"THE HISTORY OF WOOD'S POND AND THE FORESTS OF THE CHIGNECTO REGION"

BY

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The Ecological History of Wood's Pond and the Surrounding Forests in the New Brunswick-Nova Scotia Border Region

by

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ABSTRACT

The ecological history of Wood's Pond and the surrounding forests were investigated through analyses of pollen and chironomid microfossils, within an 8.0 metre core of lake sediments.

The data suggest that Wood's Pond, originally an oligotrophic lake, lies in a basin formed during the last glaciation. The lake's basin gradually filled with sediments and a sphagnum bog began to encroach upon the lake. Wood's Pond appears to have gradually evolved from an initial oligotrophic state towards the present dystrophic system. The chironomid analyses suggest a progressively decreased oxygen supply to the benthos, accelerating at about the time of settlement.

The pollen analyses reflect changes in surrounding vegetation probably attributable to a progressive climatic improvement following glaciation. With the passage of the hardwood maximum, a deterioration in soil and/or climate may account for the return of the boreal elements in the forests of the Chignecto region. Many of the most recent changes are probably attributable to man.

ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance of Dr. H. Harries, and Dr. C. G. Paterson for their aid throughout the duration of my research. Their moral and technical support, from the initial proposal through to the final criticism of this paper, were responsible for the success of the investigation.

Dr. J. G. Ogden III made his facilities at Dalhousie University available. The opportunity to borrow from his expertise was particularly valuable.

Several of my colleagues at Mount Allison University deserve recognition. Mr. Jim Carpenter, who was conducting a related investigation at Wood's Pond as part of a graduate program at the University of Western Ontario, and Marc Spence, who was frequently distracted from his own work, deserve special recognition. Many other students also contributed.

The carbon-nitrogen data, included as an appendix to this thesis, was provided by Jim Pollock, head of the Analytical Services Division of Environment Canada's water quality laboratory in Moncton, New Brunswick.

The support of Mrs. Laura Ruggles-Gates and Shell Canada, through the establishment of the Reginald Ruggles-Gates Award and the Shell Canada Summer Research Fellowships, respectively, are gratefully acknowledged. Mrs. Ruggles-Gates established the Reginald Ruggles-Gates Award in memory of her late husband, a distinguished graduate of Mount Allison.

Finally I would like to acknowledge the patience of my mother, Mrs. Elizabeth Walker, who spent many long hours carefully typing these pages.

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INTRODUCTION

Paleolimnology is a relatively new, but rapidly expanding science. Two international symposia have been held (Frey, 1969; Rozycki, 1978) and there alone over one hundred relevant papers were presented. Diatoms, rhizopods, cladocera, chironomids, plant macrofossils, and various chemical properties have been studied in relation to paleolimnology. To correlate changes within lake ecosystems to changes in the regional vegetation, pollen analysis has also been routinely applied in these investigations.

Most research, of this nature, has been directed to the study of the oligotrophic to eutrophic sequence. Consequently, the developmental history of such lakes has been well documented. Dystrophic lakes (Huttunen et al, 1978; Rozycki, 1978) have been studied to a much smaller extent. Research conducted at Wood's Pond, the subject of this thesis, was intended to provide a more complete understanding of dystrophic lakes and their historical development, particularly with respect to changes in the chironomid community. As a related effort the history of the surrounding forests in the New Brunswick-Nova Scotia border region was investigated by means of pollen analysis.

Chironomid larvae form an important component of the macro-invertebrate communities of lakes. Passing through four instars, their discarded head capsules, composed of decay resistant chitin, are incorporated into the lake's sediments. The winged adults emerge, and following mating the females deposit their eggs back into the water.

Chironomids have commonly been employed as indicators of eutrophic, mesotrophic, and oligotrophic environments. Stahl (1969), however, pointed out that these insects are better indicators of oxygen availability than trophic status. *Tanytarsus* and *Heterotrissocladius* are the normal dominants of highly oxygenated, oligotrophic lakes while *Chironomus* occupies poorly oxygenated waters. The survival of *Chironomus* in oxygen-poor waters appears to be related to high internal hemoglobin concentrations (Schmidt-Nielsen, 1979). *Sergentia* and *Stictochironomus* are most abundant where intermediate conditions prevail. Other genera may be associated with epiphyte communities or occupy other niches within the lake ecosystem. Relatively few studies have considered the chironomid fauna of dystrophic lakes. Although Stahl (1969) suggests that *Chironomus tenuistylus* is typical, *Chironomus attenuatus* is the present dominant (Ramcharan and Paterson, 1978) in Wood's Pond.

Where chironomids have been employed as indicators of past ecological conditions (Clair and Paterson, 1976; Czeczuga et al, 1979; Stahl, 1959), most investigators have recovered only low numbers of head capsules from the sediments. Small sample sizes detract from the value of these investigations, but time does not normally permit a more thorough investigation.

One further problem plagues chironomid analyses, the redistribution of microfossils during sedimentation. Currents in the epilimnion of lakes are responsible for the transport of sediment from the littoral zone (Potzger, 1956) towards the deeper central portion of the lake. How this affects the distribution of sub-fossil chironomids is a matter of concern. It has generally been accepted that at least some littoral chironomids will be redeposited in this manner.

The poor definition of the lake-sediment interface in predominantly organic lake deposits poses a problem regardless of the paleolimnological technique employed. In shallow lakes this produces sampling difficulties, but may also permit natural disturbance of the sediments during periods of mixing. A recent refinement (Merilainen, 1978) may reduce disturbance when sampling such a deposit, but natural disturbance of the sediments is still a problem. Despite these problems chironomid analysis remains an important paleolimnological tool.

Pollen grains of seed plants, as the spores of pteridophytes, may generally be identified as far as genus. Each grain is enclosed in a sporopollenin coat, the exine or exospore, which like chitinous material is particularly resistant to decay. Consequently, pollen and spores, which are similar in structure, provide important paleobotanical clues.

Pollen analytical procedures have been widely employed and standard methods exist for the treatment of pollen prior to analysis. Faegri and Iversen (1964) provide a thorough discussion of palynological technique.

Two major problems exist with the analysis of pollen microfossils. It is impossible to define boundaries for the source area of the deposited pollen. Pollen is probably largely derived from local sources but a significant fraction may have been transported over great distances prior to deposition. Interpretation of data is further complicated by the fact that pollen production differs greatly for different genera. _Betula_, _Pinus_, _Alnus_, _Tsuga_ and _Quercus_ tend to be over-represented (Faegri and Iversen, 1964) in the pollen rain, while _Abies_, _Acer_, and all insect-pollinated plants are under-represented. The R-values calculated by Livingstone (1968) and the correlation of fossil pollen spectra with modern assemblages (Ogden, 1977) are attempts to overcome this problem.

The forests of the Maritime Provinces have been the subject of several palynological investigations. Mott and Prest (1967) investigated interstadial organic deposits in Cape Breton. Deevey (1951) and Livingstone and Livingstone (1958) provided two of the earliest post-glacial records for this region. Mott's (1975) pollen diagrams for south-western New Brunswick provide further insight into the post-glacial forest history. The most thorough investigation to date is that completed by Livingstone (1968). His paper includes diagrams for cores derived from seven Nova Scotian localities. One of these is Folly Bog in the Cobequid Mountains, only 80 kilometres south-east of the Wood's Pond location. Vontso (1961) prepared a pollen diagram for the Sunken Island Bog which lies in the Tantramar Marshes near the New Brunswick-Nova Scotia border. Unfortunately, raised bog deposits seldom include a full, post-glacial record, and her diagram is no exception.

Research by Ramsay (1963) investigated the composition of a fossil forest exposed beneath the tidal deposits of the Cumberland Basin near Fort Lawrence in the same region. The stumps, dated to 3500 B.P. (Lyon and Harrison, 1960) were found to be the remnants of a hemlock dominated forest. This forest included an understory of birch, white cedar, and balsam fir. This site lies only 7 kilometres south-east of Wood's Pond.

THE STUDY AREA

Dystrophic lakes, frequently surrounded by *Sphagnum* dominated peatlands, are acid, brown-water systems with high humic acid concentrations. Wood's Pond is such a lake, lying about 25 metres above sea level on the outskirts of Sackville, New Brunswick (Fig. 1). The pond, barely exceeding 200 metres in length, has no discrete inflow, but derives its waters by seepage through the peat from a small, fifty hectare basin. Outflow is by a shallow, slowly-moving stream.

The pond has a maximum depth of two metres, yet the water remains stratified throughout most of the summer months. Oxygen concentrations at the maximum depth frequently decline to less than 10% of saturation throughout both summer and winter. The Secchi disk disappears at approximately 0.6 metres. The water maintains a pH of 4.1 to 4.7 (Ramcharan and Paterson, 1978).

About 80% of the lake supports extensive growths of *Nuphar variegatum*. *Scirpus subterminalis* is another common aquatic macrophyte. *Chamaedaphne calyculata* dominates the shoreline in association with *Calla palustris*, *Sphagnum recurvum*, and *Sphagnum magellanicum*.

Figure 1. Location of Wood's Pond near the New Brunswick-Nova Scotia border

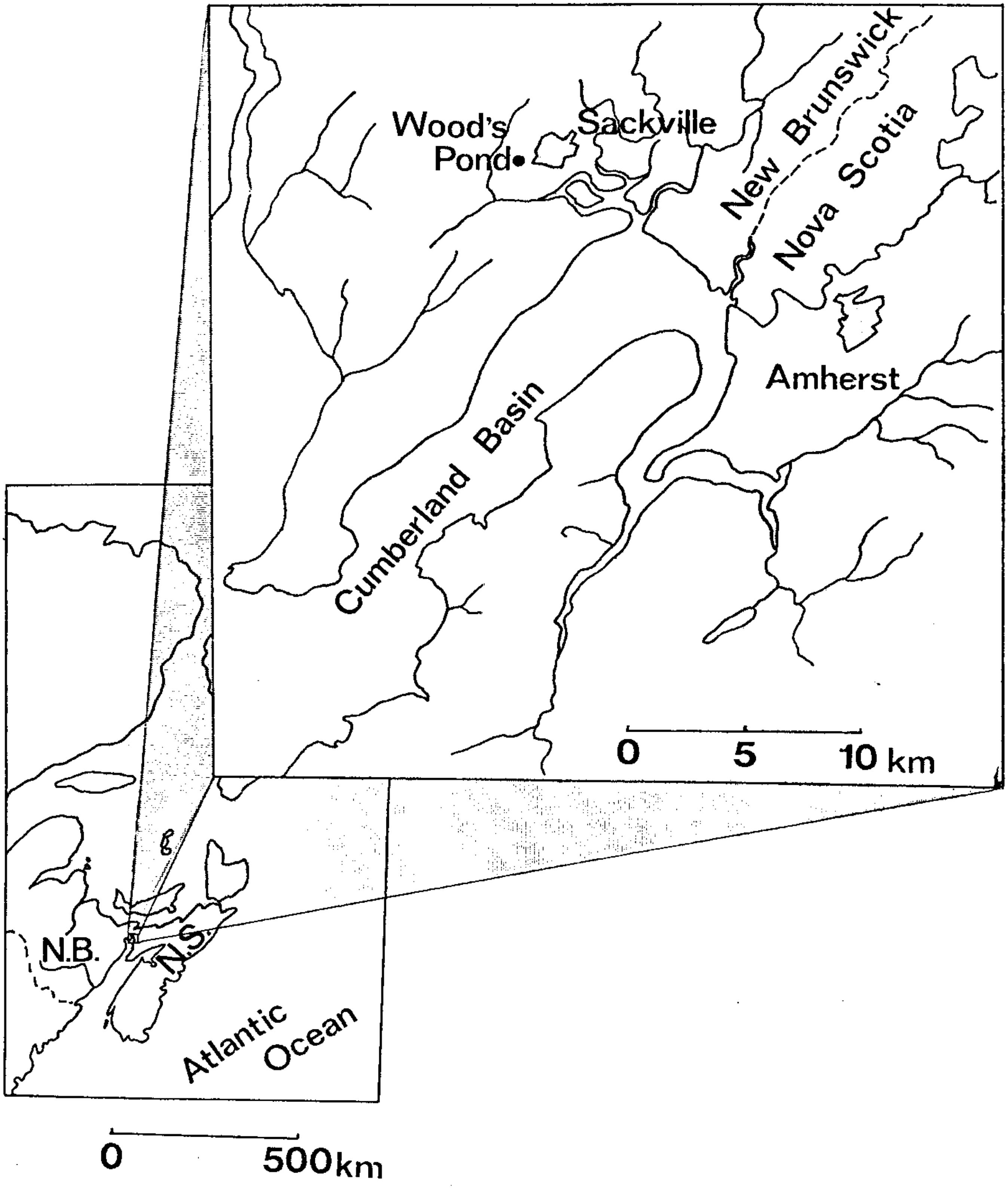

Wood's Pond
Sackville
New Brunswick
Nova Scotia
Amherst
Cumberland Basin
0
5
10 km
N.B.
N.S.
Atlantic Ocean
0
500km

Figure 2. Peatland communities surrounding Wood's Pond. Community 1, open bog dominated by *Sphagnum rubellum*, *Sphagnum fuscum*, and Ericaceae. Community 2, black spruce (*Picea mariana*) bog forest. Community 3, mixed conifer-hardwood swamp forest.

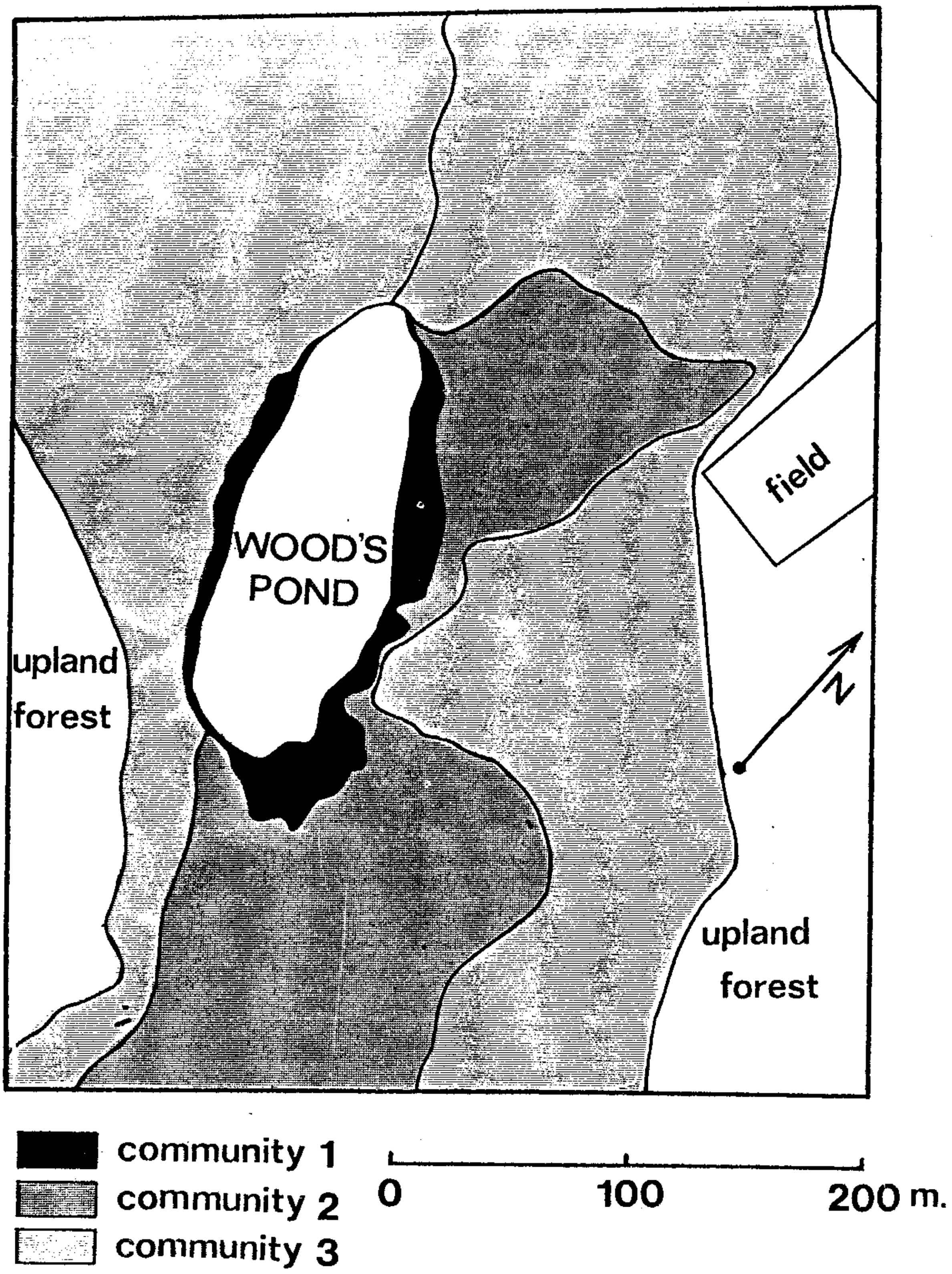
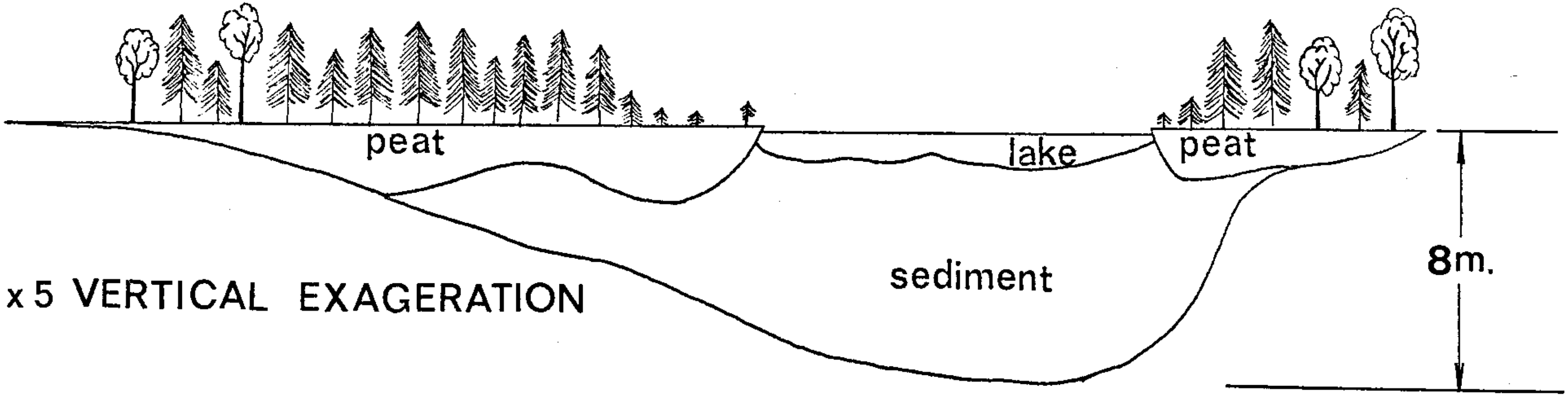

WOOD'S
POND
upland
forest
field
N
upland
forest
community 1
community 2
community 3
0
100
200 m.

Figure 3. Profile of Wood's Pond peat basin



PROFILE OF WOOD'S POND BASIN

The vegetation of the surrounding peatlands includes three communities (Fig. 2). The lake is surrounded by a bog community with *Sphagnum rubellum*, *S. fuscum*, and various ericaceous shrubs. Stunted black spruce occur throughout, but few exceed one metre in height. *Sarracenia purpurea*, the pitcher plant, is also characteristic of this peatland habitat.

Landward, the bog grades into a bog forest, formed by a dense, closed-crowned stand of black spruce (*Picea mariana*). Ericaceous shrubs form an important component of this community, while *Sphagnum nemoreum*, *Pleurozium schreberi*, and *Bazzania trilobata* are important bryophytes of the forest floor. The area of this community is raised slightly above the adjacent bog (regions 1 and 3) and consequently provides a drier environment.

A swamp forest with red maple (*Acer rubrum*), balsam fir (*Abies balsamea*) and black spruce forms a third community. Shrubs such as *Viburnum cassinoides*, *Nemopanthus mucronata*, and several ericaceae are also present. *Sphagnum recurvum*, *S. palustre*, and a number of herbaceous vascular plants are distributed throughout.

Research by Lunn, Bagnell, and White (1979), shows that the lake and surrounding peatlands occupy a 700-metre long basin (Fig. 3) with a maximum depth of 10.5 metres. The maximum depth of the pond corresponds to the point of maximum depth of the underlying basin. Infilling of the lake has reduced the pond to approximately 4% of its original volume.

Other research relevant to this investigation has been carried out at Wood's Pond. Ramcharan and Paterson (1978) investigated the structure of the chironomid communities, while Carpenter (personal communication) is currently developing a carbon budget for the pond. A hydrographic survey was completed by Hart, Kervin and Fitch (1978).

At present the upland areas surrounding the pond are composed of mixed and conifer second-growth forests. Important broad-leaved species include *Betula lutea*, *Betula papyrifera*, *Acer rubrum* and *Fagus grandifolia*. *Picea rubens*, *P. mariana*, *Abies balsamea*, and *Pinus bankisiana* are the dominant conifers. Agricultural land extends to within 150 metres of the lake's shoreline. The Tantramar Marshes border the Cumberland Basin 3 kilometres to the south-east.

METHODS

In May of 1979, a small drilling platform was positioned over the maximum depth of the pond. From this support, employing a Livingstone piston sampler, an 8.5 metre core of sediments was removed in nine segments. These segments, at this point enclosed in approximately one-metre long metal tubes, were transported to the laboratory. Upon extrusion from the tubes, the sediments compressed to 8 metres. The core segments were sealed in plastic, moisture-impermeable wrap, and refrigerated at 5° C. for the duration of the investigation. Samples of wet sediment were later removed at twenty centinetre intervals for quantitative study.

One cubic centimetre samples, dried at 40° C. for 16 hours, were used for loss on ignition analysis. The dried samples were combusted at 550° C. This procedure permitted moisture and loss on ignition of the sediments to be calculated. Loss on ignition was employed as a direct measure of the organic fraction.

Pollen Analysis

Further 1.0 cm^3 wet samples were analyzed for pollen using a standard pollen analytical method (Faegri and Iversen, 1964). This process included the following steps:

1) Two tablets containing a known amount of _Eucalyptus_* pollen (16, 180 ± 1, 460) were added to each sample. The $CaCO_3$ matrix surrounding each tablet was dissolved in 10 % HCl. Later, absolute pollen concentrations could be calculated from the ratio of the number of _Eucalyptus_ grains to the native pollen numbers.

2) The samples were heated to boiling in 10% KOH and maintained at boiling for approximately one minute.

3) Below the 4.8 metre depth it was necessary to remove excessive inorganic material with concentrated hydrofluoric acid. These samples were maintained between 65 and 75° C. in a water bath for one to three days during this treatment.

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*Louis J. Maher, Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin.

4) The remaining material was then acetolyzed at 100° C. for one minute in a 9:1 mixture of acetic anhydride and concentrated sulfuric acid.

5) Finally, the acetolyzed sample was mounted on glass slides in glycerol.

During subsequent counts, a minimum of 300 native pollen were normally identified from each slide. The 7.4, 7.6, and 7.8 metre levels contained very little pollen. There counts were limited to 100 native grains. Most counts were made within a few days of preparation. Identification was based both upon the literature (Bassett et al, 1978; Kapp, 1969; McAndrews et al, 1973; Ogden, unpublished) and a limited reference collection, prepared by the author. Counts of charcoal fragments were made for a number of these slides by H. Harries.

Chironomid Analysis

At each interval a minimum of thirty chironomid head capsules were removed from the wet sediment. Although the sediments were normally untreated, it was necessary to wash the samples in a 37 um sieve below 7.3 metres. This concentrated the microfossils by removing fine inorganic materials. Any head capsules found were mounted in A.C.S.* mounting medium and later identified with aid of keys by Mason (1973) and Roback (1957).

Diatom Analysis

A preliminary investigation of diatom distributions in the core was also made. Smears of untreated wet sediment, prepared as wet mounts, facilitated this work.

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*Searle Diagnostic, High Wycombe, Bucks, England

RESULTS AND DISCUSSION

Sediment Composition

The lowermost sediments are composed primarily of fine, red, inorganic material, but a sharp transition occurs at approximately 6.7 metres. The sediment, above this level, is dark due to a high organic component. Between 6.8 and 2.4 metres (Fig. 4a)* the inorganic fraction declines from 95 % to about 30 % of the dry sediment. A further decrease in the inorganic fraction occurs between 2.6 and 2.2 metres. In the uppermost sediments, the inorganic fraction represents only about 10 % of the total weight of dry sediment.

As might be expected, moisture content parallels these data. The material below 6.7 metres includes in excess of 50 % solids (Fig. 4b)*, while about 5 % solids is characteristic of the predominantly organic upper sediments.

Pollen Data

Thirty-four kinds of pollen (Table 1) were recognized in the sediments, including fourteen tree genera and six

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*Figures enclosed in envelope on the back cover.

Table 1. Number of pollen and spores counted at each interval

DEPTH (cm.)

	0	10	20	30	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800
Abies	4	7	10	12	7	15	14	22	10	9	13	9	9	16	5	8	7	4	5	3	5	3	4	8	12	8	6	7	22	24	23	14	8	17	28		10	1	1		2		3
Larix	4	6	1		2	2	1	4	6	3	1	2	1	2	1	4	2		3	3	1		2		1	1	1	3	14	2	4	9	1	11	9	1	1						1
Picea	42	52	51	46	78	25	47	65	39	23	25	13	13	11	28	13	25	7	7	18	22	10	7	16	26	29	25	44	124	113	67	93	111	98	114	124	48	48	11	26	32	14	55
Pinus	14	21	29	25	29	35	49	67	45	52	51	54	83	100	71	66	75	53	105	73	65	59	83	104	203	112	88	168	324	162	246	308	132	189	80	39	81	29	26	26	29	13	67
Tsuga	7	12	6	16	21	33	83	81	47	76	55	61	44	45	30	41	116	110	180	184	182	101	127	92	85	26	95	4	5	5	1	8	1	1	1		4					1	8
Acer rubrum		2	2	1	4	2	1	2	4	3	3	2		4	3	1	1	1	1		4		1	3	2	7	4	1			2		2			1							
Acer saccharum	4		2	1	7	2	4	4	1	4	1	1	3	4		2	2	1	4	2	2		1		3	4	3	1	4	2		2		2		1							
Betula	96	118	101	118	140	165	187	213	214	200	104	165	207	271	185	122	165	87	118	167	180	180	99	115	36	71	218	213	147	55	93	107	91	110	148	55	51	73	50	4	1	17	81
Fagus	19	15	8	15	28	30	33	66	55	45	17	36	14	6		3	2	4	4	1	3	8		2		1	6	5					1									1	1
Fraxinus						1						1		5			2			1	2	1								2			1										
Juglandaceae																	3									1						1											
Ostrya					3		1		1				1	2	1		1		1	1		2	1	3		1	2		1	1		1		2									
Quercus	5	4	4	2	3	2	3	4	5	6	1	5	4	24	13	8	24	9	10	14	14	23	17	18	20	62	50	17	39	24	30	33	7	7	10	4	8						8
Ulmus	1		1	1		1			4	1		2		2		1	3			2	4	2	5	3		3	4	2	4	1		1				1				1			
Tilia																																	1										
total Arboreal	196	237	215	237	322	313	423	528	431	422	271	351	379	492	337	269	428	276	438	469	484	389	347	364	388	326	502	465	684	391	466	577	356	437	390	226	203	151	88	57	64	46	224
Alnus	14	19	13	20	2	3	8	4	11	5	2	3	1	3	5	5	8	3	2	4	6	10	5	9	1	8	10	18	10	12	3	7	11	6	4		12	8	4			3	4
Corylus	1		1	1	1				2	2		1	1		1							1		1		3	1	1	4					1				2					1
Ilex	2	1	1			3	3				2		2				1		2		1	1	2			2	3		3														
Myrica	3	2	5	2	7	2	7	4	5	5	4	2	7	2	8	7	6	1	2	5	8	9	4	3		1	7	1	4		3	1		7	1	6	1	3	4	1		1	
Salix		3	1	2	3		1					1	1						3	6	3	2	3	8	5	4	9	1		1	1	1	2	1	1	6	1	27	49	12	6	11	8
Ericaceae	3	3	2	2		1	4	1	4	2									1		1	1					1											2	6			2	
total Shrub	23	28	23	27	13	9	23	9	22	14	8	7	12	5	14	12	15	4	10	15	19	24	14	21	6	18	31	21	21	13	7	9	13	15	6	14	14	42	63	13	6	17	1
Nymphaea	1				1			2	5	1	2	1			4	2	5	2	9	3	9	9	2	2	2	1			1			1											
Carex	11	3	9	8	3		1	1	2	3	1	2	1	2	8	8	4	5	4	11	5	3	2	2		1	4	2	6	4	3	4	6	2	2	4	52	72	116	11	15	22	
Chenopodium	3		4						1			1										1						1	4	1				1	1			2	1		1	2	
Compositae	1	1	3		1	1			1	2					2	2	1		2	1					1									1	1			2	6	3		1	2
Cornus and Aralia	2		4			2				1			7				1		1	1				1		1			1	3				1				3	1		1		
Lycopodium lucidulum		1		1			1	2	1				1														1		1														
Lycopodium selago																																				3	1					1	
ther Lycopodium	3	4	2	2		1	1				1	1					6	3	1			5	1	1			4	2	4	2		1	1	1	10	19	4	1	3	6	1		
onolete Fern			4		2		2	1	2	3	3		1	2	3	1	2	1	2	3	7	2	4	2	3	2	3	2	4		4	11	2	18	4	19	5		12	4		4	
phagnum and Trilete Fern	3	15	5	5	1	7	8	14	2	20	4	10	1	3	3	3	3	3	12	3	1	2	3	4		2	1	3	4	4	5	19	2	8	2	3	2	10	3	3	3		
ypha					1		1		1						1												2						2	1		3	1				1	1	
ramineae	28	32	21	12	2		1	3		2	1		2	1	2		1		1	2		2		1		2		2					2	1	2	2	6	7	4			4	
uphar	3	5	2	3		4	6	4	1	5	3	5	4	2				1	2	3		2		2			2		1													1	
otamageton	9	5	2		2		2	5	7	4	3	1	2	2	3				1	2	3			1		2																	
ndetermined	16	10	9	7	8	3	5	7	4	7	7	7	5	9	24	6	7	5	10	4	9	8	7	9	3		8	9	8	4	10	6	17	21	12	7	18	17	15	6	9	12	1
otal Herb	80	76	65	48	21	18	27	38	28	49	25	28	24	21	50	22	30	20	45	33	34	34	19	25	9	11	25	21	34	18	22	42	32	55	34	60	89	114	161	33	31	48	3
otal Native	299	341	303	305	356	340	473	575	481	485	304	386	415	518	401	303	473	300	493	517	537	447	380	410	403	355	558	507	739	422	495	628	401	507	430	300	103	307	312	103	101	111	30
ucalyptus	241	240	327	44	174	143	138	179	153	131	69	113	80	99	94	56	75	54	93	114	127	138	81	91	59	94	170	163	163	58	61	102	42	102	83	34		101	219	1516	2499	1367	56

shrubs. Although some authors (Potzger et al, 1956) have attempted to distinguish separate species within *Picea*, *Pinus*, and other genera, this, with the exception of the genus *Betula*, has not been attempted here. *Tsuga canadensis*, *Abies balsamea*, *Larix laracina*, *Fagus grandifolia*, *Ulmus americana*, and *Ostrya virginiana* are almost certainly the only representatives of their respective genera which contributed pollen to the pond's sediments.

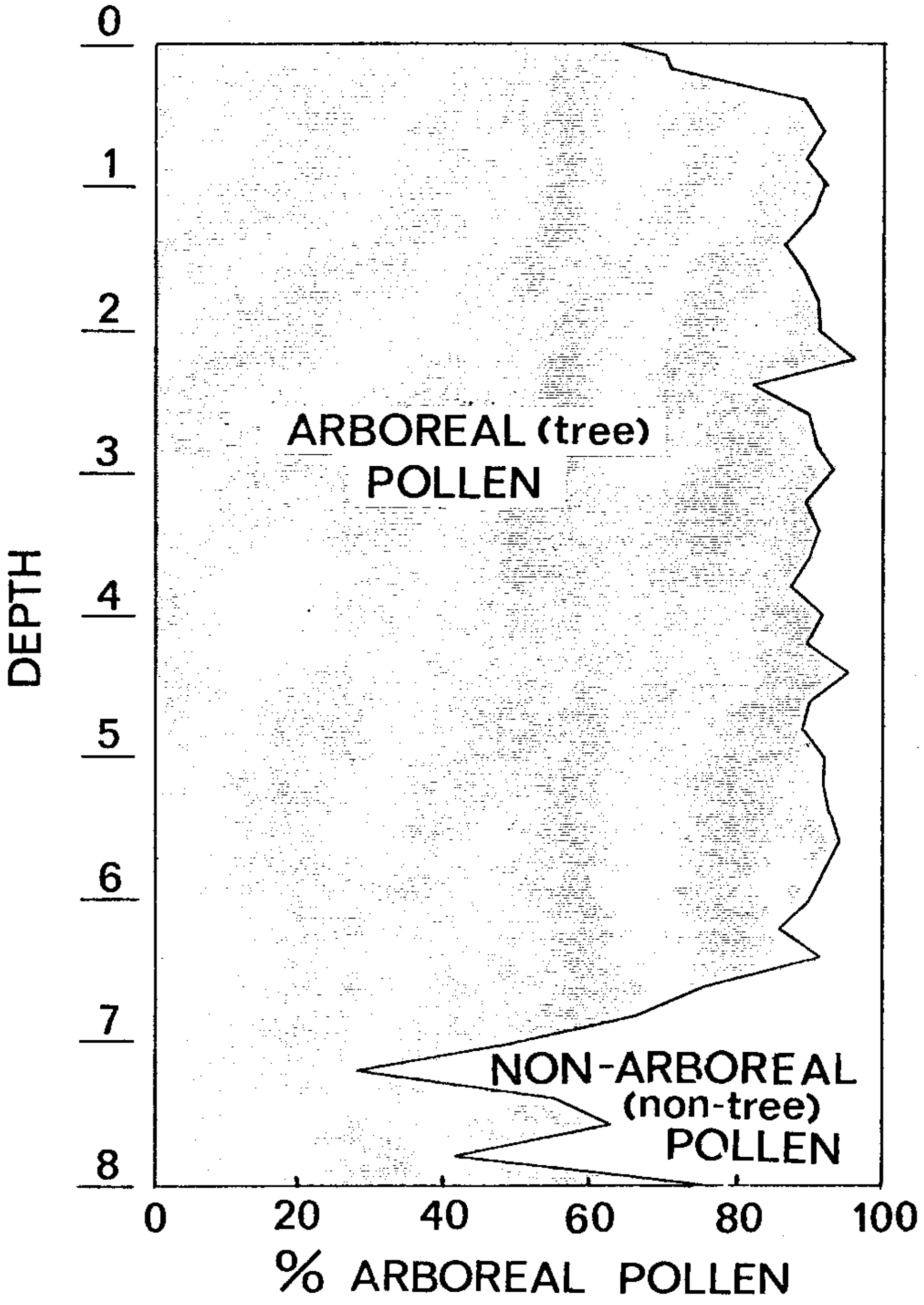
Several of the classifications of non-arboreal pollen may include pollen from a number of sources. *Nemopanthus* pollen cannot be distinguished from *Ilex*. Similarly any pollen derived from the Empetraceae would have been classified with the Ericaceae. The category "*Cornus* and *Aralia*" may include pollen of a number of species with similar-sized, tricolporate pollen. *Sparganium*, *Juniperus*, and *Populus* may have been classified with *Potamageton*. All trilete spores, with the exception of *Lycopodium* were included in the category "*Sphagnum* and Trilete Ferns". Although most of these spores are attributable to *Sphagnum*, several spores from *Selaginella* at the 6.8 and 7.0 metre levels, and *Osmunda* at 5.0, 5.4, 5.8, 6.2 and 6.4 metres, could be recognized, but had been included within this classification. No attempt was made to separate *Ranunculus* pollen from that of *Quercus*.

The data may be correlated with both Mott's (1975) diagrams for south-western New Brunswick and Livingstone's (1968) diagrams for the Folly Bog and other Nova Scotian post-glacial deposits. Based on pollen assemblages, Livingstone (1968) distinguished four major pollen zones. The 'L' zone, characterized by high sedge and willow, lay at or near the base of each of his profiles. This was succeeded first by the 'A' zone or "spruce and fir tree pollen assemblage", and then by the 'B' zone or "pine with spruce and fir tree pollen assemblage". All sediments overlying the 'B' zone belonged to the 'C' zone or "mixed temperate hardwood and hemlock tree pollen assemblage". This lettering system originated with Deevey (1939). To facilitate comparison, it is useful to apply the same designations as Deevey (1939, 1951) and Livingstone (1968).

In common with other diagrams, non-arboreal pollen was particularly abundant below 6.7 metres (Fig. 5). This fits with Livingstone's (1968) description of the 'L' zone, characterized by high _Salix_ and Cyperaceae. Other non-arboreal pollen (Fig. 6)*, including _Alnus_, Ericaceae, Gramineae, Compositae, _Sphagnum_, and pteridophytes were all strongly represented. In addition many of the _Betula_ grains (Fig. 7) were small (≤20 µm) suggesting that these were

*Figure included in envelope on back cover.

Figure 5. Distribution of arboreal and non-arboreal pollen in Wood's Pond's sediments.



0
1
2
3
4
5
6
7
8
DEPTH
ARBOREAL (tree)
POLLEN
NON-ARBOREAL
(non-tree)
POLLEN
0
20
40
60
80
100
% ARBOREAL POLLEN

Figure 7. Distribution of large (>20um) and small (≤20um) *Betula* pollen grains in the lowermost sediments (below 5 metres).

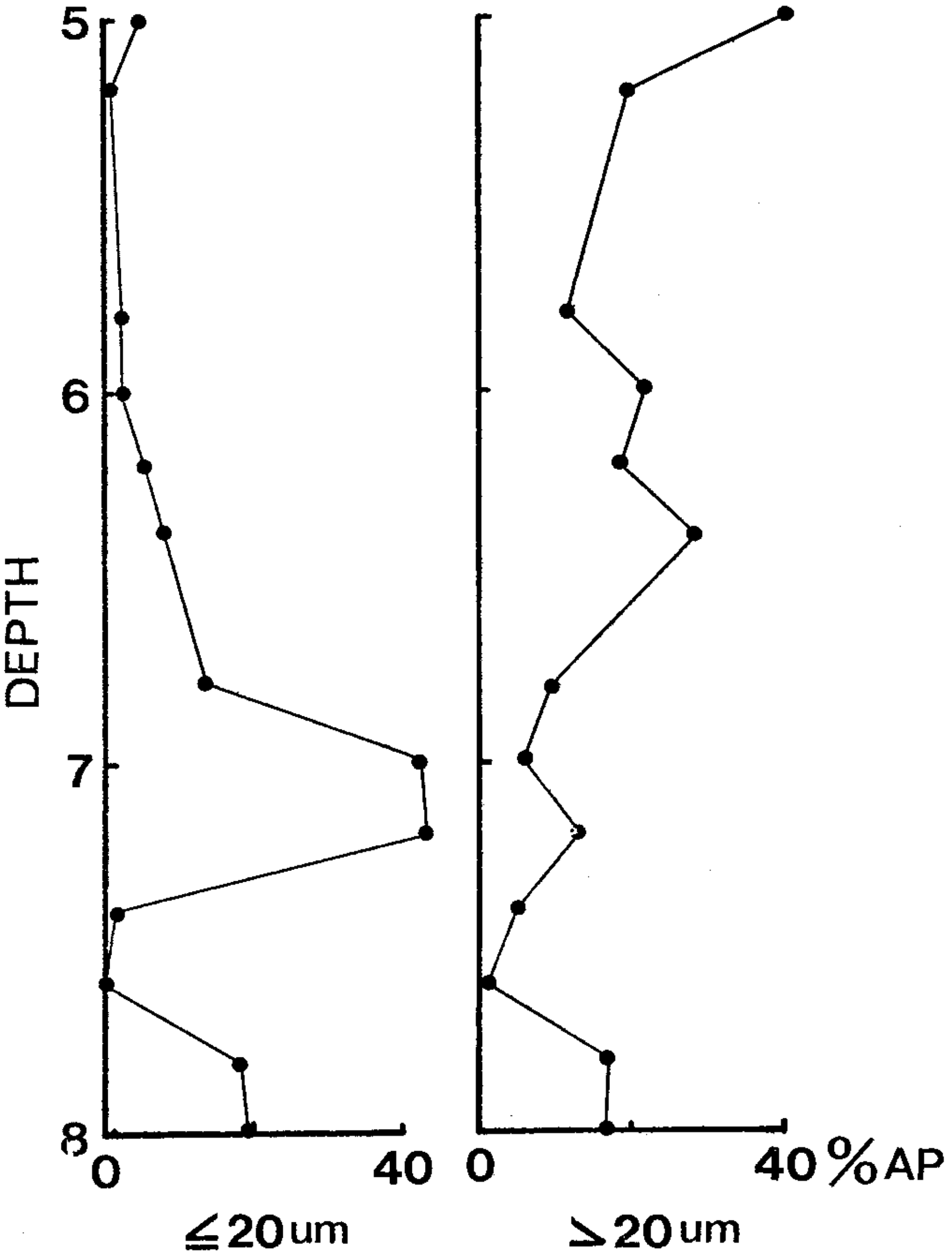
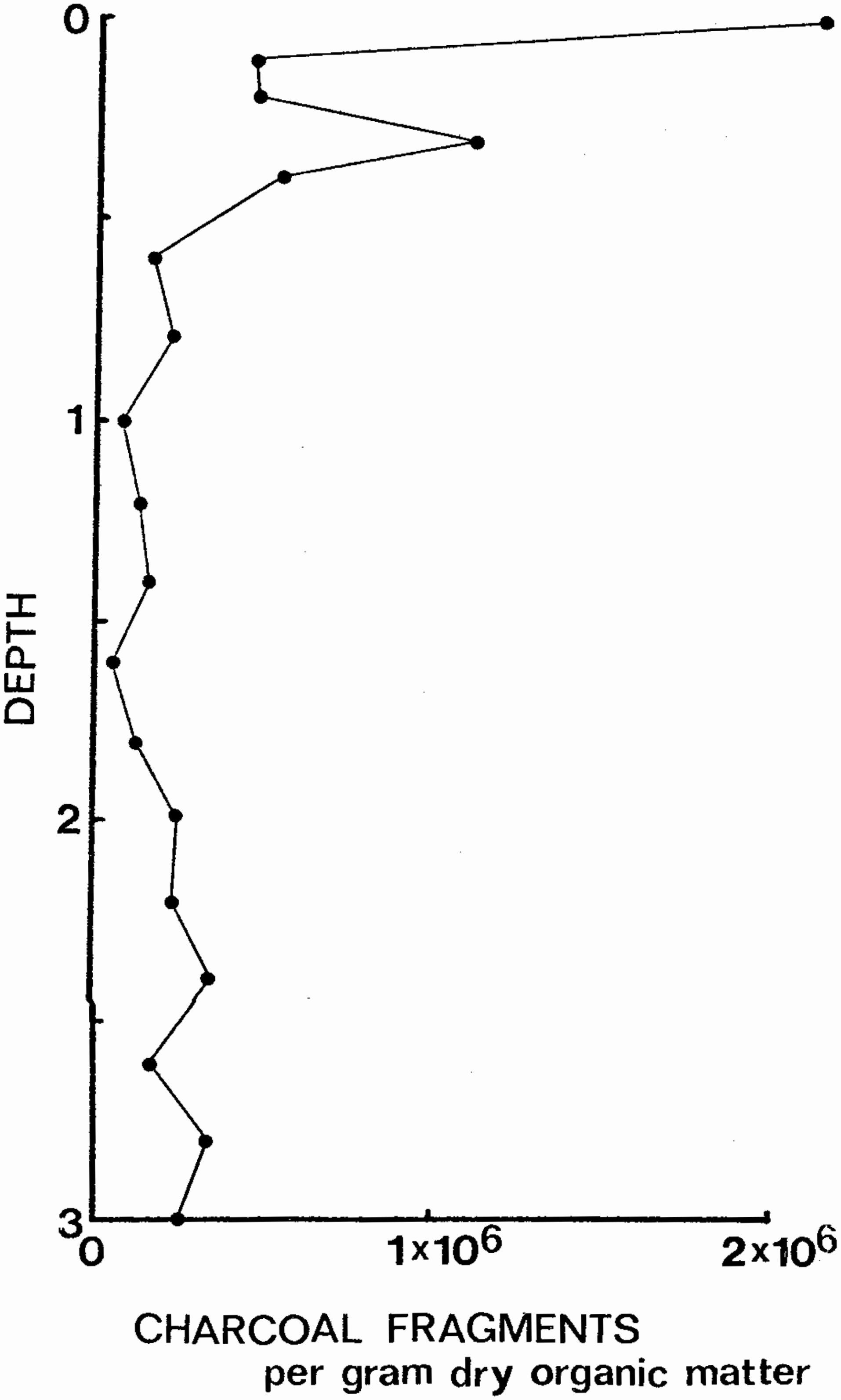

5
6
7
8
DEPTH
0
40
0
40 % AP
≦20 um
≥20 um

Figure 8. Distribution of charcoal fragments in the sediments above 3.0 metres.


0
1
2
3
DEPTH
0
1x10^6
2x10^6
CHARCOAL FRAGMENTS
per gram dry organic matter

derived from dwarf birch (Betula nana) which is a shrubby arctic species. Many of the pollen in this portion of the core were not identified but were probably derived from non-arboreal sources. Non-arboreal pollen has two peaks at 7.2 and 7.8 metres.

Above 6.8 metres (Fig. 5) non-arboreal pollen is much less strongly represented and usually formed only about 10 % as compared to the arboreal pollen. The 'L' zone is replaced first by an 'A' zone extending from 6.6 to about 6.2 metres, and then by a 'B' zone between 6.2 and 5.0 metres. Spruce and birch pollen are particularly abundant within the 'A' zone, whereas Livingstone (1968) describes the 'B' zone as a "pine with spruce and fir tree pollen assemblage". Pinus predominates throughout the 'B' zone while Abies and Larix form lesser components. The relative contribution by Quercus doubled over this interval.

At approximately 5.0 metres, Pinus, Abies, and Larix decline. Livingstone's (1968) 'C' zone, the "mixed temperate hardwood and hemlock tree pollen assemblage", would include all the sediments above 5.0 metres. An abrupt rise in Tsuga occurs at 4.4 metres. As was his practice, it is useful to define three divisions within the 'C' zone bounded by the hemlock rise at 4.4 metres and subsequent decline at 2.8 metres.

Using these divisions, the 'C-1' subzone, characterized by peaks in Acer and Quercus, lies between 5.0 and 4.4 metres. The Tsuga dominated period, 4.4 to 2.8 metres, becomes the 'C-2' sub-zone. The remainder of the diagram becomes the 'C-3' sub-division.

At 2.8 metres Tsuga was replaced by Betula as the major pollen contributor. Picea and Abies began to be more heavily represented. A decline in Quercus was accompanied by a corresponding increase in Fagus at 2.0 metres. Cyperaceae also declined at this level. Nuphar increased while Nymphaea showed the opposite trend. Sphagnum and Ericaceae also appear to increase.

Between 0.6 and 0.4 metres, representation by Picea doubled. Charcoal fragments (Fig. 8) show a similar increase. In the uppermost sediments (Fig. 5) non-arboreal pollen were more strongly represented. Alnus, Cyperaceae, and Gramineae (Fig. 6)* were all present as significantly higher proportions.

Livingstone's (1968) diagrams, in general, do not include the recent, settlement related increases in non-arboreal pollen. This human influence, readily apparent at Wood's Pond is characterized by the increased alder and grasses above 0.4 metres. This should probably be defined as another division.

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*Figure included in envelope on back cover.

High non-arboreal pollen as well as the presence of pollen from several species typical of arctic or sub-arctic vegetation* in the 'L' zone suggests that a cold-steppe or tundra-like vegetation existed in this region, following the last glaciation. This interpretation is supported by spores of _Lycopodium selago_ and _Selaginella_ and by high counts for Cyperaceae, _Salix_, and Ericaceae. The presence of dwarf birch (_Betula nana_) provides further evidence. Radiocarbon dates from other diagrams (Livingstone, 1968; Mott, 1975) place this period between ten and twelve thousand years B.P. An intriguing feature in this zone is the paired lowermost peaks for many non-arboreal pollen species. This may represent a period similar to the Two Creeks Interval described by Schweger (1969) and other authors for deposits in Michigan and Wisconsin. If so, the peak of non-arboreal pollen at 7.2 metres may indicate a partial readvance of the glaciers resulting from a

*A few anomalous grains of _Tsuga_, _Betula_ (>25 µm), and _Quercus_ may have been redeposited from glacial till or blown from a great distance. These appear at 8.0 metres in the diagram.

climatic oscillation (Schweger; 1969). This, however, has not in general been noted for diagrams in the Maritimes, (Livingstone, 1968). Low non-arboreal pollen production above 6.6 metres signals forest development.

Within the 'A' zone Picea and Betula decline leading to the post-glacial pine period or 'B' zone. This post-glacial pine period has been the subject of much controversy, especially considering the over-representation of the genus as a result of its high pollen production. Dansereau (1953) discussed this problem in detail. Although his paper raises more questions than it answers, it seems reasonable to assume that the shift from dominance by Betula and Picea to Pinus is attributable to a progressive warming trend following glaciation. This warming trend could ultimately explain the subsequent appearance of Acer, Quercus, and associated hardwood genera in the region.

The C-1 zone with the Quercus peak is comparable to that described by Livingstone (1968). A feature common to each of the diagrams prepared by Livingstone (1968) and Mott (1975) is the Tsuga maximum or 'C-2' zone. Their data suggest that Tsuga increased rapidly after 6,700 B.P., reached a maximum, and declined abruptly before 4,700 B.P.

The decline in Tsuga was accompanied by increased Betula and marks the beginning of a return by Abies and Picea in the 'C-3' zone. At 2.2 metres, Quercus declined as Fagus first appeared as an important forest tree. Interestingly, Nuphar appeared to replace Nymphaea at the same level. Cyperaceae declined, while Sphagnum and Ericaceae were increasing. These changes over the interval 2.6 to 2.2 metres appear to parallel a decreased influx of inorganic material and/or an increased organic loading to the sediments. Carbon-nitrogen data (see appendix) show a similar discontinuity. This suggests a rather important change both in the character of the lake, and the surrounding forests. Perhaps a shift towards dystrophy and/or the complete encircling of the lake by a Sphagnum bog occurred over this interval. This may have accompanied a cooling trend in the region's climate as indicated by the return of Picea and Abies, the Quercus decline, and Fagus increase. The interpretation of these changes is controversial, however, with the evolution of soil and the migration of new species into the region possibly complicating this simplistic view.

The *Picea* increase accelerates above 0.6 metres and is coupled with an increase in charcoal fragments in the sediments. These may be the earliest indicators of the arrival of European man. Forest clearance is indicated by increased non-arboreal pollen production in the uppermost sediments. The Sackville vicinity was one of the earliest localities in New Brunswick to be settled. The Acadians arrived in the region about 300 years ago.

Chironomid Fauna

Representatives of the Chironominae, Orthocladinae, and Tanypodinae (Table 2) were identified from the sediments. Difficulties with identification required that several genera could not be consistently separated. These were grouped together into broader classifications.

This applies to several genera of the Orthocladinae and Tanypodinae, which have been referred to as "other Orthocladinae" and "other Tanypodinae" for the purposes of this investigation. *Tanytarsus* was once considered to be a very broadly defined taxon, but has recently been subdivided into a number of more narrowly defined genera, most of which are extremely difficult or impossible to

Table 2. Number of chironomids identified at each interval.

DEPTH
(cm.)

	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800
Tanytarsus	5	3	4	13	15	7	18	10	15	7	2	9	22	10	7	9	12	8	5	4	11	11	14	16	10	7	8	13	13	10	5	5	12	16	9	7	6	11		7	31
Constempellina				1									1					1							3		2		1		1		1							2	1
total Tanytarsini	5	3	4	14	15	7	18	10	15	7	2	9	23	10	7	9	12	9	5	4	11	11	14	16	13	7	10	13	14	10	6	5	13	16	9	7	6	11	0	9	32
Chironomus	14	12	15	3	3	3	2		3	6	13	5	6		2	2	6	3		3	5	4	1	4	1	1	2	1		2	5	4		3	2	1	2			2	2
Dicrotendipes	1	2		2	1		5		1	2	1	2		3	2	3	2	2	4	2	3	1	1	1	9	1	3	2	2		1	4	1	1		1					1
Glyptotendipes								4	4		4	3		1	1				1									1				1	1				1				
Kiefferulus							1																								1			1							
Cryptochironomus					1	2	1	2				1										2	1								1										1
Harnischia	6	1	4	8	7	6	3	4	4	2	1	4	3	4	2		2		1	3	1	1	2		1	1					1	1	1		4	4	4				7
Pseudochironomus												1					3			1	1				1																
Xenochironomus																													1	1	1										
Pagastiella					1	2	1	2							1	1			1			1			1								2								
Paracladopelma																																					1	5		4	1
Polypedilum	2	3		2			1			5		1	4	4	2	5	3	3	4	7	3	2	4	1	3	3		3	6	4	2	2	4	1			11			4	6
Phaenopsectra								1			3				1						1										2			1	8	6	1				
Tribelos																															1			1						1	3
Endochironomus																	3																							1	
Paratendipes																				2																					1
Stictochironomus																													1												
Lauterborniella											1		1		1				2				1				1	3	9	2	1	3									
Microtendipes											2		3	2	1	3	4	1	2		1			3		2	2			1						4					1
total Chironomini	23	18	19	15	13	13	14	13	12	15	25	17	17	14	13	14	23	9	15	18	15	14	10	9	15	8	9	10	19	10	15	15	7	7	14	16	20	5	0	12	24
Thienemanniella																											1	1	1	2		1		1							
Brillia							1									1	1	1								1					1										
Psectrocladius sp(I)	3	4	3		2	3	1							1	1		3		1			1			1	3	2	1				2									
Psectrocladius sp(II)								3	9	4			2						1																						1
Psectrocladius sp(III)						1		1	1													1	1																		
other Orthocladiinae	2	4	2		2	2	1	2		2	1	2		4	2	4	2	6	3	6	2	4	1	1	6	4	2	3	2		1	1	1	3	6	3	2	19		9	13
total orthocladinae	5	8	5	0	4	6	3	6	10	6	1	2	2	5	3	5	6	7	5	6	2	6	2	1	7	8	5	5	3	2	2	4	1	4	6	3	2	19	0	9	14
Procladius	1		5		2	2	1		4	2	2	1	4	1	3	1	4	3	5	1	1		4	1	4	4	4	2	9	6	3	2			1	2	2			2	3
Labrundinia												1																	1												
other Tanypodinae	1	1	1	1	2	2									4	1	3	2		1	1	2		3	4	3	3		1	3	4	4	9	3		2				1	1
total Tanypodinae	2	1	6	1	4	4	1	0	4	2	2	2	4	1	7	2	7	5	5	2	2	2	4	4	8	7	7	2	11	9	7	6	9	3	1	4	2	0	0	3	4
Total	35	30	34	36	30	36	30	41	30	30	30	46	30	30	30	48	48	30	30	30	30	30	30	30	43	30	30	30	47	30	30	30	30	30	30	30	30	35	0	33	74

separate on the basis of their preserved head capsules. For the purposes of this investigation, only the genus Constempellina has been recognized within the Tanytarsini. All other Tanytarsini have been lumped together as Tanytarsus s. lat..

Several species of Psectrocladius (Fig. 9) are very distinctive. Psectrocladius sp(I) is distinguished by a single, broad, peaked, unpigmented median tooth on its hypostomial plate. Psectrocladius sp(II) has two distinctly triangular, unpigmented first laterals separated by a much smaller median tooth. A third species, Psectrocladius sp(III) is similar but lacks this median tooth.

In the inorganic sediments*, Tanytarsus and Orthocladinae predominate (Fig. 10)# with lesser numbers of Paracladopelma, Polypedilum, Phaenopsectra, and Harnischia. Most of the early peak in the Orthocladinae at 7.4 metres is attributable to Heterotrissocladius. This genus was not found in the upper sediments.

Although Tanytarsus continues to dominate above 6.8 metres, numerous other genera appear, including Lauterborniella, Thienemanniella, Glyptotendipes and Pagastiella. Although large fluctuations are apparent for

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*No chironomid remnants were recovered from the 7.6 metre level.

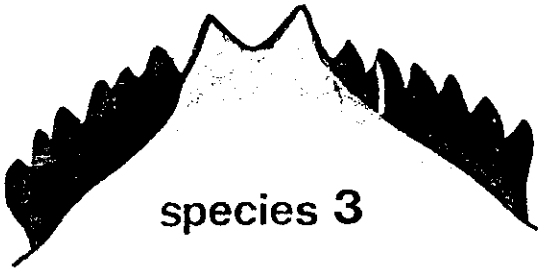
#Figure enclosed in envelope on back cover.

Figure 9. Comparison of the hypostomial plates of three species of <u>Psectrocladius</u>.

Psectrocladius

species 1

species 2



species 3

several genera, at least some of this variation is attributable to error resulting from the relatively small sample size (≥30) employed.

At 2.0 metres *Tanytarsus* is temporarily replaced by *Chironomus* as the dominant. Beginning at this level many genera begin to disappear from the sediments. Although *Tanytarsus* returns to dominance over the interval 1.8 to 0.6 metres, *Chironomus* at 0.4 metres appears to become firmly established as the dominant chironomid.

The predominance of *Tanytarsus* and *Heterotrissocladius* in the lowermost sediments suggests that Wood's Pond began as an oligotrophic lake following the last glaciation. Although *Tanytarsus* remained high throughout much of the subsequent history, *Heterotrissocladius* was replaced by a number of other chironomid genera. These genera, including *Microtendipes*, *Lauterborniella*, *Phaenopsectra* (formerly *Sergentia*) and others, may be more characteristic of mesotrophic or near mesotrophic environments (Moore, 1979; Oliver, 1971). The *Chironomus* peak at 2.0 metres, and the apparent decline in generic diversity suggests a rather important change in the lake above this level. Interestingly this event corresponds roughly to the decreased percentage of inorganic materials in the sediments, and the Nymphaea to Nuphar shift in the pollen diagram. This again raises the possibility of a shift towards dystrophy at this level.

The increased representation of Psectrocladius above this level may be related to the Nuphar increase. Ramcharan and Paterson (1978) demonstrated a relationship between Nuphar and certain species of Psectrocladius in Wood's Pond.

The single most dramatic change in the chironomid fauna, a Tanytarsus to Chironomus shift occurs with forest clearance following the arrival of European man. If Stahl's (1969) interpretation on the basis of oxygen availability is correct, this could indicate a significantly reduced oxygen supply.

Diatom Analyses

The diatom data are incomplete, but several observations are worthy of note. Diatoms, scarce in the lowermost sediments, are especially abundant above 6.7 metres. The only centrales diatom present, Cyclotella occurred between

6.6 and 5.2 metres as a regular component. Near the surface, Tabellaria replaces Pinnularia as the most abundant species. This transition, at about 0.5 metres correlates with the recent changes in the chironomid fauna and pollen rain.

Although the diatoms require further investigation, some interpretation may be possible. Cyclotella, which occurs as a regular component between 6.6 and 5.2 metres, may be an indicator of oligotrophic conditions (Stockner, 1972). Furthermore, the Pinnularia to Tabellaria transition occurs at about the time of settlement. This shift again poses the possibility that man may have influenced recent developments within that water body.

How man may have influenced these developments is open to speculation, but the argument exists that man may have accelerated the return of Picea through increased forest fires. Huttunen et al (1978) have implicated both man and the Picea increase with accelerated dystrophication. As they suggest, the Picea increase probably accompanied a shift from well-oxidized, alkaline soils to acidic, poorly-oxidized soil, and an increased migration of organic acids into the lake.

SUMMARY

In summary, these analyses suggest that Wood's Pond, originally an oligotrophic lake, had been surrounded by an open, tundra-like, or sub-arctic vegetation. As forests developed within this region, the influx of inorganic materials to the sediments decreased and/or the organic imputs increased. The increased organic loading of the sediments probably influenced the lake such that oxygen availability near the substrate gradually declined. This is supported by the appearance of chironomids typical of mesotrophic environments.

A progressive warming trend following glaciation resulted in a progressive shift from a spruce and birch dominated woodland to a pine and fir forest. Eventually hardwoods appeared as important components within the forest.

Following the hardwood maximum at 4.6 metres, Tsuga became an important forest tree. Tsuga may have dominated these forests for up to 2000 years following the hardwood maximum.

Following *Tsuga*'s decline, conditions permitted *Picea* and Abies to increase. The decline in *Quercus* appears to be coupled with increased *Fagus*. Over the same interval a *Nymphaea* to *Nuphar* shift occurs within the pond. Although Cyperaceae decline , *Sphagnum* and Ericaceae increase.

These changes may indicate an important transition. The increased organic component of the sediments, and a similar discontinuity in the carbon-nitrogen data (appendix) might be interpreted as a shift towards dystrophy and/or the complete encircling of the pond by *Sphagnum*. Further investigation will be necessary if these changes are to be adequately explained. The proposed explanations are still highly speculative.

Beginning at 0.4 metres, the effects of settlement become apparent. *Picea* representation doubles presumably as a result of man-caused forest fires. A *Tanytarsus* to *Chironomus* and a *Pinnularia* to *Tabellaria* shift, documented for the chironomids and diatoms respectively, occurs at the same level. Human alterations appear to have recently influenced the vegetation of the watershed. Perhaps, this alteration or others indirectly influenced the pond's recent history. At 0.3 metres forest clearance is indicated by increased non-arboreal pollen production.

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APPENDIX

Carbon-Nitrogen ratios are widely used in central Europe to characterize humus conditions (Harries, personal communication). Although not a common practice in paleolimnology, this ratio has been employed as an indicator of past lake conditions (Huttenen et al, 1978). Data received (Fig. 4c and 4d)* after the writing of this thesis show an increase in the C/N ratio over the lake's development. Three explanations for this increase are possible. Decreased decomposition, increased influx of allochthonous organic matter to the sediments, and/or a deceased nitrogen content of material incorporated into the sediments could be responsible. Each of these explanations is consistent with a shift towards dystrophy. The C/N ratio increases abruptly within the interval 2.4 to 1.4 metres, parallel to other observed changes as discussed in this paper.

*Figure included in envelope on back cover.

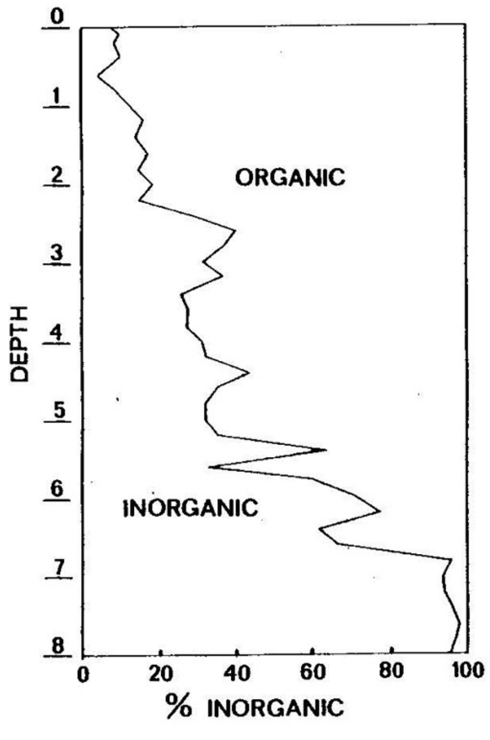
Figure 4. Sediment composition

Figure 6. Wood's Pond pollen diagram

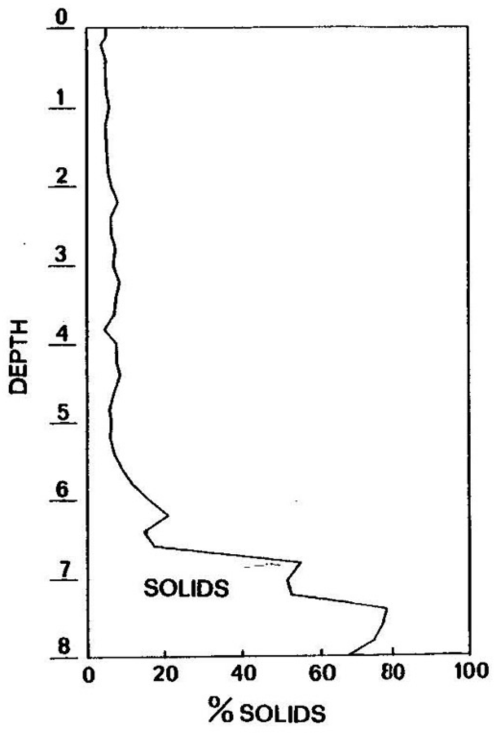
Figure 10. Wood's Pond Chironomid diagram

Figure 4.

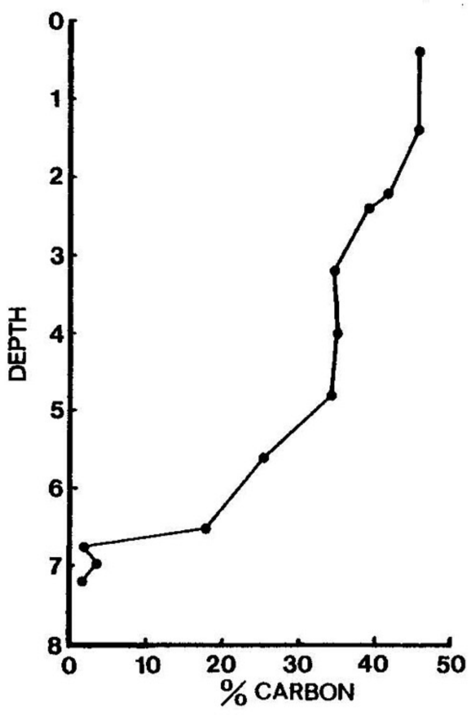
Sediment composition



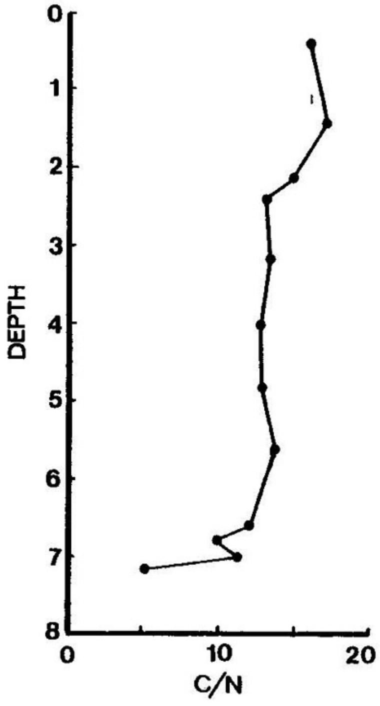
a. Composition of dry sediment by loss on ignition



b. Composition of wet sediment



c. Carbon content of dry sediment



d. Ratio of carbon to nitrogen

Figure 6.

Wood's Pond pollen diagram

WOOD'S POND PERCENTAGE POLLEN DIAGRAM

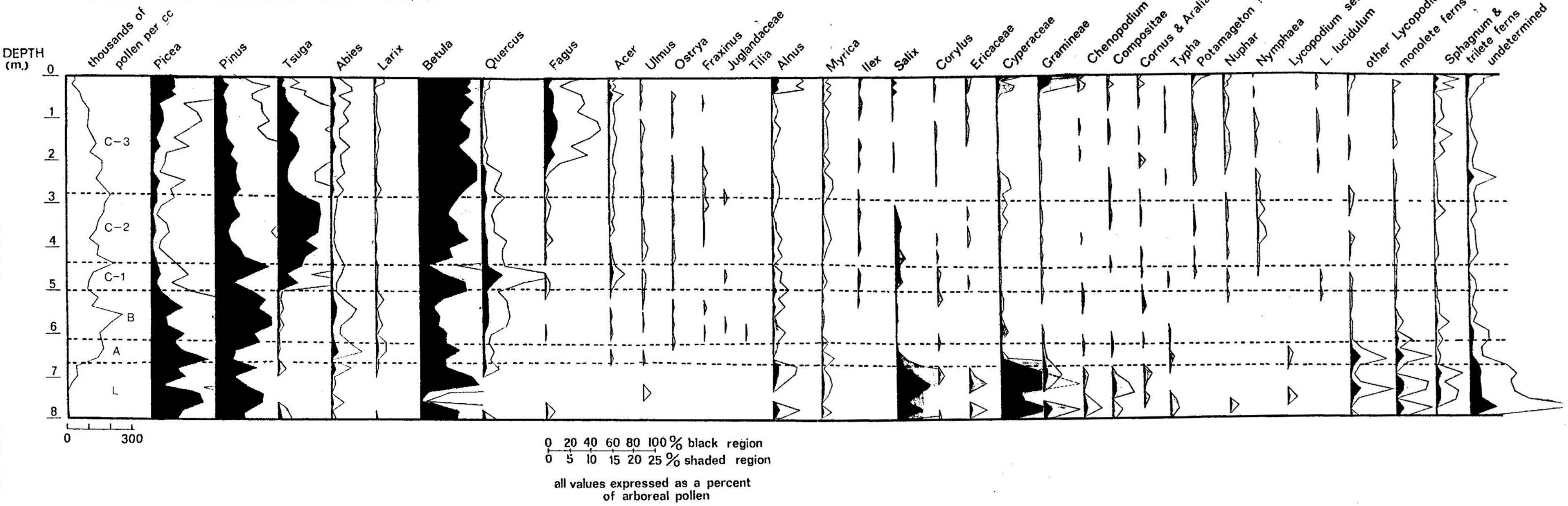


Figure 10.

Wood's Pond chironomid diagram

WOOD'S POND PERCENTAGE CHRONOMID DIAGRAM