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Aquatic Baseline on Isle Royale, Michigan

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RESEARCH GROUP

David G. Toczydlowski

Student Director, Biological Sciences

Thomas Abramson

Biological Sciences

Riley S. Burdett

Department of Chemistry and Chemical Engineering

Tanya Beecher-Rocker

Rita DePuydt

Mark A. Mitchell

Jim Rice

James Stave

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ABSTRACT

No previous research on Isle Royale has included extensive limnological studies. This project included selected lakes on the central and southern portion of the island. Insects and aquatic plants were also collected to provide essential baseline for these areas.

The pH's of the lakes ranged from 5.25 - 6.50 (mean value 5.70). Only Siskiwit Lake, Lake Richie and Intermediate Lakes had maxima greater than 6.0. This low pH combined with a mean alkalinity of 25.9 mg/kg CaCO_3 (max. value 38.6) indicates a high susceptibility to acid precipitation.

The small flagellate algae dominated most of the lakes. Siskiwit and Wood Lakes also showed subdominances of Cyclotella melosiroides, Asterionella, Rhizosolenia and Oocystis, suggesting that these are oligotrophic lakes. Chippewa Harbor and Whittlesey Lake are subdominated by the mesoeutrophic indicator Melosira. The eutrophic indicator Gloeocapsa is common in Feldtmann Lake as Scenedesmus, a warm water form.

Insect $\frac{1}{2}$ minute kick samples usually contained less than 100 individuals and were not diverse. Trichopterans and dipterans were the most abundant and the most diverse (with 32 and 40 genera, respectively). 111 insect genera were identified, 39 of which were not previously reported for the island. 5 new bryophyte species and 10 new aquatic plant species were reported (37 families, 56 genera, 101 species). Aquatic vegetation of Wallace Lake was mapped, based of quadrat samples and a dendrogram using a Jaccard coefficient.

INTRODUCTION

Isle Royale National Park, Michigan offers unique opportunities for research. Unlike most National Parks and protected areas which represent portions of much larger ecosystems, Isle Royale is isolated from the majority of man's influences that are ecologically serious and from modifying activities of surrounding areas. Unfortunately the island is not isolated from acid precipitation. Rain and snow with pH as low as 3.5 have been recorded by Stottlemeyer (personal communication). The island may be extra sensitive to acid precipitation due to the thin soils and basaltic geology.

The island is large enough to be a self-regulating ecosystem. Few ecosystems like Isle Royale exist at this latitude. Monitoring the conditions and changes of near natural systems will aid the understanding and management of similar ecosystems that are altered by man.

To detect changes comparisons must be made; and to date there is little documented baseline knowledge of the island's more than 200 inland lakes and numerous streams. Lynn et al. (1966) stresses the need for baseline studies of physical and biological characteristics of all aquatic environments associated with the island. Most aquatically related research has dealt with the commercial and sport fisheries of the island and surrounding waters of Lake Superior (Hubbs and Lagler, 1949; Sharp, 1960; and others). Taylor (1935) analyzed some phytoplankton grab samples and Prescott (1936, 1937, 1939 and 1940) compiled a list of desmids from the island. Many of the species Prescott identified were

state and North American records. Some aquatic insects were collected by the Michigan State Biological Survey of 1904 and 1905 (Adams 1908). Aquatic macrophytes have been studied by Brown (ca. 1936) and Adams (1908); however, these studies have not described the relative abundancies of aquatic plants at various locations. Lynn et al. (1966) includes an extensive bibliography.

This projects' primary goal was providing baseline data concerning several aspects of the aquatic environment. Basic limnological parameters were determined for several inland lakes and one harbor of Lake Superior. Relative abundancies of aquatic insects, macrophytes, and phytoplankton were estimated in several lakes and/or streams. Our efforts were spread over several areas of the island in an effort to detect similarities and differences among and within different habitats. We hope future research will add to this data base.

DESCRIPTION OF STUDY AREAS

The areas and maximum depths of all lakes (except Chippewa Harbor) are in Table 1 (after Humphries, 1962). The bottom of Sikiwit Lake consists of bedrock, glacial till, and sand in some shallow bays. Feldtmann Lake's bottom consists primarily of sand. Moskey Basin has a bedrock and sand bottom. The remaining lake bottoms varied within each lake from bedrock and sand to organic deposits. An underwater ridge separates Wood Lake into two approximately equal portions. This ridge is orientated in an east-west direction. Figure 1 is a map of the central and southern portions of the island. All study sites are labeled on this map. A map of the entire island appears in the appendix (figure 6).

Aquatic insect samples were taken either in lentic (standing water) or lotic (flowing water) habitats. Listed below is a brief description of each sample site.

Lotic habitats

Benson Creek is approximately 3.5 km long and drains Benson Lake. The creek is seldom wider than 3 meters and has a maximum depth of about 50 cm. During the spring the stream is full flowing, but during the summer the stream flow is reduced and even terminates in some areas.

Insect sampling sites were concentrated in the last kilometer of the stream. The current in this section of stream was generally erosional although there were few depositional areas upstream of the sampling areas. The substrate consisted primarily of large rocks and gravel. However, aquatic plants inhabited several depositional areas. The water temperature

Table 1

Areas and maximum depths of some Isle Royale lakes (after
Humphries, 1962).

	Area (acres)	Max. Depth (feet)
Lake Benson	50	7
Feldtmann Lake	461	10
Forbes Lake	16	21
Intermediate Lake	162	22
Lake John	9	20
Newt Lake	15	4
Lake Richie	520	37
Scholts Lake	5.5	5
Siskiwit Lake	4500	142
Sumner Lake	22	5
Wallace Lake	8.3	9
Lake Whittlesey	156	50
Wood Lake	118	30*

* Estimated from the present study's data

during sampling ranged from 11.5 to 18.0 degrees centigrade and the pH ranged from 5.5 to 6.0.

Wallace Creek is about 1 km long and drains Wallace Lake to Moskey Basin. The current was swift at the time of sampling but may become intermittent during late summer. The substrate of the stream ranges from bedrock and large rock to some gravel. Many rocky substrates were covered by aquatic mosses such as Fontinalis spp. Insects were collected from amongst large rocks in depths of 5-30 cm. The stream bed was shaded when the samples were collected. Water temperature at sampling time was 18.0 degrees centigrade and the pH was 6.5.

Lake Richie Outlet flows from Lake Richie to Chippewa Harbor, a distance of about 2.5 km. The stream is very swift for most of its length, although it does slow near Chippewa Harbor. The width of the stream ranges from two to five meters. Insect samples were collected from amongst rocks and gravel in depths of about 15 cm and from aquatic vegetation. Very little detritus was present in the stream. The water temperature during sampling was 19-20 degrees centigrade and the pH was 6.0.

Chickenbone Lake Outlet is about two km long and drains Chickenbone Lake into McCargo Cove. The stream is shaded during the day by steeply inclined banks. The stream flows swiftly over its entire length.

Most of the streambed consists of large rocks, many of them moss covered. Very little organic debris was present although some aquatic plants did grow in the stream. The water temperature at the time of sampling was 17 degrees centigrade and the pH was 5.5.

Feldtmann Creek flows about 1.5 km from Feldtmann Lake to Lake Superior.

The stream is naturally dammed at many points and flows slowly over most of its course.

Three samples were taken along this stream. The substrate generally consisted of large rocks and fine black muck from old beaver ponds. Many aquatic plants grew in the sampling areas. The water temperature at the time of sampling was 21 degrees centigrade. The pH was not determined.

Washington Creek is the longest creek on Isle Royale. It drains much of the southwest and of the island and empties into Washington Harbor near Windigo. The creek was sampled only once at its intersection with the Huggin Cove trail. At this point, the creek is about 7 m wide and the current was slow. The sample was collected from a small riffle about 15 cm deep. There was a considerable amount of organic debris in the stream. The temperature of the water was 19 degrees centigrade. The pH was not measured.

The small creek near Moskey Basin is little more than a ditch and drains a swamp located at the southeast end of Moskey Basin. It is about 1 m wide at its widest point. The current was very slow with many small pools forming along the course of the stream.

The samples were collected in water about 40 cm deep where the substrate consisted of fine gravel with many small sticks, leaves, and organic debris present. The water temperature at the time of sampling was 14.5 degrees centigrade and the pH was 5.5.

Samples from the small stream draining Lake John were collected from a pool just before its mouth at Lake Superior. The pool was exposed to sunshine during the day and was quite overgrown with aquatic algae and macrophytes. The pH and water temperature were not recorded.

Lentic habitats

Benson Lake is a small lake formed when beaver dammed Benson Creek. Most of the lakes shoreline is a bogmat. Beaver activity along the shoreline has produced many areas of submerged logs and branches. Samples were taken from around this bog area near the outlet of the lake. At the time of sampling the surface water temperature was 21 degrees centigrade and the pH was 6.5.

Wallace Lake is about 500 m long and 60 m wide and was formed when beaver dammed Wallace Creek. Most of the shoreline consists of bog mats covered with a variety of aquatic plants. The southwestern shore consists of sheer rock walls with virtually no littoral zone. Insect samples were collected near the bogmats and near aquatic plants. The surface water temperature at the time of sampling was 20 degrees centigrade and the pH was 6.5.

Moskey Basin is a part of Rock Harbor, which extends about 5 km inland. The sample site was located at the extreme southwest end of the basin. Samples were collected off a large sheet of bedrock which was covered by a thin film of algae and sediments. The water temperature at the time of sampling was 10.4 degrees centigrade and the pH was 5.5.

Forbes Lake is separated from Benson Lake by a high ridge. The shoreline consists of a floating bogmat approximately 2 m wide. Much of this bog mat is strewn with submerged logs. A variety of aquatic plants also grow on the bog. Insect samples were collected near this mat on the western side of the lake. The water temperature at the time of sampling was 20 degrees centigrade and the pH was 6.0.

Samples of insects were also collected from a beaver pond on the Moskey Basin Creek. The pond is overgrown with aquatic grasses which are covered with

a thin film of periphyton. The bottom of this pond is a thick black muck. Water temperature at sampling time was 20.5-21.0 degrees centigrade and the pH was 6.0.

METHODS AND MATERIALS

Limnology

Vertical distributions at two locations in several lakes were determined for the following parameters: temperature, dissolved oxygen, alkalinity, pH, total phosphorus, total nitrate-nitrogen, dissolved silicate and secchi disk depth. The following lakes were examined: Richie, Intermediate, Siskiwit, Wood, Whittlesey, Feldtmann and Chippewa Harbor. Temperature was recorded at one meter intervals with a thermistor temperature probe. The remaining parameters were measured at the surface and at several depths. Dissolved oxygen was determined using the azide modification of the Winkler method (APHA, 1976). Alkalinity was determined by titrating with sulfuric acid to the phenolphthalein and bromcresol green-methyl red end points (APHA, 1976). Short range pH paper was used for pH determinations. Two replicate samples from each depth were analyzed for dissolved oxygen, alkalinity, and pH. Sodium thiosulfate was standardized prior to each titration period.

One sample per depth was analyzed in the laboratory for total phosphorus, total nitrate-nitrogen and dissolved silicate. Total phosphorus was determined by a simplified colorimetric technique described by Eisenreich, et al. (1975). Total nitrate-nitrogen was determined using the Brucine colorimetric method (APHA, 1976). Samples were not pretreated for chlorine interference. The following changes were made in the procedure. Samples were mixed and run in

23 x 150 mm. culture tubes with mixing after addition of each reagent. The boiling water bath was constructed of a metal water bath with overhead stirrod situated at one end of the bath. Heat was supplied by two bunsen burners located under the bath, which kept the temperature above 95°C. Atomic absorption was utilized for dissolved silicate analyses. Standards were prepared from Fisher Scientific Company Certified SiO₂ Reference Solution. Laboratory samples were kept cool but not refrigerated while on the island and were refrigerated in the laboratory prior to analysis.

Figure 1 shows the approximate location of each sampling site and Table 6 contains the dates and sampling times for each location.

Phytoplankton

One liter water samples were collected at the same depths as those for chemical analyses. These were preserved with 10 ml. of Lugol's solution (Vollenweider, 1969) and were allowed to settle for approximately thirty hours. Settling containers consisted of inverted one liter bottles with tapering necks. A funnel with surgical tubing and hose clamp is attached to the mouth of the bottle. After thirty hours settling time the lower 125 ml. were drawn off for laboratory analysis.

Subsamples were resettled in Wild settling chambers and examined with an inverted microscope using a 1000x oil emersion lens. The first 300 specimens were identified to genus while scanning 60 µm wide transects. Only cells containing a protoplast were considered. Individual cells of colonial species such as Dinobryon were tabulated separately while

colonies of Aphanocapsa, Chrysocapsa, Coelosphaerium and Merismopedia were recorded as colonies. All Oscillatoria species had cells too small to count and were recorded as filaments. The individual cells of larger filaments such as Anabaena and Melosira were recorded separately. Small flagelates could not be identified consistently with confidence. This group contains species of Rhodomonas, Chromulina, Chrysochromulina, Ochromonas, and others. The group was arbitrarily divided into two groups based on maximum length excluding flagella; those less than or equal to five μm and those greater than five μm .

After counting each sample the slide was scanned at lower magnifications to develop taxa lists for each lake. Vertical net (10 μm porosity) tow samples were also collected at each location and were used in compilation of taxa lists. Samples from Wallace and Scholts Lakes consisted of open net tows only. Absolute estimates of phytoplankton concentrations and biomass were not determined. All collections are available for examination through the MTU Biology Department.

Insects

A surber sampler and a D-ring net were used for collecting insects from streams and lakes. Both methods were used in streams while only the net was used for lake sampling. Substrates were agitated to an approximate depth of 15 cm. for about one minute while using the Surber sampler. Kick sampling was continued for approximately 30 seconds while the D-ring net, and substrates were disturbed to a depth of 5 - 30 cm. depending of the substrate's characteristics. Samples from lakes were collected by sweeping the D-ring net through aquatic plant beds and across bottom sub-

strates. Insects were separated from sample debris as soon as possible after collection and before preservation. Insects were preserved with a mixture of 85% ethanol: 10% water: 5% glycerin. Collecting continued from June 8 to July 4 at the central portion of the island and from July 31 to August 2 at the southern end. Collections were made at the following streams and lakes: Benson Creek, Wallace Creek, Lake Richie outlet, Indian Portage Creek, a small unnamed creek entering Moskey Basin (labeled Moskey Basin Creek), Feldtmann Lake Creek, Washington Creek, Lake Benson, Forbes Lake, Lake John, Moskey Basin and a small beaver pond located on Moskey Basin Creek. These locations are labeled in figure 1. The majority of the collections came from streams.

Aquatic Plants

The qualitative collection of plants was approached as a location study for the inland lakes in which insect, phytoplankton and chemical data were collected. A species list for emergent, submergent, floating, littoral and some terrestrial plants was compiled for each location.

The approach taken was to canoe along the entire lake shore and several passes over the deep water areas. The vegetation was viewed and vouchers taken for each new species seen for that location. Specimens for protected species were not taken, but their presence was noted. After completion of surveillance the relative abundance of certain species was noted.

The processing of the plants took place in basically four steps; pressing, drying, identification and mounting for herbarium. Identification

was aided by references such as Britton and Brown (1963), Fasset (1957), Crum (1973), and Harlow and Harrar (1958). Dissecting scopes were available for use on the island.

RESULTS

Limnology

Figure 2 contains vertical profiles of temperature, dissolved oxygen, alkalinity and pH for each lake. Secchi disk depths are indicated by an open circle. All lakes except Feldtmann showed signs of thermal stratification. Oxygen depletions are observed at the lower depths of Richie, Intermediate, Wood and Whittlesey lakes. These depletions expressed as percent saturation are: ca. 80% at L. Richie, ca. 57% at Intermediate, ca. 79% at Wood, and ca. 84% at Whittlesey. The remaining three lakes had hypolimnetic oxygen concentrations at or above 89% saturation. A slight positive heterograde oxygen curve is present at both locations in Wood Lake. A negative heterograde oxygen curve is present at the north location of Lake Richie.

Alkalinity varied slightly within each lake and ranged from ca. 18 mg/kg as CaCO_3 at Intermediate to 38 mg/kg as CaCO_3 at Chippewa Harbor. The pH of all lakes was below neutrality with a range of 5.25 to 6.5. The minimal detectable pH change using short range pH paper is 0.25 pH units. Secchi disk depths ranged from 7.6 m. in Siskiwit Lake to 1.6 m. in Feldtmann Lake.

Mean total phosphorus concentrations ranged from ca. 43 $\mu\text{g/kg}$ PO_4 in Wood Lake to ca. 4 $\mu\text{g/kg}$ in Siskiwit Lake. Dissolved silica concentrations ranged from a mean of 3 mg/kg in Lake Richie to less than 1 mg/kg in Feldtmann Lake. Mean total nitrogen concentrations as NO_3 were less than 1 mg/kg in all lakes.

Figure 2. These graphs are vertical profiles of dissolved oxygen (O), temperature (T), alkalinity (A), and pH (P). Secchi disk depths are indicated by small circles.

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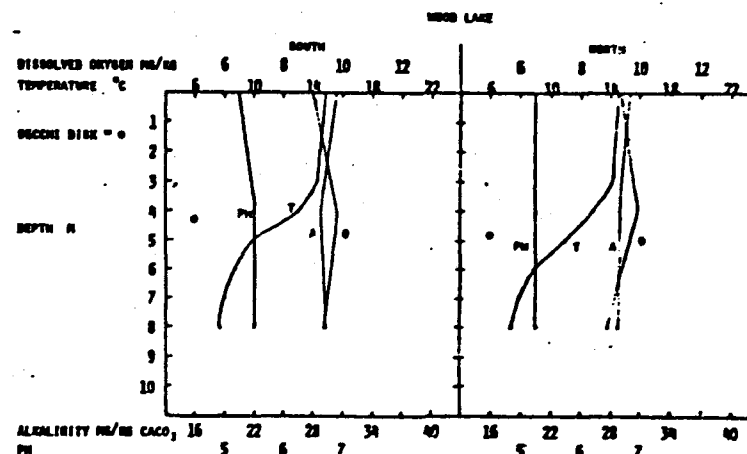
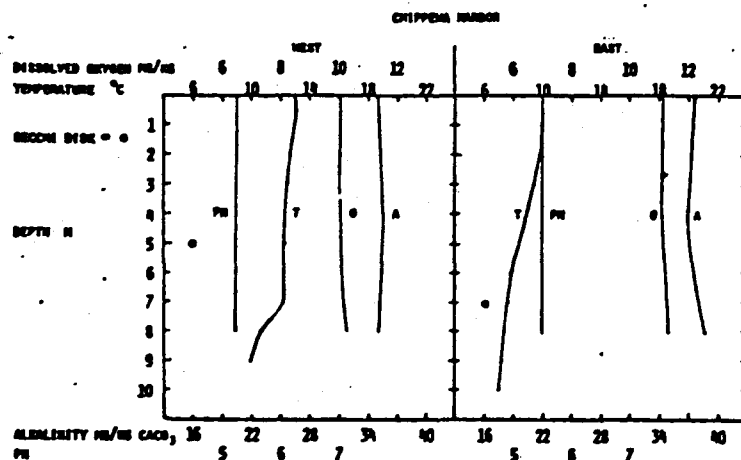
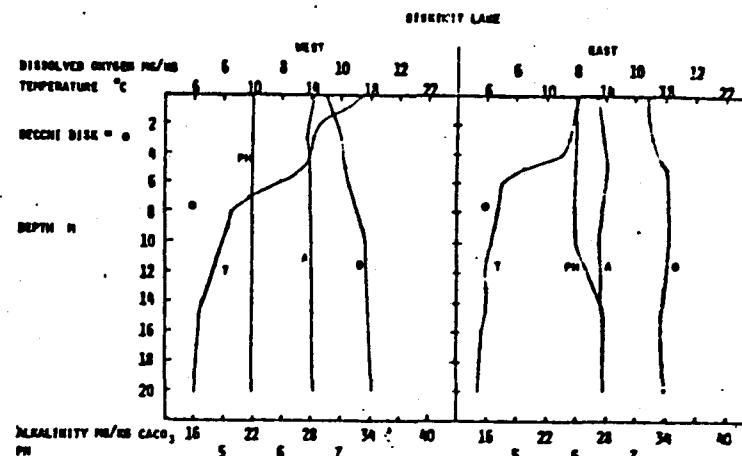
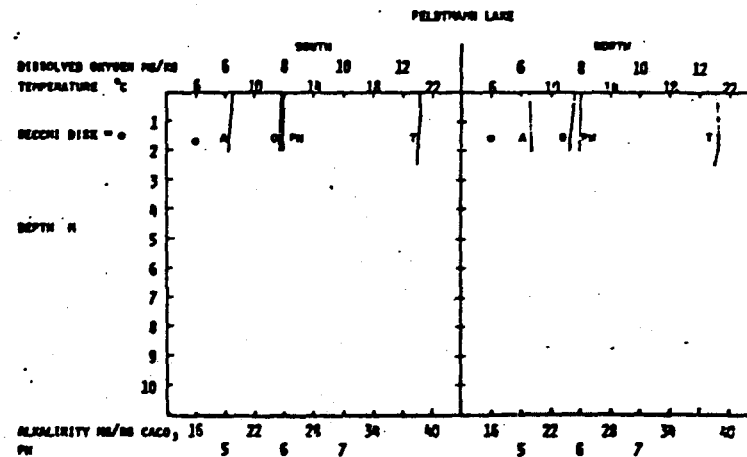
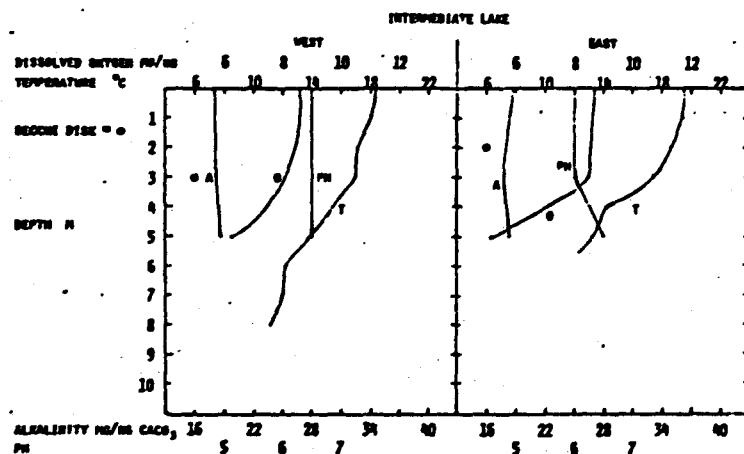
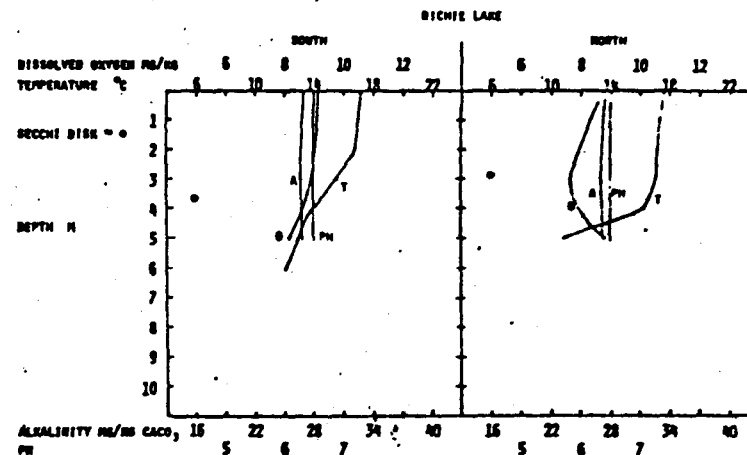
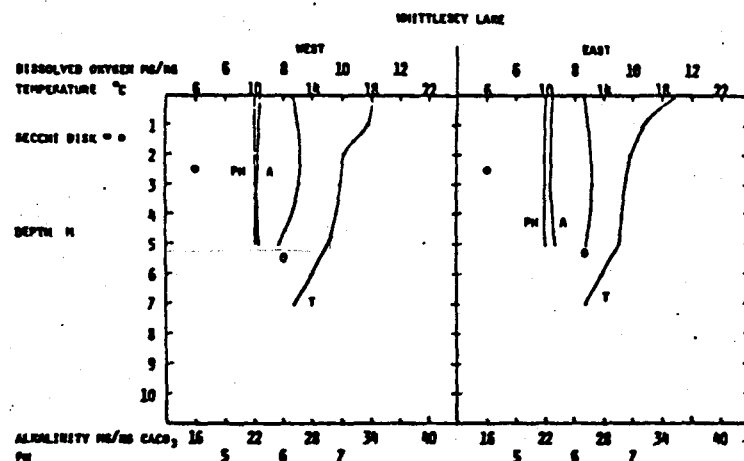


Figure 2 (cont.)



Phytoplankton

Table II contains the relative abundancies of phytoplankton at each sampling station. Each lake had a distinct phytoplankton community. The most numerous phytoplanktons in all lakes were small flagellates. This group is artificially large because it contains members of the following genera: Ochromonas, Chromulina, Chrysochromulina, Erkenia, Chroomonas and smaller species of Cryptomonas. The main differences between lakes lies in the relative abundance of small flagellates and the relative abundance or absence of diatoms (Centrales and Pennales). The relative diversity index (J' ; range from 0.0 to 1.0) range from .402 at Lake Richie to .763 at Lake Whittlesey. Table III contains the mean values of the Shannon-Wiener diversity index (H'), maximum Shannon-Wiener diversity index ($H'_{\max}$) and relative diversities (J') for each lake. Bower and Zar (1977) define these with the following formulas;

$$H' = \frac{(N \log N - \sum n_i \log N_i)}{N}, \quad \text{where } n_i = \# \text{ of individuals of species } i$$

N = total number of individuals

$$H'_{\max} = \log s, \quad \text{where } s = \text{total number of species}$$

$$J' = H' / H'_{\max}.$$

Lake Richie contained a larger proportion of small flagellates than any other lake. The dominance of this group (over 96%) is reflected by the low diversity index. Flagellates less than five μm diameter outnumbered larger flagellates by two to one. This lake lacked diatoms such as Cyclotella, Rhizosolenia and others of the Centrales and Pennales.

TABLE II

Relative abundancies of phytoplankton from the sampling locations.

Depths are in meters, s = surface or 0.25 meters

Location	Chippewa Harbor						Siskiwit Lake												Wood Lake				
	West			East			West						East						North		South		
	Depth	S	4	8	S	4	8	S	3	5	10	20	40	S	3	5	10	15	20	S	4	8	S
Flagellates ≥ 5 microns	.213	.250	.293	.283	.293	.397	.240	.210	.220	.290	.307	.423	.350	.320	.377	.417	.420	.400	.540	.413	.410	.463	.423
Flagellates < 5 microns	.340	.420	.300	.317	.387	.300	.437	.147	.143	.220	.160	.280	.267	.347	.227	.203	.230	.203	.323	.420	.317	.263	.333
Cyclotella	.043	.043	.047	.033	.030	.027	.167	.250	.123	.143	.103	.017	.180	.140	.157	.070	.037	.083	.040	.040	.017	.123	.123
Dinobryon	.003		.013	.007	.007	.007		.007	.010	.010	.003		.013	.010	.013	.007	.003	.003	.013	.020	.003	.007	.017
Melosira	.027			.017		.030					.040						.030			.003		.003	
Rhizosolenia	.017	.003	.020	.003	.013	.003	.023	.050	.023	.083	.020	.020	.023	.010	.027	.017	.030	.027	.007	.007	.047	.007	.010
Fragilaria	.017	.013	.017	.020	.017	.027	.010	.037	.023	.017	.023	.017	.023	.013	.013	.017	.010	.020		.010	.077	.010	.027
Tabellaria	.040	.083	.107	.077	.033	.057		.023	.003		.033		.020		.013								
Navicula					.003			.003	.007	.003	.003	.007		.003		.003		.007	.003	.003	.003	.003	.003
Asterionella	.027	.013	.003	.033	.007	.007		.040	.033	.027	.007	.057		.007	.007	.027	.027	.087					
Synedra	.003	.013		.037	.010	.013	.020	.010	.020	.023	.010	.013	.027	.027	.013	.023	.030	.037					
Pinnularia																							
Stephanodiscus	.003			.007										.003									
Diatoms	.047			.080	.067															.007			.007
Columbina	.010	.003	.003	.010	.017	.020		.020		.020	.023	.003	.003	.013	.023	.043	.010	.020	.003	.003	.033	.007	.003
Cryptogamia			.107		.013									.013	.013	.013	.033			.027		.013	
Scenedesmus				.003	.027	.013		.013							.007	.007	.007	.007					.013
Quadrula		.050	.003		.003					.007								.003		.003			
Ankistrodesmus	.003			.003	.007	.013	.020	.010	.017	.017	.020	.030	.010	.017	.010	.003	.007	.010	.007	.010	.030	.017	.007
Dicranosphaerium	.073	.040																					
Microneis																							
Cryptomonas	.023	.030	.020	.020	.013	.033	.010			.037	.017	.023		.003	.013	.013	.010	.020	.010	.013	.007	.040	.017
Mallomonas	.010		.007		.010	.010			.007	.010	.003	.003	.003	.007		.013	.007	.010	.007	.003		.020	.007
Leptodermis	.010	.007	.020	.010	.020	.017	.003	.007	.003	.023	.017		.020	.027	.033	.037	.020	.007	.007	.010	.020	.003	
Oocystis	.050	.020	.003	.017	.010		.050	.127	.320	.040	.150	.067	.007	.007	.017	.040	.023	.017	.010	.003	.003		
Oscillatoria filament			.013	.020	.007	.010	.020		.017	.030	.057	.020	.047	.037	.037	.037	.057	.033	.020		.033		.007
Coelosphaerium colony									.003														
Aphanocapsa colony	.003	.003	.007			.007								.003		.010	.007						
Chrysocapsa colony																							
Marismopodia colony																							
Microcystis colony																							
Gloeocapsa					.007	.007																	
Anabaena	.020																.003						
Coelastrum																							
Tetradron																							
Centritractus	.003		.003										.003										.003
Chodatella																							
Hydrotheca									.027		.003												
Spondyliolum													.003										
Glenodinium												.010						.007		.003			
Ceratium							.003																
Phacus				.003																			
Trachelomonas																			.007				
Cymbella																			.003				
Nitzschia																							
Synura colony																							
Staurastrum						.003																	
Pediastrum		.007																					

TABLE II (cont.)

Location	Whittlesby Lake						Intermediate Lake						Richie Lake						Feldmann Lake			
	West			East			West			East			North			South			North		South	
Depth	S	3	S	S	3	S	S	3	S	S	3	S	S	3	S	S	3	S	S	2	S	2
Flagellates > 5 microns	.160	.197	.257	.233	.257	.217	.407	.263	.150	.560	.247	.137	.267	.237	.340	.313	.247	.400	.180	.180	.300	.150
Flagellates < 5 microns	.193	.303	.223	.200	.247	.243	.327	.340	.197	.197	.390	.190	.693	.740	.623	.667	.723	.533	.470	.503	.437	.540
Cyclotella	.130	.107	.110	.077	.080	.093	.003	.003	.003		.003	.007										
Dinobryon	.003	.010	.007	.010	.007	.003	.010	.040	.027	.017	.027	.017	.013	.007	.003		.010	.007				.007
Valosira	.097	.107	.133	.077	.177	.110	.003		.020		.020							.037				
Rhizosolenia	.017	.020	.010	.033	.013	.027	.010	.013	.027	.010	.010	.020										
Ercillaria	.043	.020	.020	.017	.013	.027	.007	.017	.007	.013	.010	.023				.003						
Tabellaria	.007		.003		.003	.007			.007						.007		.003					
Navicula	.003	.007		.007		.007	.003		.020	.003	.003	.010	.003				.003					
Asterionella			.007		.003															.020		
Synedra																						
Pinnularia					.003																	
Stephanodiscus																						
Diatoma																						
Golenkinia	.003					.003	.020	.020	.013	.007	.010	.003					.003	.003	.003	.003	.007	
Crucigenia	.013		.023		.027	.013	.007				.007								.057	.060	.040	.053
Scenedesmus			.010		.027														.013			
Quadrifida	.037	.017	.007	.030	.007	.027						.003	.003				.003	.003	.027	.053	.003	.020
Ankistrodesmus	.080	.047	.077	.070	.043	.077	.023	.007	.010	.010	.020	.007					.010		.003	.007		.007
Microcystis				.033				.020		.013		.027							.033			.020
Kirchneriella					.013		.023					.003										
Cryptomonas	.017	.007	.020	.013	.023	.023	.003	.010	.007	.003		.003		.007		.003		.003	.013	.010		
Mallicomonas	.013	.007	.023	.017	.013	.023	.010	.003		.013	.003		.013		.003	.013	.003	.007	.003	.020		.007
Kephyrion	.010	.010	.007	.007	.003	.017					.007		.007	.013					.003			
Oocystis																			.040	.017	.037	.040
Oscillatoria filament	.090	.050	.050	.093	.017	.040	.150	.257	.453	.150	.223	.463	.003		.007	.003	.003		.010	.003	.010	.003
Coelosphaerium colony	.007	.007										.003							.007	.007	.020	
Aphanocapsa colony	.023	.023	.017	.013	.017	.017													.053	.030	.003	.070
Chrysocapsa colony	.010	.010	.010	.007	.013	.010																
Merismopedia colony																					.003	
Microcystis colony																					.003	
Gloeocapsa																			.087	.067	.113	.073
Anabaena	.013			.053		.017		.047		.013												
Coelastrum	.020																					
Tetraedron																			.007	.013	.017	.007
Centrictrachus		.010	.003	.007		.003																
Chodatella							.007	.020	.003	.003												
Hyalotheca																						
Spondylosium																						
Glenodinium	.003																		.007			
Ceratium																						
Phaeus																						
Trachelomonas																						
Cymbella			.003	.003																		
Kirchneria																						
Staurastrum colony					.003																	
Staurastrum																						
Pediastrum																					.003	

Table III

	H'	H' _{max}	J'
Chippewa Harbor	0.864	1.298	0.665
Siskiwit Lake	0.842	1.227	0.686
Wood Lake	0.639	1.173	0.547
Lake Whittlesey	0.999	1.309	0.763
Intermediate Lake	0.695	1.160	0.599
Lake Richie	0.331	0.836	0.402
Feldtmann Lake	0.727	1.183	0.614

Mean values for Phytoplankton Diversity Indexes. These values are the overall means from each lake.

Intermediate Lake contained ca. 57% small flagellates and over 28% Oscillatoria spp.. This is the only lake to contain a mean Oscillatoria abundance greater than 6%. At both sampling locations the relative abundance of Oscillatoria spp. increases with depth, and at 5 meters contributes over 45% of the phytoplankton community.

The small flagellate abundance in Siskiwit Lake was ca. 67%. Cyclotella spp. contributed ca. 12%. The dominant Cyclotella species in Siskiwit Lake was C. melasiroides. Oocystis sp. was abundant at the western location and to a lesser degree at the eastern location. This species contributes ca. 32% of the phytoplankton count at 5 meters at the western sampling site. Wood Lake contained ca. 78% small flagellates. The only other abundant genus was Cyclotella (ca. 7%).

Lake Whittlesey had a small flagellate abundance of ca. 22% which was

the lowest recorded. Other abundant genera were Melosira (ca. 12%), Cyclotella (ca. 10%), Ankistrodesmus (ca. 7%) and Oscillatoria (ca. 6%). This is the only lake where Melosira contributed more than 2% of the count. ~~Lake Whittlesey~~ had the highest mean J' value of 0.763. Chippewa Harbor contained ca. 63% small flagellates and an abundance of various diatoms. The most abundant diatom was Tabellaria spp.. Feldtmann Lake was the only lake having an absence of diatoms and an abundance of Gloeocapsa spp. (ca. 8%).

Relative abundance data are not available for Wallace and Scholts lakes. Only net tow samples were collected from these lakes, thus, the samples do not contain small flagellates. These two lakes had a more diverse representation of desmids (Zygnematales) than the other lakes. Pleurotaenium, Euastrum, Micrasterias (Zygnematales), Gloeocystis, Calothrix, and Achnanthes were identified only from the lakes. Wallace Lake contained three species of Ceratium: C. hirundinella, C. carolinianum, and C. cornutum; only C. hirundinella was identified from the other lakes.

Absolute estimates of phytoplankton numbers and biomass were not determined; however, a subjective estimate can be made. Richie and Intermediate lakes had the greatest concentrations while Siskiwit Lake and Chippewa Harbor had the lowest concentrations. Detritus was very abundant in the water column of Feldtmann Lake relative to the other lakes. Table VII is a phytoplankton taxa list with relative abundances in each lake. One hundred and forty-nine taxa have been identified.

RESULTS

Insects

Table IV contains a summary of all insect genera collected from the thirteen sample areas. Each genus is listed as being present (1 or 2 individuals), common (3-5 individuals in one sample or present in more than one sample from the same site), or abundant (more than five individuals), at each sample site. Also, those marked with an asterisk (*) are genera not previously reported on Isle Royale.

The dominant insect order in the entire collection was the trichopterans (caddisflies). This order comprised nearly 47% of the total number of insects collected. The second most abundant group was the dipterans (true flies) which contributed over 25% of the total. The ephemeropterans (may flies) were the third most abundant order. The eight orders of aquatic insects collected and their relative abundances appear in Table IV.

Table IV

Percent Composition of Insect Samples From Isle Royale Lakes and Streams

	Lakes	Streams	Overall
Trichoptera	27.3	48.5	46.8
Diptera	14.9	26.6	25.7
Ephemeroptera	15.7	11.7	12.0
Coleoptera	18.2	6.7	7.6
Odonata	21.5	3.6	5.0
Plecoptera	0.0	2.1	1.9
Hemiptera	2.5	0.8	0.9
Lepidoptera	0.1	0.0	0.0

The most abundant genera are: Lepidostoma, Glossosoma, Hydropsyche, and Cheumatopsyche (Trichoptera); Baetis (Ephemeroptera); Optioservus and Stenelmis (Coleoptera); Eukiefferella, Polypedilum, and Simulium (Diptera). Trichopterans and dipterans appear to be the most diverse groups with 32 and 40 genera, respectively. Blackflies and midgeflies may be more abundant in streams than in lakes. Caddisflies may be more numerous in stream samples than in lake samples. Stream samples had a mean of 7 ± 2.7 specimens per family per sample ($n=53$, $s=15.0$). Lakes had a mean of 2 ± 0.6 specimens per family per sample ($n=13$, $s=1.6$). A modified Student t-test produced a critical value of 1.300. The table value at 90% confidence level is 1.295. Benson, Wallace, and Feldtmann Creeks contained more blackflies and midgeflies than did the other streams. Midgeflies were especially common in Feldtmann Creek.

The total numbers of insects per sample were low compared to samples obtained from similar habitats in Houghton County, Michigan. Richard Bowden, while conducting field research on Isle Royale for his masters thesis (June-October, 1979) obtained similarly low total numbers per sample. (Personal communication). Total numbers of insects per sample for the island streams were generally less than one hundred while mainland streams generally yielded more than one hundred insects per sample.

DISCUSSION

Limnology and Phytoplankton

The phytoplankton community of each lake is distinct from that of the other lakes. The major differences are the relative numbers of small flagellates, the occurrence or absence of diatoms (Centrales and Pennales) as dominants, and the occurrence or absence of certain diatoms and blue-green algae (Cyanophyta). The dominance of small flagellates is somewhat artificial because several genera are represented in each subgroup. The grouping of these genera also lowers the diversity indexes, but these indexes are none the less useful when comparing these data. It should be stressed that small flagellates dominate the lakes numerically and may not be volumetrically dominant. One Cyclotella bodanica cell may equal the volume of 900 flagellates with a diameter of five μm .

Hutchison (1967), Palmer (1969) and others have attempted to categorize phytoplankton groups as indicators of the trophic status of lakes. Taylor et al. (1979) in a study concerning 250 southeastern U.S. lakes have identified a nutrient-rich group of genera and a nutrient-poor group of genera. The nutrient-rich group included Chodatella and Golenkinia while the nutrient-poor group contained Asterionella, Tabellaria, Dinokryon, and Ceratium. Of the 57 most common genera no single genus could be classified as indicator organisms. Truly oligotrophic lakes did not occur in that study. Rawson (1956) suggests that specific indicators of oligotrophic habitats may not exist; those plankton found in oligotrophic

lakes may be the residue of those species that are tolerant of a wide range of conditions and may also thrive under meso- or eutrophic conditions. These studies have not considered the nanoplankton (those less than ca. 20 μm ; the categories termed 'flagellates' in the present study). Hutchison (1967) points out that the dominant species numerically and/or volumetrically may be a member of the nanoplankton not collected by techniques used in earlier investigations.

In addition to the small flagellates, Siskiwit Lake was dominated by Cyclotella melosiroides with subdominants of Asterionella, Rhizosolenia, Oocystis and Oscillatoria. Hutchison (1967) describes the first three taxa as characteristic dominants in some oligotrophic lakes and further states that certain large unproductive lakes throughout the world have Oocystis species as dominants. Siskiwit Lake had a mean Oocystis abundance of over 7% and at one particular depth this genus contributes over 30% of the total. Oscillatoria is generally considered a more eutrophic genus; however, Fahnenstiel (MS thesis in progress) has found O. limnetica and O. minima common in offshore waters of Lake Superior.

The phytoplankton community of Wood Lake is similar to that of Siskiwit Lake; however, the only dominant diatom is Cyclotella operculata. C. melosiroides was not recorded in Wood Lake. The oxygen maxima observed at 4 m. in Wood Lake (figure 2) was probably due to increased photosynthetic rates. Oxygen maxima of this type are commonly observed at or just above the thermocline (Wetzel, 1975). An increase in total numbers of phytoplankton at this depth cannot be determined from these data.

The alkalinity and secchi disk depths of Chippewa Harbor, Siskiwit Lake, and Wood Lake are greater than those of the other lakes. Siskiwit Lake seems to have the lowest nutrient concentrations of all lakes examined.

Melosira is considered indicative of meso- and eutrophic habitats with M. granulata seldom occurring in oligotrophic waters (Hutchison, *ibid*). Lake Whittlesey is the only lake where M. granulata was recorded (Table VII). This lake was dominated by several Melosira and Cyclotella species with subdominants of Ankistrodesmus and Oscillatoria. Lake Whittlesey had the highest diversity index. This is partially due to relatively low number of flagellates.

An interesting observation concerning the phytoplankton of Intermediate Lake is the increasing abundance of Oscillatoria with depth. This may be due to sedimentation and/or light and temperature preferences. Some species of Oscillatoria are known to have optimal growth at low temperatures and low light intensities (Hutchison, 1967). These species may cause algal blooms in winter or shortly after the ice thaws in spring.

Oxygen deficits in the deeper waters of the lakes (most noticeable in Intermediate Lake, figure 2) are the result of aerobic decomposition. This is indicative of productive waters. The oxygen minima at 3 m. in Lake Richie (north) may be related to thermal stratification and/or differential settling rates of decomposing organic matter. Organic matter may be accumulating just above the thermocline (ca. 4 m.) and reducing the oxygen concentration through increased decomposition. The oxygen profile may be the result of temperature alone; at both 3 and 5 m. the oxygen saturation is 82%.

The major differences at Feldtmann Lake are the abundance of Gloeocapsa and the absence of diatoms. Hutchison (1967) treats Gloeocapsa as Anacystis and describes it as an eutrophic form of productive temperate lakes. Scenedesmus is described as a warm water form (Hutchison, 1967) and is a subdominant in this lake. Diatoms were scarce in Feldtmann Lake; only seven taxa were identified compared to an average of twenty-two diatom taxa per lake for the other lakes. Low diatom numbers are probably the result of seasonal succession described by Hutchison (1967) and Watzel (1975). During spring overturn there is an abundance of dissolved silica (diatoms require silica in the formation of their lorica). This abundance produces a spring algae bloom commonly dominated by diatoms. As this initial nutrient supply is depleted the diatom dominance subsides and green (Chlorophyta) and blue-green (Cyanophyta) algae become more numerous. The low concentrations of dissolved silica recorded at Feldtmann Lake support this. This lake probably doesn't stratify to any degree during the summer because the lake is shallow and unprotected from prevailing winds. These circumstances allow mixing of the water column throughout the summer. Figure 2 indicates no thermal stratification even though the water temperature has risen above 21°C. The large amounts of detritus suspended in the water column are a result of continual mixing and turbulence brought about by wave action.

There seem to be trends associated with the relative abundances of flagellates with depth. At one or both sampling locations in every lake the percentage of flagellates less than 5 μ m is at a maximum near 3-4 m.. Their abundance at the surface and the third sampling depth is less than

at intermediate depths. These observations may be the result of interactions between these small phytoplanktons and light, temperature and sedimentation. Ultraviolet radiation is greatest near the surface and is known to be detrimental to many algae (Wetzel, 1975) and Goldman et al. (1963) have demonstrated photoinhibition of phytoplankton at high light intensities. The ecology of these small flagellates is not well understood. Their importance in lake metabolism is probably greater than is generally believed, especially since they may produce dense populations at low temperatures and light intensities (Wetzel, 1975).

Prescott (1937, 1938, 1939, 1940) and Taylor (1935) have examined algae samples from Wallace Lake and others on the island. Prescott has published a list of desmid flora for the island including many state records and several North American records. Throughout the collections of the present study many genera could not be identified at the species level with available keys. Commonly the dimensions of Isle Royale phytoplankton were outside the minimum and maximum of the range of published values. Several specimens were quite different from published descriptions. Seventythree species or genera have been identified that do not appear in the lists of Prescott and Taylor.

Aquatic Plants

Several lists have been compiled of the known vascular plants of Isle Royale National Park, the most recent and extensive of which is a tentative list by Dr. Robert Janke, Michigan Tech and Dr. Edward G. Voss, ~~University of Michigan~~ ~~Michigan State University~~. Several new species can be added to the list by this study at this time, with other good possibilities (*) yet to be verified. These specimens along with others missing from the I.R.N.P. herbarium as vouchers will be given to the park herbarium. The Michigan Tech herbarium received specimens in both the aquatic plant and byrophyte herbarium.

Lemna minor L. South end Benson Lake and Wallace Lake watershed
near Moskey Basin

Eleocharis pauciflora (Light f.) Link Wallace Lake

Potamogeton robbinsii Oakes. Lake Richie

*P. spirillus Tuckerman. Lake Richie, Lake Whittlesey

*P. pusillus L. Newt Lake, Wallace Lake, Feldtman Lake
Intermediate Lake

*P. strictifolius Tuckerman. Wood Lake

*Isoetes echinospora Durieu. Wood Lake, Feldtmann Lake, Lake Livermore

*Lycopus virginicus L. Wood Lake

*Ranunculus Purshii (Gray, B&B, Rydb.) Lake Richie

*Cardamine pensylvanica Muhl. Wallace Creek

A species list by location and relative abundance of some species is found in Table IX, in the appendix.

New bryophytes include:

Anomodon rostratus Hedw. near Newt L. and Moskey Basin

Calliergonella cuspidata Hedw. Wallace Lake

Grimmia apocarpa var. stricta Turn. near Newt L. and Moskey Basin

Dicranella schreberiana Hedw. near Newt L. and Moskey Basin

Mnium cuspidatum Hedw. Wallace Lake

DISCUSSION

Insects

Dipterans and trichopterans may be more common in lotic than in lentic environments (Table IV), while the opposite may be true for the members of the order Odonata. This might be expected on the basis of the general habitat preferences of these groups. Dipterans (especially blackflies) and most of the trichopteran genera collected prefer lotic erosional habitats, while dragonflies and damselflies prefer lentic or lotic depositional environments. (Merritt and Cummins, 1978)

The results above may be biased due to a more concentrated sampling effort in the stream habitats. Out of 57 samples taken, 46 were from streams. A more equal proportion of samples is required to make accurate comparisons.

Many of the stream samples were taken from Benson Creek because of its nearness to Daisy Farm Campground. These samples contained very few aquatic insects. Twenty eight samples yielded only about three hundred insects-many of them being dipterans. One possible reason for the low insect numbers in this stream is that a flood which was reported in early June may have reduced insect numbers. The effect of floods on insect populations is well documented by Hynes (1972) among others. A second possibility is that the insects can not withstand the periods of reduced water flow which occur in Benson Creek. The creek has been reported to dry up in late summer.

The samples taken from the southwest end of the island, (especially Feldtmann Creek), contained many more chironomids than did any of the other

samples. This difference could be the result of many factors - the most likely being time. Feldtmann Creek was sampled on July 28, while the other streams were sampled during June. Richard Bowden found that the two most common genera - Eukiefferella and Polypedilum - were most abundant in island streams during July and August. (Personal communication).

Two other factors may have affected the chironomid population differences between the two areas. Since many of the early larval instars are planktonic and hard to capture they may have been overlooked in the samples from Benson, Wallace, and Lake Richie Outlet Streams. The swift current of these streams may also have limited the chironomid fauna since the least extensive chironomid fauna are found in habitats exhibiting extreme conditions of flow, salinity, temperature, etc. (Merritt and Cummins, 1978).

The genera Nymphula, Dixella, Anopheles, Hyperodes, and Dasyhelea were not common in the samples. This rarity is probably due to sampling techniques than any other reason. Nymphula, Dixella, and Anopheles commonly live in the surface film of ponds and puddles and thus may have been missed. Hyperodes usually is semiaquatic, living on aquatic plants. Dasyhelia larva are extremely small and thus may have been overlooked.

WALLACE LAKE AQUATIC PLANTS

Introduction

Wallace Lake was selected for a percent cover study of its aquatic vegetation because of its accessibility, size and the variety of plant species. Stratified random sampling was used to gather data useful in visualizing the vegetation zones of the lake. Sampling was conducted from the deep water to shoreline areas, including floating bog mats and an area adjacent to a beaver dam, to determine the plant species present and estimate their percent coverage.

Study Site Description

The lake area at sampling time is approximately 80,000 sq. meters. The greatest depth in the center of the lake was 3.4 m., which is somewhat greater than what was reported by Humpheries (1962) (Table 1). This is probably due to a rise in lake level caused by beaver dams. Numerous floating mats form a discontinuous chain parallel to the northern and western shores. The region between the mats and the shoreline contained water choked with log snags, deadfalls and numerous floating and submergent plants. This area was browsed by moose daily during the sampling period from July 8 to July 22.

The southern shore was relatively free of floating mats and much of the shore is bounded by rock walls. There were two beaver dams on the lake: one on the southeastern shore and the other at Wallace Creek, the major outlet of the lake.

The mean afternoon water temperature at a depth of ca. 50 cm. was

figure 3
WALLACE LAKE

Major Locations of Vegetational Cover

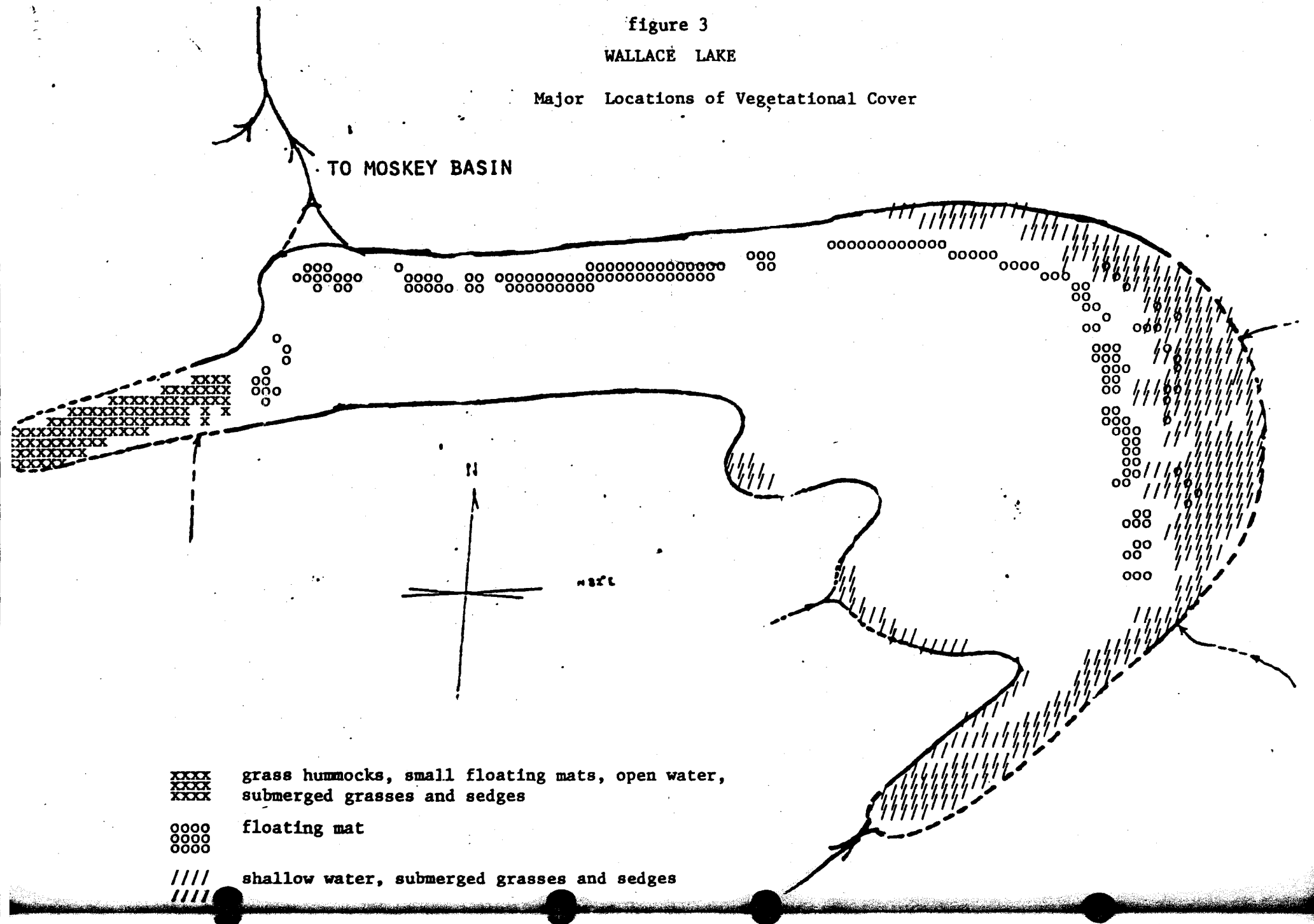
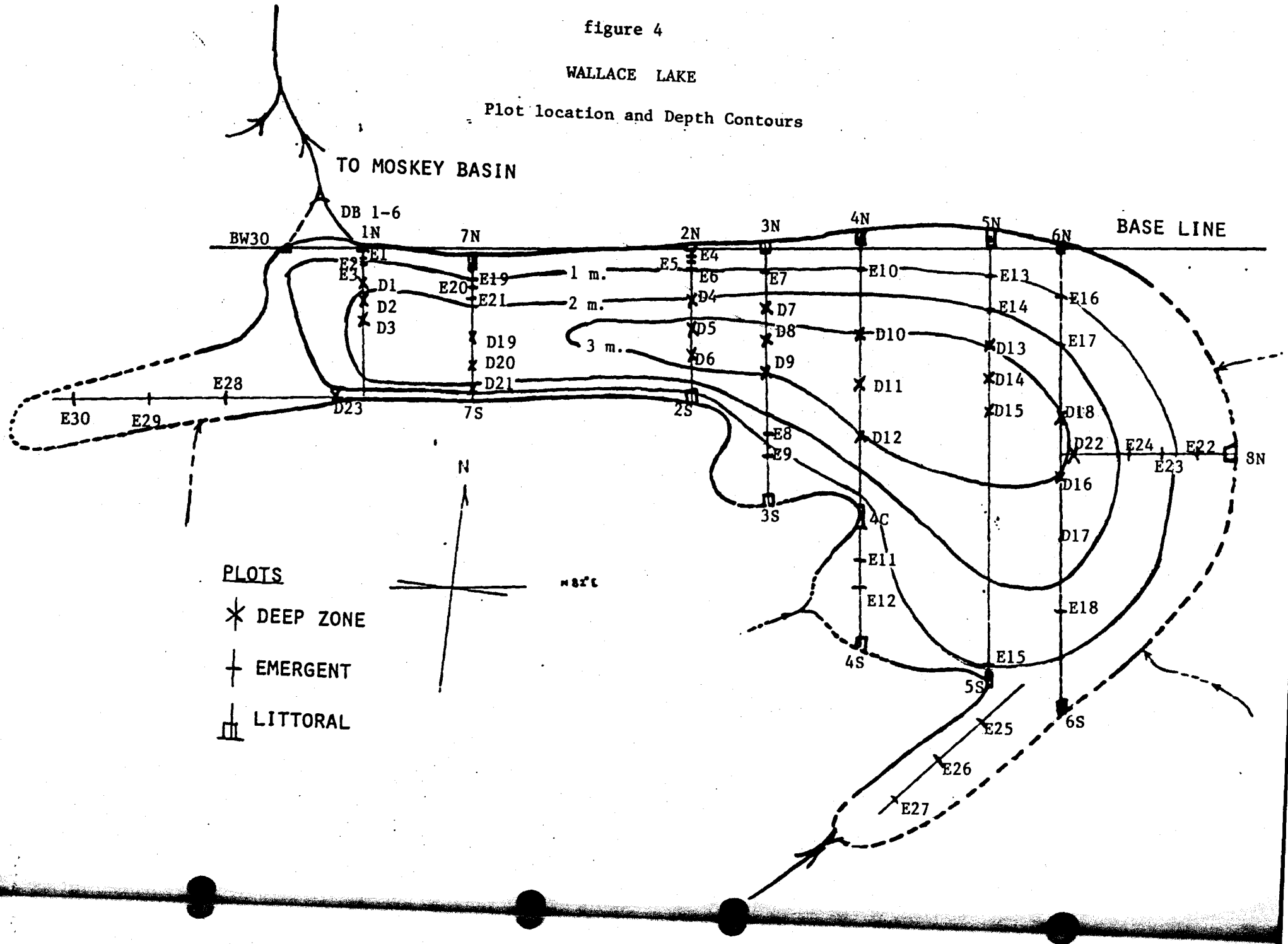


figure 4

WALLACE LAKE

Plot location and Depth Contours



23.8°C and the pH was 6.5.

Methods

Random stratified sampling began by establishing a baseline (bearing N 82° E) along the northern shoreline. Metered nylon twine was used for distance measurements. Using the length of the baseline and a topographic map the lake was divided into seven artificial regions of approximately equal surface area and shoreline distance. A sampling transect extending across the lake perpendicular to the baseline was randomly located within each of these seven regions by drawing a number from a hat. An additional sampling transect perpendicular to the seven sampling transects was located at both the east and west ends of the lake. Two other transects were established: one in a small inlet at the southeastern end of the lake and the other below a beaver dam at the Wallace Creek source. The transects were established for sampling by stringing a nylon cord across the lake and fastening at both shorelines. The plots were located along each transect in the following manner.

The shoreline zone reached from the water's edge to water 0.5 m. deep. The shoreline plots were the depth of the zone and of randomly selected width from 0.2 - 1 m. and centered on the transect line.

The next zone was called the emergent zone and continued from 0.5 m. deep water to the outer reaches of the floating plants. The length of this zone was the combined lengths of both emergent zones from opposite shores. There were no emergent zones adjacent to rock walls. A minimum and maximum spacing was selected for each transect so that each emergent zone had three evenly spaced plots of randomly selected interplot spacing.

The plots were bounded for observation by a wooden 1x1 m. square frame.

The deep zone contained few or no floating plants and was continuous throughout the lake. The length of the zone was measured, a maximum and minimum spacing established for that particular transect and the spacing for the 1x1 m. plot randomly drawn. Plant abundancies were estimated by visual observations or by grapple hook sampling. When using the grapple hook plant abundancies were estimated as abundant, common or sparse, depending on the amount of material brought up by repeated grabs. With no underwater observations these methods served as our only visualization of deep water plots. Much of the emergent and deep water sampling was from a canoe.

The mat zone was sampled as a portion of the emergent zone and as a separate zone. When we recognized that the mats were not well represented with our sampling, we selected locations for three additional plots along an unsampled portion of the mats near the northern shore. These 1x1 m. plots were randomly spaced and sampled with the same techniques as above.

The area adjacent to the beaver dam was sampled with six plots located on a grid transecting the area. The same procedures as above were used to estimate percent coverage of the plant species.

With all sampling any given species would have to be present in an amount greater than 1% surface area (total coverage of greater than 100% were possible from overlapping plants) to be tallied. The presence of the other species were noted for the location species list. Vouchers were collected for unknown species of sample plots for later determination.

Cluster analysis of the plot data used the Jaccard coefficient of association. The coefficient is defined by the equation:

$$S_j = \frac{a}{a+b+c} \quad \text{where } a, b \text{ and } c$$

are standard notation for a 2 by 2 contingency table as shown below, taken from Kaesler and Cairns (1972).

	species i	present	absent
species j	present	a	b
	absent	c	d

The computer program used (G.F. Bonham-Carter, 1967) would basically compare species present in a plot and a different plot to develop a similarity coefficient. The coefficient range is 0.0 to 1.0, 1.0 being an identical match of species. The cluster of the similar plots is then plotted as a dendrogram, where zonation patterns, if present, may be visualized.

The cluster analysis included as parameters the quantitative plot data including presence/absence and weighting of selected species having a large range and frequency in plots sampled. The weighted species either received 2 or 3 columns and the scale was one of the following: 3 column 1-10%, 11-50%, 51-100%; Graminae and Cyperaceae stem counts, 0-100, 101-300, 301-up; Equisetaceae stem counts, 2 columns, 0-50, 51-up. A table was constructed of all the columns for each species vs. the plots in which it was located.

The presence of a species in a given plot of a presence or absent column would be indicated by a 2, while an absence would be indicated by

Table V

A listing of the frequency and percent cover of given taxa found in one or more of the zones visible in the Wallace Lake dendrogram.

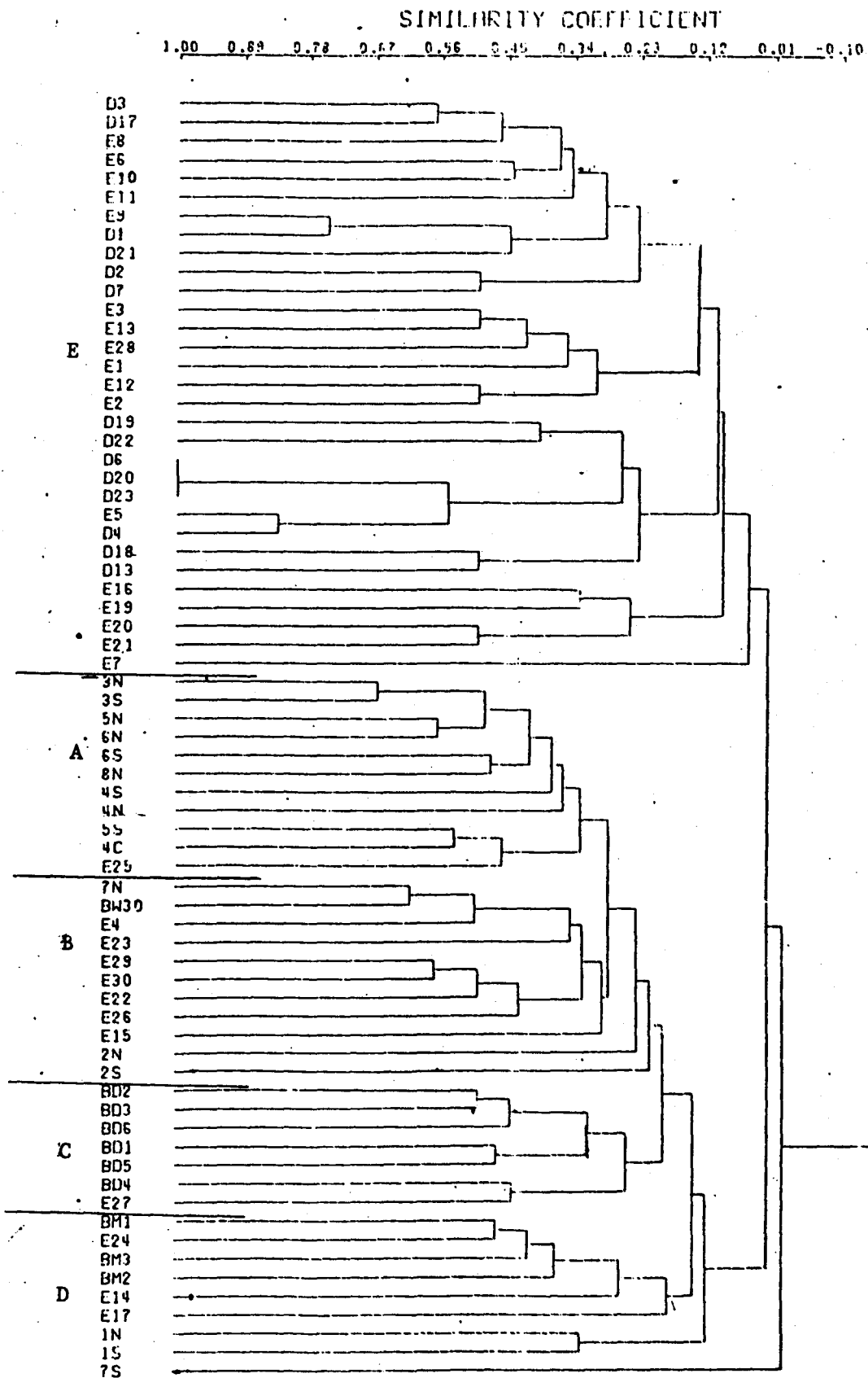
	A Shoreline Emergent 11 plots total frequency/ ave. % cover	B Littoral Emergent 11 plots total frequency/ ave. % cover	C Deeper Run 7 plots total frequency/ ave. % cover	D Deep Mat 6 plots total frequency/ ave. % cover	E Patchy Deep 31 plots total frequency/ ave. % cover
<i>Cyperaceae</i>	10 / 82 stems	8 / 95 stems	7 / 52 stems	3 / 20 stems	
<i>Cyperaceae</i>	11 / 255 stems	9 / 296 stems	6 / 200 stems	5 / 51 stems	3 / 15 stems
<i>Polichium arundinaceum</i>	4 / 32	5 / 72	1 / 12		
<i>Eleocharis</i> spp.	1 / 69 stems	2 / 8 stems	1 / 2 stems	1 / 4 stems	2 / 20 stems
<i>Scirpus arvensis</i>	7 / 23 stems	1 / 5 stems	1 / 11 stems		
<i>S. flavistylis</i>	8 / 100 stems	7 / 26 stems	3 / 20 stems		
<i>S. setispides</i>		1 / 94 stems			
<i>Potamogeton natans</i>	1 / 82				10 / 112
<i>P. perfoliatus</i>					15 / 252
<i>P. arifolius</i>	3 / 1.32				5 / 42
<i>P. perfoliatus</i>		1 / 42			2 / 322
<i>P. heterophyllus</i>	2 / 22				5 / 142
<i>Sagittaria</i> spp.		2 / 12	6 - 42		12 / 102
<i>Sagittaria</i> spp.	1 / 22	3 / 32	3 / 142		
<i>Najas variegata</i>					9 / 62
<i>Hydrochara affinis</i>	1 / 12	2 / 142		2 / 82	8 / 102
<i>Polypodium natans</i>	1 / 82	1 / 22			1 / 82
<i>Iris versicolor</i>	7 / 1.32	1 / 22	2 / 12	2 / 12	
<i>Priscularia vulgaris</i>	2 / 22	3 / 42			3 / 152
<i>P. intermedia</i>	8 / 42	9 / 32		1 / 12	2 / 32
<i>P. gibba</i>	2 / 32	1 / 12			
<i>P. minor</i>				1 / 12	
<i>Bryopside (non-Sphagnum)</i>	10 / 9.32	4 / 112		3 / 32	
<i>Sphagnum</i> spp.		2 / 102		6 / 432	
<i>Potentilla palustris</i>	11 / 102	7 / 32	1 / 42	6 / 82	
<i>Lychnis terrestris</i>	3 / 12	3 / 12	3 / 22		
<i>L. thymifolia</i>	1 / 22	1 / 12	1 / 12		
<i>Chamae</i> sp.	1 / 22	4 / 192			13 / 262
<i>Filiculus (forma)</i>	2 / 42			2 / 142	
<i>Carex</i> spp.	1 / 12	1 / 12	2 / 12	2 / 12	
<i>Andropogon glaucophyllus</i>				2 / 12	
<i>Prunella rotundifolia</i>	1 / 22			4 / 32	
<i>Fragaria virginiana</i>	2 / 22			1 / 22	
<i>Chenopodium calyculata</i>				4 / 152	
<i>Menyanthes trifoliata</i>	2 / 82			4 / 72	
<i>Ledum greenlandicum</i>				2 / 262	
<i>Lychnis latifolia</i>			3 / 342	1 / 22	
<i>Senecioium maculatum</i>			3 / 112	1 / 12	
<i>Thalictrum</i> sp.			4 / 32	1 / 42	
<i>Carex stenophylla</i>	1 / 22				
<i>Vaccinium</i> sp.				2 / 22	
<i>Prunella elliptica</i>		2 / 32			
<i>Scutellaria</i> spp.			3 / 22		
<i>Imnula</i> sp.			3 / 82		
<i>Alnus incana</i>	6 / 92		2 / 32	4 / 82	
<i>Lychnis uniflorus</i>	2 / 12			3 / 32	
<i>L. americana</i>			2 / 32	1 / 12	
shallow liverworts				1 / 12	
leafy liverworts				1 / 32	

0 - % cover conversions for grapple low data; abundant 402, common 252, sparse 22

Figure 5

Wallace Lake Aquatic Plants
Jaccards Coefficients of Association
Unweighted Pair-Group Method

Sample plots vs. Similarity coefficient



What had appeared to us to be one region, the floating plant and emergents the dendrogram showed as 2 regions, an emergent littoral and a portion of a patchy deep zone.

A Table of species percent cover and frequency in plots located in one or more of the five zones defined by the dendrogram showed the following prominent species in each lake zone (in greater than 5% abundance in the given zone):

A. Emergent Shoreline- with grass hummocks

Alnus rugosa, Menyanthes trifoliata, Potentilla palustris, Bryopsida (non-Sphagnum mosses), Polygonum natans, Equisetum arvense, E. fluviatile, Eleocharis spp., Cyperaceae and Gramineae

B. Emergent Littoral- with grass hummocks

Hypericum ellipticum, Chara sp., Sphagnopsida (Sphagnum spp.), Bryopsida, Nymphaea odorata, Sagittaria spp., Equisetum fluviatile, Dulichium arundinaceum, Cyperaceae and Gramineae

C. Beaver Dam- with grass hummocks

Impatiens sp., Thalictrum sp., Eupatorium maculatum, Typha latifolia, Potentilla palustris, Sagittaria spp., Equisetum fluviatile, Cyperaceae and Gramineae

D. Floating Mat

Alnus rugosa, Ledum groenlandicum, Menyanthes trifoliata, Chamaedaphne calyculata, Filicales (ferns), Potentilla palustris, Sphagnum spp. Nymphaea odorata

E. Patchy Deep

Chara sp., Utricularia vulgaris, Polygonum natans, Nymphaea odorata,
Nuphar variegatum, Sparganium sp., Potamogeton pusillus, P. zosteriformis,
P. natans, P. amplifolius, Eleocharis spp.

SUMMARY AND CONCLUSIONS

All lakes except Feldtmann showed signs of thermal stratification. Oxygen deficits in the deeper waters (most noticeably in Intermediate Lake) are the result of aerobic decomposition indicative of productive waters. Siskiwit Lake seems to have the lowest nutrient concentrations of all lakes examined. All the lakes are probably susceptible to acid precipitation damage since all lake pH's are acidic and the buffering capacities are relatively low.

The main differences between lakes when considering phytoplankton lies in the relative abundance of small flagellates and the relative abundance or absence of diatoms. A subjective estimate of phytoplankton numbers and biomass shows Richie and Intermediate Lakes had the greatest concentration while Siskiwit Lake and Chippewa Harbor had the lowest concentrations. Organic detritus was very abundant in the water column of Feldtmann Lake relative to the other lakes.

The insects were found to be in relatively low numbers and diversity. The dominant insect order was ~~the~~ trichopterans. Dipterans and ephemeropterans were also relatively abundant. The trichopterans and dipterans showed the most diversity in terms of genera. Previous studies principally dealt with families and were not extensive. This study adds many new species and genera to the taxa lists.

Cluster analysis of the percent cover data of Wallace Lake aquatic plants shows five vegetational zones with different plant species dominating each zone.

Plant taxa lists show several new aquatic plants and bryophytes which were not previously reported for the island.

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University of Michigan!!!
Herbarium for plant verification.

Future research should include similar studies (Limnology, insect, and phytoplankton) at other areas of the island since only a small portion of the island was included in this study.

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APPENDIX

Figure 6

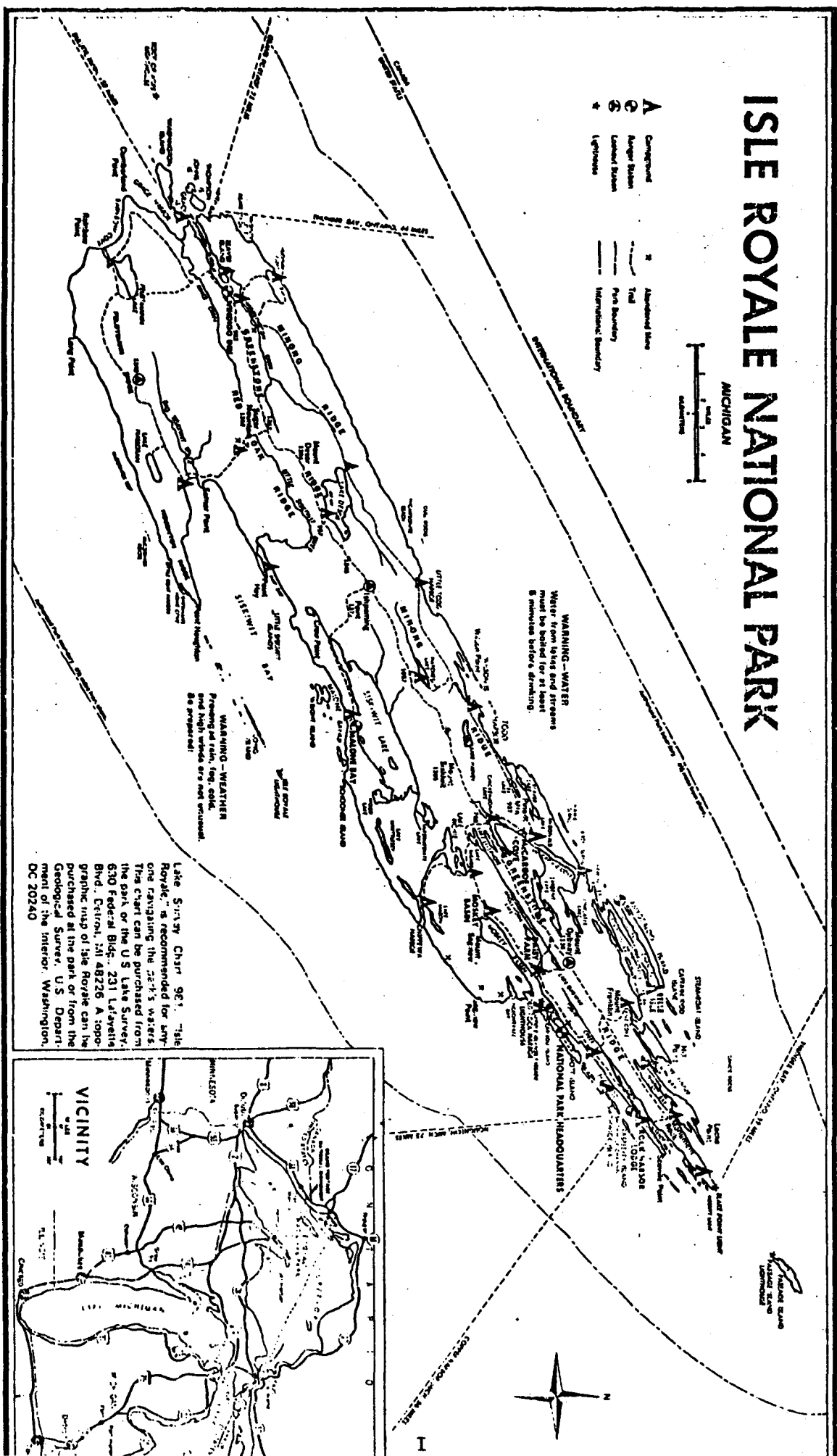


Table VI

PHYSICAL AND CHEMICAL DATA

CHIPPEWA HARBOR WEST 6/26/79		1200 Hr. secchi - 5 m.					
Depth (m.)	Temp. (°C)	DO (mg/kg) (% sat'n)	Alk (mg/kg) CaCO ₃	pH	PO ₄ (µg/kg)	SI (mg/kg)	N-NH ₄ (mg/kg)
0	13.0	10.09 (100%)	35.1	9.25	16	1.5	.00
1	13.0						
2	12.7						
3	12.5						
4	12.4	10.03 (97%)	35.6	9.25	28	1.7	.03
5	12.3						
6	12.3						
7	12.2						
8	10.0	10.30 (96%)	35.2	9.25	40	1.7	.73
9	10.0						

CHIPPEWA HARBOR EAST 6/26/79		1300 Hr. secchi - 7 m.					
Depth (m.)	Temp. (°C)	DO (mg/kg) (% sat'n)	Alk (mg/kg) CaCO ₃	pH	PO ₄ (µg/kg)	SI (mg/kg)	N-NH ₄ (mg/kg)
0	10.0	11.17 (107%)	37.5	9.5	24	1.5	.04
1	9.9						
2	9.9						
3	9.4						
4	8.9	11.18 (99%)	36.9	9.5	24	1.6	1.0
5	8.5						
6	7.8						
7	7.7						
8	7.4	11.35 (97%)	36.6	9.5	28	1.6	1.1
9	7.2						
10	7.0						
11	7.0						
12	6.8						
13	6.6						
14	6.5						
15	6.5						
16	6.3						
17	6.2						

BISKIWIIT LAKE WEST 6/18/79		1830 Hr. secchi - 7.6					
Depth (m.)	Temp. (°C)	DO (mg/kg) (% sat'n)	Alk (mg/kg) CaCO ₃	pH	PO ₄ (µg/kg)	SI (mg/kg)	N-NH ₄ (mg/kg)
0	17.4	9.34 (102%)	28.4	9.5	4	1.6	<.4
1	16.3						
2	14.7						
3	14.2	10.12 (103%)	27.6	9.5	4	1.4	.4
4	14.0						
5	13.6	10.23 (102%)	28.0	9.5	4	1.5	.4
6	12.0						
7	9.8						
8	8.7						
9	8.3						
10	8.0	10.87 (95%)	28.2	9.5	4	1.6	.49
11	7.2						
12	7.2						
13	7.0						
14	6.6						
15	6.4						
16	6.4						
17	6.3						
18	6.3						
20		11.08 (91%)	28.4	9.5	4	1.7	.50
40	5.2	10.88 (89%)	27.9	9.25	4	1.7	<.4

BISKIWIIT EAST 6/16/79		1600 Hr. secchi - 7.5					
Depth (m.)	Temp. (°C)	DO (mg/kg) (% sat'n)	Alk (mg/kg) CaCO ₃	pH	PO ₄ (µg/kg)	SI (mg/kg)	N-NH ₄ (mg/kg)
0	12.0	10.48 (100%)	27.3	6.0	4	1.7	<.4
1	11.9						
2	11.7						
3	11.6	10.66 (101%)	27.9	6.0	4	1.5	<.4
4	11.1						
5	8.5	11.14 (100%)	28.1	6.0	0	1.7	.46
6	7.0						
7	7.0						
8	6.8						
9	6.6						
10	6.4	11.20 (94%)	27.4	6.0	4	1.8	.04
11	6.1						
12	6.0						
13	6.0						
14	6.0						
15	5.9	10.91 (90%)	27.7	6.5	10	1.5	<.4
16	5.7						
17	5.7						
18	5.6						
19							
20		10.98	27.8	6.5	4	1.6	.49

Table VI (cont.)

WOOD LAKE NORTH 6/23/79 1300 Hr. secchi - 4.75							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	14.5	9.30 (93%)	29.9	5.25	16	--	<.4
1	14.4						
2	14.3						
3	14.1						
4	12.8	9.92 (97%)	28.9	5.25	20	1.2	<.4
5	11.0						
6	8.9						
7	7.9						
8	7.3	8.85 (85%)	28.6	5.25	56	1.9	<.4
9	7.0						

WOOD LAKE SOUTH 6/23/79 1200 Hr. secchi - 4.25							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	14.9	9.45 (97%)	30.0	5.25	10	--	<.4
1	14.8						
2	14.5						
3	14.3						
4	13.0	9.77 (95%)	28.9	5.5	36	1.5	<.4
5	9.9						
6	8.7						
7	8.0						
8		9.42 (83%)	29.3	5.5	112	1.5	.86

LAKE WHITTLESEY WEST 6/24/79 1445 Hr. secchi - 2.5 m.							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	18.1	8.33 (90%)	22.5	5.5	52	1.7	<.4
1	17.9						
2	16.1						
3	15.9	8.60 (89%)	22.1	5.5	36	1.7	<.4
4	15.7						
5	15.2	7.89 (81%)	22.5	5.5	24	1.7	<.4
6	13.9						
7	12.8						

LAKE WHITTLESEY EAST 6/24/79 1615 Hr. secchi - 2.5 m.							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	18.8	8.37 (93%)	22.7	5.5	4	1.7	<.4
1	16.8						
2	15.9						
3	15.6	8.65 (90%)	22.6	5.5	16	1.7	<.4
4	13.3						
5	13.1	8.39 (87%)	23.1	5.5	36	1.7	<.4
6	13.0						
7	12.8						

INTERMEDIATE LAKE WEST 6/15/79 1430 Hr. secchi - 3.0 m.							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	18.4	8.59 (95%)	17.9	6.5	10	3.8	<.4
1	18.1						
2	17.2						
3	17.0	8.26 (88%)	18.1	6.5	4	3.7	<.4
4	15.4						
5	13.9	6.27 (63%)	18.5	6.5	16	3.7	<.4
6	12.2						
7	12.0						
8	11.2						

INTERMEDIATE LAKE EAST 6/15/79 1530 Hr. secchi - 2.0 m.							
Depth (m.)	Temp. (°C)	DO (mg/kg) (X sat'n)	Alk (mg/kg) CaCO_3	pH	PO ₄ (µg/kg)	SI (mg/kg)	H-HO ₂ (mg/kg)
0	19.4	8.70 (96%)	18.8	6.0	10	3.2	<.4
1	19.4						
2	18.7						
3	17.3	8.48 (91%)	17.7	6.0	10	2.6	<.4
4	14.1						
5	13.2	5.21 (52%)	18.2	6.5	16	3.8	.49
5.5	12.4						

Table VI (cont.)

LAKE RICHIE							
SOUTH 6/13/79 1100 Hr. secchi - 2.9 m.							
Depth (m.)	Temp. (°C)	DO (mg/kg) (% sat'n)	Alk (mg/kg) CaCO ₃	pH	PO ₄ (µg/kg)	Si (mg/kg)	N-NH ₄ (mg/kg)
8	17.6	8.71 (95%)	27.3	6.3	36	2.9	.4
1	17.4						
2	17.2						
3	17.1	7.68 (82%)	27.0	6.3	10	3.0	.4
4	16.2						
5	10.9	8.79 (82%)	27.2	6.3	10	2.9	.4
LAKE RICHIE							
SOUTH 6/13/79 1000 Hr. secchi - 3.6 m.							
8	17.2	9.18 (99%)	27.0	6.3	10	2.9	.4
1	17.1						
2	16.9						
3	15.7	8.69 (90%)	26.8	6.3	10	2.7	.4
4	13.9						
5	12.9	8.19 (80%)	26.9	6.3	10	3.3	.64
6	12.1						
FELDTMANN LAKE							
NORTH 7/26/79 1100 Hr. secchi - 1.6 m.							
8	21.0	7.78 (90%)	19.8	6.0	36	<1	.44
.5	21.2						
1	21.2						
1.5	21.2						
2	21.2	7.64 (89%)	20.1	6.0	24	<1	.44
2.5	21.0						
FELDTMANN LAKE							
SOUTH 7/26/79 1200 Hr. secchi - 1.7 m.							
8	21.2	7.89 (91%)	19.8	6.0	24	<1	.44
.5	21.2						
1	21.2						
1.5	21.2						
2	21.0	7.81 (90%)	19.5	6.0	—	<1	.44
2.5	21.0						

Table VII

This list has been compiled from the population counts, entire scans of concentrated whole water samples, and net samples. The xxx and xx categories are based solely on the mean composition at all stations and depths from the enumerated samples. The x category represents a mean abundance of less than 1% from the enumerated samples and/or taxa identified from any sample type.

Chlorophyta	Chippewa Harbor	Siskiwit L.	Wood L.	Whittlesby L.	Intermediate L.	Richie L.	Feldmann L.	Schelte L.	Wallace L.
Volvocales									
<i>Chlamydomonas</i> spp. Ehrenberg					x				
<i>Volvox</i> sp. L.	x		x						
Tetrasporales									
<i>Asterococcus</i> sp. Scherffel					x				
<i>Cloacocystis</i> sp. Naegeli									x
Chlorococcales									
<i>Ankistrodesmus</i> spp. Corda	x	xx	xx	xx	xx	x	x		
<i>A. falcatus</i> (Corda) Ralfs	x	x	x	x	x				
<i>A. spiralis</i> (Turner) Lemmermann				x					
<i>Chodatella</i> sp. Lemmermann					x				
<i>Coelastrum</i> spp. Naegeli	x	x	x	x	x				
<i>C. microporum</i> Naegeli	x		x	x	x				
<i>Crucigenia</i> spp. Morren	xx	x	x	xx	x	x	xx	x	
<i>C. tetrapedia</i> (Kirch) West & West	x	x			x	x	x		
<i>C. quadrata</i> Morren			x		x			x	
<i>Dictyosphaerium</i> spp. Naegeli	xx		x	x	xx		xx	x	x
<i>D. ehrenbergianum</i> Naegeli								x	
<i>D. pulchellum</i> Wood	x			x	x		x	x	
<i>Colankinia radiata</i> Wille	xx	xx	x	x	xx	x	x	x	x
<i>Kirchneriella obesa</i> (W. West) Schmidt		x	x	x	x		x	x	x
<i>Cocystis</i> spp. Naegeli	xx	xx	x	x			xx	x	x
<i>Pediastrum</i> spp. Meyen	x	x	x	x	x	x	x	x	x
<i>P. boryanum</i> Meneghini		x	x						
<i>P. duplex</i> Meyen	x			x	x	x	x		x
<i>P. duplex</i> var. <i>clathratum</i> *			x						
<i>P. duplex</i> var. <i>rugulosum</i> Raciborsk			x						
<i>P. integrum</i> Naegeli			x					x	
<i>P. muticum</i> Kuetzing					x				
<i>P. tetras</i> (Ehrenberg) Ralfs			x			x		x	x
<i>Quadrigula</i> spp. Printz	x	x	x	xx	x	x	xx		
<i>Q. clonasterioides</i> (Bohlin) Printz			x						
<i>Q. lacustris</i> (Chodat) GM Smith	x	x							
<i>Scenedesmus</i> spp. Meyen	xx	x	x	x	x	x	x	x	x
<i>S. abundans</i> (Kirchner) Chodat									x
<i>S. arcuatus</i> Lemmermann								x	x
<i>S. armatus</i>				x	x				x
<i>S. bijuga</i> (Turpin) Lagerheim	x				x	x	x	x	
<i>S. quadricauda</i> Turpin	x		x		x	x	x		
<i>S. serratus</i> (Chorda) Bohlin		x							
<i>Selenastrum gracile</i> Reinsch				x	x				
<i>Tetradron</i> spp. Kuetzing				x	x		xx		
<i>T. caudatum</i> (Corda) Hanngirg					x		x		
<i>T. planctonicum</i> G.M. Smith				x			x		
<i>T. triponum</i> (Naegeli) Hanngirg					x				
<i>Treubaria</i> Bernard						x			

* - (A. Braun) Lagerheim

Table VII (cont.)

Chrysophyta	Chippewa Harbor	Siskiwit L.	Wood L.	Whittlesey L.	Intermediate L.	Richie L.	Feldmann L.	Schotts L.	Wallace L.
Heterococcales									
<u>Centricractus dubius</u> Printz	x	x	x	x			x	x	
<u>Characiopsis</u> spp. Borai									
<u>Ophiocytium</u> spp. Naegeli							x	x	
Heterosiphonales									
<u>Botrydium granulata</u> Greville				x					
<u>Botryococcus braunii</u> Kuetzing			x						
Chrysomonadales									
<u>Cryptomonas</u> spp. Ehrenberg	xx	xx	xx	xx	x	x	x		
<u>Dinobryon</u> spp. Ehrenberg	x	x	xx	x	xx	x	x	x	x
<u>D. bravericum</u> Imhof	x	x	x	x	x	x	x	x	
<u>D. cylindricum</u> Imhof								x	
<u>D. divergens</u> Imhof		x				x		x	
<u>D. setularia</u> Ehrenberg		x							
<u>D. sociale</u> Ehrenberg	x	x	x	x	x	x	x		
<u>D. scipitatum</u>								x	
<u>Ecphyron</u> spp. Pascher	xx	xx	x	x	x	x	x		
<u>Mallomonas</u> spp. Perty	x	x	x	xx	x	x	x		
<u>M. arcuoides</u> Perty					x				
<u>M. pseudocoronata</u> Prescott	x		x			x			
<u>Synura uvella</u> Ehrenberg				x	x			x	
Chrysocapsales									
<u>Chrysocapsa</u> spp. Pascher		x		xx	x	x	x		x
Centrales									
<u>Attheya</u> spp. T. West				x					
<u>Cyclotella</u> spp. Kuetzing	xx	xxx	xx	xxx	x	x	x	x	
<u>C. antiqua</u> Wa. Smith				x					
<u>C. bodanica</u> Eulenstein	x	x							
<u>C. melosiroides</u> Lemmermann	x	xx		x					
<u>C. meneghiniana</u> Kuetzing							x		
<u>C. operculata</u> (Agardh) Kuetzing	x	x	x	x		x		x	
<u>Melosira</u> spp. C.A. Agardh	xx	x	x	xxx	x	x		x	
<u>M. crenulata</u> (Ehrenberg) Kuetzing	x		x						
<u>M. distans</u> (Ehrenberg) Kuetzing	x	x	x	x		x		x	x
<u>M. granulata</u> (Ehrenberg) Ralfs				x					
<u>M. italica</u> (Ehrenberg) Kuetzing		x		x		x		x	
<u>Rhizosolenia ericsonii</u> Hl. Smith	xx	xx	xx	xx	xx		x	x	
<u>Stephanodiscus</u> spp. Ehrenberg	x	x	x	x	x				
<u>S. singarao</u> Ehrenberg	x	x	x		x				

Table VII (cont.)

	Chippewa Harbor	Siskiwit L.	Wood L.	Whittlesey L.	Intermediate L.	Richie L.	Feldmann L.	Scholls L.	Wallace L.
Zygnematales									
<u>Arthrodesmus</u> spp. Ehrenberg	x	x	x	x	x		x		x
<u>Closterium</u> spp. Nitzsch	x	x		x	x			x	x
<u>C. gracile</u> Brebisson							x	x	x
<u>Cosmarium</u> spp. Corda			x	x	x		x	x	x
<u>C. nonstrictum</u> Dolponte							x	x	x
<u>Desmidiium</u> spp. C.A. Agardh							x	x	x
<u>D. grevillei</u> DeBary							x	x	x
<u>Emmenanthe</u> spp. (Ehrenberg) Ralfs								x	x
<u>E. pulchellum</u> Brebisson								x	x
<u>E. sinuosum</u>								x	x
<u>Conatosygon</u> spp. De Bary							x		x
<u>Nyctotheca</u> spp. Ehrenberg		x	x						x
<u>N. densillens</u> (J.E. Smith) Brebisson			x						x
<u>Microsterias</u> spp. C.A. Agardh									x
<u>M. rotata</u> (Greville) Ralfs									x
<u>Pleurotaenium granthecula</u> Naegeli									x
<u>Spandylusium</u> spp. Brebisson		x	x						
<u>S. pyramicum</u> (Cooke) W. West		x							
<u>Staurastrum</u> Meyen	x		x	x	x		x	x	x
<u>S. curvatum</u> W. West								x	
<u>S. cuspidatum</u> Brebisson				x					x
<u>S. striale</u> Ralfs	x			x			x	x	x
<u>S. paradoxum</u>				x					
<u>S. punctulatum</u> Brebisson					x				
<u>S. sociale</u>					x				
Cyanophyta									
Chroococcales									
<u>Aphanocapsa</u> spp. Naegeli	x	x	x	xx		x	xx		
<u>Aphanotheca</u> sp. Naegeli				x					
<u>Chroococcus</u> spp. Naegeli				x			x	x	
<u>Coelosphaerium</u> spp. Naegeli	x	x	x	x	x	x	x		
<u>Gloeocapsa</u> spp. Kuetsing	x	x		x			xx		
<u>Merismopedia</u> spp. Meyen		x		x	x		x	x	x
<u>M. elegans</u> A. Braun							x	x	
<u>M. alauca</u> (Ehrenberg) Naegeli					x				
<u>Microcystis</u> spp. Kuetsing	x		x				x		
Oscillatoriales									
<u>Anabaena</u> spp. Bory	x	x		xx	xx	x		x	
<u>Calothrix</u> sp. C.A. Agardh									x
<u>Gloeotrichia</u> sp. J.C. Agardh							x		
<u>Lyngbya</u> spp. Agardh				x					
<u>Nostoc</u> spp. Vaucher						x			x
<u>Oscillatoria</u> spp. Vaucher	x	xx	xx	xx	xxx	x	x		x
<u>Spirulina</u> spp. Turpin				x	x				

Table VIII

A list of all genera of aquatic insects found on Isle Royale and their relative abundance at each sample site.

x - present

xx - common

xxx - abundant

	Beaver Pond Monkey Basin	Wallace Lake	Benson Lake	Forbes Lake	Monkey Basin	Lake John Outlet	Benson Creek	Wallace Creek	Lake Ritchie Outlet	Indian Portage Creek	Saill Creek Monkey Basin	Feldmann Creek	Washington Creek
Order Plecoptera													
<u>Amphinemura</u> Ris							xx						
<u>Isoperla</u> Banks							xxx		xx				
<u>Leuctra</u> Stephens							x			x			
<u>Zealeuctra</u> Ricker													
Order Ephemeroptera													
<u>Ecdyonurus</u> Leach			xxx				xxx	xxx	xxx			xx	x
<u>Caenis</u> Stephens													
<u>Ephemerella</u> Walsh							x						
<u>Leptophlebia</u> Westwood											x		
<u>Paraleptophlebia</u> Lestage								x				xxx	
<u>Siphonurus</u> Eaton	xx		xx						xxx				
<u>Siphonoplecton</u> Clemens					x								
<u>Stenonema</u> Traver				x								xx	
<u>Stenonema</u> Traver					x				xx	xx			
Order Odonata													
<u>Aeshna</u> Fabricius	x		x	x								xx	
<u>Boyeria</u> McLachlan		x						xx		xxx		xx	
<u>Calopteryx</u> Leach									xxx				
<u>Cordulegaster</u> Leach		xx						xx	xx			xx	
<u>Dorocordulia</u> Needham												x	
<u>Enallagma</u> Walsh			xx										
<u>Helocordulia</u> Needham		x											
<u>Ladona</u> Needham	xx												
<u>Lestes</u> Hagan	xx	xx	x										
<u>Leucorrhinia</u> Brittinger			x										
<u>Libellula</u> L.	xx		x										
<u>Nehalennia</u> Needham	x		xx										
<u>Ophiogomphus</u> Selys									xx			x	
<u>Stenochloria</u> Selys								x					
Order Trichoptera													
<u>Agapetus</u> Curtis									x				
<u>Agrypnia</u> Curtis					xx								
<u>Anabolia</u> Stephens					x								
<u>Anynarchus</u> McLachlan	x		xx	x	x	xxx			xxx	xxx		xxx	
<u>Ceraclea</u> Stephens			xx										

Table VIII (cont.)

	Beaver Pond Mosley Basin	Wallace Lake	Penson Lake	Forbes Lake	Mosley Basin	Lake John Pond	Penson Creek	Wallace Creek	Lake Richie Creek	Indian Portage Creek	Small Creek Mosley Basin	Feldmann Creek	Washington Creek
Order Trichoptera (cont)													
<u>Cheumatopsyche</u> Wallengren							XXX	XXX	X	XX		XXX	XXX
<u>Chimarra</u> Stephens									XXX	X		XXX	
<u>Cyrnellus</u> Banks										X			
<u>Diplectrona</u> Westwood							X						
<u>Dolophilodes</u> Ulmer							X					XXX	XXX
<u>Glossosoma</u> Curtis									XXX	XXX		XXX	XX
<u>Grensia</u> Ross										X			
<u>Heliopsyche</u> von Stehoda					XXX								
<u>Hydatophylax</u> Wallengren									X				
<u>Hydropsyche</u> Pictet							XXX	XXX	XXX	XXX		XXX	XXX
<u>Ironoquia</u> Banks									XX		XXX		
<u>Limnephilus</u> Leach	X			X						X			
<u>Lapidostoma</u> Rambur					XXX		XXX	XXX	XXX	XXX		XXX	
<u>Molanna</u> Curtis					X								
<u>Mystacides</u> Berthold					XX				X				
<u>Neophylax</u> McLachlan					XXX		X		X	XX			
<u>Ochrotrichia</u> Mosely									XXX				
<u>Oecetis</u> McLachlan		X							X				
<u>Onocosmoecus</u> Banks									X	XX			
<u>Polycentropus</u> Curtis							X	X					
<u>Potamyia</u> Banks							X						
<u>Pseudostenophylax</u>												X	
<u>Pseudostenophylax</u> Martynov													
<u>Pycnopsyche</u> Banks		X											
<u>Rhyacophila</u> Pictet							X						
<u>Triaxenodes</u> McLachlan			X										
Order Hemiptera													
<u>Belostomat</u> Latr.		XX											
<u>Celastocoris</u> Kirkaldy							X						
<u>Cerria</u> Fabricius	XXX												
<u>Notonecta</u> L.			X										
<u>Trepobates</u> Uhler													
<u>Trichocorixa</u> Kirkaldy					XXX								
Order Coleoptera													
<u>Agabus</u> Leach							X						
<u>Celina</u> Aube			X										
<u>Colymbetes</u> Curtis	XX												
<u>Dinotia</u> Maclean				XX									

Table VIII (cont.)

	Beaver Pond Mosley Basin	Wallace Lake	Benson Lake	Forbes Lake	Mosley Basin	Lake John Outlet	Benson Creek	Wallace Creek	Lake Richie Outlet	Indian Portage Creek	Small Creek Mosley Basin	Feldman Creek	Washington Creek
Order Coleoptera (Cont.)													
<i>Dytiscus</i> L.	XXX												
<i>Cyrtus</i> Geoffroy		XX			X								
<i>Helophilus</i> Latreille	X		XX					X					
<i>Hydrochara</i> Berthold			X										
<i>Hyperodes</i> LeConte							X						
<i>Laccornis</i> Des Gozis									X				
<i>Neoscutopterus</i> (J. Halfour) Brown						XX							
<i>Optioservus</i> L.								XX	XXX	XXX		X	XXX
<i>Peltodytes</i> Regimbart	X						X					XXX	
<i>Stenelmis</i> Dufour								X	XXX	XXX			
<i>Topisternis</i> Solier			X										
Order Diptera													
<i>Anopheles</i> Meigen	X						X						
<i>Atrichopogon</i> Kieffer							X						
<i>Bezzia</i> Kieffer							X						
<i>Brillia</i> Kieffer							X					X	
<i>Cardiocladius</i> Kieffer											X		
<i>Chironomus</i> Meigen			X										
<i>Chironomus</i> Meigen							X	X					
<i>Cnephia mutata</i> Malloch							XX						
<i>Conchapeloria</i> Arctopel- ypia, <i>Rheopelonia</i> Meigen			X				XX			X		XXX	
<i>Corynoneura</i> Winnerts					X								
<i>Cricotopus</i> Van der Wulp								X		X		XXX	
<i>Dasyhelea</i> Kieffer	X								X				
<i>Dicranota</i> Zetterstadt							X	X					
<i>Dixaella</i> Dyar and Shannon			X										
<i>Eukiefferella</i> Zavrel						X	XXX	X	XX	XX		XXX	X
<i>Eusimulium aurium</i> Fries							X						
<i>Glyptotendipes</i> Kieffer												X	
<i>Larata</i>							X					XX	
<i>Limnophila</i> Macquart	X												
<i>Micropectra</i> Kieffer								X				XXX	
<i>Microtendipes</i> Kieffer												X	
<i>Orthocladius</i> Van der							X						
<i>Parametriocheilus</i> Wulp							X			X		XXX	
<i>Polynedilus</i> Kieffer							XXX			XXX		XXX	
<i>Procladius</i> Edwards			X									X	
<i>Paectrucladius</i> Kieffer												X	

Table VIII (cont.)

	Beaver Pond Moskey Basin	Wallace Lake	Beason Lake	Forbes Lake	Moskey Basin	Lake John Outlet	Beason Creek	Wallace Creek	Lake Richie Outlet	Indian Portage Creek	Snail Creek Moskey Basin	Feldmann Creek	Washington Creek
Order Diptera (Cont.)													
<u>Simulium decorum</u>									X			X	
<u>S. jenningsi</u> Malloch						X	XXX		X			XX	
<u>S. tuberosum</u> Lundstroem							XXX	XXX				XX	
<u>S. venustum verecundum</u>							X						
<u>S. vittatum</u> Zitter ^{Sav} Städt							X						
<u>Smittia</u> Holmgren							X						
<u>Stempellina</u> * Bause										X			
<u>Tabanus</u> L.	X		X				XX	X	X			X	
<u>Tanytarsus</u> * Van der Wulp								X				XXX	
<u>Thienemanniella</u> * Kieffer							X						
<u>Trissocladius</u> * Kieffer							X						
Subfamily Tanypodinae												X	
Tribe Pentaneurini				X								X	
Order Lepidoptera													
<u>Nymphula</u>	X		X										

Table IX

Aquatic Plant Taxa List

	Beaver Lake	Pelicanum Lake	Interchadist Lake	Beaver Lake	Lake Elkhart	Wallace Lake	Wallace Creek	Beaver Lake	Lake Whittoway	Wood Lake
BUDETACEAE										
<i>Buettia arvensis</i> L.	X	X	X	X	X	X	X	X	X	X
<i>B. fluviatilis</i> L.	X	X	X	X	X	X	X	X	C	C
<i>B. viridula</i> Michx.						X	X			
ISOTACEAE										
<i>Isotus</i> sp.		X								X
TYPHACEAE										
<i>Typha latifolia</i> L.			X		X	X		X	X	X
SPARGANIACEAE										
<i>Sparganium fluitans</i> (Nees) Robinson		C				B-C		X	C	
<i>S. minimum</i> (Nees) Fries		S				X				
POTAMOGETONACEAE										
<i>Potamogeton amplifolius</i> Tuckerm.		C	X	X	C	X			X	
<i>P. zosterifolius</i> Raf.				X	X				X	
<i>P. americanus</i> L.		C		X	X	X		C	X	C-A
<i>P. natans</i> L.				X	C-A	X			X	
<i>P. zosterifolius</i> (Nees) Rydb.		C		X	C		X		X	C
<i>P. heterophyllus</i> Forst.						X		X	X	
<i>P. obtusifolius</i> Nees & Koch								X		
<i>P. rubellus</i> Oakes					X					
<i>P. zosterifolius</i> Tuckerm.						X				
NAJADACEAE										
<i>Najas flexilis</i> (Willd.) Rostk and Schmidt				X				X	X	C
ALISMACEAE										
<i>Alisma plantago</i> L.				X		X			X	
<i>A. latifolia</i>				X		X				
GRAMINEAE										
<i>Calamagrostis canadensis</i> (Michx.) Beauv.		X	X	X	X		X	X	X	
<i>C. alpestris</i> Michx.										
<i>Anthoxanthum spicatum</i> (L.) R. and S.						X				
<i>Cladonia canadensis</i> (Michx.) Trin.						X				
<i>C. borealis</i> (Michx.) Benth.		X							X	X
<i>C. rivularis</i> (Lam.) Mische.					X					
<i>Andropogon furcatus</i> (Walt.) Desf.				X						X
<i>Poa alpestris</i> Vahl				X						
<i>P. polystris</i> L.			X	X						
CYPERACEAE										
<i>Cyperus acutus</i> Nutt.	X									
<i>C. babbi</i> (Bally) Forst.										
<i>C. canescens</i> L.						X				
<i>C. carolinensis</i> (Willd.) Michx.						X				
<i>C. chondrocarpus</i> L.f.						X		X		
<i>C. ciliatellus</i> Forst. probably						X				
<i>C. diandra</i> Schrank						X				
<i>C. interior</i> Bailey				X		X				
<i>C. inopimus</i> Wedd.		X			X					X
<i>C. leucostachyus</i> Ehrh.				X		X		X		
<i>C. lenticularis</i> Michx.									X	X
<i>C. limosa</i> L.				X				X		
<i>C. patens</i> Schreb.		X	X		X			X		
<i>C. retrofractus</i> Steud.					X	X		X		
<i>C. rigens</i> Willd.		X			X					
<i>C. viridula</i> Michx.		X								
<i>C. leptostachyus</i> Forst.						X			X	
<i>C. angustatus</i> Michx.						X				
<i>C. striatus</i> L.						X				
<i>C. cristatellus</i> Britton-probably						X				
<i>Polypogon monspeliensis</i> (L.) Britton				X				X		
<i>Eleocharis acicularis</i> Britton		X	X		X					C-A
<i>E. acicularis</i> (L.) Link						X				
<i>Eleocharis acicularis</i> Michx.								X		
<i>Eleocharis acicularis</i> (L.) Vahl										
<i>Scirpus acutus</i> Nutt.					X					
<i>S. cyperinus</i> (L.) Vahl		X						X		
<i>S. cyperinus</i> var. <i>brachycephalus</i>						X			X	
<i>S. microcarpus</i> var. <i>rubra</i>										

Table IX (cont.)

	Beaver Lake	Feldman Lake	Intermediate Lake	Hart Lake	Lake Richie	Wallace Lake	Wallace Creek	Summer Lake	Lake Shiloh	Wood Lake
ARACEAE										
<i>Calla palustris</i> L.										
<i>Symplocarpus foetidus</i> (L.) Nutt.	X									
LETRACEAE										
<i>Lemna minor</i>	X									
ERIOCAULACEAE										
<i>Eriocaulon septangulare</i> Michx.			X						X	
JUNCACEAE										
<i>Juncus acuminatus</i> Raf.						X				
<i>Juncus brevicaudatus</i> (Engelm.) Pers.						X				
<i>J. tenuis</i> Willd.					X					
EPIDACEAE										
<i>Isis perfoliata</i> L.	X	X	X	X	X	X		X	X	X
MYRICACEAE										
<i>Myrica gale</i> L.		A	X		A			X	X	X
BETULACEAE										
<i>Alnus incana</i> (DuRoi) Spreng	X	A	X		X	X	X		X	X
POLYGONACEAE										
<i>Polygonum arifolium</i> L.						X				
<i>P. ellipticum</i> Michx.										
HYDRICACEAE										
<i>Ruppia variagatum</i> Engelm.		C	X	S	C	X		S-C		C
<i>Symphoricarpos alba</i> Ait.				X		X		S	C-A	
SARCOMACEAE										
<i>Calla palustris</i> L.	X									
<i>Scoroculus</i> sp.		X			X				X	X
<i>Thalictrum dasycarpum</i> Fisch. & Lall.										
ONOCITEAE										
<i>Onoclea sensibilis</i> L.										
SARRACENIACEAE										
<i>Sarracenia purpurea</i> L.						X		X		
PROSERACEAE										
<i>Proserpinaca rotundifolia</i> L.						X				
ROSACEAE										
<i>Rosa pratincola</i> (L.) Soop.		X		X		X		X		
HYPERICACEAE										
<i>Hypericum</i> sp.						X		X		
HALORAGIDACEAE										
<i>Halimolobos laetifolia</i> Sigel.		X								
HYPOPHYLLACEAE										
<i>Hypophyllum laetifolia</i> L.					X					
UMBELLIFERAE										
<i>Umbellifera</i> sp.			X	X	X	X			X	S-C
COMPOSITAE										
<i>Arnica montana</i> L.			X		X		X			X
ERICACEAE										
<i>Andromeda racemosa</i> L.				X				X		
<i>Chamaenerion angustifolium</i> (L.) Moench				X		X		X		
<i>Salix reticulata</i> Moench				X		X		X		
<i>Vaccinium myrtillus</i> L.						X		X		
PRIMULACEAE										
<i>Primula veris</i> (L.) B.S.P.			X	X	X	X			X	X
<i>P. elatior</i> L.			X			X		X		
GENTIANACEAE										
<i>Gentiana axillaris</i> L.		X	X		X	X				
LABIATAE										
<i>Lobelia inflata</i> L.										
<i>L. spicata</i> Michx.			X	X	X	X			X	X
<i>Scutellaria ovata</i> (L.) Donnell-Sm.										
<i>S. integrifolia</i> L.										

Table IX (cont.)

	Desert Lake	Feldman Lake	Intermittent Lake	Short Lake	Lake Michie	Wallace Lake	Wallace Creek	Sumner Lake	Lake Whitney	Shaw Lake
LENTIBULACEAE										
<i>Limnolobus vulgaris</i> L.										
<i>Utricularia</i> sp.										
<i>U. intermedia</i> Hayne				X	X	X		X	B-C	
<i>U. minor</i> L.						X		X		
<i>U. vulgaris</i> L.						X		X		
RUBIACEAE										
<i>Galium</i> sp.						X				
CAMPANULACEAE										
<i>Cassiope</i> sp.				X		X		X		
COMPOSITAE										
<i>Senecio</i> sp.					X				X	
LOBELIACEAE										
<i>Lobelia Dortmunda</i> L.			X							C

X - Not included in previous time lists for Lake Royale

B - Not previously listed but not yet verified

C - Common

A - Abundant

S - Sparse

3243-6
22-32