

LATE QUATERNARY VEGETATION HISTORY OF RICE LAKE, ONTARIO,
AND THE McINTYRE ARCHAEOLOGICAL SITE

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INTRODUCTION

Rice Lake (Fig. 1) has been an important focus for prehistoric human habitation because of its location on the Trent Waterway between Georgian Bay and Lake Ontario and also because it supported until recently large stands of wild rice (*Zizania*) (Boyle 1897; Dore 1969). Prominent archaeological sites include the Woodland period Serpent Mounds (Johnston 1968a, 1968b) and the Late Archaic McIntyre site (Johnston 1976).

Wild rice, *Zizania*, is the only ^{wild} cereal grass that grows in Canada. In Ontario Dore and McNeil (1980) recognize two closely related species, *Z. aquatica* and *Z. palustris*, each with two varieties. They regard specimens from north of 46° latitude as owing to human introduction, although stands in the Kenora area may be ancient.

Wild rice ranges widely but its main abundance and thus prehistoric interest was from southern Ontario westward across northern Michigan, northern Wisconsin and northeastern Minnesota into northwestern Ontario and adjacent Manitoba. It thrives best on an organic mud substrate and to a lesser extent on a silty bottom. Best growth is in waters that are calcareous. The best stands in Ontario are south of the Shield where Palaeozoic bedrock and derived glacial drift supply calcium carbonate to the water. An exception is the Shield area of northwestern Ontario and Manitoba where deposits of proglacial Lake Agassiz supply calcium carbonate.

The fossil record of wild rice is sparse although as an aquatic it grows on sites where pollen, seeds and leaves are commonly preserved. The earliest postglacial record of wild rice is the 10,000 year old macrofossils at Wolf Creek Bog in east-central Minnesota (Birds 1976). The most detailed fossil study is from Rice Lake in northwestern Minnesota where McAndrews (1969) showed by both pollen and fruit fragments that it invaded the lake about 2,000 years ago with a shift toward cooler and moister climate that led to decreased evaporation, enhanced flushing of the lake and reduced sulfate content of the water. In Bog D Pond, a similar lake in nearby Itasca Park, the presence of wild rice was inferred between 2,000 and 1,000 years ago from fossil pollen (McAndrews 1966). Bog D Pond no longer supports wild rice, probably because an encroaching bog has come to inhibit water movement and the water has become stagnant.

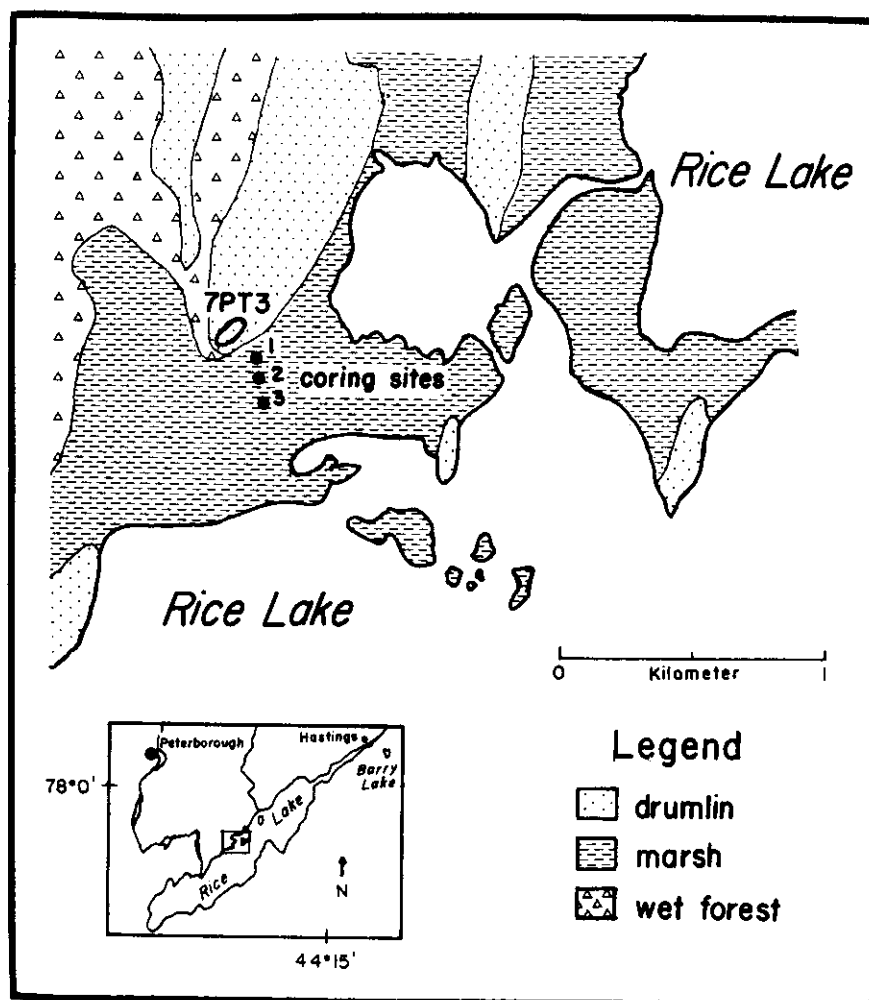


Fig. 1. Location of Rice Lake and McIntyre site. The lake core site is near East Sugar Island, about 4 km northeast of the marsh area.

Wild rice is today, and was in the past, abundant in bays along the north shore of Lake Ontario and Lake Erie. A pollen diagram from Red Head Pond at Point Pelee of Lake Erie shows abundant grass pollen that could be from wild rice from 5,000 to 4,000 years ago and from 1,500 years ago to the present (Keenlyside 1978). In contrast, pollen analysis of several kettle lakes in southern Ontario (McAndrews 1980) has yielded no indication of wild rice, probably because wild rice has been excluded owing to the dearth of flushing in these lakes.

Considering its historic importance (Jenks 1901) and presumed importance in the prehistoric economy (Gibbon and Caine 1980), wild rice is very poorly represented by archaeobotanical fossils. At only two sites, both in Minnesota, are charred grains reported in association with lakes that today support wild rice (Johnson 1969; Gibbon 1976). Charred grains are also reported at rock shelters in Ohio (Goslin 1952) and Wisconsin (Tiffany 1974), and a burial in Michigan (Ford and Brose 1975).

My purpose is to summarize the geological and vegetational history of Rice Lake and the surrounding uplands. The principle method is the study of four sediment cores for their lithology, radiocarbon age, and fossil pollen, seeds and leaves. I will show that the Late Archaic people that inhabited the McIntyre site lived adjacent to a lake that probably supported wild rice.

Rice Lake is situated in the Peterborough drumlin field, a rolling till plain (Chapman and Putnam 1973). Upon deglaciation about 12,000 years ago part of the basin of Rice Lake became a bay of proglacial Lake Iroquois (Gadd 1980). About 11,800 years ago Lake Iroquois drained when the St. Lawrence Valley became ice free and the water level in the Ontario basin dropped to the low level Admiralty Phase (Prest 1970).

The modern level of Rice Lake is maintained at 613 feet (187 m) by a dam at Hastings, an increase of 6 feet (2 m) above the bedrock sill. Since Lake Iroquois time the sill has been differentially elevated by isostatic rebound. Projection of the Lake Iroquois water plan in the Ontario basin (Gravenor 1957) northward into the Rice Lake basin indicates an elevation of 650 feet (198 m) at Hastings and 576 feet (176 m) at Bewdley in the southwestern end of the basin. Thus the differential upwarp is about 80 feet (24 m) indicating that Lake Iroquois did not fill the basin to cover the area occupied by modern Rice Lake and that the southeastern part of the basin has been subject to as much as 30 feet (9 m) of flooding. The Lake Iroquois level adjacent to the McIntyre site is projected to be 14 feet (4 m) below modern lake level and thus the water level has risen some 2 m in prehistoric time.

The drumlins around the McIntyre site, except where cleared for agriculture, are dominated today by a mixed conifer-hardwood forest that includes the conifers *Pinus strobus* (white pine), *Tsuga canadensis* (hemlock) and *Thuja occidentalis* (white cedar) and the hardwoods *Acer saccharum* (sugar maple), *Fagus grandifolia* (beech), *Quercus rubra* (red oak), *Q. alba* (white oak), *Fraxinus americana* (white ash), *Prunus serotina* (black cherry), *Ulmus americana* (white elm), *Juglans cinerea* (butternut), *Ostrya virginia* (ironwood), *Carpinus caroliniana* (hop

hornbeam), *Carya cordiformis* (bitternut hickory), *Betula papyrifera* (white birch) and *B. lutea* (yellow birch). Swamp forest is dominated by *Ulmus*, *Fraxinus* and *Acer saccharinum* (soft maple).

About 500 m of marsh separates the McIntyre site from Rice Lake (Figs. 1 and 2). The marsh is dominated either by *Typha* (cat-tail) or shrubs that include *Alnus rugosa* (alder), *Myrica gale* (sweet gale), *Cornus stolonifera* (red dogwood), *Salix spp.* (willows) and *Decodon verticellatus* (water willow). Prominent herbs are *Thelypteris palustris* (marsh fern), *Calamagrostis canadensis* (blue-joint grass), *Muhlenbergia glomerata* (Muhly grass), *Carex lacustris* (sedge), *Aster sp.* (aster), *Epilobium leptophyllum* (willow herb), *Chelone glabra* (turtlehead), *Asclepius incarnata* (swamp-milkseed), *Rumex sp.* (dock), *Cuscuta gronovii* (dodder) and *Potentilla palustris* (cinque-foil).

In 1973 and 1981 wild rice grew in the lake offshore from the marsh. Informants say that wild rice now occurs only locally, whereas Boyle (1897) writes of "hundreds of acres" - perhaps recent factors such as motor boats, dredging, water level stabilization, and carp have reduced its abundance.

The vegetation history of southern Ontario is known through a series of standard pollen diagrams (McAndrews 1980; Terasmae 1980). The nearest, and until now unpublished, diagram (Fig. 3) is from Barry Lake near Hastings (Fig. 1). It shows the standard four zones. Zone 1, the *Picea*-herb zone represents a spruce-dominated boreal woodland. Climatic warming, here dated at 9470 years BP, led to the boreal forest of zone 2; subzone 2a was dominated by jack pine (*Pinus banksiana*) and 2b by white pine (*P. strobus*). Zone 3 is subzoned on fluctuations in *Tsuga* and *Pinus*. Subzone 3a is defined by a *Tsuga* peak with a subsequent decline about 5000 years BP. Both *Tsuga* and *Pinus strobus* increase upward with a rise in *P. strobus* defining subzone 3d. Zone 4, beginning about 130 years BP is distinguished by the rise of *Ambrosia* (ragweed) and weedy Gramineae (grass) pollen that signals the beginning of modern European agriculture. Abundant Gramineae pollen attributable to wild rice is absent, probably because of insufficient flushing of the lake.

METHODS

Sediment coring was done with a Livingstone piston sampler (Wright 1967) having a diameter of either 37 mm or 52 mm. Five cores were studied. In January, 1973, a 510 cm long core was lifted from beneath 2 m of water near East Sugar Island (Fig. 1). The McIntyre site marsh was cored at three locations along a transect (Figs. 1 and 2). A preliminary core was lifted at location 2 in January, 1976, but

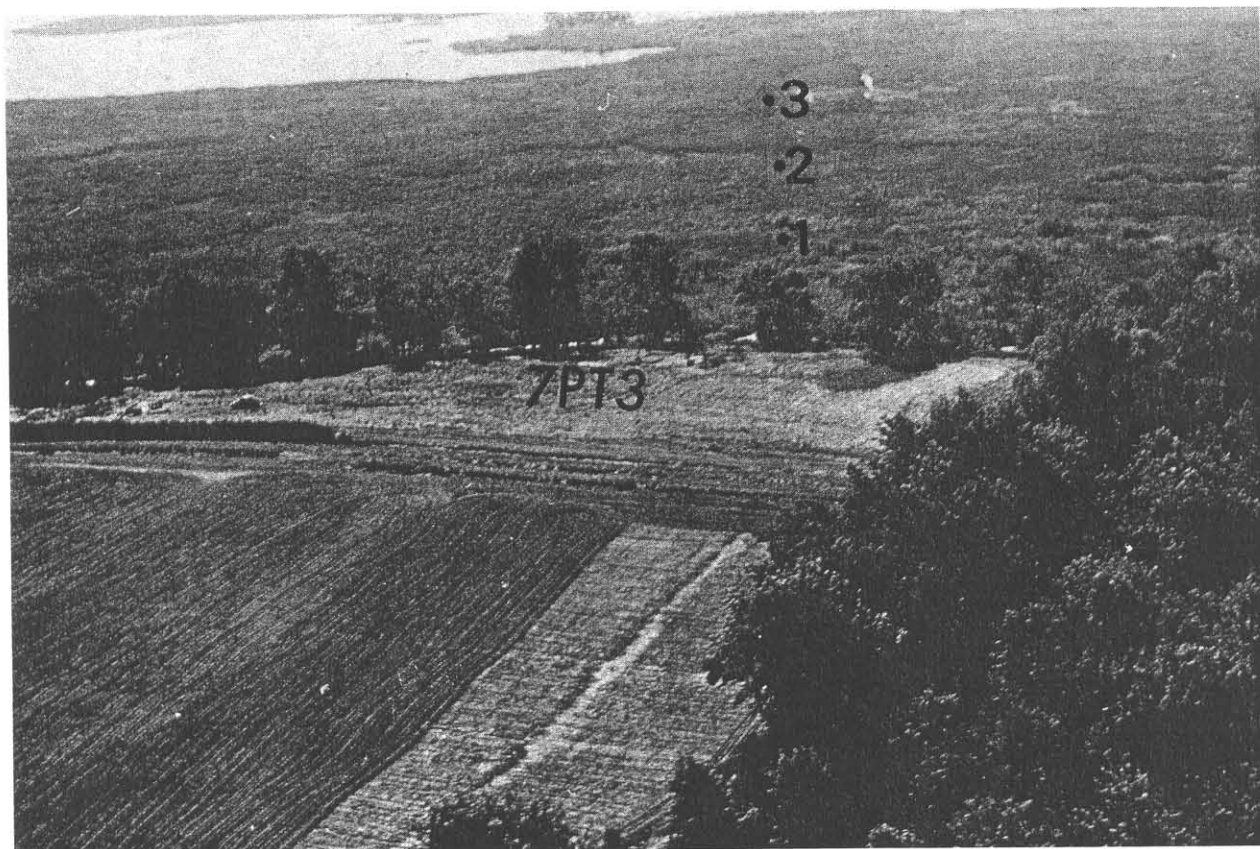


Fig. 2. Air photo of McIntyre site (7PT3) and marsh coring sites. Photo taken in 1975 by R. B. Johnston.

only the pollen analyses of the upper 130 cm are reported here. In March, 1977, locations 1, 2 and 3 were cored.

Thermal analysis (loss-on-ignition) to determine the percent organic C was done by the method of Dean (1974).

Pollen analysis samples of usually 0.9 ml volume were taken at regular intervals along the cores. A known number of exotic *Lycopodium* spores was added to each sample so that the number of pollen per ml could be calculated (Stockmarr 1971). Fossil pollen was concentrated by successive treatments with HCl, KOH, HF and acetolysis solution before staining with safranin and mounting in silicone oil (Faegri and Iversen 1975). Pollen and spores were identified by comparison with a modern reference collection assisted by the illustrated key in McAndrews et al. (1973). Pollen percentages were calculated based on an upland

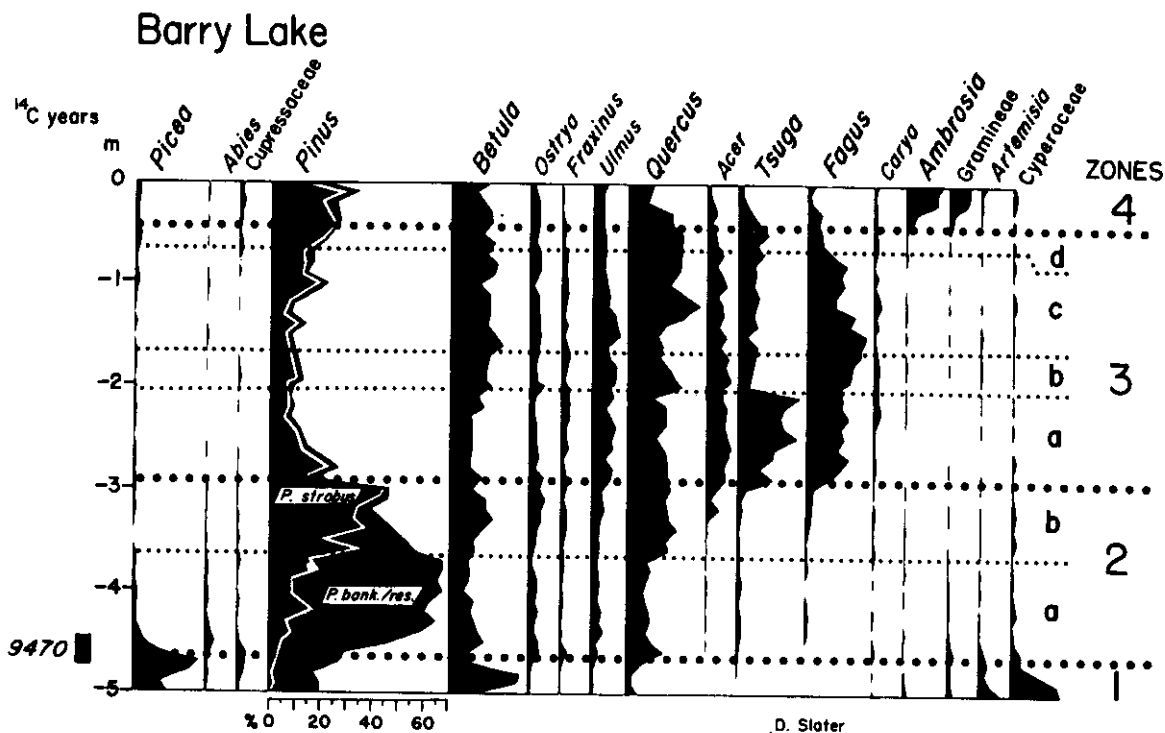


Fig. 3. Standard pollen diagram from Barry Lake. Minor taxa are not shown. Note virtual absence of Gramineae (grass) pollen except in Zones 1 and 4. The radiocarbon date of 9470 ± 210 (I-9501) is at 445-465 cm. Analysis by D. Slater.

sum; Gramineae, Cyperaceae and other pollen and spores probably derived from aquatic plants were calculated outside the sum. The sum was about 300 for the lake core and about 100 for the marsh cores.

Plant macrofossils were washed from core segments using a sieve with a hole size of 0.6 mm. Identifications were made by comparison with a modern seed collection aided by Montgomery (1977).

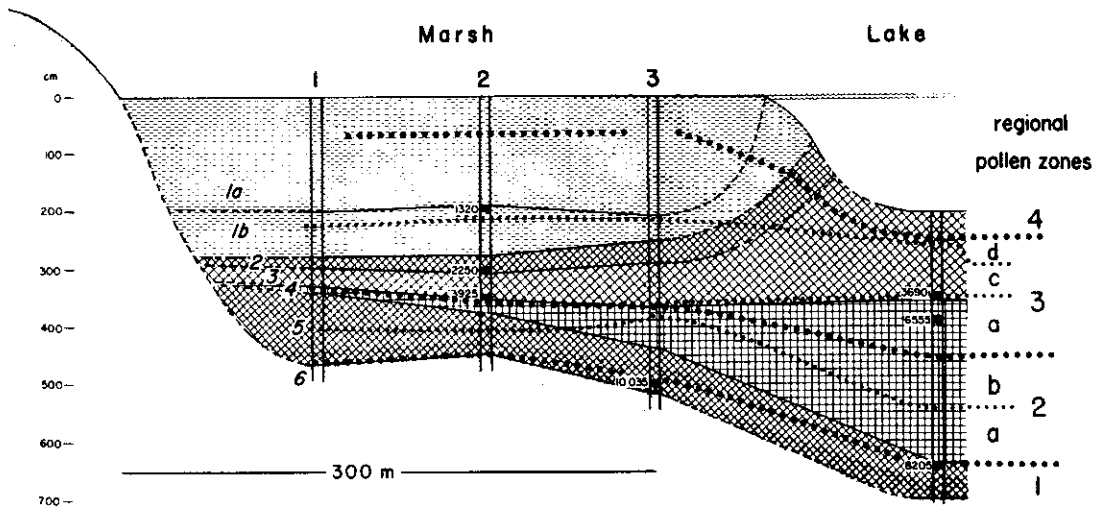


Fig. 4. Stratigraphy of Rice Lake and marsh. The radiocarbon dates are listed in Table 2. Unit 1 is peat, 2 is detritus mud, 3 is homogeneous mud, 4 is marl, 5 is detritus mud, and 6 is sand.

RESULTS

Six lithologic units are recognized (Figs. 4, 5 and Table 1).

Unit 6 is a water-deposited gray, unoxidized medium to coarse sand that underlies the lake and marsh. It was deposited by Lake Iroquois.

Unit 5 is a dark brown non-calcareous detritus mud that thickens toward the upland. In the lakeward part of this unit there is a lower facies rich in clastic silt. A dark gray organic sand layer occurs in the three marsh cores.

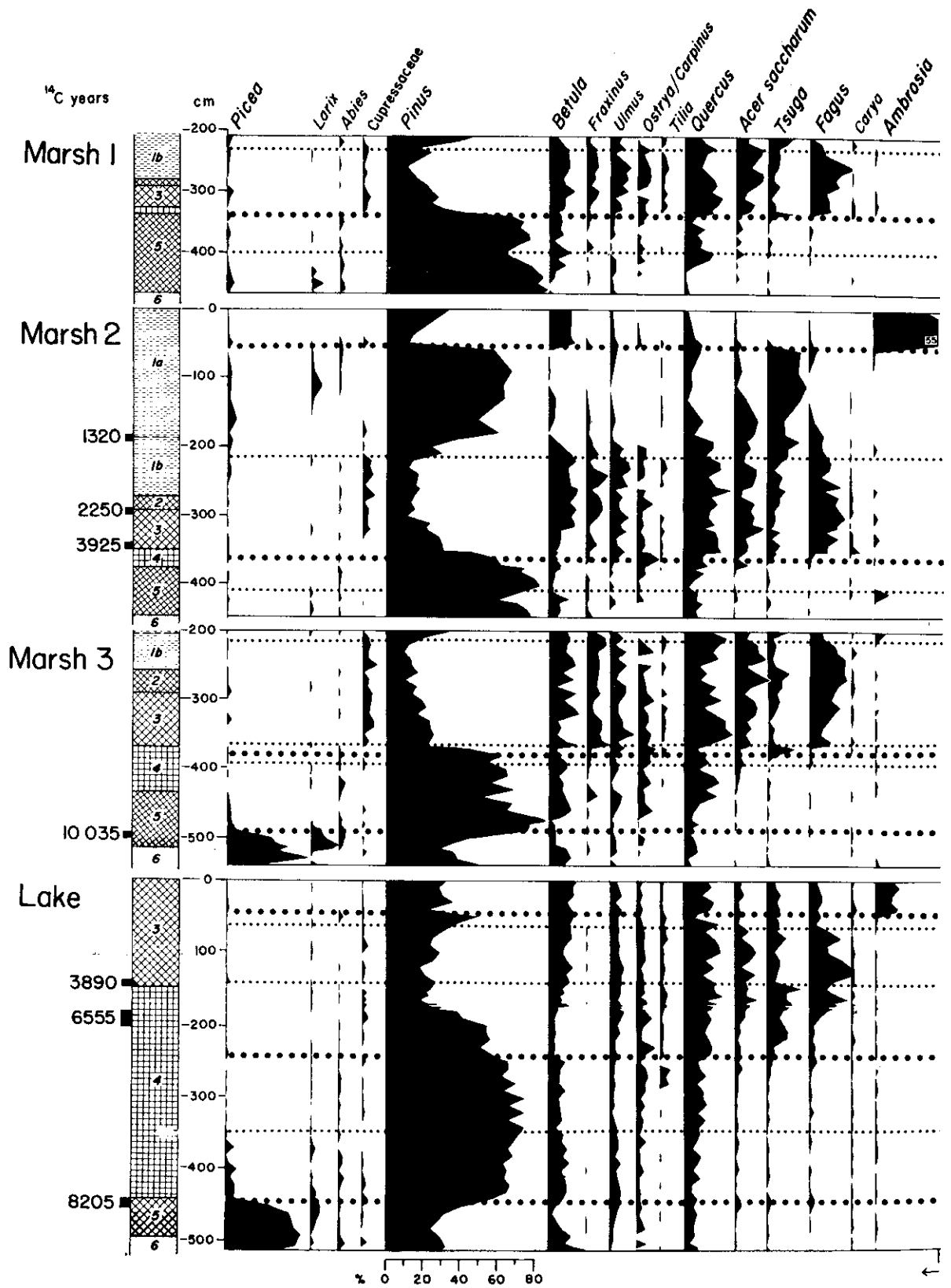
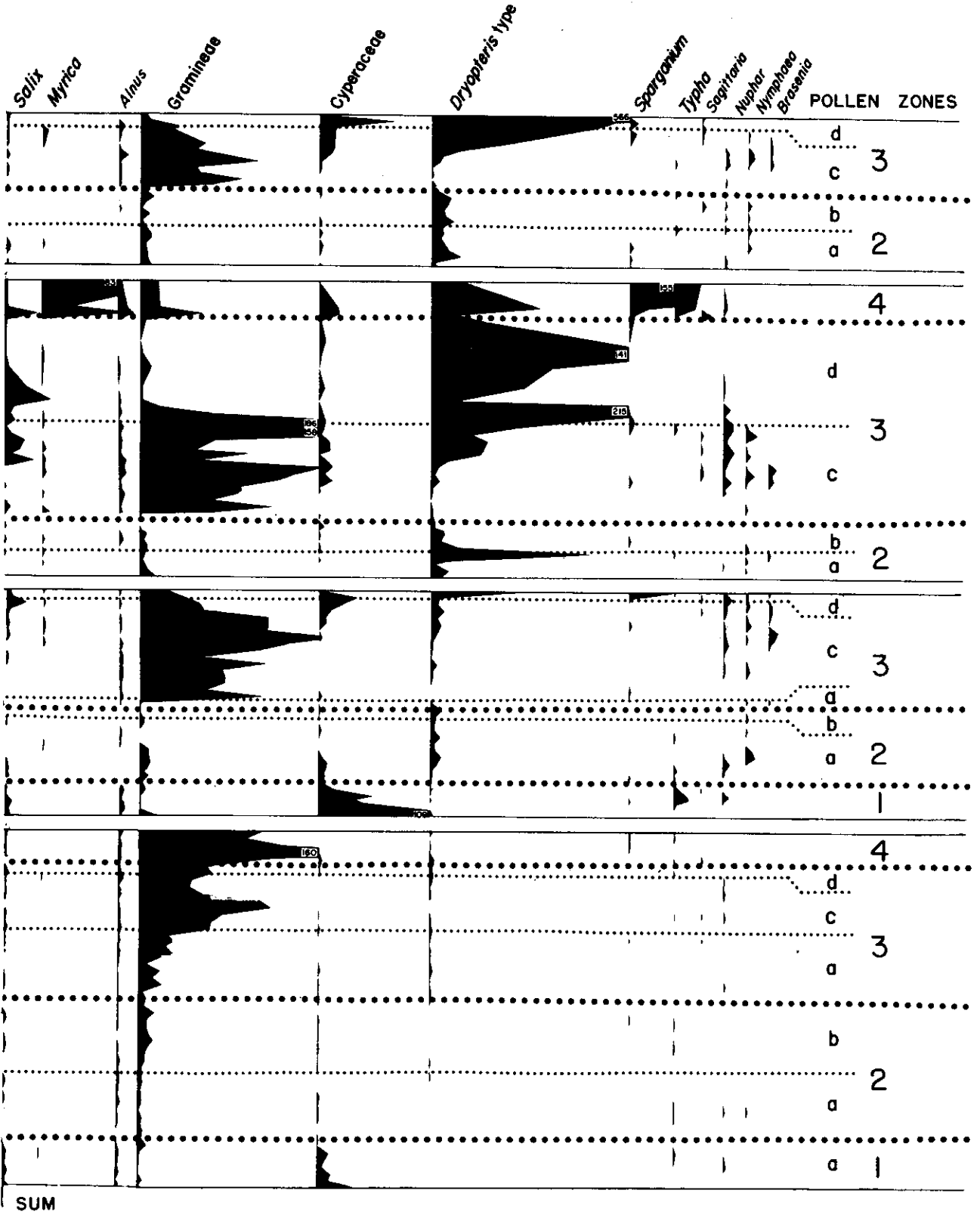


Fig. 5. Pollen diagram from Rice Lake and marsh. Pollen and spores not graphed are listed in Tables 10-13.



Unit 4 is a gray marl that thickens lakeward. It has abundant mollusk shells and is low in organic C. Its contact with the overlying unit 3 is marked by a ~~large~~ deposit of shells.

Unit 3 is a dark brown non-calcareous homogenous mud that thickens lakeward where it is currently being deposited. Its organic C content is intermediate between marl and detritus mud.

Unit 2 is a dark brown detritus mud that is transitional to the overlying peat.

Unit 1 is the modern marsh peat that is currently accumulating. It is dark brown to black with abundant twigs and other shrub macrofossils. It has the highest organic C content of all the units. Subunit 1b is separated from 1a by a distinctive macrofossil assemblage.

Seven radiocarbon dates were obtained from segments of three cores (Table 2). The two dates from unit 1 are at the synchronous pollen zone 1/2 boundary. The younger date of 8205 BP is rejected in favour of the older date of 10,035 BP that is more comparable with the Barry Lake date. In the Rice Lake core the 6555 BP date from near the top of unit 4 and the 3890 BP date from the bottom of unit 3 indicate an anomalously slow rate of sedimentation, but this can be explained by the erosion of the top of unit 4 before the deposition of unit 3. The date of 3925 BP at the bottom of unit 3 in the Marsh 2 core indicates synchronous initial position of unit 3 across the basin. The younger overlying dates in the Marsh 2 core are in correct stratigraphic order.

The pollen diagrams (Fig. 4) display the standard zonation, and the zone boundaries that represent time planes permit a chronology to be assigned to the several lithologic units. Unit 6 and the deeper water portion of unit 5 were deposited during zone 1 time prior to 10,000 years ago. No organic sediment accumulated landward of Marsh 2 because of intense wave action in shallow water. At this time waves eroded a shorecliff into the drumlin with the base at 4.5 m below the modern lake level. Both the elevation and chronology indicate this to have been Lake Iroquois.

Unit 6 was deposited while glacial Lake Algonquin discharged into Lake Iroquois via the Kirkfield-Fenelon Falls outlet and the Rice Lake basin. The sharp contact with the overlying unit 5 probably represents a subaerial erosion interval when Lake Iroquois drained. With the end of discharge from Lake Algonquin and the rebound of the sill at Hastings, Rice Lake was formed. At first the lake was confined to low elevations in the northeast but progressively rose, flooding the basin southwestward. As the water level rose a marginal marsh developed that subdued shore erosion and caused the accumulation of the unit 5

TABLE 1
 MEAN PERCENTAGES OF ORGANIC C BY LITHOLOGIC UNITS
 (N is the Number of Levels Tested)

<u>Lithologic</u> <u>units</u>	<u>Marsh 1</u>		<u>Marsh 2</u>		<u>Marsh 3</u>		<u>Lake</u>	
	\bar{X}	N	\bar{X}	N	\bar{X}	N	\bar{X}	N
1 peat	41	7	42	12	42	4		
2 detritus mud	33	3	34	3	27	4		
3 mud	24	4	20	5	23	4	22	12
4 marl	16	2	7	3	11	7	11	28
5 detritus mud	30	4	27	6	28	7	6	7
6 sand	1	3	3	2	1	3	1	1

TABLE 2
 RADIOCARBON DATES FROM RICE LAKE CORES
 (All Samples Pretreated to Remove Carbonate)

<u>Core</u>	<u>Depth (cm)</u>	<u>Years BP</u>	<u>Laboratory Number</u>
Marsh 2	190-200	1320 \pm 140	GX-5290
Marsh 2	295-305	2250 \pm 140	GX-5291
Marsh 2	340-350	3925 \pm 150	GX-5992
Marsh 3	495-505	10,035 \pm 235	GX-5293
Lake	140-150	3890 \pm 130	I-7222
Lake	183-200	6555 \pm 115	I-7223
Lake	440-450	8205 \pm 160	I-7274

TABLE 3

INTERVALS AND SEDIMENT VOLUMES EXAMINED FOR MACROFOSSILS

<u>Lithologic unit</u>	<u>Intervals (cm)</u>			
	M1	M2	M3	L
1a upper peat	100-200	50-190	100-204	
1b lower peat	200-280	190-270	204-254	
2 detritus mud	280-290	270-295	254-287	
3 mud	290-330	305-340	287-367	40-155
4 marl	330-335	350-374	367-432	155-440
5 detritus mud	335-465	374-445	432-509	432-500
6 sand	465-495	445-478	519-545	

	<u>Volumes (L)</u>			
	M1	M2	M3	L
1a upper peat	2.12	1.70	0.50	
1b lower peat	1.53	1.70	0.57	
2 detritus mud	0.21	0.53	0.37	
3 mud	0.85	0.74	0.91	1.41
4 marl	0.11	0.51	0.74	3.24
5 detritus mud	2.76	1.51	0.76	0.96
6 sand	0.64	0.70	0.30	

detritus gyttja. At the same time unit 4 marl was being deposited offshore.

A further rise in water level caused the marl to progressively cover unit 5 landward. About 5,000 years BP there was an episode of erosion of unit 4 marl followed at 4,000 years BP by mud deposition throughout the lake. Stabilization of the water level about 2250 years BP permitted marsh plants to progressively colonize shallow water, a succession that led to the deposition of the unit 1 peat by the modern marsh.

The plant macrofossils are summarized for the lithologic units of each core (Table 3) as the number of fossils per 1 (Tables 4-8).

Unit 6 has only a few sedge (*Carex*) and bulrush (*Scirpus*) seeds together with abundant sedge family (*Cyperaceae*) pollen and *Selaginella* spores (Tables 10-13). These fossils in a substrate low in organic C indicate sparse aquatic vegetation during sand deposition and the early lake phase.

In contrast, unit 5 has abundant seeds of aquatic plants that indicate a zonation of aquatic communities controlled by water depth. The shrub-dominated marsh that occupied the landward margin was bordered by a community of shallow water bulrush and spike rush (*Eleocharis*) with yellow water lily (*Nuphar*) and pondweed (*Potamogeton*) in deeper water offshore. Rising water levels caused the flooding of the marginal marsh and deposition of unit 4 marl that supported a dense growth of the submerged aquatic *Najas* with a few pondweed.

This open water community continued into the time of unit 3 although with reduced abundance. In unit 3 beginning 4,000 years BP the pollen diagram indicates partial replacement of this community with an aquatic grass, probably wild rice. The wild rice stand was invaded by other aquatic species beginning in unit 2 and was succeeded by the modern shrub-dominated marsh about 1400 years BP. Wild rice persisted in the deeper water to the present.

No grass seeds were found so that the identity of the Gramineae pollen is a problem. The pollen is similar to wild rice in that it is relatively large with a thin, smooth wall.

DISCUSSION

Rice Lake was formed about 11,800 years ago after the drainage of Lake Iroquois. Shallow margins of the lake were invaded by marsh but isostatic rebound elevated the outlet and caused progressive

TABLE 4
 NUMBER OF SEEDS OF AQUATIC PLANTS PER L BY LITHOLOGIC UNITS
 (Unit 6 has only *Cyperaceae*)

A. Submerged Aquatics

	<u><i>Najas flexilis</i></u>				<u><i>Potamogeton</i></u>				L	M1	M2	M3
	M1	M2	M3	L	M1	M2	M3	L				
1a	1	-	-		-	1	-					
1b	523	37	35		1	2	-					
2	212	294	417		-	8	3					
3	295	265	150	612	-	-	-	1				
4	528	514	334	1009	9	-	1	1				
5	271	5	61	177	10	7	14	79				

B. Floating Leaf Aquatics (Nymphaeaceae)

	<u><i>Nuphar</i></u>			<u><i>Nymphaea</i></u>			<u><i>Brasenia</i></u>		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1a	-	-	-	-	-	-	-	-	-
1b	-	3	7	-	-	2	-	1	-
2	-	4	5	-	-	3	-	4	5
3	-	-	-	1	-	-	-	-	1
4	-	-	-	-	-	-	-	-	-
5	1	-	33	-	-	-	-	-	-

C. Emergent Aquatic Herbs

	<u><i>Sparganium</i></u>			<u><i>Sagittaria</i></u>			<u><i>Typha</i></u>			<u><i>Menyanthes</i></u>		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
1a	-	1	0	1	13	-	-	-	-	80	8	18
1b	-	1	2	16	15	5	1	2	-	1	17	-
2	-	4	-	5	21	-	-	-	-	-	-	-
3	-	-	-	1	-	-	-	-	-	-	-	-
4	-	-	1	-	-	1	-	-	-	-	-	-
5	9	1	3	14	-	7	-	2	-	1	-	-

Table 4 continued:

D. Emergent Aquatic Herbs (Cyperaceae)

	<u>Scirpus</u> *			<u>Carex</u>			<u>Eleocharis</u>			<u>Dulichium</u>		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
1a	-	-	-	64	19	2	-	3	4	-	-	-
1b	12	-	4	181	107	72	120	157	555	16	-	18
2	-	6	-	24	23	3	1	192	8	5	28	3
3	1	-	-	-	2	-	1	4	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	15	32	114	1	1	15	-	-	60	1	-	-
6	-	-	7	-	1	61	-	-	-	-	-	-

* *validus* typeE. Emergent Aquatic Herbs

	<u>Bidens</u>			<u>Lycopus</u>			<u>Eupatorium</u>			<u>Sium</u>		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
1a	-	1	-	-	-	-	-	-	-	1	11	-
1b	7	2	2	7	1	-	-	1	-	3	11	-
2	-	-	-	-	2	-	-	-	-	-	-	-
3	-	1	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	1	-	1	1	-	-	-	-	-

F. Aquatic Shrubs

	<u>Decodon</u>			<u>Myrica</u>			<u>Cornus</u>			<u>Rubus</u>		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
1a	-	-	-	3	5	4	2	10	-	-	1	4
1b	6	1	-	71	7	4	1	6	2	-	-	-
2	-	2	-	14	9	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	11	11	-	10	184	-	2	7	-	1	-	-

TABLE 5

SUMMARY OF MEAN POLLEN CONCENTRATION OF UPLAND PLANTS, TREES AND AMBROSIA
(Per ml (x10) by Lithologic Units)

	<u>Marsh 1</u>		<u>Marsh 2</u>		<u>Marsh 3</u>		<u>Lake</u>	
	\bar{X}	N	\bar{X}	N	\bar{X}	N	\bar{X}	N
1 peat	47	6	45	14	39	3	-	0
2 detritus mud	163	2	157	3	129	7	-	0
3 mud	171	3	154	9	181	7	146	3
4 marl	206	2	307	3	264	8	218	27
5 detritus mud	217	13	301	8	179	4	51	3
6 sand	*	1	*	4	-	0	-	0

* less than 1

TABLE 6

MISCELLANEOUS MACROFOSSIL NUMBERS FROM MARSH 1
(x Indicates Presence)

<u>Units</u>	<u>la</u>	<u>lb</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
wood	x	-	-	x	x	x	x
buds	x	x	-	-	-	x	-
<i>Thuja</i>	-	x	-	-	-	-	-
<i>Betula</i>	x	x	x	-	x	x	-
<i>Tsuga</i>	1	-	-	-	-	2	-
<i>Larix</i>	x	-	-	-	-	x	-
<i>Pinus strobus</i>	-	-	-	-	x	x	-
<i>Ceratophyllum</i>	-	-	-	-	x	-	-
<i>Lysimachia</i>	9	2	-	-	-	-	-
fern	x	x	-	-	x	-	-
<i>Boehemaria</i>	-	59	1	-	-	1	-

TABLE 7

MISCELLANEOUS MACROFOSSIL NUMBERS FROM MARSH 2
(x Indicates Presence)

<u>Unit</u>	<u>la</u>	<u>lb</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
wood	x	x	-	-	x	x	-
buds	x	x	-	-	-	x	-
<i>Myrica</i> leaves	21	110	7	-	-	13	-
<i>Tsuga</i>	-	1	?1	-	-	-	-
<i>Thuja</i>	-	6	-	-	-	-	-
<i>Pinus strobus</i>	-	1	1	-	-	1	-
<i>Larix</i>	2	-	-	-	-	5	-
<i>Betula</i>	7	8	9	1	-	42	-
<i>Rumex</i>	4	2	-	-	-	-	-
<i>Boehemaria</i>	-	5	1	-	-	-	-
<i>Alisma</i>	-	1	-	-	-	-	-
<i>Myriophyllum</i>	-	-	1	-	-	-	-
<i>Hypericum</i>	-	3	-	-	-	1	-
<i>Asclepius</i>	-	-	-	-	-	2	-
<i>Lysimachia</i>	-	2	-	-	-	-	-
fern	23	49	1	-	-	-	-
<i>Viola</i>	-	-	-	-	-	46	-

TABLE 8
 MISCELLANEOUS MACROFOSSIL NUMBERS FROM MARSH 3
 (x Indicates presence)

<u>Unit</u>	<u>1a</u>	<u>1b</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
buds	x	x	-	-	-	-	-
<i>Larix</i> seed	-	-	-	-	-	2	-
<i>Larix</i> needle	-	-	-	-	-	11	1
<i>Picea</i> needle	-	-	-	-	-	1	2
<i>Betula</i>	-	1	1	2	1	11	-
<i>Scutellaria</i>	-	14	-	-	-	-	-
<i>Asclepius</i>	-	1	-	-	-	-	-
<i>Hippuris</i>	-	-	-	-	-	1	-
<i>Mentha</i>	-	-	-	-	-	1	-

TABLE 9
 MISCELLANEOUS MACROFOSSILS FROM LAKE CORE

<u>Unit</u>	<u>3</u>	<u>4</u>	<u>5</u>
<i>Carex</i>	-	-	1
<i>Eleocharis</i>	1	-	-
<i>Valisneria</i>	2	1	1
<i>Sagittaria</i>	-	5	-
<i>Picea</i> needle	1	2	-
Conifer seed	-	-	1
<i>Larix</i> needle	-	-	4
<i>Pinus strobus</i> needle	-	6	-
<i>P. banksiana</i> needle	-	2	-
<i>Betula</i>	-	1	24
Compositae	-	-	3
<i>Mentha</i>	-	4	-
<i>Ribes</i>	-	-	1

TABLE 11

POLLEN SUM AND MISCELLANEOUS POLLEN AND SPORES FROM MARSH 2

Level (cm)	Sum	<i>Juglans</i>	<i>Platanus</i>	<i>Artemisia</i>	<i>Tubuliflorae</i>	<i>Thalictrum</i>	<i>Pteridium</i>	<i>Equisetum</i>	Indeterminable	Unknown
1	186				29				1	Chenopodiineae 7
40	278	1			3				2	<i>Corylus</i> 1, <i>Rumex</i> 1, <i>Vitis</i> 1 <i>Iva ciliata</i> 1, Labiatae 1, <i>Lycopodium</i> 1, <i>Lemna</i> 12, Chenopodiineae 13, <i>Rumex</i> 2, <i>Plantago</i> 1, <i>Zea</i> 1
50	166	1			1		4		3	<i>Zea</i> 1
60	105						3		11	Ericales 1 <i>Polypodium</i> 1
90	138					2	8		4	
110	165					2	9	1	2	
130	135						4		7	
160	101						2		9	3 Chenopodiineae 1, <i>Sphagnum</i> 1
180	102								8	1
190	102			1			1		5	2 <i>Osmunda</i> 1
200	124	2	1		1		2		5	<i>Castanea</i> 1, Labiatae 1
210	106				1		3		6	1
220	109		1						4	1
230	107								3	1 <i>Utricularia</i> 1
240	109					1			1	1 Umbelliferae 1
255	101						1		3	1 <i>Polypodium</i> 1
260	110					1		1	3	2 <i>Corylus</i> 1
270	105	2					3		5	Umbelliferae 1, <i>Osmunda</i> 1
280	107		1			1			1	4
290	102	1							4	<i>Vitis</i> 1
300	108	1			1		1		5	<i>Vitis</i> 1
310	164								3	1 Chenopodiineae 1, <i>Osmunda</i> 1
315	110			2	1				1	
320	120	1					1		2	1
330	147	2						1	2	<i>Castanea</i> 1
340	116	1							2	
350	97									2 <i>Castanea</i> 2 Rosaceae 1, <i>Sphagnum</i> 1
351	114		1							
360	135		1						2	
370	103		1				1		2	
375	121		1						1	

TABLE 12

POLLEN SUM AND MISCELLANEOUS POLLEN AND SPORES FROM MARSH 3

Level (cm)	Sum	<i>Juglans</i>	<i>Platanus</i>	<i>Artemisia</i>	<i>Tubuliflorae</i>	<i>Thalictrum</i>	<i>Pteridium</i>	<i>Equisetum</i>	Indeterminable	Unknown
200	111	1		1			1		10	
210	107		1	1	1		1		10	1 <i>Vitis</i> 1 <i>Utricularia</i> 1
220	105	1	1						4	<i>Corylus</i> 1 Chenopodiineae 1
230	110	2	1			1			1	
240	111								1	1 Caryophyllaceae 1
250	107	1				1		1	3	1 <i>Potamogeton</i> 1
260	98			1	1		1		3	1
270	106		2		2				1	4
280	101		2						4	1 Chenopodiineae 1
290	114				1				4	1
300	103								1	<i>Castanea</i> 1
310	115					2			3	Chenopodiineae 1
320	106			2	1		2		4	
330	115					1			2	1 <i>Xanthium</i> 1
340	126			1					2	1
350	106									<i>Castanea</i> 1, <i>Myriophyllum</i> 1
360	111		1		1				3	1 Chenopodiineae
365	112								2	<i>Corylus</i> 1
370	136	1	1	1					2	1 <i>Populus</i> 1
380	111									1 <i>Corylus</i> 1
390	111									<i>Corylus</i> 1
400	130	1	1	1					2	
410	104			1					1	
420	110						1			
430	104		1				1		5	
440	117						1		1	
450	119			1			3			
460	102						1		3	<i>Vitis</i> 1

Table 12 continued:

Level (cm)	Sum	<i>Juglans</i>	<i>Platanus</i>	<i>Artemisia</i>	<i>Tubuliflorae</i>	<i>Thalictrum</i>	<i>Pteridium</i>	<i>Equisetum</i>	Indeterminable	Unknown
470	101							6	3	<i>Lycopodium</i> 1
475	103						1		3	2
480	109						1		3	2
490	122						2	1	3	1
500	121	1		2	2				1	
										<i>Corylus</i> 1, <i>Osmunda</i> 1, <i>Utricularia</i> 1
510	135	1		4				3	4	<i>Myriophyllum</i> 1
515	121		1		1			2	5	3
										<i>Shepherdia can.</i> 1, <i>Umbelliferae</i> 1
520	111			4	3		1		1	2
530	112				1				4	2
										<i>Rosaceae</i> 1, <i>Ericales</i> 1, <i>Lycopodium</i> 1, <i>Potamogeton</i> 1, <i>Selaginella</i> 1
540	107			3		1			19	5
										<i>Chenopodiineae</i> 1, <i>Sanguisorba</i> 1, <i>Lycopodium</i> 2, <i>Selaginella</i> 4, <i>Sphagnum</i> 1

TABLE 13

POLLEN SUM AND MISCELLANEOUS POLLEN AND SPORES FROM RICE LAKE

Level (cm)	Sum	Juglans	Platanus	Artemisia	Tubuliflorae	Thalictrum	Pteridium	Equisetum	Indeterminable	Unknown	
1	405	1	1		1				25	3	Castanea 1 Chenopodiineae 4, Plantago 2, Caryophyllaceae 1, Lycopodium 1, Potamogeton 1
10	473	1	2	6	2		1		19	7	Acer rubrum 2, Chenopodiineae 3, Rumex 2, Umbelliferae 1,
20	449	5					1		20	7	Corylus 1, Cornus 1, Rumex 1, Cruciferae 1
30	438	3	2	3			1		13	4	Chenopodiineae 1, Lycopodium
40	369							4	26	13	Rumex 5, Chenopodiineae 2, Sphagnum 3
50	299	2							4	1	
60	387						4		20	5	
70	323	1							4		
80	449	1							9	1	
90	418	1	2	3	1		1		8	3	Celtis 1, Corylus 1, Ephedra 1, Chenopodiineae 1, Sphagnum 1, Potamogeton 1
100	345						1		2		Chenopodiineae 1
110	440	1		2					26		Chenopodiineae 1
120	440				1		2	4	19	10	Acer rubrum 4, Corylus 1, Corylus 1, Vitis 1, Sphagnum 1, Chenopodiineae 1, Urtica 1,
130	431						1	1	18		Chenopodiineae 1, Urtica 1,
140	392						2		19	3	Chenopodiineae 1, Umbelliferae 1

Table 13 continued:

Level (cm)	Sum	<i>Juglans</i>	<i>Platanus</i>	<i>Artemisia</i>	<i>Tubuliflorae</i>	<i>Thalictrum</i>	<i>Pteridium</i>	<i>Equisetum</i>	Indeterminable	Unknown
150	407	1		1					33	Chenopodiineae 1
155	399	1		2					31	1
160	414				2				19	1
165	455	1		2					29	1 <i>Corylus</i> 1
170	439			3	1		1		34	
171	425	3	1						16	<i>Vitis</i> 1
172	474	3		2					19	<i>Vitis</i> 1
										Chenopodiineae 1
173	431	2		2	1				23	1 <i>Corylus</i> 1, Chenopodiineae 2
174	395							1	20	1 <i>Corylus</i> 2, Chenopodiineae 2
175	444	1	1	2			1		24	4 <i>Corylus</i> 1, Chenopodiineae 3, <i>Shepherdia can.</i>
176	407	1	4	1	1				23	1 Chenopodiineae 1
177	432		4	1	2				31	<i>Acer rubrum</i> 1, Chenopodiineae 1
178	434		10	1	1				24	
180	404		2				1		6	
190	415			1	1		2		5	<i>Corylus</i> 1, Chenopodiineae 1, <i>Urtica</i> 1
200	441			3					23	
210	445	1			1				9	<i>Corylus</i> 1
220	480	1							10	7 <i>Corylus</i> 3
230	453		1	1			3		10	
240	425			1					24	1
250	488				1				6	
260	382								2	<i>Shepherdia can.</i> 1, Chenopodiineae 1
270	412						4		5	1 <i>Corylus</i> 1, <i>Sphagnum</i> 1
280	440	1	1	1					15	<i>Potamogeton</i> 1
290	462	1					1		3	2 <i>Corylus</i> 1, Chenopodiineae 1,

Table 13 continued:

Level (cm)	Sum	<i>Juglans</i>	<i>Platanus</i>	<i>Artemisia</i>	<i>Tubuliflorae</i>	<i>Thalictrum</i>	<i>Pteridium</i>	<i>Equisetum</i>	Indeterminable	Unknown	
300	648			1			1		11	6	<i>Acer rubrum</i> 1
310	420		1	1		1			6		<i>Plantago</i> 1
320	404			2					4		Chenopodiineae
330	422	1		4				1	8		<i>Corylus</i> 1
340	316						2		3		
350	419	2		1					7	2	<i>Potamogeton</i> 2
360	300								1	2	<i>Vitis</i> 1, Chenopodiineae 1
370	299	1					2		1		
380	459				1				12	1	<i>Acer rubrum</i> 1
390	410			3	1		7		8	1	<i>Corylus</i> 3, <i>Urtica</i> 1, Chenopodiineae 1
400	562			3			13		17	2	
410	422	1	1	4			17		8	1	<i>Corylus</i> 1, <i>Vitis</i> 2, <i>Potamogeton</i> 1
420	439			1			6		10	7	
430	298	1									
440	288			1			1		9	1	<i>Corylus</i> 3, Chenopodiineae 1
450	331	2							7		<i>Corylus</i> 4
460	443	2		10	25			3	15	1	<i>Corylus</i> 2, Ericales 1, Chenopodiineae 1, Labiatae 1, <i>Botrychium</i> 2, <i>Potamogeton</i> 5, <i>Myriophyllum</i> 1,
480	364			4			12	2	26	5	Chenopodiineae 1
490	326	1		5	5	1	2	1	10	2	Chenopodiineae 1 <i>Selaginella</i> 1, <i>Potamogeton</i> 1, <i>Myriophyllum</i> 2
500	270				2			5	17	4	
505	290			6	2	1			5	2	<i>Selaginella</i> 4
510	257	1		8	3				13	1	<i>Selaginella</i> 4

flooding of the marshes and marl deposition. About 4,000 years ago a poorly understood factor caused marl deposition to be replaced by that of non-calcareous organic mud, an event that corresponds with the proliferation of a grass, probably wild rice. Adjacent to the McIntyre site, marsh invaded shallow water beginning at 2,250 years BP but did not eliminate local stands of wild rice until 1400 years BP when the marsh became dominated by the modern shrub community.

The six radiocarbon dates for the McIntyre site range from 4,715 to 3,650 years BP, but five of the six dates cluster between 3,650 and 3,700 years BP (Johnston 1976). If this cluster represents the most intensive site occupation, then habitation coincided with the evidence for wild rice; there was no shrub dominated marsh to impede canoe access to the lake.

The McIntyre site today is unattractive for habitation because it is mostly surrounded by wetland forest and separated from the lake by impassable marsh. The data show that 3,700 years BP the site was bordered by a lake that probably supported a wild rice stand. It is reasonable to believe that the inhabitants collected this prime food and that many wild rice seeds were carbonized, yet wild rice seeds are virtually absent in the extensive seed collection excavated from the site (Yarnell 1984).

I believe that the carbonized wild rice seed did not preserve relative to the other seeds. Wild rice seeds are long and narrow with a relatively thin seed coat covering starchy endosperm. When they are experimentally carbonized they puff as illustrated in Ford and Brose (1975) and become fragile. Our experiments show that they are much more fragile than sunflower seeds when carbonized under similar conditions (McAndrews and Fecteau, unpublished). Thus I suspect that carbonized wild rice seeds will be relatively rare in ^{other} archaeobotanical samples as they are at the McIntyre site.

An interesting and more far-reaching question is why there was an expansion of Late Archaic populations such as is represented by the McIntyre site people. Perhaps the answer lies in the profound change in the upland forest when about 4,000 years BP hemlock was all but wiped out over its range. David (1980) attributes this decline to a catastrophic disease affecting only hemlock. Pollen diagrams show that hemlock was replaced by its associates birch, beech and maple. This succession from a shady conifer forest to a seasonal deciduous forest would have encouraged the expansion of deer populations and thus provided an enlarged food supply for prehistoric people.

This new forest would produce less acid litter, less leaching of the soil and decreased lime in the ground water. If the ground

water rose at the same time, perhaps because of forest succession or perhaps because of uplift, then the increased circulation of calcium-poor water in Rice Lake would lead to organic mud deposition and wild rice habitat. Abundant wild rice, like increased deer herds, would provide an increased food supply for the expansion of Late Archaic human populations.

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