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A comparative study of three Indiana bogs

Carl O. Keller
Butler University

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Ray C. Friesner

The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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A COMPARATIVE POLLEN STUDY OF THREE INDIANA BOGS[1]

By Carl O. Keller

The topography of the northern half of Indiana is dotted with numerous lakes and bogs. Many of the lakes located north of a line running irregularly southeast from Benton to Randolph counties still have extensive areas of open water, but no natural lakes are found south of this line. There is also a great difference in the stages of maturity of the bogs located in the two areas. Some have small ponds with several feet of water in the central part, some have reached the sedge-meadow stage, and some are completely "verlandet" and are now being utilized for agricultural purposes. These differences are due to three main factors. One is the original depth of the depression to be filled in. Another is the type of vegetation which develops along the shore, since this, as Gates (4) points out, "determines the fate of the area." The primary cause of difference, however, is that of the varying age of bogs. The southern bogs had their beginnings as lakes after the retreat of the Early Wisconsin glaciation. Great blocks of ice were left buried in the glacial drift. These melted, when the climate moderated, leaving "kettle hole" lakes as deep as 50 or 60 feet. The northern bogs are similar as to origin, but younger, since they did not form and begin to fill in until after the retreat of Late Wisconsin glaciation.

A long period of steady, constant change takes place in and about a lake between the time of its origin and its ultimate extinction. Cleland (1) points out that as soon as a lake comes into existence, agencies arise which tend to obliterate it. Sediment begins to accumulate and the outgoing stream commences to deepen its channel, which, in time, may drain the lake. Such drainage, however, does not seem to have been a vital factor in the obliteration of many Indiana lakes. In the numerous bog studies made by faculty members and students in the Botany department of Butler University, only one lake has been reported to have drained out when a little stream cut deep into

[1]A portion of a thesis submitted to the Faculty of the Division of Graduate Instruction in partial fulfillment of the requirements for the degree Master of Science, in the Department of Botany, Butler University.

the retaining embankment. This is a lake which, in ancient times, covered a large part of what is now the Barlow farm in Hendricks county. A study by Potzger (10) of a peat profile from this area shows that the lake must have become drained shortly after the culmination of the spruce-fir period.

The forces most active in obliterating lakes of Indiana have been those of deposition, chiefly in the form of marl and peat. In the Jeff bog, marl had accumulated to a depth of 15 feet before the deposition of peat began. In these marl and peat deposits are found preserved in chronological order, the pollen grains of trees which constituted the forests about the lakes and later bogs from early Post-Pleistocene times to the present. The pollen grains give evidence of succession in vegetation as the lake gradually changed from a body of open water to a wet sedge-meadow, and eventually into a well solidified bog, capable of supporting forest growth. Sediments from lakes show the same story of successional changes (Potzger and Wilson, 14). These lakes even if left undisturbed, would not reach the bog stage for ages to come, although they are slowly filling in year after year. According to Gates (4), a bog mat cannot develop in lakes where wave action is a hindering factor, so we find bogs in depression areas not so large as those of the deeper Indiana lakes, or in protected bays of these lakes. Gates (4) also shows that the initial vegetation developing along the shore of such a depression will be a vital factor in determining whether it will develop into a bog or into a wooded swamp, since the initiation of a bog requires the establishment of a sufficient number of plants of Carex around the edge to form an ecological association.

This study is concerned with the analysis of deposits from three Indiana bogs located within Late Wisconsin territory, but representative of points involving geographical limits almost across the state.

DESCRIPTION OF BOGS

Shipshewana Bog

Shipshewana bog is located at the southeast corner of Shipshewana Lake in La Grange county, Newbury township, Sec. 3, T. 37N., R. 8E. It is near state road 5 and about five miles north of U. S. Highway 20. This bog is one of the deeper multiple basins of a once more extensive body of water. Shipshewana Lake has reached bog stage only in places along the periphery, or in coves which have favored mat formation. No studies have been made of the present vegetation in this area, because the lake has served as a pleasure resort for many years. It is needless to describe the effects of such cultural influences upon the natural plant associations involved. Suffice it to say that most of the typical bog species which should be found have, no doubt, been destroyed by human interference.

Culver Bog

Culver bog is located in Starke county, North Bend township, Sec. 38, T. 32 N., R. 1 W. It is one mile west of the Marshall-Starke county line, and one-half mile south of state road 10. The plant cover at present consists of an extensive Larix-*Rhus vernix* community.

Jeff Bog

Jeff bog is in Wells county, Jackson township, Sec. 14 and 23, T. 25 N., R 10 E. It is 11 miles north of Hartford City, on the east side of state road 3, on the property of Mr. Stockton. The peat samples were taken from an open area about 200 feet east of open water.

METHODS

Sediment samples were taken at one foot intervals with a movable-sleeve-cylinder type of instrument. Two borings were made in each bog, the deeper of them being used in the analysis. The other was retained for comparative purposes. The borer was washed thoroughly between each foot-level boring, and the samples were taken from the centers of the cores to eliminate the possibility of contamination. Each sample was placed in a small bottle which was corked and labeled immediately. At the laboratory each bottle was sealed with paraffin, pending its preparation for microscopic study. This kept the material in a fresh, moist condition, even though it was not analyzed for several years after being brought in. No preservative was added.

The peat was prepared for pollen counts according to the alcohol method suggested by Geisler (5). For a number of samples, however, particularly from Shipshewana bog, it was necessary to modify this method somewhat. Due to low pollen frequency in the upper 20 foot-levels of this bog, a method of repeated decantation was used. This method was developed by the writer for separating pollen from river valley sediments which have an extremely low pollen frequency. For that purpose, about 20 grams of soil are used for the sample, but in applying the technique to peat, only one gram was taken. This was covered with enough alcohol to put all particles into a state of suspension when stirred. As the heavier particles began to settle out, the lighter ones, including the pollen grains, were poured off. This operation was repeated two or three times, and then the part to be used was stained with 1% aqueous gentian violet. After staining, the material was skimmed with a small pipette just above the heavier particles. These skimmings were placed on slides in the regular manner except that in many cases five or six applications were made in order to get the desired density and pollen frequency. From this point the preparation followed the regular procedure of mixing the material on the slides with warm gelatin and affixing the cover glass.

Determinations were based on Sear's (15) key, and on samples of stained pollen grains available in the Butler University laboratories. Two hundred grains were counted for each foot-level, with the exceptions of levels 5, 6, and 7 of Shipshewana bog, and 2 and 43 of Culver bog. Due to low abundance of pollen, only 100 grains were counted at these levels. The regular count included only pollen from trees. Grass pollen was also counted, but the percentages were figured on the basis of the number of grains appearing along with the 200 or 100 of the others (table I).

RESULTS

The percentages of different pollen types found in the 3 bogs are represented in figures 1 and 2. These figures include only the tree pollen, since that supplies the primary basis for deductions pertaining to forest succession. The study, however, did not disregard the possible importance of grass pollen in the deposits. In some levels of 2 of the bogs it was very abundant (table I).

All 3 bogs showed a Picea-Abies dominance in the lowest levels. In Jeff bog this dominance extended over 12 foot-levels (53-42). In the other 2 it persisted for only 3 levels (Shipshewana 39-37; Culver 43-41). Pinus was present in small percentages in all these lower levels except at the 43-foot level in Culver bog. Quercus was represented in the lowest levels except at the 53-foot level in Jeff bog (fig. 1). It superseded Pinus for a period before the end of the Picea-Abies dominance. Pinus was dominant for a relatively short period (foot-levels 36-34 in Shipshewana bog, 39-37 in Culver bog, and 41 in Jeff bog). It persisted in low percentages to the top levels.

In Culver and Shipshewana bogs it increased slightly (12-15%) near the surface.

Quercus became the dominant genus after the decline of Pinus, showing no great variations in frequency except in Jeff bog (32- to 28-foot level) and in Shipshewana (16-foot level), where it declined somewhat in favor of Larix. There was also a sharp decline of this genus at the top two foot-levels of Culver bog, due to a marked rise in Pinus and Larix.

Ulmus appeared as an early invader and persisted thereafter through all levels of the 3 bogs. It was most prominent during and immediately following the Pinus period, averaging from 12-14%. Tilia also appeared quite regularly in small amounts, but never exceeded 3.5%. Its time of invasion parallels closely that of Ulmus.

Carya made its first appearance before the close of the Picea-Abies period. It showed highest representation (17%) in the 38-foot level of Jeff bog. Considering all 3 bogs together, however, the most significant representation of Carya came in the upper 10 feet of deposition. Juglans invaded about the same time as Carya and persisted to the topmost levels. It never exceeded 4.5% and its variations in percentage showed no correlation with that of Carya.

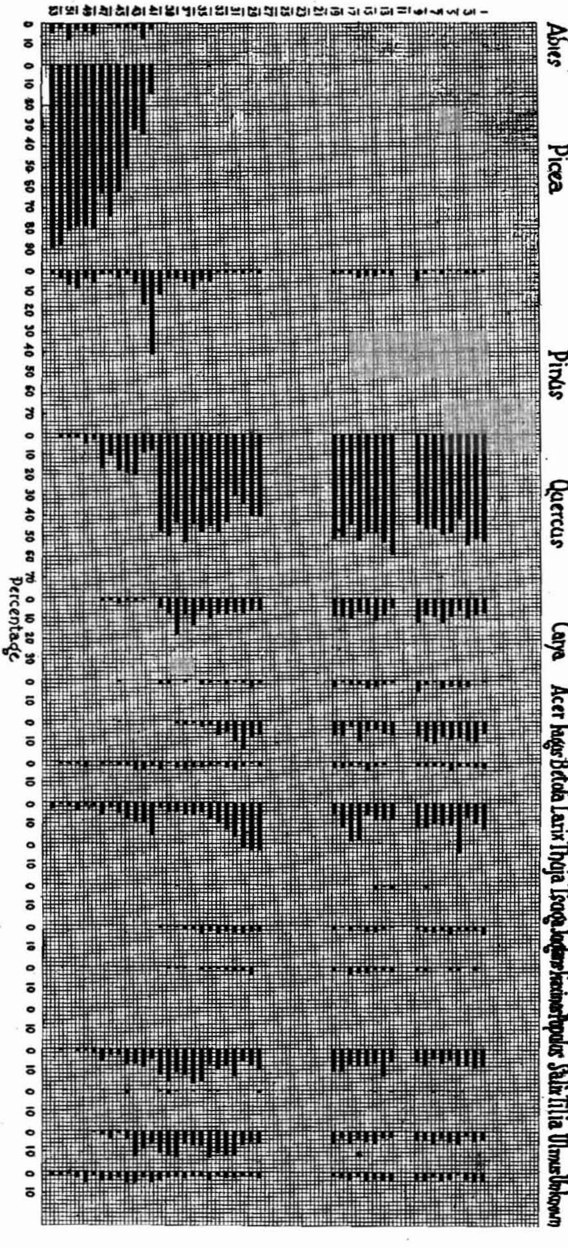
Fagus came in surprisingly early, just after the decline of Pinus. Acer was apparently associated with it, but its representation is only in low percentages. Larix was very prominent through the greater part of the Jeff bog spectrum. It appeared consistently at all levels in the other 2, but usually only in small amounts. Culver bog is at present covered by an extensive stand of Larix associated with *Rhus vernix*.

Betula and Corylus appeared in small amounts throughout most levels in the 3 bogs. The smaller of the Betulaceae type pollen was classified as Alnus on the basis of comparison with pollen of the genus found in stream deposits studied by the writer. These were omitted from the count because of their lack of significance as indicators of successional changes. Salix showed no marked aggressive tendencies except for a few foot-levels in Jeff bog.

Fraxinus was only sparsely represented, although it appeared consistently after its invasion during the early history of the bogs. Thuja, Tsuga, and Populus were infrequent components of the spectra. Tsuga did not appear in any instance before Pinus had reached its peak.

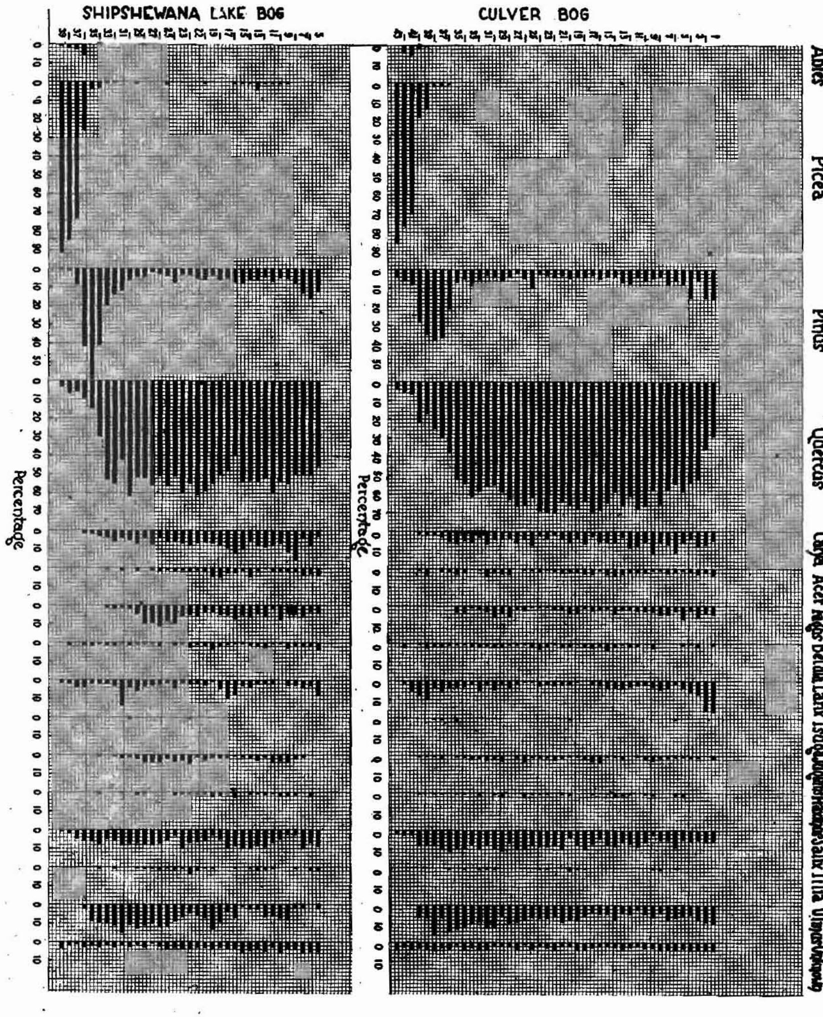
Grass pollen was not very prominent in the Jeff bog, and showed

JEFF BOG


Abies
Picea
Pinus
Quercus
Carya
Acer
Fagus
Betula
Larix
Thuja
Salix
Tilia
Ulmus
Unknown
Percentage

little importance in the other 2 below the 20-foot levels. It reached a miximum representation of 43% in the 17-foot level of Shipshewana bog and 57% at the 11-foot level of Culver bog. The percentage was based on number of grains found along with 200 of tree genera. From these levels to the top it declined somewhat, maintaining an average of from 23-25% (table I).

An attempt was made definitely to identify the species of grass which contributed most of the pollen to the sediments of levels where its frequency was high, because the correct interpretation of grass



pollen in large representation is dependent on knowing whether the contributors were prairie or aquatic grasses. Fifty grains from each of the 2 levels mentioned were measured and compared with the same number of grains from each of 12 different species of grass. From the close correlation in size (table II), and also from the similarity of appearance of the pore, the grass represented at these levels was obviously *Calamagrostis canadensis*.

DISCUSSION

The study of the pollen content of successive levels of peat and marl deposits in lakes and bogs is perhaps the best available method of determining the past vegetational history of an area, yet it has many limitations, and there is the possibility of drawing unwarranted conclusions from the data derived from such sediments. We cannot say, for instance, that the different percentages of pollen found in a certain level represent the actual percentage representation of the genera constituting the forest at the time that level was laid down. Not all trees produce pollen in equal quantities, nor does all pollen distribute itself in the same manner, as is shown by Potzger (11) in his study of bogs on the Gillen Nature Reserve. Some types of pollen may be carried by wind for great distances and be deposited into a bog, while others, especially from insect-pollinated genera as Acer and Tilia, may not get into it, though originating much nearer to the bog. Another limiting factor is our lack of knowledge concerning the relative resistance of the different kinds of pollen to oxidation and other destructive forces. We know that Thuja does not preserve well when wet, but we know little about various other kinds. There is some question as to whether or not we find them in the same relative frequencies in which they were originally deposited. Also the change in appearance of certain pollen which accompanies its process of breaking down is another source of uncertainty. Some workers question whether the large structure containing a resin globule, and customarily identified as Larix, is a pollen grain or an animal cyst. If it were not included, it would make a considerable difference in some of the other percentages. It was included here, however, on the strength of certain connecting links between it and well preserved pollen.

Despite the limitations accompanying the interpretation of pollen spectra, some very definite conclusions may be drawn from them which would not be invalidated even by introduction of a wide margin of error one way or another. The spectra clearly show that the vegetation of northern Indiana immediately following Pleistocene times was of a boreal type. This may be assumed despite the presence of a small percentage of Quercus found in the bottom levels of Shipshewana and Culver bogs. Although all borings were made down to sand, it is likely that there were still several foot-levels of pollen-bearing sand below those sampled which the movable sleeve borer could not penetrate. Potzger and Wilson (14) report such conditions existing in Winona and Tippecanoe lakes, as well as for a series of lakes on the Anoka Sand Plain in Minnesota (19), showing that Quercus would have been introduced too soon and too prominently in the lower levels had not the sandy bottom been penetrated. If the marl in these bogs was produced by Chara, it is possible that sedimentation was in progress for some time before the precipitation of great amounts of calcium carbonate resulted.

Another factor not to be overlooked is that forest migration must have followed closely upon the retreat of the ice sheet, as it has been noted to do in the Arctic regions in recent times. Griggs (7) has observed that the advance of spruce along the Alaskan coast is so rapid in some places that it is evident to persons who have lived in the neighborhood only a few years. It is not definitely known to what extent Late Wisconsin glaciation caused the deciduous forests to retreat, but with the abnormally warm climate that is generally supposed to have prevailed afterward, it should not have taken these genera long, when the coniferous forest began to move northward, to follow up and regain the ground they had lost. It is also very likely that climate at the edge of the glaciers in Indiana was not influenced greatly by the ice, since it was pushed down from centers of accumulation far to the north.

The sudden breaks between the Abies-Picea and the Pinus dominance, and also between that of Pinus and the deciduous genera which are found in this and other studies, tends to indicate that the changes were almost catastrophic in nature, but considering the rapid advance possible in forest migration as noted by Griggs (7) and by Cooper (2), and comparing that with the estimate of Potzger and Friesner (14) that each foot of deposition in the lower levels of lakes and bogs represents a period of from 400 to 500 years, it would be safe to assume that the changes merely followed the natural order of succession within a normal time range, and replacement of one genus by another may be due to interference with adequate reproduction of the preceding genera, which would thus be eliminated as soon as the existing generation of trees had died. The observation of Griggs (7) and Cooper (2) pertained to factors of primary succession where the movement of trees was very rapid into previously unoccupied territory, but succession of the type shown by the pollen spectra, involving replacement of preceding forest types, would naturally be much slower than the former.

The number of foot-levels showing Pinus dominance in these bogs corresponds to those of other bogs in the Late Wisconsin area, and the percentage of Pinus pollen also corresponds well with previous studies in northern Indiana. The percentage of Pinus at the peak of its dominance was highest in Shipshewana bog, where it reached 59%. In Culver and Jeff bogs the highest points were 37.5% and 41% respectively. Potzger and Wilson (14) found 2 levels of Pinus dominance in Tippecanoe lake, with percentages of 62 and 69. In Winona lake 2 foot-levels recorded 29.5 and 40.5%. Moss (9) records 3 levels with percentages of near 40 in Loon Lake bog. Smith (17) reports from Lake Cicott the longest Pinus period shown in any of the Indiana bogs. Five-foot levels in the spectrum show between 41 and 55% Pinus pollen. The older bogs of Early Wisconsin origin lack the periods of Pinus dominance found in those of Late Wisconsin origin.

Pinus pollen is present throughout the entire spectrum, and much of that found in the upper levels resembles the pollen of *Pinus strobus*. Although Indiana is today south of the southern limit of continuous distribution of this species, it is quite likely that it was present as relic colonies about the bogs studied up to comparatively recent times, and at the Culver bog it might possibly have persisted up to the time of settlement by civilized man. Lindsey (8) described such a relic colony of *Pinus strobus* constituting the forest cover on the Merrillville bog in near-by Lake county, covering an area of approximately 9 acres. This same species is also found as relic in Pine Hills, Montgomery county, in Fountain and Warren counties as well as on the dunes about Lake Michigan. This pine and many bog species of northern range have continued in Indiana under microclimatic conditions while the center of distribution of their kind has long since moved far northward.

Fagus and Acer were early invaders, coming in to stay shortly after the peak of the Pinus period. There is no noticeable fluctuating encroachment by one or the other of these forest types commonly defined as oak-hickory and beech-maple. Apparently they occupied fringing territory of the bogs from very early times. No doubt the species of Quercus and Carya occupied south-facing slopes or other more xerophytic habitats, and Acer and Fagus associated on the more mesophytic sites, as Potzger and Friesner (13) found to be the case over a wide area in south-central Indiana. Pollen of Acer and Fagus were as consistent in distribution throughout the levels shown in the spectra as were those of Quercus species, but lower in abundance. Since the former genera, especially Acer produce less pollen than Quercus it is quite likely that the smaller pollen representation may signify much greater importance of these genera in the forest cover than the abundance figures indicate.

The order of succession shown in the three bogs was as follows:

Quercus-Carya-Acer-Fagus
↑
Quercus
↑
Picea-Pinus-Quercus
↑
Picea-Abies

It is the opinion of the writer that Larix, Salix and some other genera represented by small pollen percentages show control by micro-climate or influence of edaphic factors rather than by larger successional trends. Ulmus is the only representative of the sub-dominant genera which shows any definite trend influenced by habitat change. Its consistently higher frequencies following the close of the Pinus period must have been due to wider areas of lowland occasioned by the broadened river valleys cut out by glacial drainage. This made available more suitable habitat sites for the genus.

The climatic changes indicated by the study apparently have run the following course: cold (Abies-Picea), cool moist (Abies, Picea, Pinus), warm dry (Quercus), warm moist (Quercus, Carya, Acer, Fagus). The arguments of some workers would lead one to expect evidences of a xerothermic period sometime between the decline of the Pinus period and the present. Gleason (5) places such a period immediately following the northward advance of the coniferous forest. Transeau (18) suggests that this period should be indicated by the pollen from the upper layers of peat from any bog within the limits of the Prairie Peninsula. This would involve the upper section of Indiana. Sears (16) and Draper (3) interpret the rise in percentage of grass and compositae pollen in certain levels of the New Haven, Ohio, bog as an indication of prairie invasion, extending as far east as the Erie Basin.

Jeff bog showed no evidences of such a prairie invasion. Grass pollen fluctuated little throughout, and never rose above 14% in any level. Pollen of composites was even less conspicuous. Tree pollen throughout all levels above those representing the coniferous period were also quite abundant, averaging about the same number to the slide of the mounted material. Shipshewana and Culver bogs showed a marked decline in abundance of pollen from tree genera above the 20-foot level, the number per slide being reduced to one-half or less. This, together with the sharp rise in frequency of grass pollen in the 16- to 18-foot levels of Shipshewana bog, and the 9- to 13-foot levels of Culver bog tended to indicate that the areas about these bogs had also been affected by a xerothermic period during comparatively recent times. However, evidence would have to be brought that prairie species contributed the grass pollen. Upon careful examination, measuring, and comparing various grass species, the pollen involved in these foot-levels appeared to be more like that of *Calamagrostis canadensis* than of any prairie species (table II). Most of the grass pollen from the 17-foot level of Shipshewana bog and from the 11-foot level of Culver bog measured from 27.5 to 33.7 microns in diameter, comparable in size to that of Calamagrostis. Pollen from the prairie grasses, such as the Andropogons, *Sorghastrum nutans, Agropyron smithii,* and *Bouteloua curtipendula* were consistently larger than this. The Poas and *Phragmites communis* had pollen smaller in size (table II). *Dactylis glomerata* might be considered in favorable comparison with Calamagrostis but none of the grains measured less than 30 microns.

From the camparisons shown in table II we must conclude that most of the grass pollen in these bogs was contributed by aquatic species, eliminating them as indicators of prairie invasion. The small representation of composite pollen throughout the spectra also do not point to expanding prairie influence. The only remaining feature indicating a xerothermic period is the low abundance of tree pollen in the upper levels, and it is very likely that this is due to destruction by oxidation of much of the pollen as it was deposited upon the bog mat before being added to the accumulating sediment.

SUMMARY

1. Pollen spectra are presented from Jeff, Shipshewana and Culver bogs in northern Indiana.

2. Depths of sediments in the bogs were as follows: Jeff bog 53 feet; Shipshewana bog 39 feet; Culver bog 43 feet.

3. Methods used were those described in previous Butler University pollen studies except for a modification in the technique of slide preparation which was used for samples with low pollen frequencies.

4. Forest succession indicated by the three spectra was practically the same: Picea-Abies, to Picea-Pinus-Quercus, to Quercus-Carya, to Quercus-Carya-Acer-Fagus. Pinus was more prominent during its period of dominance in Shipshewana and Culver bogs than in the more southern Jeff bog.

5. The following climatic changes are indicated by the spectra: cold (Abies-Picea), cool moist (Abies-Picea-Pinus), warm dry (Quercus-Carya), warm moist (Quercus-Carya-Acer-Fagus).

6. Grass pollen present in the bogs apparently was that of Calamagrostis, and so has no diagnostic value as an indicator of a xerothermic period in the upper part of Indiana.

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TABLE I

Number of grass pollen found in Jeff, Shipshewana, and Culver bogs.

Foot-levels	Jeff bog		Shipshewana bog		Culver bog	
	No.	%	No.	%	No.	%
1	19	8.7	w	w	65	24.5
2	11	5.2	w	w	16	13.8
3	9	4.3	w	w	82	29.1
4	5	2.9	w	w	64	24.2
5	4	2.0	25	20.0	41	17.0
6	2	1.0	30	23.1	57	22.1
7	10	4.8	21	17.3	49	19.7
8	10	4.8	59	22.8	41	17.0
9	15	7.0	69	25.6	118	37.1
10	w	w	49	19.7	196	49.5
11	w	w	24	10.7	268	57.3

TABLE I—(Continued)

Number of grass pollen found in Jeff, Shipshewana, and Culver bogs.

Foot-levels	Jeff bog		Shipshewana bog		Culver bog	
	No.	%	No.	%	No.	%
12	13	6.1	63	23.9	139	41.0
13	9	4.3	57	22.1	113	36.1
14	13	6.1	56	21.9	55	21.5
15	16	7.4	81	28.9	50	20.0
16	12	5.7	125	38.5	41	17 0
17	4	2.0	153	43.3	41	17.0
18	10	4.8	113	36.1	98	32.9
19	9	4.3	23	10.3	39	16.3
20	w	w	27	11.9	32	13.8
21	w	w	26	11.5	23	10.3
22	w	w	26	11.5	21	9.5
23	w	w	20	9.1	15	7.0
24	w	w	15	7.0	15	7.0
25	w	w	15	7.0	14	6.5
26	w	w	20	9.1	12	5.7
27	w	w	24	10.7	31	13.4
28	11	5.2	15	7.0	22	9.9
29	11	5.2	14	6.5	13	6.1
30	4	2.0	15	7.0	11	5.2
31	8	3.8	12	5.7	14	6.5
32	5	2.4	11	5 2	16	7.4
33	5	2.4	13	6.1	17	7.8
34	9	4.3	12	5.7	13	6.1
35	24	10.7	13	6.1	12	5.7
36	23	10.3	14	6.5	10	4.8
37	22	9.9	16	7.4	14	6.5
38	21	9.5	7	3.3	28	12.3
39	29	12.7			22	9.9
40	23	10.3			14	6.5
41	13	6.1			10	4.8
42	16	7.4			5	2.4
43	27	11.9			2	2.0
44	32	13.8				
45	19	8.7				
46	11	5.2				
47	21	9.5				
48	5	2.4				
49	5	2.4				
50	4	2.0				
51	1	0.5				
52	1	0.5				
53	1	1.5				

TABLE II

Comparison of size ranges of grass pollen found in high frequency levels of Shipshewana and Culver bogs with those of various species of modern pollen from herbarium specimens. Measurements are given in microns.

	25 26.2	27.5 28.7	30 31.2	32.5 33.7	35 36.2	37.5 38.7	40 41.2	42.5 43.7	Above 44
Shipshewana bog 17′	8	13	14	8	5	2			
Culver bog 11′	3	12	15	11	6	3			
Calamagrostis canadensis	5	8	20	11	3	2	1		
Zizania aquatica			1	2	4	8	16	12	7
Andropogon furcatus				10	17	17	5	1	
Andropogon scoparius	1	1	1	5	12	17	11	2	
Sorghastrum nutans			1	1	8	20	20		
Agropyron smithii					4	24	9	12	1
Bouteloua curtipendula				17	21	8	3	1	
Glyceria septentrionalis				24	22	4			
Dactylis glomerata			14	20	14	2			
Poa autumnalis	19	22	8	1					
Phragmites communis	29	18	3						