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Some Postglacial Forests in Central and Eastern New York State As Determined by the Method of Pollen Analysis

By

DONALD D. COX

Science Research Expert

New York State Museum and Science Service

**NEW YORK STATE MUSEUM
AND SCIENCE SERVICE
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*The University of the State of New York
The State Education Department*

Albany, N.Y.

December 1959

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ABSTRACT

DONALD D. COX*

Science Research Expert

Fourteen pollen profiles from 12 stations in New York State are presented and discussed. These stations extend from Albany to Auburn in an east-west direction and from Ogdensburg to Oneonta in north-south range. Ten stations are south of latitude 43°30' North and two are north of this parallel.

The southerly stations have profiles that are similar in general outlines but differ in important details from those in other parts of eastern North America which have been described by Deevey, Potzger, Sears and others. Most of the profiles begin with a coniferous period in which pine, spruce and fir maxima occur successively. This is followed by a short but prominent pine period. The interval of pine dominance is replaced by a hemlock-hardwoods interval extending to the surface, characterized by two *Tsuga* maxima separated by a *Tsuga* minimum. A *Fagus* maximum corresponds with the *Tsuga* decline, suggesting relative drying caused by an increase in temperature. The second *Tsuga* rise is associated with a reentrance of *Picea* to the profile.

Pine pollen size-frequency curves were constructed for eight of the stations. These suggest that *Pinus banksiana* was replaced in the pine period by *P. strobus* and/or *P. resinosa* which continue to the present.

The northern diagrams correspond closely with those described by Potzger for Quebec. They show a prominent pine period followed by a long era of pine, hemlock and deciduous genera. The top levels are identified by an increase in spruce and fir.

Samples were taken from the site where a mastodon skeleton was found. It was concluded that the animal lived during a time when the forest was dominated by spruce and pine.

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INTRODUCTION

In the last 50 years pollen analytical studies have been carried out in many regions of North America and especially in the region of the glacial border. In eastern North America broad outlines of climatic and vegetational change in postglacial time have been indicated. There remains the task of verifying and further refining these patterns of vegetational change. In order for this to be accomplished, the pollen record should be established for all parts of eastern and northeastern North America.

One large area in northeastern United States is noticeably lacking in contributions to the pollen record. There are only two published pollen profiles from stations in New York State and these stations are widely separated. A doctoral dissertation on file in the Graduate School at Syracuse University (Sheldon, 1952) gives pollen profiles for seven peat bogs in the vicinity of Syracuse, N. Y., bringing the total to nine diagrams for the State.

The present study adds 12 profiles to the above record, including an area extending from Auburn to Albany in an east-west direction and Ogdensburg to Oneonta in north-south extent (map 1).

Comparisons of the present findings with those of previous studies in New York State and surrounding areas have been made in an effort to establish climatic and vegetational phases that have transpired in New York State since the melting of the last advance of the Wisconsin ice.

In a study of this nature certain basic assumptions are essential for a complete understanding of the data presented. The first assumption is that the climatic factors that have determined plant distribution in the past are the same as those that effect plant distribution today. Sears (1931), Potter (1947), Deevey (1943) and others have suggested a correlation between the following genera and type of climate:

Abies and *Picea*—wet, cold

Pinus—dry, cool (warmer than the preceding)

Tsuga—moist, cool to warm (Hemlock is more an indicator of moisture than of temperature.)

Fagus—moist, warm (In this study beech is taken to indicate a drier degree of mesophytism than hemlock.)

Quercus—warm (As an indicator of moisture this genus is less reliable than as an indicator of warmth. Usually, as in this study, it is taken to indicate the drier side of mesophytism.)

The second assumption is that the factors that have caused succession in the past are the same as those that cause it today. Succession is ordinarily toward greater mesophytism, whether it is xerarch or hydrarch. Therefore vegetational changes other than those toward greater mesophytism, if they cover a broad area, can be taken to indicate climatic fluctuation.

ACKNOWLEDGMENTS

The location of suitable places from which to take samples was one of the major problems. This and the actual taking of the samples required a great deal of cooperation and help from many sources. A few of the people who were of very great assistance are listed here.

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Particularly, I wish to express my very great appreciation to Dr. Mildred E. Faust for the time and effort spent in directing and supervising this study.

HISTORICAL REVIEW

In most pollen profiles, which show a complete vegetational history of postglacial time in eastern North America, a period occurs in the lowermost layers of sediments, during which spruce and fir are the dominant tree species. This has been interpreted as indicating the existence of a cold moist climate at that time. It is believed by many that the forests of this age were growing relatively close to the southern margin of the Wisconsin ice sheet. Sears (1942a) refers to this as period I, while it is period A according to Deevey's (1943) classification. Potzger (1956) called this period Q-2 in his work on southern Quebec bogs. Deevey further divides this period into three subdivisions, A-1, A-2 and A-3 for New England; a warmer period of pine and spruce, followed by cooling and a maximum of spruce, and finally a maximum of fir. Potzger

describes a period, Q-1, in southern Quebec which corresponds with the A-1 interval above. Deevey delimits a period preceding the A period, which he believes to indicate tundra conditions. This has not been confirmed for most other parts of eastern North America.

The next distinct vegetational interval appearing in the pollen record is one of pine dominance. Since pines of today are, in general, less mesophytic and more warmth "loving" than spruce and fir, the pine period is taken to indicate a drier and warmer period than the preceding. Sears (1942a) identifies this as period II, Deevey (1943) as B and Potzger (1956) as Q-3. The pine period is perhaps the most common feature of North American pollen profiles, because it is found throughout the area in which pollen analytical studies have been conducted. It is noteworthy that conditions similar enough to produce such a period should have been so widespread. In attempting to explain this phenomenon, Dansereau (1953) has admitted that the number of speculations he raises is greater than the number of facts to be accounted for.

The interval of pine dominance gives way to a period characterized by the appearance of warmth "loving" and probably more mesophytic species. Sears (1942a), Deevey (1943) and Potzger (1956) have designated this period as III, C-1 and Q-4 respectively. With the decline of pine, regional variation begins to assert itself in eastern North American profiles. Potter (1947) and Sears (1931) in Ohio, and Sears (1942b) in the North Central States, find a rise of beech associated with the decline of pine. In Illinois, Wisconsin and Minnesota, Voss (1934) and Artist (1939) find a rise of oak is associated with this period, while in New Jersey and New England, Niering (1953) and Deevey (1943) report an increase in oak and hemlock as markers of this interval.

In some localities it appears that the transition to broad-leaved or deciduous genera is the last vegetational change that can be correlated with a corresponding climatic change. Potzger (1956) finds in southern Quebec that no climatic change is indicated until relatively recent times. In Illinois and Wisconsin, Voss (1934) and Artist (1939) conclude that the fluctuations of pine and oak in the upper two-thirds of the profile are due to local disturbances and have no climatic significance.

Sears (1942c) is of the opinion that there is a level in the upper one-third of the pollen record which represents a period when warmth and dryness were at a maximum for postglacial time. He refers to this as the xerothermic period. According to Potter (1947) and Sears (1932), it is represented in Ohio and the North Central States by a maximum of oak and hickory. In New Jersey a hickory maximum corresponds with this level (Niering, 1953). In New England Deevey (1949) records an oak-hickory maximum, in agreement with the Ohio diagrams. The xero-

thermic period has been designated IV by Sears (1942a) and C-2 by Deevey (1943).

In recent times the pollen record indicates that there has been a shift toward cooler and more moist climatic conditions. This is period V of Sears (1942a), C-3 of Deevey (1943) and Q-5 of Potzger (1954). Potzger (1953), and Potzger and Courtemanche (1954) in Quebec, Wilson and Webster (1943) in southwestern Ontario, and Deevey (1939) have given evidence to support this supposition. These writers base their opinions upon an increase of spruce-fir in the top part of the pollen profile for northern stations and a shift toward greater mesophytism in the more southerly stations. Fuller (1935) observes that this is a poorly marked trend, and Potzger (1948) finds no evidence at all for it in lower Michigan. Voss (1934) and Artist (1939) hold that recent increases in spruce pollen are due to the development of black spruce within the bogs. Cain (1948) points out that North Central profiles often do not show a moist, cooling trend in the upper levels.

Knox (1949) is of the opinion that the period of decreasing temperature and increasing moisture is past and we are now in a somewhat warmer, drier period. Potzger and Friesner (1948) in Maine and Krauss and Kent (1944) in New Hampshire record an increase in oak in the upper extremity of the pollen profile which would militate against a cool, moist period. Dachnowski (after Potter—1947) concludes, after examining peat deposits in Ohio, that the present period is one of rising temperatures or decreasing moisture, or both. Potzger (1941) has given data from the U. S. Geological Survey on the recession of glaciers in North America and is of the opinion that the climate of the north temperate and arctic latitudes is becoming warmer.

European workers in palynology have more or less substantiated a classification of postglacial time proposed by Axel Blytt (after Sears—1942c). He proposed seven periods based on European pollen profiles:

7. Present—cooler and drier than Atlantic
6. Sub-Atlantic—cool and moist
5. Sub-Boreal—drier and cooling
4. Atlantic—warmer, moist
3. Boreal—warm, dry
2. Sub-Arctic—cold
1. Arctic—cold, glacial

Deevey (1943) is of the opinion that his period B corresponds with Blytt's Boreal and that periods C-1, C-2 and C-3 correspond with the Atlantic, Sub-Boreal and Sub-Atlantic, respectively. He believes that, for the most part, the Sub-Arctic and Arctic periods are missing in

American profiles. Deevey (1943) and Smith (1940) are in agreement that the period preceding the pine maximum in American profiles is a Pre-Boreal period and does not correspond with either the Arctic or Sub-Arctic of Blytt.

Although there seems to be evidence to support it, few American pollen workers have recognized the Present period as suggested by Blytt (Sears 1942c) for Europe. Knox (1949) has recognized this period for New England as a somewhat warmer and drier period.

There have been three papers dealing with pollen analysis for New York stations. McCulloch (1939) did some early work on a bog in central New York. In his work on southern New England forest history, Deevey (1943) considered two stations at Queechy Lake on the southeastern border of New York State. Sheldon (1952) analyzed seven bogs within a 30-mile radius of Syracuse, N. Y.

Sandy Ridge Bog, which was the subject of McCulloch's (1939) paper, was also included as one of Sheldon's (1952) stations. McCulloch apparently did not take samples from the open pool, whereas Sheldon took samples through the ice at the center of the open pool. The profiles from this station differ in these two papers in several noticeable respects: in the bottom levels McCulloch finds *Abies* in quantities greater than 50 percent. In Sheldon's profile *Abies* is present in the lower levels in quantities less than 30 percent. On the other hand, McCulloch finds only 29 percent *Picea* in the lowest level, while Sheldon finds 48 percent. They both agree, however, in an early spruce-fir period, the main difference being in the proportion of spruce and fir.

Both of Deevey's (1943) stations at Queechy Lake are slightly truncated at the bottom and thus do not give a total picture of the early periods. They appear, however, to give a complete profile from the *Pinus* period to the surface. McCulloch (1939), Sheldon (1952) and Deevey (1943) agree in showing a very short pine period. Some of Sheldon's diagrams (Sandy Ridge Bog A and Pennellville Bog) show no pine period at all.

Sheldon (1952) and Deevey (1943) both show an increase of oak, hemlock and beech at the end of the pine period. According to McCulloch (1939), there is a maximum of hemlock followed by a rather abrupt hemlock minimum. All three writers agree in showing that the hemlock minimum is associated with an increase in oak and pine. Apparently this is the xerothermic period. Following the hemlock minimum, hemlock again ascends to a position of prominence in the upper levels of New York bogs. In the upper levels at Queechy Lake, Deevey (1943) found a reentrance of *Picea*, accompanied by an increase in *Pinus* and a decrease in *Quercus* and *Fagus*.

METHODS

Samples were taken from 12 stations in New York State (map 1). A Davis peat sampler was used to take samples from 11 of the stations and a Hiller borer was used for one. Trial borings were made along two axes of each bog to determine approximately the deepest portion. In all cases, specimens were taken from the deepest point. Six-inch intervals were maintained between samples at all stations except number 12 (map 1), where intervals of three inches were used. The sediments were either transferred directly to properly labeled glass bottles at the time of collection or placed in pint-sized plastic bags and later, in the laboratory, transferred to bottles for storage. Thirty percent alcohol was added as a preservative.

In preparing the peat for microscopic analysis, the KOH Method was used for about half of the samples. The organic sediments were boiled in 5 percent KOH, strained through cheesecloth to remove the coarser particles, then centrifuged and rinsed several times in distilled water. After the last centrifuging the water was poured off and a small portion of the top layer of the residue was placed on each of two glass slides. Several drops of warm glycerine jelly, prestained with aqueous gentian violet, were added to each slide and mixed thoroughly. A 22 x 40 mm. cover glass was applied and the slides were turned upside down to cool. Samples that contained large amounts of marl were treated with nitric acid and sandy sediments were treated with hydrofluoric acid previous to the KOH procedure.

The boiling and centrifuging operations of the KOH Method are quite time-consuming. The writer found that simply mixing the peat directly with glycerine jelly produced entirely satisfactory results. A small amount of the peat was placed on a glass slide to which a drop of water was added and mixed thoroughly with a teasing needle. To this mixture was added several drops of warm, prestained glycerine jelly. A cover glass was added and the mixture was allowed to cool as above. This method permitted the preparation of slides in about 20 percent of the time required by the KOH Method. The latter half of the samples were prepared for analysis in this fashion.

A Spencer binocular microscope with a calibrated mechanical stage was used to make the pollen counts. A count of 200 tree pollens was made at each level, except where a paucity of pollen grains forced a lower count. The entire count was made from a single slide which was examined by a series of controlled sweeps with the mechanical stage.

For some of the bogs, the size of the pine pollen was recorded as it was identified. The pollen grains were measured from wingtip to wing-

tip and the size recorded in ocular micrometer spaces. These data were converted to microns and size-frequency curves were plotted for those bogs. The pollen sizes were separated into two categories: those over 66 microns in width and those under this size. Each graph shows for each level the relationship of the number of small grains to the number of large grains. The number counted for each level varies from one or two, up to almost 200. Numbers of pine pollen less than 10 were not plotted in the graphs.

LOCATION AND STRATIGRAPHY OF SAMPLE AREAS

1. Bullhead Pond Bog is located in Geneva North Quadrangle, 7½ minute series, at latitude 42°56'32" North, and longitude 76°57'28" West. The boring was made about 100 yards back from open water on a cleared powerline right-of-way. It has been suggested that the deepest part of a pond or lake is the last part to be covered in the filling-in process of bog formation. If this is true of Bullhead Pond, the sediments in the open pool must be very deep.

Thirty-seven feet of samples were taken in the present study and the bottom still was not reached. At 37 feet the peat was so firm that the writer could not penetrate it further with a Davis sampler. A possible indication that the bottom was not reached is the absence of the first pine maximum in the pollen profile for this station (figure 1).

The sediments at Bullhead Pond consist of 32½ feet of peat in various stages of decomposition and 5 feet of mixed marl, clay and peat.

2. Cicero Swamp is located in the Cleveland Quadrangle, 7½ minute series, at latitude 43°7'47" North, and longitude 75°59'27" West. The upper 3½ feet of sediments were so greatly weathered that no pollen was recognizably preserved. Thereafter, peat persisted to the 8-foot level. Between the 8½- and 11-foot levels marl appeared. Aquatic shells were abundant at 9 and 9½ feet. Well-decomposed peat persisted to the 14-foot level. Peat graded into pure clay at the 16½-foot level. Clay graded into pure glacial sand and gravel at the 18-foot level. The sediments were so compact that no samples below this could be taken.

The pollen diagram of Cicero Swamp shows the truncating influence of the missing surface layers. The profile appears to be complete below the 4-foot level.

3. Mud Lake Bog is located in the Jordanville Quadrangle, 7½ minute series, at latitude 42°54'16" North, and longitude 74°53'56" West. The bog surrounds an open pool of considerable size. Samples were taken about 20 yards back from the edge of the floating mat. The stratigraphy

consisted of $9\frac{1}{2}$ surface feet of peat, followed by 8 feet of peat containing an abundance of marl and calcareous shells. A layer of clay extending from 18 to 30 feet was followed by sand and gravel at the 31-foot level.

The pollen profile of this station indicates that the complete record is there, although it appears to be somewhat telescoped. This may indicate a certain amount of truncation at the bottom. However, the fact that there were $11\frac{1}{2}$ feet of sterile clay under the pollen-bearing deposits militates against this conclusion.

4. Consaulus Bog covers an area of several acres which is rapidly being claimed by tree species. It lies in the Amsterdam Quadrangle, 15 minute series, at latitude $42^{\circ}59'12''$ North, and longitude $74^{\circ}2'46''$ West. Samples were taken to a depth of 24 feet. The lower 2 feet proved to be sterile, which argues for a complete profile, since the next 2 feet were also clay but contained an abundance of pollen. The region from the surface to $20\frac{1}{2}$ feet consisted of organic sediments.

5. Chestertown Bog forms a mat around the periphery of a small lake near Chestertown, N. Y. Found in the North Creek Quadrangle, 15 minute series, at latitude $43^{\circ}38'35''$ North, and longitude $73^{\circ}47'49''$ West, this bog consists of organic sediments for the first 15 feet, followed by slightly sandy peat up to 19 feet. Between $19\frac{1}{2}$ and $22\frac{1}{2}$ feet, sandy peat was taken, grading into sandy marly clay between the $22\frac{1}{2}$ - and $23\frac{1}{2}$ -foot levels. The 24-foot level was sandy clay and no samples were taken below this point.

The profile from this station appears to be incomplete, since the prominent spruce fir period recorded elsewhere is missing. Potzger is of the opinion that it is a "waste of time" to take samples from a bog with an open pool.¹ (This is not necessarily true, however, as indicated by the profile at station number 3 [figure 3].) The upper two-thirds of the profile for station 5 is complete, whereas no pollen was found in the two lowermost foot levels.

6. Worcester Bog is near New York State Route 7, southwest of Worcester, N. Y. There is no open water and the surface is covered with a growth of low ericaceous shrubs. This bog is located in the Richmondville Quadrangle, 15 minute series, at latitude $42^{\circ}36'4''$ North, and longitude $74^{\circ}42'16''$ West. Organic sediments are found throughout the 38 feet of the stratigraphy of this station, with the exception of the two bottom foot levels where marl occurs. The lower $11\frac{1}{2}$ feet were found to be devoid of pollen.

7. Highland Lake Bog consists of a relatively narrow border around a lake of considerable size. It is located in the White Lake Quadrangle, 15 minute series, at latitude $41^{\circ}31'36''$ North, and longitude $74^{\circ}51'18''$

¹ Potzger, personal correspondence.

West. Samples were taken approximately 30 yards from the edge of the water. Organic sediments comprised the entire sample column, with the exception of the lowermost level of 10 feet, where sand was encountered.

8. Perch Lake is located in the Lafargeville Quadrangle, 7½ minute series, at latitude 44°7'37" North, and longitude 75°54'30" West. Samples were taken from the north end of the lake where a very large area has filled in with peat. The peat layer is about 18 feet thick, grading into clay. Clay extended from 18½ to 38 feet, although no pollen was found below the 18-foot level.

9. Mud Lake consists of a very small central open pool surrounded by a floating mat. Samples were taken 15 yards back from the edge of this mat. This station is in the Tully Quadrangle, 15 minute series. at latitude 42°47'56" North, and longitude 76°8'43" West. Open water was encountered at a depth of 26 feet, and the sampler hit solid sediments again at 40 feet. No samples were taken below this level.

10. McLean Bog covers a small area, an acre or less in extent, with no open water. In view of the fact that very few shrubs have invaded the area, it seems probable that filling has been accomplished in relatively recent times. The bog is located near McLean, New York, in the Groton Quadrangle, 7½ minute series, at latitude 42°32'54" North, and longitude 76°15'57" West. From the 27½-foot level to the 33-foot level the sediments graded from clay into sand and gravel. No pollen was observed at these levels. Organic sediments persisted from the surface to the 27-foot level.

11. Dryden Bog is a depression with a fringe of white pine mixed with hardwoods, surrounded on all sides by cultivated fields. The entire area, an acre or so in extent, is covered with a growth of low shrubs. It is in the Dryden Quadrangle, 15 minute series, at latitude 42°27'6" North, and longitude 76°15'20" West.

The upper 25½ feet of sediments are pure organic material. From the 26- to the 32½-foot levels marl is mixed with the peat, which grades into clay in the 33- and 34-foot levels. Pollen was recorded at all levels.

12. In 1955 Myles L. Colgan, a farmer in central New York, in the process of constructing a farm pond, uncovered mastodon bones very near the surface of the ground. Acting on the suggestion of Dr. Clair A. Brown, the writer in the summer of 1956 visited this area and took samples from three sites in the vicinity where the bones were found. Site 2, at which the bones were uncovered, is about 50 yards south of site 1 and 300 yards east of site 3. At site 2 muck grades into marl and clay below the 2½-foot level. The bones were imbedded in the layer of marl and clay. Site 1 grades into marly peat and shells below the 1¾-foot level, site 2 below the 2¾-foot level and site 3 below the 3½-foot level.

The Colgan farm is located near King Ferry, N. Y., in the Genoa Quadrangle, 15 minute series, at latitude $42^{\circ}41'$ North, and longitude $76^{\circ}35'18''$ West.

SPECTRA ANALYSES

The profiles produced by this study fall into two distinct categories: group A, including those profiles that have two pronounced *Tsuga* maxima; and group B, consisting of diagrams that do not have two *Tsuga* maxima. Nine stations fall into the former category and three into the latter.

Group A

Bogs Having a Profile with Two *Tsuga* Maxima

Bullhead Pond (station 1, figure 1) shows a complete profile. It begins with a very strong representation of *Picea*, accompanied by small amounts of *Abies* and *Pinus*. *Picea* decreases gradually between the 37- and $32\frac{1}{2}$ -foot levels, while *Abies* and *Pinus* are increasing. *Abies* reaches a maximum at $32\frac{1}{2}$ feet, then declines. The drop in *Picea* and *Abies* marks the end of the period signified as period A by Deevey (1943) and period I by Sears (1942a).

The early pine period (A-1) described by Deevey (1943) does not seem apparent in this diagram. The profile begins with the A-2, or *Picea* maximum, subperiod. According to Preston Smith (1940), the *Picea* maximum is the result of a brief readvance of Wisconsin ice. He believes that the increase in *Abies* marks a Pre-Boreal period in North America.

The pine pollen size-frequency curve (figure 1B) for Bullhead Pond shows that a small-pollened pine is present during the *Picea-Abies* period. The range of *Pinus banksiana* today extends farther north into the subarctic Boreal Forest than any other pine, according to Dansereau (1953) and Potzger (1954). This species has a lower requirement for air and soil moisture, humus content and atmospheric heat than either *P. resinosa* or *P. strobus* (Dansereau, 1953). It is likely, therefore, that *P. banksiana* is the pine present during the early spruce-fir period.

Between the 32- and $28\frac{1}{2}$ -foot levels the spruce-fir period is replaced by a short, but very pronounced, pine period. The size-frequency curve (figure 1B) indicates that large-pollened pine is on the increase throughout this zone, with small-pollened pine decreasing. The large pollen reaches a maximum at the end of the period. It is probable that this represents a decrease in *Pinus banksiana* and an increase in *P. resinosa*, and/or *P. strobus*, since the latter are more mesophytic.

This is in agreement with the assumption that during the pine period, temperature and moisture were increasing. The more mesophytic pines are accompanied, and later replaced, by *Tsuga* and broad-leaved genera. In the Bullhead Pond profile, *Quercus* is prominently represented during the latter part of the pine interval, while *Betula* and *Tsuga* are less prominent.

The pine domination ends abruptly as *Pinus* is replaced by *Tsuga*, *Fagus* and *Quercus*, along with other broad-leaved genera. This hemlock-hardwoods period extends to the top of the diagram and is marked by at least two significant variations.

The first variation occurs at the 21½-foot level and is identified by a decline of *Tsuga* after it had attained a maximum, subsequent to the pine period. The second variation occurs between the 13½- and 19-foot levels, where *Tsuga* falls away to a minimum while *Carya* is increasing to a maximum. Since *Carya* is a genus that can tolerate warm, dry conditions (Sears, 1931), it is very likely that this represents the xerothermic period. A similar change is characteristic of this period in New England (Deevey, 1943) and New Jersey (Niering, 1953).

Near the top of the pollen record *Tsuga* again increases and *Picea* makes a reappearance. This probably means a return to cooler, more moist conditions.

It is interesting to observe the behavior of *Fagus* and *Quercus* throughout the profile. These genera show an alternate series of increases and decreases, each *Fagus* increment corresponding roughly with a *Quercus* decrement.

Mud Lake, Jordanville (station 3, figure 3) has a profile similar to the one above. The bottom layers seem to be telescoped, even though the complete record is present. As before, the profile begins with a high *Picea* frequency. This is followed by an *Abies* maximum and then a very short *Pinus* maximum. The *Picea*, *Abies* and *Pinus* maxima occur on consecutive foot levels 20, 19 and 18, respectively. The hemlock-hardwoods period begins at the 17½-foot level, continuing to the top of the profile.

The drop in the frequency of *Pinus* is marked by a very sudden increase in *Tsuga* and *Quercus*. As in station 1, the maximum of *Quercus* occurs immediately after the *Pinus* decline. This probably indicates the continuation of a warming trend. The great increase in *Tsuga* is an indication of increased moisture (Sears, 1931).

At the 10½-foot level *Tsuga* decreases abruptly to a minimum. This is followed by a corresponding increase in *Acer*, *Fagus* and *Quercus*. *Betula*, which has increased from the lowermost layers, reaches a maximum at this time. The sudden drop in *Tsuga* indicates a probable in-

crease in temperature. Furthermore, a relative increase in dryness is indicated by an increase in oak. This xerothermic interval apparently ends at the 4-foot level with an increase in hemlock and a decrease in oak.

Tsuga rises to a second maximum and then declines in the surface layers. *Picea* makes a reappearance at the 4-foot level, increases to the 1½-foot level, then decreases toward the surface.

Consaulus Bog (station 4, figure 4) may have the oldest profile of any in this series. It clearly shows the A-1, A-2 and A-3 periods as described by Deevey (1943) for New England. The lowermost layer indicates a forest of spruce, fir and pine. This seems to predate Deevey's A-1 pine period and may correspond with one of his L, or tundra, periods. At the 21½-foot level *Abies* disappears and *Picea* drops sharply. *Pinus* shows a rapid increase to a maximum at the 20½-foot level, accompanied by a noticeable increase in oak. The latter suggests warmer and drier conditions than those that followed, as indicated by the prominent increase in spruce at the 19½-foot level. Associated with the spruce increase is a decrease in pine and oak and an increase in fir.

Abies continues to increase and reaches a maximum immediately following the *Picea* maximum. The rise of *Abies* is accompanied by a second rise in pine, which reaches a maximum very soon after *Abies*. The pine period is short, but prominent, as in the previous diagrams.

Above the 17-foot level *Pinus* declines and the hemlock-hardwoods period begins. The rise in *Betula* is followed by a drop in *Pinus*, immediately after which a *Quercus* maximum is reached at the 14-foot level. The two *Tsuga* maxima occur at the 12½- and 5½-foot levels separated by a minimum of *Tsuga* at 8 feet. Associated with the decrease in hemlock is an increase in maple, birch, beech, hickory, oak and elm, with a decrease in pine.

The second *Tsuga* increase signifies a return to cooler, more moist conditions. This is further evidenced by the appearance of *Picea* in the top layers. The upper levels also show a decrease in *Tsuga*, *Fagus* and *Quercus*. *Fagus* and *Betula* vary inversely with *Tsuga* throughout the hemlock-hardwoods period, the peaks of the former corresponding with minima of the latter.

Potzger and Otto (1943) suggest that many bogs solidify and cease to preserve pollen, so that recent vegetational changes are not recorded. Consaulus Bog may be an example of this because it is closed and may have been closed for a considerable period of time as indicated by the number of trees and shrubs growing on it. The top part of the Consaulus profile, therefore, may not indicate very recent vegetational trends. This is true for any profile from a completely solidified bog.

The Worcester Bog (station 6, figure 6) profile is similar to previ-

ously described profiles in showing two very prominent *Tsuga* maxima. The lower portion of this profile appears to be telescoped and slightly truncated. The early pine period is missing and the diagram begins with a spruce maximum, strongly accompanied by fir and pine. The pine pollen size-frequency curve (figure 6B) reveals that the pine during this period is mostly a small-pollened pine, probably *Pinus banksiana*.

The brief A-3 period is marked by a fir maximum, and heavy representations of alder and birch with increasing oak, and is replaced at the 35-foot level by a very prominent increase in pine pollen. The pine pollen size-frequency curve (figure 6B) shows that at this point large-pollened pine is rapidly replacing the small-pollened species.

This marks the beginning of the longest pine period shown by any of the profiles. It extends to the 26-foot level and, as indicated in previous diagrams, is associated with a *Quercus* maximum. *Tsuga* is also present in large amounts but does not reach a maximum until the pine subsides. Above the 34-foot level, large-pollened pine is most abundant (figure 6B).

The hemlock-hardwoods period begins with a steady rise of *Tsuga* to the first of its maxima which it maintains with some fluctuations to the 17½-foot level. *Fagus*, *Betula* and *Quercus* are present in important numbers during this period. *Pinus* drops to a very low frequency but does not disappear entirely from the profile.

The xerothermic interval is marked at the beginning with the usual abrupt decrease in *Tsuga* at the 17-foot level. *Acer*, *Betula*, *Fagus*, *Quercus* and *Pinus* show increases corresponding with this zone. *Fagus* rises to its greatest maximum at the 13½-foot level, which corresponds with the xerothermic minimum for *Tsuga*. From this point to the top of the diagram, beech and hemlock vary inversely.

With the ending of the xerothermic period, hemlock rises to a position where it is once again a prominent component of the forest. *Tsuga* reaches a peak, decreases, then rises to a second peak in the two surface feet. The interval between these two peaks shows an increment of *Pinus* and *Fagus*. As before, a reappearance of *Picea* occurs in the top levels of the profile.

The top two foot levels in the diagram for Worcester Bog show an increase followed by a decrease in *Picea*, a slight decrease in *Pinus* and *Tsuga*, a decrease in *Betula* and *Quercus* and an increase in *Fagus*.

There is no central open pool at this station, since the bog is completely covered with ericaceous shrubs. Because there is no way of knowing how long the bog has been closed, it is entirely possible that the most recent vegetational changes are not recorded.

Mud Lake, Tully (station 9, figure 9) has a profile obviously trun-

cated at the bottom. The 40-foot level shows a high frequency of spruce and probably represents the A-2 spruce maximum. Above this level, open water extends to the 26-foot level at which point a greater incidence of fir and pine is noted.

The pine period is represented at the 25½-foot level pine maximum. The pine pollen size-frequency curve (figure 9B) shows, at this level, a small-pollened pine maximum. From this level upwards, large-pollened pine increases rapidly and becomes the major component of the pine curve.

The hemlock-hardwoods period begins at the 25-foot level with a sudden drop in *Pinus* and with just as sudden an increase in *Tsuga*. Beech and hemlock are the major constituents of the upper 25 feet of the diagram. The usual two *Tsuga* maxima are shown with an extremely long xerothermic interval. Associated with the *Tsuga* minimum is an increase in *Pinus*, *Acer*, *Carya* and *Quercus*. The *Quercus* and *Carya* maxima correspond with this period.

The behavior of *Fagus* is of especial interest in this profile, i.e., a beech minimum occurring at the hemlock minimum, because it is just the reverse of what it was in some of the previous diagrams. *Fagus* appears in a series of increases and decreases which extend throughout the hemlock-hardwoods period, making it very difficult to interpret. It is the most abundant species in the diagram for this period.

Characteristic of Group A bogs, *Tsuga* begins to rise to its second peak, in this instance at the 10-foot level. *Picea* reappears briefly and then disappears toward the surface. In the top level of the profile a slight decrease in *Tsuga* and an increase in *Fagus* and *Quercus* appears.

McLean Bog (station 10, figure 10) clearly does not reveal an early pine period. In the beginning levels *Picea* is dominant, accompanied by a small-pollened pine which is probably *Pinus banksiana*, as indicated by the *Pinus* pollen size-frequency graph (figure 10B). *Picea* decreases as *Abies* rises to a maximum, between the 26- and the 23½-foot levels. *Quercus* and *Betula* are present in the fir period and *Pinus* is very abundant in the upper levels of this period. *Pinus* reaches a maximum at the 22-foot level where *Abies* and *Picea* have all but disappeared.

The *Pinus* period is short but prominent. The size-frequency curve (figure 10B) shows at the *Pinus* maximum large-pollened pines, probably *Pinus strobus* and *P. resinosa*, have replaced the small-pollened species as dominants. *Tsuga*, *Betula* and *Quercus* are present during the pine period, but the latter two show a decrease at the pine peak. *Tsuga*, however, shows an increase at this point which continues to its first maximum in the hemlock-hardwoods period.

Pine decreases gradually and hemlock is the dominant genus for a

long interval. Hemlock considerably overshadows all of the broad-leaved genera present. The most numerous of the latter is *Fagus* which increases to a peak, then decreases up to the 10-foot level.

The xerothermic interval begins at the nine-foot level with a very sharp drop in *Tsuga* and a corresponding rise in *Fagus*. Increases in *Acer*, *Betula* and *Quercus* are also noticeable at this level. *Pinus* undergoes a gradual increment, reaching a peak toward the end of the xerothermic period and decreasing again toward the surface. Associated with the former, *Picea* makes a weak reappearance, then disappears.

After a relatively short xerothermic interval, *Tsuga* again attains a position of dominance in the surface levels. *Fagus*, after maintaining dominance throughout the thermal maximum, decreases at the surface, as does *Quercus*, *Betula* and *Acer*.

Dryden Bog (station 11, figure 11) presents essentially the same profile features as the other stations described in this section. The diagram begins with a spruce-fir-pine period, with spruce dominating. *Quercus* occurs in the lowest level along with the conifers. *Picea* and *Abies* have declined by the 32½-foot level and *Pinus* has risen. From this point to the 23-foot level, *Abies*, *Picea* and *Pinus* undergo a series of fluctuations. *Abies* rises to a second maximum (A-3) at 27 feet, after which it declines and the pine period sets in.

The pine pollen size-frequency curve (figure 11B) reveals that the earliest pines are mostly large-pollened pines. As the spruce and fir decline, the large-pollened pines are replaced by small-pollened ones. The latter reach a peak at the 29½-foot level, then gradually decline in favor of the large-pollened species toward the end of the pine period.

The pine interval is short, but very distinct. It is accompanied by a second advance of *Quercus* and low representations of *Tsuga*. Between the 22½- and 25-foot levels, *Pinus* is, without doubt, the dominant genus of tree, even if allowances are made for overrepresentation.

The beginning of the hemlock-hardwoods period is signified by a sharp drop in pine and a correspondingly sudden increase in hemlock. *Tsuga* increases rapidly to a maximum, then drops off sharply as *Quercus* develops a maximum. Other broad-leaved genera, especially beech, maple and birch, accompany the oak and persist to the top of the profile.

The hemlock frequency preceding the xerothermic depression shows two well-developed advances, with the intervening period identified by increases in birch and beech. The size-frequency curve (figure 11B) indicates an advance in small-pollened pines corresponding with the decrease in hemlock.

The *Tsuga* maximum at 12½ feet is followed by a sudden drop to a minimum. At this point *Quercus*, *Fagus*, *Betula* and *Acer* show advances

toward a maximum. *Pinus* begins a readvance which continues to the top of the profile.

The xerothermic interval comes to an end with an increase in *Tsuga*, which reaches a point where it is again the major tree component of the forest. The top levels of the profile show a reentrance of *Picea*, with a decrease in *Tsuga* and all the broad-leaved genera.

Cicero Swamp (station 2, figure 2) has a diagram which shows the complete pollen record except for the top 3½-foot levels. The profile begins with a high frequency of spruce and pine, accompanied by oak. Apparently this corresponds with the early pine period (A-1) of Deevey (1943).

Between the 16- and 15-foot levels *Picea* increases to a maximum and *Pinus* declines. Above 15 feet *Picea* drops sharply as *Abies* and *Pinus* advance. The *Abies* maximum occurs at the 14-foot level, after which it recedes and finally disappears altogether.

The pine period is short, but very well expressed between the 12½- and 10-foot levels. *Pinus* increases rapidly after the *Picea* maximum. *Betula*, *Quercus* and *Ulmus* show increases corresponding with the development of *Pinus*. The *Pinus* pollen size-frequency curve for Cicero Swamp (figure 2B) shows that the pines in the earliest layers are small-pollened ones. This is probably *P. banksiana* and it shows a steady decrease almost to the top of the profile. Early in the pine period large-pollened pines advance and at the pine maximum they account for more than 70 percent of the *Pinus* pollen. This is more than likely an indication of the replacement of the xerophytic *P. banksiana* with the more mesophytic *P. strobus* and *P. resinosa*.

The hemlock maximum is soon followed by a reduction in frequency with beech, at the same time, rising to a prominent peak. *Betula* and *Carya* show maximum development during this interval and small-pollened pines increase noticeably (figure 2B). This represents the xerothermic interval described by many workers for other localities. It is followed by a second rise of *Tsuga* to a position of dominance with a corresponding drop in *Fagus*, *Quercus*, *Betula* and *Pinus*.

Highland Lake (station 7, figure 7) differs from the preceding station in having a profile which is truncated at the bottom instead of at the top. The spruce and fir periods are missing and the diagram begins at what appears to be the pine maximum. The pine interval occurs only at the 9½-foot level, above which it gives way to the hemlock-hardwoods period.

The development of a prominent oak maximum identifies the beginning of the hemlock-broad-leaved era. This is in agreement with Niering (1953) and Potzger and Otto (1943) who found that the pine period

in northern New Jersey was followed by a long interval during which pine, oak and hemlock were dominant. The oak prominence at Highland Lake continues to the 51½-foot level, where it falls off sharply as hemlock rises to its first peak. *Pinus*, which has been declining, rises to a peak with *Tsuga* at the 41½-foot level. Above this level *Tsuga* decreases slightly as *Fagus* and *Carya* attain peaks, resulting in a rather weak indication of the Xerothermic Period.

The brief thermal maximum ends as *Tsuga* advances to a second peak, and as the mesophytic large-pollened pines increase. *Picea* makes a weak reentrance, while in the surface layer *Pinus*, *Fagus* and *Quercus* increase as *Tsuga* decreases.

Group B

Bogs Having a Profile Which Does Not Have Two *Tsuga* Maxima

Chestertown Bog (station 5, figure 5) has a more northerly location than most of the other sections. The profile from this station shows three more or less well-defined divisions. These agree rather closely with periods 3, 4 and 5, described by Potzger (1953) for the St. Lawrence Lowland. The profile appears to be truncated, because the early pine period and the spruce-fir period are missing.

The profile begins with a series of fluctuations of *Pinus*, *Betula* and *Quercus*, in which *Pinus* is dominant. In these fluctuations *Betula* and *Quercus* vary inversely with increases and decreases in *Pinus*.

Pine decreases sharply at the 16-foot level as hemlock and beech develop. *Betula* ascends rapidly to a peak which initiates the period Potzger (1953) identifies as warm and moist (period 4) in southern Quebec. The genera most important in making up the forest during this time are *Pinus*, *Tsuga*, *Betula*, *Fagus* and *Quercus*. Between the 91½- and the 6-foot levels *Fagus* reaches a maximum. During this same period *Tsuga* shows a decline, while *Pinus* increases. This may be a weak indication of the xerothermic period that is pronounced in profiles from more southerly stations.

The third recognizable division of the Chestertown profile corresponds with Potzger's Q-5 (1956) in Quebec. Spruce and fir prominently reenter the profile and pine decreases. In the surface layers *Pinus* and *Betula* increase as *Fagus* and *Tsuga* decrease.

Perch Lake (station 8, figure 8) is similar to the preceding profile in having a diagram which can be divided into three phases. The pollen record begins with a pine maximum accompanied by hemlock, beech and

oak. The 17-foot level is characterized by a drop in *Pinus* and *Tsuga* and an increase in the broad-leaved genera.

This announces the beginning of a warm, moist period (Q-4, Potzger, 1956) which is dominated by *Pinus*, *Tsuga*, *Acer*, *Betula*, *Fagus*, *Quercus* and *Ulmus*. The interval culminates in a *Tsuga* maximum at the 61½-foot level. Between the 91½- and 61½-foot levels, accompanying the *Tsuga* increase, *Pinus* increases to a maximum, then declines.

During the upper third of the Q-4 period, *Picea* begins an increment which continues into the next interval (Q-5). In the top layers *Fagus*, *Tsuga* and *Pinus* decrease, while *Betula* and *Quercus* increase.

The King Ferry Profiles (Station 12)

King Ferry, Number 1 (figure 12), presents a profile truncated at the top to the extent that only the early coniferous periods are shown. The pollen record begins late in the early pine period (A-1) of Deevey (1943). *Pinus* decreases and *Picea* increases to a maximum. *Abies* accompanies the *Picea* but the profile is telescoped, resulting in the apparent absence of an *Abies* period. The top of the profile shows a readvance of *Pinus* to a maximum position accompanied by *Tsuga*, *Carya* and *Tilia*.

King Ferry, Number 2 (figure 13), is similar to the preceding, with the exception that it seems to show an older profile. The diagram begins with a very pronounced, but brief, early pine period. The pine declines as spruce and fir advance, with spruce reaching a maximum. This, in turn, is followed by a decline in *Picea*, corresponding with a second rise of *Pinus* to a prominent position. The latter is accompanied by an increase in *Carya* and a very impressive increase in *Tilia*.

King Ferry, Number 3 (figure 14), shows an older profile than either of the above. The early pine period extends from the 43¼- to the 31¼-foot level. *Pinus* decreases at the 3-foot level and *Picea* increases to a maximum. *Abies* advances with the *Picea* reaching a peak soon after. *Picea* and *Abies* decrease as *Pinus* readvances to a second maximum in the top of the profile.

This profile is similar to the preceding two which are truncated, with the pollen record missing from the pine period to the present.

DISCUSSION

Tsuga seems to be the chief indicator for the hemlock-hardwoods section of the pollen record in New York State. Its behavior is similar for most pollen profiles which show a complete postglacial record. Hemlock makes its appearance in variable amounts in the pine period, increasing to a maximum as pine decreases, and maintaining itself for a more or

less extended period as the forest dominant. In the upper third of the profile, *Tsuga* drops in most cases very suddenly, frequently all but completely disappearing from the record. This is followed by a readvance in which hemlock again assumes a position of dominance. McCulloch (1939) and Deevey (1943) found this to be true of their work on New York bogs and Sheldon's (1952) profiles which are not truncated show this pattern.

The double peak for *Tsuga* appears in areas outside New York but does not seem to be so pronounced. In New England, Deevey (1943) and Krauss and Kent (1944) found *Tsuga* to be a major component of the C-1 and C-3 periods. In northern New Jersey, Niering (1953) and Potzger and Otto (1943) found that *Tsuga* occurs in two peaks. In Potzger's profiles from southern Quebec (1953), there is a tendency for *Tsuga* to occur in two peaks. Potzger does not attach any significance to this, however, since he does not mention it in his analyses.

The periods preceding the hemlock-hardwoods period in New York are more or less established by the present study. The earliest period shown seems to be a spruce-fir-pine interval which can be shown to have at least three subdivisions. The A-1 or early pine period of Deevey (1943) is represented at three stations (figures 2, 4, 12, 13, 14). This is followed by the *Picea* maximum, or A-2 period of Deevey. The spruce period is more universal, appearing in almost every profile that has been constructed for New York State. In the present study nine stations show a period of *Picea* dominance (figures 1, 2, 3, 4, 6, 9, 10, 11, 12, 13, 14). The *Abies* period is characteristic for the complete profiles of the present study, coming between the *Picea* maximum and the *Pinus* maximum in the diagram for eight stations (Figures 1, 2, 3, 4, 6, 10, 11, 14). The fir maximum is indicated in at least three of Sheldon's profiles (1952), even though he does not mention it in his discussion. The *Abies* advance is not shown at all in the Queechey Lake studies of Deevey (1943). McCulloch (1939) found great quantities of fir in the lowermost level of Sandy Ridge Bog. In Sheldon's (1952) work and in the present study, *Abies* nowhere exceeds 30 percent, and in most cases it is much less than this.

The profiles of the present study all indicate a period during which *Pinus* was the dominant form of arboreal vegetation in New York State. Sheldon (1952) found a pine period in all his profiles but two, and Deevey (1943) describes a pine period for Queechey Lake. This interval probably represents a drier and warmer climate than the cooler, more moist, spruce-fir period which preceded it.

The pine pollen size-frequency curves, which show the entire pine period, indicate that small-pollened pines were replaced by large-pollened

ones toward the end of this interval. This suggests that the initial drying was followed by a gradual return to mesophytism which, with subsequent warming, eventually resulted in the development of the hemlock-hardwoods forest. A warming trend is recognizable in the oak histogram. In eight of the profiles from the present study, *Quercus* increases during the *Pinus* maximum (figures 1, 2, 3, 4, 7, 8, 9, 11), whereas in one (figure 6) *Quercus* attains a maximum during this interval, while being present in very noticeable numbers in two others (figures 5, 10).

The period of pine dominance is established for New York State as being characteristically short and very well represented. This, in general, agrees with the findings of workers in surrounding regions.

The hemlock-hardwoods period in most New York profiles begins with a very prominent increase in hemlock and a corresponding decrease in pine. During the early and late phases of this interval, *Tsuga* and *Fagus* are the major forest components. It is interrupted in the middle by a more or less drastic reduction in the numbers of the *Tsuga* component, and a corresponding increase in *Fagus*.

There seems to be greater regional variation in this part of the profile than in the previously discussed periods. In New Jersey, Niering (1953) and Potzger and Otto (1943) have found that *Quercus* is the chief representative of those broad-leaved genera which replace *Pinus*. The presence of *Tsuga* in significant amounts during the broad-leaved era suggests the mesophytism which is believed to have existed during this time. In New England, Deevey (1943, 1939) found *Tsuga* and *Quercus* to be the dominants for this period (C-1). In Ohio, Potter (1947) and Sears (1942) have found that a beech maximum is characteristic for this era (Period III). Zumbeke and Potzger (1956) have identified oak and chestnut as dominants of this interval in southwestern Michigan. In Minnesota, Voss (1934) and Artist (1939) list pine and oak as the major forest entities from the spruce-fir interval to the present. In Quebec, Potzger (1953) reports that hemlock, pine and beech constitute this phase of postglacial forest history.

The middle phase of the hemlock-hardwoods period in New York is marked by a sharp decrease in *Tsuga*, complimented by a rise in *Fagus*, as expressed in the present study (figures 2, 3, 4, 6, 7, 10, 11). Deevey (1939), Potter (1947) and Sears (1931) classify hemlock as indicative of a cool, mesophytic climate. The two latter classify *Fagus* as an indicator of warm, moist conditions.

It has been suggested that a decrease in *Tsuga* accompanied by a rise in *Fagus*, as shown in this paper, can be attributed to relative drying brought about by a rise in temperature. Another possible explanation for this phenomenon is a decrease in moisture concomitant with a rise

in temperature. Either assumption will explain these frequency changes. However, the first one seems more appropriate, since it requires the assumption of only one independent variable. This paper accepts the first hypothesis, because it is simpler to make one assumption than two.

Sheldon (1952) refers to the middle phase of the hemlock-hardwoods period as an oak-beech period and finds increases in *Quercus*, *Fagus*, *Carya*, *Nyssa* and *Juglans*. McCulloch (1939) shows a maximum of *Quercus*, more or less coinciding with the *Tsuga* minimum. The Queechey Lake profiles of Deevey (1943) show a *Quercus* maximum corresponding with the latter. In the present study it was found that *Quercus* increases during the middle phase in three profiles (figures 3, 6, 11) and attains a maximum in two (figures 9, 10). In the other profiles of this study it was found that oak reaches a maximum soon after the pine period. In no instance did the oak maximum exceed 36 percent, and in most cases it was 20 percent or under.

Most of the profiles in the present study which indicate a xerothermic interval show a rise of pine in the upper part of the period, associated with a minor secondary rise of hemlock, preceding the second *Tsuga* peak (figures 1, 3, 4, 6, 7, 9, 10, 11). The pine pollen size-frequency curves for some of these same stations show an increase in small-pollened pines coinciding with the rise in *Pinus* (figures 1B, 6B, 9B, 10B).

The two most northerly stations represented in this study (map 1, stations 8, 5) have profiles which do not show any evidence for the period having a warm, dry maximum (figures 5, 8). The close of the pine period, with which both of these profiles open, is followed by a rise of hemlock and broad-leaved genera and a decrease in pine. In these profiles, however, the rise of *Tsuga* and the drop in *Pinus* are much less impressive than in the stations farther south. *Pinus* remains a prominent, if not the dominant, member of the forest throughout the remainder of the profile. Potzger (1953) found this to be the case for bogs in southern Quebec.

The return of *Tsuga* marks another phase in the vegetational history of New York State according to the present findings. This apparently was the result of a climatic trend toward cooler and more mesophytic conditions. The reentrance of *Picea* to the profile during this phase is characteristic for most of the pollen diagrams that have been constructed for New York State. In the two northern stations the readvance of *Picea* is essentially the only marker for this period.

The behavior of *Picea* in the top levels of some of the diagrams in the present study suggests the possibility of climatic change in the recent past. In several of the profiles presented here, *Picea* reaches a maximum a short distance from the top, then declines in surface levels. This phe-

nomenon appears in the *Picea* curve of several of Sheldon's (1952) diagrams. Evidence from the rate of glacier retreat (Potszger, 1941) suggests that at least in certain parts of the world climate is becoming milder. Knox (1949) has identified a recent period in New England as being warmer and drier. Potszger and Friesner (1948) have found evidence for a recent warming trend in Wisconsin and Indiana. In Europe, Axel Blytt has described a recent warm, dry period (Niering, 1953). Additional data are necessary in order to determine with finality the status of this period in North America.

The King Ferry profiles are of interest because a few years ago the bones of a mastodon were uncovered in this vicinity. This parallels, somewhat, the mastodon findings at the Orleton Farms in Ohio (Thomas, 1952). In both cases, the bones were discovered close to the surface of the ground. Sears and Clisby (1952) found that the Orleton skeleton was in a layer that showed a spruce-fir forest changing to pine. The King Ferry bones, according to Myles Colgan, were embedded in a layer of marl and clay. The pollen profile (figure 13) indicates that the top of this stratum was formed in the early stage of a spruce maximum.

The three King Ferry profiles compliment one another to a surprising degree: the 2½-foot level in station 1 (figure 12) appears to be the beginning of a spruce maximum. Station 2 (figure 13), at 2½ feet, is also in the early phase of a *Picea* period, and the same is true for that level at station 3 (figure 14). These diagrams agree level for level, with each station showing a longer and more complete record than the preceding one. The profile terminates for each location during the pine period.

The layer of marl in which the bones were found begins approximately at the same level for stations 2 and 3. Because the pollen profiles are in such close agreement, it is assumed that the layer of marl was formed at about the same time, and under approximately the same conditions, at all three stations. With this assumption, the profile from station 3 can be taken as indicative of forest conditions during the formation of the marl layer, as shown in figure 14, which clearly indicates a period of spruce and pine, with pine attaining a maximum. This corresponds with the early pine period (A-1) of Deevey (1943).

The results of carbon 14 dating for station 2 are reported by Brown (1957). At the level where clay begins he took samples of spruce wood which show an age of 11,410—plus or minus 110—years. It is assumed that this wood came from the spruce-pine forest which the pollen diagram shows to have existed at the time this level was formed. Brown is of the opinion that this forest existed as a part of the Pre-Boreal Zone of Deevey (1957).

SUMMARY

1. Twelve stations in central and eastern New York State were sampled for pollen analysis.

2. These stations fall into two natural groups: (1) the locations south of latitude $43^{\circ}30'$ North which have a profile consisting of two distinct *Tsuga maxima* and (2) the locations north of latitude $43^{\circ}30'$ North, having profiles that do not show two *Tsuga maxima*.

3. The profiles of the former stations show an early period, during which *Picea*, *Abies* and *Pinus* occur in a rather uniform sequence. This is followed by a period of *Pinus* dominance which gives way to an interval of hemlock-hardwoods. The hemlock-hardwoods era continues to the present and is characterized by three distinct subdivisions: the first phase, following the decline of *Pinus*, is identified by a pronounced rise of *Tsuga*, accompanied by *Fagus*, *Quercus* and other broad-leaved genera. The middle phase of the hemlock-hardwoods interval is marked by a sharp decrease in *Tsuga* and a corresponding increase in *Fagus*. The final phase shows a return of *Tsuga* to a position of prominence.

4. Those stations for which pine pollen size-frequency studies were made show that at the lowest levels the most abundant pines are those which are small-pollened. In most profiles these are replaced during the pine period by large-pollened pines which continue to the surface. This is interpreted as a replacement of *Pinus banksiana* by *P. strobus* and/or *P. resinosa*.

5. The profiles of the northern stations do not give any indications of a xerothermic interval. The pine period is followed by a pine-hemlock-hardwoods interval which extends to the present. The surface layers show a return of *Picea* and *Abies*.

6. Samples were taken at the location where a mastodon skeleton was uncovered near King Ferry, New York. The analyses indicate that the animal probably lived during a time when spruce-pine forests were the dominant form of vegetation in this area.

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MAPS, CHARTS AND GRAPHS

FIG. 2 CICERO SWAMP

FIG. 3 MUD LAKE JORDANVILLE

FIG 6 WORCESTER BOG

FIG. 7 HIGHLAND LAKE

FIG. 8 PERCH LAKE

FIG. 9 MUD LAKE, TULLY

Figure 98 TULLY MUD LAKE.

--- FINE FOLLEN LARGER THAN 40 MICRONS
 --- FINE FOLLEN SMALLER THAN 40 MICRONS

Figure 11B DRYDEN BOG

FIG. 12 KING FERRY NO. 1

FIG. 13 KING FERRY NO. 2

FIG. 14 KING FERRY NO. 3

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