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Ecological Survey of Muzroll Lake, Northumberland County, New Brunswick: An Assessment of Factors Influencing Biological Diversity and Productivity

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Summary

An extensive ecological survey of Muzroll Lake, located in Northumberland County, New Brunswick, was carried out between May and October, 2007 in order to better understand the nature of the biological communities present, and the physical and chemical factors that influence its ability to support a productive and diverse wildlife community. The results indicate that Muzroll Lake is an atypical wetland distinguished by low biodiversity, low productivity and numerous other features that do not allow it to be easily classified using existing wetland classification systems. It is characterized by an extremely low dissolved salt content, a substrate composed mostly of sand and gravel with low organic content, a paucity of aquatic insects, low nitrogen, but high phosphorus, levels and low diversity of aquatic vegetation. The major factors limiting its productivity and biodiversity are available nitrogen and the lack of suitable over-wintering habitat as a result of Muzroll Lake freezing almost entirely from top to bottom during the winter ice-cover period.

A number of suggestions are made on management practices that would be expected to result in an increase in both the productivity and biodiversity of Muzroll Lake. These include raising water levels during late fall to provide a more favorable over-wintering habitat during periods of ice cover. Fertilization of Muzroll Lake to increase its productivity is not recommended because its physical characteristics make it especially susceptible to nutrient over-enrichment, the symptoms of which include development of anoxic conditions and a decrease in biodiversity.

Table of Contents

Page

1. Background 1
2. Historical Overview of DUC Activities 1
3. Approach 5
   3.1 Survey Methodology 6
      3.1.1 Physical Parameters 6
      3.1.2 Chemical Parameters 7
      3.1.3 Biological Parameters 9
4. Results 11
   4.1 Morphology 11
   4.2 Physical Characteristics 11
   4.3 Chemical Characteristics 12
      4.3.1 Conductivity, Alkalinity and pH 12
      4.3.2 Nutrients 15
      4.3.3 Sediment Analyses 16
4.4 Biological Characteristics 17
   4.4.1Aquatic and Shoreline Vegetation 17
   4.4.2 Phytoplankton Biomass 18
   4.4.3 Periphyton Growth 18
   4.4.4 Zooplankton Composition and Numbers 19
   4.4.5 Emergent Insect Composition and Numbers 20
   4.4.6 Benthic Invertebrate Composition and Numbers 21
   4.4.7 Other (Opportunistic) Wildlife Observations 21
5. Discussion 22
   5.1 The Nature of Muzroll Lake 22
   5.2 Prospects for Increasing Biodiversity and Productivity of Muzroll Lake 24
6. Acknowledgements 26
7. References 26
Appendix I DUC Pre-bio Inspection Report of Muzroll Lake 27
Appendix II Notes on attempts to grow wild rice 31
Appendix III Results of Water and Sediment Quality Analyses 32
Appendix IV Results of Aquatic and Shoreline Vegetation Survey 36

List of Figures

Page

Fig. 1.1 Map of Muzroll Lake 2

Fig 2.1 Map of Muzroll Lake showing improvements made by DUC to increase management potential for waterfowl 4

Fig. 2.2 Location and times of wild rice seeding and liming applications 5

Fig. 3.1 Location of sample stations 6

Fig. 3.2 Using a core sampler to collect sediment cores 8

Fig. 3.3 Sampler used to assess periphyton growth........ 9

Fig. 3.4 Emergent insect and benthic invertebrate samplers 10

Fig. 4.1 Digital elevation map of Muzroll Lake and its watershed 11

Fig. 4.2 Mean values of physical characteristics at each station 12

Fig 4.3 Mean seasonal values of physical characteristics 12

Fig. 4.4 Mean values of pH, conductivity and alkalinity at each station 13

Fig 4.5 Seasonal variation in mean values of pH, conductivity and alkalinity 13

Fig. 4.6 Mean daily values of pH, water temperature and conductivity recorded during August and July 2007 14

Fig 4.7 Example of diurnal variations in pH, water temperature and conductivity during September 2007 15

Fig. 4.8 Mean values of nutrients at each station 16

Fig. 4.9 Seasonal variation in mean nutrient levels 16

Fig. 4.10 Mean values of phytoplankton chlorophyll *a* levels seasonally and spatially.. 18

Fig 4.11 Seasonal and spatial variation in mean daily periphyton growth rate 19

Fig. 4.12 Mean numbers and types of zooplankton at each station 19

Fig 4.13 Seasonal and spatial variation in mean zooplankton numbers 20

Fig. 4.14 Seasonal and spatial variation in mean emergent insect numbers 20

Fig. 4.15 Example of a newly constructed muskrat lodge observed during October ... 22

List of Tables

Page

Table 3.1 Summary of survey methodologies 7
Table 4.1 Sediment water content, organic content and pH 17
Table 5.1 Growth requirements of northern wild rice (*Zizania palustris*) 25

Ecological Survey of Muzroll Lake, Northumberland County, New Brunswick: An Assessment of Factors Influencing Biological Diversity and Productivity

1. Background

Muzroll Lake is a shallow wetland located within central New Brunswick (Fig. 1.1). In the early 1980s, Ducks Unlimited Canada (DUC) constructed a drainage ditch and water control structure at its outlet in order to control water levels to increase its potential for waterfowl production. However, although this resulted in increased use by waterfowl, its productivity and biological diversity are low and its current use by waterfowl is limited. Although it attracts large number of waterfowl during spring and fall migration, it appears to be used largely as a resting area with little use for either brood rearing or feeding. Preliminary surveys of water and sediment chemistry over the last several years suggested that low pH and nutrient levels, combined with high heavy metal concentrations and water colour typical of acidified systems, are likely causes of this low productivity. In order to remediate this condition and to increase and sustain biological productivity and species diversity, numerous attempts were made to raise the pH of the wetland by liming and to establish stands of wild rice (*Zizania palustris*). These efforts, however, have been largely unsuccessful.

The primary objective of the study reported on here was to carry out an extensive ecological survey of Muzroll Lake to better understand the nature of the biological communities present, and the physical and chemical factors that potentially limit its ability to support a more productive and diverse wildlife community, with particular emphasis on waterfowl.

2. Historical Overview of DUC Activities

A pre-bio site inspection report of Muzroll Lake*, carried out by DUC on 7 October 1981 (DUC file N-36-81) classified its ecotype as a 'Natural Lake Basin' located in "an isolated area of good basic fertility and surrounded by small ponds, streams and lakes which are the main producers of Blacks, Green Wing Teal and Ringnecks in the interior part of the Province". The immediate area surrounding the Lake was described as consisting of "mature mixed forest with large clear cuts nearby". The lake bottom was described as being "firm – clay and rocks". It was not clear at the time of the report as to the nature and location of all inlets and outlets of the Lake. Observations of wildlife at the time of the inspection included six black and two ringneck ducks, 12 muskrat houses and an active beaver house in an inlet. Fish were assumed to be absent due to the shallow nature of the Lake. Emergent vegetation was reported to consist mainly of sedge (*Carex sp.*) on the dry marshy areas surrounding the Lake and in shallow water areas along the shoreline. Meadow grass (*Calamagrostis sp.*) was also common, and there were some stands of bulrush (*Scirpus sp.*) and hardback (*Spirea sp.*) present. Submergent vegetation was reported to consist mainly of large dense stands of Manna Grass (*Glyceria sp.*).

* The full DUC report is contained in Appendix I.

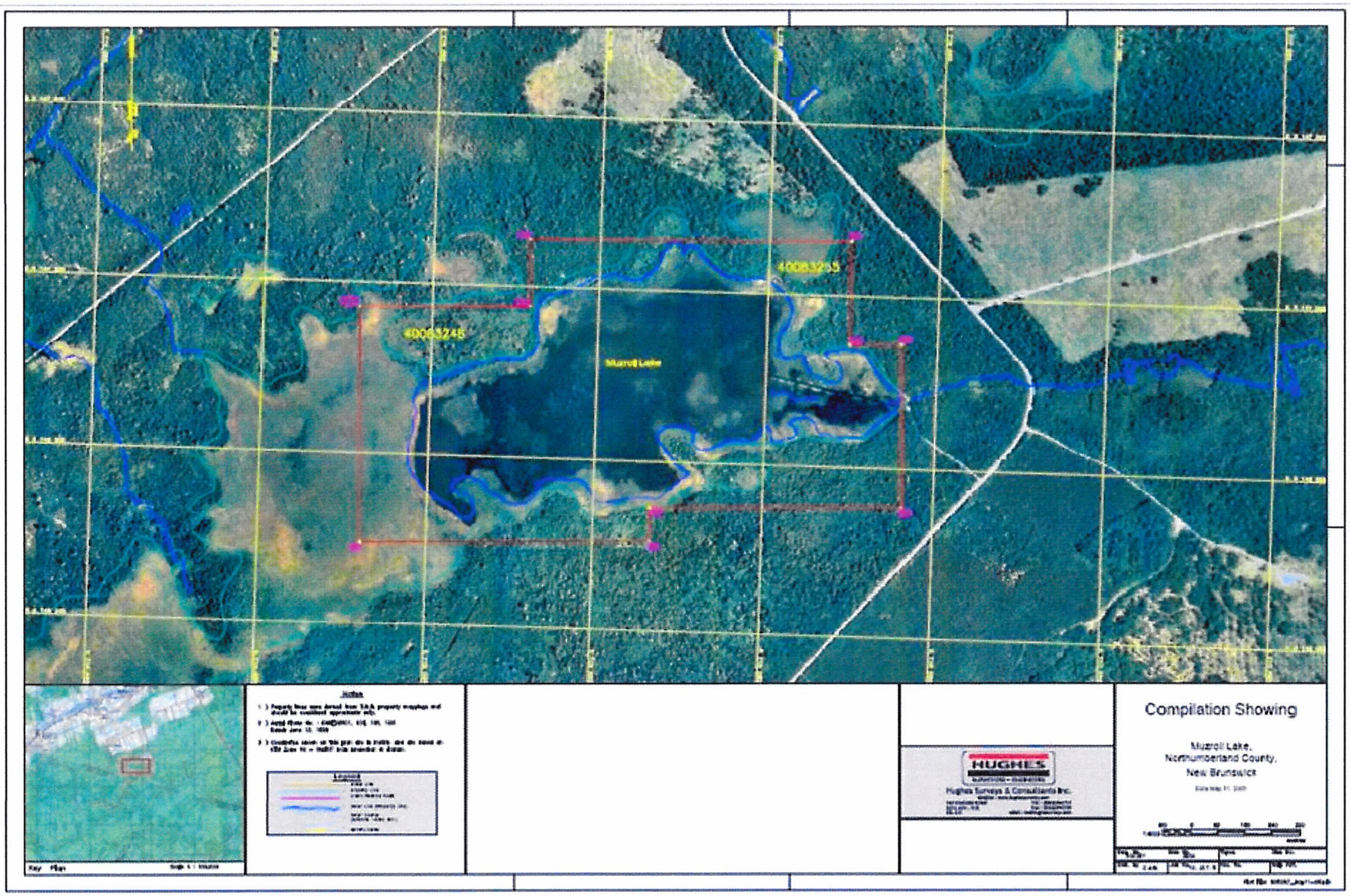

Fig. 1.1 Map of Muzroll Lake.

The area of Muzroll Lake and its surrounding watershed were determined to be 3.7 and 4.4 km^2, respectively. Although a bathymetric survey of the Lake was never completed, its bottom appears to be very flat will little variation in depth. Assuming an average annual precipitation of 100 cm and a mean depth of 0.7 m, the theoretical flushing rate would be 1.7 times/yr. A peculiar characteristic of the Lake is that it is surrounded by a dyke-like ridge that varies between 1-2 meters in height, the origin of which is uncertain.

Between 1981 and 1983 Ducks Unlimited made improvements to the wetland to better manage its potential use as waterfowl habitat (DU File No. 648-6414). The outlet of the marsh leading into Muzroll Brook was cleared and deepened to allow for complete marsh drawdown, and a small spillway was constructed to stabilize the water depth of the marsh to an average of about 0.7 m. Fig. 3.1 illustrates the nature and location of these improvements.

There is little documented information available to assess the degree to which these improvements increased the diversity and abundance of waterfowl and other wildlife in Muzroll Lake, but in the early 2000s it was generally believed that the productivity of the Lake did not reach the potential originally envisioned. During the period between 2004 and 2007, attempts were made to enhance fall staging of waterfowl by establishing wild rice in the Lake. In 2004 wild rice was seeded over a 1000 m^2 area in the northwest corner of the Lake but this proved largely unsuccessful in establishing a significant stand of wild rice. Between 2005 and 2007 additional attempts were made to establish wild rice in areas that also received applications of pelletized lime. The decision to apply lime was based on the supposition that low pH may have limited the growth of wild rice in the 2004 trial. Although liming did seem to enhance the propagation of wild rice, the stands that did develop were quite sparse and the results were generally disappointing. Fig. 2.2 summarizes the locations of these trials, and Appendix II contains a listing of field observations on the results.

During the period over which attempts were being made to establish wild rice, a number of water and sediment samples were collected and analyzed for parameters routinely used to assess water quality. The results are contained in Appendix III. A sediment sample, collected during October 2005 and analyzed by the Nova Scotia of Agriculture's soil analysis laboratory, indicated a pH of 4.7, an organic matter content of 9 percent and relatively high concentrations of iron and copper. These results suggested that pH and elevated heavy metal concentrations may be the reason why initial attempts to establish wild rice were unsuccessful. Subsequent samples taken for chemical analysis focused on water quality. A water sample collected on 16 May 2007 indicated that Muzroll Lake has low conductivity (7.7 μSi/cm), low alkalinity (1.13 mg/L), but only moderately low pH (5.7), and high colour (84 TCUs). The levels of nitrogen and phosphorus, the two nutrients most important in limiting the productivity of freshwater ecosystems, were also low. The total phosphorus concentration was 12 μg/L, a level characteristic of only moderate productivity, and nitrogen concentrations were below the limits of detection for total nitrogen, nitrate and nitrite. In addition, the concentrations of a number of heavy metals (aluminum, copper and iron) were above the levels considered to be harmful to freshwater aquatic organisms based on the Canadian Environmental Quality Guidelines

(CCME 2002). An additional water sample, collected on 28 Jan 2007 (Appendix III) when the Lake was ice covered, contained higher levels of alkalinity (5.5 mg/L) and conductivity (24.5 µSi/cm), but the same level of pH (5.7). Total phosphorus concentration was higher (53 µg/L) as were most of all of the heavy metal concentrations. These higher levels contained in samples taken during ice cover are likely a result of the difficulty of obtaining a water sample uncontaminated by bottom sediments since most of the Lake freezes almost to the bottom. Although there was a relatively high levels of total nitrogen (0.6 mg/L), nitrate was undetectable. The presence of ammonia (0.078 mg/L) in the winter sample is an indication that water beneath the ice becomes anoxic during the winter.

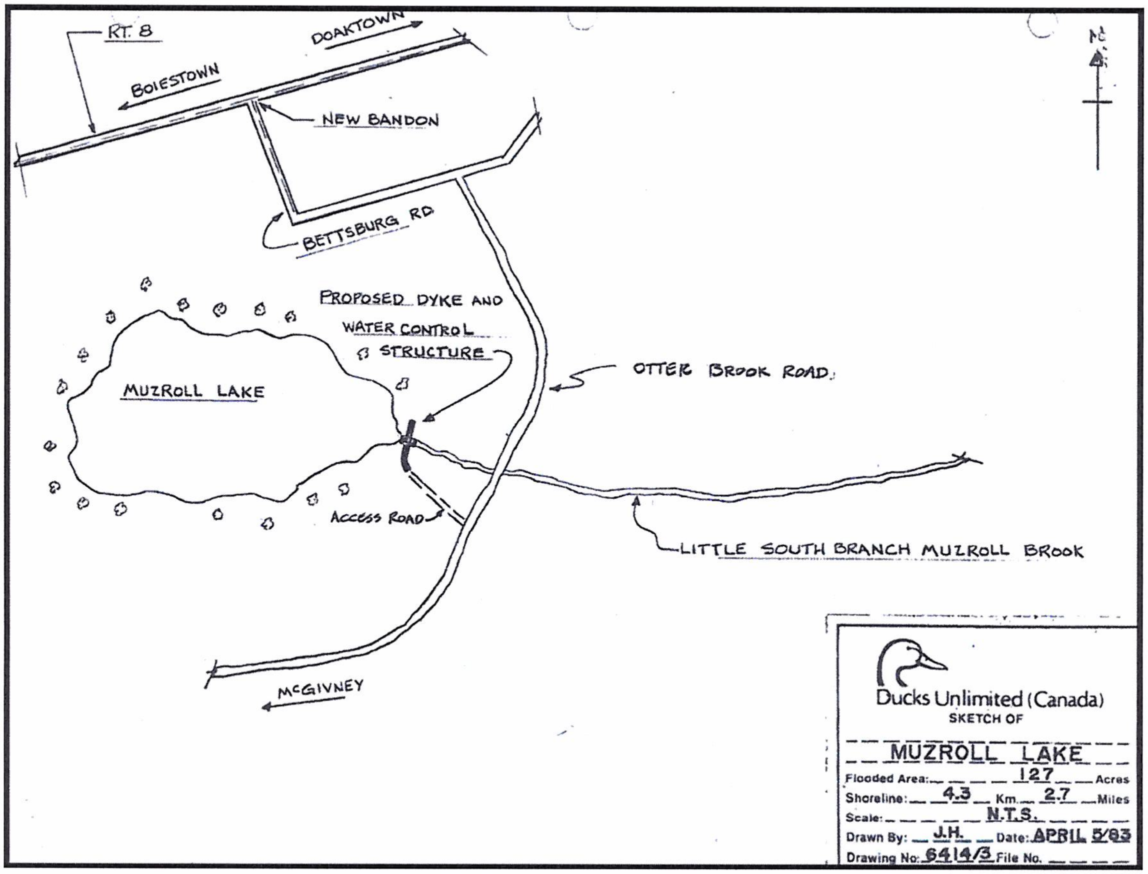

Fig. 2.1 Rough sketch of Muzroll Lake showing improvements made by DUC to increase management potential for waterfowl.

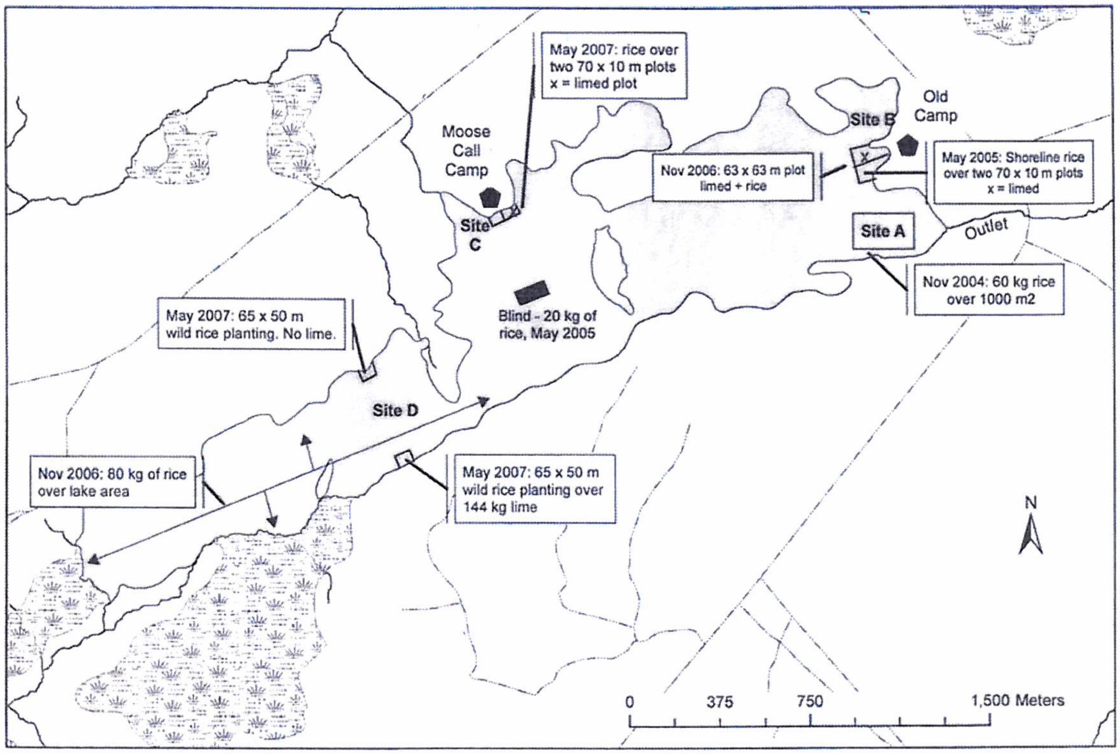

Fig. 2.2 Location and times of wild rice seeding and liming applications (prepared by Bill Hooper).

3. Approach

As previously indicated, the major objective of the study carried out in 2007 was to perform an extensive survey of Muzroll Lake in order to better assess the nature of the biological communities present and the physical and chemical factors that potentially limit the Lake's ability to support a more productive and diverse wildlife community.

The basic study approach involved carrying out a resource inventory of Muzroll Lake with emphasis on the biological habitats and communities present that directly influence waterfowl use and productivity. This included (1) qualitative and quantitative surveys of macrophyte, aquatic insect, aquatic invertebrate and zooplankton communities; (2) water quality monitoring of algal biomass and nutrient concentrations, pH, buffering capacity, color, and turbidity; and (3) sediment quality analyses for nutrients, heavy metals, and organic content. The surveys were carried out at approximately monthly intervals between 22 May and 16 October of 2007 at four to six sites within the impoundment (Fig 3.1.) in order to ensure adequate documentation of both seasonal and spatial variation.

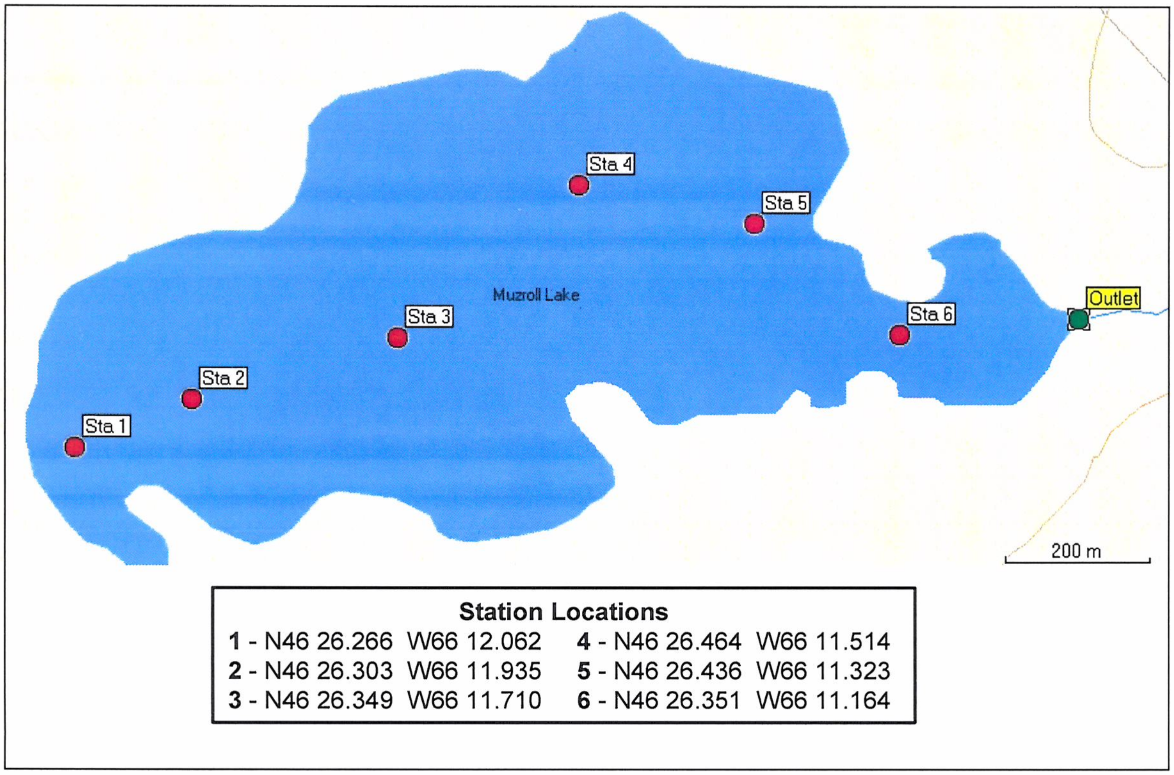

Fig. 3.1. Location of sample stations.

3.1. Survey Methodology

Table 3.1 is a listing of the specific parameters studied. .

3.1.1 Physical Parameters

Temperature: Water temperature was recorded at each station using a Yellow Springs Instruments Model 30 Salinity-Conductivity-Temperature Meter, and between 31 July and 16 Oct continuously at the outlet at 15 min intervals using a Yellow Springs Instrument Model 600XLM Mutli-Parameter Water Quality Monitor.

Colour: True color was measured using the platinum-cobalt standard procedure as described in the Environment Canada Analytical Methods Manual (1979) using water collected at mid-depth and filtered through Watman GF/C filters.

Turbidity: A Model 2100 HACH Turbidimeter was used to measure turbidity of water samples collected at mid-depth.

Table 3.1 Summary of survey methodologies.

Parameter	Methodology	Frequency of Measurement
Physical Characteristics:		
Water Temperature	YSI-SCT meter and YSI Data Logger	Monthly / Continuously
Color	Pt-Co Color Comparator	Monthly
Turbidity	HACH Turbidimeter	Monthly
Chemical Characteristics:		
Conductivity	YSI-SCT meter and YSI Data Logger	Monthly / Continuously
Hardness	EDTA Titration	Monthly
pH	YSI-SCT meter and YSI Data Logger	Monthly / Continuously
Alkalinity	Sulfuric acid titration	Monthly
Nutrients	Technitron nutrient analyzer	Monthly
Sediment Pore Water	Mass spectrophotometry	Once
Sediment Water Content	Oven drying	Once
Sediment Organic Content	Combustion	Once
Biological Characteristics:		
Aquatic Vegetation	Collection and identification of plants	Once
Phytoplankton Biomass	Filtration and acetone extraction	Monthly
Periphyton Growth	Growth on glass slides	Monthly
Zooplankton Numbers	Zooplankton net	Monthly
Emergent Insect Numbers	Emergent insect trap	Monthly (June-August)
Benthic Invertebrate Numbers	Hester-Dendy plate sampler	Monthly

3.1.2 Chemical Parameters

Conductivity: Conductivity was recorded at each station using a Yellow Springs Instruments Model 30 Salinity-Conductivity-Temperature Meter, and between 31 July and 16 Oct continuously at the outlet at 15 min intervals using a Yellow Springs Instrument Model 600XLM Mutli-Parameter Water Quality Monitor.

Hardness: Hardness was measured using the EDTA titration procedure as described in the HACH (1995) procedures manual.

pH A continuous rescored of pH was obtained at the outlet station between 31 July and 16 Oct using a Yellow Springs Instrument Model 600XLM Mutli-Parameter Water Quality Monitor set to record at 15 min intervals. Measurement of pH at all other stations were obtained in the laboratory from water samples collected at mid-depth using an Accumet Model 910 pH meter.

Alkalinity: Alkalinity was measured using the sulfuric acid titration procedure as described in the HACH (1995) procedures manual.

Nutrients: Water samples for total phosphorous and dissolved inorganic nitrogen analyses were collected from mid-depth in a 50 ml acid washed polyethylene bottle and stored refrigerated until analysis. Analyses of phosphorus and nitrogen were carried out by the water quality laboratory of the K.C. Irving Environmental Centre at Acadia University using a Technitron automated nutrient analyzer.

Sediment Pore Water: Pore water was extracted form sediment cores using a high pressure pore water extractor and the samples were processed for cation and heavy metal concentrations by ACME Analytical Laboratories of Vancouver, B.C. using mass spectrophotometic techniques.

Sediment Water and Organic Content: Sediment samples were collected using a 5 cm diameter core sampler (Fig. 3.2). The upper 2-3 cm portion of the core sample was used for the analyses. Sediment water content was determined by initially weighing and then oven drying the sample at 60-70 °C to a constant dry weight and determining the weight loss. Sediment organic content was then determined on the dried sample by combusting it at 500 °C for 3 hr and reweighing to determine the loss on ignition.

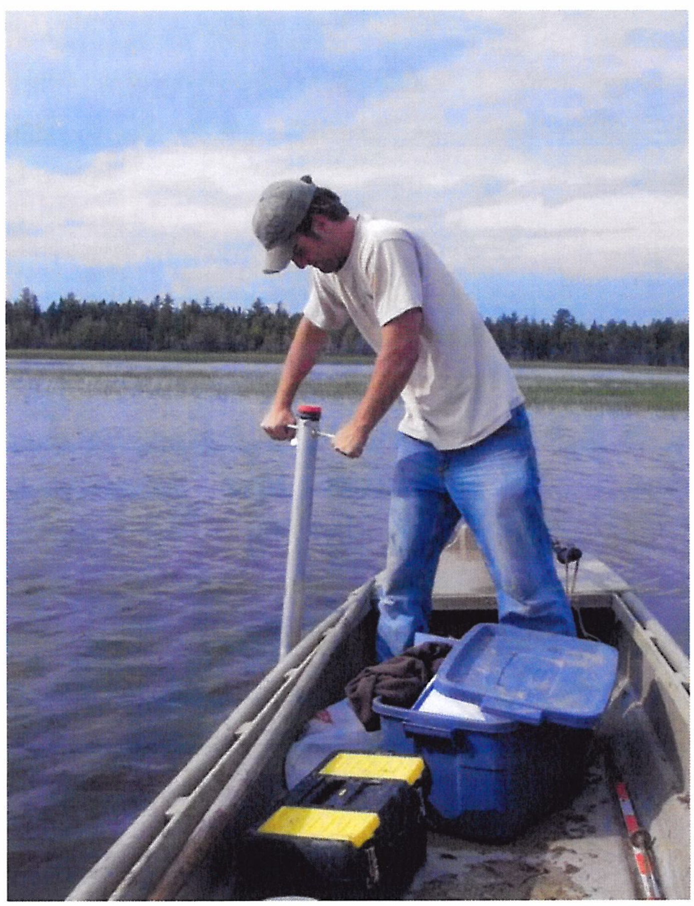

Fig. 3.2 Using a core sampler to collect sediment samples.

3.1.3 Biological Parameters

Aquatic and Shoreline Vegetation: A survey of aquatic and shoreline vegetation was carried out on 1-2 September 2007 by Ruth Newell, Curator of the Irving Biodiversity Centre. Shoreline vegetation was surveyed by foot. Emergent and submersed vegetation was surveyed by canoe.

Phytoplankton Biomass: Phytoplankton biomass was measured indirectly by determination of chlorophyll *a* concentration. Water samples were collected in 1-liter polyethylene containers and filtered the same day as collection through Watman GF/C filters under gentle vacuum (<20 mm Hg). The filters were placed into 20 ml of 95 percent acetone and stored refrigerated and in the in the dark until analysis. Analysis for chlorophyll *a* was carried out by centrifuging each sample at 2500 rpm for 5 min, decanting into a 5 cm pathlength cuvette and measuring absorption of the sample spectrophotometrically at 665 and 750 nanometers before and after acidification with 0.1 ml of 10 percent HCl. Chlorophyll *a* concentration was calculated according to the equations presented in Wetzel and Likens (1990).

Periphyton Growth: Periphyton growth was monitored using glass microscope slides contained in trays set to float just below the surface of the water. Six individual slides were placed in each tray at each site. The slides were left in place for approximately one month at which time they were collected and stored frozen until analysis which consisted of scraping the growth off of the slides and drying the sample to a constant dry weight at 70°C. Each set of samples was then weighed to determine the increase in dry weight over the period in which the slides were immersed. Because the time between sets of samples varied slightly, results are reported as growth/day.

Fig 3.3. Sampler used to assess periphyton growth

Zooplankton: Zooplankton samples were collected by pouring 50 liters of water through a 200 μm plankton net. Samples were stored preserved in 10% formalin until analysis.

Zooplankton numbers were identified and enumerated in the laboratory using a stereo microscope.

Emergent Insects: Emergent insects were collected using a 50 cm diameter cone shaped trap constructed of fiberglass window screen and floats set on stakes to lie at the water's surface (Fig. 3.4). The apex of the cone led into an open ended bottle containing 10% formalin and having a plastic funnel attached to the lower end. Each trap was set for approximately one month between samplings. At the time of collection, emergent insects contained in the trap were washed in a sample bottle and preserved with 10% formalin until analysis. Emergent insects were identified and enumerated in the laboratory using a stereo microscope.

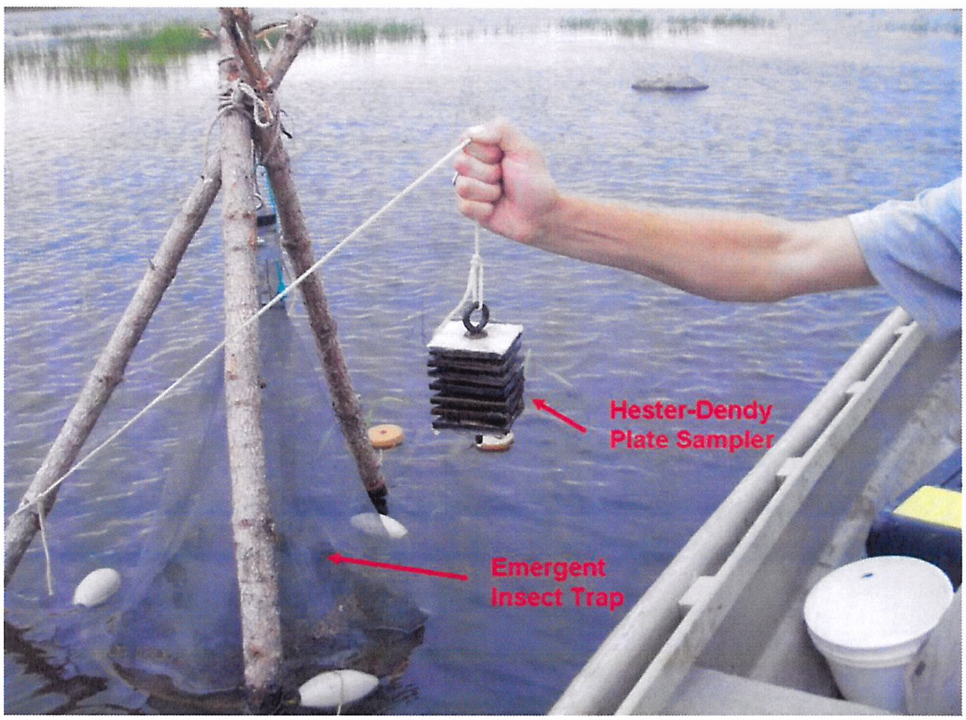

Fig. 3.4 Emergent insect and benthic invertebrate samplers.

Benthic Invertebrates: In addition to occasional sweep net samples, Hester-Dendy multiple plate samplers were used in attempts to collect benthic invertebrates. The samplers were constructed of eight 10 cm by 0.5 cm thick plywood squares stacked together with 0.5 cm wooded spacers between each square (Fig. 3.4). The samplers were deployed for approximately one month periods.

4. Results

4.1 Morphology

The morphological characteristics of Muzroll Lake have been described previously (Section 2). However, it has been unclear as to the nature of water inflows into Muzroll Lake. Figure 4.1 is a digital elevation map of the lake and its surrounding watershed which shows only two significant stream inputs to the lake, one entering at the west end and the other along the north-central shore. It is possible that other water inputs, aside from precipitation, enter from groundwater springs, but this seems unlikely as the lake contains water with a salt content much lower than what is typical for groundwater (discussed in Section 4.2).

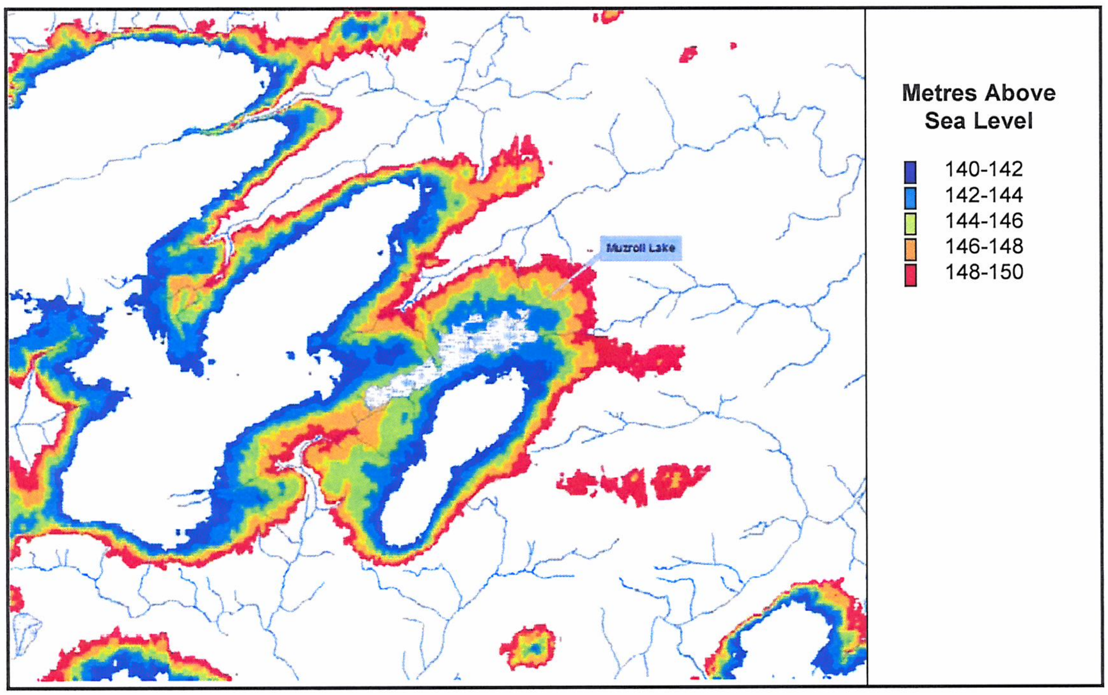

Fig. 4.1 Digital elevation map of Muzroll Lake and its watershed.

4.2 Physical Characteristics

Fig. 4.2 illustrates the variation in seasonal mean values of the physical characteristics measured at each station over the study period. Temperature showed a typical seasonal variation and was greatest in July with a maximum of about 25° C. Colour, which is mainly due to dissolved humic organic compounds which gives freshwaters their characteristic yellow-brown colour, are quite high, generally > 40 TCUs, which is typical of most wetlands. The lower mean colour measured during September and October is difficult to explain as this was a period of low precipitation which usually results in higher water colour due to concentration of dissolved substances by evaporation.

Turbidity, an indirect measure of the amount of suspended particulate matter was relatively low most of the time.

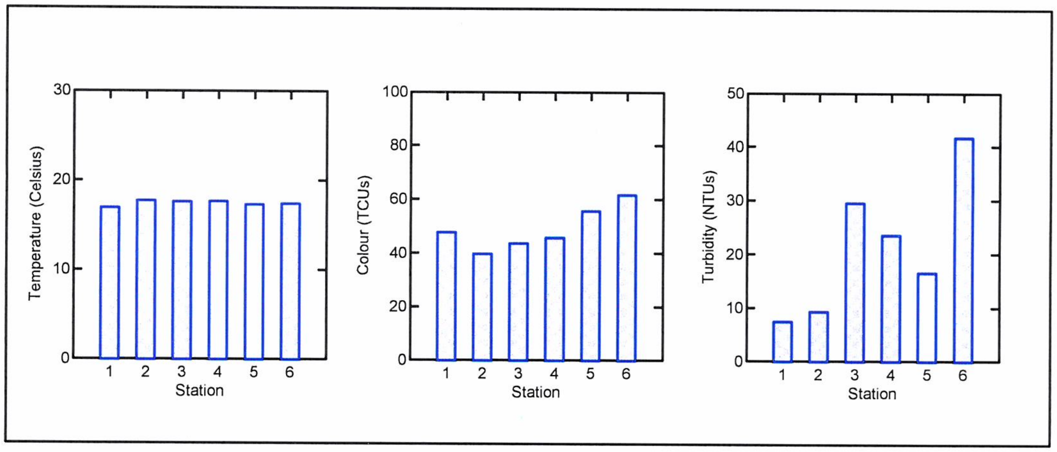

Fig. 4.2 Mean values of physical characteristics at each station.

Fig. 4.3 shows the spatial variation in mean values of the physical characteristics. There was little difference in temperature between stations. Both colour and turbidity show an increasing trend toward the Lake's outlet.

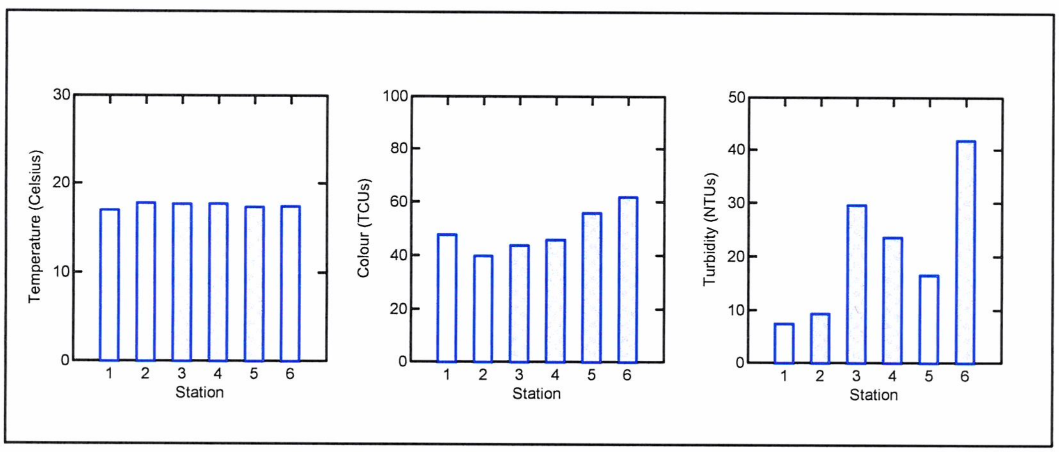

Fig 4.3 Mean seasonal values of physical characteristics.

4.3 Chemical Characteristics

4.3.1 Conductivity, Alkalinity and pH

The seasonal and spatial variation in conductivity, alkalinity and pH are illustrated in Figs.4.4 and 4.5. Conductivity, an indirect measure of the total amount of dissolved salts (usually mainly calcium and magnesium), is exceptionally low in Muzroll Lake. Mean values never exceeded 15 μSi/cm and were generally below 10 μSi/cm. Typical values for freshwater systems range from a low of about 20 to a high of about 300 μSi/cm.

Levels below 20 in natural wetlands are very rarely encountered. This indicates that Muzroll Lake contains very little dissolved salts and also explains why alkalinity, a measure of buffering capacity (i.e., the ability of water to resist changes in pH) is also low since this capacity is largely due to the presence of .carbonates of calcium and magnesium*. Despite the low salt content and low alkalinity, the pH values measured at the monitoring stations were seldom less than 5.0 and were mostly about 5.5.

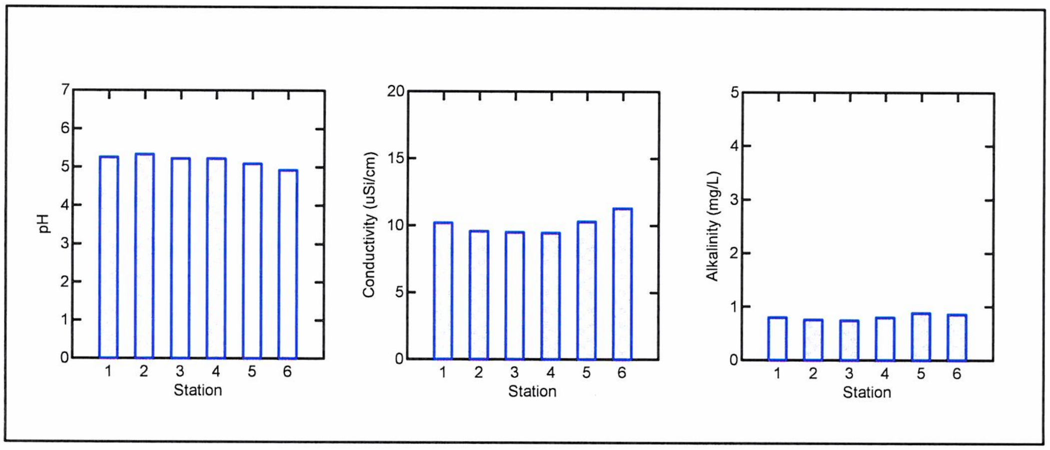

Fig 4.4 Mean values of pH, conductivity and alkalinity at each station.

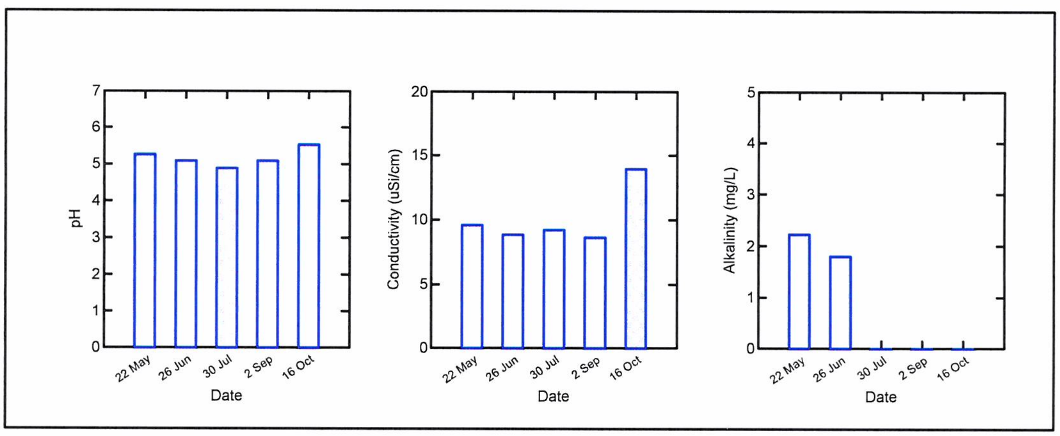

Fig 4.5 Seasonal variation in mean values of pH, conductivity and alkalinity.

Although most of these parameters did not exhibit much spatial variation, they did show significant seasonal variation. pH was lowest during summer and highest during fall, and alkalinity was essentially undetectable after June. A better indication of the seasonal variation is provided by the data collected by the continuously recording logger which

* Natural water bodies located within the Miramichi River drainage basin seldom exceed alkalinities greater than 10 mg/L and are usually 5 mg/L or less (per. comm.. Bill Hooper).

was deployed within the canal at the outlet of the Lake during August and September (Fig. 4.6). Conductivity varied little but there was a distinct increase in pH toward the fall.

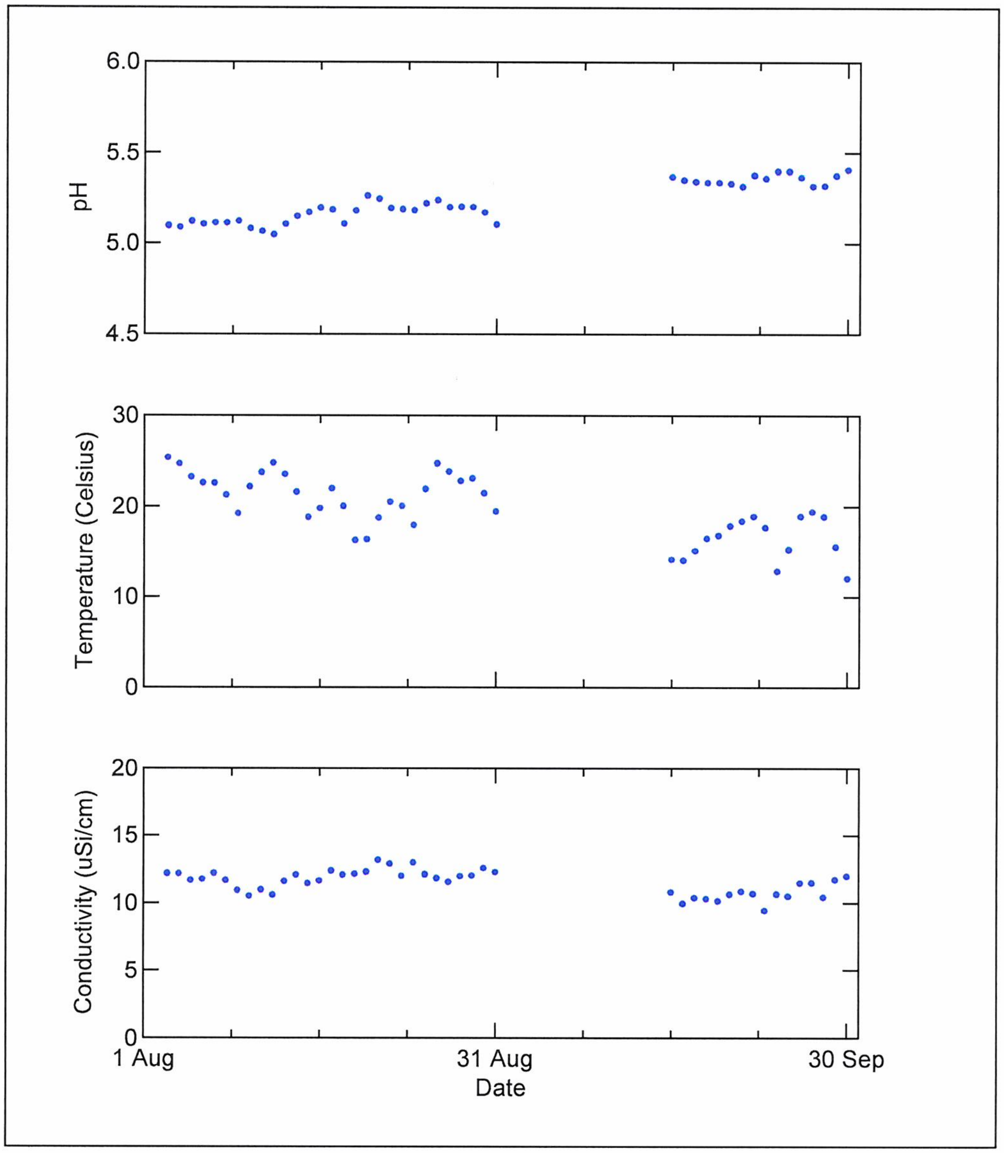

Fig 4.6. Mean daily values of pH water temperature and conductivity recorded during August and July 2007.*

There was also a distinct diurnal variation in pH, temperature and conductivity, an example of which is shown in Fig.4.7.

* Missing data between 31 August and 15 September resulted from erroneous data being recorded as a result of a moose crossing the outlet and dragging the logger onto the shoreline!

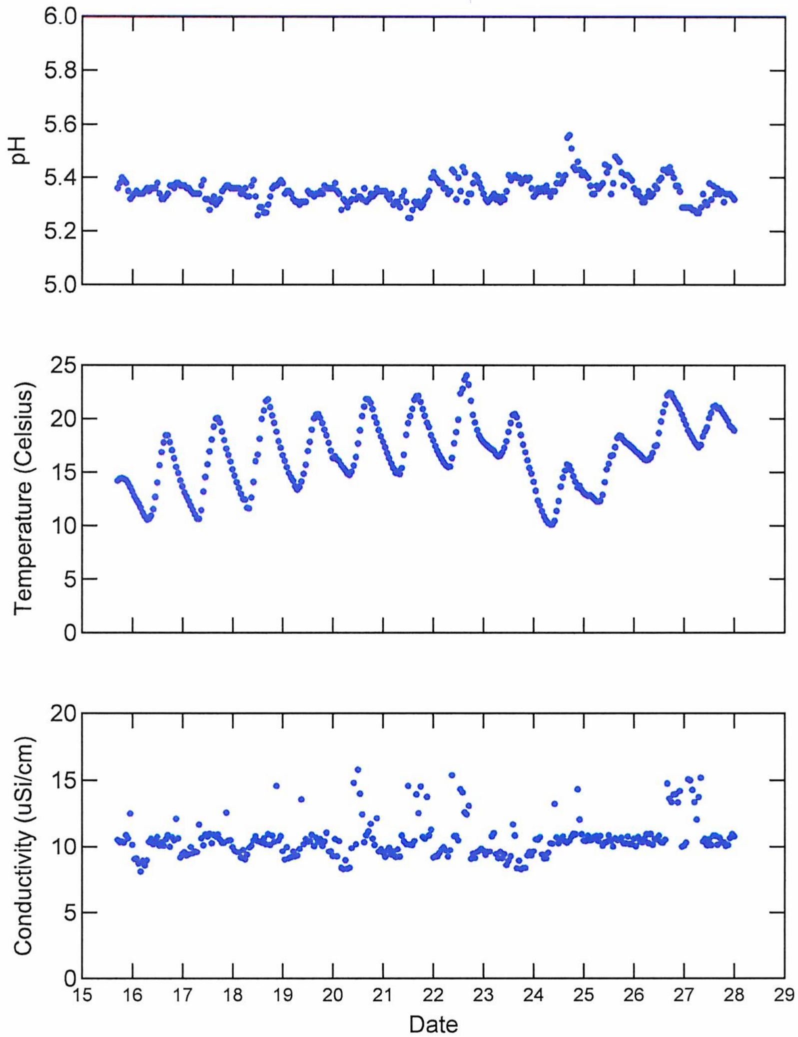

Fig.4.7. Example of diurnal variations in pH, water temperature and conductivity during September 2007.

4.3.2 Nutrients

The primary nutrients measured during the survey were phosphorus and nitrogen. Most of the measurements were made on water samples, but on one occasion sediment samples were collected for analyses of sediment and sediment pore water nutrient levels.

The spatial and seasonal variations in mean nutrient levels are illustrated in Figs. 4.8 and 4.9. Mean values of total nitrogen were generally less than 0.5 mg/L, which are quite low for a wetland. The highest values were recorded during June and July. There was little spatial variation. Dissolved inorganic nitrogen, the form most available to organisms, was very low. In contrast, mean total phosphorus values were relatively high for a wetland and ranged between 12 and 45 μg/L with the greatest values occurring during the fall.

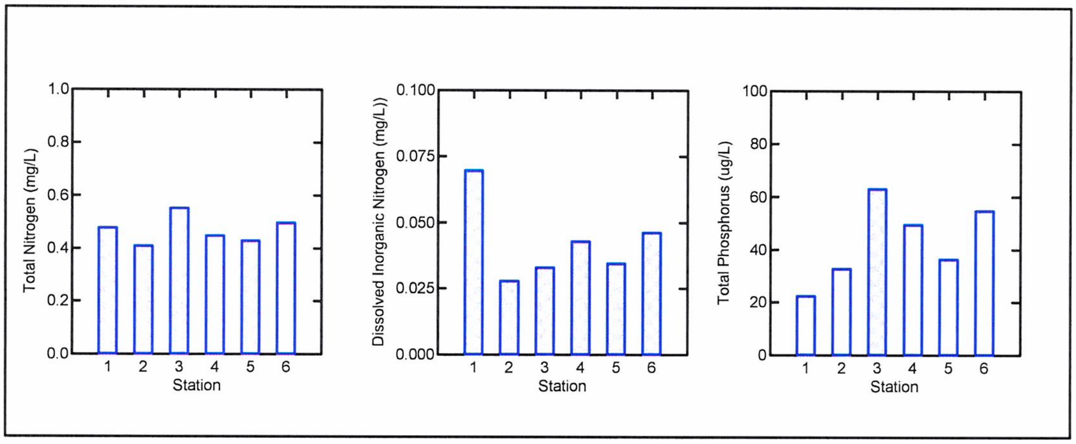

Fig.4.8 Mean value of nutrients at each station.

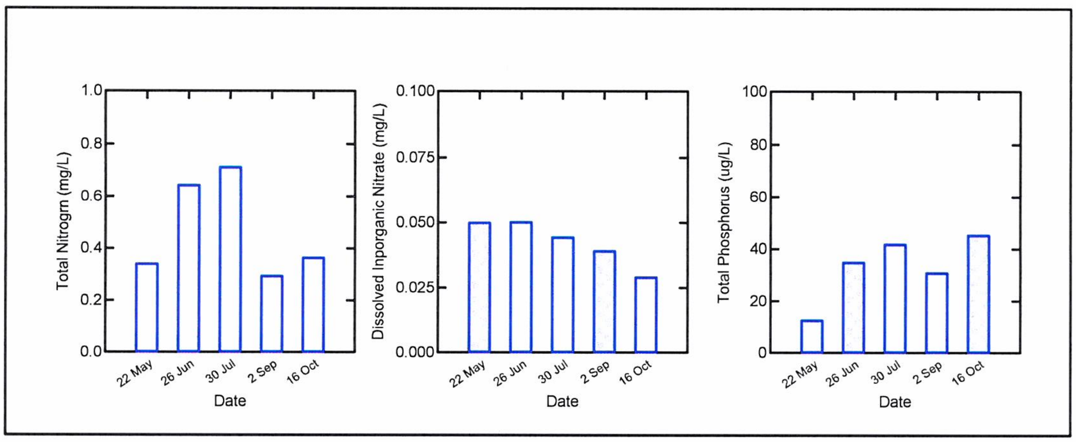

Fig 4.9 Seasonal variation in mean nutrient levels.

These results suggest that low nitrogen availability may be the primary factor limiting productivity in Muzroll Lake.

4.3.3 Sediment Analyses

Sediment analyses for water and organic content and pH were carried out to provide information on the nature of the sediments underlying Muzroll Lake. Wet weight gives some indication of sediment porosity and organic content provides an indication of the source of surface sediment in term of its relative biological or geological origin. The results are contained in Table 4.1.

Table 4.1 Sediment water content, organic content and pH.

Station	Percent Water Content	Percent Organic Content	pH
1	16.4	11.4	5.0
2	9.2	5.3	5.6
3	8.9	4.1	5.4
4	9.4	3.2	5.4
5	8.6	7.9	5.5
6	7.3	2.9	5.6

Both sediment percent water and organic content are generally low for a wetland suggesting that Muzroll Lake is not a typical wetland. The highest values for both are for Station 1 which is located farthest away from the outlet and generally has characteristics more typical of a natural wetland.

Sediment pH values were similar to that of the overlying water. The lowest value was at Station 1 and is likely a result of the bog-like nature of the vegetation contained in this area of the lake.

Visual observations of the core samples indicated little surface organic matter, and underling sediment consisted mainly of sand and gravel sized particles that most likely originated as glacial till deposits.

Note: Samples collected for heavy metals and pore water nutrients are still waiting analyses by ACME laboratories and will likely not be available until some time after March 2008. When these results are received they will be reported on separately.

4.4 Biological Characteristics

4.4.1 Aquatic and Shoreline Vegetation

Aquatic and shoreline vegetation was surveyed on the 1st and 2nd of September 2007 by Ruth Newell of the Irving Biodiversity Centre. A detailed listing and discussion of the vegetation identified is contained in Appendix IV.

The results of the shoreline plant survey indicate that Muzroll Lake exhibits characteristics of both a fen and bog type wetland. Although the shoreline vegetation can be generally classified as boggy, the presence and abundance of sedge species, and the general diversity of vegetation types present, is more typical of a fen.

Aquatic vegetation within the lake is much less diverse than the shoreline vegetation, and is dominated by extensive stands of Torrey's Bulrush (*Schoenoplectus torreyi*).

Submerged vegetation consisted mainly of a pondweed (*Potamogeton confervoides*) which is only prominent in the most western area of the Lake.

Four of the 41 species of vegetation identified during the survey are classified as rare by the Atlantic Canada Conservation Data Centre, but this may be a reflection of the limited number of surveys that have been carried out within this area of New Brunswick rather than a true indication of the presence of rare species. This is discussed further in Appendix IV.

4.4.2 Phytoplankton Biomass

Water column chlorophyll *a* concentrations, measured as an index of phytoplankton biomass, were mostly low, especially during the summer and fall (Fig. 4.10). With the exception of Station 5, there was little spatial variation. The higher values in the spring are typical of freshwater systems and are a result of nutrient regeneration over the winter. The low values in summer are also typical and result from the loss of nutrients to the sediments. The low levels of chlorophyll are most likely a result of the low dissolved nitrogen levels.

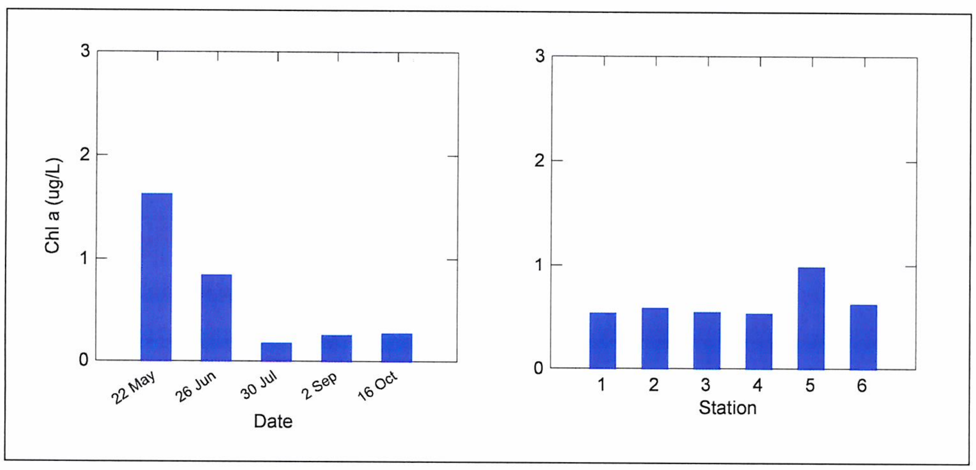

Fig. 4.10 Mean values of phytoplankton chlorophyll *a* levels seasonally and spatially.

4.4.3 Periphyton Growth

Periphyton are a community of diverse organisms, mostly microscopic, that grow on the surface of submersed substrates such as stones, twigs, and the stems and leaves of aquatic plants. Common members of the periphyton community include filamentous algae, protozoans, and rotifers. This community is considered to be an important component of aquatic ecosystems because it provides a concentrated food source for small organisms such as juvenile fish and aquatic insect larvae.

Periphyton growth was monitored by measuring their growth on glass microscopic slides placed in specially designed trays that floated just below the water surface of the lake.

The daily mean growth rates are quite high and the spatial and seasonal variation (Fig. 4.11) was very similar to phytoplankton chlorophyll *a* concentration. This suggests that periphyton growth is controlled by the same factors, the availability of dissolved nutrients.

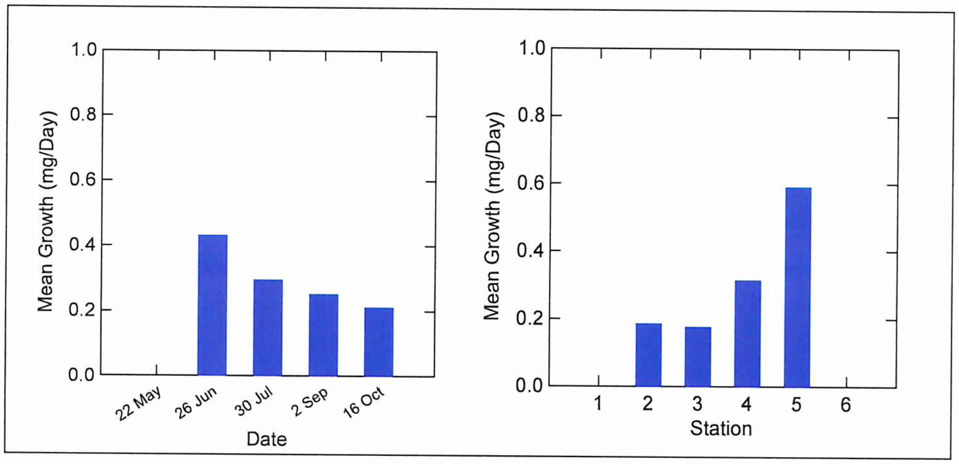

Fig 4.11 Seasonal and spatial variation in mean daily periphyton growth rate.

4.4.4 Zooplankton Composition and Numbers

Zooplankton numbers in Muzroll Lake are surprizingly high, the total number often exceeding 200/L. Rotifers, which are the dominant zooplankton present in systems having low productivity, are the most abundant group (Fig. 4.12). Copepods, which are the most common type present in moderately productive systems, and cladocerans, which are typical of highly productive systems, were much less abundant.

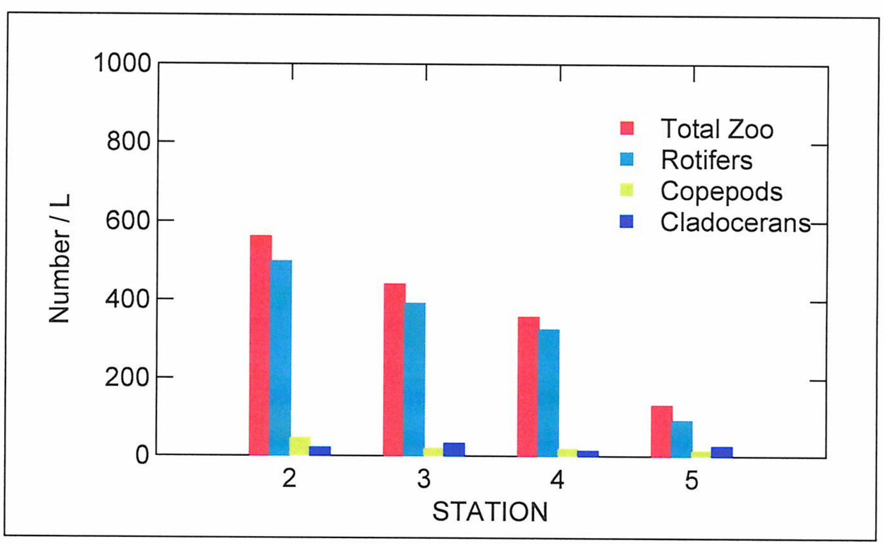

Fig. 4.12 Mean numbers and types of zooplankton at each station.

The spatial and seasonal variation in zooplankton numbers (Fig. 4.13) was almost the reverse of phytoplankton chlorophyll *a* concentrations and periphyton growth rates suggesting that zooplankton exert substantial grazing pressure on those communities. The high numbers of zooplankton is undoubtedly a reflection of the absence of grazing pressure by fish which are absent in Muzroll Lake. The absence of grazing pressure on zooplankton also explains the seasonal increase in numbers after the spring ice out period.

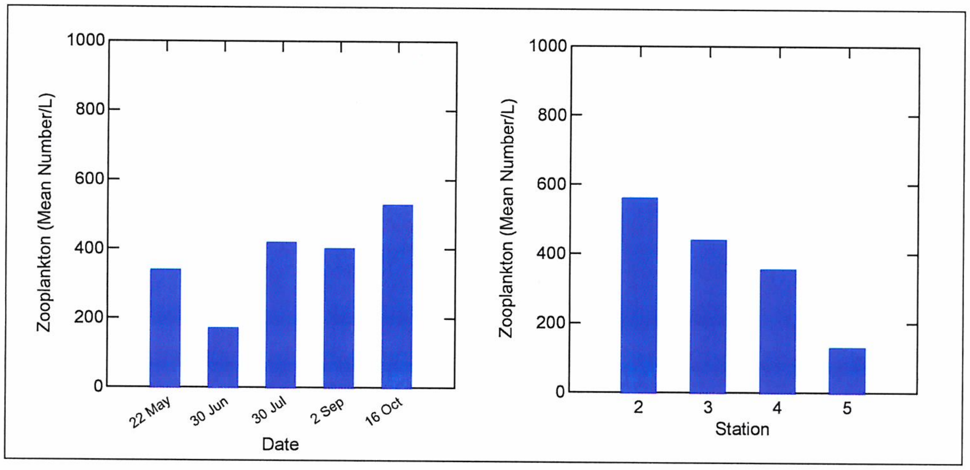

Fig. 4.13 Seasonal and spatial variation in mean zooplankton numbers.

4.4.5 Emergent Insect Composition and Numbers

The emergent insect traps were deployed between June and August. Insects collected in the emergence traps consisted mainly of dipterans, and most of these were various species of mosquitoes, although some caddis flies were collected in June. The numbers of emergent insects collected were extremely low (Fig. 4.14) and indicate that Muzroll Lake is a poor breeding ground for aquatic insect larvae.

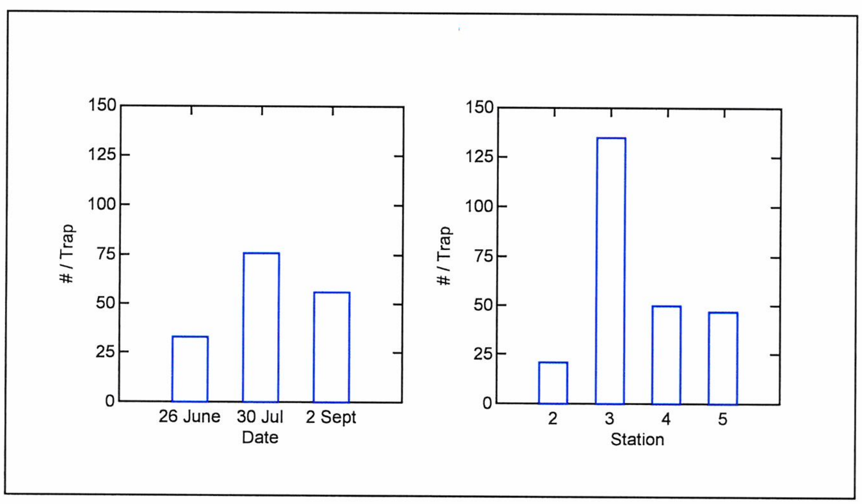

Fig. 4.14 Seasonal and spatial variation in mean emergent insect numbers.

4.4.6 Benthic Invertebrate Composition and Numbers

The Hester-Dendy plate samplers employed to sample benthic invertebrates failed to collect a single organism, further indicating that Muzroll Lake is a poor breeding ground for aquatic insects and other benthic invertebrates. This is most likely due to the Lake almost completely freezing to the bottom during the winter, which results in the development of anoxic conditions within the underlying sediments and water. Very few aquatic invertebrates have the ability to over-winter under these conditions.

4.4.7 Other (Opportunistic) Wildlife Observations

During our visits to Muzroll Lake, we made numerous observations on other forms of wildlife. Of particular note is the abundance of moose using Muzroll Lake as a feeding area. On one occasion we observed a total of 12 moose feeding, two of which had calves nearby, and it was not unusual to always observe at least one or two moose somewhere on the Lake during the early mornings and evenings. The area in which moose were most commonly seen was in a cove located at the southwestern end of the Lake. This is also the area in which pondweeds are most abundant. We also observed deer feeding along the shoreline, but they were never as numerous as moose

Waterfowl were also common, especially during the fall migration period. However, it was rare that we observed any waterfowl brood. A survey carried out on 20 June 2007 by DUC personnel reported two goldeneye with brood, 25 ringnecks, three wigeon and seven black ducks.

Although on one occasion we observed caddis fly larvae in shallow areas along the shoreline, random sweeps with dip nets at various times and locations within the lake failed to produce any evidence of other larvae. In addition, amphibians and reptiles, especially turtles, were conspicuously absent.

Although we never observed any evidence of muskrat use during most of our field visits, on our last visit in October we counted more that 10 newly constructed muskrat lodges located over various areas of the lake (Fig. 4.15).

Fig 4.15 Example of a newly constructed muskrat lodge observed during October.

5. Discussion

5.1 The Nature of Muzroll Lake

The results of this study clearly indicate that Muzroll Lake is not a typical wetland and does not fit well into existing wetland classification systems. Although it has some characteristics typical of bogs, mainly low salt content and, in areas of the east and west regions, bog like plants such as sphagnum moss and organic sediments, its pH is much higher then that of bogs which are normally in the range of 4.0 to 4.5. In addition, most of the Lake does not contain the highly organic sediments typical of bogs, but is underlain by sandy gravelly sediment.

Other characteristics that make Muzroll Lake unusual are the extremely low salt content, the relatively high pH despite a low alkalinity, low numbers of aquatic insects, high numbers of zooplankton and a relatively high phosphorus, but low nitrogen, content. Many of these factors are likely a result of the fact that Muzroll Lake freezes almost entirely to the bottom during the period of winter ice-cover.

The low salt content is most probably a reflection of precipitation being the most prominent source of the water contained within Muzroll Lake as opposed to stream or groundwater inputs. It is difficult to explain the relatively high pH in the absence of any significant amount of alkalinity, but this may be related to the regeneration of small but significant amounts of alkalinity during the period of ice-cover (discussed below).

Although the lack of emergent insects, particularly mosquitoes and black flies, might be considered a positive factor for those visiting Muzroll Lake, it is a severe limitation to biological diversity and productivity given that insects play a major role in the functioning of aquatic systems. Not only do they enhance the processes of decomposition and nutrient recycling, they are an important food source for many organisms, both terrestrial and aquatic, and particularly for waterfowl brood. The low numbers of aquatic insects is undoubtedly a result of the fact that Muzroll Lake freezes almost entirely to the bottom during winter. Since ice-cover prevents dissolved oxygen from entering the Lake, it results in the bottom sediments, and the pore water it contains, becoming anoxic, a condition which makes it an unsuitable habitat for aquatic larvae to over-winter. Zooplankton, particularly rotifers, which are the dominant form of zooplankton in Muzroll Lake, have the ability to either encyst or produce over-wintering eggs that are able to withstand anoxic conditions, and are therefore able to survive the winter conditions quite well. In addition, the lack of fish and aquatic insect larvae means that there is very little predation pressure on zooplankton during the ice-free season and explains why their high numbers and why their numbers increase over the ice free period.

The high phosphorus content, together with the low productivity of the Lake, can be explained by understanding the way phosphorus is recycled within Muzroll Lake. Since precipitation contains very little phosphorus, its source in natural systems is almost entirely from weathering of the substrate. Because of its small watershed and the lack of significant stream inputs to Muzroll Lake, the largest source of phosphorus is most likely weathering from underlying sediments, and perhaps a smaller contribution from the droppings of spring and fall migrating waterfowl. The form in which phosphorus occurs is also important. Under most conditions it exists largely as an oxidized insoluble complex formed with various substances, especially iron and aluminum, both of which are naturally present in high concentrations in Muzroll Lake. In this form it is unavailable as a nutrient to photosynthetic organisms. In order for it to be utilized as a nutrient, it must be chemically reduced to the dissolved phosphate form, and this form occurs largely only under conditions of low dissolved oxygen levels. Because Muzroll Lake is shallow and well mixed by wind during the ice-free period, the only time low dissolved oxygen conditions are likely to occur in Muzroll Lake is during the period of ice-cover, and at this time light and low temperatures become the major limiting factors for photosynthetic organisms. As a result, the only time the unavailable oxidized form of phosphorus is chemically transformed into the reduced and utilizable form is during the period of ice-cover when the bottom sediments are anoxic, and for a short period after the ice has melted, after which is becomes transformed back into the unutilizable oxidized form as the sediments become re-oxidized. This explains the occurrence of the high phytoplankton chlorophyll *a* concentrations and high periphyton growth observed during May and June (see Section 4.11), and the lower concentrations and growth during summer. It is also likely that the small amount of alkalinity present during May and June (see Section 4.3.1) is also a result of its being generated by dissolution of carbonates from bottom sediments under anoxic conditions during ice-cover in which acids, particularly hydrogen sulfide, are present.

5.2 Prospects for Increasing Biodiversity and Productivity of Muzroll Lake

It is unlikely that the biodiversity and productivity of Muzroll Lake could be significantly enhanced by either fertilization or liming treatments without first addressing the problem of winter habitat availability for aquatic organisms. This would require management practices that increase the volume of water under winter ice-cover to an extent that would allow survival of aquatic organisms that undergo winter hibernation within sediments or overlying water, such as aquatic insect larvae, amphibians as well as some reptiles. It appears obvious that the simple solution to this problem would be to raise the water level of Muzroll Lake, if not permanently, then at least in the fall prior to the formation of ice. Lower water levels during the ice-free season, if desired, could then be restored after ice-out. Determining how much higher the water level would have to be in order to provide suitable over-wintering habitat is difficult to answer without knowing the depth to which ice naturally forms in shallow water systems, and the volume of underlying water required to prevent the development of hypoxic/anoxic conditions, within this area of New Brunswick and it may have to be determined on the basis of a trial and error effort.

If this approach is adopted and it still appears that fertilization or liming is required, care must be taken in determining how much would be required. This is especially true of fertilization with phosphorus and/or nitrogen. Being a shallow lake with a relatively long retention time, Muzroll Lake is very susceptible to nutrient-overenrichment, the symptoms of which include excessive algal growth, especially toxic blue-green algae, development of anoxic conditions which result in the formation of toxic substances such as methane, hydrogen sulfide and ammonia, and loss of submerged vegetation such as pondweeds. The latter would be especially undesirable since this is the main food source of the many moose that forage within Muzroll Lake.

With respect to establishment of wild rice within Muzroll Lake, it is unlikely that this would enhance biological diversity to any great extent. Its main advantage would be to provide better fall staging habitat for waterfowl and increasing the amount of time migrating waterfowl would stay on the lake before moving on to their winter habitats.

Exactly why past attempts to establish wild rice have been unsuccessful is not entirely clear from the results of this study. Despite the importance of wild rice, both as a commercial food crop and for improving wildlife habitat, its growth requirements have not been well studied, especially with regard to nutrient requirements. A summary of what is known, and a comparison of the growth requirements of wild rice with the conditions present within Muzroll Lake, is contained in Table 5.1. The only obvious limitations within Muzroll Lake are the low values of conductivity, hardness and alkalinity, all of which are closely related to each other. However, the same factors that influence of the level of conductivity, hardness and alkalinity are to a large extent also responsible for controlling the inputs of nutrients, and it is very likely that low levels of nutrients, especially available nitrogen, are the main reason why the attempts to establish wild rice in Muzroll Lake have been unsuccessful.

Table 5.1 Growth requirements of northern wild rice (*Zizania palustris*)

Parameter	Tolerable Limits	Muzroll Lake
Soil Requirements		
Mineral Content (%)	>20	>80
Organic Content (%)	< 50	3 - 11
Carbon Nitrogen Ratio	< 16	Unknown
pH	5.0 – 8.0	5.0 - 5.6
Oxygen Content (mg/L)	> 0.4	Unknown
Water Requirements		
Water Movement	Slow or wind mixed water column	Wind mixed water column
Water Depth (m)	< 1 (preferably decreasing during summer)	< 0.7 (decreasing during summer)
Conductivity(µSi/cm)	60 - 250	10
Hardness (mg/L)	20 - 300	0.8
Alkalinity (mg/L)	40 - 200	0.9
Sulfate (mg/L)	< 10	< 1
pH	5.0 – 8.0	5.4

If it is considered desirable to continue attempts at introducing wild rice, the best approach may be to try to establish small (10 by 10 m) stands of wild rice in various areas of the Lake, using small applications of lime and fertilizer along with seed as soon after ice-out as possible, followed by hand raking to ensure that the fertilizer, lime and seed are incorporated within the sediments

6. Acknowledgements

Funding for this study was arranged by Peter Romkey, Director of the K.C Irving Environmental Science Centre. Ruth Newell, Curator of the Irving Biodiversity Centre, with the aid of Reg Newell, carried out the vegetation survey. The digital elevation map of Muzroll Lake was kindly provided by Faye Cowie of Watersheds Technologies, Doaktown, N.B. Thanks are due Bill Hooper, John Waugh and Geoff Harding for numerous discussions about the nature of Muzroll Lake and the efforts made to improve its productivity and biodiversity, and to Edmund Halfyard and John Hasty, former students of Acadia University, for their capable assistance in the laboratory and field. Special thanks are due Calvin O'Donnell for looking after our needs so well during field trips to Muzroll Lake.

7. References

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Appendix I

DUC Pre-Bio Inspection report for Muzroll Lake

DU File No. N-36-81

DUCKS UNLIMITED (CANADA)

MARITIMES PRE-BIO INSPECTION REPORT

Project Name:
Muzroll Lake

File No:
N-36-81

Province:
New Brunswick

County:
Northumberland

Topo Map No:
21J/8

Coordinates:
155 465

Area:
136.3 acres
55.2 hectares

Shoreline:
2.3 mi
3.7 km

Watershed:
1.7 mi^2
4.4 km^2

Date of Investigation:
October 7, 1981

Investigator:
G.R. Stewart

Ecotype:
Natural Lake Basin

Inventory:
Number: 1BN-11-19
Score: 36

Dominant Emergents:

Sedge (*Carex sp.*) - very common on dry marsh surrounding area and in scattered stands in shallow water.

Meadow Grass (*Calamagrostis sp.*) - common.

Bulrush (*Scirpus sp.*) - some.

Spirea sp. - some.

Dominant Submergents:

- submergent growth restricted to large dense beds of Manna Grass (*Glyceria sp.*).

Waterfowl Observed:

- 6 Blacks
- 2 Ringnecks

Other Wildlife Use:

- 12 muskrat houses.
- active beaver house in inlet.
- area too shallow to support brook trout though they are present in inlet.

Surrounding Land Use:

- area surrounded by mature mixed forest with large clear cuts nearby.
- no apparent conflicts.

Access and Distance from Road:

- direct access to lake shore via rough woods road 1/4 mile off gravel hauling road.
- access to dam site questionable as outlet to lake not found - apparently marsh drained through large boggy peat area adjacent to lake at southern end. No - outlet on north end [initials].

Type and Distance of Nearest Waterfowl Habitat:

- area an isolated one of good basic fertility in central N.B.
- surrounding area dotted with small ponds, streams and lakes which are the main producers of Blacks, GWT and Ringnecks in the interior part of the province.
- area 10 miles east of the Southwest Mirimichi, the main migration route in this part of the province.

Ownership:

- apparently all of surrounding area leased crown land.

-3-

Comments:

- area has good basic fertility and if it could be drawn down for a year and reflooded a foot higher than present should result in an area with the capability to produce a brood per five acres.

- all of lake bottom is firm - clay and rocks and appears to be similar to a prairie pothole situation - i.e. water level more or less dependant on spring melting and runoff and percipitation.

- pre engineering required as the only method of development to me is to block off drainage through peat bog and dig a new outlet channel to nearby Muzroll Brook to facilitate draw down and allow us to raise water level. No - dam outlet - build road

Recommendation:

- area biologically feasible and geographically could be an important brood rearing area.

- pre engineering required to see if development possible.

Appendix II

Notes on Muzroll Lake Wild Rice and Pelletized Lime Applications
Prepared by Bill Hooper

SITE A: Wild Rice Planting Only, Nov, 2004

Approximately 60 kg of water slaked wild rice distributed over 1000 m² at the northwest corner of the lake (see attached Figure). No lime was added. Subsequent (2005) rice regeneration was sparse, at best.

SITE B: Lime **(April 2005) and Wild Rice (May 2005) Applications**

Fifty-four kgs of agricultural lime was broadcast by shovel and dustpans 20 April 2005 covering 1400 m² (70 shoreline meters east of camp trail and out into the lake 20 meters).to the east of Old Camp trail. Twenty kgs of wild rice distributed over this limed area.
Wild rice was also distributed over a similar 1400 m² area to the west of the Old Camp trail where no lime had been applied. Rice generation was disappointing, but obviously better on the limed portion east of the Old Camp trail. Cranberries were also substantially larger along the limed shoreline.

SITE B: Lime and Wild Rice Applications (October 28, 2006)

One metric ton of lime poured from 18 kg bags over a 4000 m² area in front of Old Camp, October 28, 2006.
About 63 shoreline meters and 63 meters into the lake were limed. About 100kgs of wild rice were subsequently distributed over the 63x63 meter area.

SITE C: Lime (April 20, 2005) and Wild Rice (May 7, 2005) Applications

Fifty-four kgs of lime broadcast by shovel and dustpan along 70 m of shoreline and 10 m out from the shoreline southeast of Moose Call Camp trail for a 700 m² area. Subsequently, 20kg of soaked wild rice was distributed over the limed area on May 7, 2005).
Twenty kgs of soaked wild rice distributed to a 70m x 10m area southwest area from Moose Call Camp trail. This area was not limed.
Subsequent generation for both areas was poor although there was obviously more generation of rice on the limed area.

SITE D: Wild Rice Planting (November, 2005)

Distributed about 80 kgs of soaked wild rice over 700m x300m area at the southeast portion of the lake. There had been no previous liming.
Subsequent generation in 2006 was poor although the shallower areas adjacent and in the "thoroughfare" to the "center lake" did have better germination

SITE D: Liming and Wild Rice Distribution (May 15, 2007)

Distributed 144 kgs of lime over a 65m shoreline x 50m plot at the south east end of the lake; lime was dumped over the side of the boat from 18 kg bags. The same day we planted 40 kg of soaked wild rice (partially sprouted) over this limed area (see map).Planted 40 kgs of soaked wild rice over and adjacent and opposite plot at south west end of lake that had not been previously limed.

Appendix III

Results of Water and Sediment Chemistry Analyses

NOVA SCOTIA
Agriculture and Fisheries
Quality Evaluation Division

Soil Test Report

PO Box 550
Truro, Nova Scotia
Canada
B2N 5E3

URL: http://www.gov.ns.ca/nsaf/
Tel: 902-893-6565
Fax: 902-893-4193

FRED PAYNE
67 CAMPBELL AVE.
KENTVILLE, N.S.
B4N 1Y2

Client Number: 37099
Accession: 59467
Samples Reported: 11/29/2005
Samples Received: 11/14/2005

Lab #	1			2								
Sample ID	WILDRICE 1			WILDRICE 2								
Field Size (ha)	100.0			100.0								
Manure Code												
Sod Code												
Crop to be Grown	UNKNOWN			UNKNOWN								
	Analysis		Rating	Analysis		Rating	Analysis		Rating	Analysis		Rating
pH	4.7			4.7								
Organic Matter (%)	9.5			8.0								
P2O5 (kg/ha)	264			196								
K2O (kg/ha)	95			52								
Ca (kg/ha)	147			111								
Mg (kg/ha)	55			53								
Na (kg/ha)	74			42								
Sulfur (kg/ha)	44			42								
Fe (ppm)	364			333								
Mn (ppm)	6			7								
Cu (ppm)	0.67			0.74								
Zn (ppm)	1.2			1.2								
B (ppm)	0.10			0.10								
Nitrate - N (ppm)												
Salt (mhos x 10 -3)												
CEC (meq/100gm)	8.2			6.3								
Base Sat. K (%)	1.2			0.9								
Ca (%)	4.5			4.4								
Mg (%)	2.8			3.5								
Na (%)	2.0			1.4								
H (%)	89.6			89.8								
Lime Required (t/ha) to reach pH of	6.0		6.5	6.0		6.5	6.0		6.5	6.0		6.5
			13			10						
Required Nutrient Applications (kg/ha)	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O

Comments:
Your sulfur result(s) are obtained using Mehlich 3 extractant.

1 kg/ha = 0.89 lb/ac 1 tonne/ha = 0.45 ton/ac
To convert kg/ha to ppm divide by 2

L = Low M = Medium H = High E = Excessive

Copies To:	Analysis Approved By: Jason Burnham, M.SC. P.Ag., Technical Supervisor

Environment

New Nouveau Brunswick

Environnement

Analytical Services Laboratory/Laboratoire des services analytiques
12, rue McGloin Street, Fredericton, NB E3A 5T8
Inorganic Report / Rapport inorganique

Client Information du Client:

Date Finalized/Finalisée: **2007/02/09**

Organization/Organisation:	J.D. Irving Ltd.
Attention:	John Gilbert
Prop. No./No. de Projet:	1406
Lab No./No. de Lab. :	**81361 - 200730675**
Authorization/Authorité:	Lori Lamey
Title/Titre:	Acting Manager/Gérante intérimaire
Matrix/Matrice:	Surfacewater / Eau de Surface

Client Sample Identifier/ No d'Echantillon du client:	MUZROLL LAKE
Date Collected/Date de prelevement:	2007/01/28

Parameter/ Paramètre	**Flag**	**Result/ Résultats**	**Units/ Unités**	**L.O.Q./ L.D.Q.**	**H.A.L./ L.A.S.**
Alkalinity / Alcalinité		5.54	mg/l		
Aluminum / Aluminium		0.71	mg/l	0.001	
Antimony / Antimoine	Less than L.O.Q. / Moins de L.D.Q.		µg/l	1.0	
Arsenic		1.5	µg/l	1.0	
Cadmium	Less than L.O.Q. / Moins de L.D.Q.		µg/l	0.1	
Calcium		1.09	mg/l	0.10	
Chloride / Chlorure		1.41	mg/l	0.050	
Chromium / Chrome		0.0053	mg/l	0.0005	
Colour / Couleur		571.		5	
Conductivity / Conductivité		24.5	µS/cm		
Copper / Cuivre		0.0010	mg/l	0.0005	
Fluoride / Florure	Less than L.O.Q. / Moins de L.D.Q.		mg/l	0.100	
Iron / Fer		13.3	mg/l	0.010	
Lead / Plomb		1.7	µg/l	1.0	
Magnesium / Magnésium		0.82	mg/l	0.10	
Manganese / Manganèse		0.25	mg/l	0.005	
Nickel		0.014	mg/l	0.005	
Nitrate-nitrogen / Nitrate-azote	Less than L.O.Q. / Moins de L.D.Q.		mg/l	0.05	
Nitrate/nitrite / Nitrates/nitrite	Less than L.O.Q. / Moins de L.D.Q.		mg/l	0.05	
Nitrite	Less than L.O.Q. / Moins de L.D.Q.		mg/l	0.05	
pH		5.66			
Potassium		0.53	mg/l	0.05	
Sodium		1.72	mg/l	0.10	
Sulfate		0.794	mg/l	0.050	
Tot. Organic Carbon / Carbone organique tot.		23.5	mg/l	1.0	

Calculated Parameters\Paramètres calculés

Sum of Cations	1.017	**Sum of Anions**	0.177	**% Difference**	-70.35
Saturation Index @ 25°C	-4.750	**CO3(as CaCO3)**	0.0	**HCO3(as CaCO3)**	5.5

[LOQ/LDQ] Limit of quantitation/Limite de quantification
[HAL/LAS] Health Advisory Level(Drinking water only)/Limites acceptables pour la santé (Eau potable seulement)

Page 1 of/de 2.

Environment **New Nouveau Brunswick** Environnement

Analytical Services Laboratory/Laboratoire des services analytiques
12, rue McGloin Street, Fredericton, NB E3A 5T8
Inorganic Report / Rapport inorganique

Client information du Client:

Date Finalized/Finalisée: **2007/02/09**

Organization/Organisation: J.D. Irving Ltd.
Attention: John Gilbert

Prop. No./No. de Projet: 0894
Lab No./No. de Lab. : **81361 - 200730675**
Authorization/Authorité: Lori Lamey
Title/Titre: Acting Manager/Gérante intérimaire
Matrix/Matrice: Surfacewater / Eau de Surface

Client Sample Identifier/ No. d'Echantillon du client: MUZROLL LAKE

Date Collected/Date de prelevement: 2007/01/28

Parameter/ Paramètre	Flag	Result/ Résultats	Units/ Unités	L.O.Q./ L.D.Q.	H.A.L./ L.A.S.
Tot. Phosphorous Low Level / Phosphore tot. - niv. faible		0.053	mg/l	0.005	
Total Ammonia / Azote ammoniacal total		0.078	mg/l	0.010	
Total Hardness / Dureté totale		6.09	mg/l	0.67	
Total Nitrogen / Azote Totale		0.6	mg/L	0.3	
Turbidity / Turbidité		23	NTU	0.2	
Zinc		0.011	mg/l	0.005	

Comments:

Ion Balance : Unable to balance due to elevated iron and turbidity.

Commentaires:

Bilan des ions : impossible d^^établir le bilan en raison d^^une turbidité et d^^une quantité de fer élevées

Calculated Parameters\Paramètres calculés					
Sum of Cations	1.017	**Sum of Anions**	0.177	**% Difference**	-70.35
Saturation Index @ 25°C	-4.750	**CO3(as CaCO3)**	0.0	**HCO3(as CaCO3)**	5.5

[LOQ/LDQ] Limit of quantitation/Limite de quantification
[HAL/LAS] Health Advisory Level(Drinking water only)/Limites acceptables pour la santé (Eau potable seulement)

Page 2 of/de 2.

Appendix IV

Vascular Plant Survey of Muzroll Lake, Northumberland County, New Brunswick

Vascular Plant Survey of Muzroll Lake, Northumberland County, New Brunswick

Introduction

An aquatic and shoreline vascular plant survey of Muzroll Lake, Northumberland County, New Brunswick was conducted on September 1st and 2nd, 2007 by Ruth E. Newell, Curator of the Irving Biodiversity Centre, with assistance provided by wildlife biologist Reg. B. Newell.

Muzroll Lake is a small, shallow, hard-bottomed lake located in the east-central part of New Brunswick. Water levels are controlled by Ducks Unlimited Canada. Aquatic vegetation was surveyed by means of a canoe whilst the shoreline vegetation survey was conducted on foot.

Results

A list of the vascular plant species observed during this survey, including habitat abundance and Atlantic Canada Conservation Data Centre ranks, is provided in Table 1. It should be recognized that in all likelihood, this study does not represent a complete listing of plants occurring at this site. Some species would undoubtedly be missed due to the limitations of conducting a plant survey at a single time during the growing season. In addition, due to time restrictions, some sections of shoreline were not examined and any localized species occurrences in these areas would therefore be missed.

Muzroll Lake is surrounded almost completely by forest with the exception of an extensive bog system at its west end. There is a man made channel in the easternmost cove leading to the outlet stream.

Shoreline Vegetation

Nearly all of the shoreline of Muzroll Lake can be described in general terms as "boggy" in nature but technically may be more accurately classified as fen habitat due to the prominence of sedge species (Fig. 1). Please refer to The Canadian Wetland Classification System (1997) for a full explanation of the distinguishing features between fen and bog habitats.

Common to abundant species occurring on the shoreline included Bear Sedge (*Carex utriculata*), Few-seeded Sedge (*Carex oligosperma*), Leather-leaf (*Chamaedaphne calyculata*), Sweet Gale (*Myrica gale*), Spoon-leaved Sundew (*Drosera intermedia*), Three-way Sedge (*Dulichium arundinacium*), Least Spikerush (*Eleocharis acicularis*), Creeping Spike-rush (*Eleocharis palustris*), Brown-fruited Rush (*Juncus pelocarpus*), White Beakrush (*Rhynchospora alba*), Large Cranberry (*Vaccinium macrocarpon*) and Tawny Cotton-grass (*Eriophorum virginianum*).

Landwards, the open shoreline transforms into a narrow ericaceous shrub border which separates it from the surrounding primarily coniferous woodland. Common shrubs occurring in this border include Leather-leaf (*Chamaedaphne calyculata*), Sheep Laurel (*Kalmia angustifolia*) and Rhodora (*Rhododendron canadense*).

Fig. 1. View of shoreline habitat along the north side of Muzroll Lake (facing west). Common species occurring in this habitat include the shrub Sweet Gale (*Myrica gale*) and a variety of graminoids including the following members of the Sedge Family (Cyperaceae): *Carex oligosperma*, *C. utriculata.*, *Eleocharis acicularis*, *E. palustris*, *Rhynchospora alba*, and *Eriophorum* spp.

Table 1. Vascular Plant List for Muzroll Lake, Northumberland County, New Brunswick. Plant species with an ACCDC (Atlantic Canada Conservation Data Centre; http://www.accdc.com/) rarity ranking are bolded.

	Latin Name	Common Name	ACCDC Rank	Habitat	Abundance
1.	Brasenia schreberi	Water Shield	S4	aquatic (floating leaves)	occasional
2.	Carex canescens	Hoary Sedge	S5	"boggy" shoreline (fen)	occasional
3.	Carex limosa	Mud Sedge	S4	"boggy" shoreline (fen)	uncommon
4.	**Carex. michauxiana**	**Michaux Sedge**	**S3**	**"boggy" shoreline (fen)**	**uncommon**
5.	Carex oligosperma	Few-seeded Sedge	S5	"boggy" shoreline (fen)	common to abundant
6.	Carex utriculata	Bear Sedge	S5	"boggy" shoreline (fen)	common
7.	Chamaegdaphne calyculata	Leather-leaf	S5	"boggy" shoreline (fen)	common
8.	**Cladium mariscoides**	**Twig Rush**	**S3S4**	**"boggy" shoreline (fen)**	**uncommon**
9.	Drosera intermedia	Spoon-leaved Sundew	S5	"boggy" shoreline (fen)	common
10.	Dulichium arundinaceum	Three-way Sedge	S5	"boggy" shoreline (fen) & aquatic (emergent)	abundant
11.	Eleocharis acicularis	Least Spike-rush	S5	"boggy" shoreline (fen)	common
12.	Eleocharis palustris	Creeping Spike-rush	S5	"boggy" shoreline (fen)	locally common
13.	Eriocaulon aquaticum	Pipewort	S5	aquatic (emergent)	uncommon
14.	Eriophorum angustifolium	Narrow-leaved Cotton-grass	S5	"boggy" shoreline (fen)	occasional
15.	Eriophorum tenellum	Rough Cotton-grass	S4S5	"boggy" shoreline (fen)	occasional
16.	Eriophorum virginicum	Tawny Cotton-grass	S5	"boggy" shoreline (fen)	occasional to common
17.	Euthamia graminifolia	Flat-top Fragrant Goldenrod	S5	"boggy" shoreline (fen)	uncommon
18.	Glyceria borealis	Small Floating Manna-grass	S5	aquatic (floating leaves)	uncommon to occasional
19.	Glyceria canadensis	Canada Manna-grass	S5	"boggy" shoreline (fen)	occasional
20.	Hypericum boreale	Northern St. John's-wort	S5	"boggy" shoreline (fen)	scattered
21.	Juncus brevicaudatus	Narrow Panicled-rush	S5	"boggy" shoreline (fen)	scattered

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	Latin Name	Common Name	ACCDC Rank	Habitat	Abundance
22.	Juncus canadensis	Canada Rush	S5	"boggy" shoreline (fen)	occasional
23.	Juncus pelocarpus	Brown-fruited Rush	S5	"boggy" shoreline (fen)	common
24.	Kalmia angustifolia	Sheep Laurel	S5	'boggy shoreline fen) (in shrub border)	common
25.	Lysimachia terrestris	Swamp Candle	S5	"boggy" shoreline (fen)	occasional
26.	Muhlenbergia uniflora	Fall Dropseed Muhly	S5	"boggy" shoreline (fen)	uncommon
27.	Myrica gale	Sweet Gale	S5	"boggy" shoreline (fen)	common
28.	**Myriophyllum farwellii**	**Farwell's Water-milfoil**	**S3**	**aquatic (submerged)**	**occasional beds**
29.	Nuphar lutea ssp. variegata	Yellow Cow Lily	S5	aquatic (floating leaves)	uncommon
30.	Potamogeton confervoides	Algae-like Pondweed	S4	aquatic (submerged)	locally common
31.	Potamogeton epihydrus	Nuttall Pondweed	S5	aquatic (floating leaves)	uncommon
32.	Rhododendron canadense	Rhodora	S5	"boggy" shoreline (fen) (in shrub border)	common
33.	Rhynchospora alba	White Beakrush	S5	"boggy" shoreline (fen)	very common
34.	**Rhynchospora fusca**	**Brown Beakrush**	**S3**	"boggy" shoreline (fen)	**uncommon**
35.	Sagittaria graminea	Grassleaf Arrowhead	S4	aquatic (emergent)	uncommon
36.	Scheuchzeria palustris	Pod Grass	S4	"boggy" shoreline (fen)	occasional
37.	**Schoenoplectus torreyi**	**Torrey's Bulrush**	**S3**	**aquatic (emergent)**	**abundant (dominant aquatic; forms extensive stands)**
38	Utriculara geminiscapa	Hidden-fruited Bladderwort	S4	aquatic (submerged)	uncommon
39.	Scirpus cyperinus	Cottongrass Bulrush	S5	"boggy" shoreline (fen)	uncommon

Table 1. Vascular Plant List for Muzroll Lake, Northumberland County, New Brunswick. Plant species with an ACCDC (Atlantic Canada Conservation Data Centre; http://www.accdc.com/) rarity ranking are bolded.

	Latin Name	Common Name	ACCDC Rank	Habitat	Abundance
40.	Sparganium sp. (leaves only)	a bur-reed	–	aquatic (floating leaves)	uncommon
41.	Triadenum fraseri	Marsh St. John's-wort	S5	"boggy" shoreline (fen)	scattered
42.	Vaccinium macrocarpon	Large Cranberry	S5	"boggy" shoreline (fen)	common
43.	**Xyris montana**	**Northern Yellow-eyed Grass**	**S3**	"boggy" shoreline (fen)	**uncommon**
44.	Zizania palustris	Interior Wild Rice	S4	aquatic (emergent)	occasional small patches

Aquatic Vegetation

The most dominant aquatic plant occurring in Muzroll Lake is Torrey's Bulrush (*Schoenoplectus torreyi*). This emergent aquatic forms extensive stands throughout the main body of the Lake (Fig. 2). Other emergent aquatic species occurring in Muzroll Lake in occasional small patches are Small Floating Manna-grass (*Glyceria borealis*) and Interior Wild Rice (*Zizania palustris*). Grassleaf Arrowhead (*Sagittaria graminea*) was locally common and observed only in the outlet cove at the east end of the lake.

The southeast quadrant of the lake has islands of vegetation with a species assemblage similar to that occurring in the shoreline habitat (Fig. 3). The main cove at the west end of the lake was dominated by algae-like Pondweed (*Potamogeton confervoides*). This cove was much deeper than the rest of the lake. This increased depth may have prevented the establishment of Torrey's Bulrush in this part of the lake.

Fig. 2. Stands of Torrey's Bulrush (*Schoenoplectus torreyi*) in Muzroll Lake.

Fig. 3. Part of a series of vegetated islands located in the southeast corner of Muzroll Lake. Plant species occurring on these islands are identical to those found along the lake shoreline. The plant occurring in the foreground at the water's edge is Three-way Sedge (*Dulichium arundinaceum*)

Discussion

The rarer species documented from Muzroll Lake during this survey (i.e. those species with an ACCDC ranking of S3 and S3S4 in Table 1) may be more of a reflection of limited fieldwork having been carried out in some of the more remote parts of New Brunswick than of actual rarity.

Most of the rarer species however, have Atlantic Coastal Plain affinities. Sean Blaney, botanist at the Atlantic Canada Conservation Data Centre (pers. comm., 2007), suggests that the species list from Muzroll Lake represents an interesting outlier of a species assemblage that is best represented in southwest New Brunswick for climatic and/or lake abundance reasons.

References

Warner, B.G. and C.D.A. Rubec [eds.] 1997. The Canadian Wetland Classification System, 2nd edition, National Wetlands Working Group, Wetlands Research Centre, University of Waterloo, Waterloo, Ontario.