The Potential Impact of the Liard Highway Construction in Northern Wetlands and Alpine Habitats

by
R. W. Quinlan (Ed.)

March 1978

CANADIAN WILDLIFE SERVICE
Edmonton, Alberta

Your file Votre dossier

Environment Canada
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Canadian Wildlife Service
Service canadien de la faune

Our file Notre dossier WLT 300 Mackenzie Hwy.
1000, 9942 - 108 Street
Edmonton, Alberta
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July 21, 1978

Dr. O.H. Loken
Chairman, Environmental Working Group
Northern Environmental Protection Branch
Les Terrasses de la Chandise
6th floor
OTTAWA, Ontario
KIA OH4

Dear Dr. Loken:

Re: Letter of Transmittal - Liard Highway Studies 1977, CWS

Enclosed please find the final report summarizing studies which were conducted by the Canadian Wildlife Service along the proposed Liard Highway Alignment. The report, entitled

The Potential Impact of the Liard Highway Construction on Northern Wetlands and Alpine Habitats

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evaluates the wetlands adjacent to the highway alignment and assesses the potential changes the highway may impose upon the wetlands and the flora and fauna associated with them. Field work, commencing in 1977, was divided into three section: vegetation, invertebrates and waterfowl.

The funding was provided through the Department of Indian and Northern Affairs.

Sincerely,

M.R. Robertson
Regional Director

Encl.(1)

THE POTENTIAL IMPACT OF THE LIARD HIGHWAY CONSTRUCTION ON NORTHERN WETLANDS AND ALPINE HABITATS

by

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March 1978

Edmonton, Alberta

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ACKNOWLEDGEMENTS

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During the compilation of data, several people at CWS, Edmonton, were helpful, including R.G. Thompson, Al Smith, Al Doberstein, and M. Kingsley. Ms. Susan Popowich drafted all figures. Her patience and dedication was gratefully appreciated. Dr. H. Clifford and Mr. R. Roughley, of the University of Alberta, provided assistance in identification of freshwater invertebrates. The staff at the Alberta Centre for Remote Sensing were helpful during vegetation mapping. The Atmospheric Environment Service provided climatological information for the Ft. Simpson and Ft. Nelson areas.

Finally, Mr. S. Stephansson, Mr. K. Ambrock, and Mr. B. Munson of CWS, Edmonton, are thanked for reviewing this report and offering their advice.

ABSTRACT

Habitat of wetlands adjacent to the proposed Liard Highway alignment was evaluated to determine baseline biological conditions. Habitat of alpine regions was also evaluated since it was felt that increased access. Vegetation and freshwater invertebrates of thirty-three sites representing six different habitat types were examined for species composition, community structure, and in the case of invertebrates, population dynamics. Spring and fall migration, as well as brood production, was documented for waterfowl at each site. Aerial surveys of the Liard and Nahanni mountain ranges were undertaken to determine the presence of raptors and large mammals. An evaluation of vegetation communities and specialized plant habitats in alpine and sub-alpine locations was achieved through ground surveys and collections. Increased access resulting from Liard Highway construction may cause depletion of mammal and raptor populations by hunting and general disturbance. Perturbation of sensitive alpine plant communities may also occur due to recreational or resource developments.

The area in the vicinity of the Liard Highway was not of major importance to migratory birds although some regions supported substantial breeding bird populations. The Netla River Delta provided the most significant waterfowl breeding habitat in the area. There was a definite relationship between habitat type and waterfowl use. In the Netla area, riparian vegetation was important to dabbler species, while divers such as scaup and ring-necked duck preferred "bot-type" ponds. In alpine regions, the Nahanni Range had localized areas of good raptor habitat, which were utilized by eagles and falcons. The

Liard Range, due to its unstable cliff-nesting conditions, provided poor habitat which was not utilized. Two relatively isolated populations of dall sheep were observed, one in the Nahanni Range and one in the Liard Range. Phytogeographically significant bryophytes which are useful in determining the glacial history of the region were collected in the mountain ranges.

The Netla River area should be avoided for recreational development because of its importance to waterfowl and its significance as a native hunting area. Loss of important bryological information could occur if resource developments of an exploitive nature are undertaken without detailed ecological investigations beforehand.

1. INTRODUCTION- Richard W. Quinlan[1]

The desire for direct access between British Columbia and the Northwest Territories created a demand for the Liard Highway to be built between Ft. Nelson, B.C., and Ft. Simpson, N.W.T. Construction was completed from the Mackenzie Highway (Jean-Marie Junction) to the Poplar River (km 35.2, mile 22) in the early 1970's. The section between Poplar River and the British Columbia boundary (km 253.3, mile 158.3), is yet to be built.

An earlier study by Synergy West Ltd. (1975) presented information on climate, soils, archaeology and history, engineering criteria, regional influences, and recreational activities. The present report describes in greater detail the biology of the region and discusses influences that highway construction and use will have on the ecological balance of the area.

The purpose of this study was to evaluate the wetlands adjacent to the highway alignment and assess the possible changes the highway may impose upon these wetlands. Basically, the study was divided into three sections: vegetation, invertebrates, and waterfowl. The investigations concerned with each of these and the results obtained are included in the subsequent chapters.

A great deal of the data collected during the investigation has been presented in appendices to this report. This will be of interest to future investigators in the Liard region, especially waterfowl biologists, limnologists, and botanists. The main body of the report may be read with only occasional references to appendices but still be useful and informative.

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[1]Canadian Wildlife Service - Edmonton

Although the wetland ecosystem was of major concern, investigations of the mountain ranges to the west of Liard River were undertaken for the following reasons:

1. the increased access provided by the highway will eventually lead to development of campgrounds on the west side of the river, creating heavier hunting pressure and greater demands for non-consumptive use such hiking and back-packing;

2. the possible presence of endangered raptor species, dall sheep, and grizzly bear needed to be investigated because of the areas proximity to the Liard Highway;

3. documentation of dominant alpine vegetation types and exploration of specialized plant habitats was initiated because of possible perturbation of these sensitive areas as a result of easier access provided by the Liard Highway.

2. DESCRIPTION OF STUDY AREA - Richard Quinlan[1]

2.1 Location

The study area extends along the Liard Highway alignment in the southwest section of the District of Mackenzie, Northwest Territories. The general location is shown in Fig. 1. The N.W.T. portion of the highway is 253.3 km (158.3 miles) long, extending from the Mackenzie Highway to the British Columbia border. Geographically it is bounded by 61°30'N latitude on the north, 60°00'N latitude on the south, 121°15'W longitude on the east, and 123°30'W longitude on the west. The wetlands selected in this study are scattered along the length of the highway. All are located within 2 km of the proposed alignment (Fig. 3).

2.2 Physical Features

Kilometer 0 to km 160 (mi. 100) contains very little relief, being poorly drained lowlands with organic soils. From km 160 (mi. 100) to km 253.3 (mi. 158.3) the terrain becomes increasingly hilly with brown wooded soils and gray wooded soils covering large proportions of the area (36% and 6% respectively). Poorly drained areas have dominant soil types of gleysols (9%), humic gleysols (10%), and 17% organic soils (Synergy 1975).

Immediately west of the Liard River the terrain rises to more than 1500 m (5000 ft) in the Liard Range and further north in the Nahanni Range. The relief from the Liard River to the peaks is greater than 1200 m (4000 ft), providing great diversity of habitat from the alluvial flatlands of the river to the alpine tundra at 1500 m (5000 ft).

The study area was situated in the region of discontinuous permafrost. The distribution of permafrost is variable and dependent upon drainage, soil type, aspect, and slope angle (Strang 1973, Judge 1973 *in* Kemper *et al.* 1977).

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[1]Canadian Wildlife Service - Edmonton

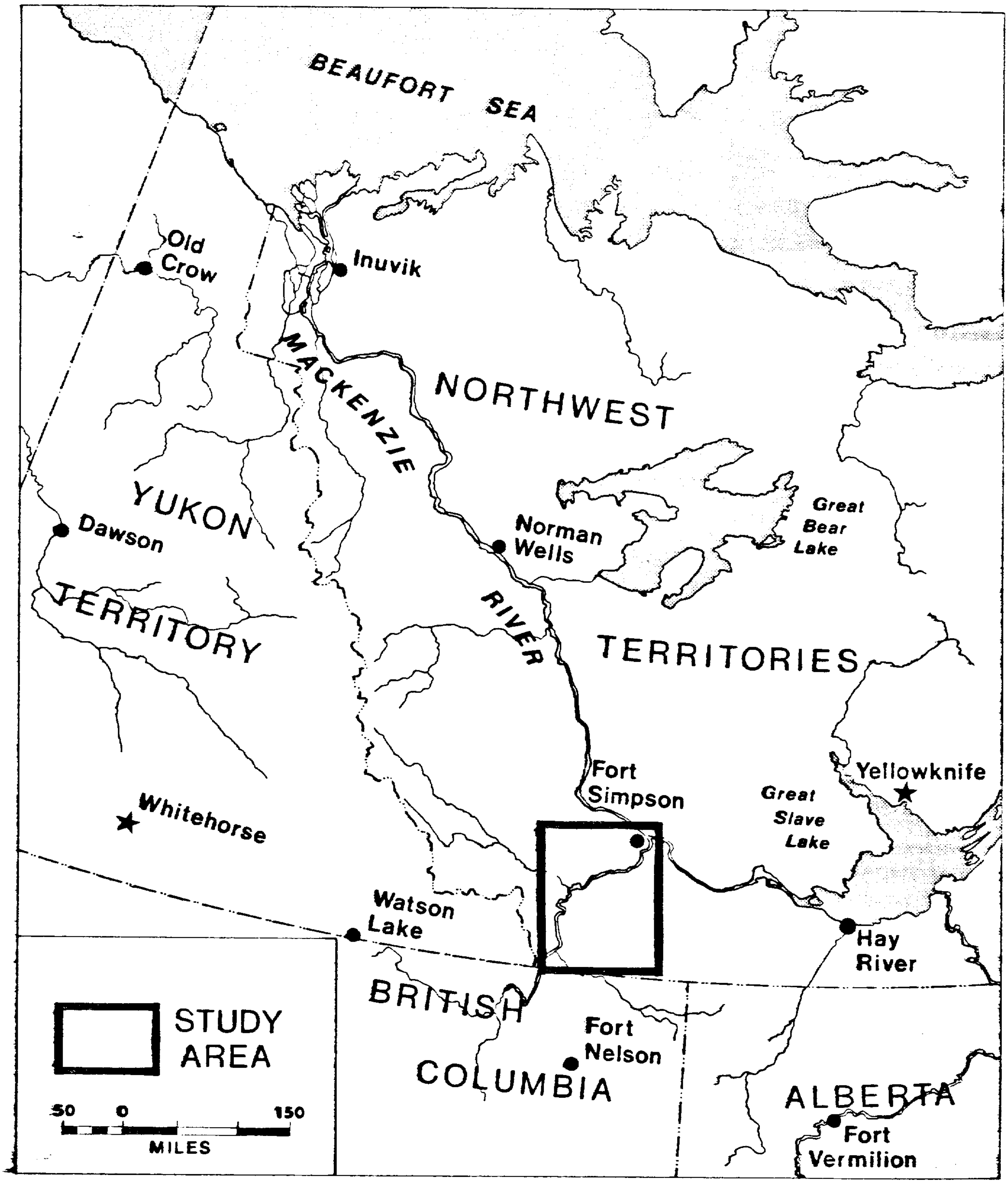


Fig. 1. Location of 1977 Liard Highway Study Area.

Lowlands with peat cover or black spruce-feathermoss cover are generally underlain by permafrost. Laukulich (1973) states: "The present locations of ground frost (perennially frozen or not) is highly correlated with the texture and drainage of the soil and with the vegetation communities which are found protecting the ice from rapid and large temperature changes."

2.3 Climate

Located in the sub-arctic climatic region, the Liard area is characterized by short summers and long cold winters. Weather patterns are governed mainly by the positions of the arctic and Pacific air masses (Bryson, Hare, 1974).

Tables 1 and 2 summarize temperature and precipitation data from the Ft. Simpson and Ft. Nelson weather stations. Ft. Simpson had a relatively warm spring in 1977 with a cooler than average summer and slightly warmer than average September. Total precipitation for the period May-September 1977 was 180.55 mm, less than the average year (209.0 mm), however, the value for the month of May is greater than three times the mean value. Ft. Simpson was subjected to a wet spring and a relatively dry summer and fall in 1977.

The Ft. Nelson temperature values show an average spring and cooler than average fall. Precipitation in Ft. Nelson was significantly higher than average in 1977. Whereas the mean total precipitation (May-September) is 270.6 mm, the 1977 total for the five months was 445.9 mm. An extremely wet May (146.7 mm) and wet months of June and July (116.9 mm and 107.3 mm) account for the high total precipitation.

Table 1. Temperatures (^{o}C) - Ft. Simpson, Ft. Nelson.

Month	Ft. Simpson, NWT		Ft. Nelson, B.C.	
	Average mean Daily Temp.*	1977 mean Daily Temp.	Average mean Daily Temp.+	1977 mean Daily Temp.
May	7.1	9.1	9.6	9.9
June	14.0	14.2	14.5	14.2
July	16.1	15.0	16.8	15.3
August	14.2	12.3	14.8	13.9
September	7.2	8.7	8.8	9.2

Table 2. Precipitation (mm) - Ft. Simpson, Ft. Nelson.

Month	Ft. Simpson, NWT		Ft. Nelson, B.C.	
	Mean total Precipitation*	1977 total Precipitation	Mean total Precipitation+	1977 total Precipitation
May	30.8	99.3	37.6	146.7
June	39.6	21.6	64.2	116.9
July	59.6	36.0	74.6	107.3
August	48.0	16.7	55.6	50.4
September	31.0	6.9	38.6	24.6

*1963-1970
+1941-1970

Fig. 2 summarizes daily precipitation value - June to August 1977 at 5 locations along the proposed highway.

2.4 Vegetation

A general description of vegetation types is contained in Synergy (1975). Raup (1974) and Jeffrey (1959) describe major plant communities and species found in the Liard Highway area. The vegetation can be classed by habitat into a few major categories. Well-drained habitats are mostly dominated by white spruce-aspen forest types, with jack pine predominating on burn sites and very dry uplands. These forest types are most predominant along the alignment between km 160 (mi. 100) and km 253.3 (mi. 158.3). Poorly drained habitats support black spruce-feathermoss communities, with sedge fens or dwarf birch communities in areas of saturated organic soils. Alluvial lowlands are characterized by willows (*Salix* spp.) and horsetails (*Equisetum fluviatile*). More detailed descriptions of these vegetation types and other less predominant communities are contained in the vegetation chapter of this report.

2.5 Study Sites

Representative study sites were selected using the following criteria:

1. sites had to be adjacent to the alignment,
2. sites were representative of the predominant habitat types,
3. aquatic habitats were chosen which were utilized to at least some degree by waterfowl and water-oriented birds.

Representative wetland types were:

a. marshland: mires, fens, and permafrost-type bogs with very small areas of open water.

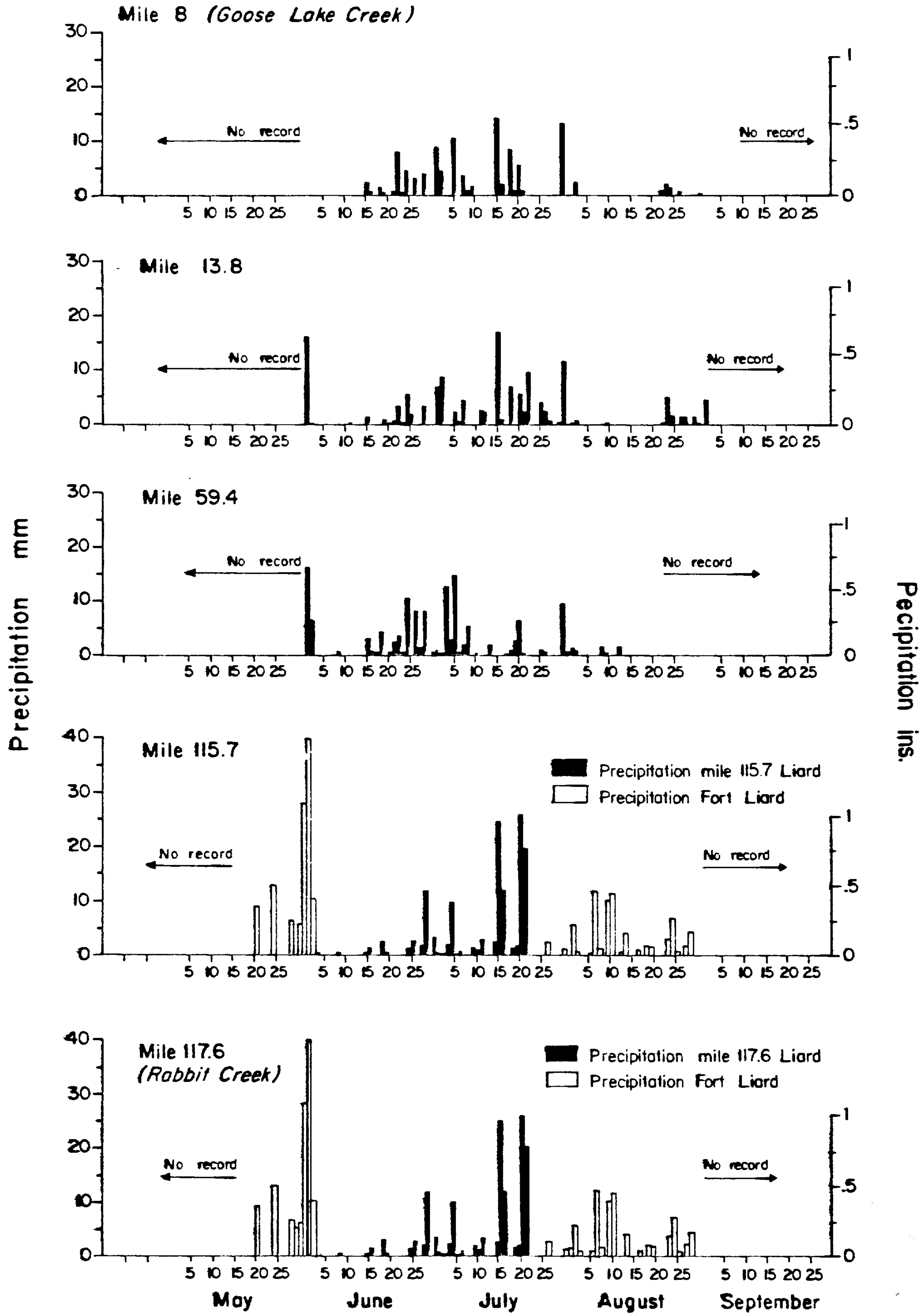


Fig. 2. Daily precipitation records for Liard Highway region, NWT, 1977.

b. Wooded ponds: Ponds closely encroached by forest. Banks may have a fairly steep slope and the mineral soil may be exposed on shorelines. Some of these ponds are present as a result of beaver damming (Plate 1).

c. Alluvial wetlands: Periodically flooded wetlands near rivers. The acquisition of alluvial sediments at least once a year provides a rich substrate for the growth of horsetails and willows (Plates 2, 3).

d. Rivers: The Netla River was the only river studied. It is a relatively slow-running meandering stream which floods in spring (Plate 2).

e. Shallow ponds: these basins are shallow enough to allow greater than 10% coverage of the water's surface area by pond lilies *(Nuphar variegatum)*. The shorelines of these ponds are usually characterized by the presence of sedge and moss mats (Plate 4).

f. Deep ponds: these ponds are too deep to allow growth of pond lilies on greater than 10% of the water surface. There may or may not be well developed vegetation mats around the periphery (Plate 5).

Plate 1. Wooded pond (Site 32): The aspen of the forested shoreline is utilized by beaver.

Plate 2. Alluvial Wetland (Site 11): Growth of horsetail *(Equisetum fluviatile)* and water parsnip *(Sium suave)* occurs after flood waters subside.

Plate 3. Netla River: Flooded condition after extremely high rainfall in May and the first week of June. Site 11 (Plate 2) is in the upper right portion of the photo.

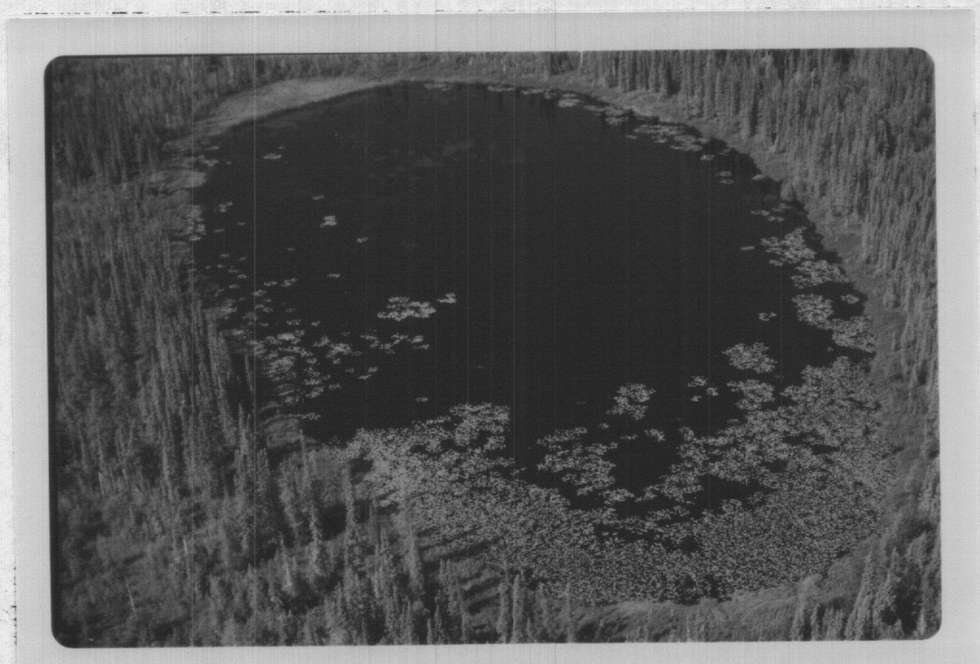


Plate 4. Shallow Pond (Site 24). Note abundant water lily (*Nuphar* sp.) coverage.

Plate 5. Deep Pond (Site 28). Note lack of aquatic vegetation beyond the vegetation mat.

Locations of sites: Fig. 3 shows the Liard Highway right-of-way with the site locations inserted on it.

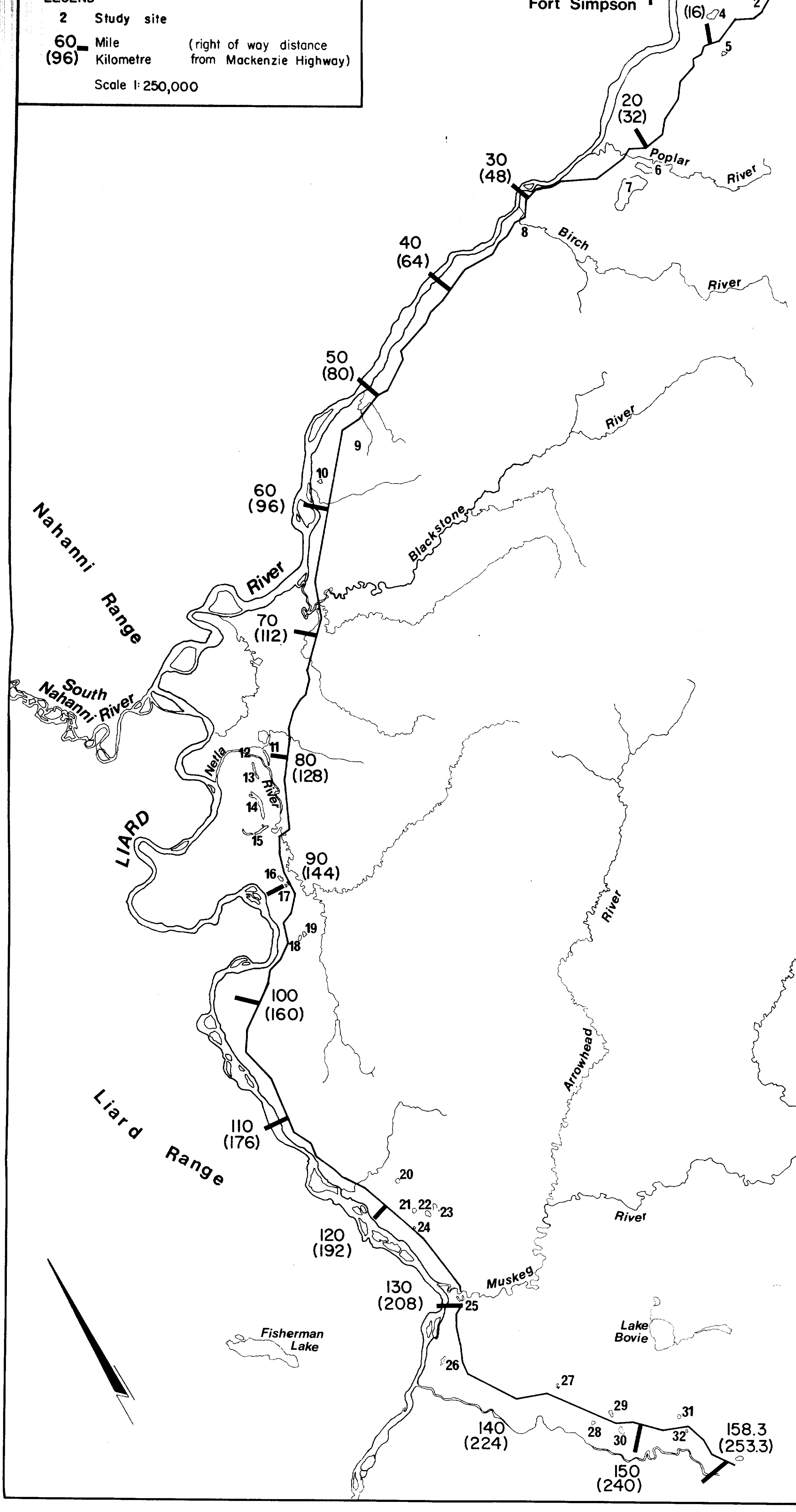


Fig. 3. Study site locations and proposed alignment, Liard Highway, NWT, 1977.

3. VEGETATION -Richard Quinland[1]

3.1 Introduction

Vegetation in and around wetlands adjacent to the Liard highway alignment was studied during July and August, 1977. This was necessary to assess the wetland habitat and also to monitor any changes in the water table resulting from highway construction. These changes may be reflected in the structure and species composition of plant communities.

3.2 Methods and Materials

Quantitative sampling of vascular plants and bryophytes was undertaken using a 1/10 m^2 frame as described in Daubenmire, 1968 (Plate 6). The frame was placed at intervals along pre-determined transects which cut across vegetation zones surrounding the ponds. This allowed a detailed description of the species composition of each plant community and determination of boundaries between each community. At each sampling point along the transect, height above the water table was measured using a survey rod and level (Plates 7, 8). Profile-type graphs in Appendix A-2 show the relation of species and community types to the height above the water table.

Aerial photographs taken by the Canada Centre for Remote Sensing allowed mapping of vegetation zones of several wetlands. True color and false color infrared 9" x 9" prints, as well as thermal heat sensing strips, were obtained in mid-November, the flights having been made on and around September 10, 1977. Although no ground truthing of photographs was possible that late in the season, careful observation during the six month field season combined with information from vegetation transects and photographs, allowed fairly accurate determinations of vegetation zones on the aerial photographs. The use of a transfer scope, interprescope, and density slicer at the Alberta Centre for Remote Sensing assisted the investigator in the task.

[1]Canadian Wildlife Service - Edmonton

Plate 6. Daubenmire-type frame used for estimating % area coverage by plant species.

Plate 7. Instrument man at vegetation transect, Site 30 (km 237.6).

Plate 8. Rodman on vegetation transect, Site 25 (km 208).

3.3 Results

Plant communities: Plant communitites were determined by the presence of one or a few dominant species. Associate species may vary between different areas having the same plant community. All associate species listed for a certain community may or may not be present. Following is a description of the species composition of each plant community and a brief description of the habitat in which it is located. The numbering of plant communitites corresponds to the numbers on site maps found in the following section.

1. Mixed wood forest.

Dominant	Associate
Populus balsamifera	*Alnus crispa*
P. tremuloides	*Salix* sp.
Picea glauca	*Viburnum edule*
Betula papyrifera	*Rosa acicularis*
	Cornus stolonifera
	Ribes sp.
	Linnae borealis
	Equisetum arvense
	Cornus canadensis
	Pyrola bracteata

The mixed wood forest occurs in well drained regions but extends to the edge of ponds where banks are steep. Generally only one or two of the dominant species is abundant.

2. Black spruce-feathermoss forest

Dominant	Associate
Picea mariana	*Pleurozium schreberi*
Hylocomium splendens	*Ptilium crista-castrense*
	Ledum groenlandicum
	Vaccinium vitis-idaea
	Cornus canadensis
	Geocaulon lividum

This is the "climax community" in lowland areas. Black spruce-feathermoss forest occupies a very large area adjacent to the Liard Highway alignment.

3. Mixed spruce-lichen woodland

Dominant	Associate
Picea mariana	*Picea glauca*
Cladonia spp.	*Pinus banksiana*
	Ledum groenlandicum
	L. palustre var. *decumbens*
	Vaccinium uliginosum

This plant community is present on hills or areas of cryoturbation-caused upheavals.

4. White spruce forest

Dominant	Associate
Picea glauca	*Betula papyrifera*
Alnus crispa	*Populus balsamifera*
Equisetum arvense	*Viburnum edule*
	Shepherdia canadensis
	Cornus stolonifera
	Rosa acicularis
	Linnae borealis
	Cornus canadensis

The white spruce forest may be considered a later stage of development in the same regions as the mixed-wood forest zones.

5. *Calamagrostis*

Dominant	Associate
Calamagrostis canadensis	*Carex rostrata*
	Equisetum fluviatile

6. *Nuphar* sp.

Dominant	Associate
Nuphar variegatum	*Potamogeton* spp.
	Utricularia vulgaris
	Hippuris vulgaris

This is the most common aquatic community. The *Nuphar* sp. is usually present as a pure stand. The *Nuphar* sp. plants grow from thick rhizomes on the bottom of ponds.

7. *Typha*

Dominant	Associate
Typha latifolia	*Calla palustris*
	Menyanthes trifoliata
	Carex aquatilis
	C. diandra
	Potentilla palustris
	Eleocharis engelmanii
	Galium trifidum
	Scorpidium scorpoide
	Drepanocladus spp.
	Helodium blandowii

8. *Sphagnum* - moss

Dominant	Associate
Sphagnum fuscum	*Chamaedaphne calyculata*
Tomenthypnum nitens	*Oxycoccos microcarpus*
	Smilacina trifolia
	Drosera anglica
	Rubus chamaemorus
	Picea mariana
	Andromeda polifolia
	Sphagnum nemoreum
	Myrica gale
	Betula glandulosa

The *Sphagnum fuscum* provides a habitat above the water table for other plants to grow on.

9. *Carex* - moss

Dominant	Associate
Carex aquatilis	*Carex rostrata*
Calliergon spp.	*C. paupercula*
	Potentilla palustris
	Galium trifidum
	Lysimachia thrysiflora
	Juncus balticus
	Eleocharis engelmanii
	Utricularia vulgaris
	Drepanoclodus spp.

The *Carex* - moss community occurs on semi-aquatic floating vegetation mats.

10. *Menyanthes - Carex - Salix*

Dominant	Associate
Menyanthes trifoliata	*Potentilla palustris*
Scorpidium scorpoides	*Drepanocladus revolvens*
Carex aquatilis	*Carex interior*
Salix mackenziana	*C. paupercula*
	C. leptalea
	Andromeda polifolia
	Equisetum palustre
	E. fluviatile
	Utricularia sp.
	Galium trifidum
	Betula glandulosa
	Campylium stellatum
	Myrica gale

Menyanthes trifoliata is a common plant at the edge of floating vegetation mats. The species associated with it are numerous. This community would likely be affected by fluctuations in water levels. Species composition and dominance would be altered after water level changes.

11. *Menyanthes - Carex*

This community is basically similar to the *Menyanthes Carex - Salix* community but lacks *Salix*.

12. *Myrica - Ardromeda - Carex*

Dominant	Associate
Myrica gale	*Betula glandulosa*
Andromeda polifolia	*Carex leptalia*
Carex aquatilis	*Oxycoccos microcarpus*
	Potentilla palustris
	Chamaedaphne calyculata
	Salix spp.
	Smilacina trifolia
	Equisetum fluviatile
	Tomenthypnum nitens

This is a very common community in fenlands.

13. Disturbed sites

These are areas where human-related or natural impacts have disturbed natural vegetation usually leaving gravel, silt, borrow pits, etc.

14. *Equisetum fluviatile - Carex rostrata*

Dominant	Associate
Equisetum fluviatile	*Sium suave*
Carex rostrata	*Salix interior*
	Salix spp.
	Typha latifolia

This community is the dominant vegetation type of large expanses of alluvial regions. Exposed mineral soil (silt) is the necessary environmental condition for promoting the growth of this community.

15. *Salix interior* - *Salix* spp.

Dominant	Associate
Salix interior	*Populus balsamifera*
Salix spp.	

This is a common plant community along river banks.

16. *Polygonum amphibium*

Dominant	Associate
Polygonum amphibium	*Myriophyllum spicatum*
	Potamogeton strictifolius
	Utricularia vulgaris

Polygonum amphibium is present in shallow water on the organic substrate of site #32.

17. Water-killed black spruce

This occurred during May-June at site #21 due to heavy rainfall.

Site Vegetation Maps: Vegetation maps (Fig. 4-20) show the locations of plant communities at several sites. The map index allows interpretation of vegetation zoning. Aerial photographs of the sites are available from the Canada Centre for Remote Sensing, Ottawa. A reference set is located in the CWS Western and Northern Region Library, Edmonton.

KEY TO MAP INDEXING

1. Mixed wood forest
   - 1a. Poplar forest
   - 1b. Birch forest
2. Black spruce-feathermoss
   - 2a. Black spruce (no feathermoss)
3. Mixed spruce-lichen woodland

4. White spruce forest
5. *Calamagrostis*
6. *Nuphar*
7. *Typha*
8. *Sphagnum* - moss
    8a. *Sphagnum* - moss with scattered black spruce
9. *Carex* - moss
10. *Menyanthes* - *Carex* - *Salix*
11. *Menyanthes* - *Carex*
12. *Myrica* - *Andromeda* - *Carex*
    12a. *Myrica* - *Andromeda* - *Carex* with scattered black spruce
13. Disturbed sites
14. *Equisetum fluviatile* - *Carex rostrata*
15. *Salix interior* - *Salix* spp.
16. *Polygonum amphibium*
17. Water-killed black spruce

3.4 Discussion

The precise effects of highway construction on natural vegetation in and around wetlands are difficult to determine. Much of the vegetation is fen-type which grows in poorly drained lowland areas. Often the only form of water movement through these areas is by seepage through the ground or actual above ground flow in moving "sheets" of water. Where such conditions occur near a roadbed the water movement must be provided for or ponding will occur on the upstream side, and drying will occur on the downstream side of the highway. At km 2.0 (mi. 1.3) of the existing Liard Highway, accumulating water has been channelled to culverts. Whether or not this method has prevented upstream ponding is unknown as no detailed vegetation or hydrological studies were conducted before construction. Water appeared to be moving in a fairly uninhibited fashion. The installation of culverts at frequent intervals in similar areas along the alignment is recommended.

An increase in water levels resulting from rain caused the defoliation of a band of black spruce surrounding pond #21 (Fig. 12). Raising of water levels of ponds by poor drainage resulting from highway construction would have similar effects, causing redistribution of some plant communities This could be prevented by proper drainage across the roadbed.

Two locations of botanical interest were found near the existing highway. Both were rich fen areas (pers. comm. D.H. Vitt) and were characterized by insectivorous plants. Pitcher plants *(Sarracenia purpurea)* and butterwort *(Pinguicula vulgaris)* were found here. Pitcher plants are noted by Porsild and Cody (1968) as "expected to occur in continental Northwest Territories." The author to date has not found any previous account of this species in the N.W.T.

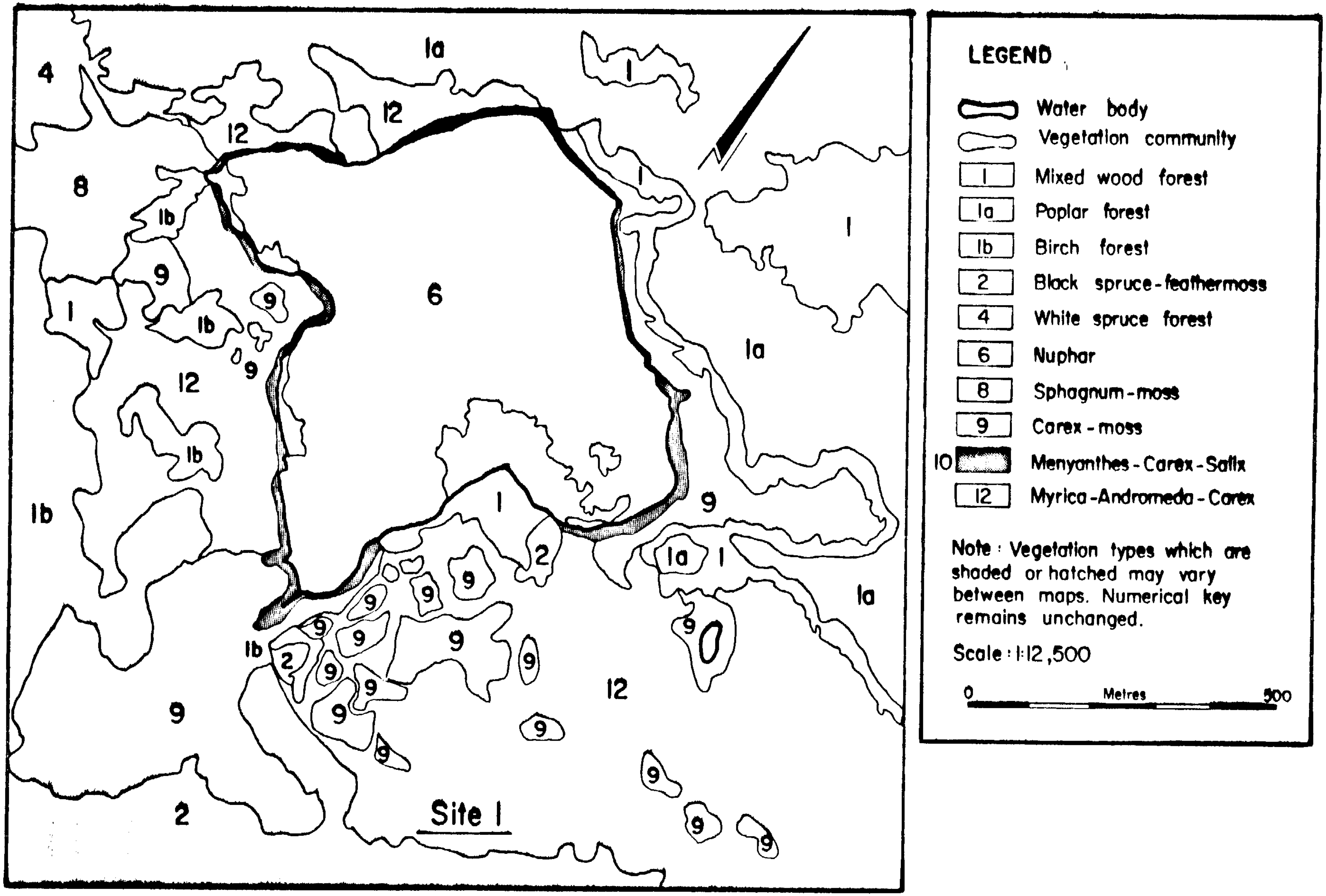


Fig. 4. Vegetation map of Site 1, Liard Highway region, NWT.

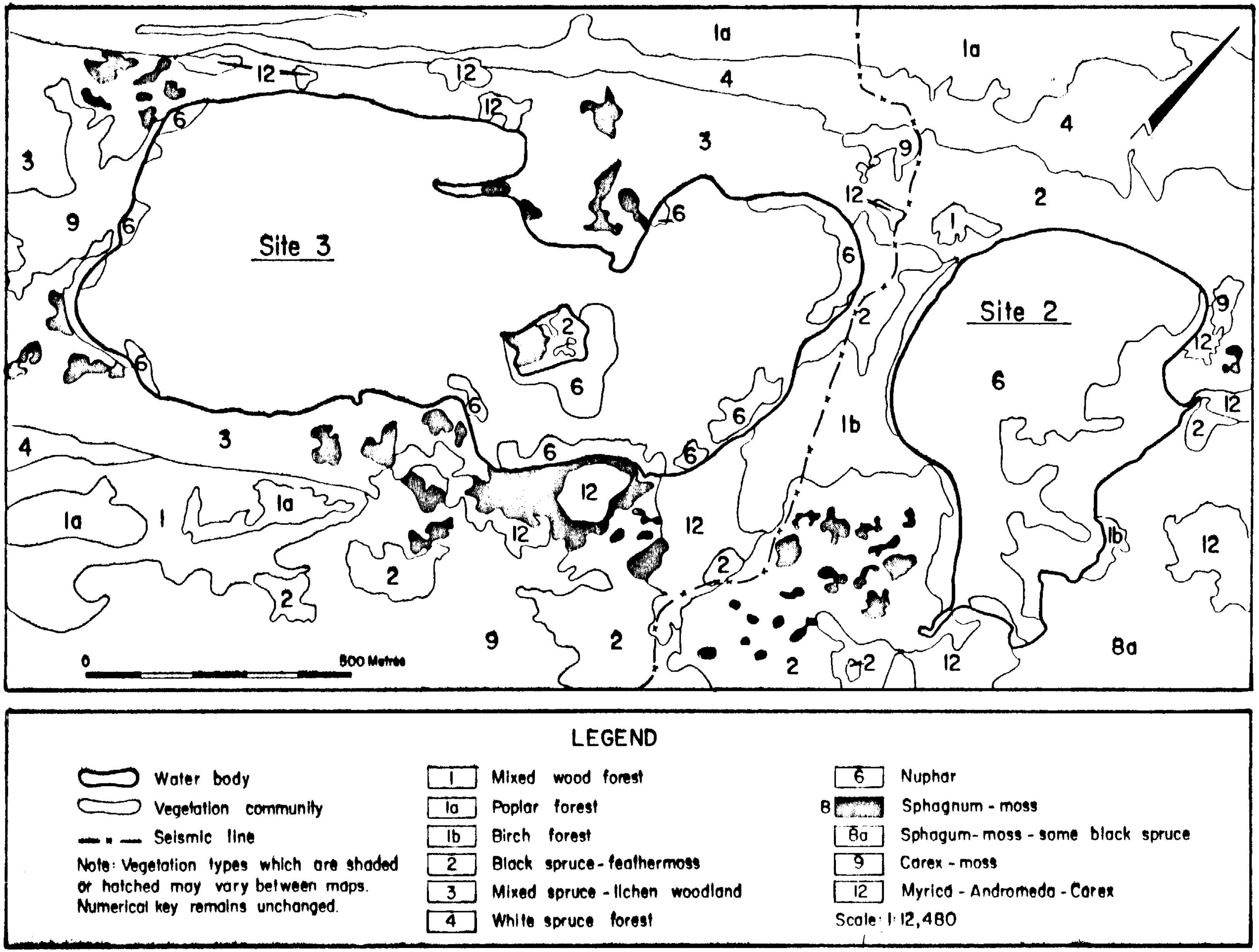


Fig. 5. Vegetation map of Site 2 and 3, Liard Highway region, NWT.

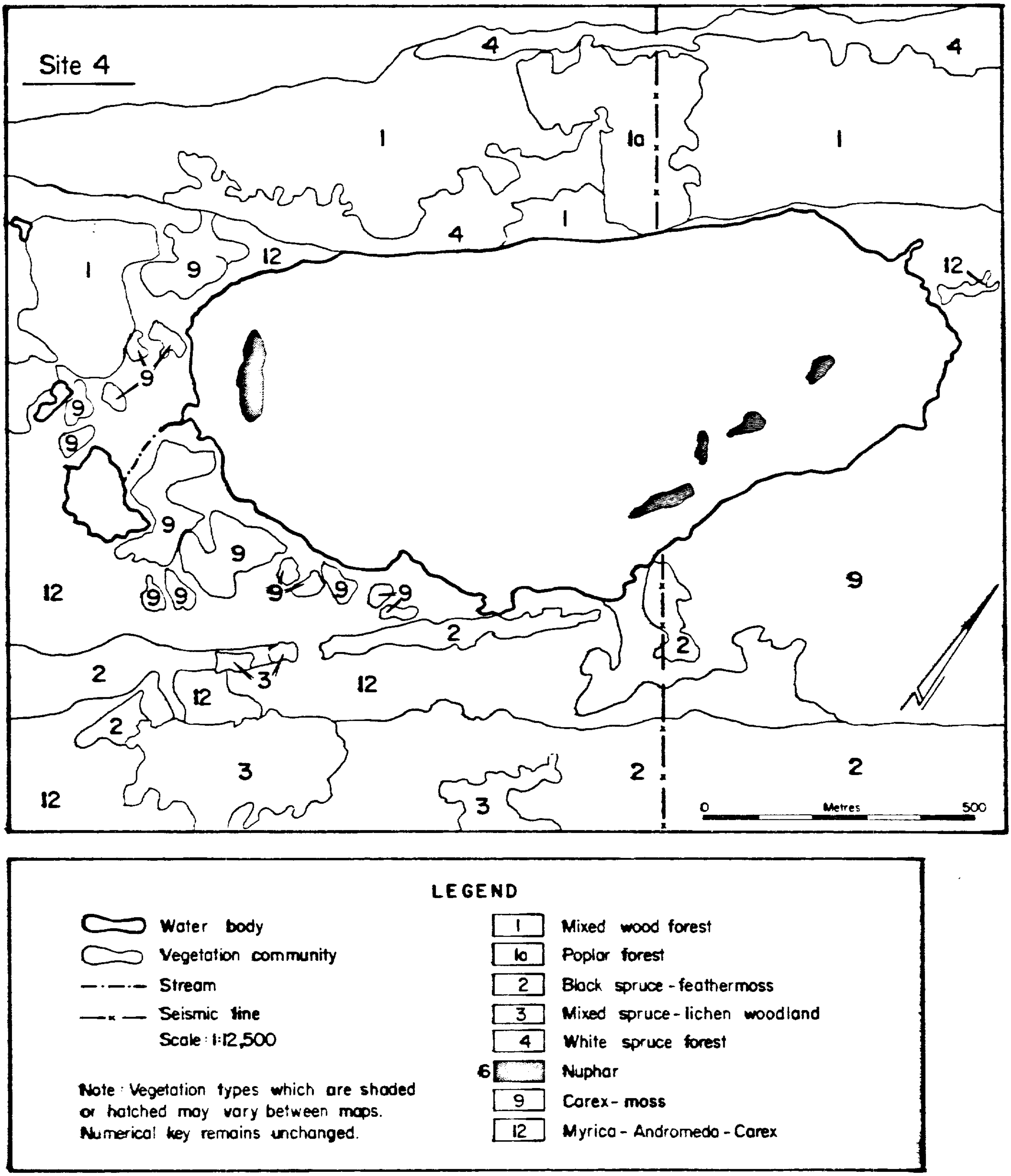


Fig. 6. Vegetation map of Site 4, Liard Highway region, NWT.

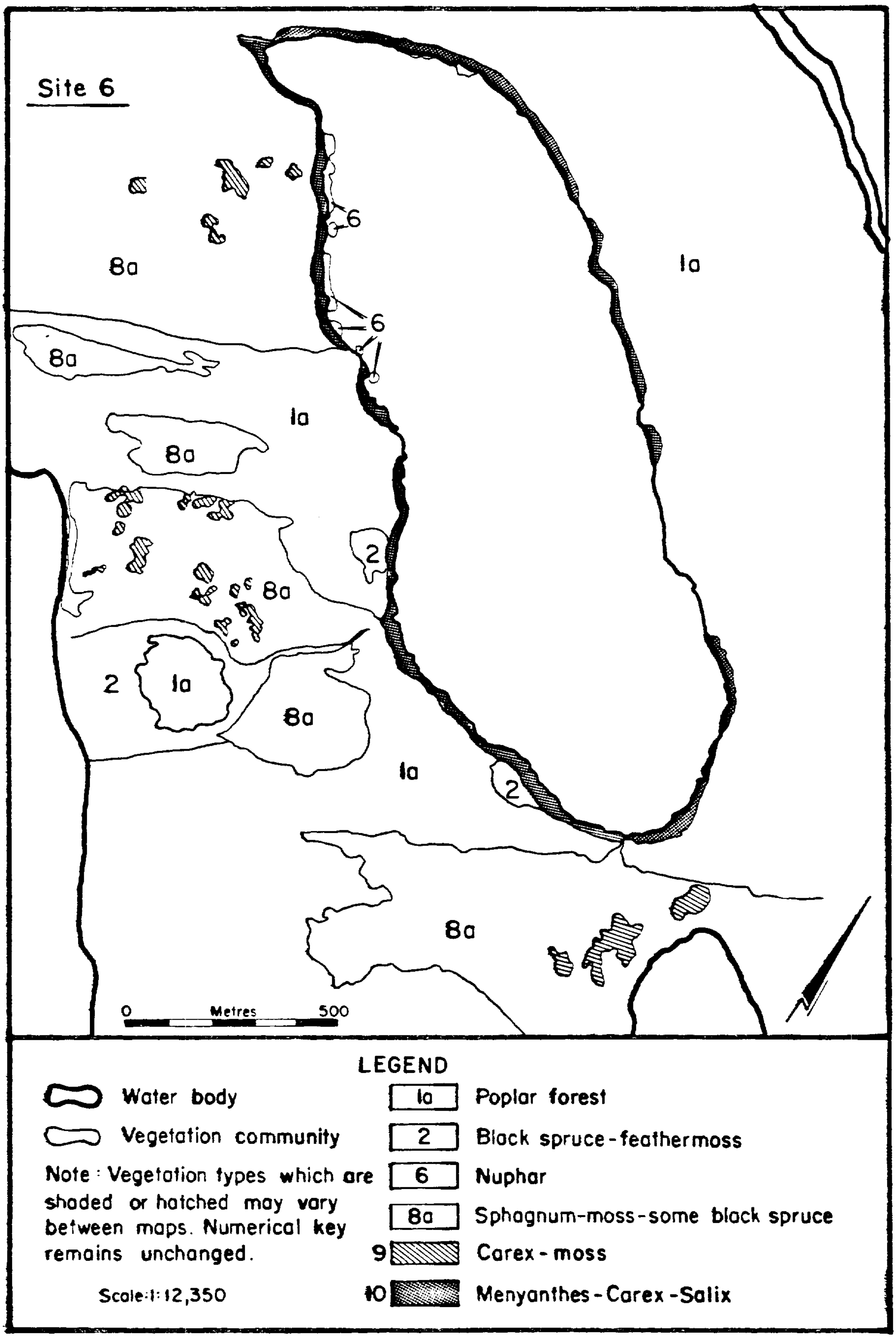


Fig. 7. Vegetation map of Site 6, Liard Highway region, NWT.

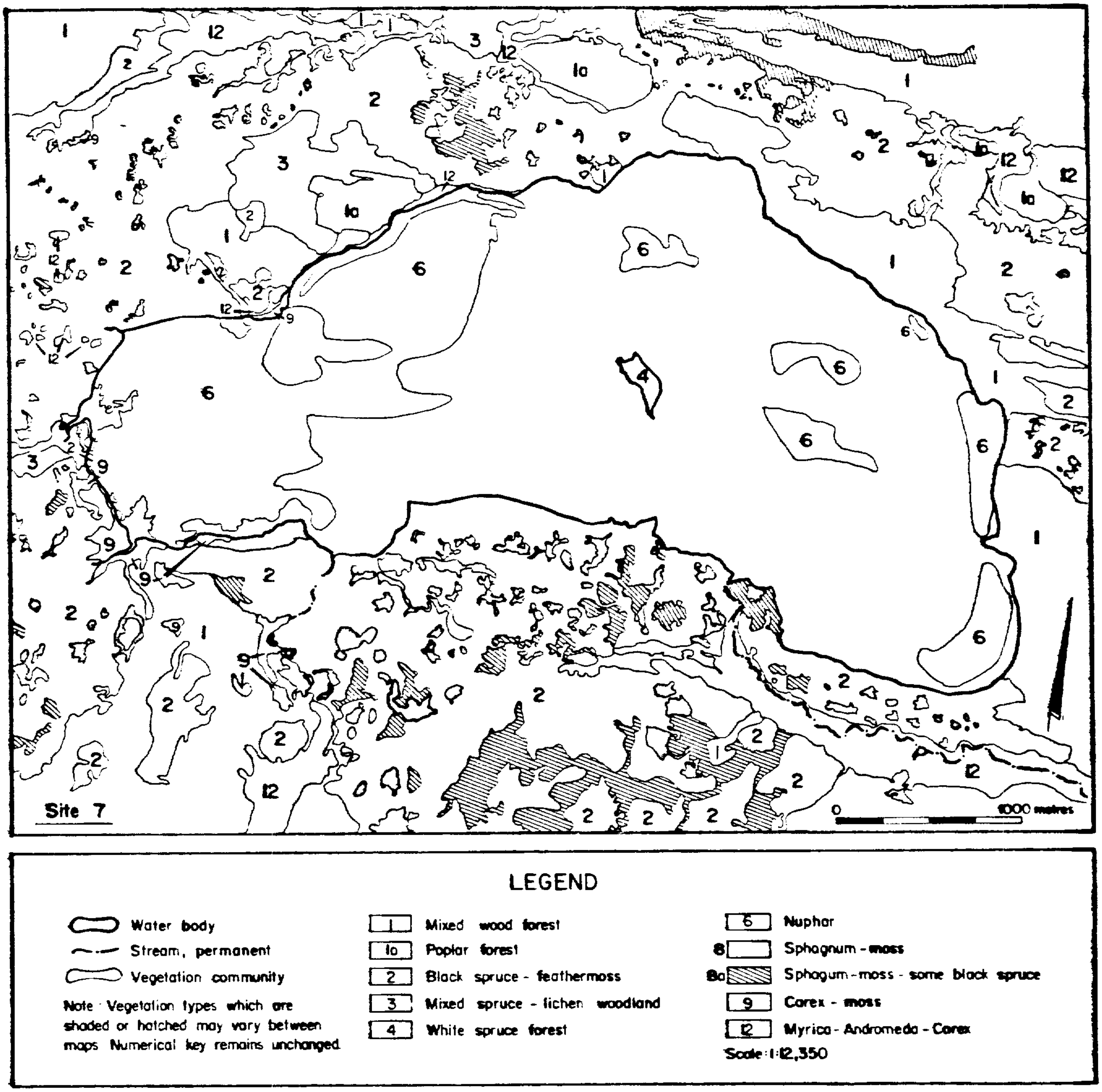


Fig. 8. Vegetation map of Site 7, Liard Highway region, NWT.

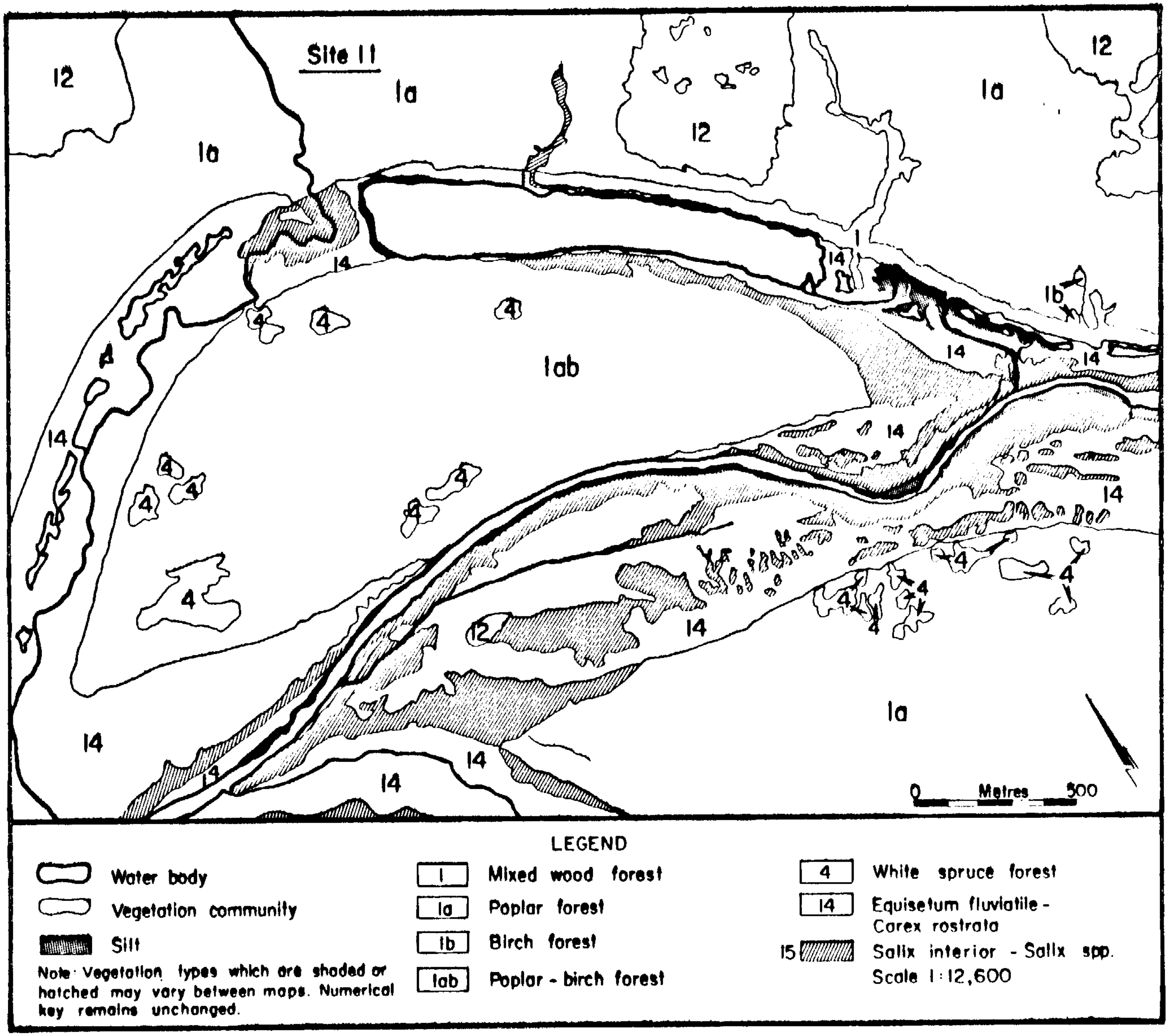


Fig. 9. Vegetation map of Site 11, Liard Highway region, NWT.

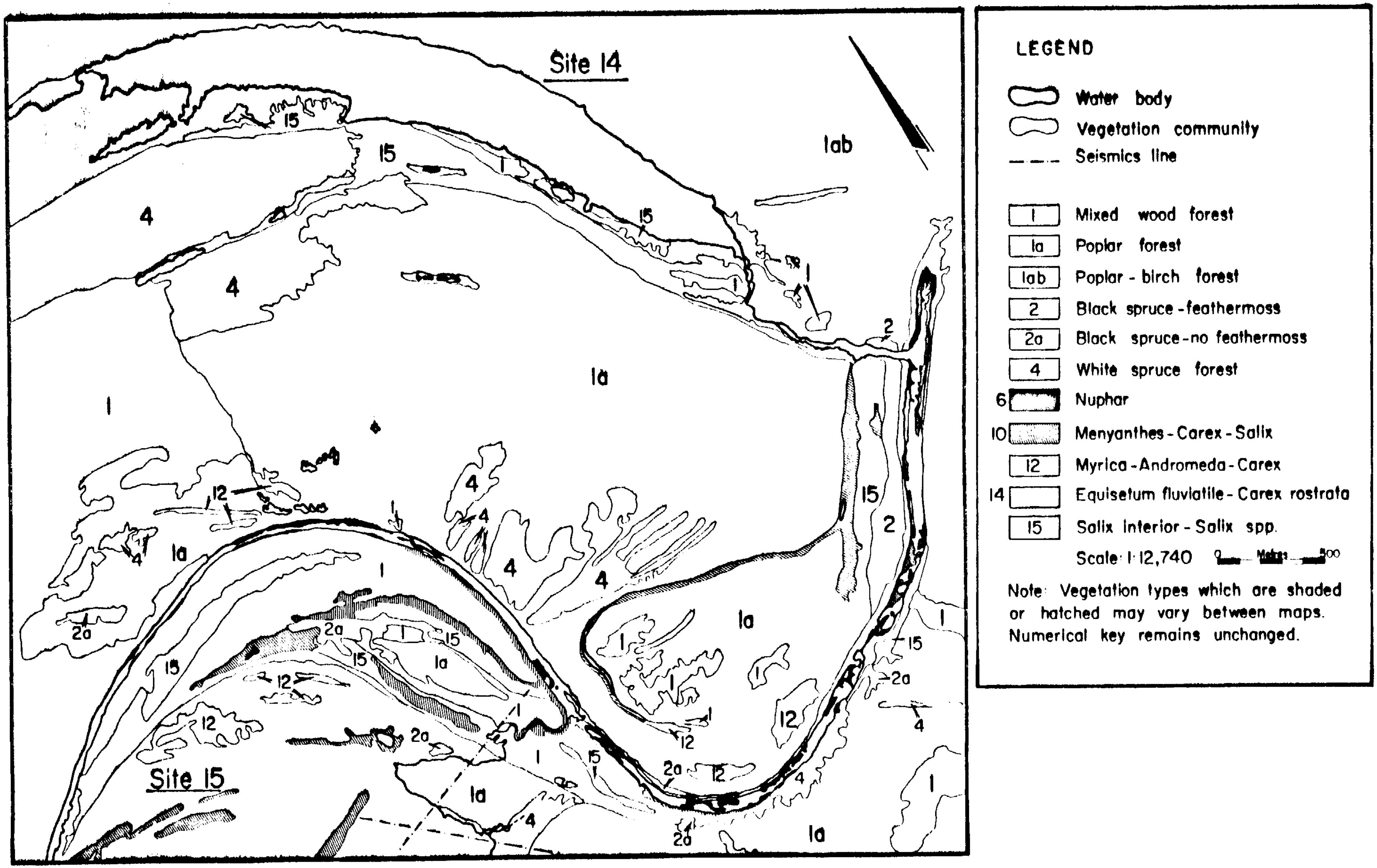


Fig. 10. Vegetation map of Site 14 and 15, Liard Highway region, NWT.

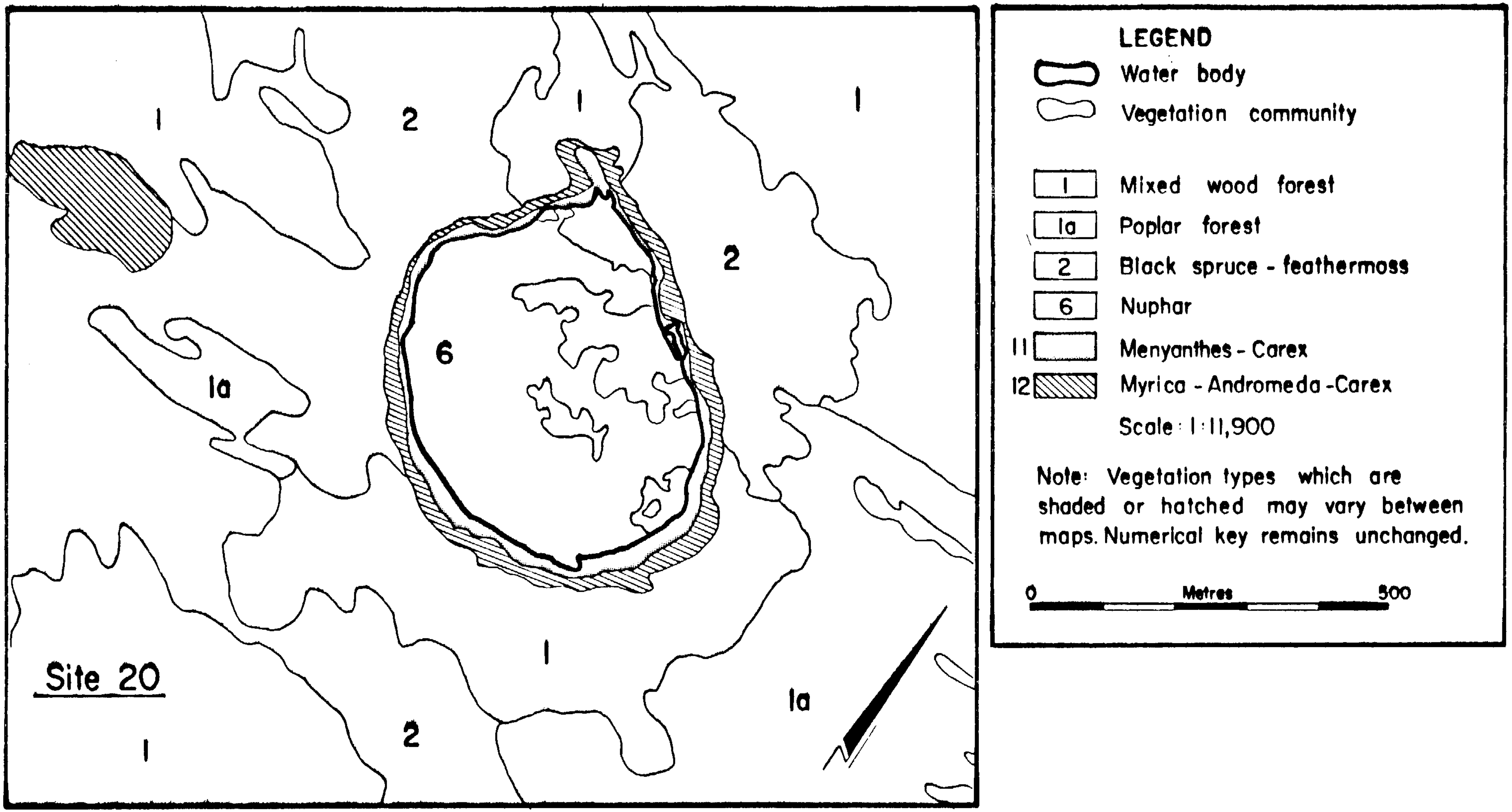


Fig. 11. Vegetation map of Site 20, Liard Highway region, NWT.

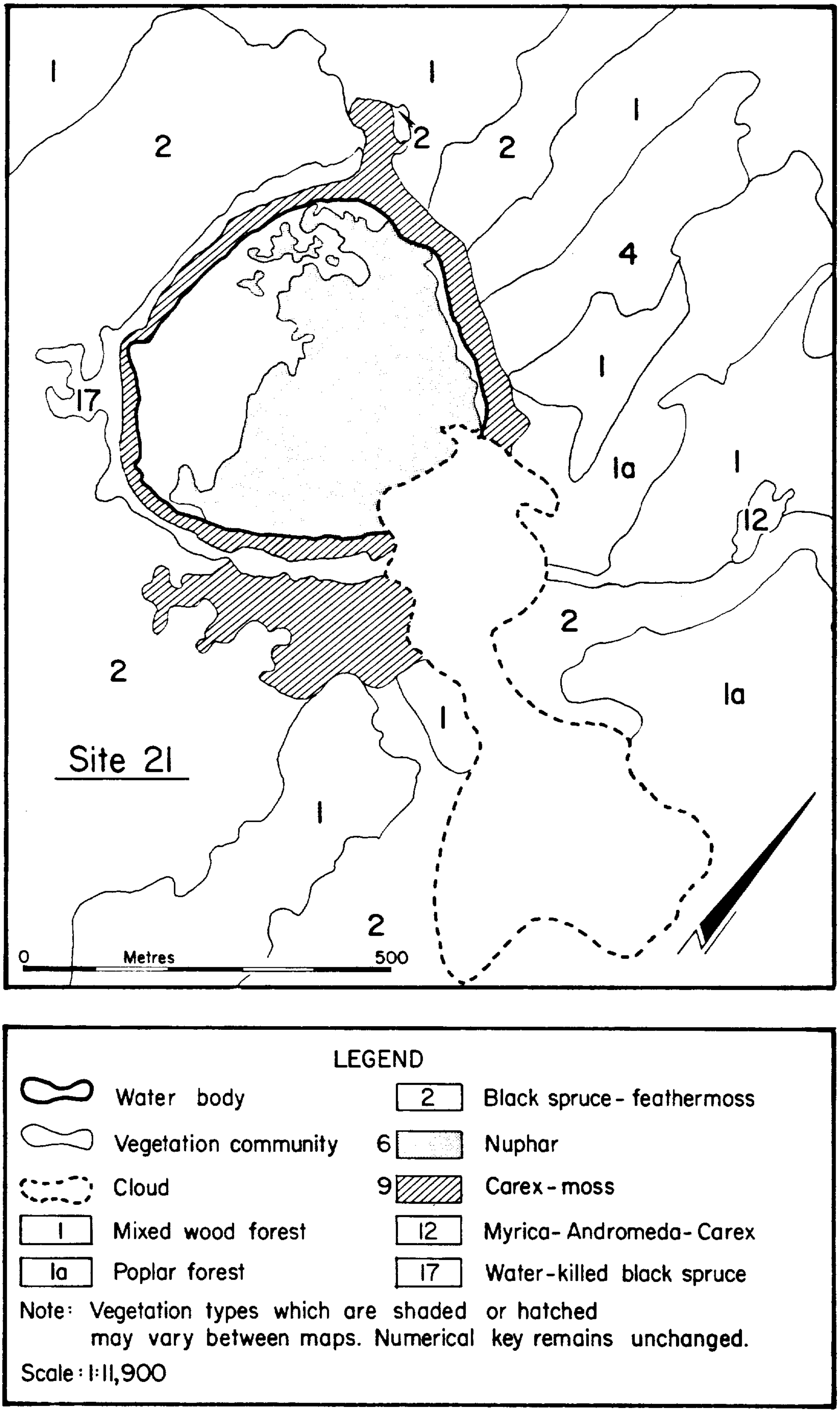


Fig. 12. Vegetation map of Site 21, Liard Highway region, NWT.

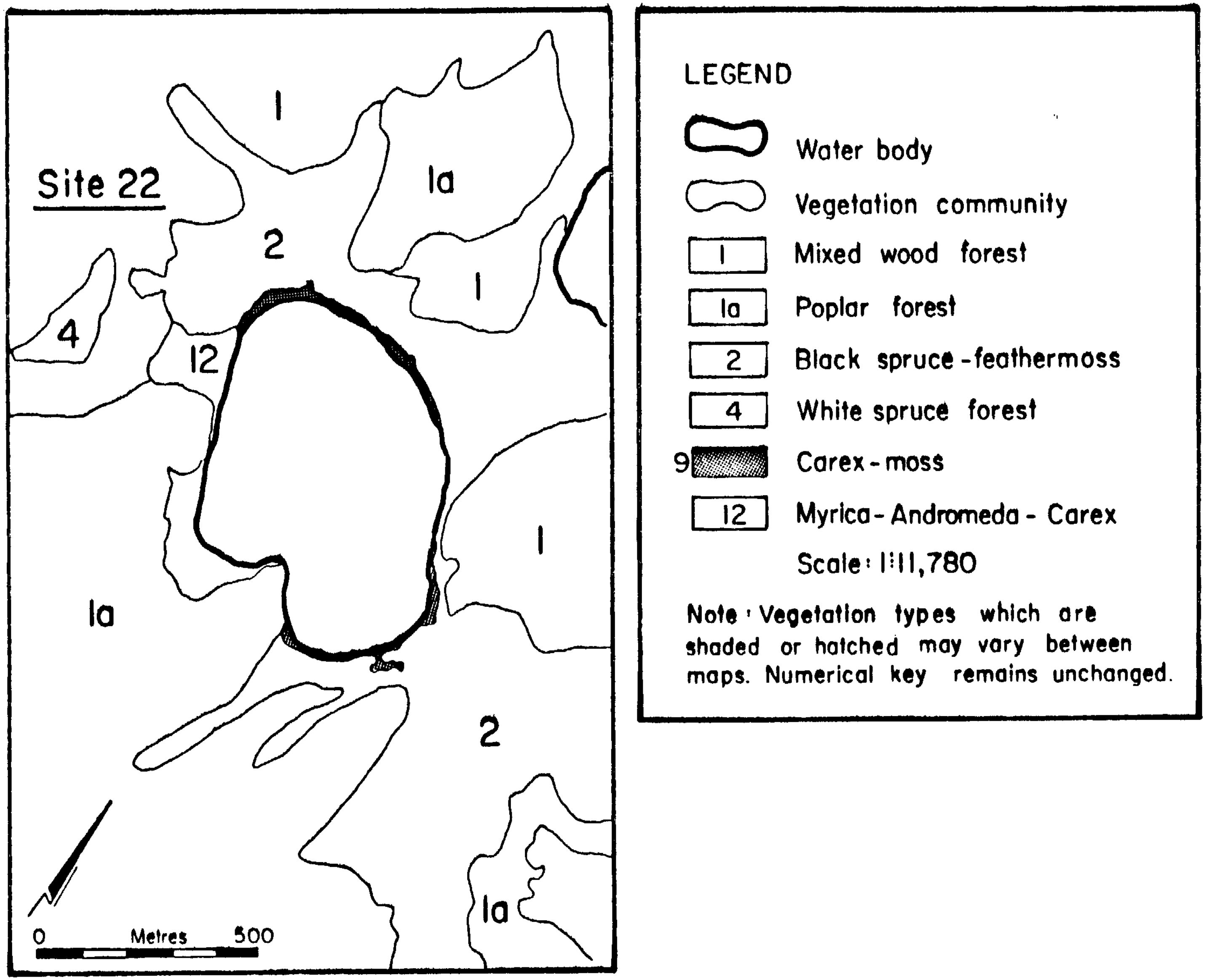


Fig. 13. Vegetation map of Site 22, Liard Highway region, NWT.

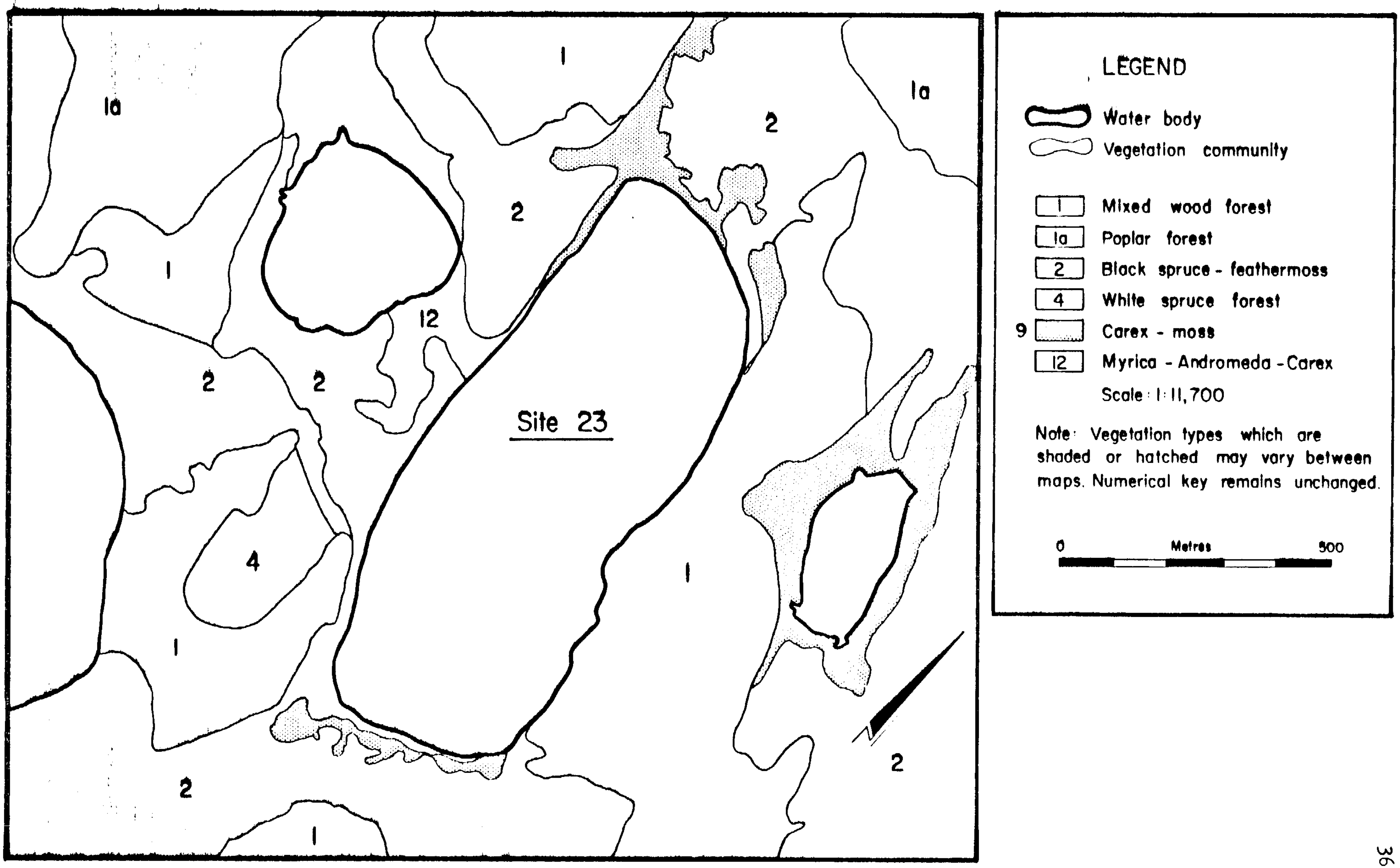


Fig. 14. Vegetation map of Site 23, Liard Highway region, NWT.

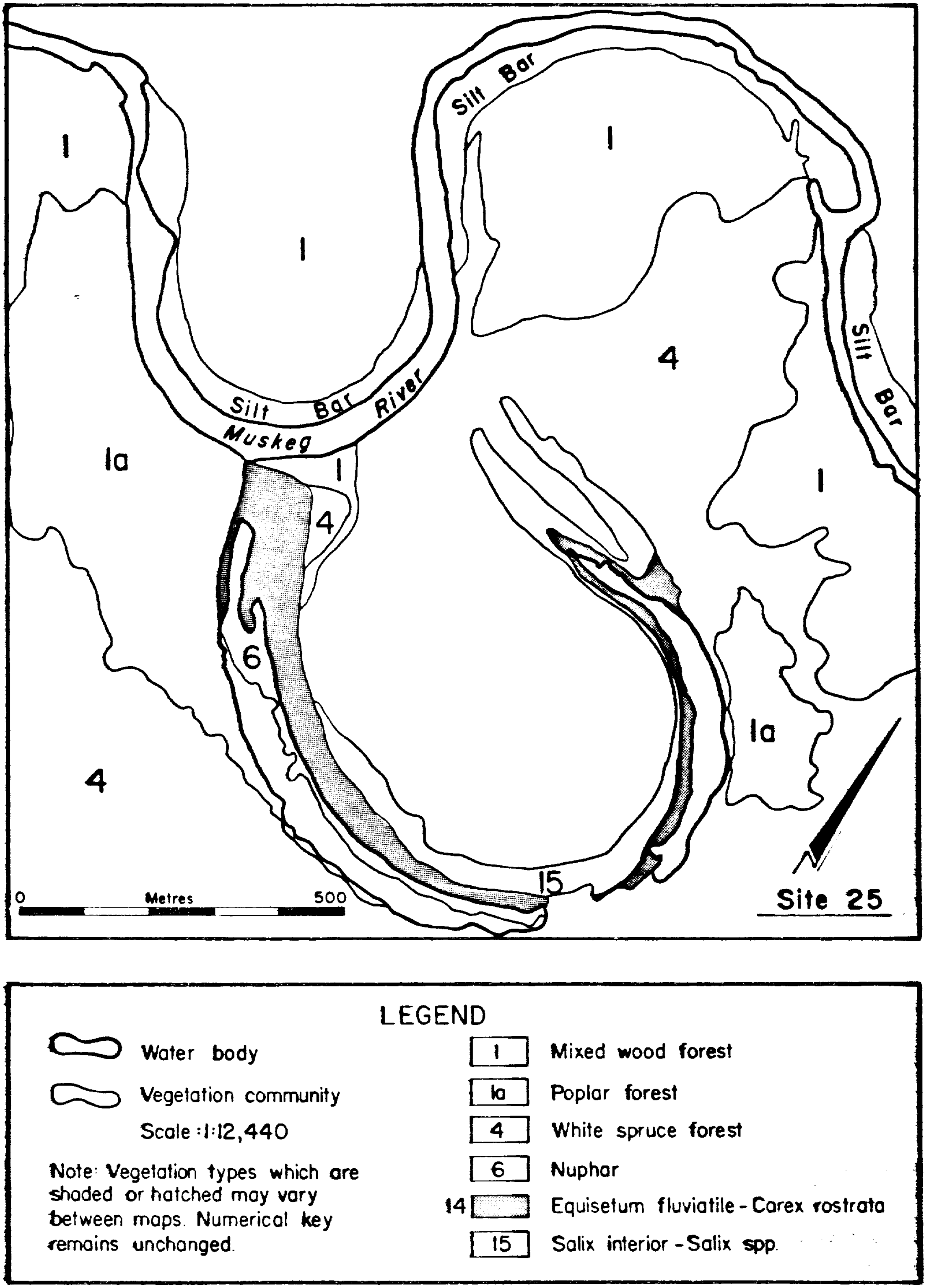


Fig. 15. Vegetation map of Site 25, Liard Highway Region, NWT.

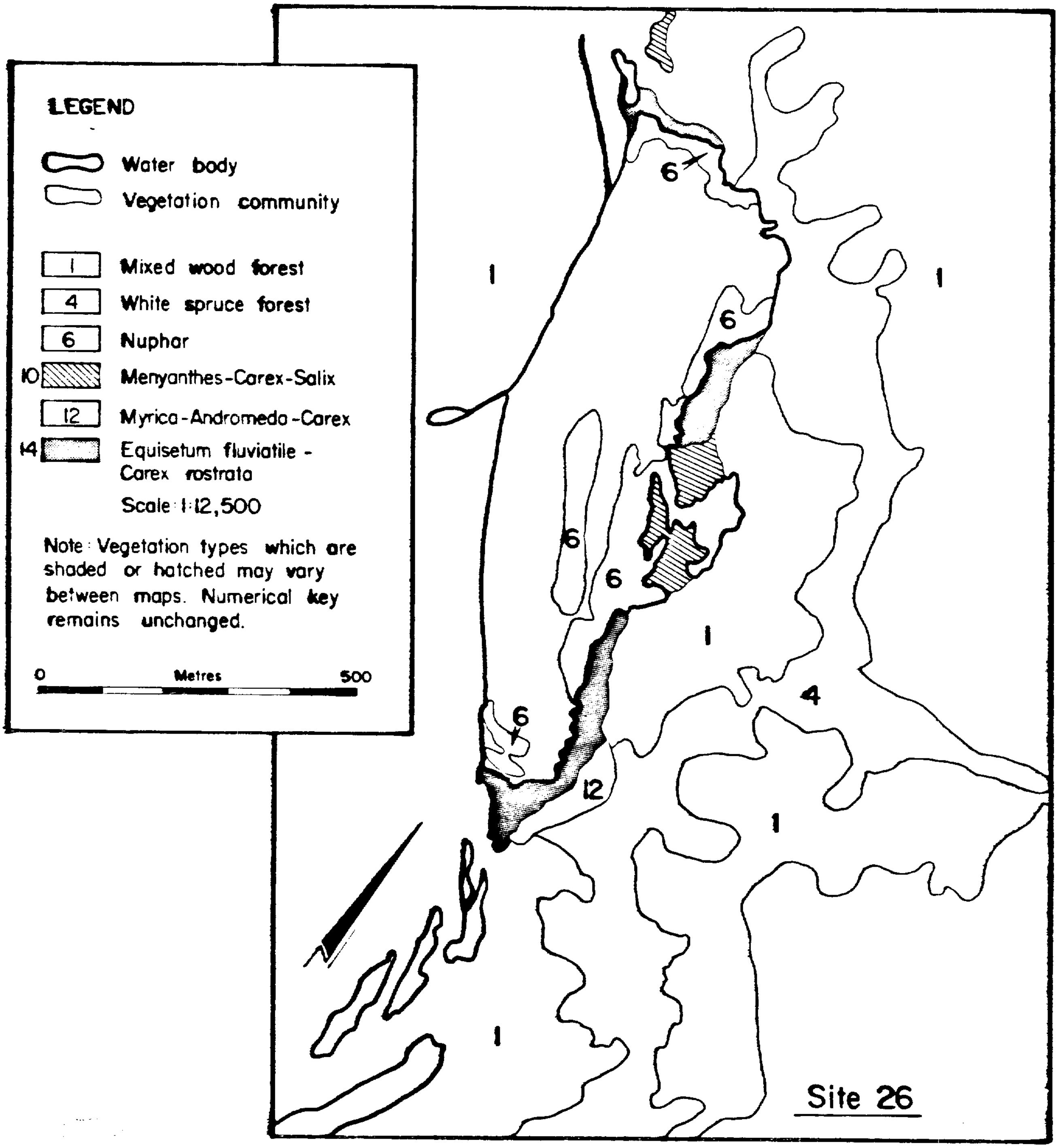
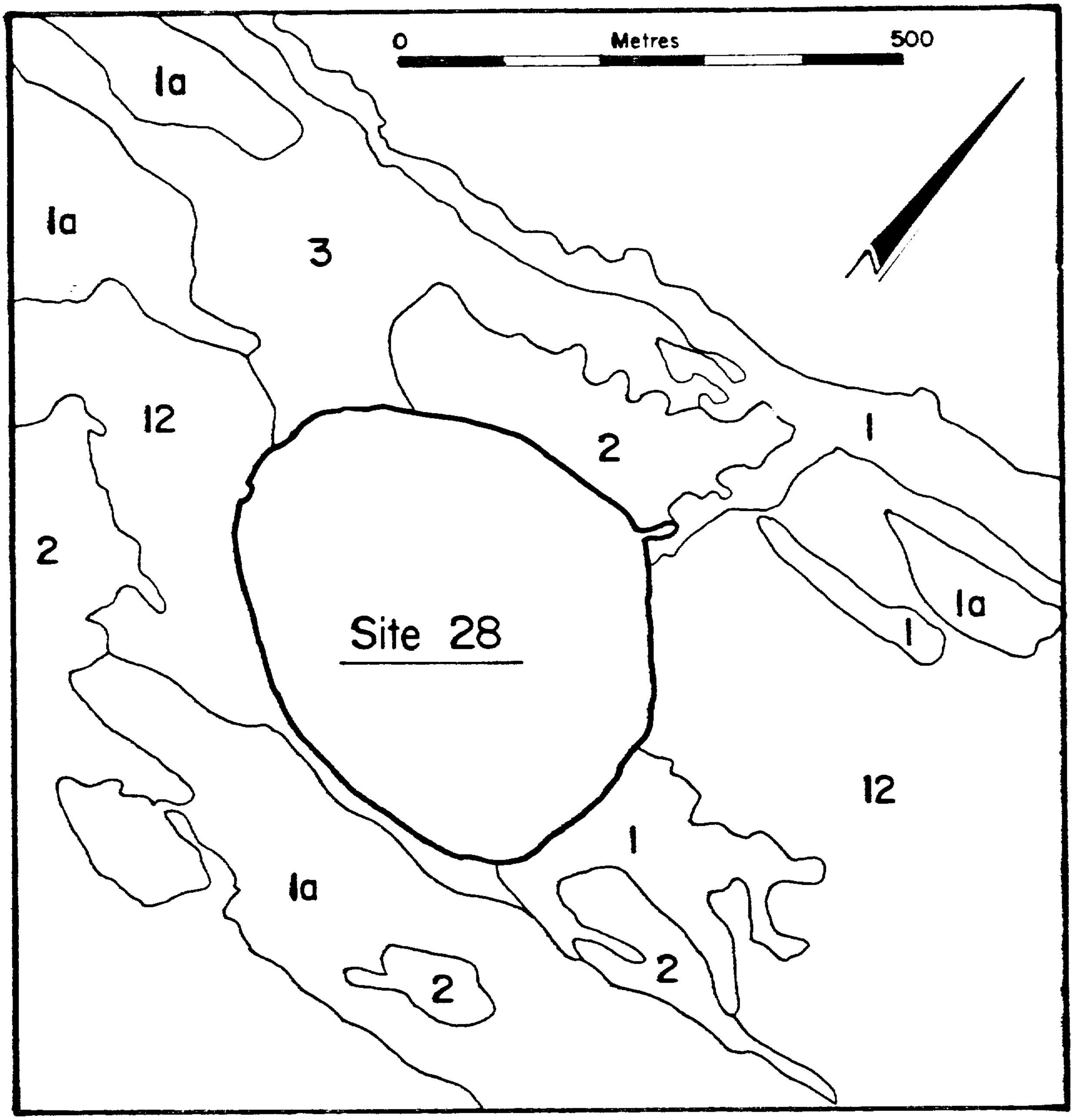


Fig.16. Vegetation map of Site 26, Liard Highway region, NWT.



LEGEND

Water body		1	Mixed forest
Vegetation community		la	Poplar forest
Scale: 1:11,300		2	Black spruce - feathermoss
		3	Mixed spruce - lichen woodland
		12	Myrica - Andromeda - Carex

Fig. 17. Vegetation map of Site 28, Liard Highway region, NWT.

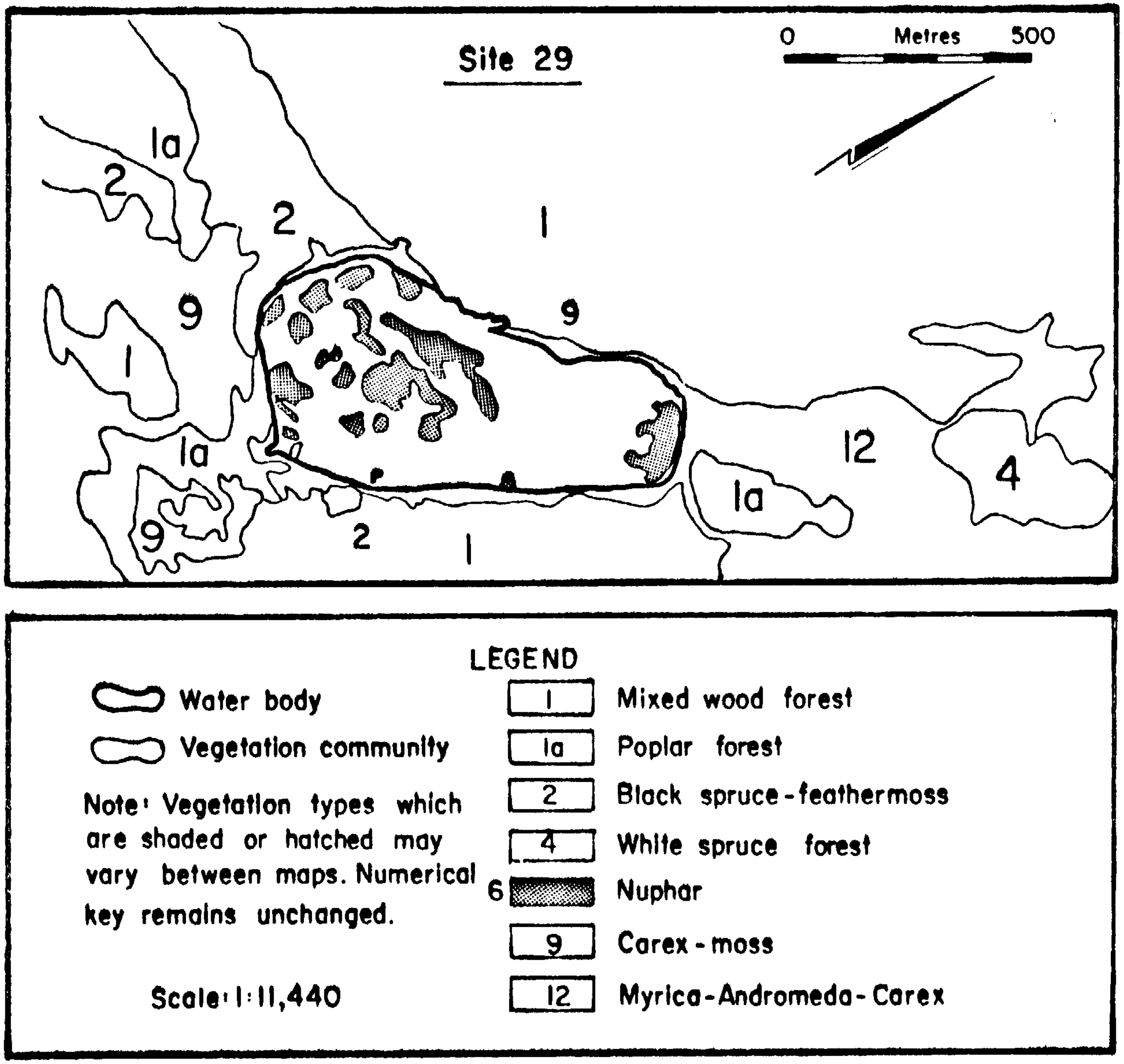


Fig. 18. Vegetation map of Site 29, Liard Highway region, NWT.

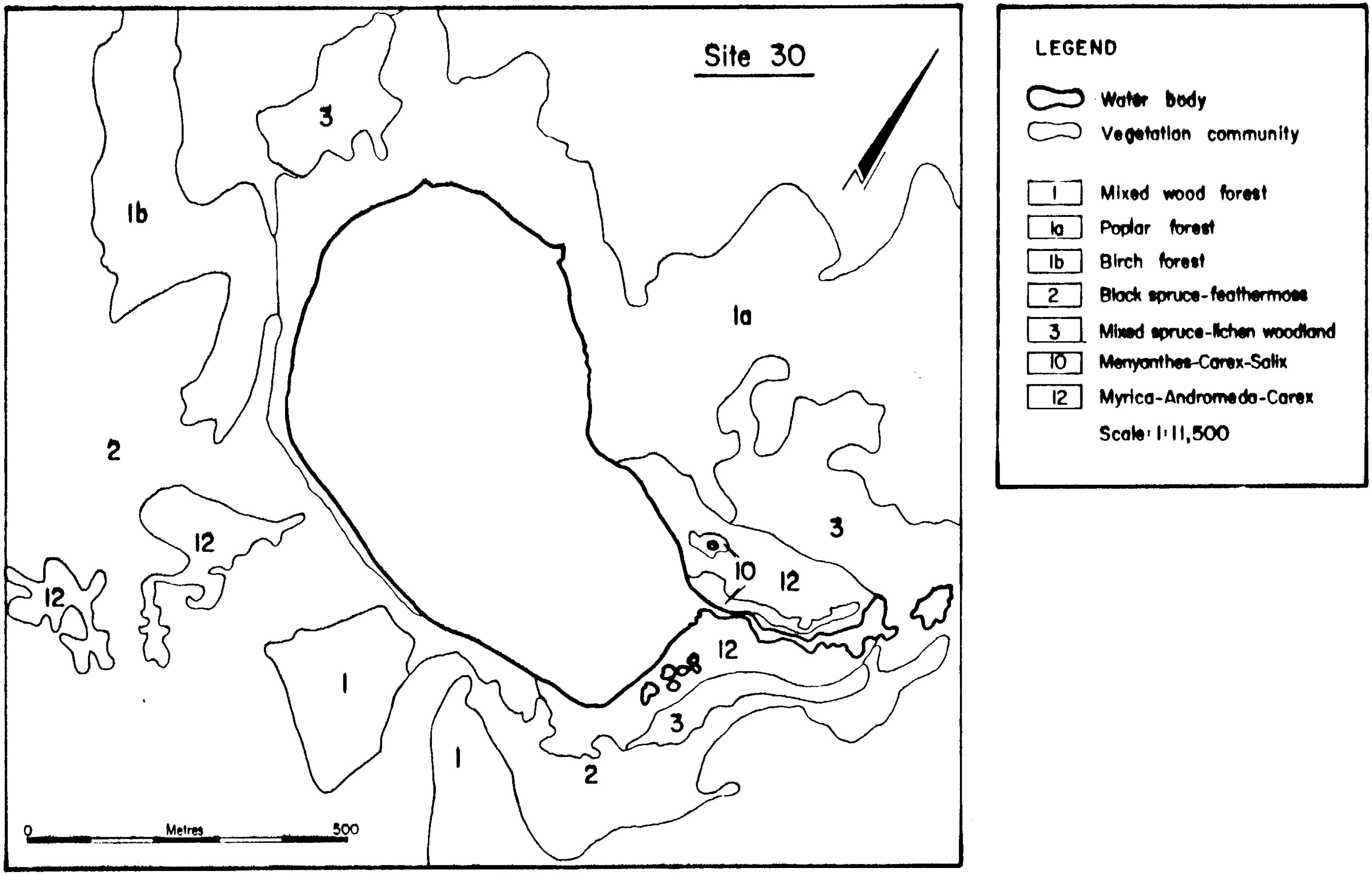


Fig. 19: Vegetation map of Site 30, Liard Highway region, NWT.

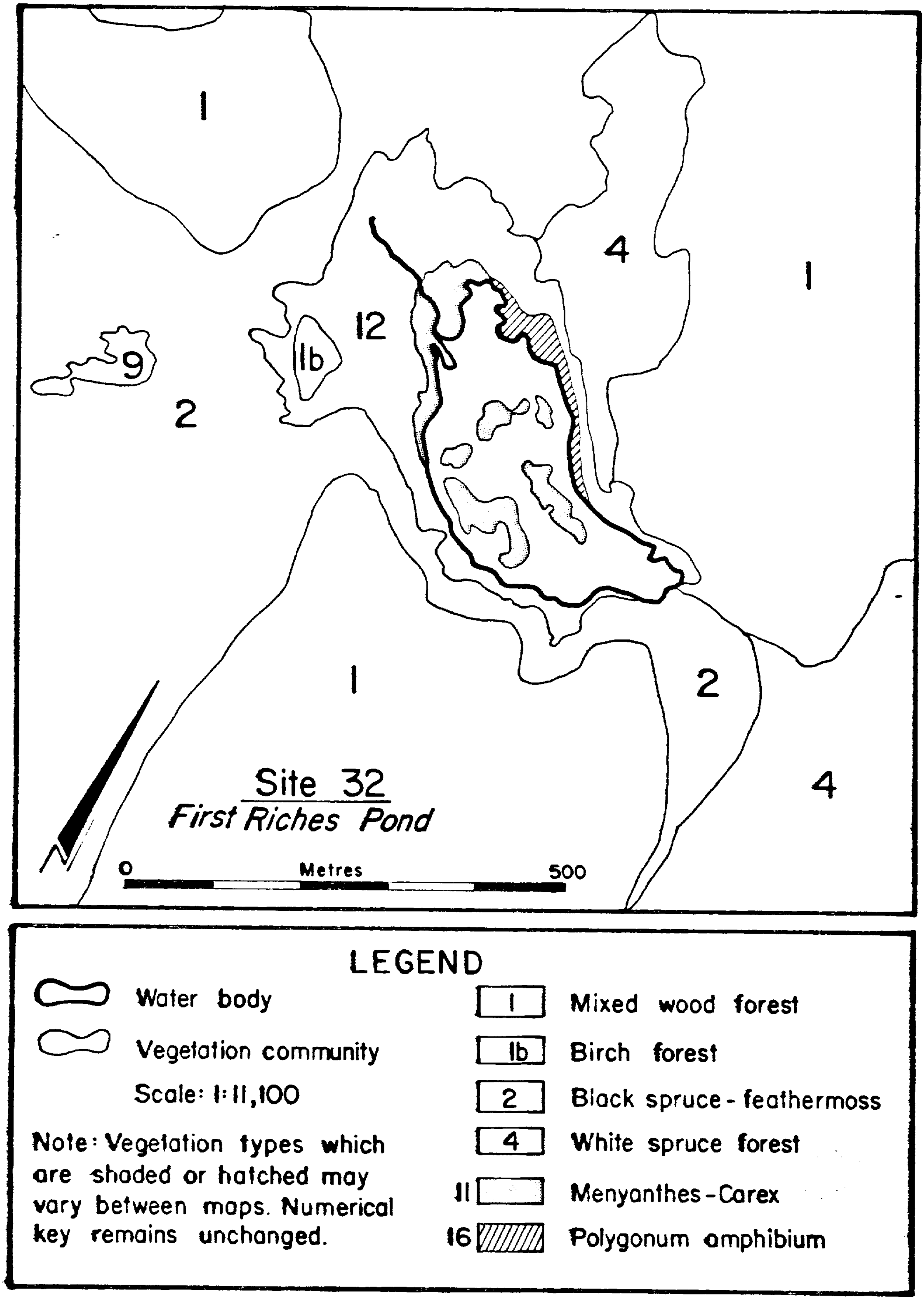


Fig. 20. Vegetation map of Site 32, Liard High[illegible] region, NWT.

4. INVERTEBRATES - Richard Quinlan[1]

4.1 Introduction

Quantitative sampling provided a detailed description of the invertebrate fauna present in the wetlands adjacent to the Liard Highway alignment. This is essential to an understanding of the biological characteristics of the region. The abundance and species composition of invertebrates may be a major factor regarding the suitability of habitats to waterfowl and water-oriented birds.

4.2 Methods and Materials

All invertebrates were collected from the littoral and limnetic zones of wetlands using a dip net with a diameter of 30.5 cm. One sample was gained from a 25 m sweep, making the volume of water 1,825.5 litres from which the invertebrates were taken. The mesh size of the net was #20 U.S. standard sieve (212.5 1 m).

Collection from a helicopter on floats (Plate 9) allowed sampling of all 33 sites in one day. The procedure was usually carried out in conjunction with waterfowl surveys. After collection, invertebrate samples were stored in 70% alcohol or 10% formalin. In the fall of 1977 the specimens were identified by R. Quinlan at the Fisheries and Marine Service trailer in Ft. Simpson and later at the CWS headquarters, Edmonton. Corixids, Tendipedidae Larvae, Hydracarinas, and Arachnids were identified by the Biosystematics Research Institute, Agriculture Canada. Dytiscidae Larvae were verified or identified by R. Roughley, Dept. of Entomology, University of Alberta. Dr. H. Clifford, Zoology Dept., University of Alberta, verified several specimens of invertebrates.

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[1]Canadian Wildlife Service - Edmonton

Plate 9. Helicopter Bell 206B on floats for invertebrate collection.

Charts of species composition and numbers were drawn for each wetland sampled (Appendix B.2). The Shannon-Weaver Diversity Index and Equitability Index was determined for each sampling date at each site using the following formula (Whitman 1974):

$$H = \sum_{i=1}^{s} (pi)(\log e\ pi)$$

where H = index of diversity
S = number of species
pi = proportion of the total sample belonging to the i^{th} taxa

The equitability component can be defined by the ratio:

$$E = \frac{H}{Hmax}$$

where E = equitability (range from 0-1)
H = observed species diversity
Hmax = maximum species diversity = log e S

A diversity chart illustrates the total number of taxa at each pond on each sample date, allowing comparison of species richness. Water temperature was taken at each invertebrate sampling point. (Appendix B.4).

4.3 Results

Two major groups made up the bulk of specimens collected, Cyclopidae *(Cyclops varicans)*, and Daphnidae *(Daphnia pulex)*. Butterfly graphs are included for each of four pond types:

a. Wooded ponds (Fig. 21 ponds 9, 14, 15, 25, 26, 32). These are ponds closely encroached by forest. There is little or no floating vegetation mat at the fringe.

In addition to *Daphnia* sp. and *Cyclops* sp., which were the two dominant taxa, Culicidae *(Chaoborus americana)* were consistently present. Other relatively common groups in the wooded ponds were Corixidae, Dytiscidae,

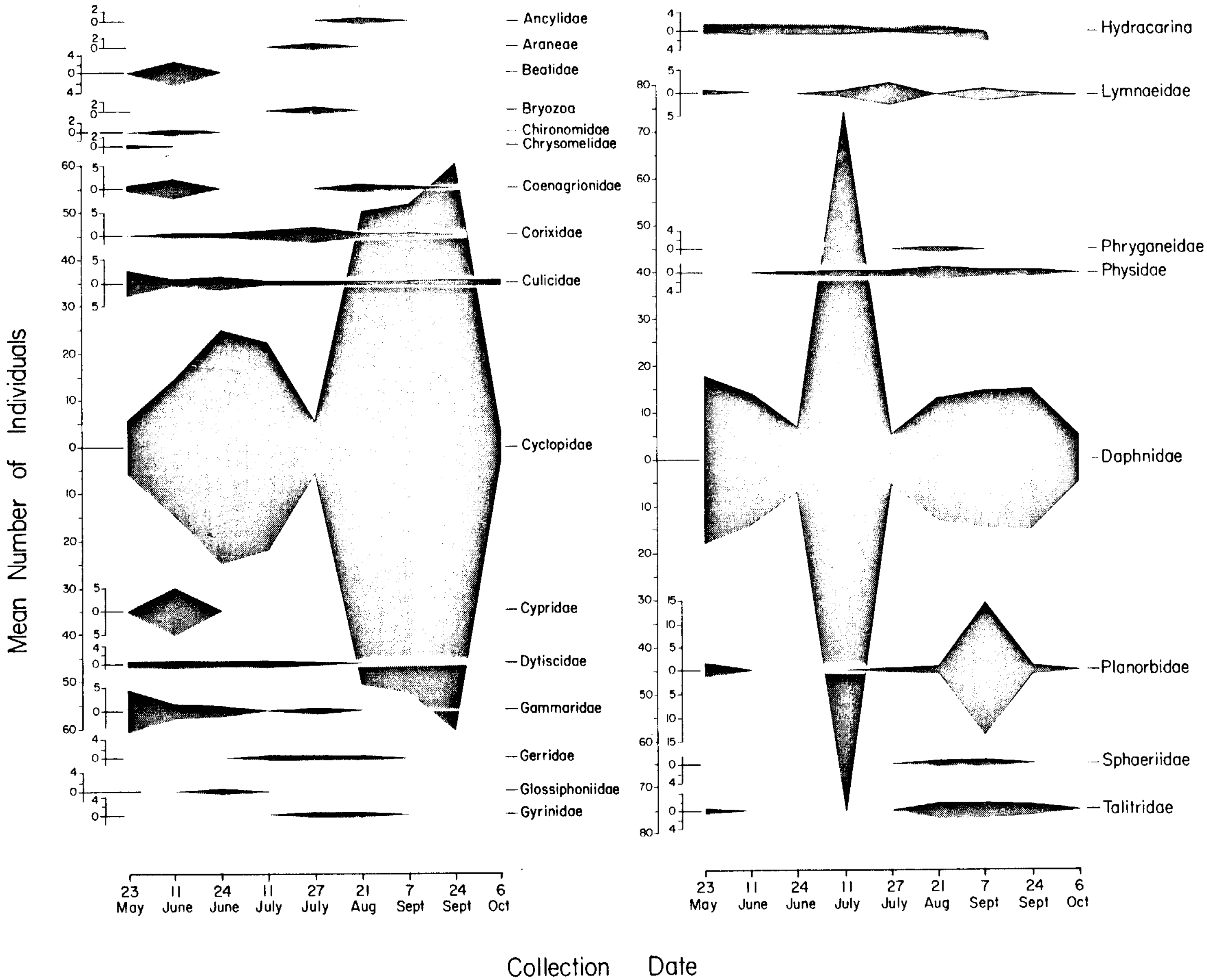

Fig. 21. Wooded pond.- Dynamics of invertebrates collected by sweep net, Liard Highway, NWT, 1977.

Gammaridae, Lymnaeidae, Physidae, Planorbidae, and Talitridae. Cypridae was present only in pond #25 (30 specimens on June 11).

b. Alluvial wetlands (Fig. 22, ponds 11, 13, 25). These are ponds which are annually inundated by spring flooding of a nearby river. Only three ponds of this type existed in the study area, two near the Netla River and one near Muskeg River. New sediments each year provide a rich substrate for growth of horsetails and willows.

Although the small number of ponds sampled may give slightly biased results, it is evident from the species composition charts (Appendix B.2) and the butterfly graph that the invertebrate community present is relatively poor. The only taxa with high numbers of individuals were Cyclopidae, Daphnidae, and Cypridae. Corixidae were present in medium numbers (5-10/sweep net sample) in August-September.

c. Shallow ponds (Fig. 23, ponds 1, 2, 7, 10, 16, 17, 18, 19, 20, 21, 24, 29, 33). These ponds are shallow enough to allow greater than 10% coverage of the water surface by pond lilies *(Nuphar variegatum)*.

Cyclops sp. and *Daphnia* sp. were the most abundant and consistent taxa. High numbers of *Cyclops* (>10/sweep net) were present at ponds 1, 2, 10, 17, 21 and 24. Site 20 was the only pond which had no *Cyclops* sp. *Daphnia* sp. numbers were high at all ponds with the exception of numbers 1, 2 and 18. Culicidae *(Chaoborus americana, Culicini* sp.) were also consistently present and nearly as abundant, having highest numbers on ponds 10 and 20. Gammaridae *(Gammarus lacustris)* showed high numbers at sites 1 and 2. Hydracarinas were abundant in May at sites 10 and 20. Talitridae had high numbers at sites 1 and 2. Helapedidae were abundant in May and June in site #19 only.

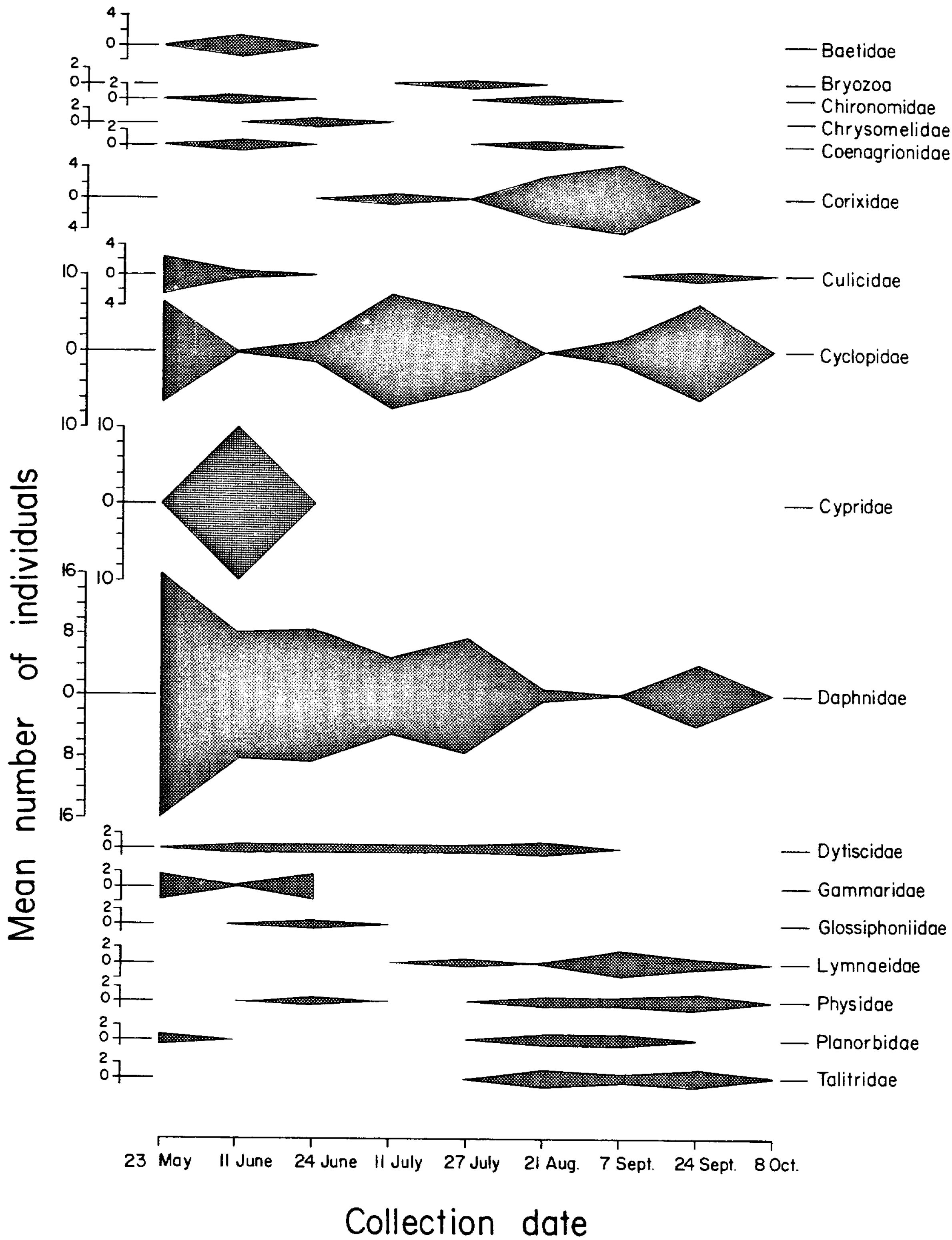

Fig. 22. Alluvial Ponds.- Dynamics of invertebrates collected by sweep net, Liard Highway, NWT, 1977.

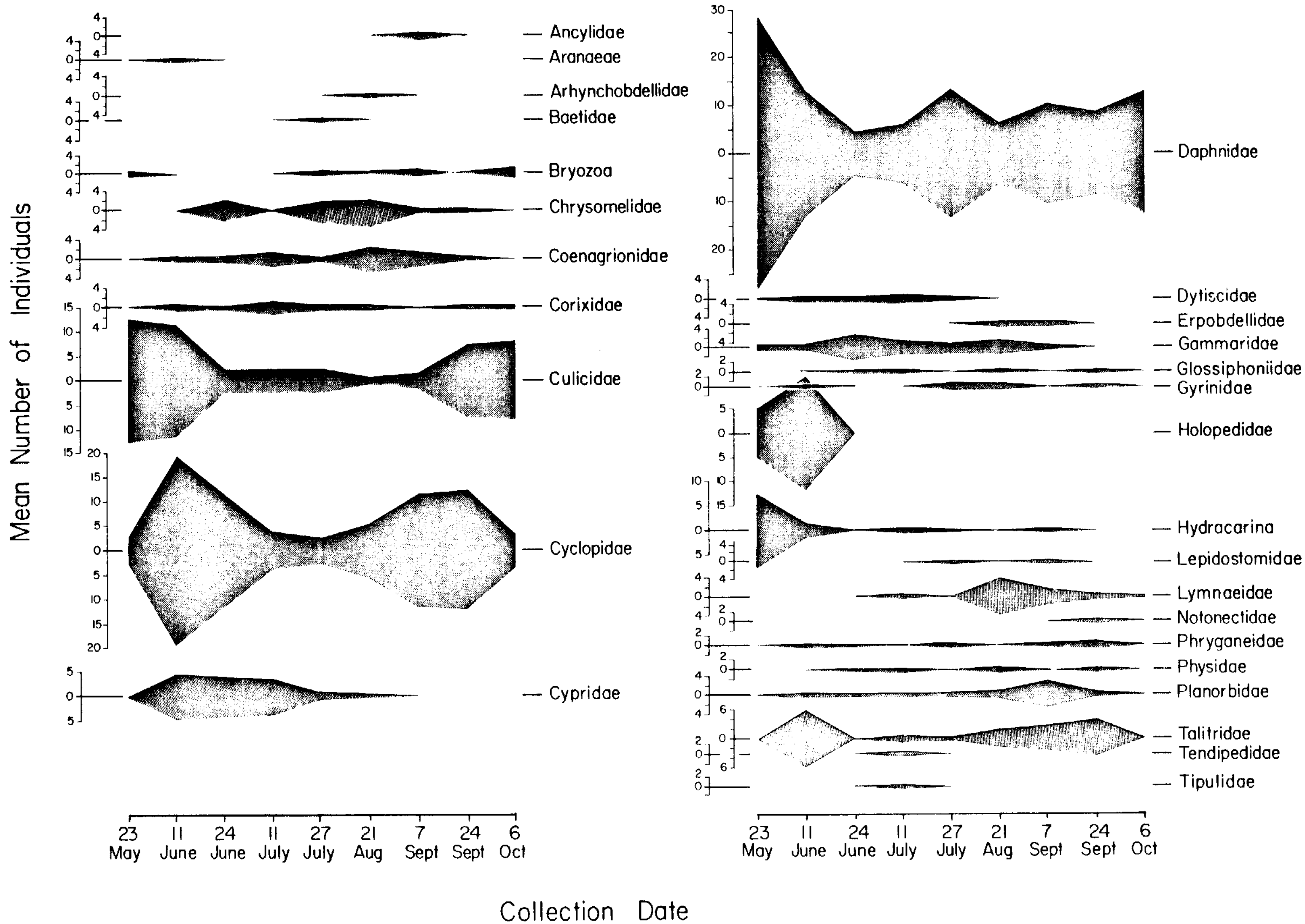

Fig. 23. Shallow Ponds. - Dynamics of invertebrates collected by sweep net, Liard Highway, NWT, 1977.

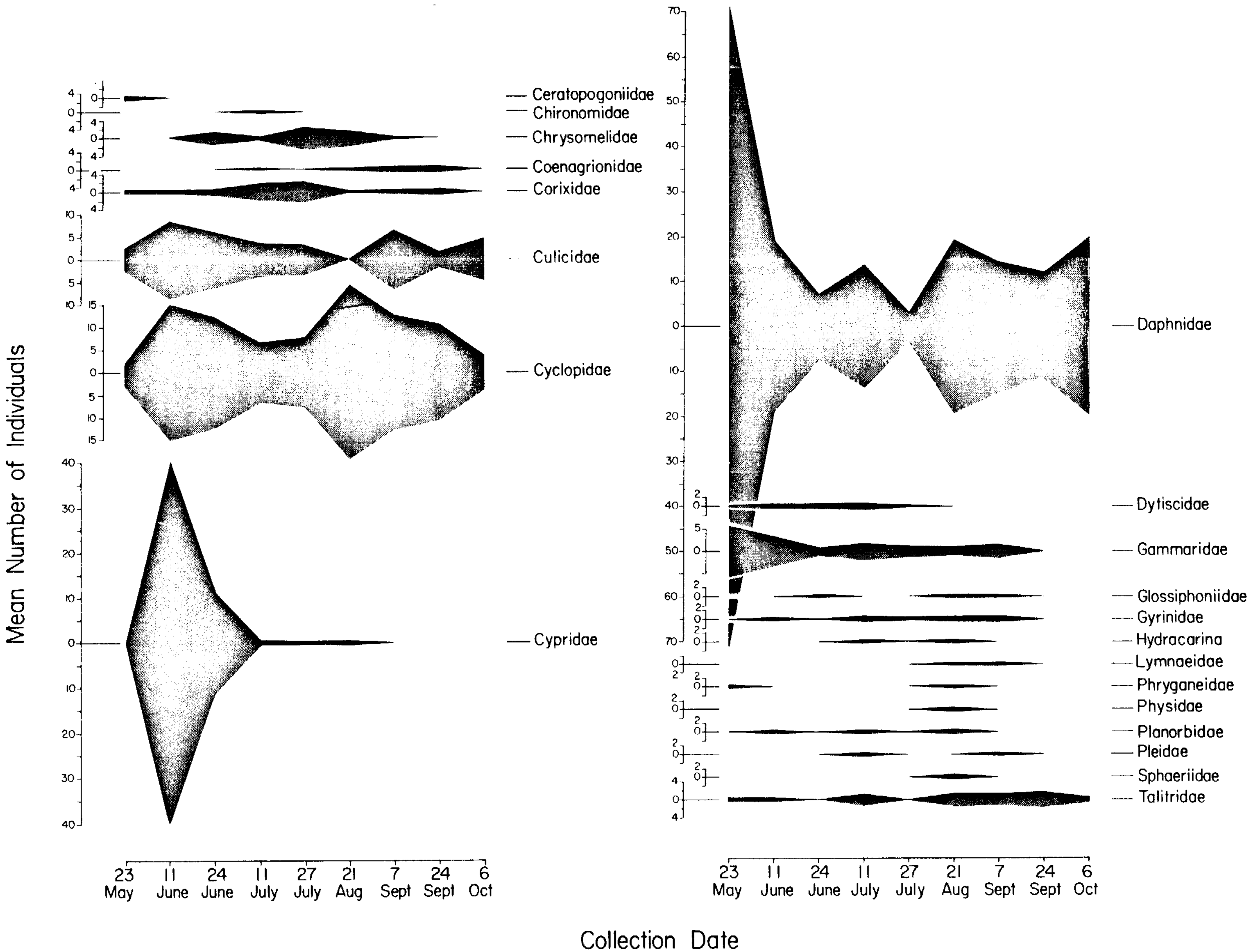

Fig. 24. Deep Ponds - Dynamics of invertebrates collected by sweep net, Liard Highway, NWT, 1977.

d. Deep Ponds (Fig. 24, ponds 3, 4, 5, 6, 22, 23, 27, 28, 30, 31). These ponds are characterized by being too deep to allow growth of pond lilies on greater than 10% of the water surface.

As was the case with other pond types, Cyclopidae and Daphnidae were the most dominant and consistent groups. Culicidae were sub-dominant. Corixidae showed consistent but low numbers, as was true of both Gammaridae and Talitridae. On August 21 some new groups were found. These were Phryganeidae, Physidae, Sphaeriidae, and Lymnaeidae. Cypridae blooms were caused by high numbers of *Cypriconcha* sp. during June in site #27.

4.4 Discussion

Sampling of the study ponds by sweep net provided an inventory of free-swimming organisms in the littoral and limnetic zones of ponds. Bottom-dwelling organisms were not sampled. For comparable data on benthic sampling in a nearby region see Kemper *et al.* (1977).

Total invertebrate abundance may be seen in Table 3. The highest number of organisms was collected on June 11. Subsequent peaks were observed on July 11, August 21, September 7 and September 24 with a significant drop in numbers in October (reduction of habitat by freezing and die-off of vegetation). The drop to 641 on July 27 was mainly because of low numbers of Cyclopidae and Daphnidae, the two dominant groups at most sites.

Table 3. Total numbers of invertebrates, selected wetlands, Liard Highway Region, NWT 1977.

Days/month	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Total	1,809	2,161	984	1,208	641	1,246	1,297	1,204	614
Mean #/sweep net	54.82	65.48	29.82	36.61	19.42	37.76	39.30	36.48	18.61

The peak of 2,161 individuals on June 11 was composed of high numbers of *Cyclops varicans*, *Daphnia pulex*, and some groups which disappeared or became much less abundant later in the season. The most significant of these were Cypridae *(Cyprichoncha* sp.). Halopedidae *(Holopedium gibberum)* were present during this period but disappeared later. Hydracarinas were also abundant at this time.

Some groups became more abundant later in the season, noteably leeches (Erpobdellidae) and snails (Lymnaeidae, Physidae, Planorbidae).

Twenty-four families of invertebrates were represented in wooded ponds. Alluvial ponds had only seventeen families. Twenty-eight families were collected from shallow ponds, whereas deep ponds supported only twenty-one families. The number of families represented at each site type is a reflection of the habitat variation in the ponds. Shallow ponds had large areas of pond lilies *(Nuphar variegatum)*, *Potamogeton* spp. and other aquatic and emergent plants which provide diverse habitats. Wherever possible, invertebrate samples were taken from these vegetated areas. Wooded ponds characteristically had well-developed emergent vegetation as well as *Myriophyllum* sp. and other aquatics. *Nuphar* was generally not present. The variability of emergent vegetation provided diverse habitats, although not as pronounced as shallow ponds. Deep ponds lacked much of the aquatic vegetation of the shallower ponds. Sampling was necessarily done in the limnetic or open water zone. Alluvial wetlands supported the least diverse invertebrate community. Shoreline vegetation was not diverse, being mainly horsetails *(Equisetum fluviatile)* and willows *(Salix* spp.*)*. This, along with the turbidity of water due to suspended silt, provided poor habitat for invertebrates.

Diversity of each site on each sampling date is shown as the total number of families present in Table 4. Table 5 summarizes those sites having greatest species diversity and also those with the highest number of invertebrates. Ponds with the highest number of invertebrates were never those with the greatest diversity. The pond with the greatest species richness was #1 which had high species diversity throughout the field season. This was a shallow pond which also had great habitat diversity. Site #25, an alluvial and wooded pond, was also fairly rich in species.

Shannon-Weaver diversity indices and equitability indices are shown for each sampling date on each pond in Appendix B.3. The mean index value for each pond over the whole sampling period is also provided. Table 6 summarizes the data in relation to pond type.

As expected, shallow ponds had the greatest mean species diversity (0.8454). Wooded ponds were next with a value of 0.7472. Alluvial ponds had a Shannon-Weaver diversity value of 0.7281 only because of the inclusion of pond #25. When data from pond #25 was excluded the value was less than 0.5000. Deep ponds had a value of 0.6474.

Shannon-Weaver diversity indices may be used as a basis for comparison of relative stability of free-swimming fresh-water invertebrate populations. Odum (1971) states: "Higher diversity means longer food chains and more cases of symbiosis, and greater possibilities for negative feedback control, which reduces oscillations and hence increases stability."

Table 4. Species diversity (species richness) of aquatic invertebrates collected at sampling sites along Liard Highway, NWT, 1977.

Date/month / Site	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
1	2	7	6	6	6	5	6	2	4
2	1	6	5	7	6	9	4	3	2
3	2	4	5	7	6	4	5	5	2
4	2	4	5	5	2	4	1	5	4
5	-	4	4	7	2	3	4	1	-
6	2	4	4	3	2	1	3	1	1
7	2	7	2	5	2	10	7	4	4
8	-	3	4	3	3	5	6	5	-
9	-	5	5	6	9	6	2	2	-
10	3	4	8	6	4	3	3	4	2
11	-	-	2	2	-	-	2	1	-
12									
13	3	-	2	-	2	4	-	-	-
14	3	2	2	2	3	4	2	2	3
15	2	6	3	2	3	5	4	1	1
16	1	4	2	3	1	3	6	3	1
17	-	3	2	3	3	3	3	2	2
18	-	5	4	1	7	6	5	2	1
19	1	2	3	4	5	2	1	2	1
20	3	4	2	4	3	5	4	8	2
21	3	6	-	5	3	5	1	3	3
22	3	5	4	5	2	2	3	4	2
23	3	4	2	5	2	3	1	2	2
24	-	4	2	4	-	4	5	2	2
25	5	7	4	4	5	4	5	6	-
26	2	3	2	2	5	3	2	4	2
27	3	2	4	2	4	3	1	1	1
28	5	4	4	6	3	7	3	4	2
29	3	5	5	3	2	2	8	4	3
30	4	5	1	4	1	3	3	4	2
31	-	3	3	4	2	1	3	3	2
32	8	2	4	3	2	2	8	3	2
33	3	3	2	3	7	6	7	7	2

Table 5. Pond diversity of aquatic invertebrates collected at sampling sites along Liard Highway, NWT 1977.

Sample Date	Most Diverse by of sp.)	Highest # of inverts
May 23	8 Site 32	550 Site 4
June 11	7 Sites 1, 7, 25	430 Site 27
June 24	8 Site 10	148 Site 27
July 11	7 Sites 1, 2, 3, 5	402 Site 15
July 27	9 Site 9	166 Site 19
August 21	10 Site 7	374 Site 9
September 7	8 Sites 29, 32	320 Site 9
September 24	8 Site 25	350 Site 9
October 6	4 Sites 1, 4, 7	125 Site 28

Equitability values indicate the degree of dominance existing. The higher the number (closer to 1.000), the more equitable the community is. This represents a situation where no one species is noticeably dominant. Alluvial ponds have an average equitability value of .7090. Shallow ponds have E = .6926. Wooded ponds have E = .6346, whereas deep ponds have E = .6299. When the possibly erroneous values of alluvial ponds are omitted, it is seen that in general, the more diverse the invertebrate community is, the more equitable it is.

Table 6. Shannon-Weaver diversity index and equitability values by pond types.

Pond #	S.-W. diversity (mean of sampling dates)	Equitability (mean)
	"wooded ponds"	
9	0.6856	.4873
14	0.6036	.6516
15	0.5736	.5816
25	1.2173	.7709
26	0.6867	.6796
32	0.7165	.6369
mean of ponds	0.7472	.6346
	"flooded ponds"	
11	0.4350	.8367
13	0.5321	.5192
25	1.2173	.7709
mean of ponds	0.7281	.7090
	"shallow ponds"	
1	1.2309	.8538
2	1.1308	.8100
7	1.0149	.6774
10	0.9818	.7363
16	0.5190	.6954
17	0.5869	.6390
18	0.7607	.7048
19	0.3753	.5816
20	1.0453	.6488
21	0.8714	.7402
24	0.7325	.6457
29	0.8043	.6325
33	0.9366	.6379
mean of ponds	0.8454	.6926
	"deep ponds"	
3	0.9785	.7165
4	0.7914	.8779
5	0.6189	.5716
6	0.5614	.7889
22	0.6513	.5668
23	0.5034	.5455
27	0.4835	.6559
28	0.7978	.5720
30	0.6496	.6973
31	0.4382	.5063
mean of ponds	0.6474	.6299

The shallow ponds,which have been shown to be rich in numbers and diversity of invertebrates,are the ponds with the greatest numbers of diving ducks, especially lesser scaup. Wooded ponds, also characterized by a fairly rich invertebrate fauna, were important to coot and bufflehead populations in the region. The alluvial ponds, poor in invertebrates, were frequented by mallard and teal which eat mainly vegetation. Deep ponds were characterized by presence of grebes and loons, as well as some scaup and other diving ducks.

A spring bloom of major invertebrate species occurred in the four pond types represented on butterfly graphs (Fig. 5, 21-24). These peaks correspond well with brood hatch dates and the period following hatch during which fresh-water invertebrates are a major part of the ducklings diet (pers. comm., Ambrock).

5. WATERFOWL - Richard Quinlan[1]

5.1 Introduction

Monitoring of migrating and breeding waterfowl populations was accomplished through aerial surveys. From the information gained during these surveys, relative importance of wetlands to migrating and breeding waterfowl was evaluated. Dates of the major migration use as well as start of incubation and hatch dates have been determined for 1977. The density of waterfowl in each wetland was also calculated.

5.2 Methods and Materials

Aerial surveys began May 5 with the last survey flown on October 20. Observations were made on the 33 sites sampled for vegetation and invertebrates. During the spring migration period, surveys were flown every 4-5 days in an Okanogan Helicopters Ltd. Bell 206B, chartered at Ft. Simpson. Surveys were flown at a height of 25-45 m above water and an airspeed of 110-150 km/hr. Two observers were present, one stationed on each side of the helicopter. A bubble side window provided good observation from the rear seat. Data was collected on TC-45 Sony cassette tape recorders. A record of numbers and species was obtained, tallied after each flight, and compiled on population graphs. At the beginning and end of each survey the time of day and weather were noted.

During June, July and August, breeding pair and brood surveys were flown. Observation altitudes were lower as greater detail in bird identification was necessary. The helicopter was flown 12-25 m above water at speeds of 95-130 km/hr. Brood surveys consisted of identifying the species by the adult bird present, counting the number of young birds, and estimating their age class according to the method described in Gollop and Marshall (1954). Backdating from the age class was used to determine the approximate hatch dates for each species.

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[1]Canadian Wildlife Service - Edmonton

Fall migration surveys were conducted during September and October. A survey was flown once every two weeks by helicopter in conjunction with freshwater invertebrate collections. Speed and altitude was similar to spring migration survey. Between these periods, censuses were performed every 5-7 days in a fixed-wing Cessna 185 chartered from Wolverine Air Ltd., Ft. Simpson. Fixed-wing censuses were flown at a height of 25-45 m above water level and at speeds of 140-190 km/hr.

During all phases of the waterfowl study, short-term camps were established at selected wetlands for observation of courtship behavior, ground truthing of species identifications and brood classifications. General waterfowl observations in conjunction with vegetation work were also recorded.

5.3 Results and Discussion

a) Spring Migration: Very few swans, geese, or cranes were observed. Their main migration route appears to be further east on a line between Mills Lake and the east side of Wrigley (Poston *et al.* 1973; pers. comm. - residents). Table 7 summarizes total numbers of each species observed on aerial surveys during spring migration. Lesser scaup was the most abundant species with a total of 3,817 for all seven surveys. Coots were second in abundance with 2,699 birds counted. Other species with relatively high numbers were Mallard (1,462), "white-headed" gulls (Mew and California gulls - 1,113), Bufflehead (662), Surf scoter (517), American widgeon (475), and Blue-winged teal (450). Seven hundred and seventy-one birds were described as "unidentified ducks" because of poor visibility or lack of time for observation of distinguishing characteristics.

Table 7. Spring aerial survey results - totals for all sites, Liard Highway Region, NWT 1977.

Species	Date of Survey							
	May 5	May 10	May 14	May 18	May 23	May 27	June 3	Total
Common loon		1		1	2		9	13
Red-necked grebe			1	20			2	23
Horned grebe				69	2	20	15	106
Pied-billed grebe						2		2
Unid. grebes			4			1		5
Whistling swan		1					3	4
Canada goose	24		4				1	29
Snow goose		16						16
Mallard	257	650	294	129	34	45	53	1462
Pintail		2	1					3
American widgeon	88	115	83	60	76	34	19	475
Gadwall							15	15
Shoveler	4	160	48	17	18	7	2	256
Blue-winged teal	25	49	184	51	58	51	32	450
Green-winged teal		4	22	14	6	56	9	111
Unid. teals	26	4	14	44	8		11	107
Unid. dabblers		6			2			8
Redhead		5	8	4	4	2	2	25
Canvasback	1	190	16	20	2	1	18	248
Ring-neck duck						95	35	130
Greater scaup			64					64
Lesser scaup	9	478	1133	447	1042	496	212	3817
Common goldeneye			58	110	72	12	49	301
Barrows goldeneye			1				1	2
Bufflehead	4	14	20	172	164	177	111	662
Oldsquaw			1	1	14	1		17
White-winged scoter	2	4	17	32	60	30	90	235
Surf scoter		100	90	105	178	5	49	517
Unid. scoters				24	20	52	26	124
Common merganser		3		16	6	1		26
Red-breasted merganser			2		2	3	4	11
Coot		133	271	442	322	1115	416	2699
Unid. divers		71	76	54	24	105	57	387
Sandhill crane	9	1				3	9	22

Table 7. Continued.

Species	Date of Survey							
	May 5	May 10	May 14	May 18	May 23	May 27	June 3	Total
"white-headed" gulls	57	12	83	95	564	107	195	1113
Bonaparte's gull		2	19	4	26		36	87
Unid. "ducks"	266	131	41	122	85	201	125	771
Total	772	2132	2555	2053	2789	2622	1606	14341
Total dabblers	400	965	646	315	192	183	141	2887
Total divers	16	898	1767	1327	2498	2095	1070	9671

Figures 25, 26, 27 illustrate the fluctuations with time in numbers of the most abundant species of waterfowl and water-oriented birds. The major spring mallard migration through the region appears to have occurred early in the season, approximately May 10. The rapid drop in numbers after that survey may indicate a movement of mallards northward with relatively small numbers remaining to breed in the study area. Similar trends were observed for other dabblers, although their numbers were much lower (184 blue-winged teal compared to 650 mallard).

Lesser scaup numbers increased from 9 on May 5 to 1133 on May 14 and 1042 on May 23. By June 3 numbers had dropped to 212, presumably representing mostly resident birds.

Fig. 28 provides a comparison of diver and dabbler population phenology during the spring migration period. Diver numbers were much higher than dabblers. This may have been a reflection of the habitat types available as few areas provided protein-rich vegetation such as horsetails *(Equisetum fluviatile)* for dabbler food. Fig. 28 also indicates that dabbler populations

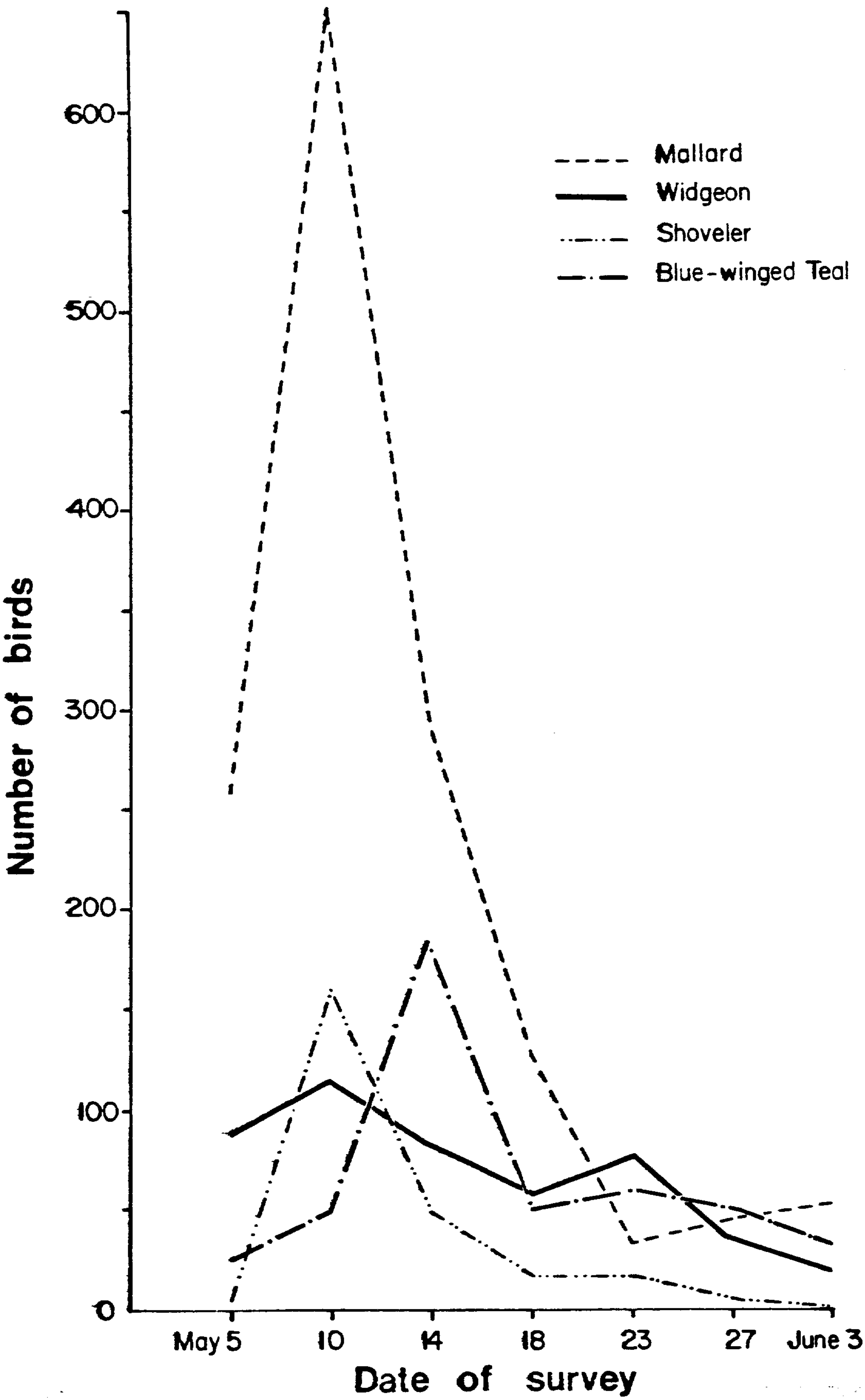


Fig. 25. Aerial Survey Totals - Spring Migration, Liard Highway region, NWT, 1977.

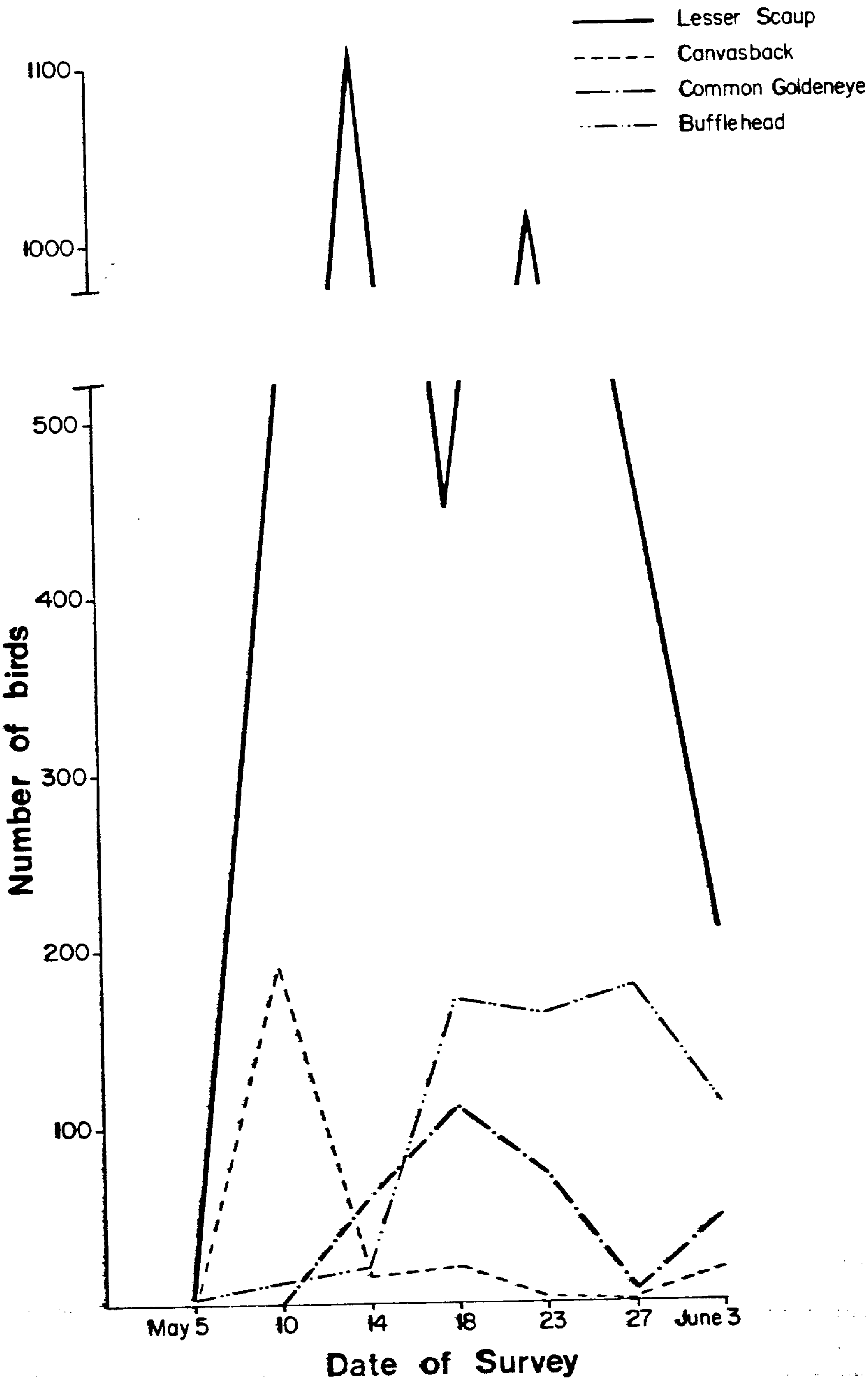


Fig. 26. Aerial Survey Totals - Spring Migration, Liard Highway region, NWT, 1977.

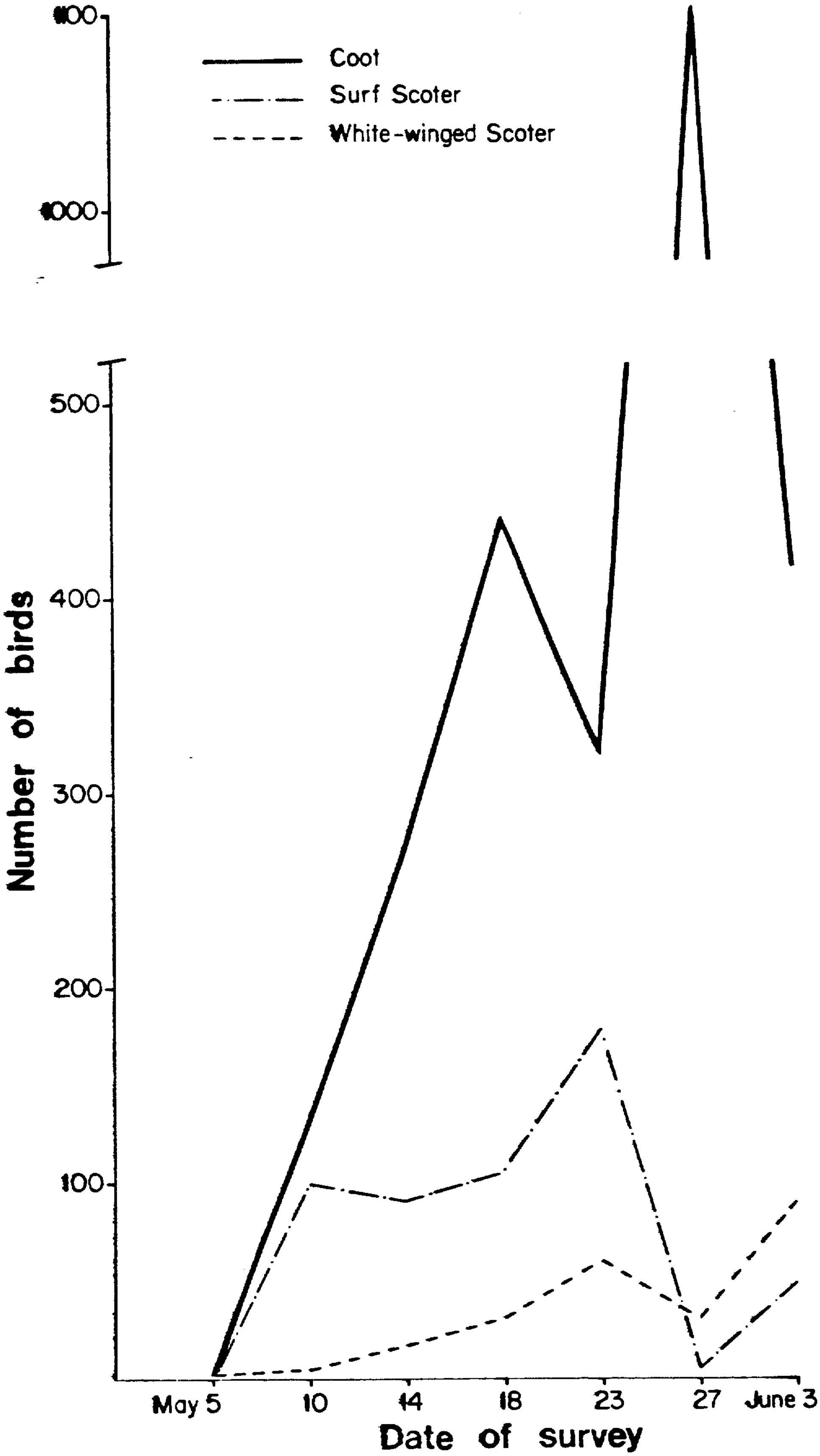


Fig. 27. Aerial Survey Totals - Spring Migration, Liard Highway region, NWT, 1977.

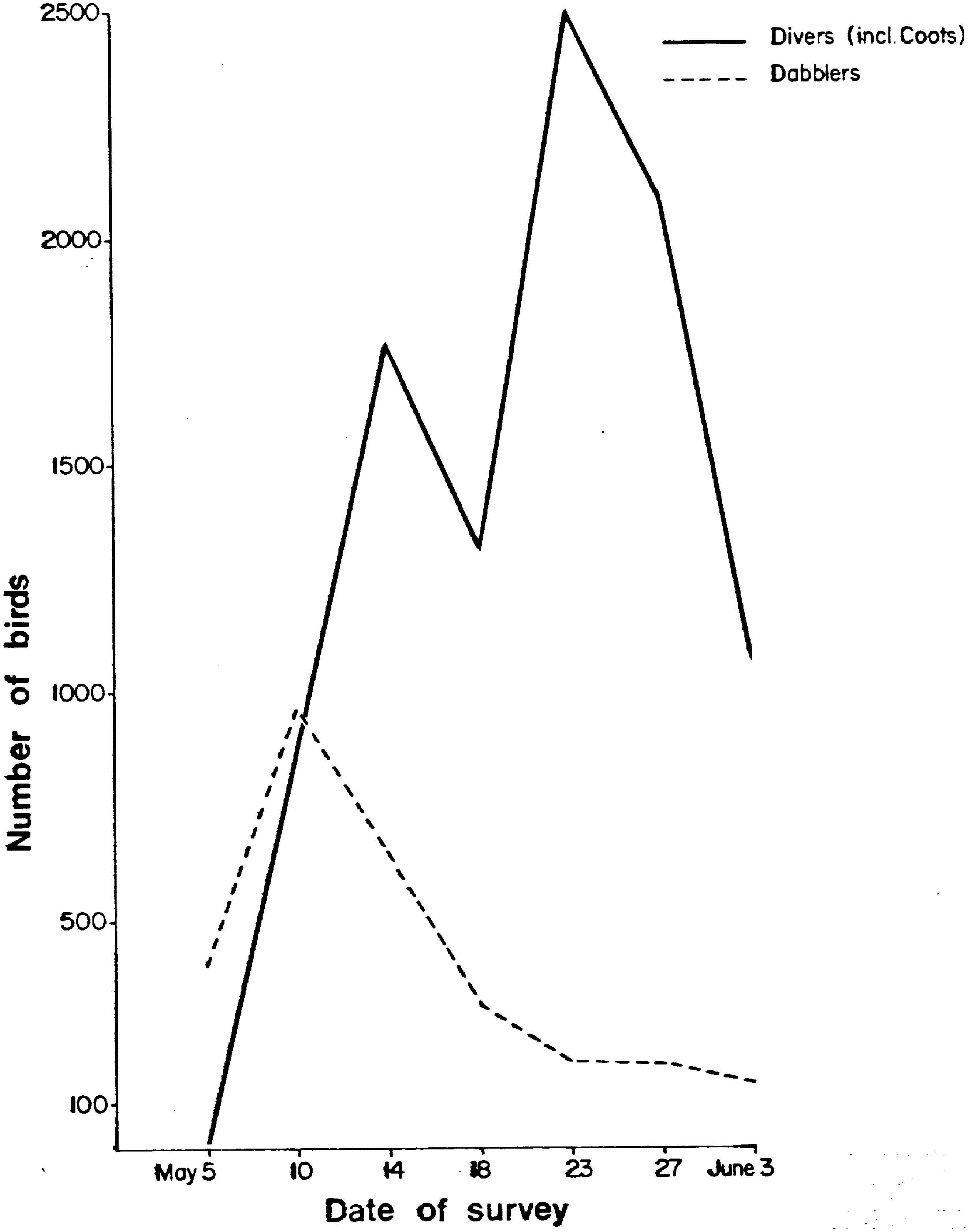


Fig. 28. Aerial Survey Totals - Spring Migration, Liard Highway region, NWT, 1977.

reached their highest numbers earlier than diver populations. Dabbling ducks utilized small potholes and virtually any open-water areas during spring migration, whereas the main flux of divers was restricted to waterways and larger ponds that were clear of ice. Dabbler populations peaked on May 10 whereas the diver numbers were highest on May 23. Both populations declined considerably by June 3 indicating that most migrating waterfowl had passed through by that date.

Density of waterfowl and water-oriented birds at three sites are shown in Table 8. The high numbers and densities of waterfowl in the Netla area May 5-May 14 was composed primarily of dabbler species. The small ponds were ice-free before large ponds such as Site 7 had opened. Whereas the highest density at the Netla site was reached on May 10, site #7 was still 8/10 frozen and had only 2 birds/sq km. Sites 22 and 23 were thawed by May 10 and already had a relatively dense population of ducks by that date.

b) Breeding Pairs and Broods

A breeding pair survey was flown June 3 which was imcomplete due to poor flying conditions. This survey was reflown June 7. Brood surveys were flown June 29 and July 13. Breeding pair and brood counts were also conducted on June 11, 24, 28, 29, July 11, 25, 26, 27, 28, and August 21, during invertebrate and vegetation surveys. The criteria used for determining breeding pairs is described in Dzubin (1969).

Breeding pair totals for each species are included in Table 9. Appendix C-2 includes in Tables the broods which were observed at each site and the density (number of broods per km shoreline). As no banding or marking program was undertaken, repeated sightings of broods of the same species on the same pond should not be distinguished as separate broods.

Table 8. Density of waterfowl - spring migration - Liard Highway Region, NWT, 1977.

Site	May 5	May 10	May 14	May 18	May 23	May 27	June 3
	# of birds/sq km (total # of birds counted)						
#7 area = 8.05 sq km.	0.8 (6)	2.0 (16)	18.8 (151)	39.0 (314)	54.2 (436)	77.5 (624)	46.0 (370)
Netla Region (#11, 14, 15) area = 2.49 sq km.	112.5 (280)	395.6 (985)	380.3 (947)	171.9 (428)	182.3 (454)	260.2 (648)	111.2 (277)
#22, 23 area = 0.81 sq km.		303.7 (246)	342.0 (277)	240.7 (195)	133.3 (108)	164.2 (133)	survey discontinued inclement weather

Table 9. Number of breeding pairs observed on study area, Liard Highway Region, NWT, June 3 and 7, 1977.

Species	Number of Breeding Pairs
Common Loon	1
Horned grebe	4
Mallard	9
Gadwal	1
Green-winged teal	2
Blue-winged teal	10
Unid. teal	5
Widgeon	4
Shoveler	1
Redhead	1
Red-necked duck	14
Canvasback	9
Lesser scaup	88
Common goldeneye	1
Bufflehead	44
White-winged scoter	31
Surf scoter	20
Unid. scoter	13
Red-breasted merganser	1
Sandhill crane	3
Total	262

Where such has occurred, the second observation was presumed to be a resighting unless some distinct feature could be used to verify it as a new sighting (Eg. a gross difference in hatching dates of young when backdated). For this reason, as well as for the limitations posed by observation methods, the number of broods documented must be regarded as a minimum number.

The ponds with the greatest brood density are #17 (4.0 broods/km). #16 (3.5 km), and #28 (3.3 km). On ponds 16 and 17, five of the seven broods were red-necked or horned grebes. The remaining two were lesser scaup. Other sites with relatively high brood densities were: #2 (2.5 broods/ km, #20 (2.5/ km, #10 (2.4/ km, #30 (2.4/ km), #33 (2.4/ km), #29 (2.2/ km), #24 (2.0/ km) and #25 (2.0 km). A total of 114 waterfowl and water-oriented bird broods were observed and recorded at 33 study sites.

Hatching dates were estimated for each species by backdating from assigned age classes (Gollop and Marshall 1954). By subtracting length of incubation period (from Johnsgard 1975) for each species from the hatch dates, the approximate date of start of incubation was determined. These dates are shown in Table 10.

Peak nesting periods for each species are illustrated in Table 11. For mallards, the April 23-May 9 period for start of incubation included 14 of the total 19 broods which were backdated. Initiation of nest building would have occurred as much as two weeks prior to start of incubation. The small number of Blue-winged teal broods sighted did not give a very accurate date for incubation and hatching. The last two weeks in May appeared to be the main nesting period for ring-necked ducks. May 21-June 5 had 13 of the

Table 10. Incubating and hatching dates of migratory birds observed on study area, Liard Highway Region, NWT 1977.

Species	Start Incubation	Hatching Date
Common loon		June 9-July 11 (one nest observed)
Red-necked grebe		June 29-July 13
Horned grebe		July 11-July 13 (one nest observed)
Mallard	April 7-17	May 5-15 (2 broods backdated)
	April 17-26	May 15-24 (1 brood)
	April 23-May 3	May 21-31 (3 broods)
	April 30-May 9	May 28-June 7 (11 broods)
	May 9-20	June 6-17 (2 broods)
Blue-winged teal	April 30-May 5	May 24-30 (1 brood backdated)
	May 19-26	June 13-21 (1 brood)
Ring-necked duck	May 17-22	June 13-18 (2 broods)
	May 31-June 5	June 27-July 2 (2 broods)
	July 1-July 10	July 28-August 6 (1 brood)
Lesser scaup	May 1-5	May 26-30 (1 brood)
	May 13-20	June 7-14 (1 brood)
	May 21-28	June 15-22 (6 broods)
	May 27-June 2	June 21-27 (1 brood)
	May 29-June 5	June 23-30 (6 broods)
	June 2-10	June 27-July 5 (2 broods)
	June 6-11	July 1-6 (5 broods)
	June 7-14	July 2-9 (1 brood)
	June 10-16	July 5-11 (1 brood)
	June 11-19	July 6-14 (6 broods)
	June 14-22	July 9-17 (6 broods)
	June 23-27	July 18-22 (3 broods)
	June 29-July 6	July 24-31 (1 brood)
	July 4-July 10	July 29-August 4 (1 brood)
Common goldeneye	May 17-23	June 16-22 (2 broods)
Bufflehead	May 7-21	June 6-20 (1 brood)
	May 17-21	June 16-20 (2 broods)
	May 21-28	June 20-27 (11 broods)
	May 21-June 4	June 20-July 3 (8 broods)
	May 30-June 6	June 29-July 5 (8 broods)
	June 6-12	July 6-12 (5 broods)
	June 11-19	July 11-19 (2 broods)
	June 14-22	July 14-22 (1 brood)
Bald eagle		June 15 (1 eaglet)
American coot		June 10-20 (1st observed young - 2 broods)

Table 11. 1977 data of full clutch* and hatch of migratory birds - Liard Highway Region, NWT.

April			May			June			July		
1	15	30	1	15	31	1	15	30	1	15	31
		MALLARD FULL CLUTCH			MALLARD HATCH						
					RING-NECKED DUCK FULL CLUTCH		RING-NECKED DUCK HATCH				
					LESSER SCAUP FULL CLUTCH				LESSER SCAUP HATCH		
					BUFFLEHEAD FULL CLUTCH			BUFFLEHEAD HATCH			

*start of incubation

Plate 10. Coot nest after flood waters had subsided (July 1977).
Site #25 (km 208, Liard Hwy., NWT).

total 41 recorded scaup start of incubation dates, while the period June 2-22 included 21 clutches. The common goldeneye dates of incubation and hatch were based on only two brood sightings. Bufflehead incubation dates show that 27 of the total 38 broods backdated to between May 21 and June 5. Coot hatch dates were established by direct observation on the coot nests. Many coot nests were flooded out during the first week in June (Plate 9).

c) Fall migration: Helicopter and fixed-wing surveys must be separated when analysing fall migration data. Fig. 29 illustrates that the three most numerous counts were on the three helicopter surveys. Fig. 31 shows that identification from the helicopter was generally more successful than from the plane.

The breakdown by species for each aerial census is shown in Table 12. Lesser scaup numbers exceeded other species on most surveys. Scaup numbers were highest on September 7 (Fig. 30), declined into the third week in September, and increased until October 11. The main scaup migration out of the area occurred during the first half of September. Decreases after October 11 corresponded to freeze-up.

Fig. 31 illustrates phenology of bufflehead populations. As buffleheads are easily seen and identified the bias between fixed-wing and helicopters surveys was less or non-existent. Fig. 32, which combines the plane and helicopter surveys, may give a better indication of the population trends. Fig. 32 illustrates the peaks which occurred largely because of high numbers of buffleheads on the large pond, site 7.

Mallard numbers were fairly constant until October 6 when they almost doubled in number (Fig. 33). October 6 mallards may have been migrants from more northerly areas. Whereas the study ponds were only partially frozen at that time, ponds near Wrigley were frozen.

Population trends for other species may be interpreted from Table 12. The population totals were highest at site #7 early in the surveys. A drop to less than 50% of the earlier numbers occurred by the end of September. By October 6 the numbers increased slightly, probably due to the influx of ducks from nearby frozen ponds. By October 20 only a few leads were left open in the ice which were densely crowded with diving ducks. The Netla Region showed a different trend with the numbers increasing to a peak on September 24. The increase represented high numbers of mallards, widgeon, teal and some scaup utilizing the good dablling duck habitat. By October 6 much of the Netla Region was frozen.

Density of waterfowl and water-oriented birds during fall migration as indicated in Table 13. The density has been calculated as the number of birds per square kilometer of water, as in the spring migration section ot the report. Only birds located on the 33 study sites were counted.

The study area was used almost exclusively by ducks, grebes, and loons. Small flocks of migrating Canada geese and a lone whistling swan were observed in the Netla region. A family of trumpeter swans was located at Yohin Lake, 15 miles west of the study area. One immature swan was observed ad pond #30 in an open lead on October 20. Two mature swans were observed at Bovie Lake on September 24.

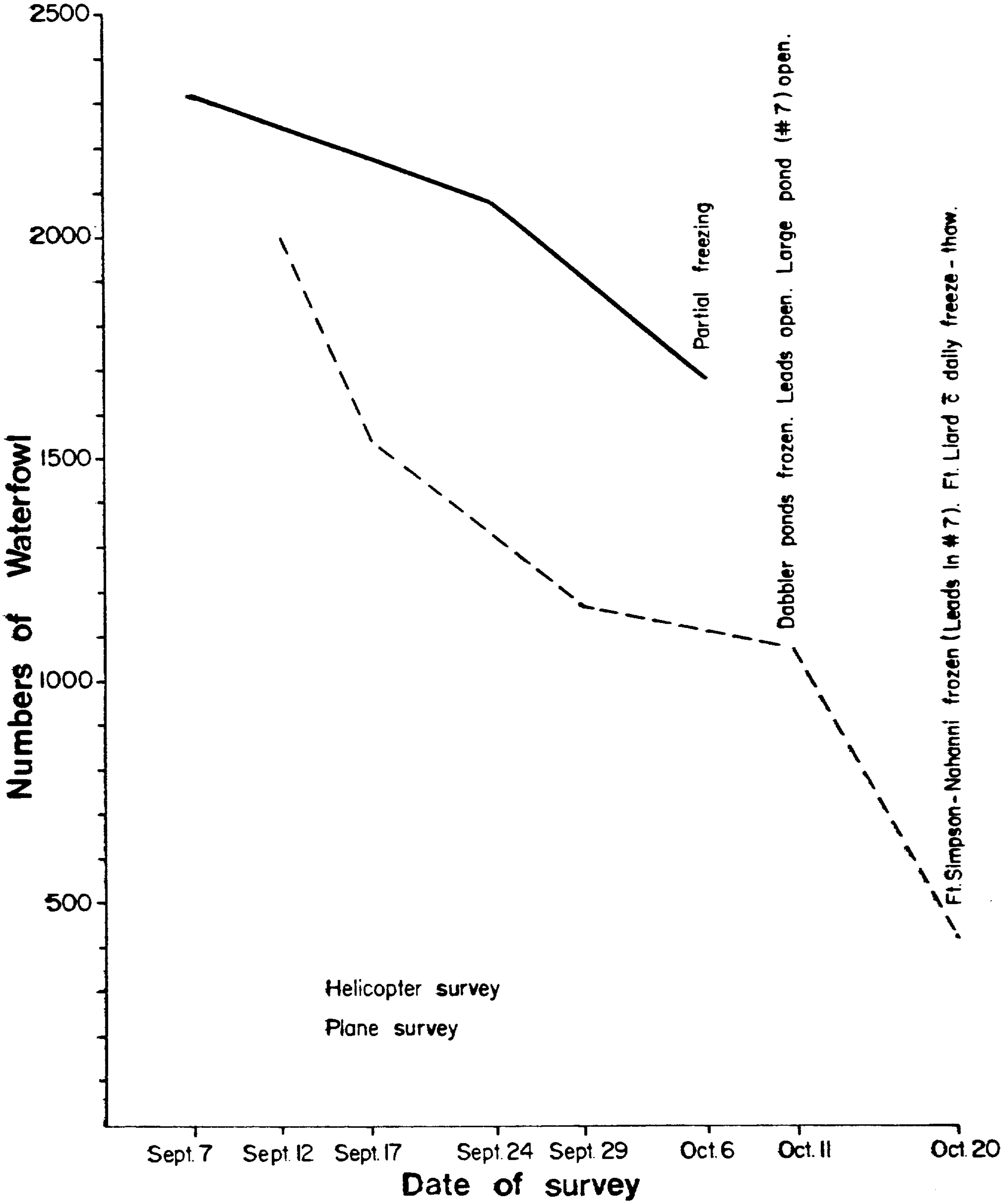


Fig. 29. Aerial Survey Totals - Fall Migration, Liard Highway region, NWT, 1977 - TOTAL SPECIES.

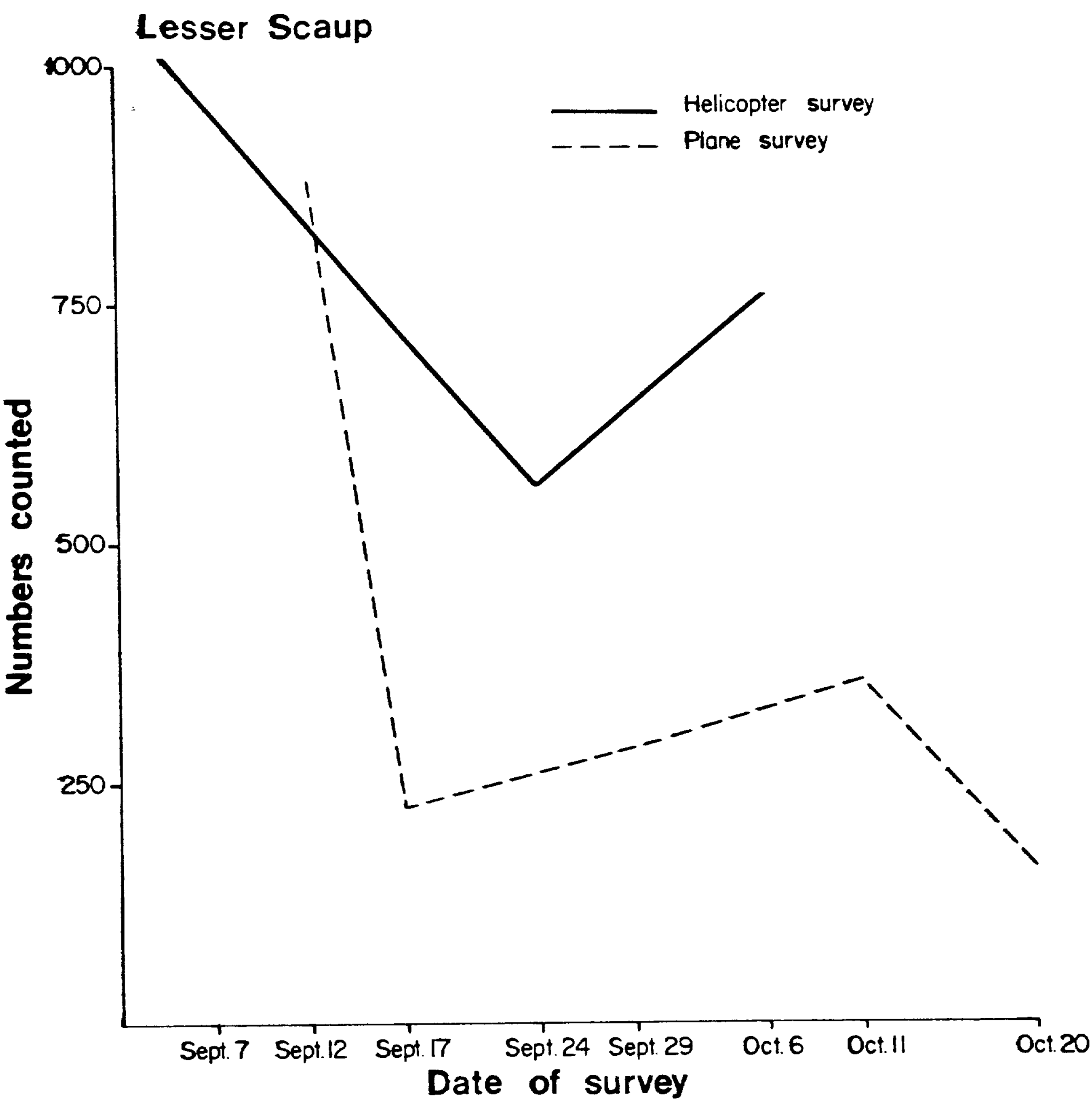
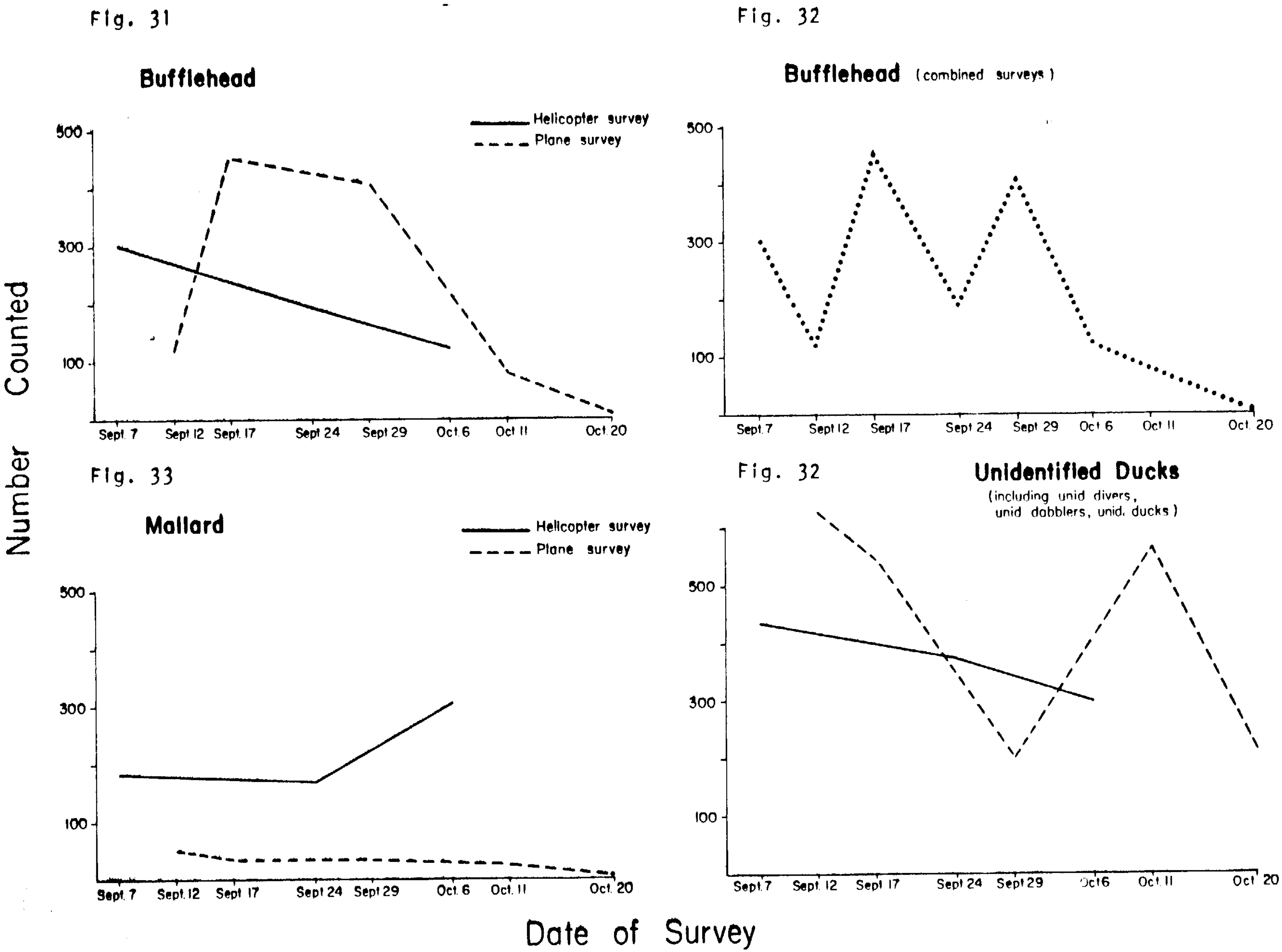


Fig. 30. Aerial Survey Totals - Fall Migration Liard Highway region, NWT, 1977.



Figs. 31-34. Aerial Survey Totals - Fall Migration, Liard Highway region, NWT, 1977.

Table 12. Fall migration survey totals - Liard Highway Region, NWT.

Species	Sept. 7	Sept. 12	Sept. 17	Sept. 24	Sept. 29	Oct. 6	Oct. 11	Oct. 20
Red-necked grebe	5	8		1	1			
Horned grebe	3	13	4			2		
Unid grebe			1	2		1		2
Unid. swan		1	1	1				1
Canada goose				10	11*			
Unid. goose			57					
Mallard	182	49	32	167	31	301	23	5
Gadwal	12	21		30				
Green-winged teal	16		3	3		3		
Blue-winged teal	34	1		11				
Unid. teal	15	30	123	118	72	18	19	
American widgeon	62	12		148				
Shoveler					7			
Unid. dabbler	2	1		70	31		7	
Ring-necked duck	40	103	1	30	5	40		
Canvasback				5				
Scaup spp.	1007	885	226	559	287	761	353	163
Goldeneye spp.	25	2	9	68	36	29	4	
Bufflehead	304	118	450	193	406	124	78	8
Oldsquaw		1						
White-winged scoter				22		47		
Surf scoter				8				
Unid. scoter		4		58	45	27	2	9
Unid. diver	393	142	508	273	123	237	498	177
Coot	172	92	69	124	67	28	2	2
Unid. ducks	38	494	36	30	43	61	79	38
Total ducks	2102	1751	1413	1943	1102	1648	1073	418
Total per survey	2282	1865	1545	2081	1173	1679	1075	423

*lesser Canada goose

Table 13. Density of waterfowl - fall migration - selected sites, Liard Highway Region, NWT 1977.

Site	Sept. 7	Sept. 12	Sept. 17	Sept. 24	Sept. 29	Oct. 6	Oct. 11	Oct. 20
	# of birds/sq km (total # of birds counted)							
#7 area = 8.05 sq km	144.1 (1,160)	146.2 (1,177)	83.1 (669)	78.6 (633)	51.4 (414)	81.0 (652)	84.1 (677)	32.9 (265)
Netla Region (#11, 14, 15) area = 2.49 sq km	64.7 (161)	70.3 (175)	97.6 (243)	153.0 (381)	76.7 (191)	43.0 (107)	18.5 (46)	12.0 (30)
#22, 23 area = 0.81 sq km	249.4 (202)	61.7 (50)	44.4 (36)	85.2 (69)	77.8 (63)	124.7 (101)	23.5 (19)	39.5 (32)
#28, 29, 30 area = 0.85 sq km	87.1 (74)	89.4 (76)	83.5 (71)	151.8 (129)	49.4 (42)	343.5 (292)	198.8 (169)	75.3 (64)

6. INCIDENTAL FAUNAL OBSERVATIONS - Richard Quinlan[1]

As well as the vegetation, invertebrates and waterfowl which have been documented so far in this report, various mammals are an integral part of the wetland ecosystem. The most influential of these are beaver, which had active lodges at sites #7, 8, 15, 20, 21, 32, and 33. Two sites (8, 32), have been greatly enlarged by beaver dam construction. Muskrats were observed on most sites. On May 7 at site #1 approximately 60 muskrat push-ups were counted on the ice as well as 40 more at site #2 (Plate 10).

Black bear were frequently observed along the alignment and at several study sites, especially those in the Netla region. Moose sightings were also frequent and are included in Appendix E, along with Dall sheep sightings.

Trapping returns from Ft. Simpson and Ft. Liard (Appendix D) show large numbers of beaver and muskrat, especially in the Ft. Liard region. The fewer numbers in other regions may simply be a reflection of lower numbers of trappers active in the Nahanni Butte, Trout Lake, and Jean Marie areas (Synergy 1975).

A species list of avifauna at wetland sites is included in Appendix C.1. No organized transects were carried out for passerine birds during this study. The list is comprised of birds observed during observation of waterfowl, and vegetation work at sites.

Plant-macroinvertebrate-waterfowl associations are described well in Kemper, Thompson, Quinlan (1977) for an area less than 100 km north of the Liard Highway region. That report cites several references on the subject of waterfowl utilization of vegetation and invertebrates. The extensive nature of the Liard Highway study did not allow such accurate

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[1]Canadian Wildlife Service - Edmonton

Plate 11. Muskrat push-ups, May 4, 1977, Site 1, Liard Highway, NWT.

Plate 12. Black bear feeding on horsetail, Site 11, Netla River Area, NWT.

determinations of feeding preferences of waterfowl. Observations made, however, agree with information presented in the Mackenzie Highway report (Kemper *et al.* 1977). These observations are summarized in 4.3, Invertebrate Discussion. Correlations between aquatic plants and invertebrate abundance and diversity are illustrated in the high invertebrate totals and Shannon-Weaver Diversity values for "shallow" pond types (Table 6).

The most interesting area for general variability of wildlife is the Netla River locality. The large alluvial floodplain near the confluence of the Netla River with the Liard River provides a habitat suitable for large numbers of dabbling ducks as well as food and browse for black bear and moose (Plates 3, 4, 11). On one aerial survey in July, 3 lone black bears were sighted within 2 km of each other in the horsetails and sedges of the alluvial floodplains. Moose sightings in the Netla region were as follows: May 29(1), June 24(1), July 11(2), Oct. 6(1 bull, 1 calf).

Large numbers of waterfowl use the Netla region during spring migration (Table 8). For dabbling ducks it provides an important feeding and breeding area, the most extensive and productive in the Liard Highway area.

7. RAPTOR SURVEYS - James Hanley Steele[1]

7.1 Introduction

Surveys for raptors were conducted by Bryan Kemper, James Steele, and Richard Quinlan during the period July 5 through July 8, 1977 in the Liard and Nahanni Ranges, NWT. The objective of the study was:

1. To determine numbers of raptors utilizing those mountain ranges more or less adjacent to the proposed Liard Highway alignment.

2. To assess potential for utilization of these areas by raptors, and

3. To determine presence or absence of breeding pairs whose progeny may eventually populate or repopulate sites adjacent to the highway.

7.2 Methods and Materials

Areas were surveyed in order of priority; those closest to the alignment or indicative of high nesting potential for raptors were surveyed initially, while the more remote or poorer ones were surveyed later. Areas surveyed are shown in Fig. 35 and 36 and covered an area of approximately 1,025 sq km (400 sq mi).

A Bell 206B helicopter on contract from Okanogan Helicopters was used, piloted by Mr. Bruce Reilly who is experienced at raptor surveys. The left front seat and rear seats were occupied by the observers. The observer sitting in front watched for birds being flushed from the cliff face, while the rear observer marked progress and sightings on a 1:250,000 scale topographical map. Both observers watched for indications of utilization such as wash, stick nests, etc. Cliffs in the area were rated

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[1]Canadian Wildlife Service - Edmonton

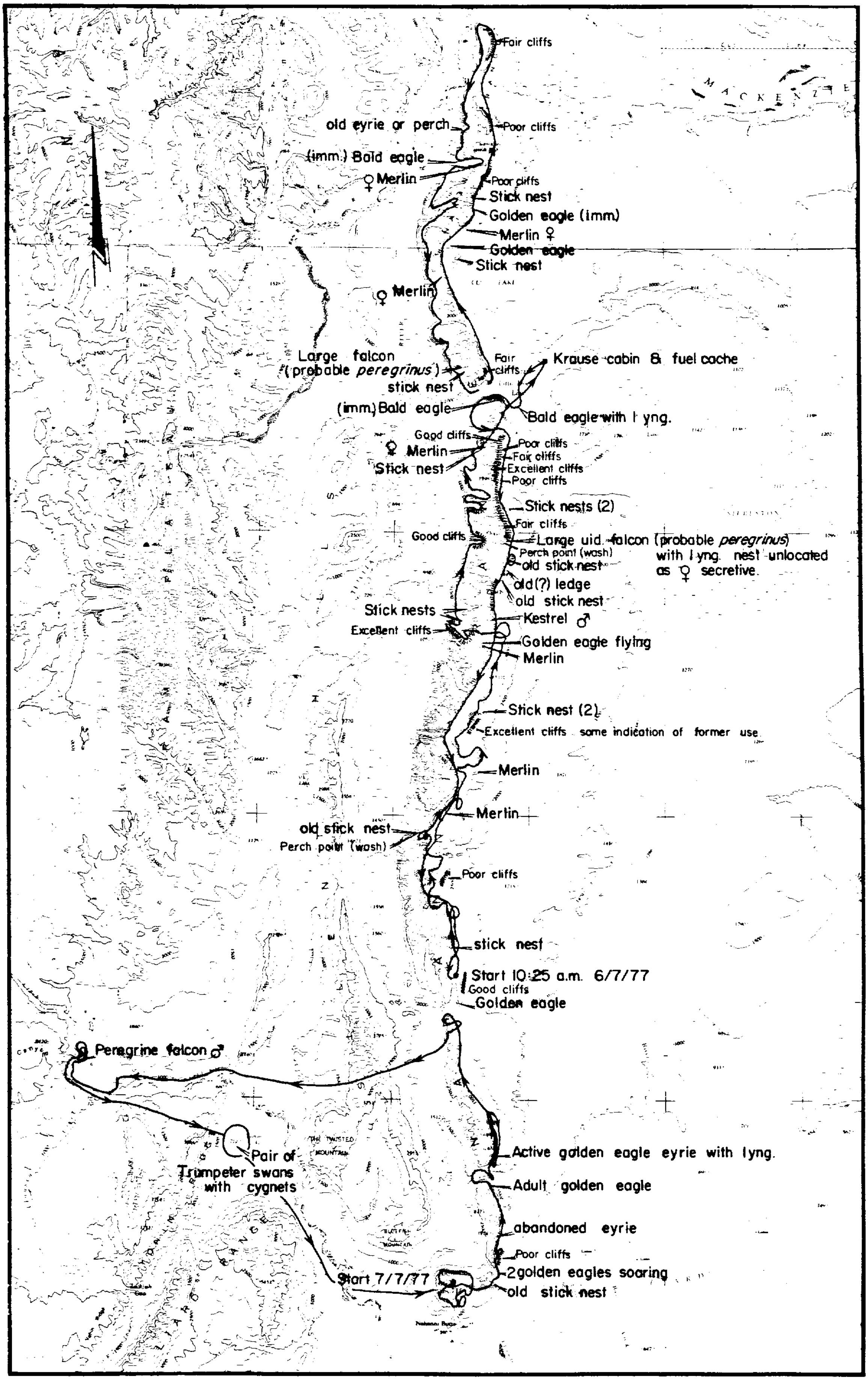

Fig. 35. Raptor survey route. Nahanni Range, NWT, 1977.

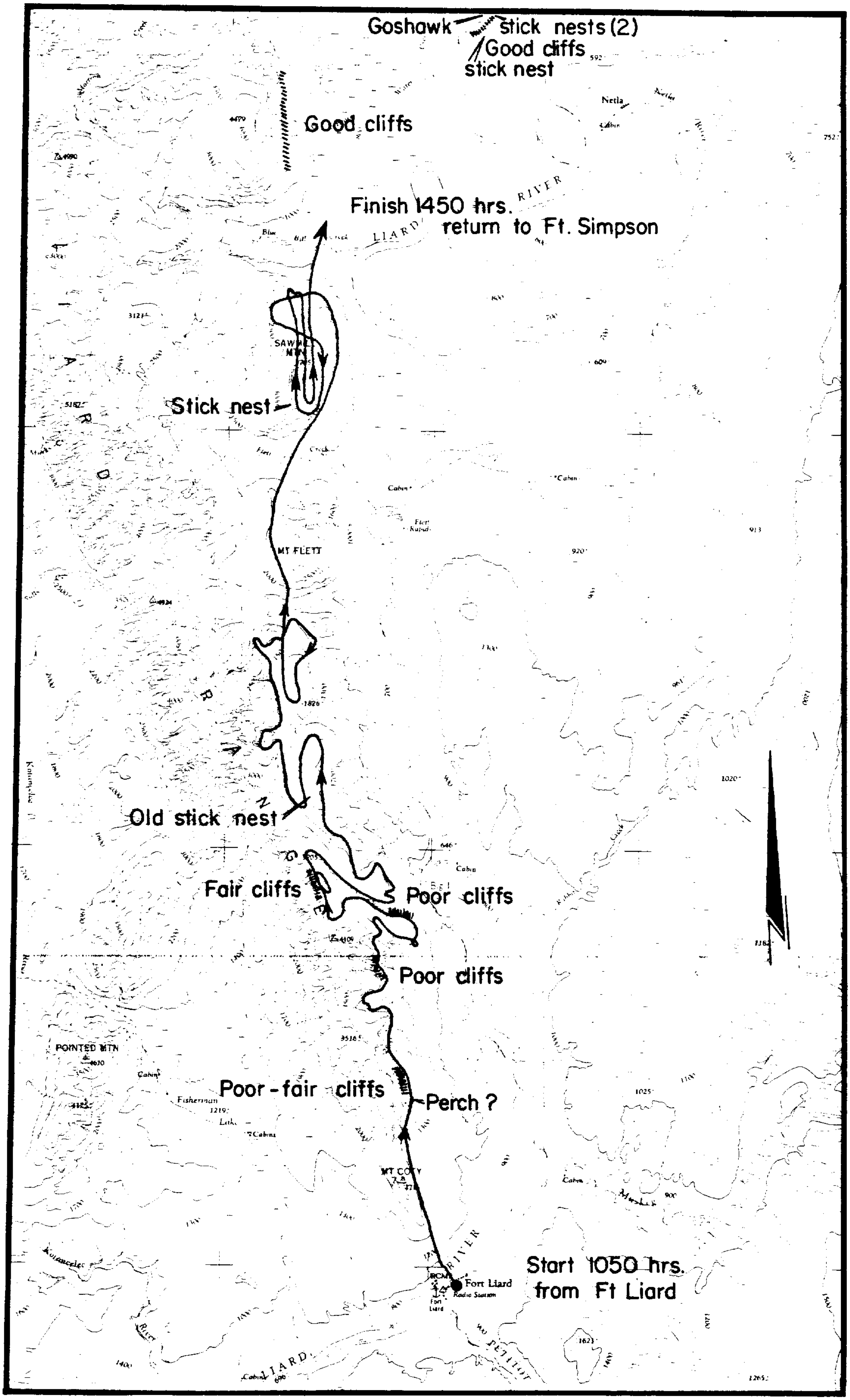

Fig. 36. Raptor survey route, Liard Range, NWT, 1977.

for nesting potential by their rock stability and availability of ledges. The cliffs were categorized as poor, fair, good, very good, and excellent. Areas of fractured unstable rock or poor nest ledge availability were given a low rating.

The survey was conducted at an average speed of 65 kph at a distance of approximately 9 metres from the cliff face. Several passes were made by the larger cliffs in order to survey the upper and lower portions of the face. When a site showed indications of recent activity (wash, etc.) an additional pass was made to determine activity, if any, at that particular location.

7.3 Results

For the most part, those mountains comprising the north end of the Liard Range yielded little in the way of suitable nesting habitat for raptors. This area lies to the west of Fort Liard and extends north to the Nahanni Butte region, and could almost be described as a foothills region as most of the peaks are below tree line (750-915 m ASL). Areas of extensive cliff formations were absent and those cliffs present were found to be very low, or formed a series of shallow steppes to the summit ranges. In most cases the rock strata showed evidence of extreme folding and other natural stresses causing the rock to become extremely friable and unstable.

There were, however, several exceptions in this area. Sawmill Mountain (95BCD6439)*, Little Nahanni Butte (95BDC7562) and an unnamed mountain (95BDC6155) afforded suitable habitat in terms of rock stability and availability at ledges. There was little evidence of former utilization by raptors as only a few old stick nests were noted in these areas.

*Denotes grid reference for Mercantor Projection

The Nahanni Range, which extends from Nahanni Butte in the south to the Cli Lake-Camsell Bend area in the north, appeared much more suitable. The cliffs in this area project well above treeline with vertical faces in excess of 150 m.

The rock in this region is more stable and appeared less prone to slides and other sudden forms of erosion. It was in this area that most of the observations were made. A significant number of stick nests were noted indicating possible utilization by golden eagles *(Aquila chrysaetos)* and possibly rough legged hawks *(Buteo lagopus)*. The possibility of utilization by ravens *(Corvus corax)* cannot, however, be ruled out. The following raptors were observed in this area:

Peregrine falcon	2	
Golden eagle	8	(1 with 1 young at eyrie)
Bald eagle	2	(immature)
Merlin	6	
Kestrel	1	

The two sightings of peregrine falcons occurred at widely separated locations. The first occurred roughly half-way along the Nahanni Range (95GDD84.5 x 45.3) on July 5. The falcon flew to a ledge with one young on it, but could not be relocated.

The second sighting was in the afternoon of the same day in the area between Little Doctor Lake and Cli Lakes (95GDD7962). The falcon was flying north. Owing to the brownish color and relatively large size, it was assumed to be an immature female.

Mr. Gus Krause reported a traditional bald eagle eyrie at the south end of Little Doctor Lake. Mr. Krause stated that he had seen an adult and one immature bald eagle in the vicinity in 1977.

In addition to those areas adjacent to the proposed highway alignment, a brief survey was made of First Canyon, South Nahanni River, which lies inside the east boundary of Nahanni National Park. This area was surveyed to verify earlier observations and attempt to locate a peregrine falcon eyrie. On the morning of July 7, a peregrine falcon was observed while we conducted a survey of the cliffs above the confluence of Lafferty Creek and the South Nahanni River (95FDC42.4 x 94.3). The falcon flew to the west side of the Lafferty Creek gorge and perched in a tree but could not be relocated upon subsequent examination. Coverage of that area failed to determine eyrie location and inadequate fuel supply allowed only a cursory investigation of adjacent massive cliffs.

A total of 50 Dall sheep *(Ovis dalli)* were recorded at various locations along the flight route. One large group of 24 sheep was spotted near the south end of the Nahanni Range. Almost all sightings of Dall sheep occurred in this range.

7.4 Discussion

The size of the area surveyed and the variability of the terrain made intensive coverage difficult. The continuous east facing cliffs received better coverage than the west facing areas which are greatly dissected by lateral cliffs, making access difficult.

There is ample evidence of past utilization of these areas as indicated by the number of stick nests and wash at various locations. A critical factor in determining potential for utilization of these areas by raptors is availability of prey, and the lack of this information for this area is hereby noted. The most common passerine species noted were cliff swallows and slate-colored juncos. Rock pikas and Columbian ground squirrels were observed at several locations, and hoary marmots apparently occur in these areas.

In the event of future surveys of this nature, the areas of the Ram Plateau and the tributaries of the South Nahanni River may be worth consideration as there are large numbers of what appear to be suitable cliffs in these more remote areas. If time and financial support are accorded to similar surveys in the future, it may prove valuable to conduct a ground-oriented survey using binoculars and spotting scopes to scan habitat of high potential to raptors.

8. VASCULAR PLANTS AND LICHENS; LIARD AND NAHANNI RANGES - Richard Quinlan[1]

8.1 Methods and Materials

An alpine vegetation survey was conducted July 5, 6, and 7, 1977 by R. Quinlan, assisted by Peter Ferris (D.I.A.N.D.). Study sites were located in the Nahanni and Liard Ranges, NWT. More detailed locations of each site are given in the following section of the report.

Vegetated areas were sampled using a 1/10 m^2 frame along a transect. Estimates of percent coverage of each species were obtained at intervals along the transect. Transects were chosen in a manner so as to include the dominant vegetation types in a given area.

Transportation between sites was achieved using a Bell 206B helicopter. While the vegetation crew was busy a raptor survey of nearby cliffs was flown. In this way several sites a day were completed while the helicopter was being efficiently used.

8.2 Site Locations and Descriptions

<u>Site 1</u> Location: Mercator Grid - 95GDD8229
(61°36'N; 123°20'W)
Nahanni Range, NWT.

Description: Alpine tundra. The study area consisted of three sections, one of which was a level col, one with a north aspect, and one with a south-east aspect. Elevation was approximately 1525 m (5000 ft).

<u>Site 2</u> Location: Mercator Grid - 95GDD8139
(61°41'N; 123°21'W)
Nahanni Range, NWT.

Description: Sub-alpine - alpine. A slight (10°) north aspect was present. Shrub and herb strata were well developed. Elevation was approximately 760 m (2500 ft).

[1]Canadian Wildlife Service - Edmonton

Site 3 Location: Mercator Grid - 95GDD8362
(61°54'n; 123°20'W)
N of Little Doctor Lake
Nahanni Range, NWT

Description: Alpine tundra. An east aspect with a slope of 45° occurred in the study area. Vegetation was clustered into rich mesic depressions with very little vegetation between clusters. Elevation was approximately 900 m (3000 ft).

Site 4 Location: Mercator Grid - 95JDD7875
(62°00'N; 123°26'W)
N of Cli Lake
Nahanni Range, NWT

Description: Alpine tundra. A mesic-hydric hollow was sampled. A slight slope (5°) facing west was present. Vegetation in the hollow was fairly lush. Elevation was approximately 900 m (3000 ft).

Site 5 Location: Mercator Grid - 95GDD7808
(61°25'N; 123°25'W)
Nahanni Range, NWT

Description: Subalpine-alpine. Well developed shrub and herb strata were present. A south-east aspect was present with slope increasing downslope from 0° to 15°. Elevation was approximately 3500 ft.

Site 6 Location: Mercator Grid - 95GDC7972
(61°05'N; 123°23'W)
Nahanni Butte
Nahanni Range, NWT

Description: Alpine tundra. The study area consisted of two sections, one on a xeric alpine meadow, the other in a mesic hollow within the meadow. Both locations had a slight slope with a south aspect. Elevation was approximately 1070 m (4500 ft).

Site 7 Location: Mercator Grid - 95GDC8378
(61°08'N; 123°18'W)
Nahanni Range, NWT

Description: Alpine tundra. The study area consisted of two sections, one of which was a west facing scree slope with a slope of 30°; the other being a meadow with 20° slope and north-east aspect. Elevation was approximately 1220 m (4000 ft).

Site 8 Location: Mercator Grid - 95GDC5485
(61°12'N; 123°50'W)
Yohin Ridge, NWT

Description: Alpine tundra. Slope varied from 0-5° as the transect ran from an area of west aspect over the apex to an area of east aspect. A very dominant lichen flora was present. Elevation was approximately 1160 m (3800 ft).

Site 9 Location: Mercator Grid - 95BDC6156
(60°56'N; 123°44'W)
Liard Range, NWT

Description: Alpine tundra. Two major areas were sampled, the first being a transect across the apex of the mountain and down into a mesic hollow on the east facing side; the second was a hollow of over 1 m in relief near the apex. Both locations proved very rich in species diversity and coverage. Elevation was approximately 1340 m (4400 ft).

8.3 Annotated Species List

For most species a brief description as to status and habitat have been included.

Vascular Plants

Cystopteris fragilis (L.) Bernh. subsp. *Dickieana* (Sim.) Hyl. (bladder fern)

A locally common species, especially in fairly moist areas such as steep north facing slopes, and at the bottom of scree slopes. Found in abundance at Site 3.

Lycopodium sitchense Rupr. (club moss)

This plant was found in only one location, in a wet hollow atop "Bluebill Mountain" (Site 9).

Lycopodium selage L. (club moss)

Found in one location at site 9.

Abies lasiocarpa (Hook.) Nutt. (alpine fir)

Found in one location (Site 9) on the east facing slope. The trees were approximately 1 m tall and had a gnarled appearance.

Picea glauca (Moench) Voss (white spruce)

A locally common tree at the high elevations studied. It was found on the peak of site #4 and the northeast facing slope at site 8, as well as the sub-alpine site 2.

Picea mariana (Mill.) BSP (black spruce)

An uncommon tree in the alpine tundra, this species was observed only at the subalpine location site 2 on a north facing slope.

Pinus contorta Loudon var. *latifolia* Engelm. (lodgepole pine)

Stunted specimens of lodgepole pine were observed infrequently in the alpine habitat. They were fairly common in the subalpine regions (Site 5).

Elymus innovatus Beal (hairy wild rye)

This species was collected in the pine grove of site 5.

Oryzopsis pungens (Torr.) Hitche (rice grass)

A trace species in the lichen dominated alpine tundra at site 8.

Carex atrosquama Mack (sedge)

Found in only one location (Site 1) on the col and also the north facing slope.

Carex scirpoidea Michx. (sedge)

Found at site 6 and site 7. At site 6 it occurred on both a dry location atop the butte and a wet hollow nearby. At site 7 it occurred on a west facing scree slope in a fairly mesic trench.

Eriophorum scheuchzeri Hoppe (cotton grass)

Found in alpine tundra in wet-mesic areas. This species was observed at site #4 and site #9 in damp hollows.

Tofieldia coccinea Richards (false asphodel)

Found at sites 6, 8, 9. At site 6 it was growing in a wet hollow. At site 8 and 9 it was on a relatively dry and exposed ridge.

Tofieldia pusilla (Michx.) Pers. (false asphodel)

Found at sites 1, 2, 6. At site 1 it occurred on both the flat and the south-east aspect. At site 6 the plant was located in a wet hollow.

Zygadenus elegans Pursh (white camas)

This species was found in relatively mesic locations in the alpine. It occurred as an understory plant in the lodgepole pine community of site 5. Also, this plant was observed on the NE facing slope of site 7.

Salix alaxensis (Anderss.) Coville (willow)

Found in one location at site 4, this species was distributed in chesters which were widely spaced in a mesic-hydric basin.

Salix reticulata L. (willow)

This very low growing woody herb was found on the north facing slope of site 1.

Alnus crispa (Ait.) Pursh. (green alder)

Found as a shrub in the lodgepole pine community of site 5.

Betula glandulosa Michx. (dwarf birch)

A fairly common shrub species in damp habitats. Found in such areas as sites 2, 7, 8 and 9. Small hollows of only a few centimetres relief provide suitable requirements for *B. glandulosa* in some cases.

Polygonum viviparum L. (knotweed)

Observed as a trace species at site 4, which was a mesic-hydric hollow with clustered *Salix alaxensis*.

Arenaria rossii R. Br. (sandwort)

A trace species found fruiting at site 6 and 7.

Silene acaulis L. var. *exscapa* (All.) DC. (moss campion)

Locally common, this plant was found at site 1 on all aspects of slope. It also occurred in mesic-hydric hollows at sites 4, 6 and 7. The plants grow in tightly packed clusters.

Aconitum delphinifolium D.C. (monkshood)

Found as a trace species at site 5.

Thalictrum alpinum L. (alpine meadow rue)

A trace species in mesic habitats, this plant was found at site 6 in a mesic-hydric hollow, and also at site 7 on the NE facing slope.

Saxifraga oppositifolia L. (purple saxifrage)

A locally common species, found at site 6 atop Nahanni Butte in an exposed area.

Saxifraga tricuspidata Rottb. (3-toothed saxifrage)

Although usually not a dominant species, these plants are present in most of the alpine regions studied.

Dryas integrifolia M. Vahl. (white dryad)

Usually one of the most dominant vascular species in terms of coverage. The plants are widespread throughout a variety of habitats within the alpine zone.

Potentilla fruticosa L. (shrubby cinquefoil)

This shrub was found scattered throughout mesic-hydric areas of the alpine zone. It was found at sites 1, 4, 6 and 7, all of which were located in mesic hollows or north aspect slopes.

Rubus pubescens Raf. (dewberry)

A trace species found in the lodgepole pine community of site 5.

Astragalus umbellatus Bunge (milk vetch)

Found in mesic habitats in the alpine zone, this plant was collected at site 1 and site 6 in hollows and north-facing slopes.

Vicia americana Muhl. (wild vetch)

Found in mesic-xeric habitats, this plant was collected at site 5 and also site 7 at the base of a scree slope.

Empetrum nigrum L. (crowberry)

In alpine and sub-alpine locations, it was observed at sites 2, 8 and 9. It usually grows associated with mosses.

Epilobium angustifolium L. (fireweed)

Growing on disturbed soils, this species was not encountered much in the alpine survey. It was observed at site 7 on the scree slope.

Pyrola grandiflora Radius (arctic wintergreen)

This species was found growing on an organic accumulation at the base of a small cliff and scree slope at site 3.

Andromeda polifolia L. (bog rosemary)

Found growing in the mesic-hydric hollow at site 4.

Arctostaphylos rubra (Rehder and Wils.) Fern. (alpine bearberry)

Fairly widespread on the alpine meadows.

Cassiope tetragona (L.) D.Don ssp. *saximontana* (Small) Porsild. (white mountain heather)

A common, sometimes highly dominant species in mesic sites in the alpine and subalpine zones.

Kalmia polifolia Wong var. *microphylla* (Hooke) Rehd. (mountain laurel)

An uncommon species in the alpine area studied, this species was observed at site 1 on both north and south-east aspects, as well as sites 4 and 9.

Ledum groenlandicum Oeder (Labrador tea)

A common plant in mesic-hydric areas of the alpine.

Ledum palustre L. var. *decumbens* Ait. (northern Labrador tea)

Found in only one location in a wet hole at site 9, this species was associated with *Cladonia* spp.

Loiseleuria procumbens (L.) Desv. (alpine azalea)

Found as a trace species at site 9 where it occurred in a mesic-hydric region.

Phyllodoce empetriformis (Smith) D. Don (purple heather)

Found in a mesic-hydric site at site 9.

Rhododendron lapponicum (L.) Wohlenb. (Lapland rosebay)

Collected one month previous to the survey atop a peak in the Liard Range. This species occurs in mesic-xeric conditions.

Vaccinium uliginosum L. (bog bilberry)

A widespread species that grows throughout the alpine in mesic and hydric areas. This species is seldom dominant.

Vaccinium vitis-idaea L. var. *minus* Ladd (cowberry)

Common in subalpine and also mesic alpine sites, this species was observed at sites 2, 5, 8 and 9.

Androsace chamaejasme Host (sweet-flowered androsace)

A trace species in alpine meadows at sites 1, 6 and 7.

Gentiana glauca Pallas (gentian)

Found in a wet heath at site 9. Locally abundant in this heath.

Pedicularis labradorica Wirsing (lousewort).

A fairly common species of alpine meadows, found in most moisture regimes with a tendancy towards mesic. Found at sites 1, 5, 6, 8 and 9.

Pedicularis larata Cham and Schlecht (lousewort).

Found one month before survey in an alpine meadow in the Liard Range.

Pinguicula vulgaris L. (common butterwort)

Found on a moist organic substrate at the base of a small cliff and scree slope at site 3.

Viburnum edule (Michx.) Raf. (low-bush cranberry)

An understory species in the lodgepole pine community at site 5.

Linnaea borealis L. var. *americana* (Forbes) Rehd. (twinflower)

Observed only in subalpine areas at site 5, where this species is fairly scarce.

Achillea borealis Bong (yarrow)

Occurring as an understory species in the lodgepole pine community of site 5, where it is a trace species in clearings.

Arnica alpina (L.) Olin

Found in mesic areas in alpine and subalpine locations. This plant was found at site 5, and the damp hollow at site 6.

Erigeron humilis Groh (Lleabane)

Found at site 5 where the plant occurred as a trace species.

Solidago multiradiata Ait. (goldenrod)

A rarely occurring plant in the study area at time of study, found on organic substrate at site 3.

Lichens

Rhizocarpon geographicum

A fairly common crustose lichen on the rocks in the alpine region. These rocks are limestone.

Xantharia elegans

A common orange crustose lichen growing on rock.

Physcia sp.

Grows on soil.

Peltigera apthosa (L.) Willd.

Found in mesic alpine and subalpine habitats. Collections were made at site 2 and also from a wet hollow at site 9.

Peltigera canina (L.) Willd.

Fairly common on alpine meadows (mesic).

Asahinea cohrysantha

Umbilicaria decussatus (Vill.) Zahlbr.

Found at one location atop Nahanni Butte (Site 6) as an occasional species in the alpine meadow.

Umbilicaria papulose (Ach.) Nyl.

Also on Nahanni Butte (Site 6).

Cetraria cucullata (Bell) Ach.

A dominant lichen species at all alpine sites. This species is commonly found with *C. islandica*, *C. tilesii*, and other fruticose lichens.

Cetraria islandica (L.) Ach.

Commonly found in alpine meadows.

Cetraria nivalis (L.) Ach.

Less common than *C. cucullata.* When present it is usually associated with *C. cucullata.*

Cetraria tilesii Ach.

A subordinate species on the alpine tundra, *C. tilesii* is usually found with *C. cucullata.*

Thamnolia subuliformis (Ehrh.) Culb.

An occasional species on alpine meadows. Fairly widespread but not abundant. Associated with *Cetraria* spp.

Dactylina arctica (Hook) Nyl.

An occasional species on alpine meadows. More abundant than *Thamnolia subaliformis.* Occasionally a clump of *D. arctica* thalli is found.

Baomyces carneus Flle.

Occurring on soil on the scree slope at site 7.

Cornicularia divergens Ach.

Associated with *Cetraria* spp., *Thamnolia subuliformis* and *Alectoria ochroleucha* in alpine meadows.

Alectoria ochreoleuca (Hoffm.) Mass

A commonly occurring lichen growing with *Cetraria* spp. in xeric area.

Alectoria sarmentosa (Ach.) Ach.

Found in small quantities at site 7 in lodgepole pine.

Stereocaulon sp.

Locally abundant in mesic alpine areas with *Cladonia* spp. and several mosses. Especially abundant at site 9.

Cladonia alpestris (L.) Rabenh.

Found in mesic-xeric areas of the alpine meadows. Collected from site 9.

Cladonia cristatella Tuck.

A possible specimen was collected from site 9.

Cladonia cyanipes (Somm.) Nyl.

Found with *C. rangiferina* at site 9.

Cladonia gracilis (L.) Willd.

Found at site 9 with *C. rangiferina*.

Cladonia mitis Sandst.

Found at site 9.

Cladonia pleurota (Flk.) Schaer.

Found at site 9.

Cladonia rangiferina (L.) Wigg.

A widespread lichen in the alpine tundra. Found with several *Cladonia* spp. and *Cetraria* spp. in xeric-mesic areas.

Cladonia squamosa (Scop.) Hoffm.

Found at site 9 with other *Cladonia* species in a mesic hollow.

Cladonia uncialis (L.) Wigg.

Fairly common in alpine areas, particularly at site 9.

8.4 Discussion

Division of the data collected into plant communities has not been undertaken. In the alpine area this is difficult and the species are probably better grouped by habitat types. Jeffrey (1961, 1964 *in* Addison 1974) presented the following data concerning vegetation types in the Mackenzie Mountains in the following manner:

1. Alpine tundra
2. Timberline forest
3. Lodgepole pine, west slope, forest
4. Alpine fir forest
5. Mixed coniferous forest, high elevation
6. Mixed coniferous forest, low elevation
7. Lodgepole pine-lichen woodland.
8. Dry, rocky slope forest

Most of the species listed here fall into the alpine tundra category, which can be generally described as a xeric habitat supporting populations of dominant species: *Dryas integerifolia, Cetraria cucullata* and *Cladonia* spp. The mesic to hydric sites are characterized by presence of *Arctostaphylos rubra,* ericaceous shrubs, and *Carex* spp.

9. MOSSES OF NAHANNI AND LIARD RANGES-Dale H. Vitt[1], Diana G. Horton[1], and Bryan Kemper[2]

9.1 Introduction

The Nahanni and Liard Mountain Ranges form the eastern-most ranges (front range) of the Rocky Mountains between 60°20'N and 62°00'N latitude. The area studied is located at about 123°50'W longitude and extends eastward to 119°50'W. The mountains of the Nahanni Range rise to 1550 meters elevation and in the Liard Range to 1502 meters. Directly west of the Nahanni Range, a broad, high, plateau rising to 1390 meters was sampled. This area is known as the Ram Plateau and like the Nahanni Plateau farther westward, is dissected by numerous, deep ravines. To the east of the Nahanni and Liard Ranges, the topography is composed of rolling hills, with numerous calcareous fens and small marshy lakes. The South Nahanni River flows between the Liard Range to the south and the Nahanni Range to the north and joins the Liard River flowing eastward at Nahanni Butte. At Fort Simpson, the Liard and Mackenzie Rivers meet and flow northward to the Arctic Ocean.

The bedrock of the area is sedimentary in origin and almost entirely calcareous in nature. Dolomites, shales, and limestones are prevalent; however, isolated outcrops of non-calcareous sandstones are rarely present. The wetlands are predominately rich to poor fens with truly ombrotropic conditions not found in the study area. In places, more eutrophic conditions prevail and marshy situations are not uncommon.

The lowland vegetation is typically boreal in character, with a mosiac of *Populus tremuloides* and *Picea glauca* on the drier sites and *Picea mariana* and *Larix laricina* predominating on the wetter sites.

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Populus balsamifera is found along streams and on alluvial soils. Forested mires or what are commonly called muskegs are frequent in the lowland areas, east of the two ranges and *Picea mariana* is the dominant tree in these habitats.

The subalpine zone is not extensive and is dominated by a variety of shrubs. *Salix, Betula* and dwarfed *Abies lasiocarpa* and *Picea* species are components of this zone.

The alpine zone is a complex mosaic of low shrub and herb communities reflecting differences in snow depth, snow melt time, and summer soil moisture. In general, the tundra is characterized by *Dryas* spp., *Betula glandulosa*, such ericaceous shrubs as *Vaccinium uliginosa* and *Salix* spp., *Carex* spp., and various grasses. Numerous rock outcrops are present and around these there are usually various moist microhabitats. In the Nahanni and Liard Ranges the tundra is usually quite dry, whereas on the Ram Plateau moist tundra habitats are common.

Steere *et al.* (1977) have summarized the vegetation and previous collections of both vascular plants and bryophytes in the southwestern Mackenzie District. As far as byrophytes are concerned, only Jeffery (1961) has reported collections from near our study are. He reported 41 taxa of bryophytes from the Liard River Area, just east of the Liard Range. Scotter and Cody (1964) recorded 483 taxa of vascular plants from the South Nahanni and Flat River drainages. Working in Nahanni National Park, just to the west of our area, Steere *et al.* (1977) and Steere and Scotter (1978) reported 269 species of mosses and 83 species of hepatics. Their collections and two papers document very well the rich and phytogeographically interesting bryophyte flora of Nahanni National Park. Our collections, taken from the area farther eastward in the front range considerably extends the ranges of many of the rare taxa and records 40 new species and two varieties of mosses from the general south Nahanni area. The presence of non-calcareous sandstone in the Liard Range forms an appropriate substrate for several rare and interesting taxa, not recorded farther westward by Steere *et al.* (1977) and Steere and Scotter (1978).

We feel that the South Nahanni area, along with the Ogilvie Mountains in central Yukon, the Brooks Range in northern Alaska, the Summit Lake-Mt. Roosevelt Area in northern British Columbia, and the Mountain Park-Grande Cache Region in Alberta are some of the most interesting areas in North America for phytogeographic and floristic research and will continue to yield disjunct and exciting species of organisms for a long time to come.

This report is based on 1089 collections of bryophtes (mostly mosses) made on August 1, 2 and 3, 1977, by D.G. Horton and D.H. Vitt. Fifteen localities were visited, with ten of these in alpine habitats and five in lowland, forested communities along the eastern slope of the Liard and Nahanni Ranges.

9.2 List of Localities

1. 44.6 km S of the Liard River Crossing of the Mackenzie Hwy. and 2.0 km W on the Liard Hwy., 61°20'N, 121°25'W, 410 m elevation. In rich fen dominated by *Larix laricina, Picea mariana, Sarracenia purpurescens,* and *Tomenthypnum nitens.*
   10257-10302; 20118-20151
2. Whittaker Falls on Trout River, ca. 29 km S of Mackenzie River, 61°09'N, 119°50'W, 420 m elevation. On limestone rock and in associated *Picea glauca-Populus tremuloides* forest in vicinity of waterfall.
   10303-10382; 20152-20220

3. Nahanni Range: 62°13'N, 123°22'W, 750 m elevation. Steep slopes with limestone rock outcrops in stunted *Picea-Abies* krummholz.
10383-10469

4. Nahanni Range: N slope of Nahanni Mtn., 62°21'N, 123°22'W, ca. 750 m elevation. In mesic, north-facing, alpine tundra slopes with dry limestone rocl bluffs exposed above.
20221-20282

5. Nahanni Range: Just N of peak at 3598 ft. (1097 m), 780 m elevation. On dry, north-facing alpine tundra with limestone outcrops.
20283-20306

6. Nahanni Range: 61°36'N, 123°22'W, ca. 780 ca. elevation. Moist apline tundra with surrounding wet, north-facing limestone outcrops.
20307-20382

7. Nahanni Range: 61°24'N, 123°25'W. On slopes and ridge-top with limestone outcrops in seepy alpine tundra; solifluction lobes and frost boils present in ridge-top.
10470-10525

8. Ram Plateau: 61°43'N, 123°53'W. On steep sided ridge with exposed limestone outcrops and small, scattered individuals of *Picea* in lush *Cetraria-Cladonia* dominated tundra.
20383-20409

9. Ram Plateau: ENE of 4553 ft. peak (1389 m), 61°44'N, 123°53'W. In moist tundra on top of broad plateau with wet limestone rock cropping out at edge of plateau.
10538-10614; 20410-20450

10. Nahanni Range: Hot Springs at 61°15'N, 124°03'W, 460 m elevation. On soil around hot sulphur spring.
20451-20453

11. Lowland East of Liard Range: 19 km NNE of Ft. Liard, 60°23'N, 123°20'W, 305 m elevation. Poorly minerotrophic fen at edge of small lake dominated by *Carex rostrata*, *C. aquatilis*, *Sphagnum teres*, and *S. obtusum*.

    10616-10632; 20454-20473

12. Lowland East of Liard Range: 32 km SE of Ft. Liard and 6.4 km N of Petitot River, 60°05'N, 123°00'W, 425 m elevation. Strongly minero trophic (rich) fen surrounding small lake, with *Picea mariana* and *Sphagnum* species abundant.

    10633-10644; 20474-20490

13. Liard Range: Seventh peak S of 4924 ft. mtn. (1502 m), 12.8 km SW of Mt. Flett, 60°34'N, 123°45'W. In mesic, shrub tundra with associated late snow melt areas and soil slumps.

    10645-10695; 10703-10710; 20491-20531

14. Liard Range: SE ridge of mtn. at 4990 ft. elev. (1522 m), NW of Sawmill Mtn., 60°54'N, 123°57'W, ca. 1300 m elevation. North-facing non-calcareous sandstone bluffs with numerous seeps and protected crevices and overhangs, exposed below *Dryas* dominated, alpine tundra.

    10696-10702; 10711-10803; 20532-20601

15. Liard Range: East-facing slope and summit of ridge on mtn. at 4479 ft. elev. (1366 m). N of Sawmill Mtn., 60°56'N, 123°43'W, 1250 m elevation. In exposed tundra dominated by *Alectoria ochroleuca* and associated, exposed quartzitic rocks.

    10804-10841; 20602-20623

9.3 Floristics

The following checklist includes 180 species and two varieties of Bryopsida (Musci), collected from the Liard and Nahanni Ranges. Nomenclature, authorities, and synonymy in most cases are based on Crum *et al.* (1973). Voucher specimens are deposited in the University of Alberta Herbarium (ALTA). Duplicate sets of collections made by D.G. Horton are housed in her private herbarium. Substantial duplicate sets of specimens have been sent to CANM, UBC, NFLD, and NY. Numbers in the following list between 10000 and 11000 are those of D.G. Horton; those between 20000 and 21000 are from collections of D.H. Vitt.

Amblystegium serpens (Hedw.) B.S.G. 20203 (with Drepanocladus uncinatus).

Amphidium lapponicum (Hedw.) Schimp. 20594.

Amphidium mougeotii (B.S.G.) Schimp. 20574.

Andreaea rupestris Hedw. 20550, 20590, 20611, 20616.

Andreaeobryum macrosporum Steere & B. Murray 20442, 20448, 20445.

* *Arctoa fulvella* (Dicks.) B.S.G. 20612.

Aulacomnium acuminatum (Lindb. & Arn.) Kindb. 20190, 20414.

Aulacomnium palustre (Hedw.) Schwaegr. 20129, 20178, 20423, 20450, 20483, 20513.

Aulacomnium turgidum (Wahlenb.) Schwaegr. 20410, 20490, 20491, 20533.

Barbula acuta (Brid.) Brid. 20251.

Barbula andreaeoides Kindb. 20274, 20344, 20444.

Barbula icmadophila C. Müll. 20294.

* *Barbula nigrescens* Mitt. 20447.

Bartramia ithyphylla Brid. 20555.

Brachythecium groenlandicum (C. Jens.) Schljak. 20342, 20429.

Brachythecium salebrosum (Web. & Mohr) B.S.G. 20502.

Brachythecium turgidum (C.J. Hartm.) Kindb. 20312, 20313, 30434, 30463, 30506.

Bryobrittonia longipes (Mitt.) Horton 20518.

Bryoerythrophyllum recurvirostre (Hedw.) Chen 20165, 20201, 20281.

Bryum argenteum Hedw. 20389.

* *Bryum neodamense* Itzigs. *in* C. Müll. 20219.

Bryum pseudotriquetrum (Hedw.) G.M.S. 20118 (with *Drepanocladus revolvens*), 20121, 20122, 20208, 20282, 20326, 20497.

Calliergon cordifolium (Hedw.) Kindb. 20455.

Calliergon giganteum (Schimp.) Kindb. 20131, 20471.

Calliergon sarmentosum (Wahlenb.) Kindb. 20564.

Calliergon stramineum (Brid.) Kindb. 20466, 20472.

Calliergon trifarium (Web. & Mohr) kindb. 20138.

Campylium chrysophyllum (Brid.) J. Lange 20213.

Campylium halleri (Hedw.) Lindb. 20254, 20256, 20262, 20304.

Campylium polygamum (B.S.G.) C. Jens 20482.

Campylium stellatum (Hedw.) C. Jens. 20123, 20167, 20248, 20338, 20340.

Catoscopium nigritum (Hedw.) Brid. 20127, 20268.

Ceratodon purpureus (Hedw.) Brid. 20200, 20407, 20598.

Cinclidium arcticum (B.S.G.) Schimp. 20271, 20310, 20375, 20431.

Cinclidium stygium Sw. 20126, 20132.

Cirriphyllum cirrosum (Schultes) Grout 20250, 20298, 20361.

* *Cnestrum alpestre* (Wahlenb.) Nyh. 20395, 20516, 20527.

* *Cnestrum glaucescens* (lindb. & Arn.) Holm. 20185.

Cratoneuron filicinum (Hedw.) Spruce 20279, 20280, 20358, 20364, 20371.

Cynodontium strumiferum (Hedw.) Lindb. 20592.

* *Cynodontium tenellum* (B.S.G.) Limpr. 20582, 20583.

Cyrtomnium hymenophylloides (Hueb.) Kop. 20286, 20335.

Cyrtomnium hymenphyllum (B.S.G.) Holm. 20241, 20339, 20354, 20362, 20522.

* *Desmatodon latifolius* (Hedw.) Brid. 20427.

* *Desmatodon laureri* (Schultes) B.S.G. 20352.

* *Desmatodon leucostoma* (R.Br.) Berggr. 20366.

Dichodontium pellucidum (Hedw.) Schimp 20499.

* *Dicranella varia* (Hedw.) Schimp 20452.

Dicranoweisia crispula (Hedw.) Milde 20613.

Dicranum angustum Lindb. 20430.

Dicranum elongatum Schleich. *ex* Schwaegr. 20192, 20563, 20399.

Dicranum fuscescens Turn. 20125.

Dicranum groenlandicum Brid. 20411, 20538.

Dicranum majus Sm. 20573, 20576, 20311, 20263, 20302, 20573, 20596.

Dicranum polysetum Sw. 20383.

* *Dicranum spadiceum* Zett. 20424.

Dicranum undulatum Brid. 20145, 20160, 20195.

Didymodon asperifolius (Mitt.) Crum *et al.* 20320.

Distichium capillaceum (Hedw.) B.S.G. 20158, 20170, 20217, 20238, 20356, 20439, 20507, 20524, 20618.

Distichium inclinatum (Hedw.) B.S.G. 20218, 20365, 20421, 20520.

Ditrichum flexicaule (Schwaegr.) Hampe 20162, 20229, 20250, 20288, 20317, 20337, 20345, 20374, 20435, 20559.

* *Drepanocladus badius* (C.J. Hartm.) Roth 20543.

Drepanocladus exannulatus (B.S.G.) Warnst. 20461, 20470, 20535, 20541.

* *Drepanocladus fluitans* (Hedw.) Warnst. 20457.

Drepanocladus revolvens (Sw.) Warnst. 20118, 20136, 20148, 20309, 20363, 20437, 20510.

Drepanocladus uncinatus (Hedw.) Warnst. 20203, 20334, 20351, 20496, 20577, 20604.

Encalypta alpina Sm. 20242, 20257, 20292, 20341, 20348, 20515.

* *Encalypta brevicolla* (B.S.G.) Aongstr. 20584, 20587, 20597.

* *Encalypta ciliata* Hedw. 20396, 20586.

Encalypta longicolla Bruch 20224, 20252, 20269, 20306, 20318, 20398, 20529.

* *Encalypta mutica* Hag. 20379, 20391, 20393.

Encalypta procera Bruch 20179, 20392.

Encalypta rhaptocarpa Schwaegr. 20171 (with *Myurella julacea*), 20350, 20373, 20401.

- *Entodon concinnus* (De Not.) Par. 20449.

Eurhynchium pulchellum (Hedw.) Jenn. 20198.

* *Fissidens arcticus* Bryhn 20174.

* *Fissidens bryoides* Hedw. 20495.

Funaria hygrometrica Hedw. 20200 (with *Ceratodon purpureus*), 20451.

* *Geheebia gigantea* (Funck) Boul. 20418, 20420, 20432.

Grimmia affinis Hornsch. 20211, 20579.

Grimmia (Schistidium) alpicola Hedw. 20153, 20239, 20504.

Grimmia (Schistidium) apocarpa Hedw. 20209, 20236, 20290, 20355, 20384, 20390.

* *Grimmia torquata* Grev. 20557.

Gymnostomum (Hymenostylium) recurvirostre Hedw. 20166.

Helodium blandowii (Web. & Mohr) Warnst. 20119.

Hygrohypnum luridum (Hedw.) Jenn. 20152, 20216, 20357.

* *Hylocomium pyreniacum* (Spruce) Lindb. 20299, 20300.

Hylocomium splendens (Hedw.) B.S.G. 20146, 20159, 20258, 20316, 20542, 20620.

Hypnum bambergeri Schimp. 20157, 20177, 20227, 20237, 20267, 20331, 20346, 20382, 20413, 20446, 20525.

Hypnum cupressiforme Hedw. 20193.

Hypnum hamulosum B.S.G. 20191, 20526.

Hypnum lindbergii Mitt. 20139, 20206, 20223.

Hypnum pratense Brid. 20484.

Hypnum procerrimum Mol. 20226, 20232, 20233, 20333, 20405, 20519, 20531.

Hypnum recurvatum (lindb. & Arn.) Kindb. 20296, 20305.

Hypnum revolutum (Mitt.) Lindb. 20246, 20609.

* *Hypnum vaucheri* Lesq. 20169, 20402, 20408.

\- *Isopterygiopsis muelleriana* (Schimp.) Iwats. 20575.

Isopterygium pulchellum (Hedw.) Jaeg. & Sauerb. 20189, 20369, 20606.

* *Lescuraea radicosa* (Mitt.) Moenk. 20503.

Meesia triquetra (Richt.) Aongstr. 20120.

Meesia uliginosa Hedw. 20128, 20259, 20260, 20314, 20329, 20487, 20511, 20524A.

Mnium blyttii B.S.G. 20330.

* *Mnium lycopodioides* Schwaegr. 20205.

Mnium thomsonii Schimp. 20322.

Molendoa sendtneriana (B.S.G.) Limpr. 20440.

Myurella julacea (Schwaegr.) B.S.G. 20171, 20176, 20264, 20372, 20388, 20508.

Myurella sibirica (C. Müll.) Reim 20182.

Myurella tenerrima (Brid.) Lindb. 20323.

Oncophorus virens (Hedw.) Brid. 20426.

Oncophorus wahlenbergii Brid. 20150, 20186, 20272.

Orthothecium chryseum (Schultes) B.S.G. 20240, 20255, 20295, 20327, 20336, 20443, 20509.

Orthothecium intricatum (C.J. Hartm.) B.S.G. 20228, 20291.

Orthothecium strictum Lor. 20287, 20367.

Orthotrichum anomalum Hedw. 20397, 20409.

* *Orthotrichum laevigatum* fo. *macounii* (Aust.) Lawt. & Vitt 20199.

Orthotrichum obtusifolium Brid. 20202.

Orthotrichum speciosum Nees *ex* Sturm 20210, 20253, 20277, 20343.

* *Paludella squarrosa* (Hedw.) Brid. 20130.

* *Philonotis fontana* (Hedw.) Brid. var. *pumila* (Turn.) Brid. 20353, 20360, 20438, 20512.

* *Plagiobryum demissum* (Hook.) Lindb. 20441.

* *Plagiobryum zierii* (Hedw.) Lindb. 20558.

Plagiomnium ellipticum (Brid.) Kop. 20140, 20459, 20486.

Plagiopus oederiana (Sw.) Limpr. 20184, 20406, 20523.

Plagiothecium cavifolium (Brid.) Iwats. 20556, 20567, 20569, 20570, 20578, 20585.

* *Plagiothecium denticulatum* (Hedw.) B.S.G. 20568.

Platydictya jungermannioides (Brid.) Crum 20368.

Pleurozium schreberi (Brid.) Mitt. 20147, 20204, 20303, 20619.

Pogonatum alpinum (Hedw.) Roehl. 20321, 20540, 20562.

* *Pogonatum urnigerum* (Hedw.) P.-B. 20554, 20615.

Pohlia cruda (Hedw.) Lindb. 20285, 20501, 20560, 20589.

* *Pohlia proligera* (Limpr.) Arn. 20588.

Pohlia wahlenbergii (Web. & Mohr.) Andr. 20275.

Polytrichum commune Hedw. 20603.

Polytrichum juniperinum Hedw. 20581.

Polytrichum piliferum Hedw. 20607.

* *Polytrichum sexangulare* Brid. 20552.

Polytrichum strictum Brid. 20149, 20220, 20477.

Pseudoleskeella nervosa (Brid.) Nyh. 20505.

Pseudoleskeella tectorum (Brid.) Broth.

* *Psilopilum cavifolium* (Wils.) Hag. 20580.

Ptilium crista-castrensis (Hedw.) De Not. 20196, 20551.

Pylaisiella polyantha (Hedw.) Grout 20194.

* *Rhabdoweisia crispata* (With.) Lindb. 20572.

Rhacomitrium fasciculare (Hedw.) Brid. 20549.

Rhacomitrium lanuginosum (Hedw.) Brid. 20385, 20534.

* *Rhizomnium gracile* Kop. 20484 (with *Hypnum pratense*), 20488.

Rhytidium rugosum (Hedw.) Kindb. 20181, 20283, 20322A, 20386, 20415, 20494, 20599, 20610.

Scorpidium scorpioides (Hedw.) Limpr. 20133, 20134.

Scorpidium turgescens (T. Jens.) Loeske 20168, 20416.

* *Seligeria calcarea* (Hedw.) Limpr. 20172, 20173, 20175, 20180.

* *Seligeria polaris* Berggr. (Ram Plateau - R. Quinlan).

Seligeria tristichoides Kindb. 20187, 20245, 20371, 20376, 20380.

Sphagnum angustifolium (Russ.) C. Jens. 20476, 20479, 20481.

Sphagnum fuscum (Schimp.) Klinggr. 20141, 20188, 20474, 20595.

Sphagnum girgensohnii Russ. 20537, 20546, 20548, 20553.

Sphagnum magellanicum Brid. 20489.

Sphagnum nemoreum Scop. 20478.

* *Sphagnum obtusum* Warnst. 20460, 20462, 20465, 20468, 20469, 20473.

Sphagnum rubellum Wils. 20539, 20593.

Sphagnum squarrosum Crome 20454.

Sphagnum teres (Schimp.) C. Hartm. 20456, 20458, 20467.

Sphagnum warnstorfii Russ. 20135, 20464, 20480.

* *Stegonia latifolia* (Schultes) Broth. 20378, var. *pilifera* (Brid.) Broth. 20387, 20493.

Tetraplodon mnioides (Hedw.) B.S.G. 20605, var. *cavifolius* Schimp. 20492, 20601.

Thuidium abietinum (Hedw.) B.S.G. 20161, 20230, 20234, 20284, 20332, 20403.

Thuidium recognitum (Hedw.) Lindb. 20212.

Timmia austriaca Hedw. 20566.

Timmia bavarica Hessl. 20183.

* *Timmia comata* Lindb. & Arn. 20164.

Timmia norvegica Zett. 20315, 20359.

Tomenthypnum nitens (Hedw.) 20119 (with *Helodium blandowii*), 20124, 20156, 20265, 20266, 20307, 20308, 20436, 20485.

Tortella fragilis (Drumm.) Limpr. 20171 (with *Myurella julacea*), 20214, 20289, 20325, 20347, 20532.

Tortella tortuosa (Hedw.) Limpr. 20221, 20222, 20247, 20270, 20297, 20600.

Tortula mucronifolia Schwaegr. 20377.

Tortula norvegica (Web.) Lindb. 20425, 20498, 20500, 20514.

Tortula ruralis (Hedw.) G.M.S. 20207, 20328.

Trematodon brevicollis Hornsch. Ram Plateau - D.G. Horton.

Trichostomum arcticum Kaal. (=*T. cuspidatissimum* Card. & Ther.) 20419.

Weissia controversa Hedw. 20530.

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*Species new to the South Nahanni Area.

9.4 Predominant Moss Habitats

Bryophytes are abundant in most habitats in the Nahanni-Liard Mountain Ranges and form an important part of the ecosystem. At the lower elevations in forested communities, mosses often form a continous ground cover as well as commonly occupying such specialized microhabtats as rotten logs, tree trunks and bases, rock faces, and exposed, disturbed soil. The most common species in the drier upland forests of *Pinus* spp., *Picea glauca* and *Populus tremuloides* are *Dicranum fuscescens*, *D. polysetum*, *Drepanocladus uncinatus*, *Eurhynchium pulchellum*, *Hylocomium splendens*, *Pleurozium schreberi*, *Polytirchum strictum*, *Ptilium crista-castrensis*, and *Pylaisiella polyantha*. Almost all of these species are circum-boreal and widespread in distribution.

In the wetland habitats at the lower elevations, fens and marshes are common. In the more stable areas, *Picea mariana* and *Larix laricina* form stunted forests and large areas of "muskeg" are present. In the drier of these, *Aulacomnium palustre*, *Dicranum undulatum*, *Sphagnum fuscum*, *S. warnstorfii*, and *Tomenthypnum nitens* are frequent. Around small lakes and ponds, mat formation is common and a spectrum of minerotrophic habitats are present, ranging from situations which are minerotrophically poor to those forming highly calcareous fens. In the poor to medium fens, such species as *Calliergon cordifolium*, *C. stramineum*, *Drepanocladus exannulatus*, *Plagiomnium ellipticum*, *Sphagnum obtusum*, and *S. teres* are found. In the richer, more calcareous situations a rich moss flora is present, consisting of such species as *Bryum pseudotriquetrum*, *Campylium stellatum*, *Catoscopium nigritum*, *Cinclidium stygium*, *Drepanocladus revolens*, *Meesia triquetra*, *Paludella squarrosa, Scorpidium scorpioides, Tomenthypnum nitens,* and occasionally the hepatic *Lophozia rutheana.*

Whittaker Falls is surrounded by an upland *Picea glauca-Populus tremuloides* forest. The bedrock is limestone and quite calcareous. Near the fall, in the outermost spray zone, large blocks of this limestone have cracked and formed deep crevices. These cracks and crevices form a series of microhabitats rich in bryophytes. Such species as *Bryoerythrophyllum recurvirostre, Distichium capillaceum, Ditrichum flexicaule, Encalypta procera, Grimmia apocarpa, Gymnostomum recurvirostre, Hypnum bambergeri, H. hamulosum, H. vaucheri, Myurella julacea,* and *Plagiopus oederiana* are present. As well, such rare or disjunct species as *Aulacomnium acuminatum, Cnestrum glausecens, Fissidens arcticus, Seligeria calcarea, S. tristichoides,* and *Timmia comata* are found in the immediate vicinity of the falls.

The higher elevations of the Liard and Nahanni Ranges are mostly calcareious in nature, and for the most part dry, lichen dominated alpine tundra. Mosses are common components of this habitat and species likely to be found in the open tundra as well as in protected microhabitats surrounding rock outcrops include *Distichium capillaceum, Ditrichum flexicaule, Hylocomium splendens, Hypnum bambergeri, H. procerrimum, Orthotrichum speciosum, Pogonatum alpinum, Thuidium abietinum, Tomenthypnum nitens, Tortella tortuosa,* and *Tortula ruralis.* In slightly more mesic situations, the hepatics *Arnellia fennica, Blepharostoma trichophyllum,* and *Radula prolifera* are not uncommon, as well the mosses *Campylium halleri, Encalypta longicolla,* and *Meesia uliginosa* are evident.

On north-facing slopes, calcareous seeps and moist overhangs are occasionally found and contain a large amount of microhabitats and a rich assemblage of bryophytes including *Cinclidium arcticum, Cirriphyllum cirrosum, Cratoneuron filicinum, Cyrtomnium hymenophyllum, Encalypta alpina, Hygrohypnum luridum, Hypnum bambergeri, Isopterygium pulchellum, Orthothecium chryseum, Philonotis fontana* var. *pumila,* and *Timmia norvegica.* On exposed soil in these situations such species as *Desmatodon laureri, D. leucostomus, Distichium inlcinatum, Encalypta mutica,* and *Tortula mucronifolia* occur. Characteristic species of late snow melt areas are *Hylocomium pyrenaicum Lescuraea radicosa,* and *Tortula norvegica.*

The Ram Plateau is a broad, flat, highland plain, deeply dissected by streams. The bedrock is calcareous and the plateau is covered by moist, calcareous tundra. Frostboils and solifluction lobes are frequent in occurrence. This area of moist tundra with exposed calcareous rocks near the tops of the deep ravines contains a rich bryophyte flora. Rare bryophytes such as *Andreaea rupestris, Arctoa fulvella, Calliergon sarmentosum, Cynodontium tenellum, Dicranum majus, Dicranoweisia crispula, Drepanocladus badius, D. exannulatus, Encalpyta brevicolla, E. ciliata, Grimmia torquata, Pogonatum urnigerum, Pohlia proligera, Polytrichum sexangulare, Rhabdoweisia crispata, Rhacomitrium fasciculare,* and *R. lanuginosum* plus the disjunct occurrence of the hepatic *Herbertus stramineus.*

Thus, in the Nahanni and Liard Ranges the three most important factors affecting moss distributions are 1) substrate type - that is soil, humus, logs, etc. but perhaps more important is the availability of calcareous or non-calcareous rock surfaces. The flora of areas influenced by calcareous rock types is markedly different from areas with siliceous tendencies. 2) The availability of water limits the occurrence of mosses, and microhabitats with the correct amount of moisture are of critical importance to bryophyte habitat preferences. 3) The presence or absence of vascular plants is the third important factor in controlling bryophyte distribution; however, mosses and hepatics are often not as sensitive to elevational zonation as vascular plants and thus very few mosses are restricted to alpine tundra, but often occur at lower elevations in open areas as well.

9.5 Pleistocene Glaciation and Phytogeographically Significant Species

Pleistocene glaciation has had a profound influence on th present day distribution of organisms. Many species were pushed southward and weathered the glaciation south of its maximum extent. However, unglaciated areas north of the Pleistocene glaciation also harboured organisms. Such an area is the unglaciated sections of Siberia, Alaska and Yukon Territory known as Beringia (Hulten, 1937). A few areas at the higher elevations farther south may have served as refugia for the heartier species of organisms and Packer and Vitt (1974) have suggested a plant refugium in the Canadian Rocky Mountains at Mountain Park, Alberta. Likewise, Vitt and Koponen (1973) suggested evidence derived from mosses that the Grande Cache area of Alberta may have remained ice free and served as a biological refugium. Various other Wisconsin glacial refugia have been postulated, including northeastern Greenland (Gelting, 1934) Kodiak Island (Ball, 1963; Karlstrom and Ball, 1969), sections of the Mackenzie Mountains (Hammer, 1955; Calder and Taylor, 1968; Ball, 1963; Calder and Savile, 1960), part of the Queen Charlotte Islands (Osgood, 1901, Calder and Taylor, 1968), Vancouver Island (Heusser, 1960), nunataks within glaciated areas of Beringia (Youngman, 1967) and the Cypress Hills Alberta-Saskatchewan (Prest *et al.*, 1968). In addition Youngman (1975) suggested that there was geological evidence for a driftless area in the Okanagan Range of the Similkameen district of southern British Columbia. Many authors have suggested that an ice-free corridor may have existed between Beringia n Alaska-Yukon and the areas south of the glacial advance. How extensive this corridor might have been is not known at present. If Prest's (1969) interpretation is anywhere correct, then the unglaciated corridor extended southward to just above 60°N latitude and extended north-northwest, west of the Mackenzie River. According to Prest's map, the Laurentide glacier stopped its maximum advance about 30 to 40 km west of the Nahanni and Liard Ranges at about the general area of the Funeral Range. An ice-free corridor existed to the west for some 20 to 60 km and then the Cordilleran Glaciers began. Youngman (1975) discussed the development of the ice-free corridor and suggested that at 12,200 BP the corridor was continuous between Beringia and areas south of the Laurentide glaciers.

Thus, geologically at least, it is feasible for at least the heartier plants and animals to have existed in the vicinity of the Nahanni Area during Pleistocene glaciations. Evidence gained from present day distribution patterns can be used to substantiate the likely occurrence of organisms in these ice-free areas during the glaciations of the Pleistocene. Highly disjunct occurrences of organisms, which are not specialized for long distance dispersal, are indicative of these organisms weathering the glaciations *in situ*. Likewise, the extension into an area such as the Nahanni Region of predominantly arctic-Beringian taxa is also suggestive that these organisms survived the Wisconsin glaciation *in situ*. Steere *et al.* (1977) listed 10 species they found in Nahanni National Park as significant circumpolar Arctic taxa with occasional outlying stations farther south. We recollected five of these in our area which lies to the east of theirs. These species are *Andreaeobryum macrosporum*, *Aulacomnium acuminatum*, *Bryobrittonia longipes*, *Entodon concinnus*, and *Scapania simmonsii* Bryhn & Kaal. (a hepatic). We can also add to this list *Encalypta longicolla*, *Geheebia gigantea*, *Herbertus stramineus* (Dum.) Trev., *Orthothecium intricatum*, *Psilopilum cavifolium*, *Radula prolifera* Arn., *Seligeria polaris*, and *Trichostomum arcticum*. Other very disjunct taxa which we can report from this area include *Arctoa fulvella*, *Isopterygiopsis muelleriana*, *Rhabdoweisia crispata*, and *Seligeria calcarea*. The occurrences of these numerous arctic species as well as the disjunctive stations seems to favor the view that at least some plant species survived the rigors of Pleistocene glaciation very near to their present occurrences in the Nahanni area. However, it is certainly possible that at least some fo the species were dispersed into the Nahanni area from eastern Beringia very early in late glacial times and actually survived the glaciations farther north.

The Nahanni and Liard Ranges are of great bryogeographic interest because the moss flora of the area contains numerous arctic species which reach their southern most limit somewhere between the Nahanni Area and the Rocky Mountains of Alberta. These essentially outlying alpine stations of predominantly arctic species suggest that some of these taxa may have weathered the Pleistocene glaciations not only in Beringia, but also were found in refugia farther south. Likewise some of the species which in

Nahanni reach their southern most or are close to their southernmost limit in western North America are disjunct in the eastern part of North America - predominantly south of the maximum extent of Pleistocene glaciation. Steere (1965) first suggested that these predominantly southern species were present in northern Alaska in his "Umiat syndrome". Based on phytogeographic evidence, it seems, highly likely that some moss species survived glaciation in two centers and presently have a bicentric distribution pattern in North America. Ten of the moss species are discussed in more detail below and maps of their North American distributions given (Figs. 1-10). Schofield (1972) and Steere (1978) have given distribution maps of some of these species plus other northern bryophyte species.

1. *Arctoa fulvella* (Dicks.) B.S.G. (Fig. 37). This species has a bicentric distribution pattern in North America. It is a species of non-calcareous rock crevices and occurs on moist ledges at the higher elevations. The Liard Range specimen is the farthest the species is known in the interior. It is also known from widely distributed localities in Europe and Japan.
2. *Aulacomnium acuminatum* (Lindb. & Arn.) Kindb. (Fig. 38). This species occurs in tundra habitats, often with *Aulacomnium turgidum*. It is frequent in northern Alaska, throughout the Yukon and continues eastward through the Canadian Arctic Archipelago to Greenland and southward to Great Slave Lake in the west. Disjunct occurrences are present at Tuchodi Lakes and Racing River, British Columbia and Grande Cache, Alberta. It is known from one locality in southern Ontario and there is a subfossil, post-glacial record from New York (Miller, 1973). It may be that this species survived glaciation in

Beringia, mountain refugia in British Columbia and Alberta as well as south of the maximum glacial advance in eastern North America.

3. *Encalypta mutica* Hag. (Fig. 39). This species was recently reported as new to North America by Horton and Murray (1976) and has a distribution pattern suggesting survival in Beringia as well as possibly in mountain refugia in the Western Cordillera.

4. *Geheebia gigantea*(Funck) Boul. (Fig. 40). Known in North America from only a few collections along coastal Alaska, from the north slope of the Brooks Range and from the Queen Charlotte Islands, and recently collected on Bathurst Island. The Ram Plateau collection is a significant extension of its former range into the interior, continental portion of western North America.

5. *Isopterygiopsis muelleriana* (Schimp.) Iwats. (Fig. 41). This species has a bicentric distribution pattern and occurs on non-calcareous substrates in rock crevices. The northwestern segment of its range is nearly restricted to the unglaciated area of Alaska-Yukon. It is an excellent example of a speciec which theoretically survived Pleistocene glaciation in two centers in North America.

6. *Psilopilum cavifolium* (Wils.) Hag. (Fig. 42). This arctic species continues south in alpine habitats only in western Canada. The Glacial Lake locality in northern British Columbia is the farthest south this species has been collected. The Liard Range locality extends the range into the southwestern Mackenzie District.

7. *Rhabdoweisia crispata* (With.) Lindb. (Fig. 43). This species is found on moist, shaded sandstone rock faces. It is likely distributed and Lawton (1961) recorded it from Bolivia, Hawaii, Japan, Amur, China,

Korea, and Java. Steere (1978) recently reported it from northern Alaska and it occurs in several localities in southern Alaska including Kodiak Island. It is scattered in occurrence in the eastern part of the North America. The Nahanni locality is strongly disjunct and adds weight to the hypothesis that this species may have survived glaciation in Beringia as well as in eastern North America. Kodiak Island is a well documented refugium as well (Karlstrom and Ball, 1969).

8. *Seligeria calcarea* (Hedw.) B.S.G. (Fig. 44). It will be interesting to see if this species is recorded, in the future from farther north; the Whittaker Falls station is significantly north and west of the Alberta locality. It seems possible, that like several other *Seligeria* species, *S. calcarea* will have a bicentric distribution pattern in North America (See Vitt, 1976).

9. *Seligeria polaris* Berggr. (Fig. 45). This species, like *Trematodon brevicollis* and *Andreaeobryum macrosporum* have "Beringian" distribution patterns, with *S. polaris* continuing eastward into the Canadian Arctic Archipelago. The Ram Plateau records for these three species are range extensions eastward and near the southern boundary for all three. Two hepatics, *Herbertus stramineus*, now known from only two localities in North America (See Schuster, 1957), and *Scapania simmonsii* have similar Beringia distribution patterns in North America.

10. *Trichostomum arcticum* Kaal. (Fig. 46). This circum-arctic species reaches its southern most known locality in the Ram Plateau area; however, there is no reason why it shouldn't be collected in northern British Columbia as well.

9.6 Summary

As more evidence accumulates about the plants and animals of Beringia and northwestern North America, it seems that organisms occupying formerly glaciated regions were derived entirely from Beringia or other northern refugia or from areas south of the margins of the glaciers as was much of the flora and fauna of the remainder of North America. In order to better understand the effects of isolation by glaciers and survival in refugia, we need to study, in detail, population variation, geographical variation and evolution of subspecies of bryophyes much like that which has been done by zoologists and others (e.g. Rand, 1954; MacPherson, 1965). Of course, as a beginning to these more comprehensive studies, documentation of the present day distributions of these taxa is needed. The data obtained in the collections reported on here are one step in understanding more about the Beringian component of the distributions of these species.

With the advent of easy assessibility into these mountains, assessment of the sensitivity and abundance of the flora and fauna is critical.

Twenty-one per cent or 39 of the species of mosses collected in the Nahanni-Liard Ranges can be considered as rare taxa. Most of these have the majortiy of their geographical occurrences in the High-Arctic and alpine habitats farther north or are extreme disjunct ranges. Almost all of these taxa are rare in the Nahanni-Liard Region and only one or two populations of each were found. A few of these species may be represented in these mountain ranges by only a few isloated populations and as a result they are extremely sensitive to human disturbance.

As more and more people utilize these sensitive tundra environments, the chances for survival of these rare organisms becomes less and less. The Nahanni and Liard Mountain Ranges contain a unique and rare moss flora, and care should be used in opening these areas up to the general public.

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9.8 Figure Legends

Figure 37. North American distribution of *Arctoa fulvella* (Dicks.) B.S.G.

Figure 38. North American distribution of *Aulacomnium acuminatum* (Lindb. & Arn.) Kindb. (The triangle represents a late-Wisconsin subfossil locality).

Figure 39. North American distribution of *Encalypta mutica* Hagen.

Figure 40. North American distribution of *Geheebia gigantea* (Funck) Boul.

Figure 41. North American distribution of *Isopterygiopsis muelleriana* (Schimp.) Iwats.

Figure 42. North American distribution of *Psilopilum cavifolium* (Wils.) Hagen.

Figure 43. North American distribution of *Rhabdoweisia crispata* (With.) Lindb.

Figure 44. North American distribution of *Seligeria calcarea* (Hedw.) B.S.G.

Figure 45. North American distribution of *Seligeria polaris* Berggr.

Figure 46. North American distribution of *Trichostomum arcticum* Kaal.

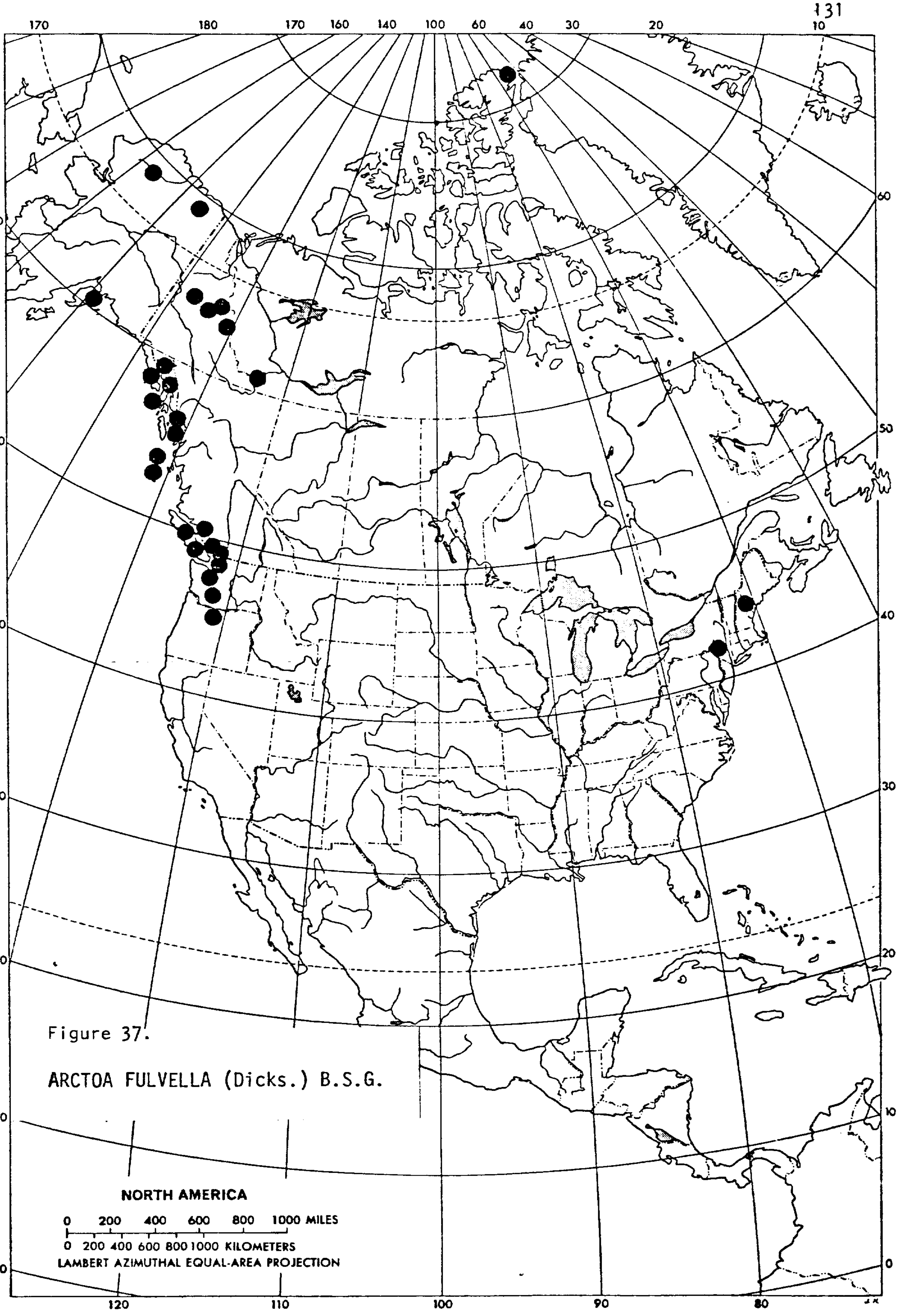

Figure 37.

ARCTOA FULVELLA (Dicks.) B.S.G.

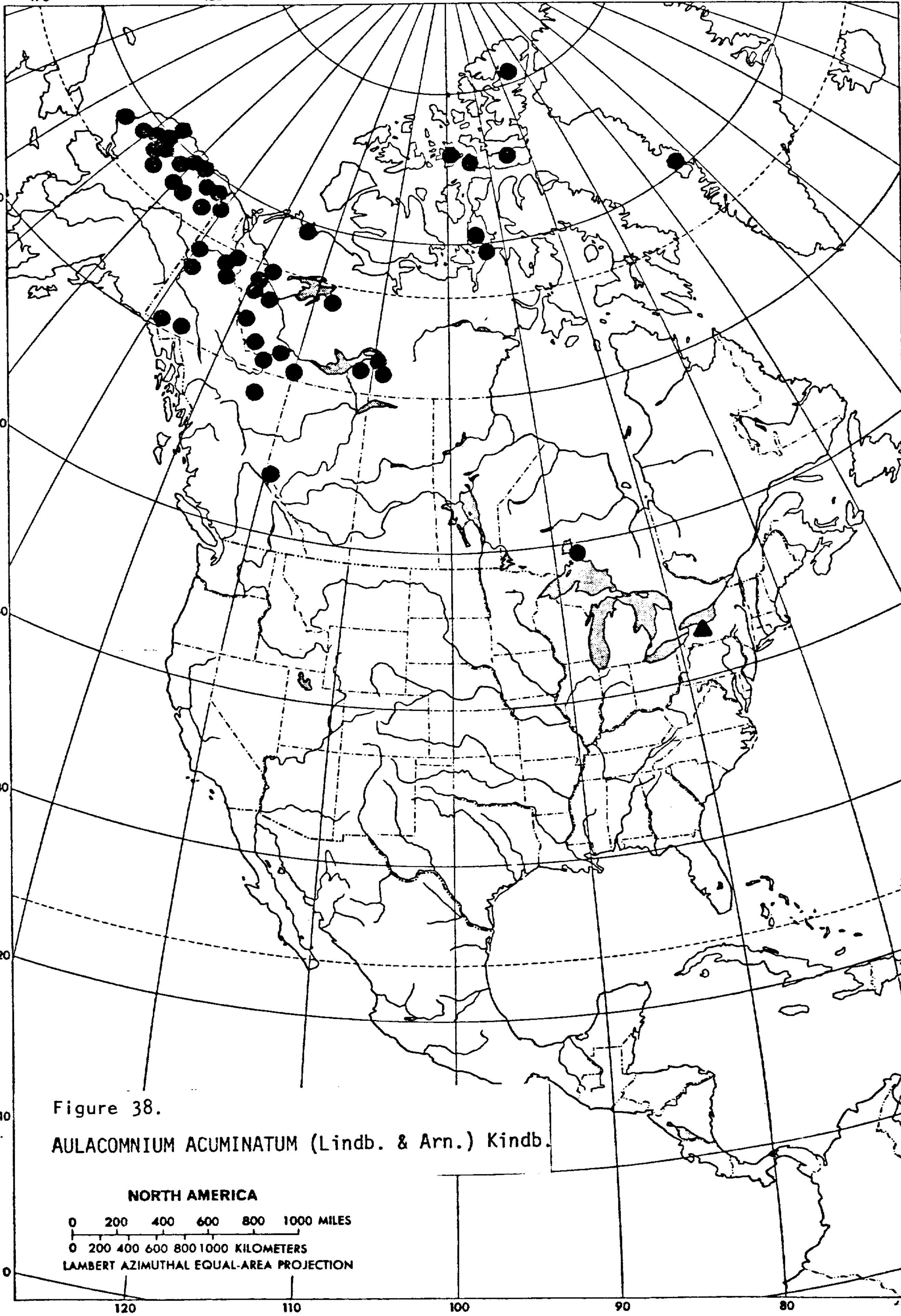

Figure 38.

AULACOMNIUM ACUMINATUM (Lindb. & Arn.) Kindb.

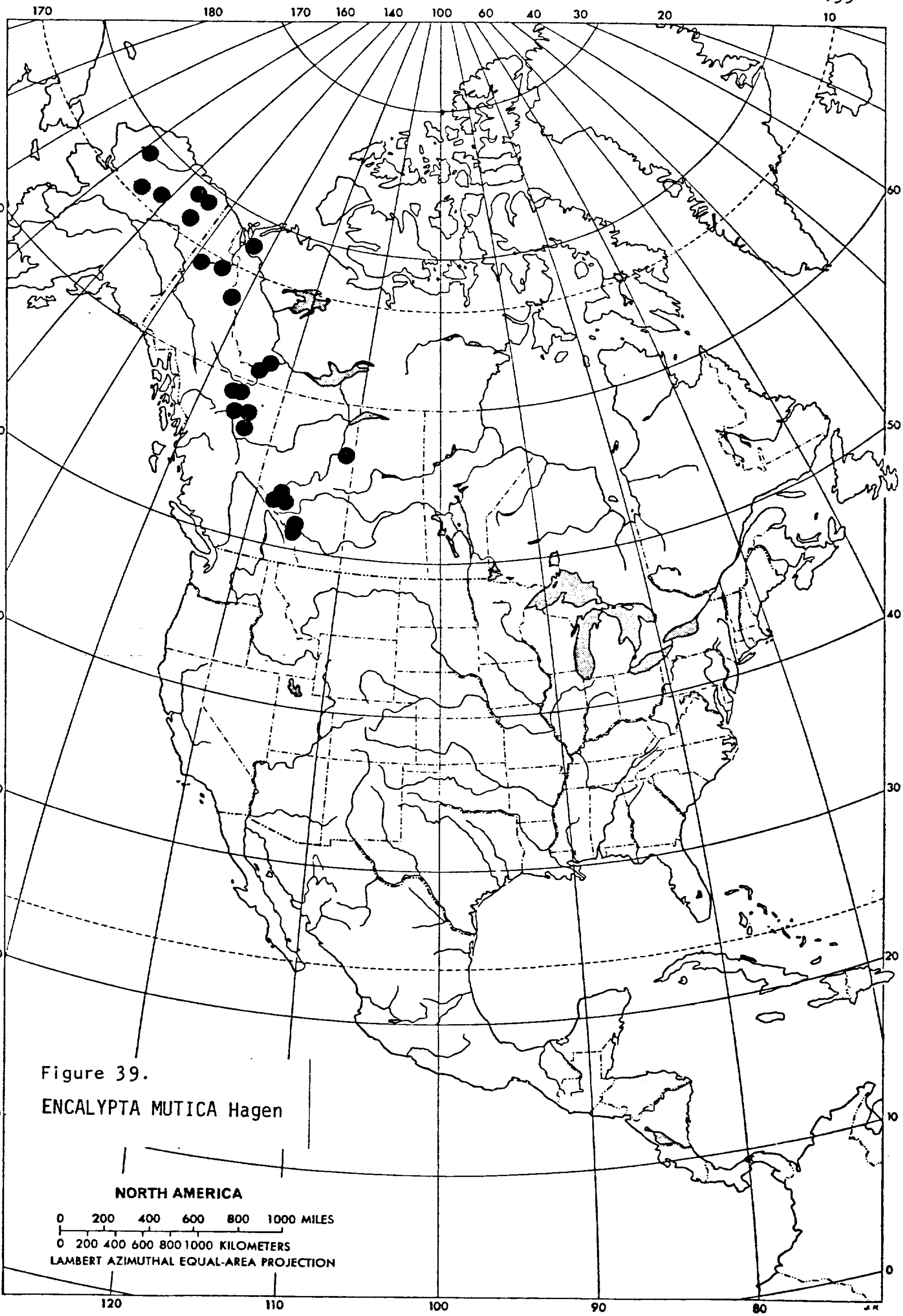

Figure 39.
ENCALYPTA MUTICA Hagen

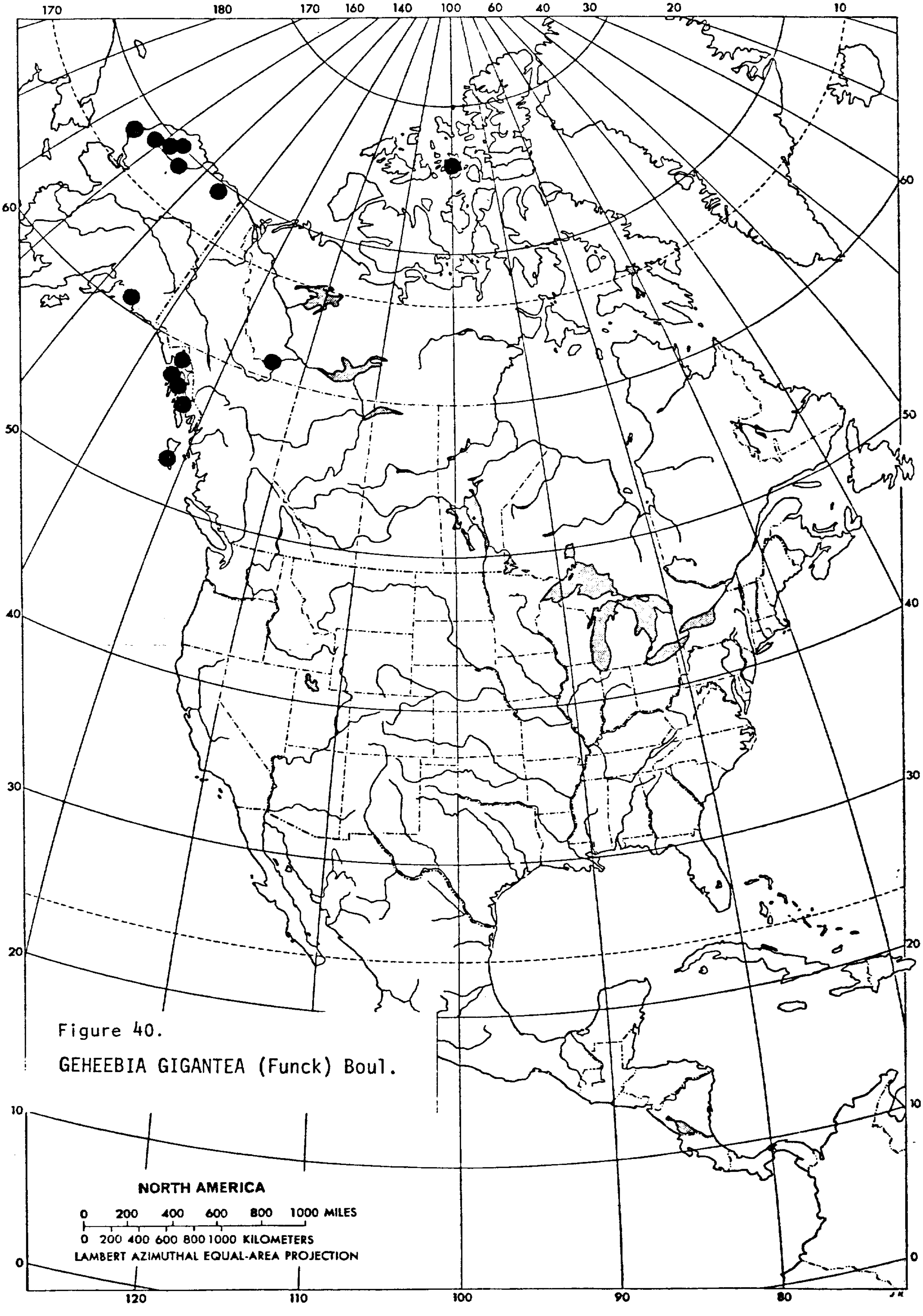

Figure 40.
GEHEEBIA GIGANTEA (Funck) Boul.

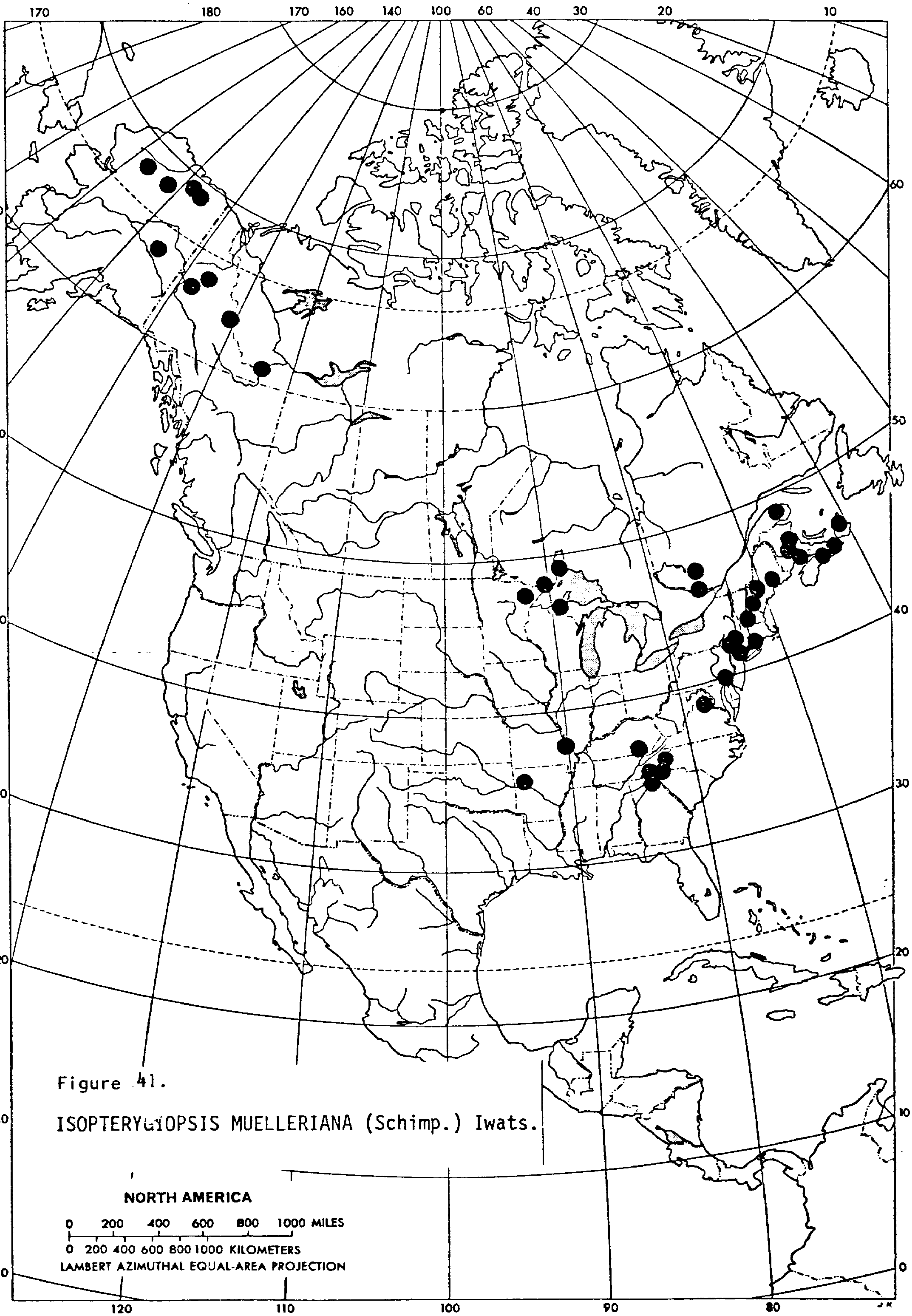

Figure 41.

ISOPTERYGIOPSIS MUELLERIANA (Schimp.) Iwats.

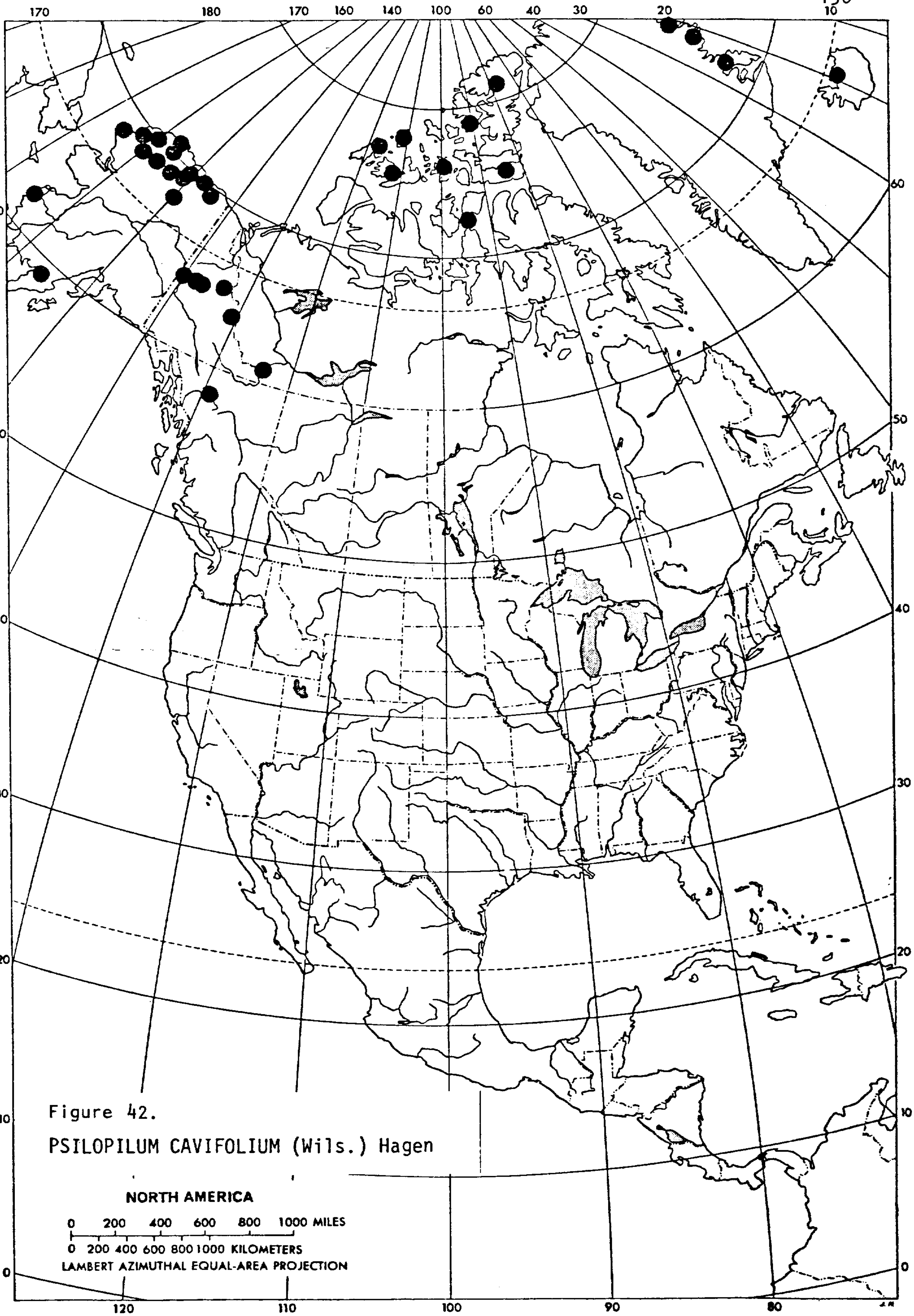

Figure 42.

PSILOPILUM CAVIFOLIUM (Wils.) Hagen

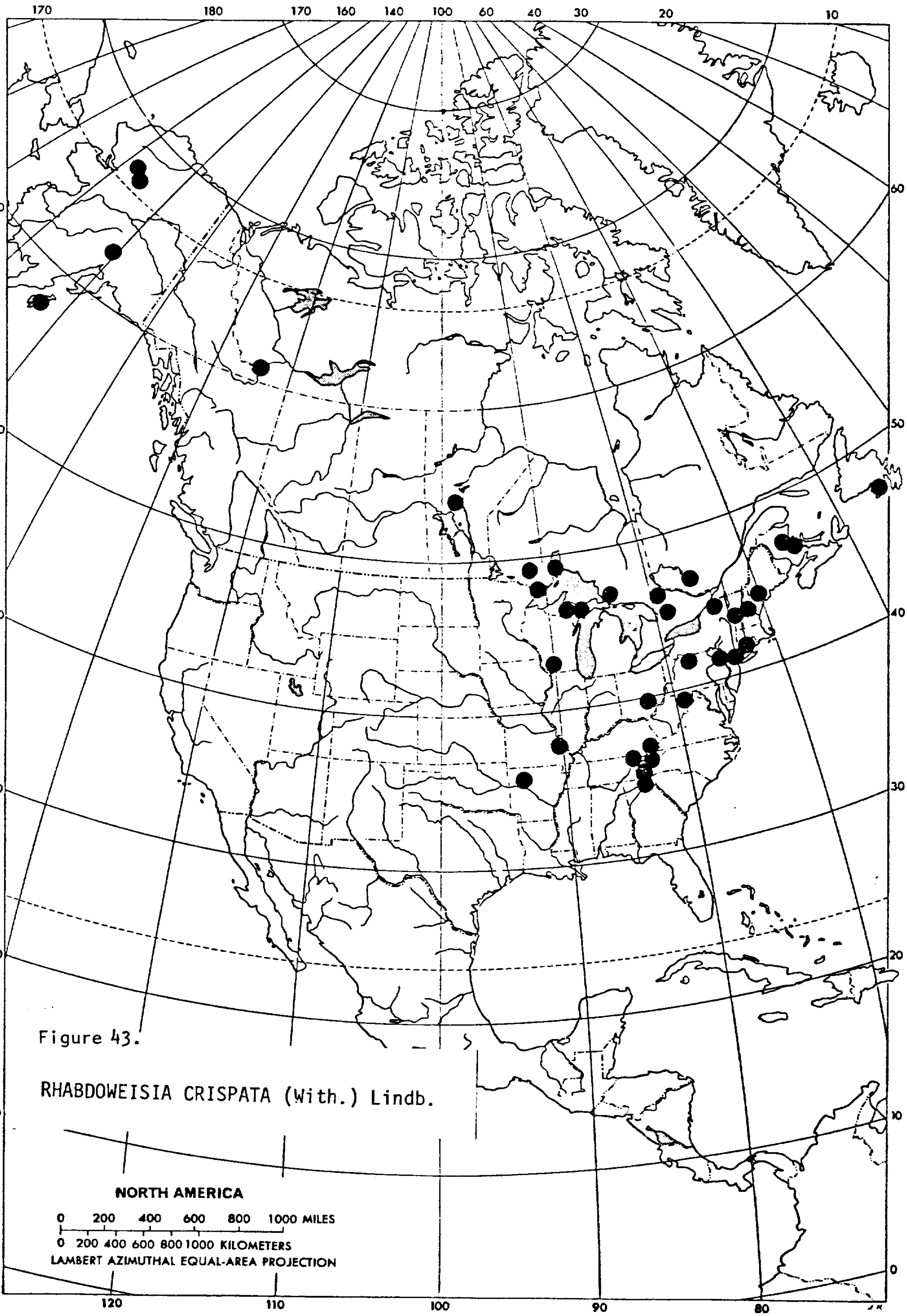

Figure 43.

RHABDOWEISIA CRISPATA (With.) Lindb.

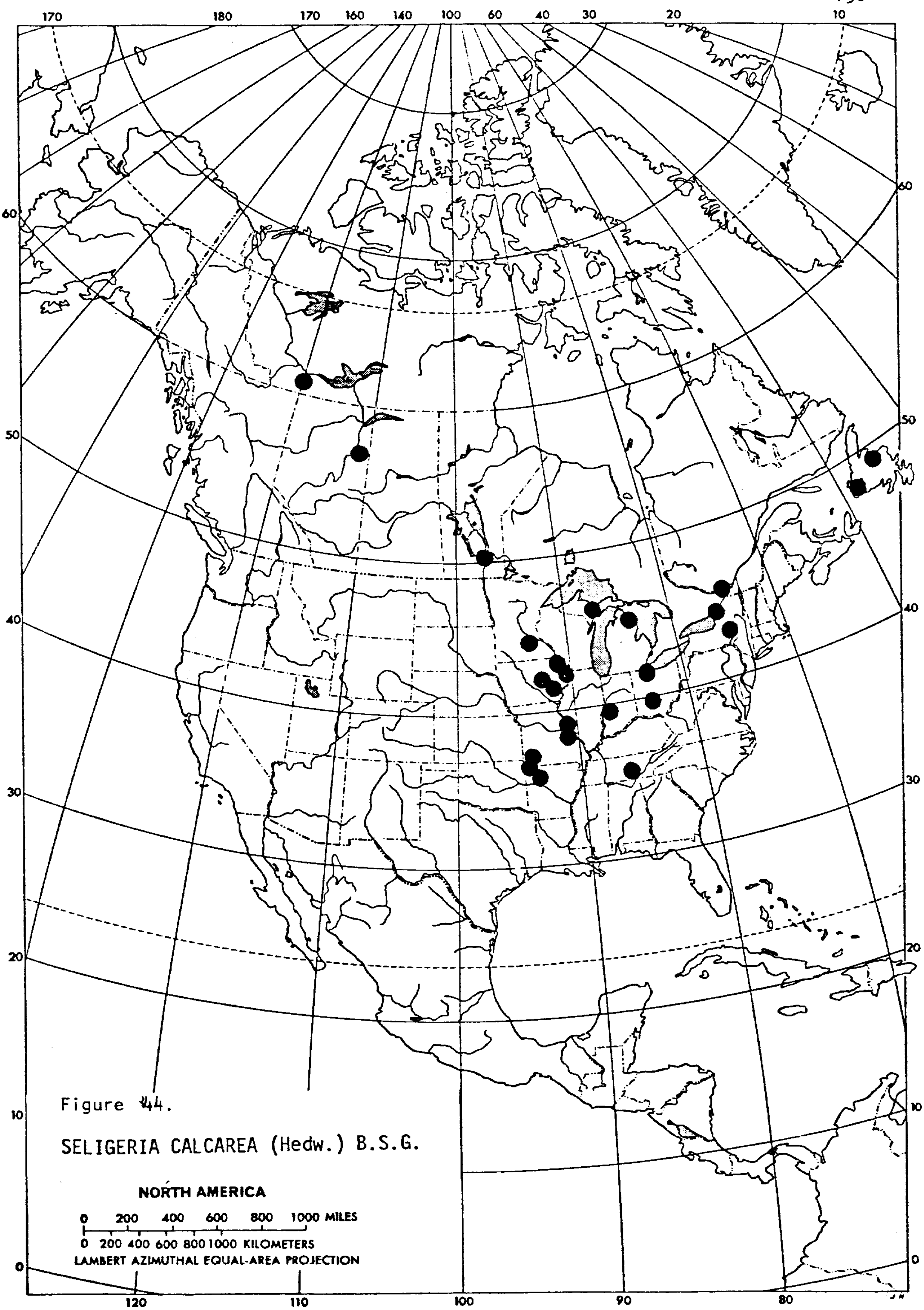

Figure 44.

SELIGERIA CALCAREA (Hedw.) B.S.G.

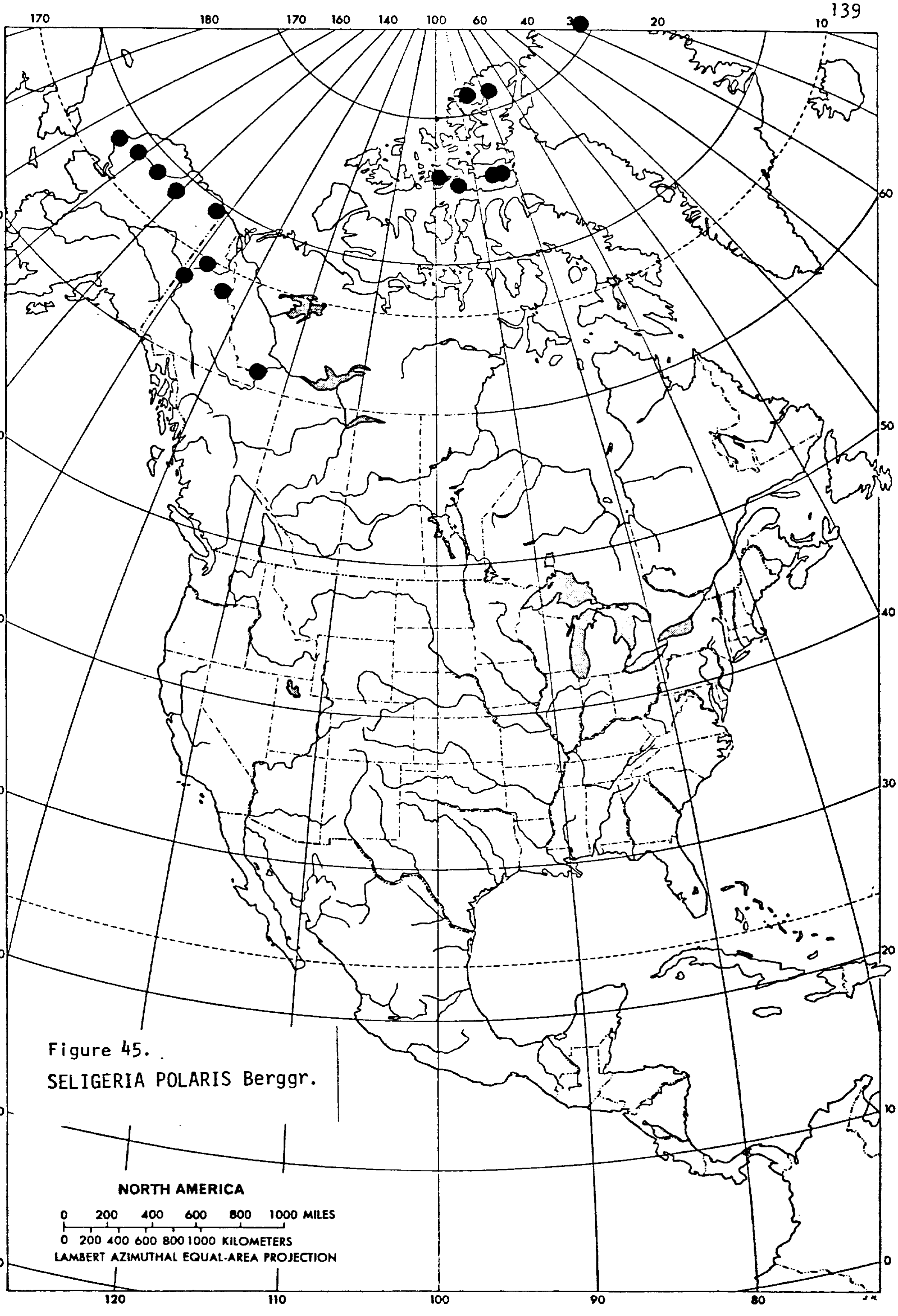

Figure 45.
SELIGERIA POLARIS Berggr.

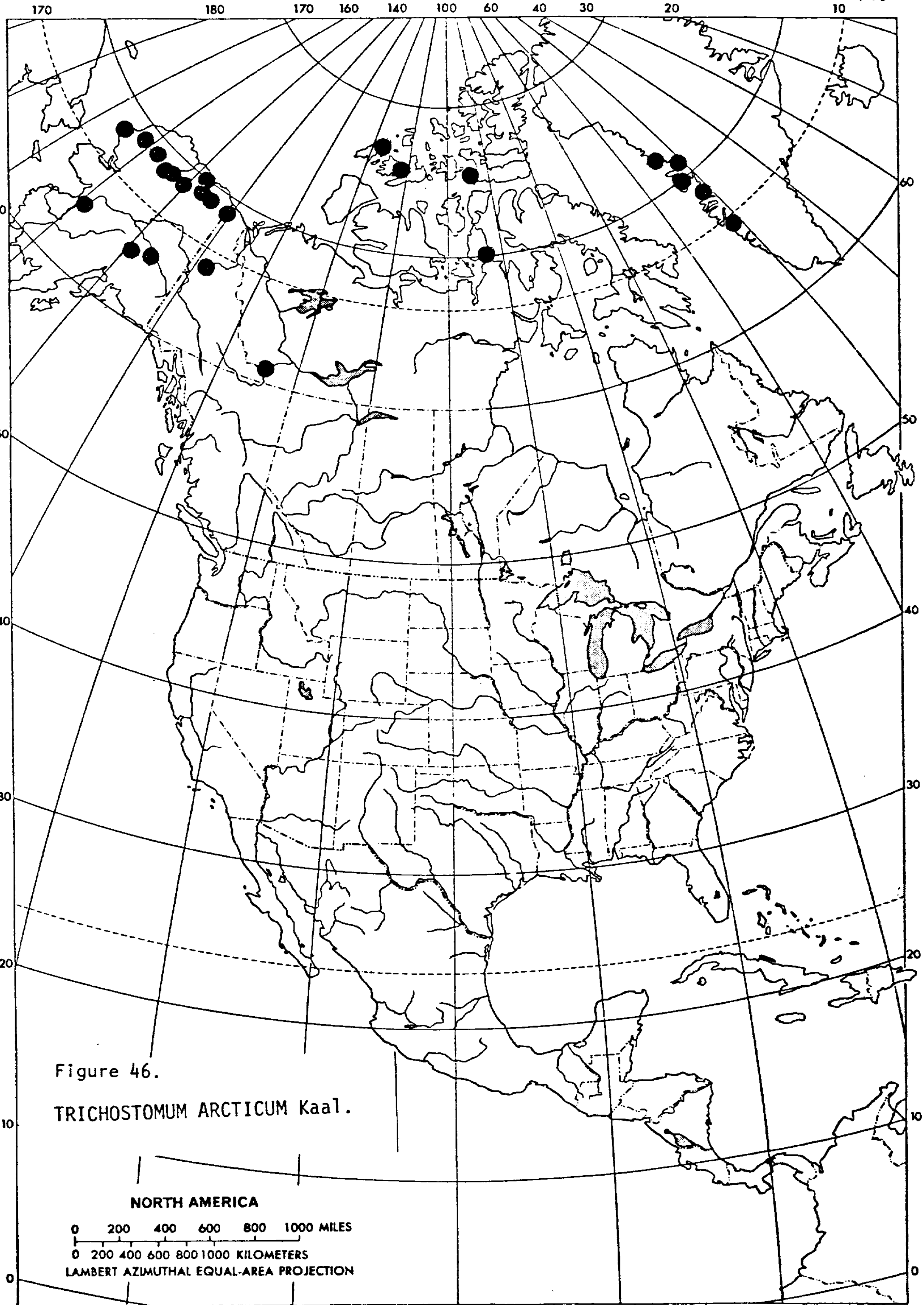

Figure 46.

TRICHOSTOMUM ARCTICUM Kaal.

10. SUMMARY

1. Thirty-three wetlands were selected for study based on the following criteria:

    1. Sites adjacent to the Liard Highway alignment.
    2. Sites representing a variety of habitat types.
    3. Sites utilized by waterfowl and water-oriented birds.

2. Descriptions of plant communitites were undertaken at selected sites. This was accomplished by analysis of species' percent coverage data collected using a 1/10 m^2 Daubenmire frame (Daubenmire 1968), placed at intervals along a predetermined transect. Correlation of the species cover percentages to height above water level is given in cover-comparison figures. Communities were determined and named by characteristic dominant species. Relative positions of major plant communitites at several sites are illustrated in the site maps which were drawn directly from aerial photographs of the ponds.

3. Invertebrate sampling was carried out at two week intervals from May through October at all study sites. Butterfly graphs indicate the blooms and recessions of major taxa for each site type. Totals for taxa on each sampling date at each pond are given in Appendix B.2. The sampling technique, a 25 m sweep (1825.5 litres) net sample per pond, showed presence and abundance of free-swimming invertebrates which were available for waterfowl feeding.

4. Waterfowl data was collected for spring and fall migrations, breeding pair, and broods, mainly through aerial surveys. The information gained indicates the following conclusions:

a) No major migration corridor for swans, geese or cranes occurs in the vicinity of the proposed Liard Highway.

b) Substantial numbers of ducks use wetlands adjacent to the alignment during spring and fall migrations. The Netla River district and Poplar River district (Site 7) are outstanding in this respect.

c) Substantial numbers of ducks and grebes nest in wetland habitats in the Liard Highway area. In particular, lesser scaup and bufflehead broods were abundant in the study areas. Nesting periods were determined for these species and others found in study sites.

5. The Liard Mountain Range, the mountain habitat made most accessible by highway construction, contains very little good raptor habitat. No peregrine falcons were observed during helicopter surveys of the range, although sightings were made in the more northerly Nahanni Range. The Pettitot River offers potential good falcon nesting habitat although no peregrine falcons were observed during surveys conducted in the region.

6. Dall sheep are present in certain areas of both the Liard and Nahanni Ranges. Increased hunting pressure as a result of highway access may be a threat to those populations unless they are closely monitored.

7. Phytogeographically interesting collections of bryophytes were obtained in mountain regions adjacent to the proposed highway. These discoveries may be significant in providing information concerning the glacial history of the southwestern Mackenzie District of Northwest Territories.

11. RECOMMENDATIONS

1. Rerouting of the Liard Highway at km 208 (mi. 130) to 0.5 km east of its present location should be considered. The purpose of this re-alignment would be to avoid disruption and loss of waterfowl nesting and feeding habitat and also to prevent spring flooding of the roadbed. The present alignment goes between two oxbow ponds which were inhabited by many coot in 1977. The location of the alignment was flooded in 1977 after heavy rainfall during May-June.

2. The Netla River area should be avoided in terms of recreational developments such as public campgrounds. The area contains preferred habitat for migrating and breeding waterfowl and is a traditional hunting and fishing region for natives of Nahanni Butte and surrounding areas.

3. Installation of culverts at frequent intervals in muskeg areas must be undertaken. Drainage through these regions is achieved by seepage through the organic substrate. Construction of a roadbed across such habitats causes upstream ponding and downstream drying. Provision should be made for drainage as has been done with reasonable success near km 2.0 (mi. 1.3) of the constructed portion of the Liard Highway.

4. Development of areas for recreational purposes should be restricted to the Poplar River area. This locality already has a small campsite and is presently used by Ft. Simpson residents on weekend camping, hunting, and fishing trips. The length of the proposed highway does not warrant installation of more campgrounds along the route. The Village of Ft. Liard will likely develop a municipal campground and travellers' facilities as the need arises. The biting fly problem during the summer will probably lead to eventual utilization of the well-drained uplands to the west of Liard River for recreational purposes. Mosquitoes, blackflies, and horseflies are not as prevalent here as in the wetter lowlands.

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APPENDIX A

WETLAND VEGETATION

Table 1. Vascular Plant Species List

Family	Species	Common Name
Equisetaceae	*Equisetum arvense L.*	horsetail
	E. fluviatile L.	horsetail
	E. palustre L.	horsetail
Pinaceae	*Juniperus horizontalis Moench*	creeping juniper
	Larix laricina (Du Roi) K. koch	larch
	Picea glauca (Moench) Voss	white spruce
	P. mariana (Mill.) BSP.	black spruce
	Pinus banksiana Lamb	jack pine
Typhaceae	*Typha latifolia L.*	cattail
Najadaceae	*Potamogeton amplifolius Tuckerum*	pondweed
	P. filiformis Pers.	pondweed
	P. richardsonii (Benn.) Rydb.	clasping leaved pondweed
	P. strictifolius Benn.	pondweed
Juncaginaceae	*Triglochin maritima L.*	arrowgrass
Gramineae	*Calamagrostis canadensis (Michx) Beauv*	marsh reed-grass
Cyperaceae	*Carex aquatilis Wahlenb*	sedge
	C. diandra Schrank	sedge
	C. interior Bailey	sedge
	C. leptalea Wahlenb	sedge
	C. paupercula Michx	sedge
	C. rostrata Stokes	sedge
	Eleocharis engelmanii Steud	spikerush
	Eriophorum scheuchzeri Hoppe	cottongrass
	E. viridi-carinatum (Ergel.) tern.	cottongrass
	Scirpus hudsonianus (Michx.) Fern.	bulrush
Araceae	*Calla palustris L.*	wild calla
Lemnaceae	*Lemna minor L.*	common duckweed
Juncaceae	*Juncus balticus Willd.*	wire rush
Liliaceae	*Smilacinia trifolia (L.) Desf.*	3-leaved Solomon's seal
	Tofieldia glutinosa (Michx) Pers.	false asph del
	Zygadenus elegans Pursh	white camas
Orchidaceae	*Calypso bulbosa (L.) Oakes*	Venus' slip
	Habenaria hyperborea (L.) Br.	northern green orchid

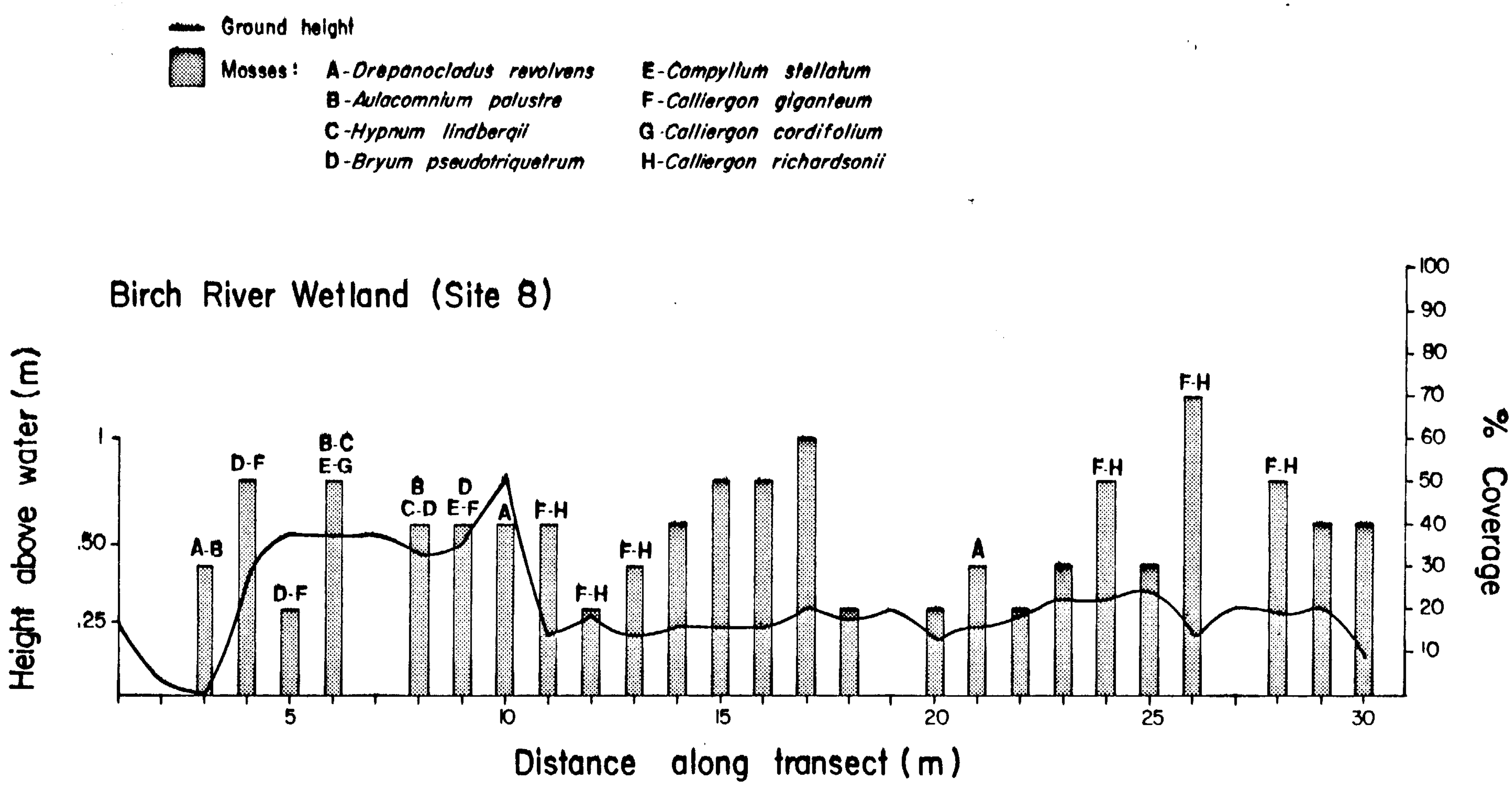
Family	Species	Common Name
	Orchis rotundifolia Banks	round-leaved orchid
	Spiranthes roman zoffiana (Lam & Sch.)	ladies' tresses
Salicaceae	*Populus balsamifera L.*	balsam poplar
	Salix interior Rowlee	sandbar willow
	S. mackenziana (Hooke) Barrott	willow
Myricaceae	*Myrica gale L.*	sweet gale
Betulaceae	*Alnus crispa (Ait) Pursh.*	green alder
	Betula glandulosa Michx.	bog birch
	B. papyrifera Marsh	
Santalaceae	*Geocaulon lividum (Richards.) Fern.*	bastard toadflax
Polygonaceae	*Polygonum amphibium L.*	water smart weed
Caryophyllaceae	*Stellaria crassifolia Ehrh*	chickweed
Nymphaeaceae	*Nuphar variegatum Engelm*	yellow pond lily
	Nymphaea tetragona Georgissp Leibergii (Morong) Porsild	white water lily
Ranunculaceae	*Actaea rubra (Ait) Willd.*	baneberry
Sarraceniaceae	*Sarracenia purpurea L.*	pitcher plant
Droseraceae	*Drosera anglica Huds*	sundew
	D. rotundifolia L.	sundew
Saxifragaceae	*Parnassia palustris L. var Neogaea Fern.*	grass of Parnassus
	Ribes sp.	currant.
Rosaceae	*Potentilla fruticosa L.*	shrubby cinquefoil
	P. palustris (L.) Scop.	marsh cinquefoil
	Rosa acicularis Lindl.	prickly rose
	Rubus acaulis Michx.	dwarf raspberry
	R. chamaemous L.	cloudberry
Empetraceae	*Empetrum migrum L.*	crowberry
Violaceae	*Viola selkerkii Pursh*	great spurred violet
	V. renifolia A. Gray	kidney-leaved violet
Onagraceae	*Epilobium palustre L.*	willow herb
Haloragidaceae	*Myriophyllum spicatun L.*	water milfoil
Hippuridaceae	*Hippuris vulgaris L.*	mare's tail

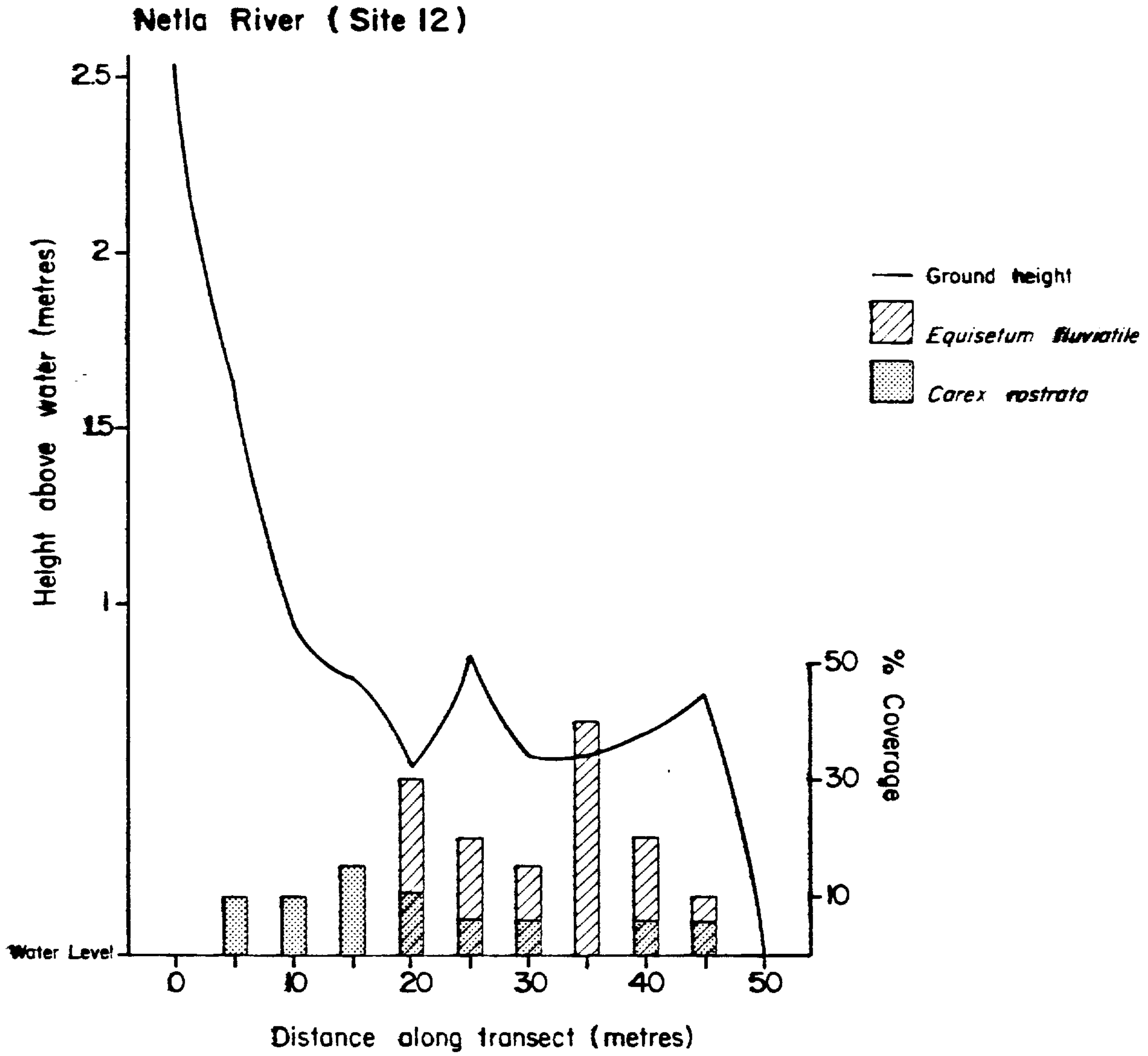
Family	Species	Common Name
Umbelliferae	*Sium suave Walt*	water parsnip
Cornaceae	*Cornus canadensis L.*	bunchberry
	C. stolonifera Michx.	red-osier dogwood
Pyrolaceae	*Moneses uniflora (L.) A. Grey*	one-flowered wintergreen
	Pyrola asarifolia Michx.	wintergreen
	P. bracteata Hook	large wintergreen
	P. grandiflora Radius	wintergreen
Ericaceae	*Andromeda polifolia L.*	bog rosemary
	Arctostaphylos rubra (Reher and Wils.) Fern.	red bearberry
	Chamaedaphne calyculata (L.) Moench	leatherleaf
	Ledum groenlandicum Oeder	labrador tea
	L. palustre L. var. decumbens Ait	northern labrador tea
	Oxycoccos microcarpus Turcz.	small bog cranberry
	Vaccinium uliginosum L.	bilberry
	V. vitis - idaea L. var. minus Lodd	dryland cranberry
Primulaceae	*Lysimachia thyrsiflora L.*	tufted loosetrife
	Primula misstassinica Michx.	dwarf Canadian primrose
Gentianaceae	*Menyanthes trifoliata L.*	buckbean
Lamiaceae	*Lycopus uniflorus Michx.*	water horehound
	Scutellaria galericulata L.	skullcap
Scrophulariaceae	*Pedicularis labradorica Wirsing*	lousewort
Lentibulariaceae	*Pinguicula vulgaris L.*	butterwort
	Utricularia vulgaris L. var. americanus A. Gray	bladderwort
Rubiaceae	*Galium trifidum L.*	small bedstraw
Caprifoliaceae	*Linnaea borealis L. var. americana (Forbes) Reld.*	twinflower
	Lonicera dioica L. Var. glaucesons	honeysuckle
	Viburnum edule (Michx.) Raf	low-bush cranberry
Compositae	*Achillea borealis Bang*	yarrow

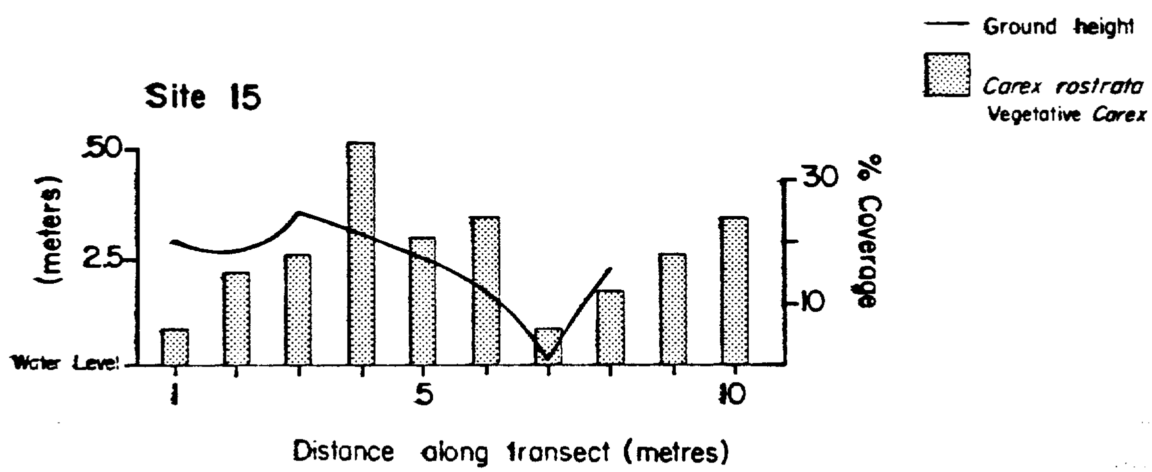
Bryophyte Species List

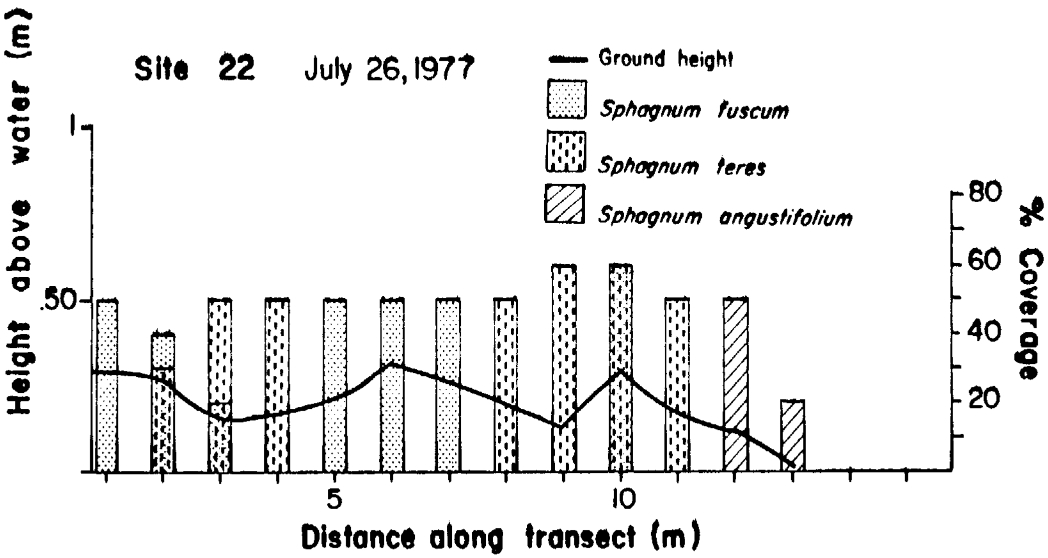
Family	Species
Sphagnaceae	*Sphagnum fuscum (Schimp) Klinggr.*
	S. nemoreum
	S. recurvum P - Beauv
	S. russowii Warnst
	S. squarrosum Crome
	S. teres (Schimp) Angstr. ex Hartin
	S. magellanicum
Dicranaceae	*Dicranum undulatum Brid*
Bryaceae	*Pohlia cruda (Hedw.) Lindb.*
	Bryum pseudotriquetrum (Hedw.) Gartin, Meyer and Scherb.
Mniaceal	*Plagiomnium cuspidatum (Hedw.) kop*
	P. elliptricum
	P. medium (B.S.G.) kop ssp. curvatum
Aulacomniaceae	*Aulacomnium palustre (Hedw.) Schwaegr*
Meesiaceae	*Meesia triquetra (L. ex. Richt.) Angstre*
	Paludella squarrosa (Hedw.) Brid.
Leskeaceae	*Thuidium recognitum (hedw.) Lindb.*
Amblysdegiaceae	*Campylium stellatum (Hedw.) C. Jens.*
	Leptodictyum trichopodium (Schultz) Warnst. var. kockii (BSG) Broth
	Drepanocladus exannulatus (BSG) Warnst.
	D. revolvens (Sw.) Warnst.
	D. vernicosus. (Lindb. ex. C.J. Hartm) Warnst.
	Calliergon cordifolium (Hedw.) Kindb.
	C. giganteum (Schimp) Kindb.
	C. richardsonii (Mitt.) Kindb. ex. Warnst.
	C. stramineum
	C. trifarium (Web and Mohr.) Kindb.
	Scorpidium scorpiodes (Hedw) Limpr.
Brachytheciaceae	*Tomenthypnum nitens (Hedw.) Loestre*
	Brachythecium turgidum (C.J. Hartm) Kindb.
	Pleurozium schreberi (Brid.) Mitt.
Hypnaceae	*Hypnum lindbergii Mitt*
	H. pratense koch ex. spruce
	Ptilium crista - castrensis (hedw.) De Not
	Platydicta jungermannioides (Brid.) Crum
Hylocomiaceae	*Hylocomium splendens (hedw.) BSG*
Polytrichaceae	*Polytrichum juniperinum Hedw.*

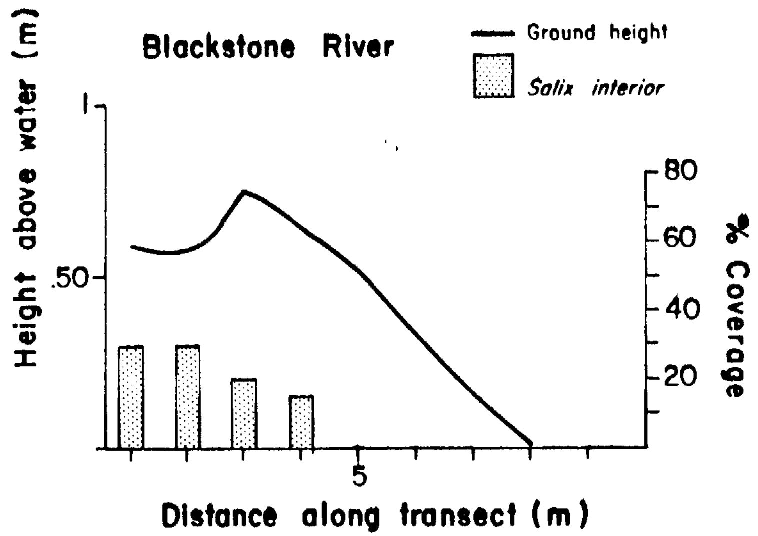
Appendix A.2. Transect profiles showing species percent coverage relative to water levels selected methods, Liard Highway vicinity, NWT.

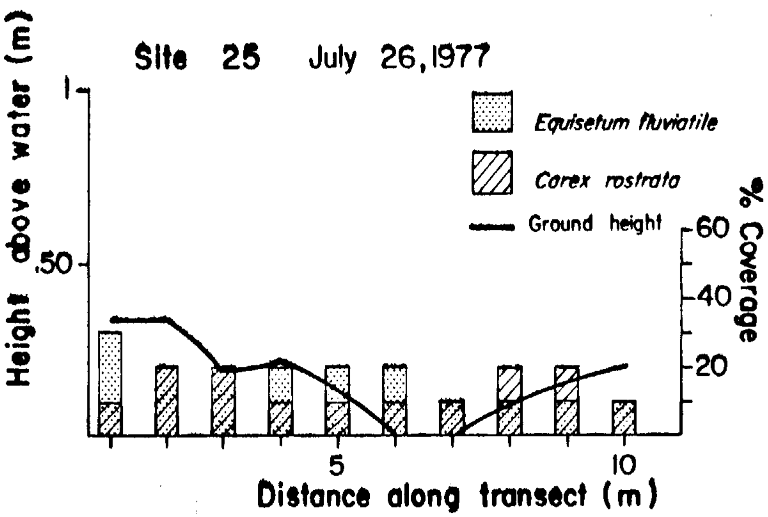


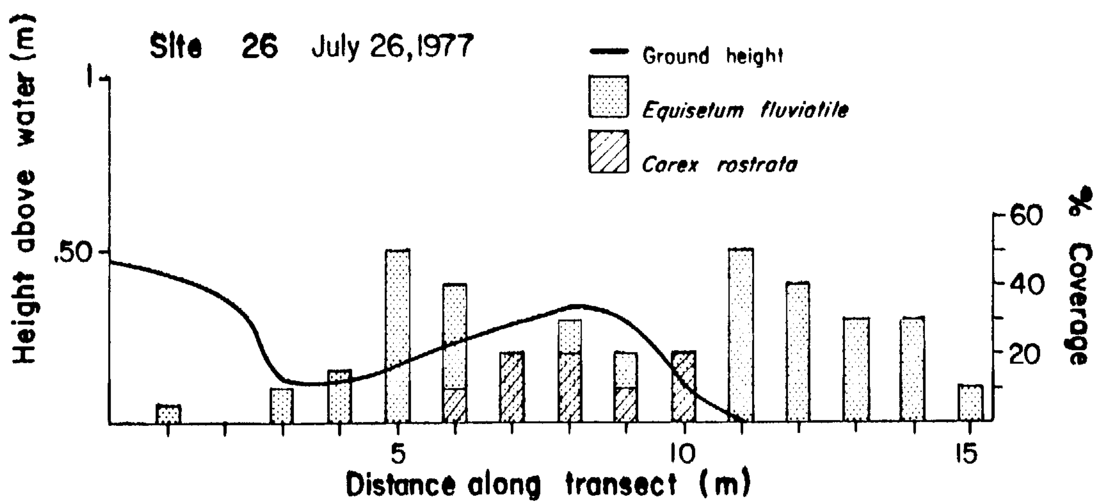

Netla River (Site 12)
2.5
2
1.5
1
Water Level
Height above water (metres)
0
10
20
30
40
50
Distance along transect (metres)
50
30
10
% Coverage
Ground height
Equisetum fluviatile
Carex rostrata

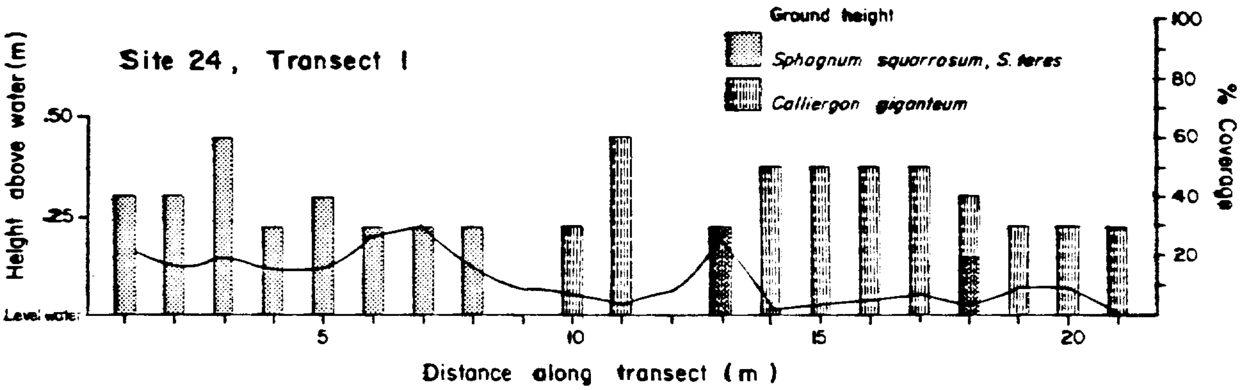

Ground height
Carex rostrata
Vegetative Carex
Site 15
.50
2.5
Water Level
(meters)
1
5
10
Distance along transect (metres)
30
10
% Coverage

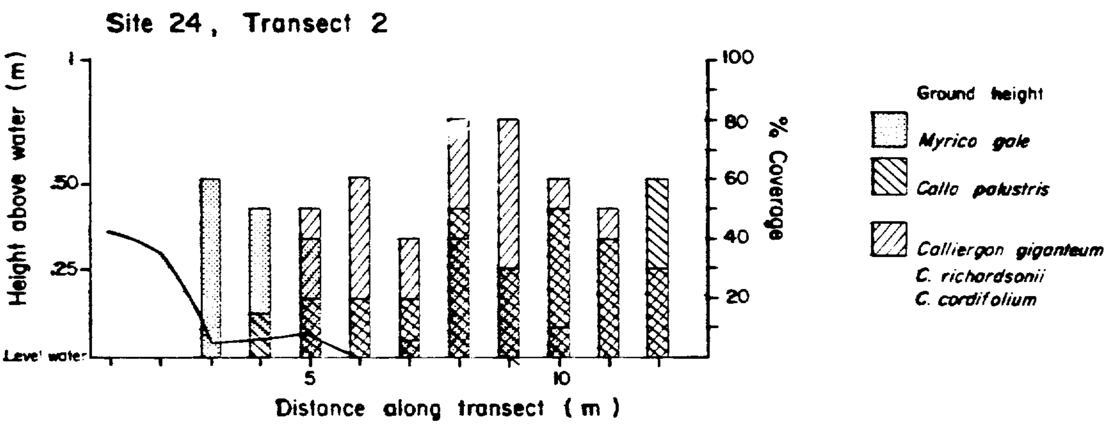

Site 22 July 26, 1977
Ground height
Sphagnum fuscum
Sphagnum teres
Sphagnum angustifolium
Height above water (m)
1
.50
% Coverage
80
60
40
20
5
10
Distance along transect (m)

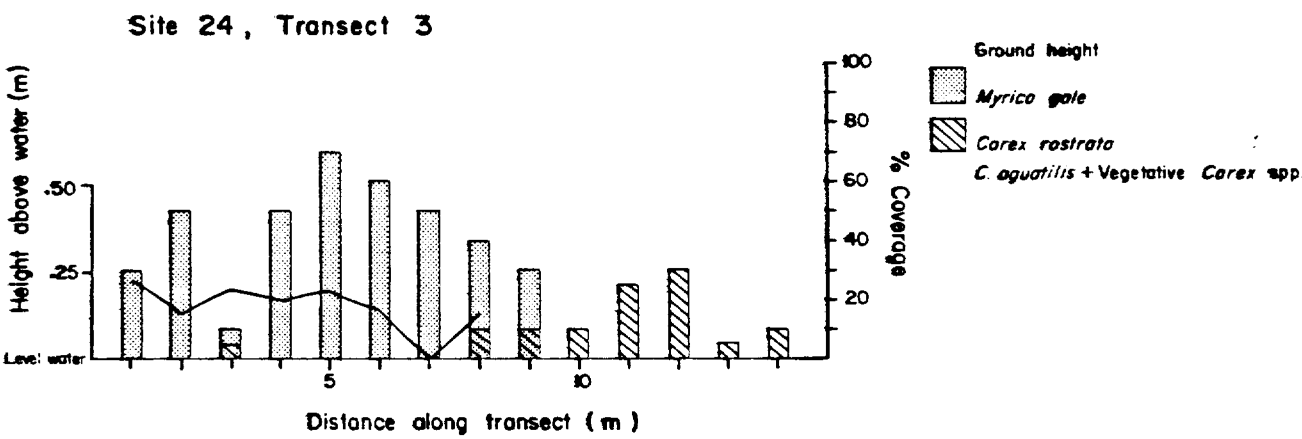

Blackstone River
Ground height
Salix interior
Height above water (m)
1
.50
% Coverage
80
60
40
20
5
Distance along transect (m)

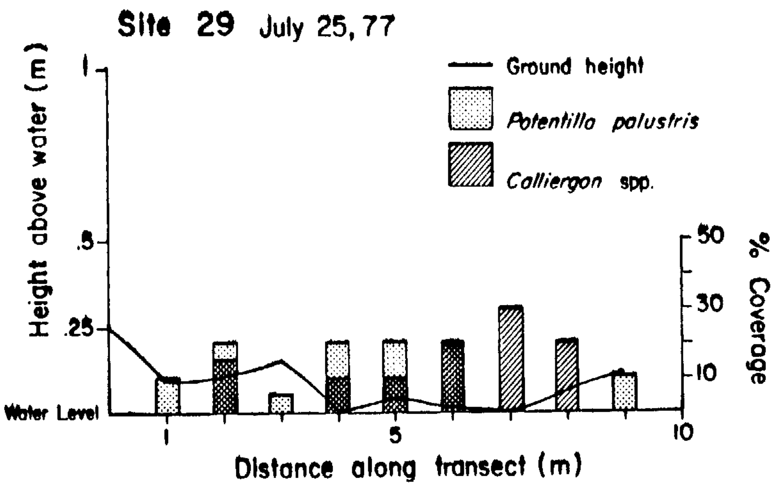

Site 25 July 26, 1977
Equisetum fluviatile
Carex rostrata
Ground height
Height above water (m)
1
.50
% Coverage
60
40
20
5
10
Distance along transect (m)

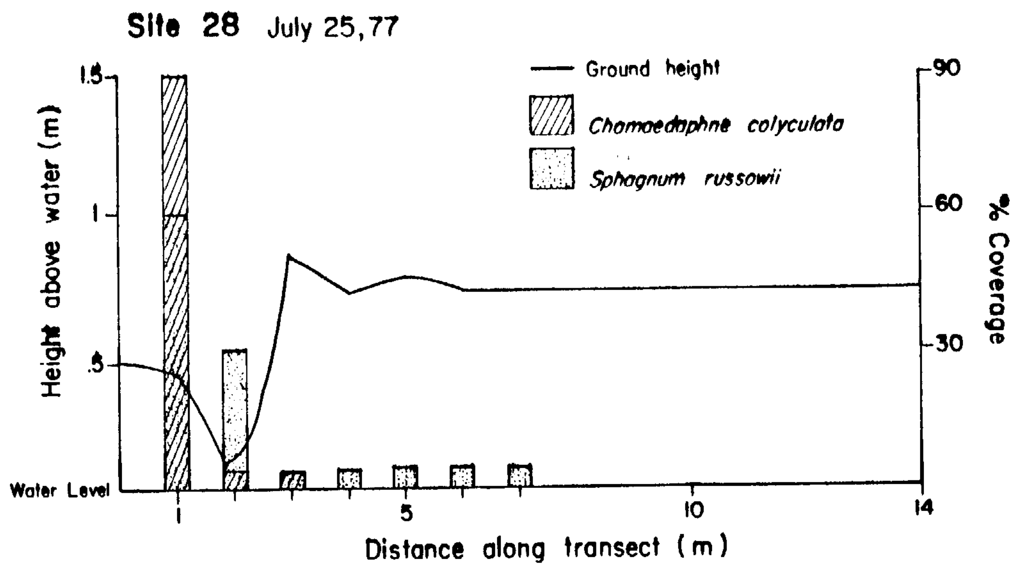

Site 26 July 26, 1977
Ground height
Equisetum fluviatile
Carex rostrata
Height above water (m)
1
.50
% Coverage
60
40
20
5
10
15
Distance along transect (m)

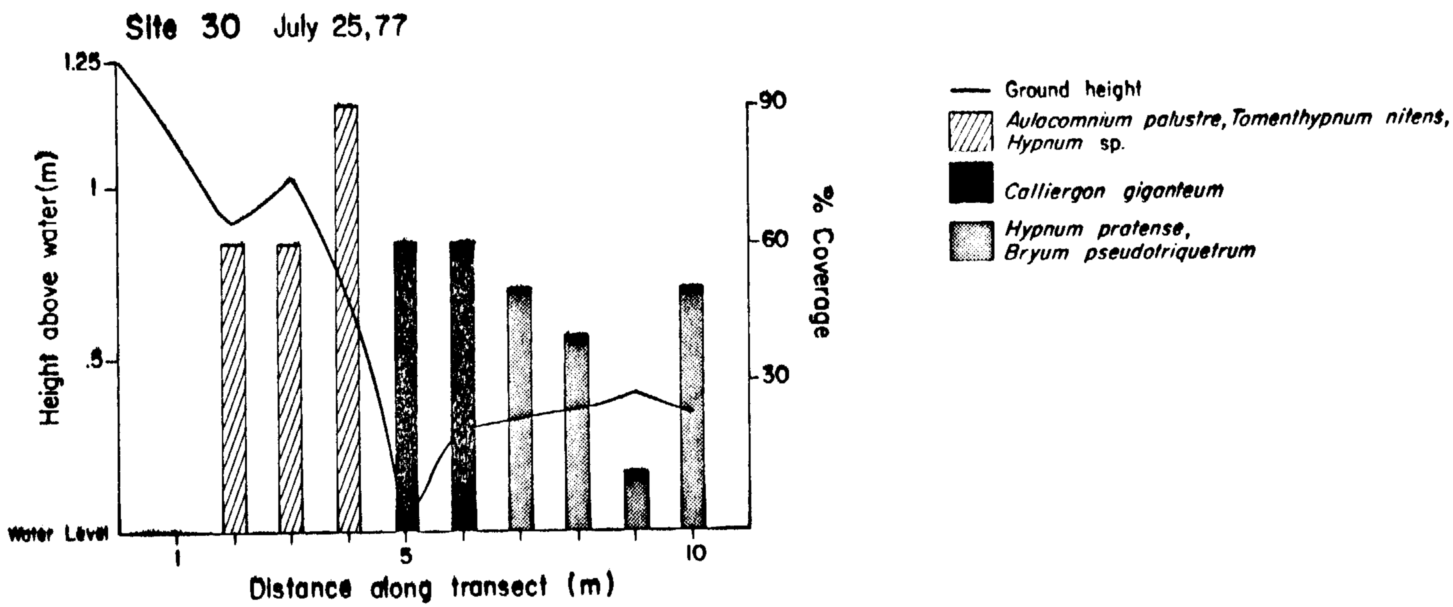

Site 24, Transect 1
Ground height
Sphagnum squarrosum, S. teres
Calliergon giganteum
Height above water (m)
.50
.25
Level water
5
10
15
20
Distance along transect (m)
100
80
60
40
20
% Coverage


Site 24, Transect 2
Ground height
Myrica gale
Calla palustris
Calliergon giganteum
C. richardsonii
C. cordifolium
Height above water (m)
1
.50
.25
Level water
5
10
Distance along transect (m)
100
80
60
40
20
% Coverage


Site 24, Transect 3
Ground height
Myrica gale
Carex rostrata
C. aquatilis + Vegetative Carex spp.
Height above water (m)
.50
.25
Level water
5
10
Distance along transect (m)
100
80
60
40
20
% Coverage


Site 29 July 25, 77
Ground height
Potentilla palustris
Calliergon spp.
Height above water (m)
1
.5
.25
Water Level
% Coverage
50
30
10
1
5
10
Distance along transect (m)


Site 28 July 25, 77
Ground height
Chamaedaphne calyculata
Sphagnum russowii
Height above water (m)
1.5
1
.5
Water Level
% Coverage
90
60
30
1
5
10
14
Distance along transect (m)


Site 30 July 25, 77
Height above water (m)
1.25
1
.5
Water Level
% Coverage
90
60
30
1
5
10
Distance along transect (m)
Ground height
Aulacomnium palustre, Tomenthypnum nitens, Hypnum sp.
Calliergon giganteum
Hypnum pratense, Bryum pseudotriquetrum

APPENDIX B.1

INVERTEBRATES

Classification of invertebrate fauna collected from the thirty-three study sites in 1977.

Order	Family	Genus	Species
Bryozoans			
Ctenostomata	Paludicellidae	Paludicella	*articulata* (Ehr.)
Plumatellina	Cristatellidae	Cristatella	*mucedo* Cuvier
	Lophopodidae	Pectinatella	*magnifica* Leidy
	Plumatellidae	Fredericella	*saltana* (Blumenbach)
Leeches			
Rhynchobdellida	Glossiphoniidae	Glossiphonia	*complanata* (L.)
		Helobdella	*fusca* (Castle)
		Placobdella	*papillifera*
		Theromyzon	sp.
Arhynchobdellida	Erpobdellidae	Dina	*parva* Moore
		Nephelopsis	*obscura* Verrill
Water fleas			
Cladocera	Daphnidae	Daphnia	*pulex* (de Geer)
	Holopedidae	Holopedium	*gibberum* Zaddach
Eucopypoda	Cyclopidae	Cyclops	*varicans* (Sars)
Seed shrimps			
Ostracoda	Cypridae	Cypriconcha	sp.
Scuds			
Amphipoda	Talitridae	Hyallela	*azteca* (Saussure)
	Gammaridae	Gammarus	*lacustris* (Sars)
Water mites			
Hydracarina	Hydrachnidae	Hydrachna	sp. nr. *cruenta* Müller
	Limnocharidae	Limnochares	*americana* Lundblad
	Pionidae	Piona	*carnea* (Koch)
Spiders			
Araneae	Erigonidae	Grammonota	sp.
	Philodromidae	Tibellus	*oblongus* (Walckenaer)
	Salticidae	Pellenes	sp.
Mayflies			
Ephemeroptera	Baetidae	Caenis	sp.
Damselflies			
Zygoptera	Coenagrionidae	Lestes	sp.
		Enallagma	sp.
		Ischnura	sp.

Continued.

Order	Family	Genus	Species
Water bugs			
Hemiptera	Gerridae	Gerris	*buenoi* kld
		Trepobates	sp.
	Notonectidae	Notonecta	*borealis* Botltus
		Notonecta	sp. nymphs
	Pleidae	Plea	*striola* Fieber
	Corixidae	Callicorixa	*audeni* HLd.
		Cenocorixa	sp.
		undet. nymphs	
		Cymatia	*americana* (Hassey)
Caddis flies			
Trichoptera	Leptaceridae	Triaenodes	sp.
	Limnophilidae	Nemataulius	sp.
	Phryganeidae	Agrypnia	sp.
		Phryganea	sp.
Beetles			
Coleoptera	Haliplidae	Haliplus	sp.
	Dytiscidae	Acilius	sp.
		Dytiscus	sp.
		Graphoderus	sp.
		Helisoma	sp.
		Hygrotus	sp.
		Ilybius	sp.
		Laccophilus	sp.
		Rhantus	sp.
	Gyrinidae	Gyrinus	sp.
	Chrysomelidae	Donacia	sp.
		Galerucella	*nymphaea*
Midges, flies			
Diptera	Culicidae	Chaoborus	*americanus* (Joh.)
		Culicini	sp.
	Ceratopogoniidae	Palpomyia	sp.
	Tendipedidae	Ablabesinia	sp.
		Cricotopus	sp.
		Endochironomus	sp.
		Microtendipes	sp.
		Procladius	sp.
	Tipulidae		

Continued.

Order	Family	Genus	Species
Snails, Limpets			
Pulmonata	Planorbidae	Carinifex	sp.
		Gyraulus	sp.
	Physidae	Physa	sp.
	Lymnaeidae	Lymnaea	sp.
	Ancylidae	Ferrissia	sp.
Clams			
Pelecypoda	Sphaeriidae		

APPENDIX B.2

"INVERTEBRATE COMPOSITION FOR ONE

SWEEP NET ON EACH SAMPLING DATE"

Site #1 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Bryozoa	(40%) 2								(43.5%) 10
Daphnidae	(60%) 3	(5.3%) 10				(17.4%) 4		(33.3%) 11	(26.0%) 6
Cyclopidae		(42.1%) 80	(41.7%) 50		(17.6%) 3		(22.7%) 5	(66.6%) 22	(17.4%) 4
Cypridae		(5.3%) 10	(25%) 30	(68.6%) 35	(5.9%) 1				
Talitridae		(21.0%) 40				(41.2%) 7	(36.4%) 8		
Gammaridae		(26.3%) 50	(10%) 12	(7.8%) 4	(41.1%) 7				
Coenagrionidae				(13.7%) 1		(17.6%) 3	(9.1%) 2		
Corixidae			(0.8%) 1						
Lepinostonidae					(17.6%) 3		(4.5%) 1		
Dytiscidae		(0.5%) 1		(2.0%) 1			(4.5%) 1		(13.0%) 3
Chrysomelidae			(10%) 12	(3.9%) 2	(11.7%) 2	(17.6%) 3			
Culicidae		(7.9%) 15	(12.5%) 15						
Planorbidae				(2.0%) 1	(5.9%) 1				
Lymnaeidae				(2.0%) 1		(35.3%) 6	(22.7%) 5		
Total	5	190	120	51	17	23	22	33	23

Site #2 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Arhynchobellidae						(2.3%) 1			
Chrysomelidae			(2.2%) 2		(11.1%) 2(L)	(25.6%) 11	(5.3%) 1		
Coenagrionidae				(10.4%) 5		(14.6%) 2			
Corixidae		(1.1%) 1		(14.2%) 2	(11.1%) 2	(4.6%) 2		(2.7%) 1	
Calicidae		(11.7%) 11	(8.8%) 8	(4.2%) 2					
Cyclopidae		(26.6%) 25	(38.9%) 35	(41.7%) 20	(38.9%) 7	(11.6%) 5	(52.6%) 10	(67.6%) 25	(72.7%) 8
Cypridae			(27.8%) 25		(11.1%) 2	(2.3%) 1			
Daphnidae		(5.3%) 5							(27.3%) 3
Gammoridae	(100%) 6	(23.4%) 22	(22.2%) 20	(20.8%) 10	(22.2%) 4	(39.5%) 17	(26.3%) 5		
Lymnaeidae						(2.3%) 1			
Physidae				(2.1%) 1					
Talitridae		(31.9%) 30	90	(16.7%) 8	(5.6%) 1	(7.0%) 3	(15.8%) 3	(29.7%) 11	
Total	6	94		48	18	43	19	37	11

Site #3 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysometidae			(4.9%) 2		4(ad)←(12.5%) 11(L) ←(34.4%)		(8.3%) 1		
Coenagrionidae								(4.4%) 2	
Corixidae				(4.8%) 3	(3.1%) 1			(4.4%) 2	
Calicidae		(9.7%) 11	(7.3%) 3		(3.1%) 1				
Cyclopidae		(44.2%) 50	(48.8%) 20	(3.2%) 2	(15.6%) 5	(86.5%) 45		(55.6%) 25	(72.7%) 8
Daphnidae	(40%) 2	(44.2%) 50	(36.6%) 15	(64.5%) 40	(6.2%) 2	(5.8%) 3		(22.2%) 10	
Dytiscidae				(1.6%) 1					
Gammaridae	(60%) 3	(1.8%) 2	(2.4%) 1	(8.1%) 5	(25%) 8				
Glossiphoniidae							(8.3%) 1		
Lymnaeidae						(1.9%) 1	(8.3%) 1		
Pleidae				(1.6%) 1			(8.3%) 1		
Talitridae				(16.1%) 10		(5.8%) 3	(66.7%) 8	(13.3%) 6	(27.3%) 3
Total	5	113	41	62	32	52	12	45	11

Site #4 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae			(7.1%) 2		(75%) 3(L)	2(L) ← (6.9%) 16(ad)←(55.2%)			
Coenagrionidae								(2.8%) 1	
Culicidae		(5.3%) 5	(10.7%) 3	(5%) 1				(14.3%) 5	(5.3%) 1
Cyclopidae		(26.3%) 25	(71.4%) 20	(10%) 2				(57%) 20	(78.9%) 15
Cypridae			(7.1%) 2						
Daphnidae	(90.9%) 500	(52.6%) 50		(30%) 6				(5.7%) 2	(10.5%) 2
Dytiscidae			(3.6%) 1						
Gammaridae	(9.1%) 50	(15.8%) 15		(50%) 10	(25%)	(24.1%) 7	(100%) 12		
Physidae						(3.4%) 1			
Talitridae						(10.3%) 3		(20%) 7	(5.3%) 1
Total	550	95	28	20		29	12	35	19

Site #5 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chironomidae				(4%) 1					
Chrysomelidae			(8.3%) 2		(80%) 4(L)	(33.3%) 1	(16.6%) 1		
Coenagrionidae				(4%) 1			(50%) 3		
Corixidae			(4.2%) 1	(4%) 1					
Culicidae			(4.2%) 1						
Cyclopidae		(75%) 15	(83.3%) 20	(60%) 15		(33.3%) 1		(100%) 10	
Daphnidae		(15%) 3		(20%) 5			(16.6%) 1		
Dytiscidae		(5%) 1							
Gammoridae					(20%) 1				
Hydracarina				(4%) 1					
Phryganeidae									
Planorbidae						(33.3%) 1			
Talitridae		(5%) 1		(4%) 1			(16.6%) 1		
Total		0	24	25	5	3	6	10	

Site #6 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Ceratopogonidae	(9.1%) 1								
Coenagrionidae							(14.3%) 1		
Corixidae		(9.1%) 1	(15.4%) 2	(50%) 5					
Culicidae		(63.6%) 7	(61.5%) 8				(42.8%) 3	(100%) 6	(100%) 3
Cyclopidae			(15.4%) 2						
Daphnidae	(90.9%) 10	(9.1%) 1		(40%) 4					
Dytiscidae					(50%) 1				
Gammaridae		(18.2%) 2	(7.7%) 1	(10%) 1	(50%) 1				
Sphaeriidae						(100%) 1			
Talitridae							(42.8%) 3		
Total	11	11	13	10	2	1	7	6	3

Site #7 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Bryozoa						(1.2%) 1			
Chrysomelidae						(7.0%) 6	(3.3%) 2		
Coenogrionidae						(15.3%) 13			
Corixidae		(5.9%) 1		(6.4%) 2		(1.2%) 1			(20%) 2
Culicidae	(95.2%) 100	(23.5%) 4	(13.8%) 4	(6.4%) 2	(50%) 4	(5.9%) 5	(1.7%) 1		(60%) 6
Cyclopidae					(20%) 1	(11.8%) 10	(50%) 30	(8.3%) 1	(10%) 1
Daphnidae	(4.8%) 5	(17.6%) 3	(86.2%) 25	(80.6%) 25			(16.7%) 10	(50%) 6	(10%) 1
Dytiscidae		(5.9%) 1							
Erpobdellidae						(3.5%) 3			
Lymnoeidae						(35.3%) 30	(6.7%) 4		
Notonectidae								(8.3%) 1	
Phryganeidae		(5.9%) 1					(1.7%) 1		
Physidae						(7.0%) 6			
Talitridae		(29.4%) 5		(3.2%) 1		(11.8%) 10	(20%) 12	(33.3%) 4	
Tipulidae				(3.2%) 1					
Gammaridae		(11.8%) 2							
Total	105	17	29	31	5	85	60	12	10

Table Site #8 - Invertebrate Composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/8	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Bryozoa		(12.5%) 1						(8.3%) 1	
Chrysomelidae						(7.7%) 1			
Coenagrionidae			(16.6%) 1	(37.5%) 3			(5%) 1		
Culicidae		(50%) 4						(25%) 3	
Cyclopidae							(30%) 6		
Daphnidae		(37.5%) 3	(33.3%) 2					(50%) 6	
Gerridae					(6.2%) 1	(46.2%) 6			
Glossiphoniidae								(8.3%) 1	
Halipidae						(7.7%) 1			
Hydracarina							(15%) 3		
Lymnaeidae				(25%) 2	(68.8%) 11	(30.8%) 4	(5%) 1		
Physidae				(37.5%) 3	(25%) 4	(7.7%) 1	(5%) 1	(5.3%) 1	
Planorbidae			(33.3%) 2				(40%) 8		
Sphaeridae			(16.6%) 1						
Total	0	8	6	8	16	13	20	12	

Site #9 - Invertebrate composition for one sweep net on each sampling date.

Family	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
	Collection Date								
Araneae					(3.8%) 1				
Corixidae		(1.7%) 1	(0.7%) 1	(2.7%) 3	(26.9%) 7	(0.3%) 1			
Culicidae		(3.3%) 2	(3.4%) 5						
Cyclopidae		(83.3%) 50	(86.3%) 120	(90.9%) 100	(3.8%) 1	(80.2%) 300	(78.1%) 250	(85.7%) 300	
Daphnidae		(8.3%) 5	(7.2%) 10		(3.8%) 1	(18.7%) 70	(21.9%) 70	(14.3%) 50	
Dytiscidae		(3.3%) 2	(2.2%) 3	(0.9%) 1					
Gerridae				(0.9%) 1	(3.8%) 1	(0.3%) 1			
Gyrinidae					(7.7%) 2				
Hydracarina						(0.3%) 1			
Lymnaeidae				(2.7%) 3	(42.3%) 11				
Phryganeidae						(0.3%) 1			
Physidae				(1.8%) 2	(3.8%) 1				
Planorbidae					(3.8%) 1				
Total	0	60	139	110	26	374	320	350	0 = 1,379 tH

Site #10. Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae			(12%) 6						
Coenagrionidae			(6%) 3	(3.2%) 1					
Corixidae			(2%) 1						
Culicidae	(8.7%) 10	(54.0%) 40		(32.2%) 10	(68.6%) 24	(16.6%) 2	(6.6%) 4	(15.9%) 7	(16.4%) 9
Cyclopidae		(1.4%) 1	(50%) 25	(32.2%) 10		(33.3%) 4	(27.9%) 17	(56.8%) 25	
Daphnidae	(52.2%) 60	(27.0%) 20	(24%) 12	(19.4%) 6	(25.7%) 9	(50%) 6	(65.6%) 40	(27.3%) 12	(83.6%) 46
Dytiscidae			(2%) 1	(3.2%) 1					
Gyrinidae					(2.8%) 1				
Hydracarina	(39.1%) 45	(4.0%) 3		(9.7%) 3					
Anaylidae			(2%) 1						
Phsyidae			(2%) 1						
Talitridae								(2.3%) 1	
Total	115	74	50	31	35	12	61	44	55

:. Site #11 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date									
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Chrysomelidae			(50%) 1							
Corixidae							(85.7%) 12			
Culicidae										
Cyclopidae			(50%) 1	(66.6%) 2				(100%) 9		
Daphnidae				(33.3%) 1						
Planorbidae							(14.3%) 2			
Total	0	0	2	3	0	0	14	9	0	= 28 tH

Site #13 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date									
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Chironomidae						(7.1%) 1				
Corixidae						(64.3%) 9				
Culicidae	(13.9%) 5									
Daphnidae	(83.3%) 30		(96.2%) 25		(83.3%) 5	(7.1%) 1				
Dytiscidae			(3.8%) 1		(16.7%) 1					
Planorbidae	(2.8%) 1									
Talitridae						(21.4%) 3				
Total	36	0	26	0	6	14	0	0	0	= 82 tH

Site #14 - Invertebrate composition for one sweep net on each sampling date.

Family	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
	Collection Date									
Bryozoa					(8.3%) 2					
Crenagrionidae						(11.1%) 1				
Culicidae	(2.4%) 1			(9.1%) 2				(1.9%) 1	(8.3%) 1	
Cyclopidae		(44.4%) 20	(60%) 6		(45.8%) 11		(87.5%) 28	(98.1%) 50	(8.3%) 1	
Daphnidae	(73.2%) 30	(55.6%) 25	(40%) 4	(90.9%) 20	(45.8%) 11	(55.6%) 5			(83.3%) 10	
Gammaridae	(24.4%) 10									
Planorbidae						(11.1%) 1	(12.5%) 4			
Talitridae						(22.2%) 2				
Total	41	45	10	22	24	9	32	51	12	= 244 t[illegible]

Site#15 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Ancylidae						(14.3%) 1				
Baetidae		(23.8%) 10								
Coenagionidae		(23.8%) 10				(28.6%) 2				
Corixidae					(33.3%) 1					
Cyclopidae		(9.5%) 4	(19.2%) 5							
Daphnidae	(90.9%) 10	(16.7%) 7	(76.9%) 20	(99.5%) 400				(100%) 10	(100%) 4	
Gammaridae		(23.8%) 10								
Glossiphoniidae			(3.8%) 1							
Hydracarina		(2.4%) 1		(0.5%) 2						
Lymnaeidae					(33.3%) 1		(14.3%) 2			
Physidae					(33.3%) 1		(21.4%) 3			
Planorbidae						(14.3%) 1	(57.1%) 8			
Sphaeriidae						(14.3%) 1				
Talitridae	(9.1%)					(28.6%) 2	(7.1%) 1			
Total	11	42	26	402	3	7	14	10	4	= 519 tH

Site#16 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae						(33.3%) 2			
Coenagrionidae		(14.3%) 1							
Corixidae		(14.3%) 1				(50%) 3		(2.6%) 1	
Culicidae				(66.7%) 10		(16.6%) 1	(3.6%) 2		
Cyclopidae		(57.1%) 4	(28.6%) 4				(1.8%) 1	(18.4%) 7	
Daphnidae	(100%) 1	(14.3%) 1	(71.4%) 10				(89.3%) 50+	(78.9%) 30	(100%) 5
Dytiscidae				(26.7%) 4					
Erpobdellidae							(1.8%) 1		
Hydracarina				(6.7%) 1	(100%) 1				
Lymnaeidae							(1.8%) 1		
Planorbidae							(1.8%) 1		
Total	1	7	14	15	1	6	56	38	5

Site #17 - Invertebrate composition for one sweep net on each sampling date.

Family	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Corixidae		(5.5%) 3		(4%) 1					
Culicidae					(16.6%) 1				
Cyclopidae		(90.9%) 50	(83.3%) 15	(36%) 9	(16.6%) 1		(68.6%) 35	(93.8%) 30	(50%) 1
Daphnidae		(3.6%) 2	(16.7%) 3	(60%) 15	(66.6%) 4		(29.4%) 15	(6.2%) 2	(50%) 1
Planorbidae							(2.0%) 1		
Total	0	55	18	25	6	0	51	32	2

Site #18 - Invertebrates composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Bryozoa					(4.2%) 1		(23.5%) 4		
Chrysomelidae			(70%) 7(L)	(50%)	1L(4.2%) 12ad	(13.3%) 4			
Coenagrionidae		(30.8%) 4	(10%) 1		(4.2%) 1	(36.7%) 11	(35.3%) 6		
Corixidae					(4.2%) 1				
Cyclopidae		(15.4%) 2		(100%) 2	(4.2%) 1	(6.7%) 2	(29.4%) 5	(75%) 15	(100%) 5
Daphnidae		(30.8%) 4			(16.7%) 4	(13.3%) 4		(25%) 5	
Dytiscidae		(7.7%) 1	(10%) 1		(12.5%) 3				
Erpobdellidae							(5.9%) 1		
Planorbidae		(15.4%) 2				(26.7%) 8	(5.9%) 1		
Sphaeriidae						(3.3%) 1			
Glossiphoniidae			(10%) 1						
Total	0	13	10	2	24	30	17	20	5

Site #19 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae			(66.6%) 4	(7.7%) 1(L)	4(ad)-(2.4%) 4(L) -(2.4%)				
Coenagrionidae					(1.2%) 2				
Culicidae					(0.6%) 1				
Cyclopidae		(2.0%) 3		(77.0%) 10	(3.0%) 5			(20%) 5	
Daphnidae					(90.3%) 150		(100%) 1	(80%) 20	(100%) 60
Dytiscidae			(16.6%) 1						
Glossiphoniidae				(7.7%) 1		(50%) 1			
Holopedidae	(100%) 65	(98%) 150							
Planorbidae			(16.6%)						
Talitridae						(50%) 1			
Tendipedidae				(7.7%) 1					
Total	65	153	6	13	166	2	1	25	60

Site #20 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae		(62.5%) 25	5(ad) 2(L)		(12.5%) 1	(10.5%) 2			
Coenagrionidae						(26.3%) 5	(16.7%) 5		
Corixidae				(36.3%) 4					
Cypridae		(12.9%) 12							
Culicidae	(9.1%) 20	(68.8%) 64		(18.2%) 2	(12.5%) 1	(5.3%) 1	(30%) 9	(57.1%) 40	(90.9%) 40
Daphnidae	(68.2%) 150			(27.3%) 3				(7.1%) 5	(9.1%) 4
Dytiscidae				(18.2%) 2					
Gyrinidae					(75%) 6				
Hydraearina	(22.7%) 50	(17.2%) 16						(1.4%) 1	
Lymnaeidae						(52.6%) 10	(33.3%) 10	(1.4%) 1	
Phryganeidae		(1.1%) 1	(12.5%) 1					(14.2%) 10	
Physidae								(2.8%) 2	
Phanorbidae								(1.4%) 1	
Talitridae						(5.3%) 1	(20%) 6	(14.2%) 10	
Total	220	93	8	11	8	19	30	70	44

Site #21 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Araneae									
Chrysomelidae						(16.6%) 1			
Coenagrionidae				(5.3%) 1		(16.6%) 1			
Corixidae		(2%) 2		(10.5%) 2					
Culicidae	(8.3%) 5	(3.9%) 4						(20%) 6	(23.5%) 4
Cyclopidae	(50%) 30	(43.7%) 45		(26.3%) 5	(88.9%) 16	(16.6%) 1	(100%) 32	(66.7%) 20	(58.8%) 10
Cypridae		(48.5%) 50		(52.6%) 10	(5.6%) 1				
Daphnidae	(41.7%) 25								(17.6%) 3
Dytiscide		(1%) 1		(5.3%) 1					
Gyrinidae					(5.6%) 1	(16.6%) 1			
Talitridae						(33.3%) 2		(13.3%) 4	
Total	60	103	0	19	18	6	32	30	17

Site #22 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Ceratopogonidae	(6.8%) 3								
Coenagrionidae								(5.5%) 1	
Corixidae			(7.7%) 1	(50%) 5	(90%) 9	(50%) 1			
Culicidae	(2.3%) 1	(17.6%) 6		(20%) 2			(2.8%) 1	(11.1%) 2	(7.0%) 6
Cyclopidae				(10%) 1				(6.7%) 12	
Cypridae			(76.9%) 10						
Daphnidae	(90.9%) 40	(73.5%) 25					(83.3%) 30	(16.7%) 3	(93.0%) 80
Dytiscidae		(2.9%) 1	(7.7%) 1						
Gammaridae		(2.9%) 1	(7.7%) 1	(10%) 1					
Gyrinidae		(2.9%) 1		(10%) 1	(10%) 1	(50%) 1	(13.9%) 5		
Total	44	34	13	10	10	2	36	18	86

Site #23 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Coenagrionidae						(4.3%) 1			
Corixidae	(25%) 1		(13.0%) 3	(1.2%) 1	(5.4%) 4			(2.4%) 1	
Culicidae	(50%) 2	(7.1%) 3							
Cyclopidae		(71.4%) 30	(87.0%) 20	(47.0%) 40	(94.6%) 70	(87.0%) 20	(100%) 21	(97.6%) 40	(76.5%) 13
Daphnidae	(25%) 1	(19.0%) 8		(47.0%) 40					(23.5%) 4
Gammaridae		(2.4%) 1		(1.2%) 1					
Gyrinidae				(3.5%) 3					
Lymnaeidae						(8.7%) 2			
Total	4	42	23	85	74	23	21	41	17

Table Site #24 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Anaylidae							(16.7%) 5		
Bryozoa							(3.3%) 1		
Coenagrionidae				(3.8%) 1	no sample				
Corixidae				(11.5%) 3		(1.3%) 1		(4.8%) 1	
Culicidae		(1.4%) 1							
Cyclopidae		(55.6%) 40	(71.4%) 5			(66.2%) 51	(50%) 15	(95.2%) 20	(22.2%) 4
Daphnidae		(41.7%) 30		(76.9%) 20		(19.5%) 15	(20%) 6		(77.8%) 14
Dytiscidae		(1.4%) 1	(28.6%) 2	(7.7%) 2					
Planorbidae						(13.0%) 10	(10%) 3		
Total	0	72	7	26		77	30	21	18

Site #25 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Baetidae		(6.1%) 4								
Bryozoa					(2.8%) 1					
Chironomidae		(1.5%) 1								
Coenagrionidae		(3.0%) 2				(20%) 1				
Corixidae				(5.3%) 2			(7.7%) 1		no sample	
Culicidae	(4.3%) 2	(1.5%) 1						(6.2%) 2		
Cyclopidae	(43.5%) 20		(30%) 3	(52.6%) 20	(42.8%) 15		(38.5%) 5	(31.2%) 10		
Cypridae		(46.2%) 30								
Daphnidae	(39.1%) 18	(38.5%) 25		(39.5%) 15	(48.6%) 17	(20%) 1		(37.5%) 12		
Dytiscidae		(3.0%) 2		(2.6%) 1	(2.8%) 1					
Gammaridae	(10.8%) 5		(50%) 5							
Clossigphoniidae			(10%) 1							
Lymnaeidae					(2.8%) 1		(38.5%) 5	(6.2%) 2		
Physidae			(10%) 1	(10%) 1		(20%) 1	(7.7%) 1	(9.4%) 3		
Planorbidae	(2.2%) 1					(40%) 2				
Talitridae							(7.7%) 1	(9.4%) 3		
Total	46	65	10	10	35	5	13	32		= 233 tH

Site #26 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date 23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Corixidae					(10%) 1					
Culicidae					(10%) 1					
Cyclopidae	(27.3%) 15	(50%) 12	(92.8%) 13	(88.2%) 15	(50%) 5	(26.7%) 4	(71.4%) 30	(25%) 2	(60%) 15	
Daphnidae	(72.2%) 40	(41.7%) 10		(11.8%) 2	(20%) 2		(28.6%) 12	(37.5%) 3	(40%) 10	
Dytiscidae		(8.3%) 2								
Hydracarina			(7.2%) 1							
Physidae					(10%) 1	(23.1%) 3		(12.5%) 1		
Talitridae						(53.3%) 8		(25%) 2		
Total	55	24	14	17	10	15	42	8	25	= 210 tH

Site #27 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Chrysomelidae			(4.4%) 7(L)						
Culicidae	(2.4%) 1				(16.6%) 1				
Cyclopidae	(48.8%) 20	(7.0%) 30	(27.0%) 40	(16.6%) 1	(33.3%) 2	(44.0%) 120	(100%) 95		(100%) 3
Cypridae		(93%) 400	(67.6%) 100	(53.3%) 5	(33.3%) 2	(1.1%) 3			
Daphnidae	(48.8%) 20				(16.6%) 1	(54.9%) 150		(100%) 1	
Dytiscidae			(0.7%) 1						
Total	41	430	148	6	6	273	95	1	3

Site #28 - Invertebrate composition for one sweep net on each sampling date.

Family	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Coenagrionidae								(2.6%) 2	
Corixidae	(1.5%) 1	(1.8%) 1		(4.3%) 2	(8.7%) 5			(2.6%) 2	
Culicidae	(33.8%) 22	(70.2%) 40	(21.3%) 10	(54.3%) 25	(52.6%) 30		(63.8%) 37	(2.6%) 2	(20%) 25
Cyclopidae				(10.9%) 5		(9.2%) 5	(3.4%) 2		
Cypridae				(2.2%) 1					
Daphnidae	(61.5%) 40	(26.3%) 15	(74.5%) 35	(21.7%) 10	(38.6%) 22	(74.1%) 40	(32.8%) 19	(92.1%) 70	(80%) 100
Dytiscidae	(1.5%) 1	(1.8%) 1	(2.1%) 1	(4.3%) 2					
Glossiphoniidae			(2.1%) 1						
Gyrinidae						(1.8%) 1			
Hydracarina						(1.8%) 1			
Phryganeidae	(1.5%) 1								
Physidae						(1.8%) 1			
Planorbidae				(2.2%) 1					
Sphaeriidae						(1.8%) 1			
Talitridae						(9.2%) 5			
Total	65	57	47	46	57	54	58	76	125

Site #29 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Bryozoa									(50.0%) 3
Chrysanelidae							(6.6%) 1		
Coenagrionidae							(40.0%) 6	(1.6%) 1	
Corixidae		(1.8%) 1	(10%) 1	(23.0%) 3	(66.6%) 2				
Culicidae	(1.6%) 1		(20%) 2				(6.6%) 1	(82.0%) 50	
Cyclopidae			(10%) 1				(13.3%) 2		
Cypridae				(15.4%) 2					
Daphnidae	(98.0%) 100	(89.2%) 50	(50%) 5	(61.5%) 8		(88.2%) 45		(8.2%) 5	(33.3%) 2
Dytiscidae		(3.6%) 2							
Gammaridae	(1%) 1		(10%) 1				(6.6%) 1		
Gyrianidae		(1.8%) 1				(11.8%) 6			
Hydracarina		(3.6%) 2							
Lymnaeidae									(16.6%) 1
Phryganeidae					(33.3%) 1		(6.6%) 1		
Planorbidae							(6.6%) 1		
Talitridae							(13.3%) 2	(8.2%) 5	
Total	102	56	10	13	3	51	15	61	6

Table 29. Site #30 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/8	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Coenagrionidae								(20%) 2	
Corixidae		(1.4%) 1		(9.5%) 2	(100%) 1				
Culicidae	(13.6%) 16	(45.2%) 33	(100%) 5	(4.8%) 1			(10.0%) 4	(30%) 3	(46.1%) 6
Daphnidae	(84.7%) 100	(47.9%) 35		(71.4%) 15		(33.3%) 1	(87.5%) 35	(40%) 4	(53.8%) 7
Dytiscidae				(14.3%) 3					
Gammaridae	(0.8%) 1	(4.1%) 3				(33.3%) 1			
Glossiphoniidae							(2.5%) 1		
Gyrinidae						(33.3%) 1			
Planorbidae		(1.4%) 1							
Talitridae	(0.8%) 1							(10%) 1	
Total	118	73	5	21	1	3	40		13

Site #31 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date								
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10
Corixidae	No Sample				(7.7%) 1		(2.0%) 2	(3.1%) 1	
Culicidae		(13.3%) 2	(10.7%) 3	(19.0%) 4			(19.6%) 20		(50%) 5
Daphnidae		(26.6%) 4	(71.4%) 20	(71.4%) 15	(92.3%) 12		(78.4%) 80	(93.8%) 30	(50%) 5
Dytisiidae				(4.8%) 1					
Gammaridae		(60.0%) 9	(17.8%) 5	(4.8%) 1					
Gyrinidae						(100%) 1			
Talitridae								(3.1%) 1	
Total		15	28	21	13	1	102	32	10

Site # 32 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date									
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Chrysanilidae	(2.0%) 1									
Coenagrionidae	(9.8%) 5						(2.6%) 1			
Corixidae				(7.1%) 1	(33.3%) 1	(33.3%) 1	(2.6%) 1			
Culicidae	(27.4%) 14	(14.3%) 2	(14.3%) 2				(2.6%) 1	(11.1%) 2	(42.8%) 3	
Cyclopidae								(5.5%) 1		
Daphnidae	(19.6%) 10	(85.7%) 12	(71.4%) 10	(71.4%) 10			(7.9%) 3	(83.3%) 15	(57.1%) 4	
Dytiscidae	(9.9%) 3		(7.1%) 1	(21.4%) 3						
Gammaridae	(19.6%) 10		(7.1%) 1		(66.6%) 2					
Gyrinidae						(66.6%) 2				
Lymnaeidae	(3.9%) 2						(2.6%) 1			
Planorbidae	(11.8%) 6						(57.9%) 22			
Sphaeriidae							(5.3%) 2			
Talitridae							(18.4%) 7			
Total	51	14	14	14	3	3	38	18	7	= 163 tH

Site #33 - Invertebrate composition for one sweep net on each sampling date.

Family	Collection Date									
	23/5	11/6	24/6	11/7	27/7	21/8	7/9	24/9	6/10	
Baetidae					(7.7%) 1					
Bryozoa					(7.7%) 1					
Chrysomelidae						(9.0%) 1		(7.4%) 2		
Coenagrionidae							(4.8%) 1			
Corixidae			(20%) 1		(7.7%) 1					
Culicidae	(59.6%) 31	(16.3%) 8		(33.3%) 1		(18.2%) 2	(23.8%) 5		(13.0%) 3	
Cyclopidae					(38.5%) 5		(4.8%) 1	(3.7%) 1		
Daphnidae	(38.5%) 20	(81.6%) 40	(80%) 4	(33.3%) 1	(23.1%) 3	(45.4%) 5	(52.4%) 11	(18.5%) 5	(86.9%) 20	
Dytiscidae				(33.3%0 1						
Gammaridae						(9.0%) 1	(4.8%) 1			
Glossiphoniidae								(3.7%) 1		
Hydracarina	(1.9%) 1	(2.0%) 1					(4.8%) 1			
Lymnaeidae						(9.0%) 1		(11.1%) 3		
Phryganeidae					(7.7%) 1					
Planorbidae							(4.8%) 1	(11.1%) 3		
Talitridae					(7.7%) 1	(9.0%) 1		(44.4%) 12		
Total	52	49	5	3	13	11	21	27	23	= 204 tH

APPENDIX B.3

SHANNON-WEAVER DIVERSITY

AND EQUITABILITY INDICES

Pond #1. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.6730	0.9709
11/6	1.5397	.7912
24/6	1.4703	.8206
11/7	1.0953	.5629
27/7	1.5630	.8723
21/8	1.5324	.9521
07/9	1.5388	.8588
24/9	0.6365	.9182
06/10	1.0294	.9370
mean	1.2309	.8538

Pond #2. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.0000	undefined
11/6	1.5129	0.8443
24/6	1.3554	.8422
11/7	1.5724	.8080
27/7	1.5948	.8900
21/8	1.6967	.7720
07/9	1.1364	.8197
24/9	0.7227	.6579
06/10	0.5862	.8457
mean	1.1308	.8100

Pond #3. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.6730	0.9709
11/6	1.0203	.7360
24/6	1.1476	.7130
11/7	1.1688	.6006
27/7	1.3796	.7700
21/8	0.5310	.3830
07/9	1.0965	.6813
24/9	1.2038	.7480
06/10	0.5862	.8457
mean	0.9785	.7165

Pond #4. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.3048	0.4397
11/6	1.1364	.8197
24/6	0.9749	.6057
11/7	1.2375	.7689
27/7	0.5623	.8112
21/8	0.9878	.7125
07/9	0.0000	undefined
24/9	1.1841	.7357
06/10	0.7350	.5301
mean	0.7914	.6779

Pond #5. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11.6	0.7999	0.5770
24/6	0.6250	.4508
11/7	1.2721	.6537
27/7	0.5004	.7219
21/8	1.0986	1
07/9	0.0361	.0260
24/9	0	undefined
06/10	undefined	undefined
mean	0.6189	.5716

Pond #6. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.3048	0.4397
11/6	1.0341	.7459
24/6	1.0726	.7737
11.7	0.9433	.8586
27/7	0.6931	1
21/8	0	undefined
07/9	1.0045	.9143
24/9	0	undefined
06/10	0	undefined
mean	0.5614	.7887

Pond #7. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.1925	.2778
11/6	1.7591	.9040
24/6	0.4013	.5789
11/7	0.7454	.4631
27/7	0.5004	.7219
21/8	1.9219	.8346
07/9	1.3991	.7190
24/9	1.1260	.8122
06/10	1.0888	.7854
mean	1.0149	.6774

Pond #8. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	0.9743	0.8868
24/6	1.3291	.9588
11/7	1.0821	.9850
27/7	0.7762	.7065
21/8	1.3114	.8148
07/9	1.4616	.8157
24/9	1.3132	.8159
06/10	undefined	undefined
mean	1.1783	.8548

Pond #9. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	0.6528	0.4056
24/6	0.5493	.3413
11/7	0.4383	.2446
27/7	1.6621	.7564
21/8	0.5606	.3128
07/9	0.5256	.7583
24/9	0.4103	.5920
06/10	undefined	undefined
mean	0.6856	.4873

Pond #10. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.9189	0.8364
11/6	0.8662	.6248
24/6	1.4252	.6854
11/7	1.4950	.8343
27/7	0.8077	.5826
21/8	1.0108	.9201
07/9	0.8123	.7393
24/9	1.0538	.7602
06/10	0.4462	.6437
mean	0.9818	.7363

Pond #11. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	undefined	undefined
24/6	0.6931	1
11.7	0.6365	0.9182
27/7	undefined	undefined
21/8	undefined	undefined
07/9	0.4103	.5920
24/9	0	undefined
06/10	undefined	undefined
mean	0.4350	.8367

Pcnd #13. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.5266	0.4793
11.6	undefined	undefined
24/6	0.1615	.2330
11/7	undefined	undefined
27/7	0.4510	.6507
21/8	0.9894	.7137
07/9	undefined	undefined
24/9	undefined	undefined
06/10	undefined	undefined
mean	0.5321	.5192

Pond #14. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.6620	0.6026
11/6	0.6868	.9909
24/6	0.6730	.9709
11/7	0.3048	.4397
27/7	0.9217	.8390
21/8	1.1484	.8284
07/9	0.3767	.5435
24/9	0.0941	.1357
06/10	0.5649	.5142
mean	0.6036	.6516

Pond #15. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.3048	0.4397
11/6	0.4196	.2342
24/6	0.6427	.5850
11/7	0.0314	.0454
27/7	1.0986	1
21/8	1.5498	.9629
07/9	1.1159	.8049
24/9	0	undefined
06/10	0	undefined
mean	0.5736	.5816

Pond #16. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0	undefined
11/6	1.1543	.8326
24/6	0.5985	.8634
11/7	0.8039	.7318
27/7	0	undefined
21/8	1.0108	.9201
07/9	0.5104	.2849
24/9	0.5929	.5397
06/10	0	undefined
mean	0.5190	.6954

Pond #17. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	0.3659	.3330
24/6	0.4510	.6507
11/7	0.8030	.7309
27/7	0.8666	.7888
21/8	undefined	undefined
07/9	0.6966	.6341
24/9	0.2324	.3353
06/10	0.6931	1
mean	0.5869	.6390

Pond #18. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	1.4985	0.9311
24/6	0.9404	.6783
11/7	0	undefined
27/7	0.1285	.0717
21/8	1.5507	.8654
07/9	1.4017	.8709
24/9	0.5623	.8112
06/10	0	undefined
mean	0.7606	.7048

Pond #19. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0	undefined
11/6	0.0980	0.1414
24/6	0.8666	.7888
11/7	0.7937	.5725
27/7	0.4262	.2648
21/8	0.6931	1
07/9	0	undefined
24/9	0.5004	.7219
06/10	0	undefined
mean	0.3753	.5816

Pond #20. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.8157	.7425
11/6	0.8738	.6303
24/6	1.4074	.0020 (?)
11/7	1.3424	.9683
27/7	0.7356	.6695
21/8	1.2372	.7687
07/9	1.3481	.9724
24/9	1.3428	.6457
06/10	0.3048	.4397
mean	1.0453	.6488

Pond #21. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.9178	.8354
11/6	1.0095	.5634
24/6	undefined	undefined
11/7	1.2372	.7687
27/7	0.4279	.3895
21/8	1.5602	.9694
07/9	0	undefined
24/9	0.8603	.7830
06/10	0.9582	.8722
mean	0.8714	.7402

Pond #22. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.3562	0.3243
11/6	0.8397	.5217
24/6	0.7942	.5729
11/7	1.3592	.8445
27/7	0.3250	.4689
21/8	0.6931	1
07/9	0.1606	.1462
24/9	0.9725	.7015
06/10	0.3614	.5214
mean	0.6513	.5668

Pond #23. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	1.0397	.9463
11/6	0.8332	.6010
24/6	0.3863	.5574
11/7	0.9331	.5797
27/7	0.2101	.3031
21/8	0.4689	.4268
07/9	0	undefined
24/9	0.1132	.1633
06/10	0.5452	.7866
mean	0.5034	.5455

Pond #24. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	0.8108	0.5848
24/6	0.5985	.8634
11.7	0.7721	.5570
27/7	undefined	undefined
21/8	0.9135	.6589
07/9	1.3101	.8140
24/9	0.1925	.2778
06/10	0.5294	.7638
mean	0.7325	.6457

Pond #25. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	1.1890	0.7388
11/6	1.2316	.6329
24/6	1.1682	.8427
11.7	0.9554	.6891
27/7	1.0142	.6301
21/8	1.3321	.9609
07/9	1.3269	.8244
24/9	1.5210	.8489
6/10	no sample	no sample
mean	1.2173	.7709

Pond #26. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.5875	.8476
11/6	0.3454	.3144
24/6	0.2587	.3733
11/7	0.0108	.0156
27/7	1.3592	.8445
21/8	1.0261	.9340
07/9	0.5985	.8634
24/9	1.3208	.9528
06/10	0.6730	.9709
mean	0.6867	.6796

Pond #27. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.7897	.7188
11/6	0.2536	.3659
24/6	0.7897	.5696
11/7	0.4497	.6488
27/7	1.3291	.9588
21/8	0.7400	.6736
07/9	0	undefined
24/9	0	undefined
06/10	0	undefined
mean	0.4825	.6559

Pond #28, Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.8543	.5308
11/6	0.7445	.5370
24/6	0.7109	.5128
11/7	1.3435	.6904
27/7	0.9177	.8353
21/8	0.9502	.4883
07/9	0.3598	.2595
24/9	0.5004	.7219
06/10	no sample	no sample
mean	0.7978	.5720

Pond #29. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.0160	.0146
11/6	0.4859	.3019
24/6	1.3592	.8445
11.7	0.9250	.8419
27/7	0.6365	.9182
21/8	0.3629	.5235
07/9	1.8033	.8672
24/9	0.6390	.4609
06/10	1.0108	.9201
mean	0.8043	.6325

Pond #30. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.4887	0.3525
11.6	0.9619	.5977
24/6	0	undefined
11/7	0.8880	.6405
27/7	0	undefined
21/8	1.0986	1
07/9	0.4393	.3998
24/9	1.2798	.9232
06/10	0.6901	.9957
mean	0.6496	.6973

Pond #31. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	undefined	undefined
11/6	0.0430	0.0391
24/6	0.7866	.7160
11/7	0.8475	.6113
27/7	0.2713	.3915
21/8	0	undefined
07/9	0.5884	.5356
24/9	0.2754	.2506
06/10	0.6931	1
mean	0.4382	.5063

Pond #32. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	1.8729	0.9006
11/6	0.4103	.5920
24/6	0.0397	.0286
11/7	0.7580	.6899
27/7	0.6365	.9182
21/8	0.6365	.9182
7/9	1.3640	.6559
24/9	0.0481	.0438
6/10	0.6828	.9851
mean	0.7165	.6369

Pond #33. Shannon-Weaver diversity indices and Equitability indices for invertebrate communities sampled by sweepnets.

Date	Diversity Index	Equitability Index
23/5	0.7512	0.6837
11/6	0.5393	.4909
24/6	0.5004	.7219
11/7	0.0157	.0143
27/7	1.6924	.8697
21/8	1.5376	.8581
7/9	1.4082	.7236
24/9	1.5979	.8211
6/10	0.3866	.5577
mean	0.9366	.6379

APPENDIX B.4

POND TEMPERATURES

Pond Temperatures (°C).

Site #	Date							
	June 11	June 24	July 11	July 27	Aug. 21	Sept. 7	Sept. 24	Oct. 6
1	12	17	18	18	11	10	8	4
2	12	16	17	19	11	10	8	-
3	12	16	17	19	12	11	8	3
4	13	17	18	19	12	11	9	4
5	12	16	18	19	12	10	9	-
6	13	17	18	19	12	11	9	2
7	12	17	18	19	12	10	10	3
8	12	16	16	17	11	9	-	0
9	14	17	17	18	11	11	9	0
10	13	17	17	18	14	11	9	4
11	12	17	19	16	16	15	10	3
12	12	17	16	16	14	12	-	-
13	12	16	17	16	16	-	-	-
14	12	14	18	16	16	12	-	4
15	12	16	18	17	15	13	9	3
16	12	18	20	18	16	13	10	4
17	15	18	20	19	16	14	9	4
18	16	17	18	18	17	14	-	4
19	15	18	19	18	16	13	10	4
20	17	18	17	18	16	15	10	4
21	16	18	18	19	-	11	10	4
22	17	18	17	19	15	14	10	4
23	17	18	17	19	16	14	10	4
24	18	19	18	20	19*	14	10	3
25	17	18	17	20	19	14	10	4
26	15	17	18	19	20	12	[illegible]	4
27	16	17	18	19	19		10	3
28	17	17	18	19	18		11	3
29	17	17	18	19	13		-	3
30	17	17	18	20	18		11	4
31	16	17	18	19	17		10	3
32	15	17	18	19	17		10	3
33	15	16	17	18	17		-	3

*

APPENDIX C.1

AVIFAUNA

List of birds sighted in Liard Highway Area, NWT. 1977.

Common Name	Scientific Name
Common loon	*Gavia immer*
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*P. auritus*
Pied-billed grebe	*Podilymbus podiceps*
Snowy egret	*Egretta thula*
Whistling swan	*Olor columbianus*
Trumpeter swan	*O. buccinator*
Canada goose	*Branta canadensis*
Snow goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Gadwall	*A. strepera*
Pintail	*A. acuta*
Green-winged teal	*A. carolinensis*
Blue-winged teal	*A. discors*
American wigeon	*A. americana*
Shoveler	*A. clypeata*
Redhead	*Aythya americana*
Ring-necked duck	*A. collaris*
Canvasback	*A. valisineria*
Greater scaup	*A. marila*
Lesser scaup	*A. affinis*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*B. islandica*
Bufflehead	*B. albeola*
Oldsquaw	*Clangula hyemalis*
White-winged scoter	*Melanitta deglandi*
Surf scoter	*M. perspicillata*
Common merganser	*Mergus merganser*
Red-breasted merganser	*M. serrator*
Goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
Rough-legged hawk	*B. lagopus*
Golden eagle	*Aquila chrysaetos*
Bald eagle	*Haliaeetus leucocephalus*
Marsh hawk	*Circus cyaneus*

Continued.

Common Name	Scientific Name
Peregrine falcon	*Falco peregrinus*
Merlin	*F. columbiarius*
American Kestrel	*F. sparverius*
Spruce grouse	*Canachites canadensis*
Ruffed grouse	*Bonasa umbellus*
Ptarmigan	*Lagopus* sp.
Sharp-tailed grouse	*Pedioecetes phasianellus*
Sandhill crane	*Grus canadensis*
Sora	*Porzana carolina*
American coot	*Fulica americana*
Common snipe	*Capella gallinago*
Spotted sandpiper	*Actitis macularia*
Solitary sandpiper	*Tringa solitaria*
Lesser yellowlegs	*T. flavipes*
California gull	*Larus californicus*
Mew gull	*L. canus*
Bonaparte's gull	*L. philadelphia*
Common tern	*Sterna hirundo*
Great horned owl	*Bubo virginianus*
Common nighthawk	*Chordeiles minor*
Belted kingfisher	*Megaceryle alcyon*
Common flicker	*Colaptes auratus*
Downy woodpecker	*Picoides pubescens*
Eastern kingbird	*Tyrannus tyrranus*
Tree swallow	*Iridoprocne bicolor*
Bank swallow	*Riparia riparia*
Cliff swallow	*Petrochelidon pyrrhonata*
Gray jay	*Perisoreus canadensis*
Common raven	*Corvus corax*
Black-capped chickadee	*Parus atricapillus*
American robin	*Turdus migratorius*
Hermit thrush	*Catharus guttatus*
Bohemian waxwing	*Bombycilla garrulus*
Red-winged blackbird	*Agelaius phoeniceus*
Rusty blackbird	*Euphagus carolinus*

Continued.

Common Name	Scientific Name
Western tanager	*Piranga ludoviciana*
White-winged crossbill	*Loxia leucoptera*
Savannah sparrow	*Passerculus sandwichensis*
Dark-eyed junco	*Junco hyemalis*
Chipping sparrow	*Spizella passerina*
White-crowned sparrow	*Zonotrichia leucophrys*
White-throated sparrow	*Z. albicollis*
Lapland longspur	*Calcarius lapponicus*
Snow bunting	*Plectrophenax nivalis*

APPENDIX C.2

BROOD PRODUCTION AT EACH WETLAND

Site 1. (Shoreline length = 3.37 km) Density = 1.5 brood/km of shoreline.

Species	Date			
	June 29	June 29	July 11	July 13
Horned brebe		1 nest - 3 eggs flat in palm	- 2 eggs sit up in palm	
Red-necked grebe				1 - 1 young (very young)
Lesser scaup				1 adult with 7 class 1a young
Bufflehead	1 adult with 7 class 1a young	1 adult with 6 class 1a young (same brood)		
Coot		1 nest - 3 eggs		

Site 2. (Shoreline length = 2.80 km) Density = 2.5 brood/km of shoreline.

Species	Date		
	June 29	July 13	Aug. 21
Red-necked grebe	1 adult on nest - 4 eggs - eggs flat in palm 1 on nest - 4 eggs - eggs tip up in palm 1 on nest - 2 eggs - eggs tip up	2 nests still being incubated	
Ring-necked duck		1 - 2 class 2 young	
Lesser scaup		1 - 6 class 1a 1 - 12 class 1 - or 2a	10 class 2e young 6 class 3 young
Bufflehead		1 - 1 class 1 young	

Site 3. (Shoreline length = 4.88 km). Density = 0.8 brood/km of shoreline.

Species	Date: July 13	July 27	Aug. 21
Lesser scaup	1 - 8 class 1c 1 - 10 class 1a 1 - 7 class 1b	1 - 7 class 3	5 class 2c young 10 class 2e young
Bufflehead			1 class 2 c young

Site 4. (Shoreline length = 4.18 km). Density = 1.0 brood/km of shoreline.

Species	Date: June 29	July 13	Aug. 21
Red-necked grebe		1 - 1 young 1 on nest	
Ring-necked duck		1 - 11 class 1c	
Lesser scaup		1 - 9 class 1a	8 class 2a young

Site 5. (Shoreline length = 1.24 km). Density = 1.7 brood/km of shoreline.

Species	Date: July 13	July 25	Aug. 21
Lesser scaup		1 - 9 class 1c	1 - 3 class 2b
Bufflehead	9 class 1b young		

Site 6. (Shoreline length = 5.50 km). Density = 1.3 brood/km of shoreline.

Species	Date			
	June 24	June 29	July 13	Aug. 21
Mallard	1♀- class 1c young			
Ring-necked duck				3 class 2a you
Lesser scaup				5 class 2b you 8 class 2c you
Bufflehead		6 class 1a young 1 - 6 class 1a young	1 - class 1c 6 class 1b or 1c, 5 class 1c	

Site 7. (Shoreline length = 14.94 km). Density = 0.3 brood/km of shoreline.

Species	Date		
	June 29	July 13	Aug. 21
Red-necked grebe	1 - 1 chick 1 nest - no eggs	1 on nest - eggs	
Mallard	1 - 5 class 3		
Lesser scaup			1 - 6 class 2c
Bufflehead	1 - 2+ class 1		

Site 9. (Shoreline length = 1.29 km). Density = 1.5 brood/km of shoreline.

Species	Date			
	June 24	July 11	July 13	July 27
Bufflehead			5 class 2b	3 class 2b or 2c
Coot	6 young	2 young		

Site 10. (Shoreline length = 1.71 km). Density = 2.4 brood/km of shoreline.

Species	Date: June 29	Date: July 11
Mallard	5 class 2c young	
Bufflehead	1 - 5 class 1b 1 - 3 class 1b	
Coot		1 - 2 young

Site 11. (Shoreline length = 2.62 km). Density = 0.8 brood/km of shoreline.

Species	Date: June 29	Date: Aug. 21
Mallard	4 class 3 young	1 - 7 class 3 young

Site 13.

Species	Date: June 29	Date: July 13	Date: Aug. 21
Mallard	2 class 2 young	1 - 5 class 2c	12 class 3 4 class 3

Site 14. (Shoreline length = 10.37 km). Density = 0.4 brood/km of shoreline.

Species	Date: July 13	Date: Aug. 21
Mallard	6 class 2b young 6 class 2c 5 class 2 c	
Lesser scaup	6 class 1c	1 - 3 class 2b

Site 15. (Shoreline length = 19.68 km). Density = 0.4 brood/km of shoreline.

Species	Date June 3	June 29	July 13	Aug. 21
Mallard		4 class 3 young	7 class 3 young 6 class 3 1 - 3 class 2c	1 - 4 class 3
Blue-winged teal		2 class 2c young	1 class 2b young	
Lesser scaup		1 - 3 class 2b-2c		
Bufflehead			4 class 2a or 2b 5 class 2a	
Coot	11 nests (3 eggs)			

Site 16. (Shoreline length = 1.42 km). Density = 3.5 brood/km of shoreline.

Species	Date June 3	June 24	June 29	July 13
Red-necked grebe	1 on nest	hatched	1 on nest 1 - 1 young 1 - 1 young	grebe nest - 1 egg flat in palm
Horned grebe				1 - 2 young
Lesser scaup				1 - 3 class 1c young

Site 17. (Shoreline length = 0.52 km). Density = 4.0 brood/km of shoreline.

Species	July 13
Red-necked grebe	1 - 1 young
Lesser scaup	1 - 5 class 1a or 1b

Site 18. (Shoreline length = 1.20 km). Density = 0.8 brood/km of shoreline.

Species	Date: June 3	Date: July 13
Red-necked grebe	1 on nest	1 - 1 young

Site 19. Nothing. (Shoreline length = 1.73 km).

Site 20. (Shoreline length = 1.65 km). Density = 2.5 brood/km of shoreline.

Species	July 11
Red-necked grebe	1 - 1 young 1 - 1 young 1 - 1 young 1 - 1 young

Site 21. (Shoreline length = 1.68 km). Density = 1.2 brood/km of shoreline.

Species	Date: June 3	Date: June 29
Horned brebe	1 pr. on nest	
Bufflehead		1 - 5 young

Site 22. (Shoreline length = 2.32 km). Density = 1.7 brood/km of shoreline.

Species	Date: June 29	Date: July 11	Date: July 13
Red-necked grebe	1 nest - 4 eggs - float 1 - 3 class 2b		1 near nest
Lesser scaup		1 - 9 class 1c	1 - 15 class 1c or 2a
Bufflehead	1 - 1 class 1c or 2a		

Site 23. (Shoreline length = 2.87 km). Density = 1.0 brood/km of shoreline.

Species	Date		
	June 29	July 13	Aug. 21
Mallard		7 class 2c young	10 class 3
Ring-necked duck		1 - 4 class 2b young	
Bufflehead	1 - 7 class 1b	1 class 1c young	

Site 24. (Shoreline length = 0.52 km). Density = 2.0 brood/km of shoreline.

Species	Date	
	June 24	July 13
Common goldeneye	1♀ - 6 class 1a	5 young

Site 25. (Shoreline length = 3.58 km). Density = 2.0 brood/km of shoreline.

Species	Date					
	June 3	June 24	June 29	July 11	July 13	Aug. 21
Mallard	1 - 7 class 1a young					
Blue-wing teal				1 - 8 or 9 class 1a		
Coot		nest - 7 eggs - sit up nest - 5 eggs - flat in palm	1 - 1 young 1 - 1 young 5 young 3 young FLOODED NESTS		1 - 1 young	33 young
Bufflehead					5 class 1c	

Site 26. (Shoreline length = 2.96 km). Density = 0.7 brood/km of shoreline.

Species	July 13
Lesser scaup	7 class 2a young
Bufflehead	2 class 1c young

Site 27. (Shoreline length = 1.40 km). Density = 0.7 brood/km of shoreline.

Species	June 29
Coot	1 - 3 young

Site 28. (Shoreline length = 1.47 km). Density = 3.3 brood/km of shoreline.

Species	Date		
	June 29	July 13	July 25
Red-necked grebe			1 - 5 young 1 - 2 young
Lesser scaup		1 - 2 class 1b 1 - 3 class 1b	1 - 6 class 2a
Bufflehead	1 - 4 young		1 - 3 class 2b

Site 29. (Shoreline length = 2.26 km). Density = 2.2 brood/km of shoreline.

Species	Date			
	June 24	June 29	July 13	July 25
Red-necked grebe		1 nest - 5 eggs float		1 - 1 young 1 - 3 young
Bufflehead	1 - 8 class 1a 1 - 6 class 1a	1 - 6 class 1b 1 - 6 class 1b 1 - 4 class 1b	1 - 6 class 1c	

Site 30. (Shoreline length = 3.33 km). Density = 2.4 brood/km of shoreline.

Species	June 24	June 29	July 13
Red-necked grebe		1 on nest (3 eggs float, 1 hatched)	
Lesser scaup			2-15 class 1c
Bufflehead		1 - 11 class 1b or 1c 7 class 1a or 1b	1-3 class 1b 1-3 class 1b 1-3 class 1c 1-6 class 1c 1-6 class 1c 1-4 class 1b 2 class 2a

Site 31.

Species	June 24	June 29	July 11	July 13
Common loon	1 pr on nest (3 eggs)	on nest	1 chick	1 chick

Site 32. (Shoreline length = 1.49 km). Density = 1.3 brood/km of shoreline.

Species	July 11	July 13
Ring-necked duck		1 - 7 class 1c or 2a
Coot	1 young	

Site 33. (Shoreline length = 2.47 km). Density = 2.4 brood/km of shoreline.

Species	Date	
	June 29	July 13
Red-necked grebe	1 nest - 1 egg 1 - 1 class 1b young	1 - 1 young
Mallard		1 - 4 class 2b young
Lesser scaup		1 - 5 class 1b 1 - 6 class 1b
Bufflehead	1 - 7 class 1b	

Table 3. Mercator Grid References for Observations of Raptors, July 5-8, Liard and Nahanni Range, NWT.

Species		Grid Reference
Peregrine Falcon		95 G DD 79.6 x 62.4 (flying)
		95 G DD 84.5 x 45.3
		95 F DC 42.4 x 94.3 (flying)
Golden Eagle		95 G DC 8373 (pair, soaring)
		95 G DC 8382
		95 G DC 83.0 x 84.5 (active, eyrie w̄ lying)
		95 G DC 8099 (soaring)
		95 G DD 8335 "
		95 J DD 7976 "
	(immature)	95 J DD 8280 "
Bald Eagle	(immature)	95 G DD 8558 (soaring)
	"	95 J DD 7982 "
Merlin		95 G DD 7814 (flying)
		95 G DD 8235 "
		95 G DD 8256 "
		95 G DD 7671 "
		95 J DD 8279 "
		95 J DD 8183 "
Kestrel		95 G DD 8338 (flying)
Goshawk		95 B DC 7763 (flying)
Stick Nests		95 G DC 83.0 x 72.2
		95 G DD 79.5 x 03.5
		95 G DD 8228
		95 G DD 8439
		95 G DD 8444
		95 G DD 84.5 x 48.5
		95 G DD 84.5 x 48.8
		95 G DD 8154
		95 G DD 81.7 x 54.7
		95 G DD 80.5 x 62.0
		95 G DD 75.7 x 16.6
		95 G DD 8072
		95 J DD 8281
		95 B DC 7662
		95 B DC 7661
		95 B DC 6336
		95 B DC 6411

Table 3. Continued.

Species	Grid Reference
Suspected Eyries (inactive)	95 G DC 84.0 x 77.3 95 G DD 75.7 x 16.6 95 J DD 8186
Perches (as indicated by wash)	95 B DB 71.5 x 90.0 95 G DD 75.7 x 16.6

APPENDIX D

FUR RETURNS

Table 1. Fur Returns* - Liard Highway region, NWT (1976-77).

Species	Ft. Liard	Nahanni Butte	Trout Lake	Jean Marie
Beaver	1,064	122	63	50
Marten	759	77	182	13
Fisher	4	2	1	
Mink	70	18	10	3
Muskrat	2,104	138	308	155
Squirrel	2,922	134	173	45
Weasel	92	9	12	
Red fox	1			
Otter	3	1		
Wolverine	2		1	
Lynx	12	1	3	
Wolf	2			

*Hudson's Bay Co., Ft. Liard
H. Deneron, Ft. Liard
Hudson's Bay Co., Ft. Simpson
Ft. Simpson Service, Ft. Simpson

APPENDIX E

DALL SHEEP AND MOOSE SIGHTINGS

Appendix E.1. Dall Sheep Sightings.

Nahanni Range:	July 5, 1977 - 50 sheep sighted between 61°30'N and Little Doctor Lake (61°52'N). This area corresponds to that in 1972 where 50 sheep were sighted during winter (Nolan *et al.* 1973).
Liard Range:	Aug. 3, 1977 - 72 sheep between 60°40'N and 60°47'N.

Appendix E.2. Moose Sightings.

May 10 - Site 10 - 2 moose
May 14 - Site 14 - 2 moose
May 18 - Site 8 - 1 moose
- Mile 48 alignment - 2 moose
- Site 30 - 1 moose (swimming)
May 29 (F+MS)*- Mile 80 alignment - 1 moose
- Rabbit Creek at alignment - 1 moose
June 3 - Site 8 - 2 bull moose
- Site 9 - 1 cow moose
- Site 10 - 1 cow moose
June 21 - Mile 65 - 1 cow moose with 2 calves
June 24 - Netla River alignment crossing - 1 moose
July 5 (F+MS) - Mile 29.0 - 1 moose and 1 calf
July 6 (F+MS) - Mile 45.0 - 1 moose
July 11 - Site 3 - 1 bull moose
Site 14 - 2 bull moose
Site 22 - 1 cow, 1 calf moose
(F+MS) - Mile 45.9 - 1 bull moose
July 13 - Mile 70 - 1 bull moose
- Mile 78 - 1 bull moose
(F+MS) - Mile 51.5 - 1 cow moose
July 27 - Site 8 - 1 cow moose
Aug. 21 - Site 27 - 1 young bull moose
- Site 6 - 2 young bull moose
Aug. 24 - Site 9 - 2 moose
Sept. 24 - Fen S. of Swan Pt., Liard River - 1 cow, 1 bull
- Site 23 - 1 cow, 1 calf moose
- Site 27 - 1 bull, 1 cow moose
- Site 33 - 2 bull moose
Sept. 29 - Site 9 - 1 bull moose
Oct. 6 - Site 10 - 1 cow moose
- Site 13 - 1 bull moose, 1 calf
Oct. 20 - 3 miles NW of Site 7 - 1 cow, 1 bull moose

*(F+MS) denotes observations by Fisheries and Marine Service personnel (received from F. Hnythca).