, and Great Egg Harbor. Dennis Creek, Maurice River, and Rancocas Creek head in the Pine Barrens. The other drainage systems in the Coastal Plain are wholly outside the barrens.

The average depth of the forest peats in New Jersey was calculated to be 9 feet; however, many of the bogs are much shallower, and on the other hand, depths of more than 39 feet have been encountered. The forest peat bogs are underlain with sand or with clay and many of them rest upon a layer of aquatic peat. Since the nature of forest peats depends upon the nature of the tree growth, whether deciduous or coniferous, and upon the admixture of grasses or sphagnum, as well as upon the topography of the region and upon the composition of the waters, the forest peats in the different parts of the State vary greatly in nature.

FOREST BOG VEGETATION

Harshberger recognized a series of natural plant associations; three of these were said to be due to fire, repeated cutting of the forest, or to the conversion of cedar swamps and bogs into areas suitable for cranberry culture. In the order of their importance, they were classified as follows:

Pine-barren
Cedar swamp
Deciduous swamp
Savanna
Marsh
Pond
River bank
Bog
Plains
Cranberry bog
Scrub oak
Oak coppice
Mixed pine-oak

Further studies of the "cedar swamp" vegetation have been made by Stone (95), Moore and Waldron (69), and many others.

Many bogs in the Coastal Plain contain peats that can be classified with the sedge and reed types. They are usually much more acid than the corresponding peats in the northern part of the State, as shown in table 60. They are also shallower and tend to be much higher in ash. It is the forest peats, however, which, together with the alluvial peats and the salt marshes, form the characteristic peat types of this area.

TABLE 60

Sedge and reed peats in the coastal plain of New Jersey

Drainage region	Profile depth *feet*	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Barnegat	3	91.9	14.8	2.25	5.3
Barnegat	4	91.3	12.1	1.61	4.3
Barnegat	5	87.0	6.7	1.81	4.0
Barnegat	3	89.0	18.2	1.82	4.7
Metedeconk	3	85.6	17.4	1.32	3.4
Metedeconk	4	81.4	45.7	1.56	5.7
Mullica	3	85.2	22.8	1.61	3.5
Mullica	4	84.6	20.6	2.47	3.7
Mullica	4	85.9	14.6	2.23	3.8
Navesink	2	87.3	8.7	....	3.6
Rancocas	3	85.2	17.2	1.25	3.9

FOREST PEATS

The forest peats of the Coastal Plain have often been divided into the *cedar swamp* type and the *deciduous swamp* type. The forest trees and shrubs commonly found in the first are the white cedar, sweet magnolia, laurel, sweet hay, reed or swamp maple, smooth alder, sweet pepperbush, and others. In the deciduous forest, the pitch pine, white oak, and a variety of shrubs and ferns predominate. The white cedar is able to grow in wetter soil than are the ash, elm, and maple. The alder or willow may be the first of the forest vegetation to develop.

Most of the forest bogs are in a wild state and are covered with deciduous trees and shrubs, sedges, reeds, cattails, ferns, and some mosses; in some bogs, coniferous trees and sphagnum moss are rather abundant. The forest peats are characterized by the predominance of woody material. The woody layers occur at, or very near, the surface and are underlain with layers of sedimentary or sedge peats, or a combination of these. However, sedimentary peats are more commonly associated with forest peats in the glaciated northern part of the State where the depressions are of greater depth.

TABLE 61

Forest peats of the New Jersey Pine Barrens

Drainage region	Profile depth *feet*	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Cohansey*	5	85.5	9.0	1.57	3.7
Cohansey*	3	85.1	21.9	1.84	3.7
Lower Delaware	5	82.6	17.6	1.76	4.7
Maurice*	1	85.0	25.8	1.37	5.2
Maurice	5	87.0	19.4	1.97	5.2
Mullica	1	84.2	14.4	1.70	4.0
Mullica	2	89.5	14.0	1.76	5.3
Mullica	2	88.4	14.7	1.92	4.3
Mullica	2	86.7	5.6	1.45	3.9
Mullica	2	83.9	23.2	....	4.0
Mullica	2	83.9	24.0	....	4.1
Mullica	3	88.0	24.1	1.46	5.1
Rancocas	1	86.7	28.1	1.64	4.6
Rancocas	1	74.6	30.0	1.29	3.7
Rancocas	4	87.9	17.3	1.68	4.7
Rancocas	5	85.7	16.9	1.93	5.2
Rancocas	4	84.8	22.0	1.34	5.1
Rancocas	5	87.5	12.2	1.50	4.7
Rancocas	5	85.0	7.4	0.88	4.7
Tuckahoe	3	89.2	19.7	1.81	4.3
Tuckahoe	5	84.4	33.1	1.35	4.3

* Located outside the Pine Barrens.

Chemical analyses of some representative forest and sedge peats in the Coastal Plain are given in tables 61 and 62. The moisture content of these peats is relatively high, ranging from 75 to about 90 per cent. The nitrogen content is about 1.5 per cent and the ash is decidedly variable, ranging from as little as 4.9 per cent to as much as 60 per cent in the upper layers, the upper part of the profile being usually higher in ash than the deeper layers. These peats are rather acid, the pH values averaging about 4.0 in contrast to values of 5.0 to 6.5 in the northern forest peats. There seems to be a slight tendency for the pH to decrease with increasing depth.

The forest peat bogs of the Coastal Plain range in size from 4 acres to several thousand acres, and the average depth is only 2 to 3 feet. None of the areas are cultivated, except for the cranberry bogs. Unsuccessful attempts have been made in the past to use some of these lands for other forms of agriculture.

FOREST PEATS WITH SPHAGNUM LAYER

Although many bogs in the State have been described as sphagnum bogs, or sphagnum peats, none can be so designated in a true sense, since they cannot be compared with bogs of the highmoor type or

TABLE 62

Some typical peats of the Maurice River region

Size of bog	Depth of peat in bog		Organic matter, dry basis		Nitrogen dry basis	pH		Additional strata
	average	maximum	upper stratum	maximum		upper stratum	change with depth	
acres	*feet*	*feet*	*per cent*	*per cent*	*per cent*			
SEDGE AND REED PEATS								
388	2	6	84.6	84.6		4.3	increase	Forest
134	3	5	63.2	63.2	2.55	5.7	variable	Forest-alluvial
71	2	3	73.6	73.6		4.2	decrease	Forest
200	3	5	79.4	81.8	1.96	5.0	increase	Forest
FOREST PEATS								
312	1	4	65.9	65.9	1.85	4.6	increase	Fibrous
178	3	4	67.0	86.5	1.65	4.6	decrease	Colloidal
464	3	4	80.0	80.0	1.84	3.6	increase	Colloidal
170	3	10	90.4	90.9	1.56	4.4	increase	Fibrous
46	2	4	70.1	70.1		4.9	decrease	Alluvial
150	3	4	74.2	74.2	1.37	5.2		

even with bogs predominantly sphagnum in nature. At best, the sphagnum occupies only the surface layer of the bog, although it may be very abundant there. One can thus easily interpret the work of many botanists who have spoken of sphagnum bogs in the State of New Jersey. It is sufficient to illustrate this by an examination of the results of a recent peat survey made by Rigg (80), who described the Helmetta, Buckingham, Ongs Hat, and Forked River bogs.

In the Helmetta bog (area, 30 to 40 acres), a floating surface mat about 1 foot thick is underlain by 4 feet of water and by 2 feet of sedimentary peat resting on a clay bottom. The surface mat consists of a dense growth of *Chamaedaphne calycylata* with some *Sphagnum,* together with shrubs. *Sphagnum* plants were also found growing abundantly in the water bordering on one side of the bog. This bog is believed to have been developed by the formation of a mat on the surface of a shallow pond over a layer of sedimentary peat.

The Buckingham bog (area, 15 to 20 acres), is covered with living *Sphagnum* and other plants. A few small white cedars were the only trees observed. Borings have also shown remains of *Sphagnum* and other plants to a depth of about 18 inches, underlain by a foot of black sedimentary peat.

The "heath pond" near Ongs Hat was also believed to represent an early stage in the development of a sphagnum bog. *Carex bullata* was found to project a foot or more above the surface of the water. *Pinus rigida* and *Chamaedaphne calyculata* were abundant. *Kalmia angustifolia* and *Acer rubrum* were also found. Although much *Sphagnum* was found in the water, Rigg reported that "there was no evidence that it had formed any peat. The underlying peat consisted mainly of the remains of sedges, roots, and small stems, followed by a foot of black water sedimentary peat mixed with some macroscopic plant debris". It was concluded that "if the sedge continues to grow and fill up the pond with its living parts and dead remains, and *Sphagnum* continues to flourish, conditions will be favorable for the continued invasion of *Chamaedaphne* and *Kalmia,* and the pond will be thus transformed into a sphagnum bog."

The Forked River bog has a continuous cover of *Sphagnum,* extending to the river bank and forming hummocks. It formerly was covered by a forest of *Chamaecyparis thyoides,* which has been cut over. Young trees, 3 inches to 3 feet high, are present in abundance. As Rigg pointed out, "Beneath the living *Sphagnum* at the surface is two feet of general plant debris with much water in the second foot. Below this is sedimentary peat, black at the top and brown below, extending down to the sand."

These observations clearly substantiate the statement made previously that the *Sphagnum* associations came too late in the bog development of New Jersey to result in the production of typical sphagnum bogs.

CEDAR SWAMPS

Among the most interesting forest peat formations in New Jersey are the cedar swamps. They are characteristic of the Pine Barrens, where they may occur in several layers superimposed one upon another. An early student of American peats (55) wrote in 1867 that the cedar swamps

> . . . are common in all the counties south of Monmouth; but probably the most extensive are in Cape May, and the adjoining parts of Cumberland and Atlantic counties. The cedar-swamp creek, which runs in Tuckahoe river, and Dennis creek, which runs into Delaware bay, head in the same swamp; and the whole length of the two streams—a distance of seventeen miles—is one continuous cedar swamp. The wood is the white cedar. It grows on peat, and its roots run near the surface. In the present growth of standing timber, scarcely any trees are to be found more than one hundred years old; but these rest upon a formation containing we know not how many generations of trees which have lived and fallen before them. Large stumps are found frequently standing directly on other large logs, and with their roots growing all around them, and then other logs still under these; so that one soon becomes perplexed in trying to count back to the time when the lower ones were growing.

The cedar stumps were calculated to be at least 1,000 years old, as shown by nearly 1,100 rings of annual growth of a large stump attached to the trunk of a prostrate tree which in itself was 500 years old. Shaler (85, 86) believed that the cedar trees belonged to the genus *Taxodium*. He said that this genus was widely distributed in Miocene and Pliocene times. It was considered to be much more tolerant of swamp conditions than other forest trees, having developed a peculiar anatomical structure which fitted it ideally for growing in swamps. This species was looked upon as the last remnant of what was once a cosmopolitan genus. The northernmost point at which it was found was said to be central New Jersey. In this district, however, it was believed to be in its decadence, since it was much smaller than specimens buried in the swamps.

The effect of peat upon the life of the forest was described by Miller and Skertchley (67) as follows:

> Peat gradually creeps up the trunks of the trees and keeps them constantly cold. Eventually the peat moss, cold and wet, becomes so thick, that the trees will be chilled to the heart-wood. The sap will no longer be able to rise. The trees, which have long been languishing will die, and for years stand gaunt, leafless, and dead. The dry withered branches crack and fall with every passing

breeze. The trunks will rot at the surface of the peat, where they are exposed to the air and to continual moisture. Finally the trees will go down before the strong S. W. gales, and the peat, their destroyer in life, will become their preserver in death.

Alternate wet and dry periods, accompanied by gradual subsidence of the land brought about the development of the several layers. The dry periods were marked by forest growths and the wet periods by the formation of peat. It was emphasized that this must have happened five times at least in the history of the Fens, the five forests denoting five dry epochs.

The geological evidence that forms the background of the formation of submerged cedar forests, superimposed one upon another, has been the subject of much discussion. In 1857, George H. Cook reported on the subsidence of the land along the coasts of New Jersey and Long Island.

More recently, Johnson (48) made a detailed study of the problems of subsidence of land. He divided the botanical evidence of recent subsidence of the Atlantic Coast into three classes, as follows:

(1) fictitious appearance of changes of level; (2) phenomena produced by local changes in tidal heights without any real change in the general level of either land or sea; and (3) phenomena really produced by a sinking of the land, but produced so long ago that they cannot properly be cited as proofs of a subsidence within the last few thousand years.

The submerged stumps were believed to supplement the botanical evidence of subsidence, for such stumps are found along all parts of the Atlantic Coast at depths varying from a few inches below high tide to more than 10 feet below low tide level. Johnson said that a study of the submerged stumps convinced him that there were many ways in which their occurrence could be explained independently of coastal subsidence.

Bartlett (5, 6) submitted evidence from a peat bog at Quamquisset Harbor, near Woods Hole, of active recent subsidence. This bog occupies a glacial kettle and represents successive layers of vegetation continuously built up to the surface of a ground-water table that rose higher and higher as the land subsided. This subsidence required over 2,000 years, and is still in progress, the sea having recently cut into the bog deposit.

In spite of this seemingly conflicting evidence, both investigators agreed on the existence of earlier, if not more recent, subsidence.

In New Jersey, whole regions, as in Cape May County, were once covered by forests of white cedar (*Chamaecyparis thyoides*), which have been submerged, have emerged, and have been submerged again.

This procedure has been repeated several times and has resulted in a great accumulation of buried forests.

The relationships of the tidal marsh to the cedar swamp in southern New Jersey may be described as follows: tidal marsh has not been formed in exposed positions, either on the ocean side or on the Delaware Bay side. Protective barrier beaches invariably separate the marsh from the ocean, and, in exposed positions, these barriers protect the marsh from the waters of the bay. Tidal marsh may in turn be said to protect the cedar swamps, which are universally found inland, from the more exposed sections of the tidal marsh. In many instances the streams are tidal for considerable distances into the interior of the cedar forests, and, in such cases, tidal marsh is found along the banks of the streams. The juncture of tidal marsh and cedar swamp is ordinarily of interest because of the flora and the types of peat present. In a majority of cases, the marsh vegetation gives way abruptly to that of the swamp. The demarcation line may be as sharp as would be that of a windbreak planted in an upland meadow. In some instances, stunted cedar trees are found scattered in the marsh, forming a less distinct boundary. In most cases the trees bordering on the marsh or on tidal streams are dwarfed, and increase to full size with distance from the marsh or stream. In all cases, the cedar swamp vegetation is raised somewhat above the level of the tidal marsh or streams. Temporary flooding by fresh water coming from the uplands, apparently does not injure the stand of cedar. The swamp cedar flourishes at the immediate edges of fresh-water brooks; it has been observed in permanent shallow ponds, where the roots elongate to permit the tree to escape drowning. Fresh-water flooding, if long continued, results in the extinction of mature trees, although in many places a secondary generation prospers. Apparently any degree of flooding by saline water may result in the destruction of the cedar forest. The brackish water of the tidal marsh streams, and of those streams entering the seaward extensions of the cedar swamp, is kept within bounds by the flow of fresh water through the swamp. The balance between fresh and salt waters is most delicate, and this is apparently the most decisive single factor involved in the growth of the cedar forest. If, by reason of subsidence or other factors, flooding occurs, then the trees will die; but a new cedar forest may be imposed upon that which was destroyed if the shallow waters remain fresh. If saline water enters permanently, then tidal marsh peat is deposited over the forest peat. Once the tidal marsh has built above mean tide, cedar swamp may again appear.

FOREST PEATS IN VARIOUS REGIONS OF THE COASTAL PLAIN

In order to illustrate in detail the occurrence and nature of the forest peats in the Coastal Plain, several of the important drainage regions in that part of the State may well be examined. In many cases, there is considerable overlapping between the forest peats and the salt marshes, because of the simultaneous occurrence of both types.

Raritan. Only a fractional part of the Raritan drainage region is in the Coastal Plain. Tidal marsh is found below head of tide on the Raritan and subsidiary streams, but since the marshes to the south are more extensive and of greater interest, the minor marshes occurring along the Raritan will not be discussed. All of the fresh-water peats in this region are alluvial in nature or consist of mixtures of alluvial and sedge and reed peats.

Two of the numerous large, shallow bogs found in the Raritan region are near Dayton; one is situated 1½ miles to the northeast, the other an equal distance to the southwest. The former, known as Pigeon Swamp, is the main source of Lawrence Brook. It is 2½ miles long and has a maximum width of 1 mile; peat is found in only half this area. The greatest depth of peat is 5 feet, though in much of the bog the depth ranges between 1 and 3 feet, the material consisting of mixed sedge and reed and alluvial peat. The area is everywhere underlain by sand and clay and covered by deciduous forest.

TABLE 63

Profile of Monmouth Junction bog

Area 1, Field map 74.34–40.22

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown, well-decomposed reed and sedge peat	88.8	6.6	4.1
1–3	Brown, fibrous reed and sedge peat	87.9	9.8	4.7
3–4	Gray-brown alluvial peat and sand	....	....	...
4–5	Brown sand	....	....	...

[1] Nitrogen content, 1.51 per cent.

The second bog extends south from Monmouth Junction for 3 miles and has a maximum width of slightly over half a mile (table 63). It is covered partly by deciduous forest and partly by reeds and sedges. It drains into Millstone River. The northern half of the bog contains peat of good quality, the greatest depth being 4 feet; however, peat is absent in some sections, alluvium filling part of the basin. In the southern half of the bog, peat is found in only one small section.

Assanpink. The only important bog in the Assanpink region is locally known as Bear Swamp. It is situated on Assanpink Creek near Lawrence and is more than 1 mile long and one-half mile wide. Peat is found in much of the bog, although sand covers the southern part. The bog is shallow, the greatest depth of peat being 4 feet. Wood is found in some sections, but the peat is predominately of the sedge and reed type.

Crosswicks. The forest peat of the Crosswicks region contains large amounts of alluvium. These bogs have been used in part for the culture of cranberries. The common practice in cranberry growing of adding sand to the surface of the bog, together with the flooding in winter and draining during the growing season, has resulted, over long periods, in the disappearance of some of the peat. Throughout southern New Jersey abandoned cranberry bogs are numerous. Although many were abandoned because the cranberry plants were obliterated by improper culture or by lack of culture, in some cases abandonment may have been the result of loss of peat. The Crosswicks region includes three types of vegetation: cranberry bogs, white-cedar forest, and deciduous forest. The relationships involved in these associations are discussed in connection with the following region.

Rancocas. Rancocas Creek attains the greatest length of any Coastal Plain stream entering Delaware River, some of the tributaries heading approximately 15 miles from Barnegat Bay. Thus a large proportion of this drainage region lies within the limits of the Pine Barrens. Tide-water extends to Lumberton and Mount Holly, and the narrow basins of Rancocas Creek and its South Branch are filled with tidal marsh where the land has not been reclaimed for construction or other use. Southeast of Lumberton the South Branch divides into Haynes Creek on the west, Little Creek in the center, and Cedar Run on the east. Haynes Creek divides again near Medford, and the minor streams, dividing again and again, constitute a far-reaching bog system which is extensively utilized for cranberry culture. The divide between this stream system and that of the great Mullica River system which drains to the Atlantic Ocean, occurs near Braddocks Mill, the headwaters of the two stream systems originating in the same large cranberry bog. Little Creek rises in Bear Swamp, in the Pine Barrens, the main bog of which is 5 miles long and less than

1 mile wide. Cedar Run also rises in the Pine Barrens in an intricate bog system the chief member of which has dimensions of approximately 3 by 2 miles. Joining Cedar Run in the vicinity of Retreat, is Friendship Creek, which drains an involved bog system extending nearly to Chatsworth. In several instances, divides between the headwaters of the Rancocas and the Mullica occur in bogs.

South of New Lisbon is a bog measuring 3½ by 1½ miles, largely planted to cranberries. This bog drains directly to Rancocas Creek at Pemberton and into Cedar Run at Vincentown, by means of the quaintly named stream "Stop the Jade". The headwaters of the main stream of Rancocas Creek lie in a bog, devoted extensively to cranberry culture, which occurs between Whitesbog and Whitings. This bog is 7 miles long and 2½ miles wide.

A comparatively small part of Bear Swamp is devoted to cranberry culture; the remainder is largely covered by deciduous forest, although tracts of white cedar forest are found. Peat is virtually absent from the western half of the bog, but the eastern half contains a shallow stratum of forest peat heavily admixed with alluvium and ranging in depth from a few inches to 4 feet. Peat is absent in the shallower parts, the organic layer consisting of forest litter. In the deeper sections of the bog the macerated forest-alluvial peat contains 33 to 55 per cent ash; the nitrogen values vary from 1.02 to 1.75 per cent; and the pH values from 3.5 to 4.7.

Considerable portions of the wet depression along Cedar Run are devoted either to cranberry culture or to reservoirs holding water for the flooding of the cranberry lands. The wild part of the depression is largely covered by deciduous forest, together with fairly extensive tracts of white cedar. In the greater part of the depression the sand extends nearly to the surface, peat is absent, and only forest litter present. One to 6 feet of excellent forest peat, however, is found in some sections. Abandoned cranberry bogs are found in the region.

The large depression draining into Rancocas Creek near New Lisbon and into Cedar Run near Vincentown contains relatively little peat. Active and abandoned cranberry bogs are numerous. The wild part of the area is largely covered by deciduous forest, although some typical white cedar forest also occurs, particularly in the vicinity of Ongs Hat where it is at present being lumbered. The forest peat at Ongs Hat contains fairly high concentrations of ash (table 64).

The widespread lowlands drained by the Cranberry and associated brooks into Rancocas Creek, near New Lisbon, contain the Whitesbog cranberry bogs, some of the most important in the State of New Jersey. These have been in existence for many years and the peat

TABLE 64

Profile in cedar swamp at Ongs Hat

Area 1, Field map 74.32–39.54

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Brown macerated forest peat and alluvial material	87.5	27.3	5.0
1–4	Brown macerated forest peat	88.9	8.3	4.4
4–5	Brown macerated forest peat and sand	72.9	55.2	4.4
5–6	Gray sand	....	....	...

[1] Nitrogen content, 1.68 per cent.

in some of them, which must have been present initially, has disappeared as the result of drainage, flooding and sanding. Huge cedar forests are found in wild parts of the bog, notably in the eastern half. The towering white cedars form an impressive picture where the forest is fringed by active cranberry bogs. In these lowlands the peat varies from a few inches to 7 feet deep. Large areas of flood plain are devoid of peat, the sand reaching to the surface. The peat is representative of the southern white cedar forests (table 65).

TABLE 65

Profile in cedar swamp east of Whitesbog

Area 2, Field map 74.28–39.56

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Dark brown macerated forest peat	84.9	5.8	3.9
1–4	Dark brown macerated forest peat containing reeds and sedges	86.9	3.3	3.6
4–5	Dark brown macerated forest peat and clay	87.0	26.6	3.8
5–7	Dark brown macerated forest peat	89.0	8.7	4.4
7–8	Gray sand	....	....	...

[1] Nitrogen content, 1.47 per cent.

Cohansey. Forest peat is found overlain by tidal marsh peat almost everywhere in the Cohansey region. In one section of the land-locked marsh along Cohansey Creek, between Lanning's Wharf and Tindell's Landing, a narrow arm, barely 100 yards wide, extends to the north from the main body of the marsh. The peat in this arm extends below 30 feet (table 66), 12 feet of tidal marsh peat overlying 18 feet or more or fresh-water peat consisting of forest peat and stumps. One mile distant, at the southern edge of the tidal marsh, wood is found even in the surface material (table 67).

TABLE 66

Tidal marsh peat covering forest peat on Cohansey Creek

Area 2, Field map 75.18–39.22

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–12	Clay, containing reeds and sedges	65.0	84.1	5.5
12–22	Woody, reed and sedge peat	88.3	25.0	5.0
22–30	Woody, reed and sedge peat	86.5	28.0	5.0
	Bottom not reached	....	....	...

TABLE 67

Forest peat near edge of tidal marsh on Cohansey Creek

Area 1, Field map 75.18–39.22

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Macerated tidal marsh and forest peat	86.3	35.6	....	5.2
1–2	Macerated tidal marsh and forest peat	88.0	13.5	....	6.0
2–13	Macerated reed, sedge, and forest peat	92.6	6.1	2.19	5.0
13–15	Macerated reed, sedge, and forest peat and alluvial material	91.9	23.3	1.92	4.6
15–16	Sand containing wood	65.5	78.7	....	4.6
16–17	Sand	....	....	....	...

Maurice River. The fresh-water peats of the Maurice region range from a true forest to typical alluvial types, all gradations being present. The type of peat actually found depends upon several factors, among which may be mentioned the topography, the type of soil, and the plant cover. An example of one of the best peats found well within the limits of the Pine Barrens, is that of Centreton at the headwaters of Muddy Run (table 68). The occurrence of charcoal at various depths in this bog indicates the possibility that it was burned over during the peat-forming period. In other parts of this bog system large amounts of alluvium have been deposited, the ash value reaching 62 per cent in one instance. The bogs and the alluvial plain of Manantico Creek may be considered typical of the tributaries of the Maurice River which emerge from the Pine Barrens. Little peat is found above tide and that which is present is limited in depth and is heavily admixed with mineral matter, not differing from that of Muddy Run.

TABLE 68

Profile of Muddy Run bog

Area 1, Field map 75.12–39.30

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Forest peat	83.9	12.1	3.5
1–2	Forest peat	87.0	5.1	3.3
2–4	Forest peat	88.9	5.0	3.3
4–6	Forest peat	86.8	6.5	3.7
6–7	Sand	....	....	...

[1] Nitrogen content, 2.44 per cent.

The largest expanse of bog in this region is found north of Union Lake, above tide at Millville. The peat in this flood plain ranges in depth from a few inches to 10 feet. The ash concentration varies between 9 and 15 per cent and the pH values between 3.9 and 5.3. The nitrogen in the surface stratum is 1.56 per cent.

Buckshutem Swamp drains into Maurice River near Port Elizabeth. The peat averages 3 feet in depth; the ash varies from 14 to 81 per cent, the pH from 3.6 to 4.6, and the nitrogen in the surface material was found in two locations to be 1.65 and 1.84 per cent respectively.

From the head of tide at Millville, to Delaware Bay, woody peat is everywhere present, overlain by greater or lesser depths of tidal marsh peat. All of the land-locked marsh was reclaimed in the past but some of this has since been lost, probably through compacting and flooding. In that part of the river valley west of Port Elizabeth, 7 feet of tidal marsh peat and clay were found to cover 5 feet of woody and alluvial peat. In the same region, slightly above high tide, is a small bog consisting of fresh-water peat overlying tidal marsh peat, which, in turn, overlies fresh-water peat. The variation in pH values between the buried forest peat and the other strata is of interest.

Cedar logs in an excellent state of preservation are found in the vicinity of Port Norris where they have recently been mined in an area midway between that community and Mauricetown. In marsh-covered cedar bogs of this nature, more accurate information can be gained through the location of the stumps and logs by means of probing, than by means of the peat material obtained by sampling, inasmuch as the sound trees cannot be sampled readily by the usual means and only the material surrounding the trees can be obtained. The latter may consist of macerated remnants of the forest peat, perhaps heavily admixed with the clay coming from more recent tidal marsh deposits. Thus in a shallow section of the marsh which is being mined of its logs (table 69), 4 feet of clay covers a 2-foot stratum known to contain logs. Despite the presence of logs, the material obtained in one sample contained 43.6 and 54.1 per cent ash. The deeper strata were more representative of forest peat, the ash values being 25.0 and 16.2 per cent respectively.

TABLE 69

Profile in tidal marsh containing cedar logs

Area 1, Field map 75.02–39.16

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–4	Clay	....	....	...
4–5	Macerated reed and sedge peat and clay (logs present)	82.1	43.6	3.9
5–6	Macerated reed and sedge peat and clay (logs present)	82.3	54.1	5.2
6–7	Macerated woody peat and clay	87.6	25.0	...
7–8[1]	Macerated woody peat and clay	89.7	16.2	4.9
8–9	Sand	....	....	...

[1] Nitrogen content, 1.29 per cent.

The tidal marsh reaches depths of 40 feet or greater; it tends to thin near the edge of Delaware Bay, where shoals or barrier beaches apparently were formed at some time in the past.

Dennis. Great Cedar Swamp is situated at the extreme southern boundary of the Pine Barrens and constitutes one of the largest and potentially one of the most important cedar swamps in southern New

Jersey. Some 6 miles long and 1 to 2 miles wide, it extends to the tidal marshes of both Delaware Bay and Tuckahoe River. Approximately half of the bog is drained to the southwest by the headwaters of Dennis Creek, the remainder draining to the northeast by way of Cedar Swamp Creek. It contains forest peat of low ash content, to a maximum depth of 10 feet. The stratum adjacent to the sand bottom tends to consist of an admixture of sand and clay. In spite of the extent of the bog, the analytical results obtained from a single profile are quite representative (table 70). Great Cedar Swamp appears to constitute a remnant of the huge white cedar forests which may once have fringed the State and which are now, for the most part, buried under many feet of tidal marsh peat and sand.

TABLE 70

Profile of western portion of Great Cedar Swamp

Area 1, Field map 74.50–39.10

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Forest litter and forest peat	86.7	8.9	3.8
1–3	Forest peat	87.2	2.8	3.4
3–6	Forest peat	88.0	8.1	3.6
6–9	Forest peat	84.0	37.7	4.4
9–10	Forest peat	74.6	51.2	4.8
10–11	Sand	....	....	...

[1] Nitrogen content, 1.48 per cent.

Tuckahoe and Great Egg. Above tide limits, which extend far inland, a typical bog, possibly representing a former stream bed, is separated from Great Egg Harbor River by low sand ridges. It contains forest peat which varies considerably in quality. In the northern part of the bog the ash content is low; whereas towards the south, the alluvial material is high, having probably been carried there by the several small streams which enter this area (table 71).

Babcock Creek enters the Great Egg Harbor River at Mays Landing. Several bogs are found along this stream and its branches, and the peaty material does not appear to differ from that found in other bogs of this region. Near the juncture with Great Egg Harbor River, the depth of the forest peat reaches 6 feet, with a clay and sand bottom.

TABLE 71

Profile in Great Egg Harbor River bog

Area 1, Field map 74.46–39.28

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1[1]	Macerated forest peat	94.5	10.4	4.5
1–3	Macerated forest peat	91.9	7.5	4.4
3–5	Macerated forest peat	89.6	12.5	4.3
5–6	Macerated forest peat	88.5	17.4	4.6
6–8	Macerated forest peat and sand	89.4	37.4	4.6
8–9	Gravel	....	....	...

[1] Nitrogen content, 2.12 per cent.

Deep Run enters the Great Egg Harbor River two-thirds of a mile south of Weymouth. It heads 8 miles to the west in Landisville, flowing through peat bogs of the forest type for the entire distance. The bog is much wider than those to the south, the greatest width being 1 mile. It contains, at least in part, excellent forest peat to a depth of 9 or more feet. The surface vegetation is chiefly deciduous, but large groves of white cedar also occur.

Approximately 3 miles north of Weymouth, adjoining Great Egg Harbor River, are the cranberry bogs of the Atlantic Cranberry Bog Company. These are part of a large system of bogs, mostly in a wild state. Extensive cranberry bogs are also found just north of Mays Landing, adjacent to the main river. These bogs, as well as those of the Atlantic Company, have been in use for many years, and the forest peat which was once present has been destroyed or obliterated by such use. A large part of the wild bog west of the cultivated lands is devoted to the storage of water for the flooding of the cranberry bogs. East of the Atlantic Cranberry bogs, the peat in the wild area ranges from 4 feet to a few inches of forest litter; it is largely alluvial. South of the Atlantic bogs, the peat, wherever it occurs improves in organic content. Peat is not found throughout the area, large sections containing only forest litter.

The peat found in the bogs along Watering Race Branch is of better quality than that in most of the other bogs in the watershed of the Great Egg Harbor River. Peat of good quality is found also in the headwaters of some of the smaller streams, as, for example, 2 miles north of the Atlantic bogs. Here the mineral content for the

2 upper feet of forest peat is little over 5 per cent. The nitrogen content is 1.45 per cent.

The quaintly named "Penny Pot Stream", heading in a large bog near Winslow, flows through extensive bogs, partly used for the production of cranberries, and enters the Great Egg Harbor River near its junction with the equally oddly named "Hospitality Branch". This is a many-branched stream heading near Janvier. The main and tributary streams flow through narrow shallow deposits of forest-alluvial peat. Some parts of the stream contain sand covered to only a slight depth by forest litter. This is particularly true of the region near the Great Egg Harbor River, peat of fair quality being found in the stream headwaters. As is commonly the case, the cranberry bogs contain no peat. The peat of this area varies in ash content between 7 and 80 per cent or more. The nitrogen varies from 1 to 2½ per cent. The average pH values are about 4.0, although in one instance a value of 2.0 was encountered.

The Great Egg Harbor River flows through bogland from a point near Berlin, a distance of 17 miles from the fork of Hospitality Branch. South of the fork of Big Bridge Branch the flood plain is narrow, but above this stream the bog widens to almost a mile in some places. In the narrow terrace above the river, peat is absent or consists largely of alluvium. Where the valley is wider, the character of the peat changes; the alluvium largely disappears, and forest peat takes its place. Close to the main stream, the peat contains considerable ash, but this decreases away from the river. Thus, near the entrance of Squankum Branch, 50 yards from the river, the ash contents of the first and second feet are 35 and 79 per cent respectively, whereas the peat in the low ground separated from the river by a sand ridge several hundred yards wide, contains at the same depths, only 19 and 44 per cent ash, respectively. Still farther from the river, the ash in the upper 3 feet averages only 12.5 per cent, the nitrogen content is 2.47 per cent, and the average pH is 3.9.

Farther up the Great Egg Harbor River the quality of the forest peat improves slightly. In the vicinity of Broad Lane, the upper 3-foot stratum averages only 8 per cent ash. Still farther north, above Four Mile Branch, the ash content of the peat increases to 14 per cent in the vicinity of Sicklertown. The percentage of mineral material increases with the approach to the headwaters of the river, reaching 62 per cent south of Berlin.

Mullica. The Mullica River flows through extensive tidal marshes from Green Bank, at the head of tide-water, to Great Bay. In many places, wood of the white cedar type is found in these marshes under tidal clays and peat; in some instances, it is buried to a depth of 15 or 20 feet. White cedar and soft-maple bogs extend down the many smaller streams entering the main river, and, sometimes, well out into the tidal marsh. Thus, Wolf Run and other streams drain an extensive cedar swamp west of Tuckerton which forms a broad peninsula extending 1½ miles from the mainland. Farther west, Bass River rises in and drains more than 5 miles of cedar swamp and cranberry bog. North of New Gretna, the Merrygold and Ives Branches of Wading River drain a complex cedar (partly maple) swamp. The forest peat in this bog is of good quality, and the average depth of peat is greater than is commonly found. Cranberry bogs, for the most part long abandoned and overgrown, remain as evidence of former agricultural use.

One of the most notable bogs in southern New Jersey is along the west bank of Wading River. It is more than 5 miles long, has a maximum width of 3 miles, and bulges deeply into the tidal marshes of the Mullica and Wading Rivers. Abandoned cranberry bogs are found near the latter. Cedars, maples, and tidal marsh plants intermingle at the edge of the salt marsh, and the scattered, stunted forest plants gradually assume height and dominance away from the river. The area is not entirely occupied by peat; the sand rises to or above the surface in many localities. The part of the bog adjacent to the tidal marsh appears to be better drained than that lying farther inland. The streams entering the bog have considerable fall. In the spring and summer this survey was made the peat was exceedingly dry to a depth of at least 2 feet. Here, over a region of hundreds of acres, the cedars have been recently cut and the stumps have rotted to a marked degree. This decomposition can probably be attributed to the excellent drainage, for in the wetter areas of the cut-over cedar swamps the stumps may persist for many years. In this dry bog, the organic stratum appears to consist of fibrous forest litter rather than of true peat, but the layer of litter is of far greater thickness than is normally encountered in the forests of the region, averaging over 2 feet. It appears probable that the forest litter can be readily removed and might possess value for the mulching of acid-loving plants.

The greatest depth of peat encountered in the cedar swamp was 10 feet. In one typical profile, the 6 feet of forest peat covering the sandy bottom averaged 6 per cent ash and 1.63 per cent nitrogen, with a pH of 3.7. It is of interest to contrast these values with those of the peat found in the adjacent tidal marsh. At one location, for example, 5 feet of tidal marsh peat, with an ash content greater than

The stream called "Head of Tranquillity" enters Wading River from the east at a point 3 miles north of Harrisville. Three miles of cranberry bogs fill a large part of the basin of this stream. Sand, sometimes covered lightly by forest litter, is commonly found in the wet depression. When peat occurs, it is mixed with considerable alluvium and its maximum thickness is only 5 feet. The ash content ranges between 17 and 83 per cent, and the pH between 3.2 and 3.7.

Shoal Branch of Wading River joins the latter at Speedwell and extends almost to Union clay works, 8 miles distant. Cedar forests line the main stream and its tributaries. Peat is not found everywhere, but where it occurs it may be of good quality, although extremely acid. One profile, 4 feet deep, had an ash content of 9 to 12 per cent and pH values of 2.0 to 3.8. The nitrogen content of the surface stratum was 2 per cent.

A bog 5 miles long with a maximum width of 2 miles occurs east of Chatsworth, Jones Mill, and Speedwell. Peat is virtually absent from this flood basin, which is largely covered by deciduous forest. A large bog, lying along Gates Branch and 2 miles north of Chatsworth, contains 1 or 2 feet of forest and alluvial peat.

Four miles south of Speedwell, Shoal Branch is joined by a stream flowing from the north. Along this stream and its tributaries, for a distance of 7 miles to Harris Station, are found cedar forests and cranberry bogs, both productive and abandoned. Little peat is present, however, and sand fills the valley bottom.

Along the west bank of Mullica River, southeast of Batsto and northwest of Chestnut Neck, are found extensive cedar, or cedar and maple swamps. South of Green Bank, these bogs fringe the tidal marsh, which contains cedar stumps in many locations, both on and below the surface, showing that the marsh has encroached on the forest.

Mullica River divides into several branches in the vicinity of Batsto of which one, Batsto River, rises at Hampton Gate, far to the north, in a fan-shaped series of large cedar and deciduous swamps which are utilized to a considerable extent for cranberry culture. Another, Atsion River, rises near Piper's Corner and flows in a southeasterly direction through cedar swamp and sandy flood plain. The Mechescatauxin Branch flows through a great expanse of bog-land, 15 miles long and attaining a width of 1½ miles, the headwaters rising in the region between Chesilhurst and Braddock's Mill. Only a small part of this is underlain by peat, however, for sand rises to and above the surface in much of the region. Productive cranberry bogs are numerous and there are also many abandoned bogs.

45 per cent, is superimposed upon 9 feet of forest peat, averaging only 16 per cent ash: The pH values were 5.7 and 6.3 respectively.

The average depth of peat in the tidal marsh is greater than that of the peat in the wetter parts of the cedar swamps. The latter, however, is deeper than the peat in the drier parts of the swamp.

A large cedar swamp drains into Wading River from the northeast, in the region between Bridgeport (now called Wading River) and Harrisville. Part of the northern end was once a cranberry bog, but has long been abandoned. North of Harrisville and along the whole length of Oswego River and its branches, are extensive and interesting cedar swamps. At Harrisville a factory was once located in which paper was manufactured from the reeds or sedges that grew in the marshes of the vicinity. Ascending the river from Harrisville, one finds the cedar swamp spotted with peat, sand displacing the peat in many places until the Pappoose Branch is reached. Just above this point large cranberry bogs and their associated water storage ponds are encountered, and the peat areas become larger as compared with the pure sand areas. The broad expanse of bog in the vicinity of Martha contains more peat than sand, the greatest depth of the forest peat being 4 feet. North of this region, peat is virtually nonexistent until Penn Place is reached. In the vicinity of the large cranberry bog previously cited, the forest peat may reach depths of 7 feet (table 72).

TABLE 72

Profile in cedar swamp on branch of Wading River

Area 1, Field map 74.26–39.44

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–1	Forest peat	88.0	12.9	1.58	3.6
1–3	Forest peat	92.9	10.8	....	3.7
3–5	Forest peat	88.7	8.9	....	3.7
5–7	Forest peat	88.9	7.1	1.17	3.7
7–8	Sand	....	....	....	...

In the vicinity of Cedar Grove, the peat maintains its depth but is admixed with considerable quantities of alluvium. The first 3 feet of a 6-foot profile contained 29, 37, and 46 per cent ash, respectively, with pH values of 4.4, 3.9, and 4.0. The nitrogen content of the surface material was 1.94 per cent.

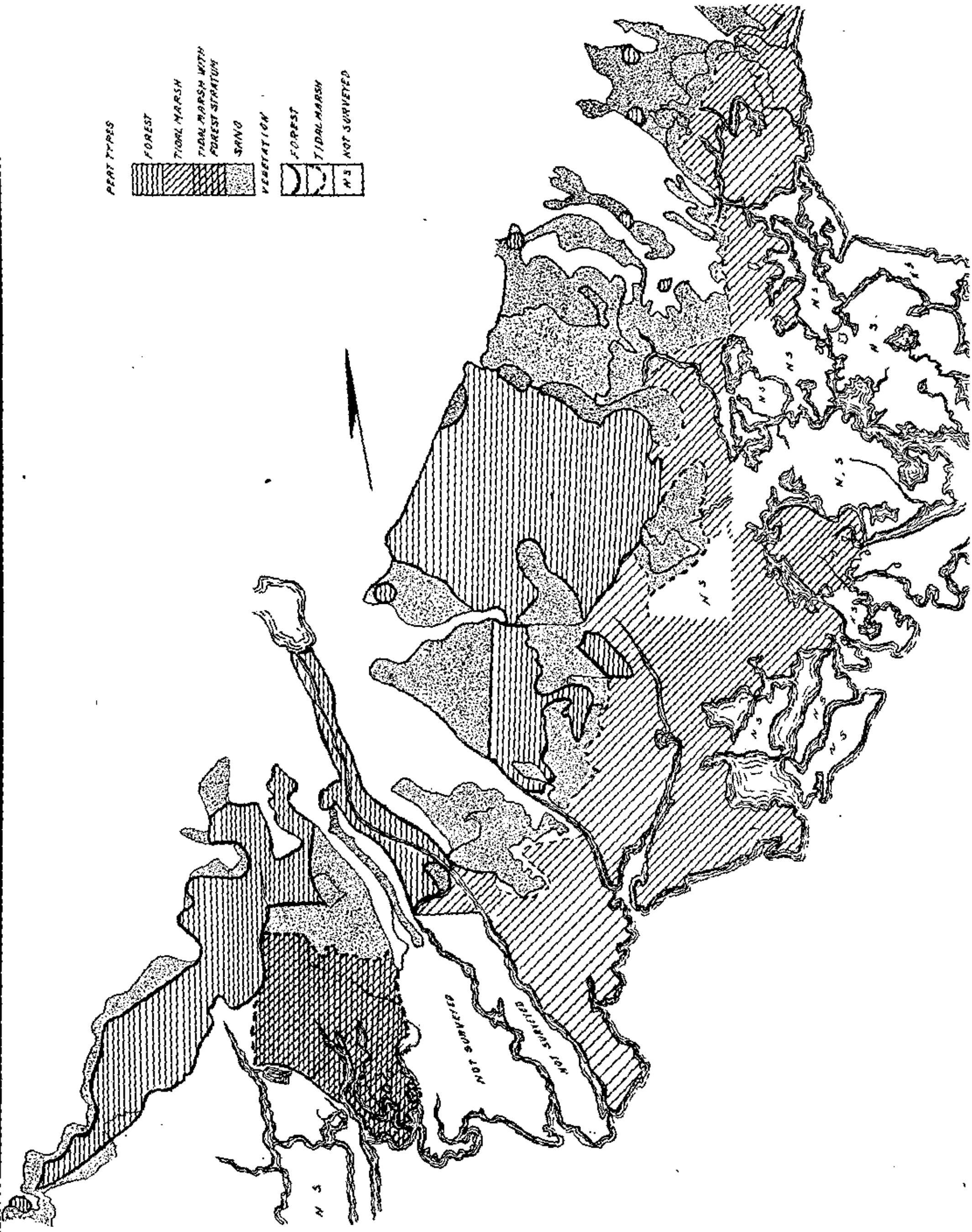


FIG. 39. White cedar forests and tidal marsh; region between West Creek and Barnegat.

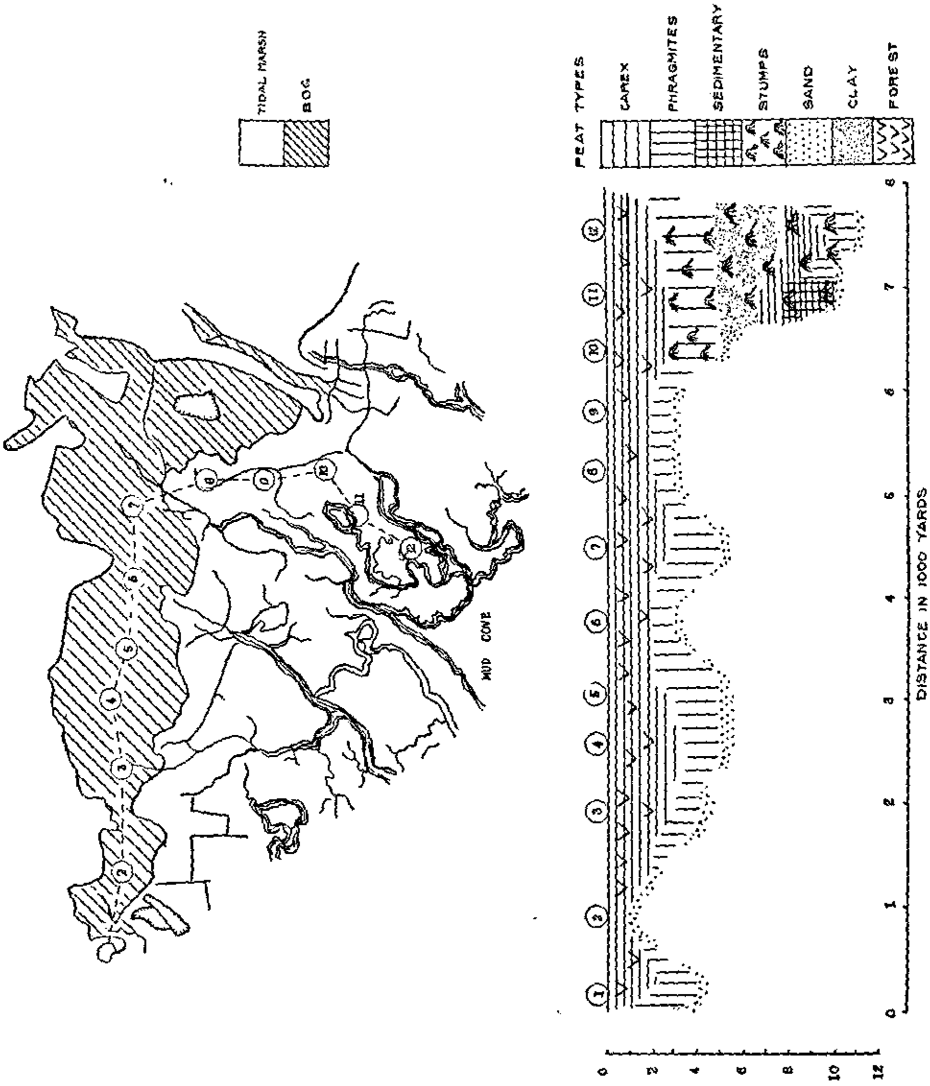


FIG. 40. Cross section of white cedar swamp and tidal marsh between Mayetta and Mud Cove.

An almost unbroken expanse of white cedar forest fringes a region between West Creek and Barnegat having a length of 8 miles and a maximum width of 2 miles. Cedar logs and forest residues are encountered under the tidal peat in many places, showing that the forests were much more extensive in the past than now. In the vicinity of Mayetta, for example, submerged logs are found from the edge of the forest to Mud Cove, a distance of nearly 2 miles. The cedar forest peat in this region has a maximum depth of 6 feet. The upper strata may contain alluvium (ash in one instance 13 per cent), and the lower strata very little ash (2 to 5 per cent). The nitrogen content is less than 2 per cent and the pH values range between 3 and 5. The tidal marsh peat, even where stumps are encountered, is apt to be very high in clay (50 to 85 per cent ash). The nitrogen values are correspondingly low (figure 40).

North of Manahawkin, where the white cedar forest is 2 miles wide, the depth of the forest peat may be greatly in excess of that of the tidal peat (table 73). This is further illustrated in figure 41.

TABLE 73

Profiles in Manahawkin cedar forest and tidal marsh

Areas 1 and 2, Field map 74.14–39.42

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
	CEDAR FOREST			
0–2[1]	Macerated forest peat	90.4	11.2	4.6
2–6	Macerated forest peat	90.0	4.7	5.0
6–7	Macerated forest peat	89.8	8.1	5.7
7–11	Macerated forest peat	90.4	7.9	6.0
11–12	Sand	....	....	...
	TIDAL MARSH			
0–2[2]	Tidal peat and clay	79.2	61.2	4.8
2–3	Tidal peat and clay	83.6	50.0	4.8
3–4	Tidal peat and clay	75.5	53.0	5.4
4–5	Sand	....	....	...

[1] Nitrogen content, 1.85 per cent.
[2] Nitrogen content, 1.07 per cent.

The narrow streams which flow into the coastal white cedar forests and tidal marshes are almost invariably separated from the coastal waters by dams. These may impound lakes or may serve merely to permit flooding of cranberry bogs during the winter months. In most cases a whole series of low dams, many of them earthen, are found at various levels ascending the stream. In some cases, cranberry

FIG. 41. Cross section of white cedar swamp and tidal marsh between Mayetta, Beach View, and Flat Creek.

bogs have been abandoned, but the former reservoirs remain as lakes.

Barnegat. Cedar Creek, entering the bay near the Village of Cedar Creek, may be considered typical of the streams of the Barnegat drainage region south of Toms River. Much of its course is through white cedar forests. There are extensive cranberry bogs at Double Trouble, above which the stream forks into the Middle and Factory

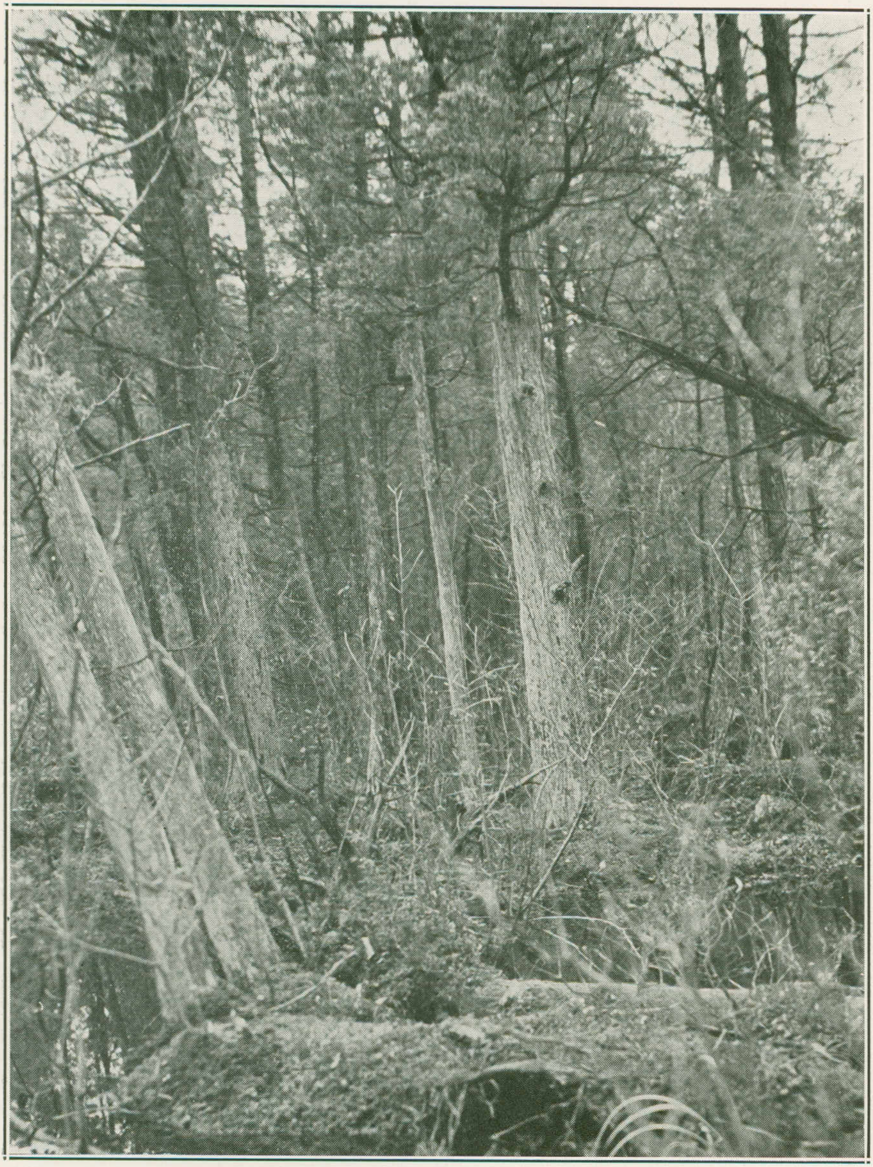


PLATE XIV. Typical white cedar forest on the Lower Plains.

Branches. Most of the forest peat along this stream and its tributaries is fairly deep (8 feet) and of excellent quality. The ash varies only between 3 and 20 per cent, even though some of the tributaries flow through sand banks. The nitrogen content ranges from 1.75 to 2.25 per cent, and the pH from 3.0 to 5.0 (plate XIV).

The most important peat deposits along Toms River are in the headwaters of Ridgeway Branch. Toms River and such subsidiary streams as Union Branch, Daves Mill Branch and Manapaqua Branch, possess narrow flood plains which are filled chiefly with alluvium. Only a little peat is found along the streams of this system. Cranberry bogs, both abandoned and productive, are fairly numerous. Both cedar forest and deciduous forest are found along the streams of this system, which lies wholly within the pine-barren region.

Even along the several branches of Ridgeway Branch, where, for a distance of 6 miles, cedar or cedar-deciduous forests occur along the broad, flat valley, peat is present only in places. Where it occurs it may attain depths of 7 feet. The ash content may be as low as 5 per cent; the pH ranges between 3.0 and 4.0; and the nitrogen is usually below 2 per cent.

Metedeconk. The Metedeconk has relatively little tidal marsh along its shores, the largest area being that which extends south to Kettle Creek. Many of the long, narrow valleys in which the intricate network of streams flow contain forest peat that is high in organic matter, but some of the streams flow through alluvial beds or peat deposits, the surfaces of which are composed of alluvium.

A tidal stream enters the Metedeconk at Wardells Neck. It rises almost 3 miles to the north and flows through mixed cedar and deciduous forest until it enters the marsh. The tidal marsh peat contains large quantities of clay and sunken logs. Some of the strata are typically forest, modified by tidal clays after submergence. The white cedar forest peats in the higher levels of the basin are found to attain depths as great as 6 feet. Here the stream has covered the peat with alluvium. A profile 4 feet deep, showed for the surface stratum 93 per cent ash; for the second foot, 25 per cent; and for the third and fourth, 16 and 48 per cent. Downstream the alluvium appears to have been exhausted, for in one profile, 5 feet deep, the ash content was less than 10 per cent at all depths. In this same profile the nitrogen varied between 1.58 and 1.75 per cent, and the pH from 4.1 to 6.0.

CHAPTER V

SALT MARSHES AND ALLUVIAL PEATS

The salt marshes in New Jersey have long attracted the attention of the naturalist and the practical farmer. It was not until the end of the last century, however, that attempts were made to throw light upon the origin and nature of these formations.

The peat formations in the salt marshes occupy a unique place because of the long and indented coast line which they fringe. The rivers bring down to the sea large quantities of sediments and when these come in contact with the salty waters, they are precipitated and especially the colloidal particles. A characteristic association of plants develops in these areas and, in time, they are converted into a high ash-containing peat. This type of peat formation is aided by the barrier beaches which the sea continuously builds up, as well as by the slow subsidence of the land. The process is also aided by the action of the tides which supply a large part of the inorganic materials in the peat.

The term "marsh" was intended to designate a low, wet, treeless area, usually covered by standing water and supporting a growth of coarse grasses. Marshes have been subdivided into (a) tidal marshes, broad stretches of low-lying and almost treeless land along the coast which are inundated by rising tides, and (b) fresh-water marshes, near the heads of tidewater estuaries where fresh water is backed up over the marshland by each rising tide (11).

The nature of the accumulated material in tidal marshes shows little variation. The surface layer usually consists of a matted, partly decomposed mass of plant material, commonly consisting of eel-grass and roots, which is filled with grayish silt or clay. This accumulates and gradually a soft sticky mud or clay is produced which constitutes the main portion of the subsoil (11).

FORMATION OF SALT MARSHES

According to Chapman (19), two theories gradually evolved to explain the formation of salt marshes along the Atlantic Coast: (a) Shaler's (85) and (b) Dawson and Mudge's (71). According to Shaler's theory, the lagoons become silted and covered by eel-grass which induces further silting; thus the ground finally becomes high enough for marsh grasses to grow out from the shore. No movement of the coast in relation to mean tide level is involved, and the depth of the marine marsh deposit cannot be more than the maximum tidal range except where there are local depressions in the subsurface. Dawson and Mudge's theory is based on coastal submergence. According to this theory, the gradual accumulation of material continues during the process of submergence, thus enabling marshes to develop. The depth of the marsh deposit in the older parts tends to be more than the maximum tidal range, and gradual transitions are found between salt marshes and fresh-water peat formations.

A large number of factors which control the flora and fauna of the salt marshes, as well as the rate of decomposition of the plant residues and the nature of the resulting peat, enter into the formation of salt marshes. Among these factors, the following have received the greatest attention (65, 19): salinity, tides, drainage, aeration, water table, and rainfall. Consideration has further been given (70) to the height of the marshes, proximity of creeks, physical character of the mud, slope of the ground, distance from the sea, and presence or absence of vegetation. A brief summation of the factors resulting in the formation of salt marsh follows.

At first, eel-grass beds are formed, the water above the level of the grass continuously bringing much sedimentary matter. As the tide falls, the plants became entangled and held until they gradually sink to the bottom. Each tide contributes some sediments which make the water shallower. After the bed has risen to a point where it became dry at low tide, the eel-grass gives place to other seaweeds and grasses. Frequently, as along the New Jersey coast, the eel-grass stage may be omitted, and extensive salt marshes have been formed directly on sand. If a constant connection with the sea is maintained, the salt marshes gradually win the ground from the sea. These areas become completely occupied by salt marshes except for the streams.

In examining the strata of a *Chamaecyparis* bog at Woods Hole, Massachusetts, Bartlett (6) recognized three distinct zones: (1) a *Zostera* stratum, followed by (2) a *Spartina glabra* stratum as the bog became built up to a high tide level, and (3) a *Spartina patens* and *Juncus gerardii* layer. The fresh-water flora of this bog, which was cut into at one end by wave erosion, was killed back for a considerable distance from the sea. In some cases, the peat was found to extend 16 feet below high tide level. When peat began to form in the bog, the floor of the depression must have been 16 feet higher than at present. By Shaler's estimate of peat deposition of one-tenth of an inch a year, about 2,300 years would have been required for the growth of 16 feet of peat below high tide level, and the 3 feet above high tide level. The subsidence must have been during this time at a minimum, namely, about 8½ inches a century.

Johnson (49) also estimated that it took 2,000 years for the Coastal Plain marshes to develop, which compares favorably with the figure obtained by Chapman (20) of 2,290 years, before the *Juncus gerardii* stage is reached (figure 42).

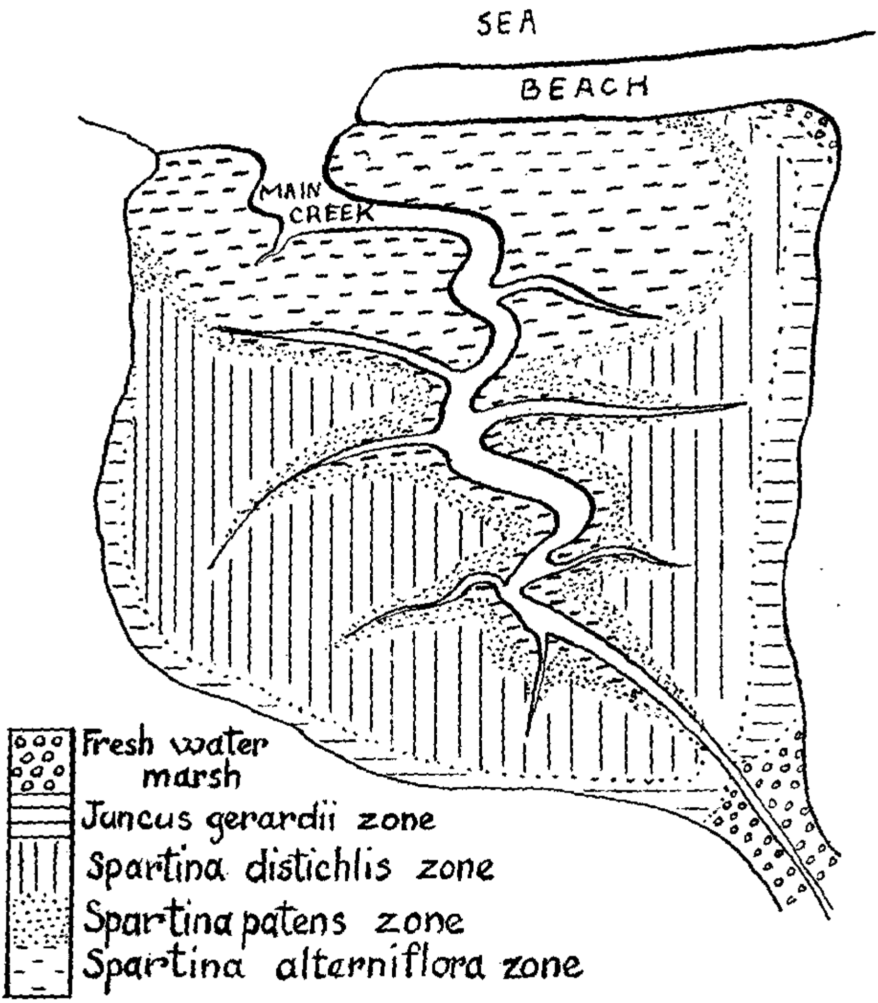


FIG. 42. Diagram showing distribution of plant zones on a New England marsh (from Chapman).

The mechanical composition and the organic content of some typical English salt marshes have been determined by Chapman. The chloride concentration in summer may be as high as 7 per cent in some of the salt marshes, due to long periods of non-tidal flooding with consequent evaporation. According to McAtee (62), salt marshes reach their best development where the coast has long been slowly sinking. The extent of these marshes indicates the degree to which the low-lying shores and the estuaries of streams are being "drowned".

A detailed study of the vegetation of the salt marshes in New Jersey has been made by Harshberger (41, 43). He brought out the fact that the natural, undisturbed surface of the salt marshes of the Atlantic Coast is fairly uniform in character from Cape Cod to the mouth of Chesapeake Bay.

As a result of the action of strong eddying currents of wind blowing across the salt marsh, the grasses and other plants become matted and twisted so that the marsh surface has a billowy appearance, with extensive areas of erect marsh plants and depressed portions of prostrated grasses. High tides bring in dead stems, leaves, and other remains of marsh plants which are deposited on the surface of the living salt-marsh plants, especially in the hollows of the grassy surface which have been caused by the wind. With tidal retreat, the drifted material tends to smother the growing plants beneath, and their decomposition sets in. The underground parts of the plants and the surface of the salt-marsh sod, which is above the permanent ground water level, are also said to be attacked by bacteria, thus resulting in depressions in the salt marsh which vary from a few square feet to more than an acre in extent. These depressions usually have steep sides and become filled with water at high tides, thus giving rise to the typical salt-marsh pools.

FAUNA OF SALT MARSHES

The salt marsh may be looked upon as the meeting place of fresh-water and marine faunas. As a result of prolonged acclimatization, a specialized brackish water fauna has evolved, much of which seems to have become incapable of living for any length of time in its old environment. A similar specialized fauna is found in estuaries, land-locked seas, lagoons, and salt marshes all over the world, and, to a lesser extent, in inland saline lakes. In temperate regions the number of species forming the community is relatively small, but in tropical waters it is very large (65).

SALT MARSHES IN NEW JERSEY

A careful computation of the tide-marsh areas of the State has been made by various geologists and engineers (90, 91, 101). Their reports state that the tide marshes comprise 296,500 acres and consist of clay, clay mixed with peat, and peat alone. The marshes may be divided and described as follows, proceeding from north to south:

1. *Hackensack and Newark Meadows.* This group comprises the tidal marsh extending from Newark Bay northward,

> . . . in a belt five miles wide, stretching west from the Hackensack River to the Arlington ridge. To the north the belt is cut into two parts by a tongue of upland at Secaucus, and the Snake hill marks the southern end of this uplift in the meadows. Englewood and Hackensack are about the limits of this tract of marsh land. The meadows southeast and south of Newark and bordering Newark Bay on the west to Elizabeth, are properly a part of this natural division. The Passaic and the Hackensack rivers flow through tidal lands and reach the Newark bay in it.

This area covers 26,890 acres.

2. *Kill von Kull and Woodbridge Meadows.* This marsh of 4,252 acres is irregular in width and extends from Elizabethport southwest to Perth Amboy. Woodbridge Creek flows through it.

3. *Raritan River Meadows.* These marshes extend over 4,715 acres. They cover the area from New Brunswick to the mouth of Raritan River in a continuous belt of tidal marsh land. They also extend along South River to Old Bridge.

4. *Cheesequake Creek, Matawan Creek, and other small tracts on Raritan Bay,* forming indentations of the upland, from 1 to 3 miles long, roughly triangular in shape, and comprising 3,582 acres.

5. *Atlantic Coast belt,* embracing the largest group of marshes in the State. Small marshes are found along the banks of Shrewsbury River and its tributaries where they widen into shallow bays. The largest marsh stretches southward from Point Pleasant and is continuous to Cape May, with wide arms running up Mullica and Great Egg Harbor Rivers, and with shorter and narrower strips along the smaller streams. Along the southeastern end of Burlington County and the eastern side of Atlantic County the marshes are wider, being 5 miles across from Absecon to Atlantic City, and nearly 4 miles wide southward to Cape May. This area of tidal marsh comprises 151,012 acres.

6. *Delaware Bay and Delaware River.* This is the second largest group of marshes in New Jersey. They are separated into several areas along the larger creeks and tributaries of the Delaware, from Crosswicks Creek, near Trenton, south to the bay. The marshes are generally narrow, but in some cases they extend up the stream

several miles. The total marsh area along the Delaware comprises 26,767 acres from Trenton to Salem, and between Salem and Cape May, 79,282 acres.

TABLE 74

Composition of eastern New Jersey tidal marsh peat, either entirely alluvial or with fibrous or colloidal layers

Drainage region	Depth feet	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Barnegat	0–1	68.3	65.9	0.96	3.5
	3–4	76.7	70.0	....	4.0
	8–9	62.9	85.5	....	4.6
Barnegat	0–1	58.6	86.8	....	5.6
	2–3	73.7	71.7	0.79	5.1
	4–5	64.1	82.3	....	5.8
Barnegat	0–1	69.1	76.8	0.65	5.8
	2–3	59.2	90.2	....	7.0
	4–5	83.1	70.7	....	7.0
Hackensack	0–1	61.2	68.2	0.94	4.0
	5–6	76.2	63.6	1.08	6.0
Metedeconk	0–1	86.9	35.4	1.91	5.2
	3–4	90.0	29.9	....	5.4
	12–13	87.4	9.8	1.43	5.5
Passaic	0–1	77.8	48.1	1.75	4.5
	2–3	84.7	54.4	....	5.0
	4–5	69.5	....	....	3.9
Passaic	0–1	33.8	92.1	....	7.0
	2–3	77.5	60.0	....	7.0
	5–6	82.8	50.0	....	7.0
Passaic	0–1	77.5	65.9	1.15	5.7
	5–6	79.3	63.7	....	5.7
	8–9	88.5	26.0	1.80	6.1
Rahway	0–1	71.4	44.9	....	5.2
	2–3	88.6	37.8	....	5.5
	5–6	90.1	35.4	....	6.3
Raritan	0–1	74.1	66.4	....	3.8
	3–4	83.5	51.5	....	2.3
	6–7	59.4	81.0	....	3.6
Raritan	1–2	69.4	46.8	....	4.0
Raritan	0–1	63.8	81.5	0.66	6.4
	2–3	78.1	49.4	1.63	6.2
	4–5	54.1	85.9	0.34	6.4
Raritan	0–1	60.1	81.5	....	5.7
	4–5	59.1	87.2	....	6.2
	6–7	84.5	43.5	1.48	5.9

In the marshes comprising the Newark and Hackensack Meadows, the peat usually contains varying amounts of well-preserved fibrous material of the sedge and reed type, as well as a large amount of alluvium. Some representative chemical analyses of some of these peats are recorded in table 74. The ash content drops below 26.0 per cent in only one instance (i.e. 9.8 per cent) in a layer of reed peat. Seventy-four per cent of the analyses show 50 per cent ash or more, and some, even as high as 80 to 90 per cent. Total nitrogen is low, never being above 2.0 per cent and frequently being as low as 0.3 per cent.

In spite of the fact that the sea-water with which these peats are continually flooded is alkaline, or about pH 8.0, the peats are usually acid in reaction. This is due to the reduction by bacteria of the sulfate in the sea-water to sulfide, a process which results in an increase in acidity. The pH values of the peats range from 2.3 to 7.0, the majority falling between 4.0 and 6.0.

The major areas of the southern marshes examined lie along the large rivers, such as the Great Egg Harbor and Maurice, and their tributaries. These streams are tidal, the effect of the tide decreasing as one proceeds inland. Because of this, the fresh-water swamps are found to merge with brackish marshes, and the latter with the true salt marshes. In the brackish marshes, the salt content is often not sufficiently high to suppress the growth of all trees; consequently a mixed vegetation of salt grasses, coniferous and deciduous trees, and sometimes mosses, including sphagnum, is found. The peat is mainly of sedge and reed origin, with a large admixture of alluvium washed in by streams and tides. Forest peats are commonly overlain by peats of tidal origin. The ash content is invariably high, except in the few isolated layers of fibrous sedge and reed or forest peat. Over 82 per cent of the ash analyses (table 75) are above 50 per cent and they frequently range between 60 and 80 per cent. The nitrogen content is low except in one area where concentrations of 2.42 and 2.47 per cent were recorded. The pH values range between 2.2 and 7.1, and are evenly distributed above and below pH 5.0.

The salt-marsh peats having a forest peat layer are found to range in size, in the northern areas, from 200 to 2,500 acres, with an average depth of 8 feet. The vegetation consists uniformly of sedges, reeds, and cattails, with the remnants of a dead forest in one area. These areas are all found along the Hackensack and Passaic Rivers, and are very similar in nature. Since the cedar forests will not grow in tidal waters, the presence of a forest stratum indicates that either the land has sunk or the water level has risen. It seems probable

TABLE 75

Composition of southern New Jersey tidal marsh peats, either entirely alluvial or with colloidal or fibrous layers

Drainage region	Depth feet	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Cohansey	0–1	75.5	69.4	....	2.6
	4–5	72.7	66.3	....	3.3
	8–9	70.1	67.7	....	4.2
Cohansey	3–4	69.7	70.3	....	4.5
	8–9	69.1	67.4	....	4.8
	12–13	64.9	77.7	....	5.2
Cohansey	9–10	88.5	17.7	1.83	4.7
	10–11	87.0	44.0	....	4.8
Dennis	0–1	77.6	74.8	0.96	4.5
	4–5	73.6	78.8	....	4.9
	13–14	70.5	72.8	....	3.8
	15–16	82.4	39.8	....	5.7
	19–20	43.3	15.6	....	7.1
Dennis	5–6	79.1	75.7	....	5.5
	11–12	86.3	42.6	1.15	5.8
	15–16	79.4	55.7	....	5.9
Dennis	0–1	78.8	57.9	1.32	6.2
	2–3	58.0	80.7	....	5.8
Dennis	0–1	62.0	81.4	0.42	6.4
	5–6	53.0	91.7	....	6.9
	9–10	68.1	80.0	....	6.9
Dennis	0–1	78.0	55.1	1.27	3.6
	1–2	85.4	48.0	....	4.7
Lower Delaware	6–7	74.6	54.5	....	3.7
	9–10	78.9	54.3	....	2.2
	15–16	69.9	78.7	....	4.0
Lower Delaware	0–1	57.8	81.8	....	6.0
	7–8	84.6	31.4	2.42	6.3
	9–10	88.8	18.2	2.47	7.0
Lower Delaware	2–3	84.1	38.4	....	5.7
	6–7	69.5	78.1	....	4.8
	10–11	88.9	40.5	....	5.6
Maurice	2–3	75.2	61.4	1.03	4.2
	6–7	79.0	70.6	....	4.5
	10–11	85.4	28.7	....	4.0
Tuckahoe	0–1	59.1	83.6	....	4.8
	6–7	80.8	59.4	0.81	4.5
	9–10	81.4	54.8	....	4.4
Tuckahoe	0–1	64.1	71.3	0.73	2.6
	5–6	75.6	70.5	....	3.7
	12–13	75.9	66.4	....	3.3
Tuckahoe	0–1	65.0	76.8	0.68	4.7
	6–7	60.8	82.6	....	4.9
	12–13	70.5	65.0	....	5.3
	16–17	63.8	62.8	0.71	5.9

that the former explanation is correct. The peat is typically salt marsh, except for the woody layer, as brought out in table 76. The ash contents are high in the alluvial layers and much lower in the woody layers. Correspondingly, the nitrogen values are low in the

TABLE 76

Composition of New Jersey tidal marsh peat with forest layer

Drainage region	Depth feet	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Barnegat	0–1	78.9	10.9	....	4.1
	3–4	76.2	63.0	....	4.9
Barnegat	0–1	61.1	78.5	0.55	5.3
	4–5	86.8	39.4	1.79	4.8
	8–9	84.6	37.6	....	6.0
Barnegat	0–1	81.0	12.9	....	4.3
	1–2	85.5	3.4	1.51	4.8
	3–4	67.9	65.6	....	4.2
Hackensack	0–1	76.5	61.5	....	4.2
	4–5	84.8	36.9	1.60	5.4
	6–7	89.6	17.7	1.39	5.6
Hackensack	0–1	66.4	71.3	....	4.1
	5–6	88.7	29.1	2.15	6.3
	7–8	81.3	14.1	2.75	6.0
Hackensack	0–1	85.0	30.4	1.71	5.8
	4–5	92.9	11.3	....	6.4
	7–8	90.1	12.2	....	6.0
Metedeconk	0–1	40.6	82.5	0.51	6.1
	2–3	80.2	21.6	1.72	5.3
	4–5	85.6	27.2	1.70	5.5
Metedeconk	1–2	88.6	7.6	1.64	4.3
	4–5	82.4	34.3	1.30	4.7
Metedeconk	0–1	88.3	36.2	2.37	3.6
	2–3	83.6	16.6	1.10	3.8
	4–5	75.5	58.8	0.58	4.4
Metedeconk	0–1	81.4	15.3	2.06	4.1
	2–3	67.6	54.8	0.61	5.3
Metedeconk	0–1	86.4	13.8	1.49	4.2
	2–3	81.3	21.5	1.00	4.2
	4–5	68.1	71.2	....	4.2
Passaic	0–1	86.0	25.2	2.28	5.0
	3–4	87.5	22.3	....	5.5
	6–7	85.4	56.2	....	5.9
Raritan	0–1	74.2	45.7	1.04	4.8
	2–3	78.2	51.8	0.72	4.2

former and much higher in the latter. The pH values are typical of the salt marsh, ranging from less than 3.5 to 6.5, and usually lying between 4.0 and 5.5.

In the southern regions, the salt marshes are found to range in size from 20 to several thousand acres, with an average depth of 5 to 6 feet. The vegetation is similar to that of the other marshes, and the peat is also similar. In many cases the forest stratum is deep, indicating that at one time the land level was much higher than at the present time. In some areas, however, the forest peat is on the surface or is continuous from the surface to the bottom. In these cases land submergence has been recent. The forest layers are invariably much lower in ash and higher in nitrogen than the accompanying tidal formations (table 77). About 68 per cent of the ash values are below 50 per cent. The nitrogen values average about 1.7 per cent and vary between 0.58 and 3.11 per cent. The pH values range between 2.3 and 7.0, most of them being 4.5 to 6.0.

The marshes along the Delaware vary in size from 10 to 400 acres and have an average depth of about 7 feet with a maximum of 20 feet. Although they are flooded by tides, the water is not saline enough in all cases to suppress completely the growth of shrubs and trees. Consequently the vegetation consists of reed and sedges, with shrubs and trees in the more elevated areas. In the past, much of the land was diked and used for agriculture. Now, however, most of the dikes have broken, and farming is practiced in only a few isolated areas. Some of the land is now used for pasture. The peat is of the typical salt-marsh variety, containing a large amount of alluvium usually mixed with rather well preserved residues of reeds and sedges. The ash is high except in a few cases. The nitrogen is low, usually less than 1 per cent, and the reaction is in most cases very acid.

A few of these marshes have a forest layer about 10 feet deep. Several of these are found along the tributaries of Delaware River, but in most cases enough alluvium has been deposited to make the ash content rather high.

FRESH-WATER ALLUVIAL PEATS IN NEW JERSEY

The group of marshes or bogs along the lower Delaware forms the transition group between the fresh-water alluvial bogs and the salt marshes. The process of peat formation or "paludification" of flooded lands has been described by ecologists (16, 17, 2).

Alluvial peats have been found in all sections of the State. In the north this type of peat usually occurs along the banks of streams

TABLE 77

Composition of tidal marsh peats in southern New Jersey, of alluvial type with forest layer

Drainage region	Depth feet	Moisture per cent	Ash per cent	Nitrogen per cent	pH
Cohansey	5–6	78.4	41.8	....	5.1
	9–10	90.2	16.7	1.38	5.7
	11–12	89.8	9.4	....	5.8
	13–14	85.8	30.6	....	5.5
Cohansey	0–1	66.4	82.3	....	5.4
	8–9	63.6	85.9	....	5.6
	13–14	88.3	25.0	....	5.0
	27–28	86.5	28.0	....	5.0
Cohansey	2–3	77.0	49.1	1.34	5.6
	3–4	85.4	16.4	2.21	4.4
	10–11	86.1	60.6	....	5.6
Dennis	0–1	84.8	40.8	....	3.9
	2–3	87.8	15.6	....	5.0
	5–6	85.2	57.4	....	5.3
Dennis	0–1	85.9	37.0	1.41	5.9
	4–5	89.5	16.0	....	5.0
	5–6	86.4	47.8	....	5.4
Dennis	4–5	81.5	61.6	....	4.7
	13–14	87.7	33.7	....	6.0
	15–16	59.0	77.2	....	7.0
Lower Delaware	0–1	81.1	37.0	2.00	4.1
	1–2	83.3	22.2	....	4.5
	3–4	88.1	28.6	....	4.6
Lower Delaware	1–2	88.0	14.8	1.68	5.1
	3–4	89.2	16.5	3.11	5.4
	6–7	91.2	14.6	....	5.6
	9–10	84.0	36.1	....	4.8
Maurice	2–3	88.0	60.9	....	4.3
	3–4	86.6	20.9	1.73	4.4
	4–5	87.1	64.2	....	5.9
Maurice	4–5	66.8	79.5	0.58	4.5
	7–8	85.5	14.4	1.06	4.3
	11–12	62.8	34.0	....	4.0
Tuckahoe	1–2	90.1	9.3	1.99	5.6
	3–4	85.8	26.0	....	4.8
	6–7	85.9	41.4	....	5.4
Tuckahoe	0–1	70.5	77.7	....	3.8
	2–3	87.9	19.4	1.67	4.2
	4–5	72.9	68.9	....	4.7
Tuckahoe	0–1	87.9	17.0	2.23	4.6
	2–3	92.7	8.2	....	5.0
	4–5	86.8	50.6	....	4.7

where periodic flooding has deposited alluvial material. The peat is characterized by a high mineral content, and this is mixed with organic material in a colloidal state or in the form of residues of sedges, wood, and similar materials. In the two areas where extreme depths were recorded, layers of colloidal, woody, and sedimentary peat were found, but the ash content was always very high, ranging between 20 and 85 per cent.

In the eastern part of New Jersey, alluvial peat deposits range in size from 2 to 600 acres, with an average depth of 3 to 4 feet, and maximum depths of 14 feet. Some of these are entirely alluvial or have a colloidal layer, whereas others have a forest layer. Most of

TABLE 78

Composition of fresh-water alluvial peats, with forest layer

Drainage region	Depth feet	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Barnegat	0–1	83.4	14.4	2.17	3.8
	2–3	67.3	64.7	....	4.7
Barnegat	0–1	66.4	63.9	....	4.8
	2–3	85.0	4.1	1.28	4.4
Metedeconk	0–1	45.3	69.7	0.36	5.9
	3–4	88.1	26.7	1.23	5.4
	6–7	70.2	70.5	0.52	5.8
Metedeconk	0–1	37.6	81.9	0.45	6.0
	6–7	77.0	44.2	1.01	6.1
	9–10	71.2	60.5	1.07	5.8
Metedeconk	0–1	51.8	82.0	0.56	5.4
	2–3	86.8	31.6	1.27	5.3
Metedeconk	0–1	65.9	82.8	0.54	6.0
	4–5	85.7	16.9	2.34	6.0
	9–10	72.8	67.7	0.72	5.8
Metedeconk	0–1	38.2	93.2	....	5.4
	2–3	84.7	15.6	1.32	4.4
Metedeconk	1–2	86.4	13.0	1.72	4.5
	3–4	80.7	52.2	....	5.3
Metedeconk	1–2	83.4	24.3	1.28	4.5
	5–6	76.5	55.2	....	4.0
Raritan	0–1	67.0	36.6	1.68	4.2
	3–4	85.0	22.8	....	4.8
	6–7	84.4	36.9	....	4.0
Raritan	0–1	61.4	73.8	0.60	4.3
	2–3	73.0	50.9	1.00	4.9
	5–6	57.0	82.3	0.28	5.5

the deposits are in a wild condition but are used for pasture; few are cultivated. The surface vegetation is much the same as that described for the forest peat areas, although no sphagnum was observed. As would be expected, the ash in these peats is very high. The nitrogen ranges from about 0.5 to 1.5 per cent, except in one

TABLE 79

Composition of fresh-water alluvial peat in southern New Jersey

(a) Alluvial or with colloidal or fibrous layers

Drainage region	Depth feet	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
Cohansey	0–1	60.7	81.2	....	5.7
	2–3	61.9	80.3	....	5.0
	4–5	64.3	69.0	....	4.9
Dennis	1–3	84.8	54.6	....	5.2
	6–7	89.8	40.2	....	6.2
	10–11	88.8	18.8	1.70	2.8
	12–13	76.8	63.6	....	5.0
Dennis	0–1	84.2	44.3	....	5.3
	2–3	86.6	38.8	....	4.9
Lower Delaware	0–1	48.9	84.4	....	4.4
	1–2	62.0	76.0	....	5.0
Lower Delaware	2–3	74.5	60.0	....	3.3
Maurice	2–3	69.6	66.4	....	4.1
Maurice	0–1	68.5	72.7	0.79	4.7
	1–2	75.4	54.7	....	4.6
Tuckahoe	0–1	57.7	72.3	0.74	3.9
	1–2	31.0	93.1	....	4.3
(b) Alluvial with forest layer					
Cohansey	0–1	62.4	68.4	....	4.4
	2–3	82.6	25.3	1.60	4.0
	3–4	83.5	20.0	....	4.0
	5–6	63.7	67.7	....	4.4
Cohansey	1–2	78.4	42.6	....	2.6
	3–4	86.1	15.8	1.43	3.8
Lower Delaware	5–6	78.5	23.4	2.66	4.2
	7–8	61.4	83.2	....	4.5
Maurice	0–1	82.2	21.9	....	4.9
	2–3	74.6	57.9	....	4.5
Maurice	0–1	90.3	33.0	1.65	4.6
	2–3	88.1	13.5	....	4.3

case where 2.5 per cent was recorded. The pH values are exceedingly variable, ranging from 2.0 to 7.2.

The areas with a forest layer are also largely alluvial in character, and in most cases the ash content (table 78) is high. The nitrogen is variable, being low in the mineral layers and high in the forest layers. The pH values vary between 2.9 and 6.0.

In the south, the fresh-water alluvial bogs are found to range from 50 to 1000 acres in size, with an average depth of about 3 feet and maximum depths of 8 to 13 feet. None of these areas are cultivated and all have a characteristic vegetation of coniferous and deciduous trees. They also usually have a heavy under growth of shrubs as well as ferns and mosses. Sphagnum is found in most areas. Most of the peat is alluvial, with a frequent mixture of layers of sedge and reed peat or colloidal peat. The ash content is very high except in a few cases, especially in the forest layers (table 79). Correspondingly, the nitrogen values are low. The pH values range between 2.6 and 6.2, with an average of about 4.6. Even the forest layers have a relatively high ash value, due to their alluvial nature.

On the western side of the State, the alluvial bogs were found to range in size from 4 to 400 acres with an average depth of 2 to 3 feet. For the most part these areas are in a wild condition. Some are used for cranberry production, and a considerable acreage was once cultivated but has since been abandoned. It has been reported that the peat in some areas was destroyed by fires. The vegetation usually consists of deciduous trees and shrubs, ferns, sedges, and mosses. In some areas pines and cedars are found. Chemically, the peat is very similar to the alluvial formations found in other sections of the State. The ash is high, except in a few areas; correspondingly the nitrogen values are low, averaging about 1.2 per cent and ranging between 0.13 and 2.76 per cent. The reaction is decidedly acid, the pH values ranging between 2.0 and 5.8, with an average of about 4.2.

Many colloidal peats also occur in deposits ranging from 1 to 1,000 acres in size. Their average depth is 2 feet, and their maximum, 7 feet. Many have alluvial layers. The nitrogen content averages 1.75 per cent, and occasionally is as high as 2.5 per cent. The pH varies from 2.9 to 5.3.

TIDAL MARSHES

Lower Delaware. The reclaimed tidal marsh of this region, when accessible for survey, proved in most cases to be so low in organic matter as to constitute virtually mineral soil. Where reclaimed marsh has been abandoned, it may be densely covered by forest, mainly deciduous, but containing pines and white cedars in the wetter parts. The large bog along Little Timber Creek contains many pines and cedars together with shrubs, heath bushes, and large and small deciduous trees; and it presents the appearance of a cedar swamp of the Pine Barrens type which has been cut over in the past. Fresh or brackish water covers that part of the bog which was formerly tree-covered and where the peat was initially high in clay.

Forest and sedge and reed peat overlain by 2 to 14 feet of tidal marsh peat and clay occur along the tributaries of Repaupo Creek and the peaty stratum is 2 to 10 feet thick (table 80). Almost

TABLE 80

Profile of Repaupo Creek tidal marsh

Area 1, Field map 75.18–39.48

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–1	Dark brown macerated reed and sedge peat and clay	68.7	67.4	4.1
1–2	Gray clay	....	....	...
2–4	Dark brown fibrous reed and sedge peat	....	....	...
4–12[1]	Brown woody forest peat and sand	88.0	24.2	3.6
12–13	Gray sand	....	....	...

[1] Nitrogen content, 1.58 per cent.

TABLE 81

Profile of Little Timber Swamp

Area 2, Field map 75.20–39.48

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	Nitrogen *per cent*	pH
0–3	Dark brown macerated reed and sedge peat containing wood and clay	79.6	45.6	....	5.0
3–9	Light brown reed and sedge peat containing wood	91.3	9.8	1.70	5.1
9–12	Olive-green sedimentary peat	89.2	31.9	1.86	5.3
12–14	Gray clay and sedimentary peat	47.9	53.7	....	5.4
14–15	Gray clay	....	....	....	...

without exception, wherever large areas of tidal marsh occur in New Jersey, a forest peat is found below. Little Timber Swamp contains sedge and reed peat mixed with clay and wood (table 81). The peat is from a few inches to 14 feet deep, and in many places is overlain by clay.

Tidal marsh occurs at intervals along Delaware River, but north of Salem these areas are small. Extensive reclaimed marshes border Salem Creek. In some instances the marshes have not been drained; in others reclaimed areas have reverted to poorly drained land. The fresh-water bogs above tide level uniformly contain large amounts of alluvium.

Between Alloway Creek and the mouth of Cohansey Creek there are extensive tidal marshes most of which are in a wild state.

Tuckahoe and Great Egg. The tidal marsh found along these two rivers varies from 1 to 6 miles in breadth and has a maximum length of 15 miles from Great Egg Inlet to Mays Landing on the Great Egg Harbor River. Sufficient profiles were found to contain wood to justify the conclusion that extensive white-cedar forests have been submerged. In many places the presence of wood is partly or completely masked by tidal clays and peat.

Above tidewater, Tuckahoe River and its tributaries flow through relatively narrow valleys filled by alluvium, and containing wild and abandoned cranberry bogs. White cedar forests are present, but on abandoned cranberry bogs, or on cut-over land, deciduous vegetation is dominant. Where peat occurs, it is of the forest type. The river flows through 8 miles of tidal marsh before entering Great Egg Bay.

South of Mays Landing, the Great Egg Harbor River flows through tidal marsh. Numerous tributaries, largely or entirely above tide, enter the main stream. Their valleys are ordinarily narrow and contain little peat, the flood plains consisting largely of sand. Where small deposits of peat occur in such sand plains it may be of fair quality (table 82). The only large peat deposit southeast of Mays Landing is in a bog which constitutes the source of Gravelly Run. This bog is 3 miles long and has a maximum width of slightly more than 1 mile. The forest peat found in the basin is of fair quality, although in some places the peat thins to a few inches of forest litter. The greatest thickness encountered was 5 feet.

Metedeconk. The tidal marsh at Cedar Bridge, though of slight extent, contains peat that is considerably lower in mineral matter than that of most tidal deposits. In one profile the surface stratum contained 35 per cent ash and the fourth foot 30 per cent, whereas the eleventh and thirteenth feet contained 16 and 10 per cent

TABLE 82

Profile in Stephens Creek bog

Area 1, Field map 74.46–39.22

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–3[1]	Macerated reed, sedge, and forest peat	90.9	10.4	5.5
3–4	Macerated reed, sedge, and alluvial material	85.8	26.0	4.8
4–6	Macerated reed, sedge, and alluvial material	80.3	35.7	4.5
6–8	Sand containing reeds, sedges, and wood ..	85.9	41.4	5.4
8–9	Sand	....	....	...

[1] Nitrogen content, 1.99 per cent.

respectively. Non-tidal peats are probably present in the lower strata. The peat under the cedar-deciduous forest adjoining the marsh, varies in mineral content between 5 and 8 per cent to depths as great as 7 to 9 feet. The pH values are remarkably constant, ranging between 4.5 and 4.8. The nitrogen is less than 1.75 per cent.

The South Branch of the Metedeconk River heads near Jacksons Mills, some 13 miles from tide-water. Near Burrsville as the South Branch is ascended the peat deposits become less abundant and of poorer quality, until Lakewood is reached. The ash contents of the peat in a bog 1 mile east of Lakewood are 14, 10, and 22 per cent for the first three feet, and 22, 59, and 71 per cent for the next three feet. Half a mile farther west, the alluvial deposit contains 63 to 93 per cent ash and nitrogen values are correspondingly low. North of Lakewood there is a typical forest peat bog. Above this, for a distance of 1½ miles or more, peat is entirely absent from the bed of the South Branch. Farther northwest, in the vicinity of Bennetts Mills and Jacksons Mills, the peat survey was not completed and analyses are not available. It is doubtful whether peat of good quality occurs in this region, since sand and clay are common in most of the strata of the bogs tested.

The North Branch of Metedeconk River and its numerous subsidiary branches, drains a wide region between a point north of Jacksons Mills on the west, and Oak Glen on the east. Much of the peat in this region is alluvial or consists of forest peat mixed with more or less alluvium. As on the South Branch, the amounts of alluvium increase towards the headwaters. Thus, at Lanes Mills, 1 mile from the confluence of the North and South Branches, the ash content of the forest peat in the first four feet ranges between

CHAPTER VI

UTILIZATION OF PEATS IN NEW JERSEY

The danger of using raw, freshly dug peat, and the need for aerating fresh peat so as to render it suitable for soil improvement, were fully recognized by Cook (25), who, in his report for 1878, makes the following significant statement:

> Muck or black earth in the swamp is undergoing no further change. It has then no fertilizing value, but when dug and exposed to sun, air, moisture and to frost, it soon begins to change and decay. Its change can be hastened by the addition of lime, lime and salt, or barnyard manure. It is then in good condition to apply to soil. Its office appears to be to improve the texture of the soil, to increase its power of absorbing moisture from the air, to furnish a solvent for the mineral substance in the soil and in mineral fertilizers, and to become the medium of communication between the soil and the growing crops. It does not contain more potash or phosphoric acid than is found in ordinary soils, and of course can of itself only help to exhaust them quicker, but mixed with marl or other fertilizers in the soil, it increases the crop very largely.

Cook made a number of analyses of samples of New Jersey peats. One such, a sample of forest peat taken from a bog near Toms River, was reported to have the following composition.

	per cent
Water	7.95
Organic matter	77.80
Nitrogen	1.04
Phosphoric acid	0.03
Potash	0.07
Alumina	0.17
Iron oxide	0.25
Lime	0.03
Magnesia	0.22
Sulphuric acid	0.03

It is evident that this peat sample was first thoroughly air-dried. The analysis shows it to be characteristic of acid forest peats. The average depth of the deposit was said to be about 3 feet.

In 1879, two samples of peat from an area near Tuckerton were examined (25). One was taken from a fresh-water bog and the other from a pine-forest bog, at the border of a tidal marsh. The results were apparently reported on a dry basis:

Composition, per cent	Fresh-water bog	Tidal-marsh forest bog
Ash	9.89	23.06
Insoluble in acid	7.10	18.80
Nitrogen	0.76	0.83
Phosphoric acid	0.03	0.08
Lime	0.27	0.25

8 and 12 per cent. One and one-half miles to the north, the flood plain of the main stream contains only 1 foot of peat, with an ash content of 39 per cent. One mile farther west, the peat deepens to 4 feet, but the percentages of ash in successive depths are 42, 54, 41 and 50 per cent respectively. The peat farther upstream is also high in inorganic matter.

The stream valleys farther to the north are smaller than the rivers discussed. In these valleys peat is either lacking or is alluvial in nature.

Navesink. An interesting example of the formation of tidal marsh in exposed positions is found at Union Beach on Raritan Bay. Here a barrier beach was originally formed half a mile off shore (Conaskonck Point) which must have been separated completely from the mainland by a shallow sound. Behind the sand barrier, tidal deposits accumulated to depths not exceeding 7 or 8 feet. The bogs, occurring in extremely narrow valleys, may be fairly deep, but the peat contains large quantities of alluvium, the ash content often decreasing with depth. This is well illustrated by the bogs near and east of East Freehold (table 83).

TABLE 83

Profile in alluvial bog near East Freehold

Area 1, Field map 74.16–40.16

Depth feet	Physical description	Moisture *per cent*	Ash *per cent*	pH
0–2	Alluvial	53.1	82.7	4.5
2–4	Alluvial	75.3	69.6	5.7
4–12[1]	Alluvial, containing plants and wood	81.1	46.0	5.0
12–13	Sand	....	....	...

[1] Nitrogen content, 1.45 per cent.

In some peats the high ash content is due to the presence of bog iron. Such peats are highly acid and likely to prove injurious to vegetation if removed and utilized for soil improvement.

These samples also are representative of the acid, low-nitrogen peats which are so abundant in the State. The need for composting and the value of lime for this type of peat were well recognized.

Cook (25) also recognized that the cedar swamps of the State cover many thousands of acres and vary greatly in depth. He confessed to a lack of knowledge of the fertilizing value of such peat. Chemical examination of a sample revealed that it contained only 3.35 per cent ash on a dry basis and he concluded that this type of peat contains large quantities of material that may be useful in soil and for the growing of plants. Composts with stable manure were made by sprinkling the dried and crumbled peat in stables and stalls so as to absorb the liquid manure, or by throwing it into barnyards, cattle pens, and pig sties, to be trodden by the animals and mixed with the manure. He also recommended that alternate layers of peat and stable manure be piled in a compost heap and mixed thoroughly. Other animal manures, as night soil, slaughter-house refuse, waste from glue and soap factories, could also be used for compost purposes. For the preparation of composts of peat with ashes, it was suggested that a bushel or more be used with each load of peat, a few months being allowed for composting. Lime was considered the best common alkaline material for addition to peat.

Cook (25) wrote that peat has been much used as a fertilizer in agriculture. Those forms of peat which crumble easily were looked upon as particularly valuable, and were considered as comparable in their action to stable manure. He emphasized that peat was greatly improved when composted with lime or with stable manure, or when exposed to the weather in heaps for some months before use. Those types of peat which contain too much mineral matter were said to form, on drainage, excellent soils. Some of the richest and most valuable soils in the State were thus produced.

Parmelee and McCourt (73) found that two peats from Netcong contained 7.05 and 8.9 per cent ash, 0.49 and 0.44 sulfur, and 2.38 and 1.87 per cent nitrogen, respectively, other peats with ash contents varying from 15.82 to 24.95 per cent were considered to be of too low a grade calorifically for commercial development.

In more recent studies on the utilization of New Jersey peats, Soper and Osbon (92) described two important peat developments:

1. A deposit in Sussex County, about 2½ miles north of Netcong, which comprised about 150 acres, the peat being 10 feet deep. A large part of the surface was cleared of heavy growth of trees, the remainder, being covered with sedges, reeds, and shrubs. The lower layer of the peat profile consisted of sedimentary material, whereas

the upper layer was made of sedge and reed peat. Peat fertilizer had been produced from this deposit by the Commercial Humus Company, of Newark. The peat was excavated by hand, loaded into wooden tram cars, and hauled by cable to the loading station, where it was macerated and discharged into a large rotary drier. The thoroughly disintegrated peat was then loaded into railroad cars. The product was used as a filler in commercial fertilizers and was regarded as an important nitrogenous ingredient.

2. A plant of the Alphano Humus Company on Great Meadows. It was estimated that 1,500,000 short tons of air-dry peat were available for production. This plant is no longer in operation, and at present the peat is used for the growth of truck crops such as celery, onions, and lettuce.

These two deposits comprise sedge and reed peat types, and not the acid forms. Such types of peat were also analyzed by Cook, who recognized their potential value as a fertilizer or soil improver, although he, as well as many others at that time were thinking in terms of the utilization of peat for fuel purposes.

THE AGRICULTURAL USE OF TIDAL MARSHES

There are two distinct methods for reclaiming salt marshes, namely, diking and draining. In diking, all sea water is kept out by means of dams and the water accumulating behind these dams is allowed to escape through gates at low tide. For low marshes or areas remote from shore, especially when the marshes receive much drainage, the tide gates are not sufficient; the water accumulating behind the dams must be removed in some other way. The vegetation of the typical salt marsh tends to disappear and that of the fresh-water bog takes its place. The reclaimed land will grow good crops of celery, onions, and other truck. The dikes and tide gates must be kept in good condition; and, with the sinking of the land, the accumulating drainage water must be removed by pumps. In reclamation by draining, the surface water is removed by ditching. The productive power of the land is thereby considerably increased, and mosquito-breeding places are eliminated.

The drainage of peaty marshes in an effort to utilize the land for agricultural purposes has a long and eventful history. Many years ago Cook (25) wrote:

> In the northern and eastern part of the state very little has been done towards effectually reclaiming these lands, although their improvement has been much discussed. In West New Jersey, the reclaiming of meadows and marshes from the domain of the tides, has been thoroughly studied and effectually

practiced from the earliest settlement of the country. In Salem County, some of those on Alloways Creek were banked in, so as to shut out the tide, as early as 1700. The successful improvement of these meadows and salt marshes has been effected by shutting out the high tides (or flood tide) by means of embankment and draining them by sluices. By this means they are drained to low water mark, and thereby rendered valuable farming lands. This work of banking in meadows has constantly gone forward—until the territory actually rescued from the sea amounts to fifteen thousand acres in Salem County alone, besides large areas in Gloucester, Cumberland and Cape May Counties.

Early efforts to utilize the marshes in the eastern and southern parts of the State were described by Woodward (108):

Proposals to drain the marshes along the coast came up from time to time, and in places were actually carried out. In 1814 Samuel Swartout drained and diked a marsh area at Hoboken, on which he kept a herd of 100 cows, marketing the milk in New York. He also grew grain and vegetables, but from lack of funds was unable to maintain the enterprise. A plan for draining the Newark meadows in 1820 did not materialize. In Cumberland County along the Maurice river, by means of dikes and tide gates, marsh areas were converted into fertile meadows which produced exceptional yields. The early settlers found cranberries growing wild in the swamps and learned from the Indians that they were not only an edible fruit but when properly prepared an exceedingly tasty addition to the diet. It was not long before the wild berries became an important article of trade, the shipment of pickled cranberries to Europe being on record. Legislation to protect the cranberry was effected in 1789.

A plan for the reclamation of the Hackensack Meadows by the Iron Dike and Land Reclamation Company of New York was discussed by Collins (23). The area comprised about 4,500 acres, which were purchased at an average price of $50 an acre. The cost of surrounding this area with an embankment and of cutting the main ditches and drains was estimated at about $250,000, or $55 an acre, thus making the total cost of the reclaimed land about $105 an acre. It was believed that if this land were thoroughly drained, it would be worth $1,000 an acre, and that by renting it at the rate of $50 an acre per annum, it would repay in 3 years an equivalent of $675,000, or $200,000 in excess of the original cost. It was recognized that the location of the particular land near New York had much effect upon its value, and it was not intended to convey the idea that all reclaimed land would be equally valuable. This was in line with Cook's statement that the value of banked meadows in southern New Jersey ranged from $200 to $500 an acre, whereas, previous to banking, most of the land was worthless. In the Hackensack Meadows development the proprietors neglected to care for the banks and they were destroyed by muskrats which burrowed below the level of high water. The tide soon completed the demolition of the embankment. In discussing this project, Smock (90) remarked that it was a failure. He also wrote:

The experience in the State in reclaiming tidal meadows, particularly in Salem and Cumberland counties, has shown that the subsidence is in some cases enough to lower the surface to low-tide level and to make further improvement and successful tillage no longer practicable or profitable: and embanked meadow lands have been abandoned from this cause.

Smock emphasized the fact that in many localities, the necessity exists for co-operative work, instead of individual enterprise, a fact which has prevented in a large degree the reclamation of the tide-marsh lands in the State. Warren (106) emphasized that sufficient time must elapse to allow the draining of the fresh water which flows into a marsh; otherwise, it is difficult to reduce the water table sufficiently to enable agricultural crops to grow. Detailed information on the utilization and drainage of salt marshes is given by Means (66) and Wright (109). In many cases, the main purpose of draining a marsh has been to rid it of mosquitoes. Smock (90) wrote in 1892 that

There are in the State 296,500 acres of these tide-marsh lands, nearly all of which is without forest and much of it capable of drainage. This area is nearly one-eighth of that of the cleared upland, in farms, in the State. At present it yields crops of salt grass and sedge which have some value and are salable, but the income is probably not one-tenth that of rich upland in the same locality. The relative importance of *salt meadows* to upland had declined within the last half century and such land is neglected for agricultural purposes. The addition of this area to the cleared and productive farm lands of the State would amount to more than 10 per cent, of additional farm lands and would yield an increase of twenty or more per cent of farm products. The development of the natural resources of the State should include the marshes as a leading element in the production of wealth, and the attention of capitalists and of the citizens of the State should be directed to them by the Survey.

Very little work in draining tide marshes has been done on the eastern side of the State, except on the Newark meadows east of Newark, where a company was organized and began the work of reclaiming a tract of about 6,000 acres lying between the Passaic and Hackensack rivers, and on the line of the railways which there cross the meadows. The banks were built with an iron-plate core, for security against the ravages of muskrats, and for greater strength. The water shut out down to the level of low tide and the meadows became comparatively dry, and upland plants and vegetation appeared. This work was done about twenty-four years ago, but the project to drain lands there for farming was a failure. According to the survey, about 4,000 acres is embanked and 1,550 acres of it is improved. The total area of tide-marsh land embanked in the State was, in 1888, 34,304 acres. Of this area, about 30,000 acres were along the Delaware Bay and the streams flowing into it, and in the southern part of the State.

By the year 1896, the viewpoint of those interested in the drainage of the Hackensack and Newark Meadows had altered. Utilization of the land was still contemplated, but it was considered incidental to sanitary and other benefits. It was known, because of the experience of the New Jersey Land Reclamation Company, that embankment and the installation of sluice gates would provide drainage for only a comparatively short period, followed necessarily by pumping. In

1887, or less than 20 years after diking and drainage, the subsidence of the marsh was about 3½ feet, the marsh level reaching a point almost a foot below mean tide. It was further appreciated that subsidence of clayey marsh would, following drainage, be considerably less than that of land containing greater quantities of organic materials. The prediction was made, in the report of 1896, that the land in the vicinity of Hasbrouck Heights would require no pumping, and this has been found to be true. At the present time, the former marsh appears to be typical upland, and lies well above the tides.

Considerable portions of the tidal marshes of the region have been drained or filled. Some portions are farmed; some provide space for industry. Much, however, remains in the wild state or, in some places, where subsidence has followed embankment with subsequent deterioration of the banks, in a condition worse than it was initially.

Some of the difficulties encountered in the reclamation of tidal marsh have been indicated in the historical survey of the Newark and Hackensack Meadows. An additional major difficulty remains to be mentioned, namely, subsidence of the coast line of New Jersey. Subsidence of peat, following drainage, begins at once; coastal subsidence, on the other hand, may not exert its influence for many years, but its effect, over an extended period of time, is marked. The effect of especially violent storms upon the vegetation of coastal fresh-water bogs should also be mentioned. Many instances of the killing of white cedar forests by unusually high tides or by wind-carried salt spray have been recorded.

AGRICULTURAL UTILIZATION OF OTHER PEATLANDS

Among the special crops grown on peatlands in New Jersey, the cranberry occupies a prominent place. For the successful cultivation of the cranberry, peat soils are commonly used. The bushes and trees are first removed, as well as the top layer of soil to a depth of 2 to 4 inches. The surface is then graded, dams and sluice gates are constructed, and ditches dug to facilitate the drainage. Next, the surface is sanded to a depth of 3 to 4 inches and the young plants set out as cuttings. During the growing season, the water level is kept within a few inches of the surface. From November to May, in regions where it is necessary to protect the plants from insects and from late spring frosts, the bogs are flooded with water to a depth of 18 inches to 2 feet.

The early utilization of peatlands for cranberry culture is well described by Cook, who cites a statement by Bishop, of Manahawkin, as follows:

The lands in the State of New Jersey, that are adapted to the production of the American cranberry may be divided into two classes—peatlands and savanna lands. Both of the above have greater or less claims upon the attention of the cultivator, but the deep peat bottoms thus far, under proper cultivation, have returned a larger percentage upon the capital invested than the latter class. Peat is its principal food, and it succeeds well upon cedar, whortleberry and maple swamp-bottoms, better indeed than upon other soils. The experience of many old cultivators induces them to prefer the cedar swamp bottom to any other sort of peat locality. A porous soil is of great benefit to the growth of the vine. This character the heavy peat-bottoms possess in great perfection. The savanna and black-sand lands are found in small and large areas, throughout the southern part of the State. These, to be adapted to cranberry cultivation, must be free from clay, loams, etc. In these soils the peat and vegetable decomposition is found mixed with the sand, hence the vine is furnished with both the great necessary elements to feed upon. The tightness of these firm bottoms are an objection. Drought easily affects this sort of land, and nowhere have we found such vast number of worms, the enemies of both vine and fruit, as in the savanna plantations. Yet these soils have brought forth during wet summers, some very good crops; but all experienced cultivators know that this money is better invested in an expensively-worked, deep peat bog, than in a less costly and less reliable black sand or savanna plantation. These lands in the course of time are exhausted, and the patches of vines become thin.

Pitt, Beckwith, and Grant (76) conducted a survey of the New Jersey cranberry and blueberry industries in 1932. In the previous year, the 305 cranberry growers had produced 145,289 barrels of cranberries from 11,944 acres of bogs; 107 growers had reservoirs for bog flooding, and 197 had none. Five drainage regions, namely Barnegat, Metedeconk, Mullica, Rancocas and Tuckahoe, contain 91 per cent of the lands abandoned following cranberry culture. At the present time, 93 per cent of the bogs are found in the Barnegat, Mullica, Rancocas, and Tuckahoe regions.

The culture of blueberries has expanded markedly since 1932, when according to the survey, 53 growers had 419 acres in production. Blueberries are grown commercially in but few instances on true peatland.

UTILIZATION OF NEW JERSEY PEATS FOR SOIL IMPROVEMENT PURPOSES

Peat is also used extensively, especially in New Jersey, for soil improvement purposes. In 1934, Shore (87) made a survey of peat producers in the United States and he received replies from 36 operators, who reported a total production of 40,544 short tons having a total value of $214,185 at producing plants. New Jersey contributed more than any other state. Shore emphasizes that:

Remoteness of deposits from markets, cost of transportation, more readily accessible and cheaper products suitable for the uses for which peat is available, and to some extent, inadequate knowledge of the several kinds of peat, the differences between peat deposits, and the possible uses of peat products are some of the factors that have contributed to limitation in the use of the country's peat resources. Reports as to the form in which the peat was produced for market indicate that 24 operators produced shredded peat, 20 raw peat, 8 cultivated peat, and 2 kiln-dried peat. As the figures indicate many of the plants produced peat in more than one form.

The United States federal government has established designations and specifications in purchasing its peat requirements (87) based upon the recognition of only three types; namely, moss, reed muck or sedge muck, and reed peat or sedge peat. The New Jersey Agricultural Experiment Station has drawn up its own (105) peat specifications, based upon the four major types established previously; namely, moss peat, sedge and reed peat, forest peat, and peat soil.

Peat is not a "fertilizer", in the ordinary sense of the word. It is low in plant nutrients but rich in organic matter, the latter being the primary concern in its purchase. In order to evaluate peat it is essential to know, first of all, its content of moisture and ash, inasmuch as the remainder is organic matter. Two typical analyses of peat are here given:

	Peat No. 1	Peat No. 2
	per cent	*per cent*
Moisture	65	80
Organic matter	32	15
Ash	3	5
Total	100	100
	Per ton of material	
	pounds	*pounds*
Moisture	1,300	1,600
Organic matter	640	300
Ash	60	100
Total	2,000	2,000

On the basis of these calculations, peat No. 1 contains more than twice as much organic matter as peat No. 2. A ton of peat No. 1 is, therefore, worth more than twice as much as a ton of peat No. 2 as a source of organic matter. Since the consumer is interested primarily in buying organic matter, his interest should be centered upon this rather than upon the moisture or mineral matter. To obtain 1 ton of actual organic matter, 3.1 tons of peat No. 1 and 6.7 of peat No. 2 are required.

A number of bogs in the State have been partly or fully drained, and have been utilized as sources of humus for soil improvement purposes as well as for the growth of crops. Among these the Great Meadows near Pequest and the Hyper-Humus bog near Newton are best known. A plant operating under the trade name "Alphano-

Humus" used to produce large quantities of peat, which was artificially dried in special ovens. This peat was sold for soil improvement purposes, as a carrier of bacteria, and as a fertilizer filler. Soon after World War I, however, the company went into bankruptcy, and the area from which the peat was dug is now utilized for the growth of truck crops, for which it is preeminently suited.

Successful large-scale peat producers have never been numerous in New Jersey. Although many individuals have removed peat for personal use or for sale in small quantities, the United States Bureau of Mines reported only three peat producers in New Jersey in 1935. One, the Hyper-Humus Company, with a plant near Newton, had been in business for many years, and has continued to the present time. Another, with a plant at Stanhope, Sussex County, was operated by J. G. Marcrum, who, in dry weather, stripped peat from the surface of his bog, shredded it in a revolving macerator, and sold it in the wet, raw state. The third reporting producer in 1935 was J. H. Sprague, Jr., of Barnegat, whose peat was probably of the forest type. Analyses and production values are not available.

In 1936, Hyper-Humus and Marcrum were still in operation; J. H. Sprague, of Barnegat, had retired from the field, and his place was taken by M. E. Reeves, of the same municipality. In 1937 and 1938, in addition to the three plants producing peat for sale during the previous year, David L. Temple was operating in Middletown and Charles Wainwright in Waretown.

Reeves, Hyper-Humus, and Marcrum were the only reporting peat producers in 1939 and in 1940 Marcrum sold out to Cornelius Daly, who operates the Stanhope plant under the name of Netcong Natural Products Company. In 1940 this company sold 600 cubic yards of "Netcong sedge peat" at $3.00 a yard at the plant; and in the following year, 1400 cubic yards were sold on the same basis. The peat sold consists of the more fibrous underlying strata. Some of the peat is shredded, some is sold in blocks, and some is split into 1-inch layers for mulching purposes. It is not otherwise composted or treated. The following analysis of the material in the bog is typical; moisture, 82 per cent; ash, dry basis, 7.4 per cent; nitrogen, dry basis, 2.34 per cent; pH 4.3 at the surface, increasing to pH 6.0 at a depth of 8 feet. The peat is composed of reeds and sedges, admixed with forest remnants. Diatomaceous earth, which occurs beneath the peat, was also sold for a time by J. G. Marcrum.

The Hyper-Humus Company produces what is known as cultivated peat (plate XV). It grows green cover crops upon the surface of its well-drained bog and these are disced under and allowed to

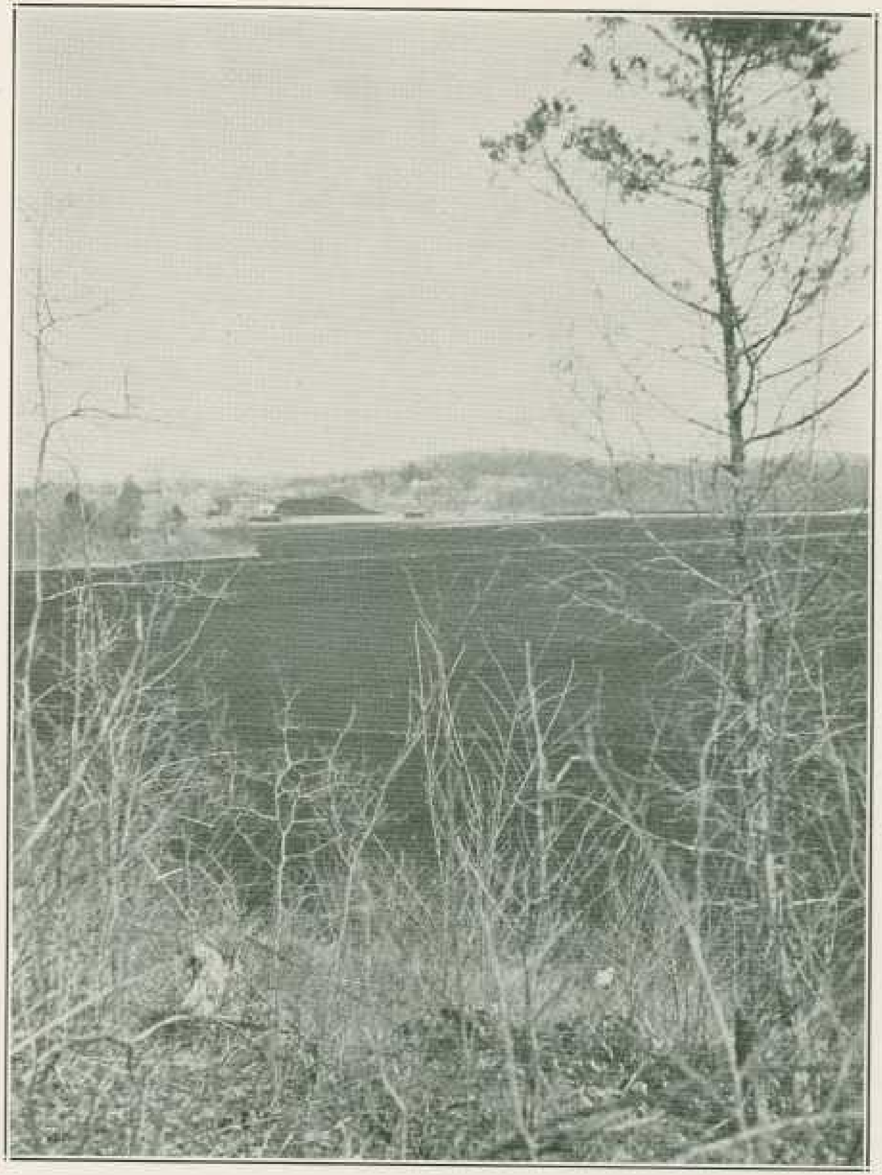


PLATE XV. Hyper-Humus bog at Newton; plant in background.

decompose. The surface stratum of the peat is then scraped off and piled in heaps for drainage. Later it is brought to the plant by means of a narrow-gauge railroad and there screened and piled for further drying before it is bagged for sale. In physical appearance, the cultivated peat is black and granular. A stock pile sample received in December, 1939, had the following analysis: pH 5.3, moisture 66.5 per cent; ash, dry basis, 9.1 per cent; moisture-holding capacity, dry basis, 375 per cent. A similar sample received in February, 1942, had 65.6 per cent moisture, pH 5.0, ash 11.3 per cent, and moisture-holding capacity 390 per cent.

To the spring of 1942, the Hyper-Humus Company had produced and sold 204,150 tons of peat. The following table presents yearly sales:

	Year	Tons
Total quantity prior to	1932	124,314
	1932	7,969
	1933	6,934
	1934	5,990
	1935	7,478
	1936	7,913
	1937	7,979
	1938	8,368
	1939	7,013
	1940	8,742
	1941	11,450
Total		204,150

The Hyper-Humus bog has been deeply ditched to provide excellent drainage, particularly in that part from which peat is being removed. The peat is of good quality, and the whole deposit is remarkably uniform. Plant equipment is good and is well maintained, and the process has been carefully thought out. The net result has been the economical production, over many years, of superior quality sedge and reed peat.

Numbers of smaller producers were or are found in New Jersey. Few of these companies give annual reports. For example, a firm produces "Natural black humus" at Wayne, Passaic County, from a 50-acre reed and sedge bog varying in depth from 1 to 6 feet. Shredded, limed and cultivated peat, as well as shredded raw peat, are sold for $5. or $6. a ton at the plant. The plant in 1940, had been producing for 6 years. In 1938, three stock samples were analyzed: the first contained 71.3 per cent organic matter, on a dry basis, with a pH of 4.9; the second had a pH of 5.1 and 73 per cent organic matter; and the third had a pH of 5.4 and an organic content of 89.6 per cent. In 1940, two samples were analyzed with the following results:

	Moisture	Ash dry basis	Nitrogen dry basis	pH
	per cent	*per cent*	*per cent*	
Raw peat	60.8	16.5	2.63	5.2
Cultivated peat	50.7	25.7	2.59	5.4

"High grade certified humus and peat moss" was produced from a three-quarter-acre bog at Springfield, Union County, in 1940. The plant, hand operated, had been in service for three years. Sales volume had been small; the humus sold at $1. per 120-pound bag, whereas a product designated as "peat moss" sold for $1.60 per 100 pounds. The humus consisted of granulated, well-decomposed screened surface material; the "peat moss" consisted of the shredded fibrous lower layers. This material was, of course, not moss peat. In 1938, two samples were analyzed; the fibrous material contained 16 per cent moisture and 94.3 per cent organic matter, on a dry basis; the humus sample contained 25 per cent moisture and 81 per cent organic matter. Two samples submitted in 1940 analyzed as follows:

	Moisture	Ash dry basis	Nitrogen dry basis	pH
	per cent	*per cent*	*per cent*	
"Peat moss"	47.4	13.4	1.57	4.7
Humus	46.0	34.8	1.21	5.3

A sample of peat obtained in 1941 from the Thompson bog near Middletown, Monmouth County, gave the following analysis: pH 4.8; moisture, 42.5 per cent; organic matter, 52.8 per cent, dry basis; nitrogen, 1.6 per cent, dry basis.

The Essex County Hy-Grade Humus Company operates a plant on Troy Meadows near Troy Hills where the deposit is difficult to drain. A sample submitted in 1940 showed a moisture content of 71.2 per cent; the organic content was 67.2 per cent of the dry matter; and the pH was 5.2. Approximately 1,000 cubic yards of material were sold in 1941.

Of the various major types of peat, New Jersey lacks only peat moss. Although sphagnum and other mosses occur in a number of bogs in the State, the accumulated peaty deposit is usually not more than a foot or so in depth. A peat layer which is so shallow is quite unsuitable for large-scale development. Much sphagnum moss, however, has been collected in the cedar swamps, both for surgical dressings and for horticultural purposes (79). In southern New

Jersey particularly, sphagnum is gathered for use in packing plants, and it is also baled for shipment to gardeners and nurserymen. Sphagnum is also used extensively in the cultivation of orchids, ferns, and pitcher-plants, as well as for grafting and propagation of various plants.

The gathering of sphagnum moss from the cedar forests of the Pine Barrens is so widespread that no effort was made to tabulate it; for moss has been gathered from virtually every bog in the entire region at one time or another. Moss gathering, drying, and baling represents a considerable industry in southern New Jersey, and many people are so employed, working mainly in their spare time.

PRODUCTION OF "ORCHID PEAT"

The utilization of the roots of the cinnamon fern (erroneously termed "orchid peat") has increased markedly in the last decade, as a result of the development of orchid culture. The largest growers of orchids in the country, Thomas Young Nurseries, Inc., of Bound Brook, N. J., use an average of eight to ten thousand bags (40 to 50 tons, dry basis) of Osmundi fibre (the fibrous product obtained by the maceration of and cleaning of the fern roots) each year. They, as well as many other orchid growers, including some in the middle west and even in California, obtain their material from the bogs of northern New Jersey. The total quantity of New Jersey "orchid peat" employed by the large number of smaller growers is not accurately known, but is probably double and perhaps treble the amount utilized by Young Nurseries. In the case of Lager and Hurrell, of Summit, for example, 400 bags are used for potting, and 600 to 700 bags are sold at retail. Of these amounts, about 40 per cent is obtained from New Jersey, the remainder from New York and Pennsylvania. This grower prefers the quality of the New Jersey product to that of the other two regions.

In cutting the roots of the fern in the bog, the fibrous mass is removed in blocks and spread in the open to dry. A bag (the commercial unit of measure) of the freshly cut product weighs approximately 50 pounds; when dry, it weighs between 8 and 12 pounds. Every bog in northern New Jersey contains greater or lesser numbers of the cinnamon fern; where cutting has been heavy and persistent, as in Bear (Lake Owassa) Swamp and associated bogs, the stand of ferns may be almost pure. In the vicinity of Lake Owassa, 12,000 to 15,000 bags of fern roots were removed in 1930; at present 1,000 or fewer bags are removed annually, the present market price being $1.35 a bag. After an area has been cut over, a period of time must elapse before the ferns again develop the fibrous root system demanded by the trade.

PRODUCTION OF LEAF MOLD

Leaf mold, or forest litter, is obtained in considerable quantities from the forests of southern New Jersey. One of the most active producers of this excellent soil-conditioning material is Earle Dilatush, of Robbinsville, who not only sells many tons but also utilizes large quantities in his own holly nursery. As dug, this material is from 6 to 18 inches deep and consists of the litter of oak and associated trees, in places somewhat mixed with decomposed pine needles. The pH of the material is 4.4. The leaf mold is readily removed from the sandy forest floor by means of grub hoes. Well-established forest trees and shrubs are apparently unaffected by its removal. The leaf mold is allowed to drain in a large pile, after which it is macerated by passage through a threshing machine, followed by rotary screening. In 1936 and 1937 the nursery sold five tons of "oak leafmold" each year, and in 1938 ten tons. Shredding and screening equipment was installed in 1939, and 198 tons of material were sold in that year and 200 tons in 1940. The quantity trebled in 1941, when 611 tons were sold. An increase is expected in 1942, although the supply as a whole appears to be decreasing.

A second producer of leaf mold in 1940 was Samuel Reynolds, of New Egypt. A sample of the material which he offered for sale showed 45.9 per cent dry matter, 20.1 per cent ash (dry basis), 0.93 per cent nitrogen (dry basis), and had a pH value of 4.3.

OTHER USES OF PEATS IN NEW JERSEY

In addition to the aforementioned uses, New Jersey peats have proved valuable in other ways. For example, peatlands serve as safeguards against drought, floods, erosion, and lowered ground waters (32).

Many peat bogs in southern New Jersey have been converted into reservoirs for the flooding of cranberry bogs. In some cases these become permanent lakes, or old bogs may be permanently flooded for recreational purposes. In northern New Jersey the conversion of peat bogs into artificial lakes is essentially for recreational purposes, other uses being subordinate. In some cases, peat and alluvial lands have been flooded to provide water for dairy herds. Northern New Jersey was formerly heavily lumbered to provide charcoal for iron smelting and in some cases the ore was crushed by water power.

It appears certain that prior to the Civil War artificial flooding of peatlands for industrial purposes must have occurred. Numbers of mills, run by water power, were probably in existence in the northern part of the State; in southern New Jersey large numbers are known to have occurred.

PASTURE AND HAY

The utilization of bogland for pasture has been slighted in the glaciated part of the State. Usually, except in certain dangerous bogs, or in the remote mountainous regions where farming is not practiced, bogs are utilized in small part for wild pasture. Elsewhere in northern New Jersey, comparatively slight amounts of hay are cut from peat areas, the land being used primarily for pasture. In southern New Jersey, on the other hand, particularly on reclaimed tidal marsh, large quantities of hay are cut each year.

The Lower Delaware drainage region is notable for the amount of land which was once utilized for hay production or pasture and later abandoned. Almost fifty per cent of all the land in the entire State known to have been used for this purpose is in this region. Here the earliest and most extensive attempts at marshland reclamation were made and much of this reclaimed land has since been lost to the tides for reasons previously mentioned. This region contains 14 per cent of all the surveyed land devoted partly to hay and pasture, and, together with the Navesink, Maurice and Cohansey drainage regions, embraces 31 per cent of the State totals. An additional 50 per cent of the State totals is found in the Wallkill drainage region. Pasture predominates over hay in the Raritan, Pequest, Paulinskill, and Passaic drainage regions.

FIELD AND TRUCK CROPS

At the present time, 16 per cent of all surveyed land containing reclaimed marshes devoted to field and truck cropping is found in the Lower Delaware region. Twenty-one per cent more is in the Delaware, Maurice, Navesink, and Rancocas regions, and an additional 50 per cent is in the Passaic, Paulinskill, Pequest, Raritan and Wallkill regions.

Some of the most important agricultural land in the State is that in the Pequest Meadows which is now used almost exclusively for truck crops. The history of the reclamation of this land is not only interesting and informative, but also of fundamental importance in its application to the development of similar lands.

This part of the State was taken up by settlers soon after 1750 (Cook, 1884) and as early as 1808-1810 efforts were made by two men to drain the meadows. The work was not properly done, however, and the land went back to its original condition.

Individudal efforts to drain parts of the meadows were continued during the next 60 years and though many of these resulted in temporary improvements, occasional floods continued, and in time the ditches were filled and conditions reverted to what they were prior to settlement of the land.

In 1870 a survey of the meadows was made for the New Jersey Geological Survey and the recommendations which were made for deepening the main channel and digging subsidiary ditches were put into effect within the next 10 years. Cook described the improvements effected as follows:

> The effect of this improved drainage is seen throughout the whole length of the meadows. The lands are accessible at all seasons. The Goose Pond is now entirely dry, and corn has grown upon it this year. The saw mill streams, formerly lost in the marshy ground, are now plainly marked by open channels quite to the Pequest. The water in the stream has scarcely overflowed its banks, in time of freshet, since the channel was deepened. And the whole of the meadows is now dry enough to be tilled and cropped the same as upland. Some 500 acres are already cleared and in cultivation, and most excellent crops are grown upon them.

It was found that lands along the Pequest and subsidiary streams above the improved lands were markedly benefited by the drainage of Great Meadows.

Great Meadows, in whole or part, has been in cultivation since drainage was completed. Subsidence of the land, following drainage, has been accompanied by increasing numbers of floods. When these occur in the winter or in early spring, little harm is done, but when growing crops are covered by flood waters, extremely heavy loss may result. Drainage projects on these lands did not cease in 1880; they will necessarily continue if the land is to remain in production.

Another large bog at Oxford Furnace, Warren County, was once drained and cultivated, but is now subjected to repeated and lasting floods. Part of the area is utilized as pasture and grasses and reeds, together with a comparatively few shrubs and trees, are supported on the wet, clayey soil; but for much of the year the water level is such as to render the land worthless.

CEDAR SWAMPS AND CEDAR MINING

In many bogs buried cedar logs have been "mined", or dug, and these have yielded a fine type of lumber. The wood is soft, but on account of its non-resinous character and straight grain, it is used for boat-building, cooperage, and the manufacture of woodenware. Shingles made of this white cedar are known to last for many years. After more than two hundred years of exploitation, good cedar logs are still being removed. Benjamin Franklin published an essay in Poor Richard's Almanack (1749) in which he recommended the planting of red cedar after the white cedar has all been dug. Harshberger (43 or 45) adds to this: "But the supply is still far from exhausted." The cedar logs are found in the bog in an almost

Cook (26), in his first report on the geology of New Jersey, emphasized the importance of cedar trees in bogs and the utilization of some of these for practical purposes. Leavitt (55) wrote that the annual product sent from Dennisville averaged about 200,000 rails, worth $8 to $10 per hundred, and 600,000 shingles, worth $14 to $15 per thousand. Harshberger (41, 42) also mentioned that the white cedar yielded a fine grade of lumber for vats, tanks, churns, buckets, and firkins. The shingles made from white cedar covered many of the houses built in New Jersey in the last century.

The mining of cedar logs was on a fairly extensive scale along Maurice River and Dennis Creek. It is probable that cedar was mined in other places, but here again, information is incomplete. Lumbering on bog land has been, and still is, so extensive that no attempt was made to evaluate the industry, which is largely conducted by individual owners. It can probably be said safely that no bog of any extent in the entire State has escaped lumbering operations. At the present time, a few large-scale operations are in progress, such as the removal of timbers for the zinc mines of northern New Jersey, but most of the lumbering operations are conducted by the individuals who own or control the bogs. White cedar has been, and still is, the most valuable product of the pine barren bogs; and much white cedar together with hemlock and other woods, was formerly removed from the forest bogs of the mountainous regions of northern New Jersey.

INDUSTRIAL AND RESIDENTIAL USE OF TIDAL MARSHES AND PEATLANDS

Many industries have used the marshland in the vicinity of our large tide-water cities as the sites of industrial plants, and there has even been some residential use of such land. Moreover, the marshes have influenced both the type and location of our early settlements, some of them having been abandoned because of the mosquitoes and other specific effects of wet land on the population. Of all the surveyed land containing peat devoted in part to industry or for residential purposes, 69 per cent occurs in the Lower Delaware, Hackensack, Passaic, and Raritan drainage regions.

EPILOGUE

In completing this survey one can do no better than cite a statement of Smock, made prophetically, just half a century ago:

> In these days of more intensive farming and wider competition these alluvial lands of the State deserve attention. They may be compared to some of the more valuable irrigation-farm lands, since they may be made to be practically irrigable in some cases, and in all they are more easily tilled than the older uplands, and to that extent more valuable. The alluvial lands of Europe are its food-producing territory, and the wet lands of New Jersey are comparatively as important as elements in our agricultural development. They ought to be in a high state of cultivation and much of the mountainous land as well as the more uneven and stony hills and valleys, now skimmed over by a slovenly and almost wasteful kind of farming, should be restored to forestry and to valuable gathering territory for large supplies of water for our cities.

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SUBJECT INDEX