# MICROFOSSIL STUDIES OF THREE NORTHCENTRAL WISCONSIN BOGS

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## INTRODUCTION

The region of northcentral Wisconsin is one of pine forests with smaller areas of hardwoods. Pine and hemlock are, or recently were, important species, and the region may be described as being part of the lake forest (Weaver and Clements, 1929). Hemlock at present is but a minor element but appears to have been more important before lumbering was begun. Upon the heavier soils the forests contain an important hardwood element which includes sugar maple, yellow and white birch, basswood, American elm, and red oak. Mixed with the hardwoods is white pine, hemlock, balsam fir, and white spruce. The lighter, sandy soils are forested at present with jack and red pine, white birch, quaking aspen, and pin cherry. The virgin forests contained heavy stands of red pine. Large areas of the sandy soils in northern Wisconsin have been logged and severely burned and are at present covered by little more than sweet fern (*Myrica asplenifolia*), scrub oak (*Quercus ellipsoidalis*), and young stands of jack pine. They are frequently referred to as the pine barrens, sand barrens, or barrens. Agriculture is almost impossible in such areas.

The virgin forests of northcentral Wisconsin contained some of the most valuable timber in the state, and because they represented such a fine example of the lake forest, a study of its history was undertaken.

The region in which the present study was conducted is central Vilas County in Wisconsin. The fossils in three bogs are reported from this investigation. These bogs are located in kettles upon the pitted outwash plains of Wisconsin substage 4, and near lakes after which each is named.

## The Fossils

The peat material studied was collected by means of a Davis peat sampler. In the laboratory, about 50 grams of dry peat were pulverized and boiled in about 200 cc. of water until it became a humic mass. Then a few centimeters of concentrated sodium hydroxide solution was added to the material, which was thoroughly stirred. This treament is usually sufficient to free the fossils and make them suitable for study. The material was then screened through a one millimeter mesh and diluted with water. The diluted solution was then centrifuged and washed several times. Some material was stained with saffranin for 12 hours and again washed and centrifuged. Material for permanent reference was mounted in glycerine jelly, but the counts were made from temporary slides. The photographs were made from stained glycerine and glycerine jelly mounts. The identification and counting of the fossil pollen was done with a compound binocular microscope using 15× oculars and 10 mm. and 3mm. objectives. The slides were controlled with a mechanical stage, and usually two hundred fossils were counted for the analysis. The photomicrographs were made with a Zeiss Ikon camera supplemented with a detachable Eastman Kodachrome adapter. The film used was 35 mm. Panatomic-X; it was developed in D-11 and D-8 developer. The magnification used in the photographing varied according to the size and structure of the microfossils. The compound microscope used is a monocular, and combinations were made with oculars of 5×, 10×, and 20× magnification, and 10 mm. and 3 mm. objectives.

At present the illustrative material of pollen and spores is very scanty and it is necessary for each worker in paleoecology to collect and prepare for himself a collection of the most common spores and pollen. Regardless of the abundance of illustrations and descriptions of spores and pollen, it will always be necessary for each worker to have at his disposal such a collection for study and frequent comparison. It is now becoming apparent that pollen of the same species varies not only within the same sporange, but also there appear to be differences in the pollen of the same species in various portions of their geographic ranges. However, the value of further illustrations cannot be overlooked, since they may serve to clear up problems of identification, and also may be a real help to the innovate. With this in mind, the authors are presenting the following photomicrographs and the

accompanying notes of the most common fossils found in the Vilas County bogs. Numerous abnormal grains appear in peat deposits and illustrations of them are worth recording, since these forms may be confusing to the beginner, and, too, they are of morphological interest.

*Sphagnum* sp (Plate I, Figs. 1, 2). Triangular to round when seen in proximal or distal view; diameter 25-29 microns; wall thin, unornamented; trilete mark on proximal surface.

This is an important fossil since it is indicative of local ecological conditions.

*Lycopodium lucidulum* (Plate I, Fig. 5). Triangular, sides concave in proximal or distal view; diameter 25-30 microns; wall uniformly papillate (1.2 mu.) on distal surface, papillae on proximal surface finer or absent; trilete mark on proximal surface.

The occurrence of *L. lucidulum* in peat is rather uncommon. The senior author, when monographing the genus (1934), noted that the proximal surface of this species and *L. selago* were unornamented. This appears to be the usual condition of the spores when they are subjected to the drastic KOH treatment used in the preparation of the material described in that paper. The spores found in the Vilas County peat were not smooth on the proximal surface.

*Lycopodium annotinum* (Plate I, Figs. 8, 9). Triangular to round in proximal or distal view; diameter 28-33 microns; proximal surface smooth, distal surface somewhat wavy reticulate, reticulum extending to the equator and ending as plainly visible projections. The number of projections upon the equator is approximately twenty, fewer than any other species of American lycopod. This species and its varieties are frequent inhabitants of peat bogs.

*Lycopodium clavatum* (Plate I, Figs. 10, 11). Triangular to round in proximal or distal view; diameter 28-35 microns; proximal and distal surfaces polygonally reticulate, 35 or more projections are present on the equator, reticulum upon the proximal surface extends three-fourths or higher into the angles of the trilete mark.

The spores of this species are differentiated from *L. complanatum* by the greater number of projections on the equator and the higher extent of the reticulum into the angles of the trilete mark. In the latter species the projections are usually about 30,

and the reticulum enters very slightly into the angles of the trilete mark.

*Lycopodium clavatum* and its varieties are frequent inhabitants of peat bogs, and their spores are common fossils in some peat deposits.

*Lycopodium inundatum* (Plate I, Figs. 6, 7). Triangular to round in proximal or distal view; diameter 43-48 microns; proximal surface papillate, especially in the angles of the trilete mark, distal surface wavy reticulate.

*Lycopodium inundatum* appears as an abundant fossil in the lower levels of the Winchester Bog (Wilson and Webster, 1942). This species is interesting because McLaughlin (1932) has pointed out that it is at present associated with many species of Coastal Plain plants that appear to have migrated inland during the stages of Glacial Great Lakes. The occurrence of the fossils in Vilas County substantiates the early appearance of the species.

*Thelypteris* sp. (Plate I, Fig. 3). Bean-shaped in lateral view; length 37-45 microns; thickness 24-34 microns; wall smooth, monolete mark on proximal surface.

Fern spores are abundant in peat and need further study as fossils. The spore illustrated appears to be *Thelypteris palustris*, but definite identification with this species is withheld, for other spores of the same genus appear to lose their perisphoral structures when subjected to boiling. This results in a spore the type of which is illustrated.

*Osmunda* sp. (Plate I, Fig. 4). Spherical; diameter 36-39 microns; wall densely and irregularly covered with blunt projections, 1-3 microns long; trilete mark extends to equator.

The spores of *Osmunda* should prove interesting to the taxonomist, for they appear to have specific characters. *Osmunda* spores are frequently observed in the peat.

*Picea mariana* (Plate I, Figs. 12, 13). Winged grains; greatest dimension of tube cell 55-65 microns; bladders somewhat half-moon-shaped when seen in distal (ventral) view of the grain (Fig. 13); in transverse view (Fig. 12) the bladders join the tube cell at a nearly straight angle; a marginal crest appears to be absent.

The photomicrographs show typical examples of this species, but there are transitional forms that make separation of it from *P. glauca, Pinus resinosa,* and *P. Strobus* very difficult. The pollen of conifers need a critical study and comparison since there is

considerable overlapping of the characters used to distinguish them.

*Picea glauca* (Plate I, Figs. 15, 16). Similar to *P. mariana,* but larger (tube cell 65-75 microns in greatest dimension), and the bladders are frequently more angular when seen in distal (ventral) view (Fig. 16).

This species has undoubtedly been mistaken for *Abies* by many workers in peat fossils. *P. glauca* is very abundant in the basal levels of nearly every peat bog in the Middle West.

*Abies balsamea* (Plate I, Figs. 17, 18). Largest winged pollen in the Middle West; tube cell 72-81 microns in greatest dimension; bladders bulbous, joining the tube cell at a sharp angle near the dorsal (proximal) roots, round or nearly so in distal view (Fig. 18); tube cell also frequently round in this view.

Wodehouse (1935) states that a faint triradiate streak is sometimes present on the dorsal (proximal) side of the grain, but it has never been seen in fossil material by the authors. This may be due to corrosion of the exine, since the trilete mark is at best a very indefinite feature of the tube cell.

*Abies* does not occur as abundantly in middlewestern peat as was previously supposed by many authors.

*Tsuga canadensis* (Plate I, Fig. 14). Wingless, doubly convexed to round in optical section; diameter 60-80 microns; coarse exine texture.

A very abundant pollen in some middlewestern peats. Sears (1930) has pointed out the danger of mistaking pteridophyte spores for pollen of *Tsuga.* He further points out that the former may be distinguished by the presence of triradiate prismatic faces on the proximal side. The fern spore most closely resembling *Tsuga* is *Osmunda,* and in this genus the trilete mark is not always apparent, even in fresh material. With some practice it is possible to separate *Osmunda* and *Tsuga* by exine structure. The exine of *Osmunda* is generally less reticulate and is more spinose. Another adjunct in determining the presence of *Osmunda* in peat is the occurrence of the wool-like trichomes. These have characteristic thickenings that give the appearance of joints. They preserve well as fossils and are easily recognized.

*Pinus Banksiana* (Plate II, Figs. 19, 20, 21). Smallest winged pollen in the Middle West; tube cell 41-48 microns in greatest dimension; marginal crest frequently well defined; bladders nearly round when seen in distal view.

## Explanation of Plates I-II

Fig. 1, 2. *Sphagnum*, sp.

Fig. 3. *Thelypteris* sp.

Fig. 4. *Osmunda sp.*

Fig. 5. *Lycopodium lucidulum*

Fig. 6, 7. *Lycopodium inundatum*

Fig. 8, 9. *Lycopodium annotinum*

Fig. 10, 11. *Lycopodium clavatum*

Fig. 12, 13. *Picea mariana*

Fig. 14. *Tsuga canadensis*

Fig. 15, 16. *Picea glauca*

Fig. 17, 18. *Abies balsamea*

Fig. 19, 20, 21. *Pinus Banksiana*

Fig. 22, 23, 24, 25, 26. *Pinus Strobus* or *P. resinosa*

Fig. 27, 28. *Alnus* sp.

Fig. 29, 30, 31, 32. *Betula* sp.

Fig. 33, 34, 35. *Quercus* sp.

Fig. 36. *Corylus* sp.

Fig. 37, 38. *Ulmus americana*

Fig. 39, 40, 41. *Tilia americana*

Fig. 42, 43. *Juglans cinerea*

Fig. 44. *Carya cordiformis*

PLATE I

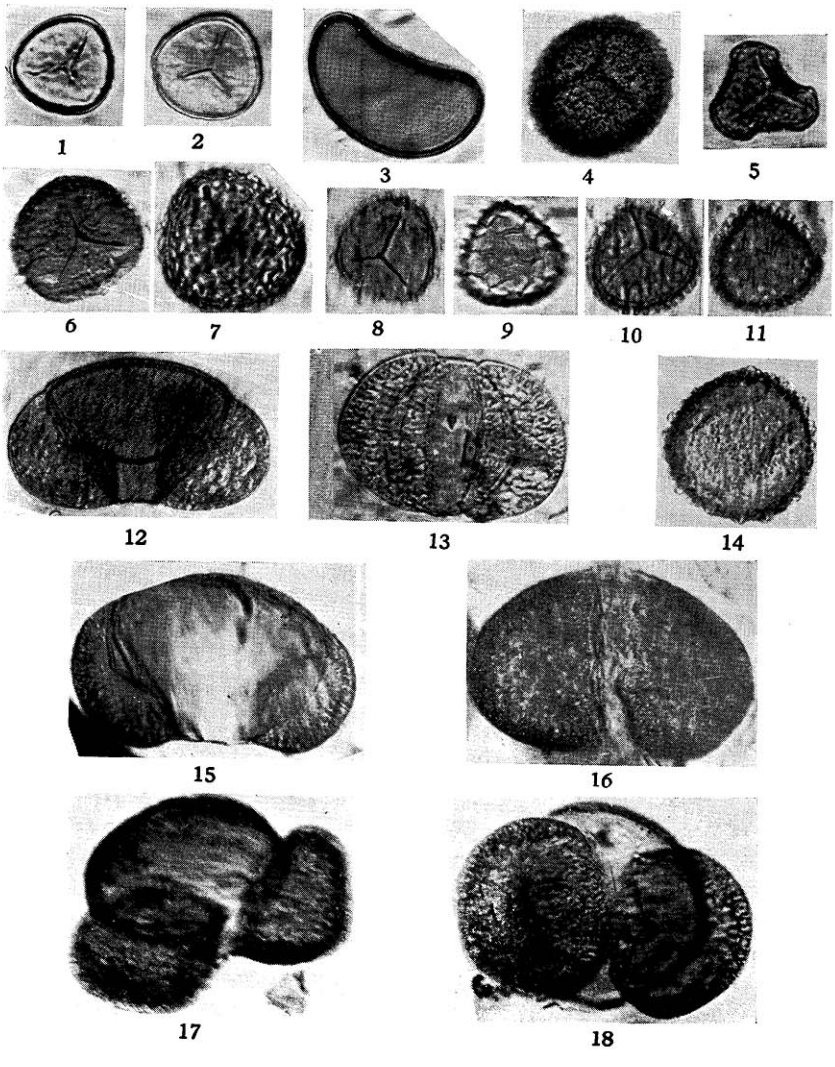
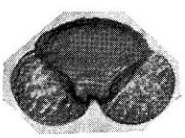


PLATE II



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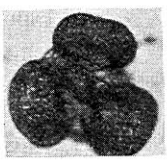

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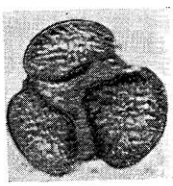

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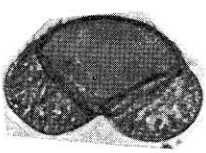

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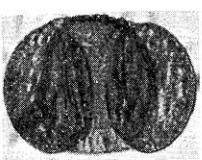

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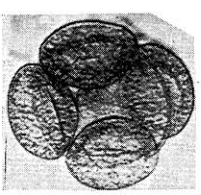

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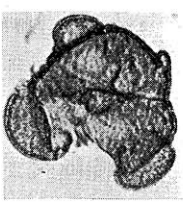

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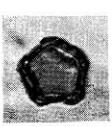

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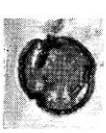

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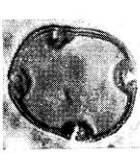

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Cain (1940) has shown by size-frequency determinations that *P. Banksiana* may be distinguished from other pines of the east by its smaller size. Figure 21 is a photomicrograph of an abnormal grain with three, possibly four bladders.

*Pinus Strobus* or *P. resinosa* (Plate II, Figs. 22, 23, 24, 25, 26). The distinction of these two species as fossils is very doubtful, for even in fresh material, no constant character appears to be present. In fresh material of *P. Strobus* the reticulation of the bladders is fairly uniform, while that of *P. resinosa* appears to be finer near the edges when the grains are viewed on the distal side. However, this method of distinction is not a satisfactory one. Both species of pollen are about the same size, the tube cell measurements being 55-67 microns in longest dimension. Figures 22, 25, and 26 are abnormal grains.

*Alnus* sp. (Plate II, Figs. 27, 28). Diameter 18-27 microns; pores, narrowly elongate, generally four or five in number; subexineous thickenings usually extend from pore to pore along the equator. Not all fossil specimens examined have had these thickenings present. The specimens illustrated are either *A. crispa* or *A. incana.*

*Betula sp.* (Plate II, Figs. 29, 30, 31, 32). Diameter 20-31 microns, generally about 26 microns; usually three elliptical pores; two- and four-pored forms have been observed (Figs. 30, 31, 32); exine at pore expanded, appearing as broad knobs when viewed in optical section.

Several species of *Betula* pollen are present in the Vilas County peat, but these cannot be differentiated with certainty.

*Corylus* sp. (Plate II, Fig. 36). Diameter 22-26 microns; three circular or elliptical pores; exine at pores club-shaped when viewed in optical section.

*Quercus* sp. (Plate II, Figs. 33, 34, 35). Diameter 25-37 microns; spheroidal or flattened; three-furrowed; exine granular or warty, no regular pattern. When flattened, the grains frequently split along the furrows and appear in fossil form as illustrated in Figure 35.

*Ulmus americana* (Plate II, Figs. 37, 38). Diameter 28-38 microns; oblately flattened; usually four or five elliptical pores; subexineous reticulation.

*Ulmus* is one of the important trees of the swamp forest in northern Wisconsin and has an extensive fossil history in the peats.

*Tilia americana* (Plate II, Figs. 39, 40, 41). Diameter 25-37 microns; oblately flattened; usually three elliptical pores that are deeply sunken, and have marked subexineous thickenings which are seen in optical section; exine uniformly pitted.

Two- and four-pored grains have been observed in the peat, but these are rare.

*Juglans cinerea* (Plate II, Figs. 42, 43). Diameter 32-35 microns; spheroidal; 9 to 12 circular pores restricted to one hemisphere; subexineous thickening around pores; exine smooth.

This species and *Carya cordiformis* are considered more fully below in the discussion.

*Carya cordiformis* (Plate II, Fig. 44). Diameter about 40 microns; spheroidal or oblately flattened; pores usually three, elliptical to circular, and generally in one hemisphere; exine somewhat granular.

### Spruce Lake Bog

This peat deposit is an extensive bog covering several thousand acres. The location where borings were made is the NW ¼ of the SW ¼, Section 7, Township 41 N., Range 5 E. Near the center of this deposit is a bog lake known as Spruce Lake, and from this the bog takes its name. The deposit is relatively shallow as one would expect in a bog of such large size. At the location where samples were collected, the contact of peat with sandy clay was found nine feet below the surface. Samples were collected from one-foot intervals. The surface of the bog is covered with a dense growth of heaths and a few small, black spruces. The heaths are species of *Vaccinium, Chamaedaphne, Gaylussacia, Ledum, Kalmia,* and *Andromeda.*

The forests around the bog are of recent second growth and consist of red, white, and jack pine, balsam fir, white spruce, white birch, aspen, soft maple, and scrub oaks.

Figure 1 shows graphically the abundance and succession of the microfossils in the Spruce Lake Bog, and Table I gives further details. From these microfossil studies there is evidence that the pine forests were preceded by a more northern type of forest composed largely of white spruce. This early gave way to the pine forest, as is indicated by the increase in pine pollen about two-thirds of the distance from the top of the deposit. Near the middle levels there is a suggestion that basswood and ash were more abundant than they are today. Birch pollen is more important in the top level than below. Some of the birch

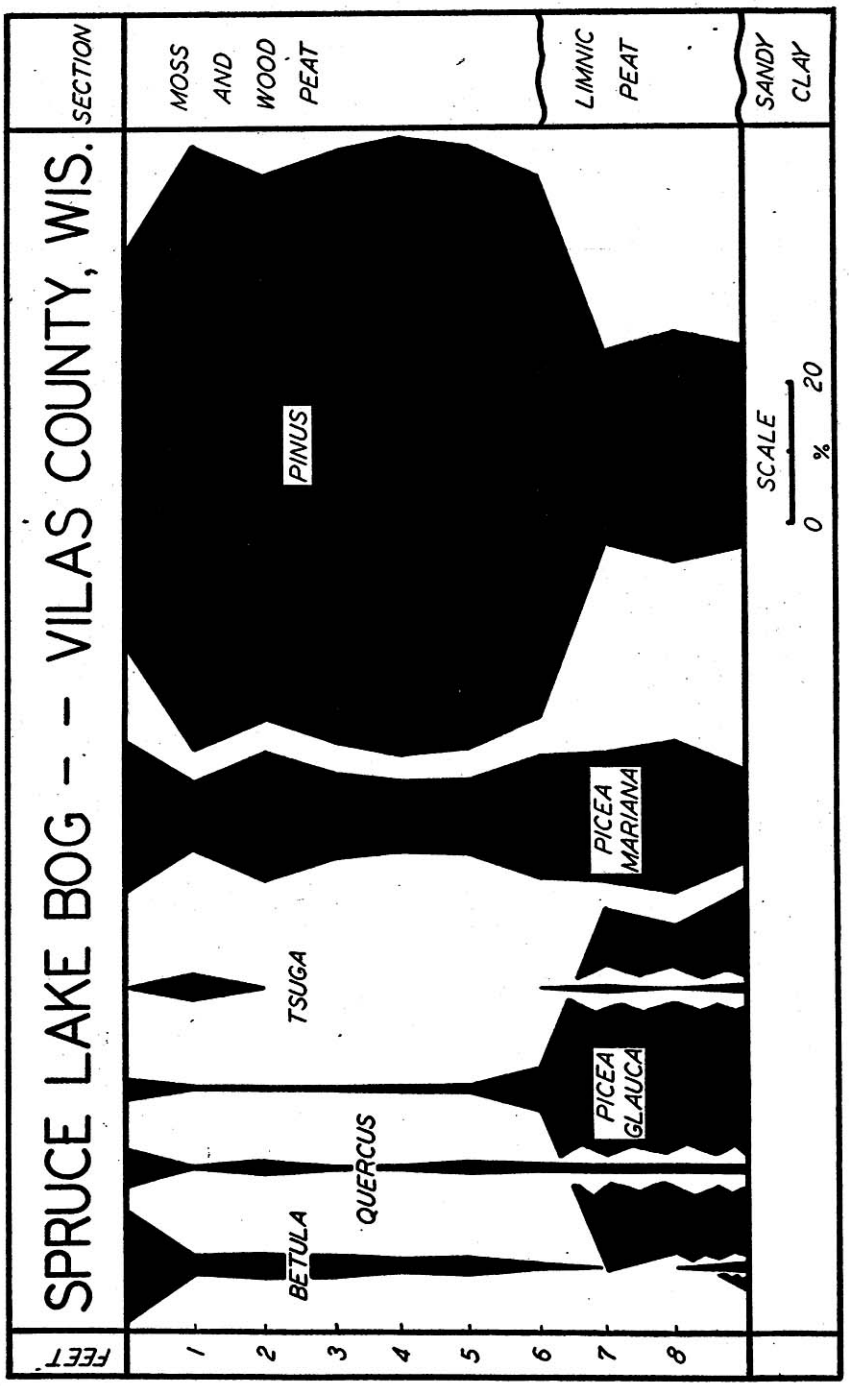


**Fig. 1. Diagram showing the distribution and succession of microfossils in in the Spruce Lake Bog.**

fossils undoubtedly are of bog species, and therefore this pollen does not give a true picture of the forest composition. The occurrence of hemlock at the bottom and near the top of the bog is of interest, since this species of tree has not been seen in the immediate vicinity today. Such occurrence supports other evidence that this species has had a wider distribution in the past than at present. Black spruce pollen usually occurs abundantly in two levels of the spectrum, and these are separated by levels where it is scarce. An explanation of this occurrence may be that the black spruce was early an upland tree along with the white spruce. When most of the latter migrated northward, some of the black spruce probably remained near the edge of the lake in which peat was accumulating, and attained greater importance when subaerial peat was formed and a bog such as the present one came into existence. The return of white spruce fossils to the spectrum may be suggestive of climatic change and reverse to cooler conditions. Such has been suggested by Cooper (1942).

TABLE I.

Percentages of fossil pollen in the Spruce Lake Bog, Vilas County, Wisconsin.

| Species | Depth in Feet | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| ABIES BALSAMEA | | 1.0 | 3.0 | .5 | .5 | 1.0 | .5 | .5 | .25 | |
| PICEA GLAUCA | 56.0 | 45.0 | 50.0 | 6.0 | 1.0 | 1.0 | .5 | .5 | .5 | 3.0 |
| PICEA MARIANA | 13.0 | 21.0 | 18.0 | 17.0 | 10.5 | 10.0 | 12.0 | 18.0 | 9.5 | 21.0 |
| PINUS BANKSIANA | 16.0 | 19.0 | 8.0 | 46.0 | 27.5 | 20.0 | 22.0 | 14.0 | 20.75 | 8.0 |
| PINUS RESINOSA & PINUS STROBUS | 12.0 | 13.0 | 19.0 | 29.0 | 56.0 | 65.5 | 60.5 | 61.5 | 62.5 | 48.0 |
| TSUGA CANADENSIS | 1.0 | | 1.0 | | | | | 3.5 | | |
| BETULA | 1.0 | | | .5 | 2.5 | 2.0 | 3.0 | 3.5 | 2.75 | 15.0 |
| QUERCUS | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | .5 | .5 | 2.0 | .25 | 5.0 |
| FRAXINUS | | | | | | | .5 | | | |
| TILIA AMERICANA | | | | | .5 | | .5 | | | |

## SILVER LAKE BOG

Silver Lake Bog is located in the SE ¼ of the SW ¼ of Section 24, Township 41 N., Range 6 E. It is about one-quarter of a mile

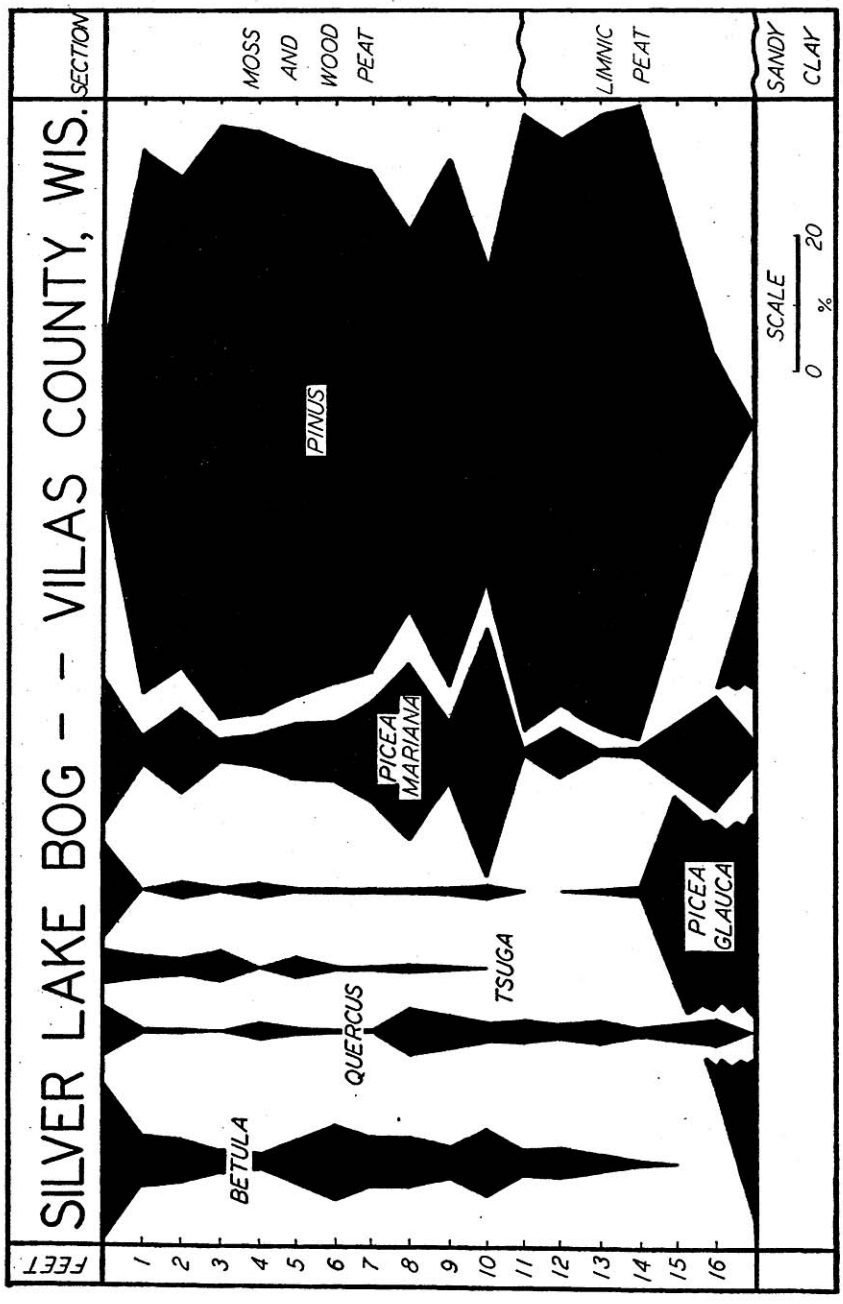


**Fig. 2. Diagram showing the distribution and succession of microfossils in the Silver Lake Bog.**

east of Silver Lake and approximately the same distance south of Trout Lake. The bog is about three acres in area and located in a rather deep kettle hole near the edge of an outwash plain. Thwaites (1929) maps the area immediately to the south as part of the Muskellunge Moraine.

The forest surrounding the bog is second growth with a predominant element of white birch and aspen. In addition, white and red pine, balsam fir, white spruce, red oak, and soft maple occur. A few small black spruces grow upon the bog and the remaining cover is that of heaths and other characteristic bog plants.

The depth of the peat is seventeen feet to the contact with sandy clay. Samples were collected at one foot intervals, except from the fifteenth foot level where a water pocket was encountered, and no peat was recovered.

Table 2 and Figure 2 illustrate the abundance and succession of the fossil pollen in the Silver Lake Bog. The same general succession of the forest species is indicated as is suggested in the Spruce Lake Bog. Hemlock again appears in the peat but is not present in the immediate vicinity of the bog today. The surface sample, however, shows hemlock to be present. Two possibilities exist; the sample taken from the surface may have extended deep enough to include peat that was formed before lumbering began, or, hemlock pollen is being deposited upon the bog from a small stand that is nearly three miles away. Hickory pollen occurs in the eight foot and one foot levels, and butternut in the one foot level. These are not living in the region today. The nearest hickory is found about 65 miles southward, and butternut about 60 miles westward.

### White Sand Lake Bog

The location of White Sand Lake Bog is the NW ¼ of the SE ¼ in Section 28, Township 42 N., Range 7 E. It is approximately one acre in area and seven feet deep near its center. Sandy clay underlies the deposit.

The cover of the bog is *Chamaedaphne* and a few small, black spruces. The upland is typical jack pine barrens, as is much of the area of outwash plain in that region. In addition to having been logged, the region has been severely burned. There is evidence in the stumpage that the immediate vicinity did support a heavy cover of red pine. Many of the stumps are two and three feet in diameter.

TABLE II.

Percentages of fossil pollen in the Silver Lake Bog, Vilas County, Wisconsin.

| Species | Depth in Feet | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| ABIES BALSAMEA | | | | 1.0 | | | | .5 | 1.0 | .5 | 1.0 | 1.5 | .5 | 1.0 | .5 | 3.0 | 4.5 | |
| PICEA GLAUCA | 96.0 | 59.0 | | 1.5 | 0.5 | | | 2.0 | 1.0 | .5 | .5 | .5 | .5 | 2.0 | .5 | 2.5 | | 14.0 |
| PICEA MARIANA | 4.0 | 17.0 | | 1.5 | 1.0 | 7.5 | 1.5 | 36.5 | 9.0 | 26.0 | 15.0 | 9.0 | 8.5 | 5.0 | 3.5 | 12.5 | 4.5 | 21.0 |
| PINUS BANKSIANA | | 13.0 | | 58.0 | 34.5 | 14.5 | 40.5 | 6.0 | 12.5 | 4.5 | 9.0 | 7.0 | 14.5 | 20.5 | 23.5 | 17.5 | 14.0 | 2.0 |
| PINUS RESINOSA & PINUS STROBUS | | 7.0 | | 35.0 | 55.5 | 69.5 | 50.5 | 40.5 | 66.0 | 51.0 | 65.0 | 69.5 | 66.0 | 65.0 | 63.5 | 54.5 | 64.0 | 25.0 |
| TSUGA CANADENSIS | | | | | | | | | .5 | 1.0 | .5 | .5 | 3.0 | | 4.5 | 2.5 | 3.5 | 5.0 |
| BETULA | | | | .5 | 2.5 | 4.5 | 4.0 | 10.0 | 5.0 | 7.5 | 7.5 | 11.0 | 6.0 | 2.5 | 3.5 | 6.5 | 7.5 | 23.0 |
| QUERCUS | | 4.0 | | 1.5 | 3.5 | 2.5 | 3.5 | 3.0 | 5.0 | 7.0 | .5 | .5 | 1.0 | 2.5 | | .5 | .5 | 7.0 |
| ULMUS AMERICANA | | | | | .5 | :5 | | | | .5 | | | | | .5 | | | |
| ACER | | | | 1.0 | 2.0 | 1.0 | | .5 | | .5 | 1.0 | .5 | | 1.5 | | .5 | | 3.0 |
| JUGLANS CINEREA | | | | | | | | | | | | | | | | | .5 | |
| CARYA CORDIFORMIS | | | | | | | | | | | | | | | | | .5 | |
| TILIA AMERICANA | | | | | | | | 1.0 | | | | | | | | | .5 | |

Table 3 and Figure 3 indicate the abundance and succession of the microfossils. It will be noted again that the fossil spectrum suggests that the earliest forest was spruce and that this gave way to pine. Again there appears to have been a period during which hemlock was more abundant than at present. Also, elm is present in the middle levels and not found on the surface. Birch and oak show a fairly strong percentage at the two foot level, and the latter is present through the entire section of the bog.

TABLE III.

Percentages of fossil pollen in the White Sand Lake Bog, Vilas County, Wisconsin.

| Species | Depth in Feet | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7 | 6.5 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| ABIES BALSAMEA | 1.0 | | | | | | | | |
| PICEA GLAUCA | 82.0 | 1.5 | | | 1.5 | 2.5 | 1.5 | | 1.0 |
| PICEA MARIANA | 11.0 | 10.0 | 11.0 | 6.5 | 24.5 | 27.0 | 28.5 | 7.5 | 10.0 |
| PINUS BANKSIANA | | 79.5 | 8.0 | 29.5 | 4.0 | 6.5 | 5.5 | 14.0 | 55.0 |
| PINUS RESINOSA & PINUS STROBUS | 3.0 | 7.5 | 74.5 | 60.0 | 64.0 | 61.0 | 46.5 | 70.0 | 18.0 |
| TSUGA CANADENSIS | | | 1.5 | | .5 | | .5 | 4.5 | |
| BETULA | | 1.0 | 3.5 | .5 | 3.0 | 1.5 | 13.0 | 3.5 | 11.0 |
| QUERCUS | 3.0 | .5 | 1.5 | 2.0 | 2.0 | 1.5 | 4.0 | .5 | 5.0 |
| ULMUS AMERICANA | | | | 1.0 | | | .5 | | |
| ACER | | | | .5 | | | | | |
| TILIA AMERICANA | | | | | .5 | | | | |

## DISCUSSION

The three bogs give a rather definite history for the development of the lake forest in northcentral Wisconsin. It appears to have early succeeded the boreal forest of white spruce and has remained the important formation of the region since. It has been pointed out above that near the middle levels in each bog there is evidence of an abundance of certain hardwoods, namely, oak, hickory, birch, basswood, ash, elm, and maple. This minor fluctuation in species of hardwood pollen is general throughout upper Wisconsin. There appears to be a direct correlation with a greater fluctuation of hardwood pollen in bogs of southern Wis-

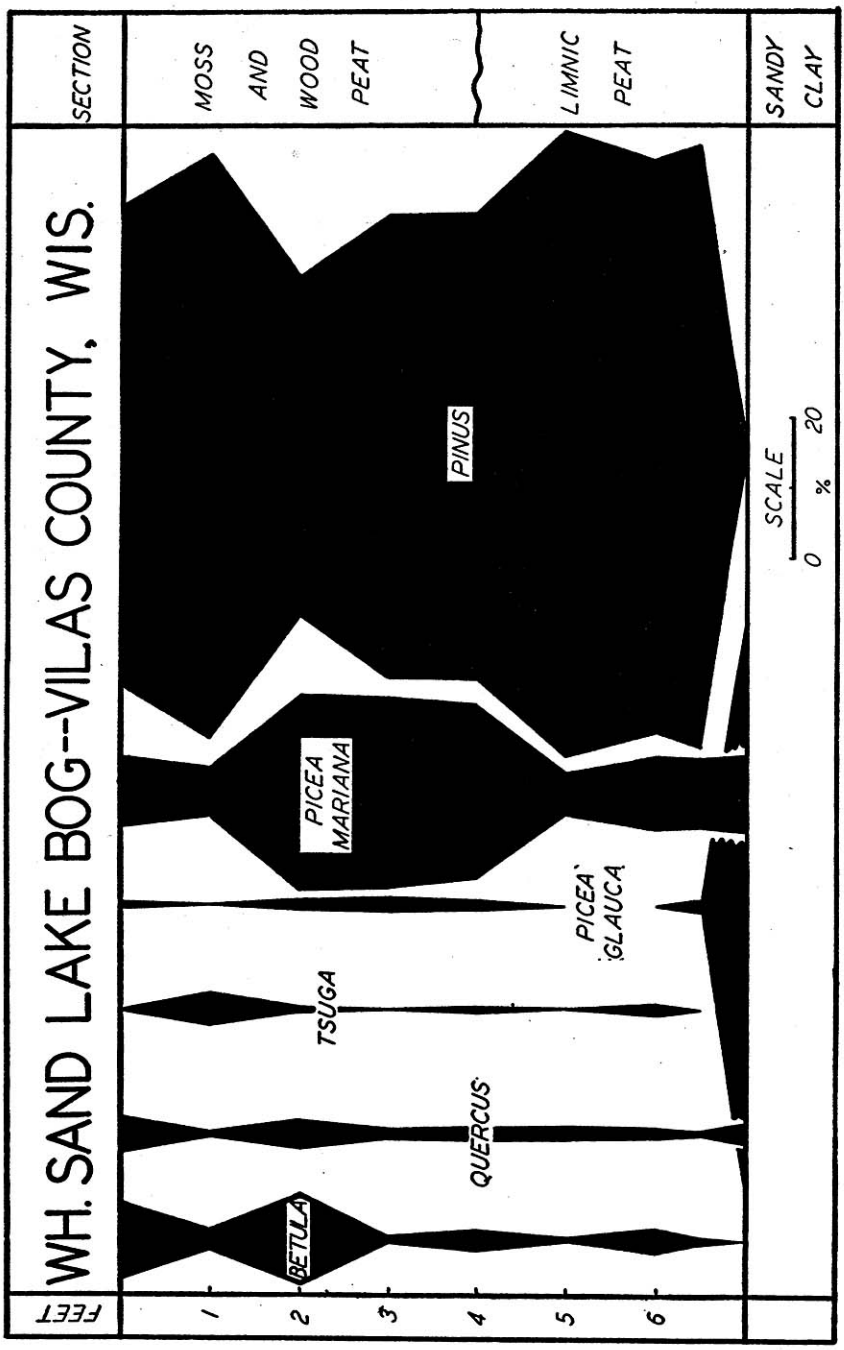


**Fig. 3. Diagram showing the distribution and succession of microfossils in the Sand Lake Bog.**

consin, Illinois, Indiana, and Ohio, but closer comparison must wait a critical examination of many more intermediately located bogs and a careful study of age relationships. The wide distribution of hardwood forest elements approximately in the center of a pine forest period is not a normal sequence of forest succession. This irregularity has been suggested as evidence of a climatic shift, and supports the climatic hypothesis of Von Post (1930). He suggests that there were three generalized phases: (1) increasing warmth, (2) maximum warmth, and (3) decreasing warmth. The strongest fossil pollen evidence for this hypothesis in northcentral Wisconsin is the occurrence of hickory pollen in the Silver Lake Bog, noted above, and the Winchester Bog located about twenty-five miles northwest (Wilson and Webster, 1942). Both of these localities are north of the present range of hickory in Wisconsin and suggest that during the so-called "xerothermic period", the oak-hickory forest of southern Wisconsin extended farther north than it does at present. A return to a cooler climate is suggested by the disappearance of hickory, the decrease in abundance of other hardwoods, and the increase of conifers such as white spruce and possibly hemlock.

## Summary

1. Three bogs in Vilas County, Wisconsin, were investigated paleoecologically to determine the history of the lake forest present in that region.

2. Notes and photomicrographs of common and abnormal spores and pollen found in the deposits are included in the studies.

3. The fossils indicate that the lake forest was preceded by a boreal forest composed largely of white spruce. Near the middle of the pine forest period there is a small amount of hardwood fossil pollen including hickory and butternut, two species which no longer grow within the region.

4. The occurrence of hickory and other hardwood pollen is interpreted as evidence of a warmer period of climate in late postglacial time, supporting the Von Post hypothesis.

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