THE SPECIES COMPOSITION, ABOVEGROUND BIOMASS AND CARBON CONTENT OF VEGETATION IN TWO BASIN BOGS IN THE EXPERIMENTAL LAKES AREA, NORTH-WESTERN ONTARIO

BY

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A Thesis
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ABSTRACT

The preflood species composition, aboveground biomass and carbon content of vegetation in an experimental basin bog, L979, and reference basin bog, L632, were studied as part of the Experimental Lakes Area Reservoir Project (ELARP) in north-western Ontario. Using aerial photographs, six plant communities were delineated in L979 and two in L632. Communities were sampled in proportion to the area occupied by each.

Cover was estimated for all trees (>10 cm circumference at breast height (CBH)), saplings and tall shrubs (<10 cm CBH, >1.5 m tall), tree and tall shrub seedlings (<1.5 m tall), low shrubs (<1.5 m tall), herbs, bryophytes and lichens in 1 m x 0.5 m plots. The eight communities were classified into physiognomic groups of open, or low to high density treed bog (11 to 54% tree cover, 362 to 2,726 trees ha^{-1}). *Picea mariana* was dominant except in an area in L979 that burned 12 years earlier where low density *Pinus banksiana* was dominant. Two communities in L979 had sparse (10 and 14%) *Alnus rugosa* cover. The abundant low shrub cover (43 to 81%) was dominated, or co-dominated by *Chamaedaphne calyculata* and *Ledum groenlandicum*. The ground layer was predominantly *Sphagnum* spp. (*S. angustifolium/fallax* and *S. magellanicum*) and *Pleurozium schreberi* was co-dominant with *Sphagnum* in the community with dense *Picea mariana*. Surface water pH of the sites ranged from 3.45 to 4.95, conductivity from 20.5 to 90.5 $\mu S\ cm^{-1}$ and was not significantly different among communities.

The biomass of trees, saplings and tall shrubs was estimated using allometric regression equations, and the biomass of tree and tall shrub seedlings, low shrubs, herbs, bryophytes and litter was estimated from harvested samples. Estimates of total aboveground biomass in the communities of L979 and L632 ranged from 7,189 ± 924 kg ha^{-1} (s.e.) in the Open bog - *Carex oligosperma* community of L632 to 72,909 ± 20,627 kg ha^{-1} in the High density *Picea mariana* - *Ledum* shrub community of L979.

Carbon concentrations ranged from 430 ± 4 to 540 ± 5 mg C g^{-1} among species and tissue types analyzed. The community carbon pool of aboveground vegetation varied from 3,140 ± 480 to 35,010 ± 8,840 kg C ha^{-1} (excluding litter). The available carbon pool (including litter and excluding tree branches and trunks) in aboveground vegetation in the experimental site, L979, is approximately 8% of the total carbon pool estimated in the peat.

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CHAPTER 1. Introduction and literature review

1.0 INTRODUCTION

In 1991, the Experimental Lakes Area Reservoir Project (ELARP) was initiated to investigate the increased flux of greenhouse gases (CO_2 and CH_4) to the atmosphere observed in hydroelectric reservoirs (Rudd *et al.* 1993; Kelly *et al.* 1994) and natural ponds situated on peat in northern Canada (Hamilton *et al.* 1993). An additional non-human source of increased methane emission in the subarctic and boreal regions is dam building by beaver (Naiman *et al.* 1986; Naiman *et al.* 1988).

By 1992, about 20,000 km^2 of reservoir surface area existed in Canada and another 11,000 km^2 were planned (Kelly and Rudd 1993). Concern and debate regarding the magnitude and significance of reservoirs as a source of greenhouse gases have been raised in the literature, not only in reference to reservoirs in Canada (Rudd *et al.* 1993) but also in other parts of the world such as the Brazilian Amazon region (Fearnside 1995; Rosa *et al.* 1996).

Mercury contamination of fish stocks is another environmental problem that has been observed in almost all hydroelectric reservoirs (Kelly *et al.* 1997). The increased flux of CO_2 and CH_4 to the atmosphere and mercury contamination of waters are linked because the production of these gases and mercury methylation are microbial activities supported by the decomposition of flooded organic material (Kelly *et al.* 1997)

ELARP was designed to examine hydroelectric reservoirs as potentially significant sources of the greenhouse gases CO_2 and CH_4 and mercury contamination by measuring the change in CO_2 and CH_4 flux and mercury concentration in an experimental reservoir after flooding. The mechanisms controlling changes in CO_2 and CH_4 flux and Hg concentration were to be modeled so that these parameters could be predicted for existing and future hydroelectric developments. When this was accomplished, it would allow for a more informed evaluation of the environmental impacts and potential mitigation associated with hydro-generated power.

The study sites of ELARP are two basin bogs in the Experimental Lakes Area administered by the federal Department of Fisheries and Oceans south-east of Kenora in the Lake of the Woods region of north-western Ontario. One bog, designated L979, was to be flooded by 1.3 m in 1993 to simulate a hydroelectric reservoir while the other, L632, served as a reference.

A peatland was chosen to be experimentally flooded because (1) many hydroelectric reservoirs in northern countries include peatlands, and flooding of peatlands is becoming more common, (2) natural peatlands are important sources of methyl mercury to downstream boreal ecosystems and flooding is expected to further enhance methyl mercury production, and (3) peat is a large organic carbon pool and if it decomposes after flooding will contribute a large quantity of CO_2 and CH_4 to the atmosphere (Kelly *et al.* 1997).

When the experimental bog was flooded, it was converted from a net carbon sink of -7.6 g C m^{-2} yr^{-1} to a net carbon source of 180 g C m^{-2} yr^{-1} resulting in a net release of CO_2 from the experimental reservoir to the atmosphere and an increased release of CH_4. The change from net CO_2 fixation to net CO_2 release in the experimental bog is due to the combined effect of (1) the death of much of the terrestrial vegetation in the bog, and thus the loss of it's CO_2 fixing ability, and (2) the decomposition of this large pool of available carbon. The increased release of CH_4 is due to increased microbial production and decreased microbial oxidation to CO_2. It was concluded that the source of increased gas flux is the decomposing aboveground vegetation, although the peat is likely to continue to decompose at a significant rate for some time after flooding (Kelly *et al.* 1997). The amount of carbon available to be released as CO_2 and CH_4 through the death and decomposition of aboveground vegetation is dependent on the type and mass of the vegetation cover.

The data presented in this thesis are a component of the baseline data collected in 1992 and 1993 prior to the flooding of L979 in June, 1993. The objectives of this component of ELARP are to (1) describe the preflood species composition of the experimental and reference bogs, (2) estimate the preflood aboveground biomass of plant communities in the experimental and reference bogs, and (3) estimate the preflood carbon pool in aboveground vegetation of the experimental and reference bogs.

The thesis is divided into four chapters. The first chapter provides a general introduction and literature review relating to North American boreal bogs; their species composition, biomass and carbon content. Chapter two deals with the species composition and aboveground biomass of plant communities in two bogs (L979 and L632) in northwestern Ontario. In chapter three the aboveground biomass of strata and species, and carbon pool in the vegetation of these two bogs are estimated. Chapter four provides a summary.

1.1 LITERATURE REVIEW

1.1.0 North American boreal bog genesis and classification

According to the Canadian Wetland Classification System (CWCS), a wetland is defined as "land saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity which are adapted to a wet environment" (National Wetlands Working Group 1988, p. 416). Peatlands are wetlands which have an accumulation of more than 40 cm of organic matter in the form of peat on which Organic soils develop. Bogs are described as peatlands with the water-table at or near the surface and virtually unaffected by nutrient-rich groundwaters influenced by surrounding mineral soils. Bogs are generally acidic and low in nutrients. They may be treed or treeless and are dominated by *Sphagnum* spp. and ericaceous shrubs (National Wetlands Working Group 1988).

Hydrology, climate, topography and geology are determining factors in the genesis of bog ecosystems. In general, bogs tend to form in small depressions or basins in glacial moraine, or in broad, sometimes sloping plains where water drainage is blocked or impeded. Recently glaciated areas are conducive to bog formation, where fluvioglacial deposits of rock, sand or clay form a largely impermeable substrate. The accumulation of water, especially in areas with no water circulation and reduced wind action to aerate the water, results in a lack of oxygen and therefore a very low decomposition rate dominated by anaerobic processes (Dansereau and Segadas-Vianna 1952). This favors the accumulation of organic material in the form of peat.

Small basins undergo the lake-filling process. Rushes and sedges colonize and add organic material to the edges of the water body. As the rush and sedge peat accumulates it forms a floating mat which advances towards the center of the water body. *Sphagnum* becomes established in this floating mat behind the zone of rushes and sedges, eventually forming a continuous *Sphagnum* ground layer. Sedge and *Sphagnum* peat gradually accumulate from the edges of the basin to the center and from the bottom to the top of the water body. Low ericaceous shrubs and trees become established as the organic soil becomes better developed and conditions at the surface become slightly drier due to the growth and evapotranspiration of *Sphagnum*. Shrubs and trees add organic material to the soil in the form of woody peat.

Under typical conditions, peat accumulation will continue and form a raised bog mound. The water-table rises above the initial water level, as does the bog surface. Moore and Bellamy (1974) and others contribute this rise, at least in part, to capillary forces. However, it is not likely that capillary forces could account for the great heights maintained by perched water-tables observed in the field, and the accumulation of free water in natural pools and holes dug at the surface indicate that it is not under tension (Damman 1986). Damman (1986) suggests that the low hydraulic conductivity of compacted, well-decomposed peat is more likely responsible for the maintenance of a high water-table in bogs. The surface layer of an actively growing bog has relatively high hydraulic conductivity, allowing for horizontal water flow, but water is impeded from gravitational drainage by underlying layers of well-decomposed, compacted peat. The maintenance of the water-table is therefore dependent on the balance between recharge (mostly from precipitation, since the raised water-table of the bog mound is isolated from the groundwater of the surrounding area) and seepage. Peatland areas isolated from the influence of groundwater that has been in contact with mineral soil (minerotrophic), and receiving water inputs primarily from precipitation are termed ombrogenous (National Wetlands Working Group 1988). The margins of ombrogenous bogs are influenced by minerotrophic water inputs due to runoff from the surrounding upland areas. Minerotrophic water is generally more nutrient-rich, containing elements such as Fe, Al, Mn and Si that are largely absent from precipitation. It also has higher concentrations of many other elements, especially Ca (Damman 1986).

Since precipitation is the only major source of water input, climate is a major factor in bog development. Temperature is also an important climatic factor, as it affects the rate of evaporation, the presence of permafrost and growth conditions. Vitt *et al.* (1994) observe that bogs develop in areas where precipitation exceeds evapotranspiration, and in general where precipitation is greater than 500 mm annually and the mean annual temperature is less than 2°C. Regional differences in climate, geology and hydrologic patterns result in differences in bog landforms that permit the mapping of zones with distinct and characteristic bog landform types (Moore and Bellamy 1974; Foster and Glaser 1986; Glaser and Janssens 1986; Glaser 1992; Vitt *et al.* 1994).

The microtopography of the bog surface is not uniform. It varies in a series of microtopographical classes. These are named pool, carpet, lawn, and hummock. They correspond with an increasing depth to the water-table (Okland 1990). Pools are open water areas with submerged vegetation. Carpets have emergent vegetation on loosely consolidated peat, while lawns are flat areas with well-consolidated peat. Hummocks are small mounds formed by *Sphagnum* and low ericaceous shrubs, and are always associated with lower and thus wetter hollows found interspersed among the drier hummock habitats (Bubier *et al.* 1995).

The CWCS is hierarchical, at the highest level acknowledging five wetland classes (bogs, fens, swamps, marshes and shallow, open waters) based on the overall genetic origin of the wetland ecosystem. It recognizes 18 bog 'forms' based on surface morphology and pattern, water quality, relationship to open water and morphology of the underlying mineral soil (National Wetlands Working Group 1988). Commonly used bog form terms include basin or kettle-hole bog (Damman 1986), blanket bog, domed bog, and plateau bog. A basin bog is situated in a basin with essentially closed drainage and a flat peat surface. A blanket bog is an extensive, relatively shallow peat deposit occurring uniformly over gently sloping hills and valleys. A domed bog is relatively large, with a convex surface raised several meters above the surrounding area. In concentric domed bogs, the highest point is in the centre with small crescent-shaped surface pools in a concentric pattern around it. If the highest point and surface pool pattern is off-center, it is termed an eccentric domed bog (National Wetlands Working Group 1988). A plateau bog also has a raised surface but with steep marginal slopes and relatively flat central surface (Moore and Bellamy 1974). Grigal *et al.* (1985) use the terms raised bog for bogs with a raised water-table that develop on broad, flat plains, and perched bog for bogs formed by lake-fill processes that occupy small depressions in glacial moraines.

The lowest and most specific level in the CWCS is the wetland type which is based on vegetation physiognomy. Vegetation physiognomy is commonly used as a classification feature of bogs and other wetlands in classification systems developed for use not only in Canada (Jeglum *et al.* 1974; National Wetlands Working Group 1988; Riley and Michaud 1994), but also Finland and Scandinavia (Pakarinen 1995). Vegetation physiognomy is classified into open (treeless) and treed categories, with low-density, medium-density and high-density treed sub-categories. Physiognomic groups are based on the tallest well-developed understory stratum ($\geq$10% cover), and dominance types recognize the dominant species of the three most important strata (Jeglum *et al.* 1974; Riley and Michaud 1994). Harris *et al.* (1996) have developed a wetland classification system for north-western Ontario that uses indicator species in addition to vegetation physiognomy.

1.1.1 Low Boreal bog vegetation

The Low Boreal wetland region, as defined by the National Wetlands Working Group (1988) of the Canada Committee on Ecological Land Classification, extends from the north-east corner of Manitoba to the central region of Quebec. The bog flora of this region is said by Glaser (1992) to be the most species poor in eastern North America and limited to the most common bog species. Plant communities found in bogs in this region are generally either 'open' (treeless) or treed with low to high tree densities.

Open bog communities have a higher, more widely fluctuating water-table than forested communities. Typically they are dominated by the low ericaceous shrub *Chamaedaphne calyculata*[1] in the low shrub layer and *Sphagnum fuscum* in the ground layer. *Andromeda glaucophylla*, *Kalmia polifolia*, *Ledum groenlandicum* and *Oxycoccus quadripetalus* are common low shrubs. In addition, *Kalmia angustifolia* is often present in the eastern portion of the region (Kenkel 1987). Sedges, such as *Carex oligosperma* and *Eriophorum vaginatum*, and *Smilacina trifolia* occur in the herb layer. Although they do not have a high amount of cover, *Drosera rotundifolia* is prominent on the sides of hummocks and *Sarracenia purpurea* in the hollows (Vitt and Bayley 1984). Other *Sphagnum* species include *S. angustifolium*, *S. fallax*, *S. capillifolium* and *S. magellanicum*. Widely scattered young trees of *Picea mariana* and *Larix laricina* are often present (Reader and Stewart 1972; Jeglum *et al.* 1974; Vitt and Bayley 1984; Harris *et al.* 1996), with occasional *Alnus rugosa* and *Salix* spp. either as localized occurrences or forming a tall shrub layer (Reader and Stewart 1972; Vitt and Bayley 1984). *Alnus rugosa*

[1]Nomenclature follows Scoggan (1978-79) for vascular species, Anderson (1990) for *Sphagnum* spp. and Anderson *et al.* (1990) for other mosses, and Brodo (1981) for lichens (Appendices A.1 & A.2).

and *Salix* spp., along with *Myrica gale*, which is occasionally a common species in the low shrub layer, are indicators of minerotrophic influence (Vitt and Bayley 1984).

Treed bog communities are dominated by an overstory of *Picea mariana* with occasional *Larix laricina*. *Ledum groenlandicum* dominates the low shrub layer with *Chamaedaphne calyculata*, *Kalmia polifolia* (also *K. angustifolia* in the eastern portion of the region), *Oxycoccus quadripetalus* and *Vaccinium vitis-idaea* as common low shrubs. *Smilacina trifolia* and sedges, including *Carex trisperma*, are important in the herb layer. *Sphagnum* species (*S. angustifolium*, *S. fuscum* and *S. magellanicum*) are common in the ground layer but most notable is the prominence of *Pleurozium schreberi* (Reader and Stewart 1972; Jeglum *et al.* 1974; Vitt and Bayley 1984; Harris *et al.* 1996).

There is a difference in species composition between low and high density treed bogs. In low density treed bog communities the water-table is typically higher than in high density treed bog communities. As a result, they tend to have a higher cover of *Chamaedaphne calyculata* (Dansereau and Segadas-Vianna 1952) and *Sphagnum* spp., and lower cover of *Pleurozium schreberi* than high density treed bog communities (Reader and Stewart 1972).

The species composition of open and treed bog communities in the Low Boreal wetland region is similar to that of the central Mid Boreal (Segadas-Vianna 1955; Jeglum 1971, 1991; Bubier 1995) and Low Arctic (Sjörs 1959; Sims and Stewart 1981) regions to the north, and north-central Minnesota to the south (Heinselman 1970; Glaser *et al.* 1981, 1990; Glaser 1983, 1987; Swanson and Grigal 1991).

Hydrology and nutrient status are important factors in the variation in species composition among bog community types. Jeglum (1971) showed that among treed and *Sphagnum*-rich types in Mid Boreal Saskatchewan sites, variation in species composition was most highly correlated with a gradient in depth to the water-table. In a study of Low Boreal bogs in north-western Ontario, variation in species composition was most highly correlated with minerotrophy (the degree of influence of nutrient-rich groundwater), depth to the water-table and shade. Depth to the water-table and shade were correlated along the same axis (Vitt and Bayley 1984).

In a study of subarctic bogs in south-east Norway, the vegetation varied along three gradients (1) depth to the water-table, (2) minerotrophy and (3) peat productivity (Okland 1990). Okland relates the gradient in the depth to water-table to the mire expanse - mire margin gradient described by Sjörs (1948, 1950). The mire expanse and mire margin are floristically and physiognomically distinct. The mire expanse has a shallow water-table and is dominated by low ericaceous shrubs, such as *Chamaedaphne calyculata* in North America, and *Sphagnum* hummocks, while the mire margin has a deeper water-table and minerotrophic influence from upland run-off which supports the growth of trees (Malmer 1986). The mire expanse - mire margin gradient was also found to be important in peatland sites in Wyoming by Cooper and Andrus (1994). They found that the variation in species composition of these sites is best related to depth to the water-table and groundwater discharge rates. They relate changes in the depth to the water-table and duration of soil saturation to the mire expanse - mire margin gradient and conclude that hydrologic patterns and processes apparently control the mire expanse - mire margin gradient.

1.1.2 The carbon cycle in bogs

Estimates of net primary production (NPP) in North American bogs show a strong trend of increasing NPP with decreasing latitude, ranging from 264 g m^{-2} $annum^{-1}$ in central Alberta to 1,045 g m^{-2} $annum^{-1}$ in West Virginia (Swanson and Grigal 1991; Szumigalski and Bayley 1996a). Undisturbed bogs are in general carbon sinks, not because they are highly productive ecosystems, but because the acidic, nutrient poor conditions result in relatively low decomposition rates (Moore and Bellamy 1974; Malmer 1986; Szumigalski and Bayley 1996b).

Microbial populations are important decomposers in peatlands, although their activity is low due to limiting environmental conditions such as constant lack of oxygen, low temperature, low pH, and low nutrient availability, and/or poor substrate quality in the peat (Bartsch and Moore 1985; Szumigalski and Bayley 1996b). Bartsch and Moore (1985) and Szumigalski and Bayley (1996b) suggest that poor substrate quality, in terms of high lignin and cellulose content, high C/N ratios and low N, P and K concentrations, are more important than environmental conditions in limiting the rate of decomposition in bogs. Because mosses have higher C/N ratios and lignin and cellulose content, and lower concentrations of N and other nutrients, they have a slower rate of decomposition than higher plants (Bartsch and Moore 1985; Reader and Stewart 1972; Szumigalski and Bayley 1996b).

The result of the imbalance between NPP and the overall rate of decomposition is net carbon storage in typical, undisturbed peatland ecosystems and hence the long term accumulation of organic matter in the form of peat. Gorham (1991) roughly estimates the global, long term, net dry-mass carbon flux from the atmosphere to undisturbed boreal and subarctic peatlands at 29 g C m^{-2} yr^{-1}. Armentano and Menges (1986) estimate the long term net carbon accumulation rate in Canadian peatlands at 19 g C m^{-2} yr^{-1}. In the experimental L979 site, this was estimated to be 20 g C m^{-2} yr^{-1} (Kelly *et al.* 1997).

1.1.3 Bog biomass

The trend of increasing NPP with decreasing latitude in North America is also reflected in the biomass of vegetation in treed bogs. The aboveground biomass of a subarctic low to medium density treed bog was estimated by Sims and Stewart (1981) to be 7,939 kg ha^{-1}, which is lower than the approximately 10,000 (Reader and Stewart 1972) to 102,000 kg ha^{-1} (Grigal *et al.* 1985) estimated for low to high density treed bog communities in the boreal zone. Reader and Stewart (1972) estimate the aboveground biomass of a low density and high density treed bog communities in south-east Manitoba to be 9,950 and 46,545 kg ha^{-1} respectively. The estimates of Swanson and Grigal (1991) for low (31,300 kg ha^{-1}) and high density (79,400 kg ha^{-1}) treed bog communities in north and central Minnesota are approximately twice these figures, but similar to the aboveground biomass (excluding bryophytes) estimated for treed raised (35,920 kg ha^{-1}) and perched (101,755 kg ha^{-1}) bogs by Grigal *et al.* (1985) in the same region.

Reader and Stewart (1972) calculate the aboveground biomass of an open bog community dominated by *Chamaedaphne calyculata* and *Ledum groenlandicum* in southeastern Manitoba to be 5,546 kg ha^{-1}. The aboveground biomass of open bog communities estimated by Wallen and Malmer (1992) in Maine, however, are slightly lower, 4,710 and 5,270 kg ha^{-1} for *Kalmia angustifolia* and *Gaylussacia baccata* dominated communities, respectively. The estimated aboveground biomass of a *Chamaedaphne calyculata* dominated site in Maine is significantly less, 1,090 kg ha^{-1} (Bartsch and Schwintzer 1994).

Picea mariana is the only tree species reported in studies of bog community biomass in the Low Boreal region (Reader and Stewart 1972; Grigal *et al.* 1985). The *P. mariana* biomass in a mature 'Bog forest' community with a high density of 7,829 trees ha^{-1} in south-east Manitoba is estimated at 41,860 kg ha^{-1} (Reader and Stewart 1972). *Picea mariana* biomass values of 100,730 kg ha^{-1} and 30,980 kg ha^{-1} are reported for the tree strata of perched bogs with 2,800 trees ha^{-1} and basal area of 27 m^2 ha^{-1}, and raised bogs, with 4,200 trees ha^{-1} and basal area of 10 m^2 ha^{-1}, respectively (Grigal *et al.* 1985). Swanson and Grigal (1991) suggest that *Larix laricina* may constitute a portion of the tree cover dominated by *P. mariana* but report only total tree biomass estimates of 57,500 kg ha^{-1} for high density treed, 15,200 kg ha^{-1} for low density treed, and 500 kg ha^{-1} for open bog communities.

Reader and Stewart (1972) give low shrub biomass estimates of 4,123 kg ha^{-1} for open bog, 4,614 kg ha^{-1} for 'Muskeg' and 1,345 kg ha^{-1} for 'Bog forest' communities. In the open bog community there is slightly more *Chamaedaphne calyculata* than *Ledum groenlandicum*, but in the treed 'Muskeg' and 'Bog forest' communities there is more *L. groenlandicum*. *Chamaedaphne calyculata* and *L. groenlandicum* contribute the 970 and

4,540 kg ha^{-1} of low shrub biomass to the estimates for the perched and raised bog communities of Grigal *et al.* (1985). The low shrub biomass estimates of Swanson and Grigal (1991) are lower, 1,000 kg ha^{-1} for open and low density treed bog communities and 800 kg ha^{-1} for high density treed bogs. Reader and Stewart (1972) estimate bryophyte biomass at 937 to 2,000 kg ha^{-1}, less than half that of Swanson and Grigal (1991), 4,800 to 5,400 kg ha^{-1}. Bryophyte biomass of the open and 'Muskeg' communities of Reader and Stewart (1972) is dominated by *Sphagnum fuscum* but in the 'Bog forest' community by *Pleurozium schreberi*. Differences in biomass estimates may in part be due to the methods used to estimate biomass. Reader and Stewart (1972) biomass estimates are based on harvested 0.06 m^2 samples, and Grigal *et al.* (1985) and Swanson and Grigal (1991) used allometric regression equations.

Few studies have undertaken the challenge of estimating below ground biomass in bogs because of the difficulty in distinguishing dead and live plant material. Vasander (1981) estimated the below ground biomass of a subarctic treed bog at 5,267 kg ha^{-1} which was 45% of total community biomass. Malmer and Nihlgard (1980) also estimated the below ground biomass of a subarctic open bog at 45% (4,050 kg ha^{-1}) of total community biomass. The biomass of bog communities estimated by Reader and Stewart (1972), however, show a trend of increasing percentage of below ground biomass with decreasing tree cover. In the high density treed 'Bog Forest', low density treed 'Muskeg' and open 'Bog' communities, below ground biomass was 33, 62 and 78% of total biomass, respectively.

1.1.4 Carbon content of bog vegetation

There are few studies that report the concentration of carbon in the components of bog species but those that do, show that the overall carbon content of bog tree and shrub species is a third more than that of bog bryophyte species (Malmer and Nihlgard 1980). Malmer and Nihlgard (1980) found that the mean percentage dry weight of carbon is 58 and 57 ± 1% in current, and 1 and 2 year old stems of the ericaceous shrub *Empetrum hermaphroditum*, respectively, while the mean percentage dry weight of carbon in *Dicranum* and *Sphagnum* spp. is significantly lower at 43 ± 1 to 44 ± 7%. The mean percentage dry weight of carbon in *Sphagnum* and feather moss species reported by Bodaly *et al.* (1987), which range from 40 to 42 % is similar to the percentages reported for bryophyte species by Malmer and Nihlgard (1980). The mean carbon content of *Ledum groenlandicum* with 47% in twigs and 41% in foliage, however, is lower than in *E. hermaphroditum*. As in *L. groenlandicum*, the mean carbon content of the foliage in *Picea mariana*, 42%, is lower than that of the woody tissue, 47% for twigs, 52% for bark and 50% for wood (Bodaly *et al.* 1987). The mean percentage dry weight of carbon in organic litter, according to Bodaly *et al.* (1987) is similar to that of bryophyte species at 41%.

Schwintzer (1983) reports the mean percentage dry weight of carbon at 52% in the leaves of *Myrica gale* and 50 to 51% in current, 1, 2 and 3 year old stems. In the fruit and male buds, this is slightly higher being 55 and 56%, respectively.

The global carbon pool per unit area of bogs/mires in cool or cold climates is roughly estimated at 20,000 kg C ha^{-1} (Olson *et al.* 1983), however, there are no detailed, site-specific estimates of the carbon pool in vegetation of bog communities in the literature.

CHAPTER 2. Vegetation composition and aboveground biomass of vegetation in two basin bogs in the Experimental Lakes Area, north-western Ontario

2.0 INTRODUCTION

Wetlands are common on the Canadian Shield where they develop in closed depressions in the granite bedrock. Zoltai (1979) estimates that they occupy between 5 and 25% of the Low Boreal wetland region, which extends from the south-east corner of Manitoba into the central region of Quebec. Treed basin bogs are characteristic wetlands of this region (National Wetlands Working Group 1988). Peat fills the topographic basin so that the surface is nearly level. The peat is usually deepest near the centre and becomes shallower towards the periphery. Such peatlands are acidic, pH <4.5, and nutrient-poor. Although mostly ombrotrophic, many of these peatlands receive run-off from the surrounding upland or surface streams. However, these inputs tend to be acidic and nutrient-poor due to the nature of the granite bedrock and coniferous vegetation, thus contributing to, rather than buffering, these conditions (Vitt and Bayley 1984).

The bog flora of this region is said by Glaser (1992) to be the most species poor in eastern North America. It is characterized by coniferous trees when present, ericaceous shrubs, relatively few herb species and a number of *Sphagnum* spp. Tree cover is absent or varies from low to high density black spruce (*Picea mariana*), with a few larch (*Larix laricina*) in wetter habitats. The low shrub layer is dominated by labrador tea (*Ledum groenlandicum*) or leather-leaf (*Chamaedaphne calyculata*), with bog-laurel (*Kalmia polifolia*), and bog cranberry (*Oxycoccus quadripetalus*). Sheep-laurel (*K. angustifolia*) is a low shrub species found in the eastern part of the region (Segadas-Vianna 1955; Kenkel 1987). Common herbs include three-leaved Soloman's seal (*Smilacina trifolia*), and various sedges (e.g. *Carex oligosperma, C. trisperma*). The ground layer is dominated by *Sphagnum* spp. (*S. angustifolium, S. capillifolium, S. fallax, S. fuscum, and S. magellanicum*) (Dansereau and Segadas-Vianna 1952; Segadas-Vianna 1955; Reader and

Stewart 1972; Jeglum *et al.* 1974; Vitt and Bayley 1984; Glaser 1992). The species composition of bogs in northern Minnesota is consistent with that of the Low Boreal wetland region (Heinselman 1970; Glaser *et al.* 1981, 1990; Glaser 1983, 1987; Swanson and Grigal 1991).

The species composition of peatlands varies along environmental gradients including depth to the water-table, shade, minerotrophy, peat productivity, mire expanse - mire margin, and duration of soil saturation (Sjörs 1948, 1950; Jeglum 1971; Vitt and Bayley 1984; Okland 1990; Cooper and Andrus 1994). Despite the continuous variation in species composition along gradients, physiognomically distinguishable plant communities are found in the field (Sims *et al.* 1982; Bergeron and Bouchard 1983; Kenkel 1987; Glaser 1987; Jeglum 1991; Okland 1991). Vegetation physiognomy is an important characteristic used to classify peatland communities (Jeglum *et al.* 1974; National Wetlands Working Group 1988). The Canadian Wetland Classification System involves factors such as hydrology and surface topography that influence the development and succession of vegetation, and thus the physiognomy of a site (Zoltai and Vitt 1995).

Aboveground biomass is also a reflection of the factors that determine the development and structure of plant communities, although there are few examples in the literature that include estimates for all community components. Estimates of aboveground community biomass range from 5,546 kg ha^{-1} (including vascular and bryophyte species) for an 'open' (aforested) bog community in south-east Manitoba (Reader and Stewart 1972) to 101,975 kg ha^{-1} (including vascular species only) for black spruce forested bog communities in north-central Minnesota (Grigal *et al.* 1985).

This research is part of the Experimental Lakes Area Reservoir Project (ELARP). The ELARP study involves the flooding of an experimental basin bog in north-western Ontario to simulate a hydroelectric reservoir. Postflood changes in concentrations of the greenhouse gases CO_2 and CH_4, and methyl mercury will be compared with those of a reference bog and modeled. The objectives of this component of the project are to (1) describe the plant communities and their species composition of the experimental bog L979, prior to flooding, and reference bog L632, and (2) to estimate the aboveground biomass of these communities.

2.1 STUDY AREA

The two bogs, designated L979 and L632, are approximately 7 km apart, in the Experimental Lakes Area (ELA) (49°40'N, 93°44'W) administered by the Canadian Department of Fisheries and Oceans, about 56 km south-east of Kenora in north-western Ontario.

The bedrock in this part of the Canadian Shield is composed of Archean granite and gneiss. The region was glaciated most recently in Wisconsin time and became ice-free between 12,500 and 12,200 years BP. (Prest 1969). The terrain is irregular, local relief is 10 to 30 m and more, with numerous outcrops and ridges, and closed depressions containing lakes and deposits of peat (Teller and Bluemle 1983), commonly with maximum peat depths of 5 to 7 m (National Wetlands Working Group 1988). Wet sites typically support black spruce and tamarack while upland sites have trembling aspen, paper birch and Jack pine in early successional stages, and white spruce, black spruce and balsam fir in later stages (National Wetlands Working Group 1988).

The climate is characterized by cold winters, warm summers and high precipitation (National Wetlands Working Group 1988). From 1970 to 1987 the mean annual air temperature at ELA was 2.4°C, with a mean of 201 ice-free days. The monthly mean air temperature ranged from -17.6°C in January, to 19.2°C in July . The mean annual precipitation was 679 mm, 27% falling as snow, while the mean annual evaporation was 701 mm (Beaty and Lyng 1989).

Both peatlands may be classified as basin (National Wetlands Working Group 1988) or kettle-hole bogs (Damman 1986). Each is situated within a bedrock basin, with a central, shallow, open water body. The water body is surrounded by bog vegetation rooted in well-developed organic soils, overlying peat. The most important water input in L979 is a surface inflow stream originating from L240, a relatively small, cold, oligotrophic lake typical of the region. Both bogs receive water inputs in the form of runoff from the surrounding uplands. This is the most significant water input in L632 (Beaty *et al.* 1994).

Prior to flooding, the surface area of the open water of L979 was 2.38 ha and the peatland, 13.98 ha for a total of 16.36 ha (Beaty *et al.* 1994). The maximum depth of the water body was approximately 4 m.

Studies by Yazvenko *et al.* (1994) indicate that according to radiocarbon dating, deposition of organic material in L979 began by 8,700 years BP. The modern *Sphagnum* peatland was developed about 3,000 to 2,000 years BP. Stratigraphy reveals that the surficial *Sphagnum* peat, which extends to a depth of approximately 3 m near the central water body, is underlain by detrital peat near the peatland-upland interface and by cyperaceous peat towards the water body. Maximum peat depth of the main basin is 9.1 m, with an average thickness of 1.7 m. Peat thickness in the sub-basin that extends towards the north-east (Fig. 2.1) ranges from 1 to 1.5 m. Peat deposits are underlain by clay and silty clay in the central depression and coarse to medium sand on the sides of the basin. The upland surrounding the site is dominated by Jack pine as a result of fire in 1980.

The L632 site is a headwater system covering 4.25 ha. The water body is 0.86 ha with a maximum water depth of 3.5 m, and the vegetated area 3.39 ha (Beaty *et al.* 1994). The surficial layer of *Sphagnum* peat is underlain by cyperaceous peat, then ericaceous and woody peat near the water body, and detrital peat near the peatland-upland interface (Branfireun *et al.* 1996). The maximum peat depth of the basin is approximately 6 m. Near the peatland-upland interface the peat layers are underlain by well-sorted sand and gravel (Branfireun *et al.* 1996). The surrounding upland is dominated by mature Jack pine and black spruce.

2.2 METHODS

2.2.0 Sampling design

Aerial photos of L979 and L632 were examined using a Dietzgen stereoscope with 3x magnification. The photos were taken on September 20, 1991 with a Wild RC8 camera and a 15-UAg-351 lens. Color photos of L979 taken at 3,000' above sea level with a scale of 1:3,440, and black and white photos of L632 taken at 3,900' above sea level with a scale of 1:5,320 were used. Community types within each site were delineated along the boundaries of areas that varied in tree density and height, as determined by the length of tree shadows, and the tone, texture and pattern of understory vegetation in the photos.

Six vegetation community types were delineated in L979 (Fig. 2.1) and two in L632 (Fig. 2.2). The number of samples in each community type was assigned in proportion to the area occupied by each community. A stratified random sampling design was employed, with community types subdivided into approximately equal sized blocks and plots randomly distributed within blocks. An equal number of plots was sampled in each block. The vegetation was divided into three vertical strata for sampling purposes; (1) trees, ≥10 cm circumference at breast height (CBH), (2) saplings and tall shrubs, <10 cm CBH and >1.5 m tall, (3) tree and tall shrub seedlings and low shrubs, ≤1.5 m tall, herbs, bryophytes and lichens.

2.2.1 Species cover

In July, 1992, the percentage cover of tree, tall shrub, low shrub, herb, bryophyte and lichen species was estimated within 1 m x 0.5 m plots, consisting of two adjacent 0.5 m x 0.5 m quadrats. Plot size and shape were chosen based on the analysis of preliminary sampling data (Kenkel and Podani 1991). One hundred and ninety-five plots were sampled in L979, and 46 in L632. Plant cover was estimated to the nearest 10%, with cover categories of 5%, 1% and 0.5% (trace) used for small and/or less abundant species. Five randomly chosen 0.5 m x 0.5 m quadrats were flagged in each community type for the harvest of aboveground seedling, low shrub, herb and bryophyte biomass at a later date.

Because of the difficulty in distinguishing *Sphagnum angustifolium* from *S. fallax* in the field, the cover of these species was combined into one *S. angustifolium/fallax* category, although it should be noted that they occupy different habitat niches (Vitt and Bayley 1984).

2.2.2 Statistical analysis of species composition

The cover data were analyzed separately for each bog using a series of multivariate techniques. Correspondence analysis (CA) was performed on square root-transformed cover data of species with a mean of 5% or greater in at least one community type using the CANOCO program (ter Brakk 1987). CA was used to summarize the data sets into a few meaningful axes which could then be used as variables in canonical variates analysis (CVA) to test for a significant difference and observe maximum separation among communities based on species composition. Plot component scores for the first three axes resulting from CA were used as variables in CVA. The SYN-TAX software package (Podani 1990) was used to perform CVA in which the resulting scores were spherized.

2.2.3 Surface water chemistry

Two water samples were collected from randomly selected 1 m x 0.5 m plots. Fifty samples were collected in L979, and 25 in L632. The water samples were collected in 125 ml plastic nalgene bottles from surface pools, or from shallow pits dug to the groundwater table and allowed time to equilibrate. The water samples were refrigerated within 4 hours of collection. Conductivity was measured using a Radiometer CDM 2e conductivity meter and pH measurements were made using a Fisher digital pH meter 109. Conductivity and pH were measured within 48 hours of collection. Conductivity measurements were corrected for the presence of H^+ ions (Sjörs 1950).

2.2.4 Tree, sapling and tall shrub density

The density and CBH of trees in each community were sampled using the point quarter method (Cottam and Curtis 1956). The density of saplings and tall shrubs was sampled by recording the number of stems of each species present in 2 m x 2 m plots in communities with a well-developed sapling and tall shrub stratum (≥10% cover of saplings and tall shrubs), and 4 m x 4 m plots in other communities. In addition, the sapling and tall shrub stems in the plots were assigned to a stem diameter class for the purpose of biomass estimation (Ohmann *et al.* 1976). Stem diameter classes represented the stem diameter 15 cm above ground level rounded to the nearest cm. Class 1 included stems 0.5 to 1.4 cm in diameter, class 2 stems 1.5 to 2.4 cm in diameter, class 3 stems 2.5 to 3.4 cm in diameter, and class 4 stems 3.4 to 4.4 cm in diameter.

2.2.5 Tree biomass

Species-specific, allometric biomass regression equations in the form;

$$Y = a * b^X$$

where Y is biomass, a and b are regression coefficients, and X is DBH (diameter at breast height) were used to estimate *Picea mariana* biomass. These equations were developed by Grigal and Kernik (1984) from samples collected in a bog in north-central Minnesota. The DBH values were derived from CBH values collected during the sampling of tree density. The biomass of other species (*Betula papyrifera*, *Larix laricina* and *Pinus banksiana*) was estimated from the logarithmic regression equations ($\log Y = a + b * \log X$) of Ker (1980). The mean biomass of each species was estimated from the point quarter data and summed to give the total tree biomass for each community.

2.2.6 Sapling and tall shrub biomass

Aboveground sapling and tall shrub biomass was estimated from regression equations developed from the biomass of saplings and tall shrubs collected from L979 and

L632 in September, 1992, and June and July, 1993. Thirty individuals of stem classes with more than 25 stems in the plots sampled for sapling and tall shrub density, and 10 of stem classes with less than 25 stems were collected for each species present in the density plots. Only individuals with a typical growth pattern or crown shape were collected. Three predictor variables were measured on each individual; (1) stem diameter at 15 cm above ground level, (2) stem height and (3) canopy area (Ohmann *et al.* 1976). The saplings and shrubs were separated into stem, branch and leaf components and dried at 80°C to a constant mass.

The total oven-dried mass of each species was plotted against each of the three predictor variables measured, and D^2H, where D = stem diameter and H = stem height. Univariate and multivariate (using every possible combination of predictor variables) linear ($Y = a + b * X$), log-log linear ($\log Y = a + b * \log X$) and allometric ($Y = a * b^X$) regression models were applied to the data using SYSTAT 5.1 (Wilkonson 1989). The regression model and predictor variable(s) that provided the best fit based on a comparison of coefficients of determination (R^2), standard errors (s) and F-ratios was used to estimate the biomass of saplings and tall shrubs sampled in the density plots. The midpoint of the diameter class of each sapling or tall shrub was used as the diameter variable (Tilton and Bernard 1975).

2.2.7 Seedling, low shrub, herb, bryophyte and litter biomass

In August, 1992, the aboveground tree and tall shrub seedling, low shrub, herb and non-vascular plant material was clipped, and standing and fallen litter collected, from flagged 0.5 m x 0.5 m quadrats to the level at which the *Sphagnum* ceased to be green (Sjörs 1991). The living plant material was separated from litter and then sorted by species. Cyperaceous and non-vascular species were grouped into Cyperaceae and bryophyte categories. The leaves of seedlings and low shrubs were separated from branches and stems. Each category of plant material was dried at 80°C to a constant mass.

Regressions were calculated on the relationship between percentage cover and biomass for the categories present in the harvested samples. Overall, these regressions did not adequately provide a predictable relationship between percentage cover and biomass (Fig. D.2). Since there was no clear relationship between cover and biomass, the seedling, low shrub, herb, bryophyte and litter biomass of each community type was estimated as the mean of the harvested plots.

2.2.8 Standard error

Biomass estimates were expressed as biomass per unit area (kg ha^{-1}) ± standard error. Biomass estimates and associated standard errors were calculated as follows; for trees, saplings and tall shrubs the biomass per unit area was calculated as

$$Y = B * D$$

where Y is the tree (sapling or tall shrub) biomass per unit area, B is the biomass per tree and D is tree density. The standard error of the estimate was

$$S_Y^2 = Y^2[(S_B^2/B^2) + (S_D^2/D^2)]$$

where S_Y is the standard error of the estimate, S_B is the standard error of the biomass per tree and S_D is the standard error of tree density.

Community biomass is the sum of the biomass for each stratum. The associated standard error was calculated as

$$S_C^2 = S_T^2 + S_{S,TS}^2 + S_{S,LS,H,N}^2$$

where S_C is the standard error of community biomass, S_T is the standard error of tree biomass, $S_{S,TS}$ is the standard error of sapling and tall shrub biomass, and $S_{S,LS,H,N}$ is the standard error of seedling, low shrub, herb and bryophyte biomass (Grigal 1991).

2.3 RESULTS

2.3.0 Species composition

In L979, 60 taxa were recorded in the sample plots and an additional nine species were observed outside these plots (Appendix A.1). In L632, 48 taxa were present in the plots sampled, with 21 species observed outside these plots (Appendix A.2). Forty-two species were found in the plots at both sites. Relatively common species with a mean cover ≥5% in both sites included *Picea mariana*, *Chamaedaphne calyculata*, *Kalmia polifolia*, *Ledum groenlandicum*, *Myrica gale*, *Oxycoccus quadripetalus*, *Pleurozium schreberi*, *Smilacina trifolia*, *Sphagnum angustifolium/fallax*, *S. fuscum*, and *S. magellanicum* (Table 2.1).

In L632, the surface of the peat mat extends into the central water body forming a narrow zone of loosely consolidated, floating peat. Rooted in this zone were species usually associated with minerotrophic conditions including *Carex pauciflora*, *Rhynchospora alba*, *Scheuchzeria palustris* and *Xyris montana* a species at the north-west extent of its distribution and considered rare in Minnesota (Coffin and Pfannmuller 1988; Wright *et al.* 1992). Of these species *X. montana*, in particular, is known to prefer conditions where there is reduced competition from other species (Wright *et al.* 1992), which in this site is likely due to the loosely consolidated nature of the peat and hydrologic fluctuations of the adjacent water body.

In L979, a zone of floating peat and minerotrophic species was absent, probably because a faster flow-through rate (Beaty *et al.* 1994) had prevented extension of the peat surface into the central water body. Also, although the conductivity of water samples collected from surface pools in the various communities did not indicate this, the groundwater and central water body of L632 may be slightly more minerotrophic than that in L979 because it is a headwater system.

Eight plant communities were recognized, six in L979 and two in L632. The physiognomy and vertical structure (i.e. strata) of the communities were defined according

Table 2.1. The mean percent cover of species with a mean of ≥5% in at least one community of L979 and L632. Letters in brackets following the species names correspond to the species centroids on CA ordinations (Figs. 2.3 & 2.4).

	L979 Community types						L632	
	1*	2	3	4	5	6	7	8
Species	(n=32)	(n=32)	(n=91)	(n=4)	(n=24)	(n=12)	(n=40)	(n=6)†
Trees								
Larix laricina (Ll)	6	8	2	-	-	-	t	-
Picea mariana (Pm_t)	37	17	1	54	-	-	9	-
Saplings								
Picea mariana (Pm_s)	6	8	5	-	6	2	-	1
Pinus banksiana (Pb)	-	-	t	-	-	9	-	-
Tall shrubs								
Alnus rugosa (Ar)	-	-	-	10	14	-	-	1
Low shrubs								
Chamaedaphne calyculata (Cc)	7	18	49	12	27	8	26	18
Kalmia polifolia (Kp)	1	7	6	1	3	1	5	4
Ledum groenlandicum (Lg)	50	39	7	56	26	63	29	3
Myrica gale (Mg)	-	-	8	-	-	-	15	15
Oxycoccus quadripetalus (Oq)	2	10	11	1	3	6	6	3
Herbs								
Carex oligosperma (Co)	-	-	-	-	-	-	1	16
C. trisperma (Ct)	1	-	1	-	2	3	8	-
Lycopodium annotinum (La)	2	3	-	12	12	-	1	2
Smilacina trifolia (St)	5	11	3	-	4	15	9	9
Bryophytes								
Pleurozium schreberi (Ps)	27	3	3	6	2	1	9	-
Sphagnum angustifolium/fallax (Sa)	27	53	36	18	45	21	37	64
S. fuscum (Sf)	6	12	27	-	-	6	13	5
S. magellanicum (Sm)	15	15	8	33	25	26	16	18
Litter	16	8	16	25	12	31	18	7

* see Figs. 2.1 & 2.2 for corresponding community descriptors.
† number of 0.5 m x 0.5 m plots
t trace (<1%)

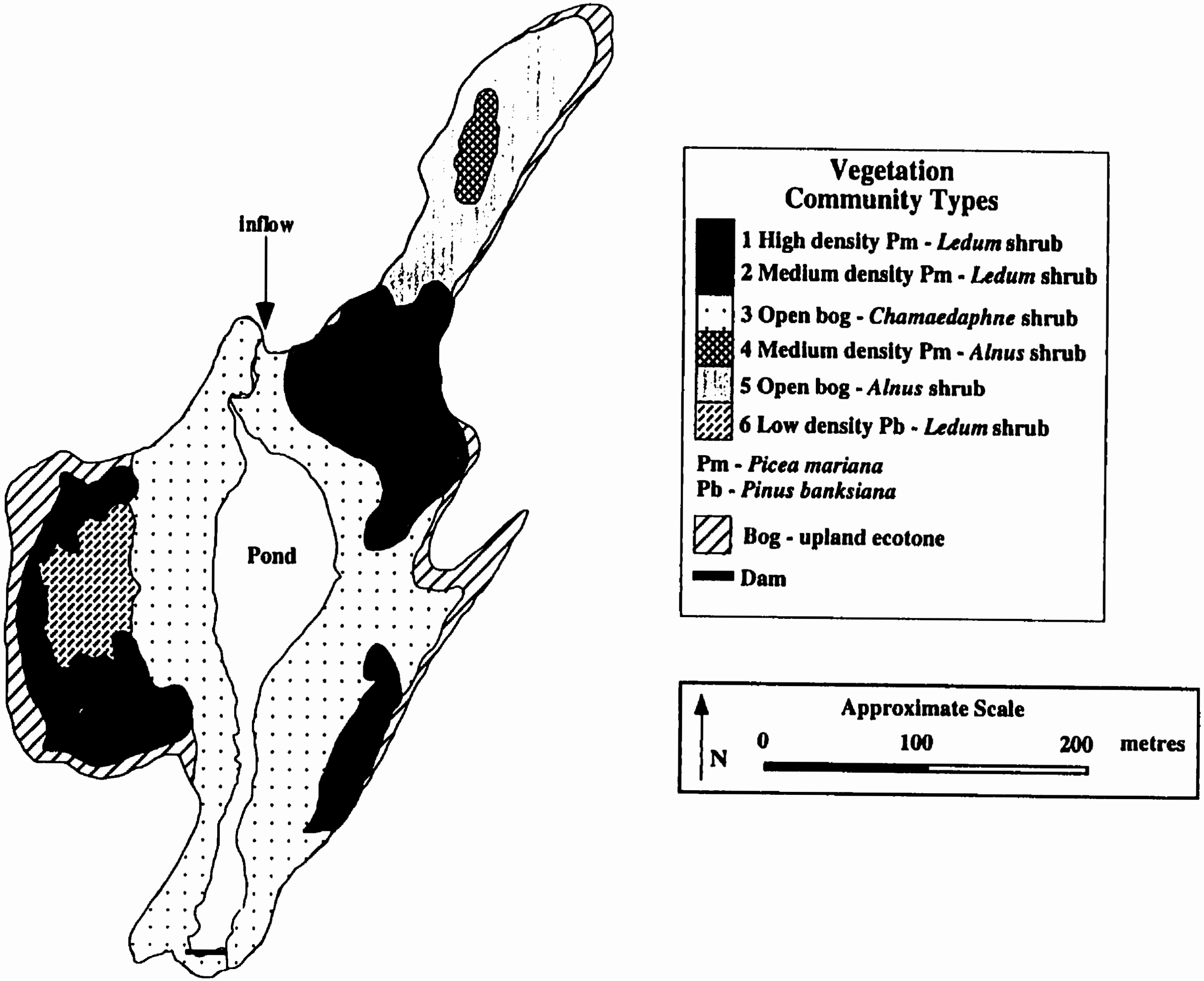

Figure 2.1. Vegetation map of L979 showing the six communities delineated from aerial photographs.

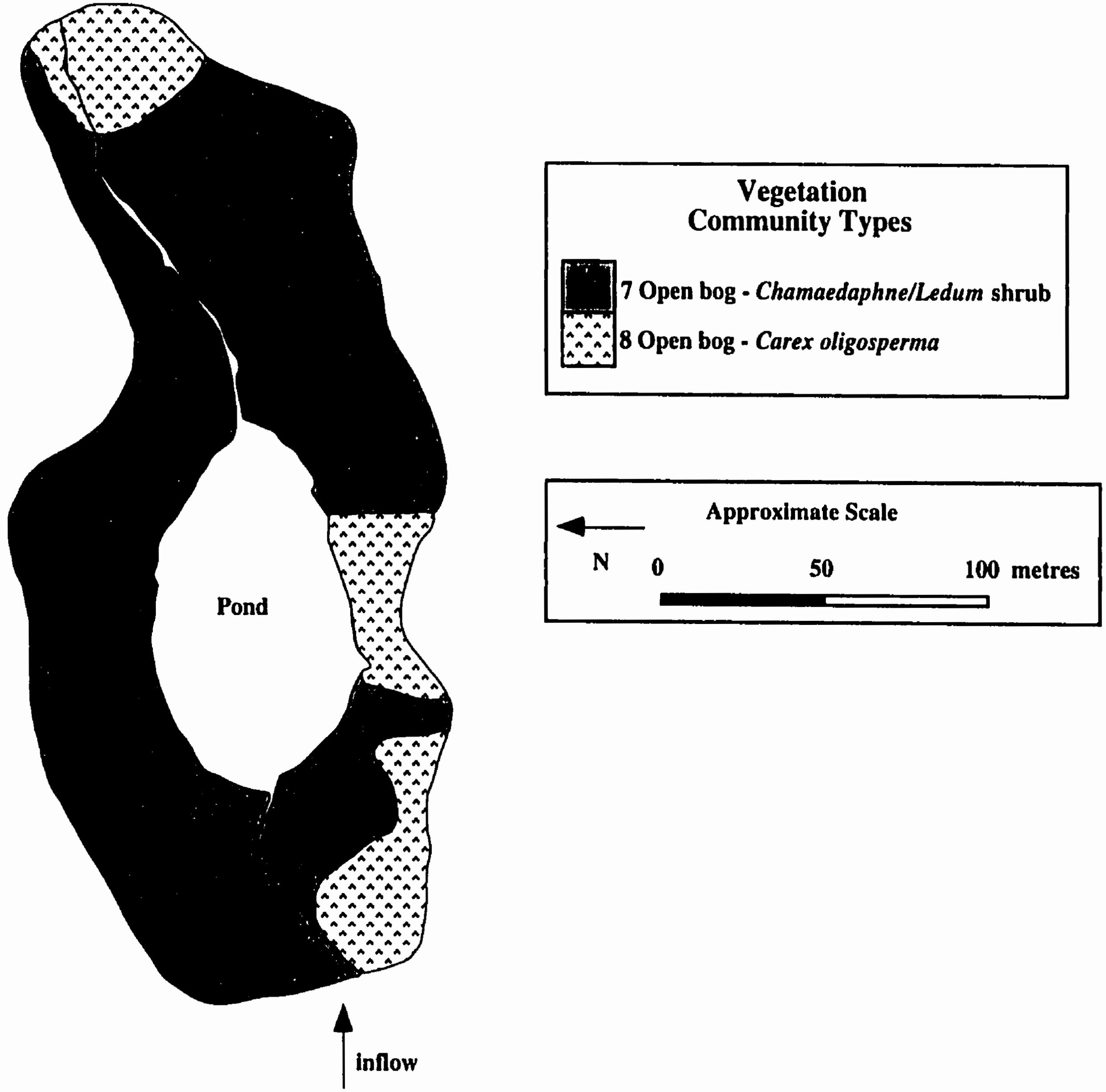

Figure 2.2. Vegetation map of L632 showing the two communities delineated from aerial photographs.

to the wetland classification proposed by Jeglum *et al.* (1974) where tree and tall shrub strata have a total species cover of ≥10%.

Community physiognomy was either open in communities lacking continuous tree cover or treed, with trees in low to high densities (11 to 54% cover, 362 to 2,726 individuals ha^{-1}). *Picea mariana* dominated the tree cover except in the area that burned 12 years earlier where *Pinus banksiana* dominated. The two communities of the north-east sub-basin of L979 had well-developed, albeit sparse (10 and 14% cover), tall shrub strata dominated by *Alnus rugosa*.

All eight communities had a well-developed low shrub layer with 43 to 81% cover, composed mostly of ericaceous species and dominated either by *Chamaedaphne calyculata* or *Ledum groenlandicum*, or with approximately equal cover of both. The cover of herbs in these communities was relatively low (4 to 27%) and dominated by *Carex oligosperma*, *Lycopodium annotinum*, *Smilacina trifolia* or co-dominated by *Carex trisperma* and *S. trifolia*. The ground layer was predominantly *Sphagnum* spp. (*S. angustifolium/fallax* and *S. magellanicum*) except in the community with the highest density of trees where *Pleurozium schreberi* was co-dominant with *S. angustifolium/fallax*.

Community 1 High density *Picea mariana - Ledum* shrub

Community 1 was adjacent to the upland along on the east and west side of the main peatland basin of L979 (Fig. 2.1). It had a relatively dense overstory of trees dominated by *Picea mariana* (37% cover), with a small number of *Larix laricina* (6% cover) (Table 2.1). There were 2,726 trees ha^{-1} (Table 2.2), with a mean area at breast height of 11.5 m^2 ha^{-1}. The low shrub layer was dominated by *Ledum groenlandicum* (50% cover). *Smilacina trifolia* was the most common herb (5% cover). The ground layer was co-dominated by *Sphagnum angustifolium/fallax* (27% cover) and the feather moss *Pleurozium schreberi* (27% cover) (Table 2.1).

Community 2 Medium density *Picea mariana - Ledum* shrub

Community 2 was located between community 3, which surrounds the central pond of L979, and the north-east sub-basin (Fig. 2.1). In the tree overstory, *Picea mariana* had the highest cover (17%) and a small number of *Larix laricina* (8%) were present. The tree density was 1,370 trees ha^{-1}, with a mean area at breast height of 8.8 m^2 ha^{-1}. *Ledum groenlandicum* had the highest cover (39%) in the low shrub layer. *Smilacina trifolia* was the most common herb (11%). *Sphagnum angustifolium/fallax* (53%) dominated the ground layer.

Community 3 Open bog - *Chamaedaphne* shrub

Community 3 surrounded the central water body of L979 (Fig. 2.1). It lacked continuous tree and tall shrub cover but the low shrubs had a cover of 81%, to which *Chamaedaphne calyculata* contributed 49%. *Smilacina trifolia* (3% cover) was the most common herb. *Sphagnum angustifolium/fallax* (36%) dominated the ground layer, however, *S. fuscum* (27%) was also an important species found on the tops of hummocks.

Community 4 Medium density *Picea mariana - Alnus* shrub

Community type 4 was located in the center of the north-east sub-basin of L979 (Fig. 2.1). It had a mean tree cover of 54%, composed of *Picea mariana* with 1,372 trees ha^{-1} and a mean area at breast height of 7.1 m^2 ha^{-1}. The sparse *Alnus rugosa* tall shrub stratum had a mean cover of 10%. The low shrub layer was dominated by *Ledum groenlandicum* (56% cover), while *Lycopodium annotinum* was the most common herb (12% cover) (Table 2.1). The ground layer was dominated by *Sphagnum magellanicum* (33% cover).

Community 5 Open bog - *Alnus* shrub

Community 5, also located in the north-east sub-basin of L979, lacked a well-developed overstory of trees (Table 2.1). As in community 4, *Alnus rugosa* tall shrubs were present. They had a mean cover of 14% and density of 14,583 stems ha^{-1}. The low shrub layer was co-dominated by *Chamaedaphne calyculata* (27% cover) and *Ledum groenlandicum* (26% cover) (Table 2.1). *Lycopodium annotinum* had a cover of 12% in the herb layer, and the ground layer was dominated by *Sphagnum angustifolium/fallax* (45%).

Community 6 Low density *Pinus banksiana* - *Ledum* shrub

Community 6 was located on the west side of the basin in an area that burned 12 years earlier. It had a sparse overstory of tree saplings composed mainly of *Pinus banksiana* (9%), with some *Picea mariana* (2% cover) which together had a density of 7,708 saplings ha^{-1} (Table 2.1). The low shrub layer was dominated by *Ledum groenlandicum* (63% cover). *Smilacina trifolia* was the most common herb (15% cover). The ground layer was dominated by *Sphagnum magellanicum* (26% cover). Community 6 had the highest mean cover of litter (31%) among the communities of L979.

Community 7 Open bog - *Chamaedaphne/Ledum* shrub

Community 7 vegetation covered the bog at L632 except for three relatively small areas with no trees that were delineated as community 8. The mean tree cover of community 7 was just below the 10% threshold to be considered a treed bog community. *Picea mariana* dominated the tree cover which had a density of 2,250 trees ha^{-1} and a mean area at breast height of 5.9 m^2 ha^{-1}. The low shrub layer was co-dominated by *Ledum groenlandicum* (29% cover) and *Chamaedaphne calyculata* (26% cover). *Smilacina trifolia* (9% cover) and *Carex trisperma* (8% cover) were common herbs. The ground layer was dominated by *Sphagnum angustifolium/fallax* (37%).

Table 2.2. Environmental and vegetation characteristics of the plant communities in L979.

	High density Pm - *Ledum* (1)	Medium density Pm - *Ledum* (2)	Open bog - *Chamaedaphne* (3)	Medium density Pm - *Alnus* (4)	Open bog - *Alnus* (5)	Low density Pb - *Ledum* (6)
Surface water						
pH mean	3.70	4.05	3.90	4.25	4.25	3.65
range	3.45 - 4.15	3.90 - 4.20	3.55 - 4.90	4.15 - 4.30	4.00 - 4.55	3.65 - 3.70
K_{corr} ($\mu S\ cm^{-1}$) mean	65.5	38.0	47.5	52.0	36.0	74.5
range	37.0 - 90.5	30.0 - 42.5	27.5 - 76.5	26.0 - 77.5	21.5 - 58.0	72.5 - 75.5
Microtopography	hummock and hollow	hummock and hollow	hummock and hollow	hummock and hollow	lawn	hummock and hollow
Density (ha^{-1})						
Tree	2,726	1,370	1,766	1,372	865	362
Sapling and tall shrub	1,406	1,406	625	-	14,583	7,708
Biomass (± s.e. $kg\ ha^{-1}$)						
Tree	66,506 ± 20,613	33,978 ± 7,051	22,600 ± 9,200	24,750 ± 7,184	6,556 ± 4,207	898 ± 1,726
Sapling	1,454 ± 458	1,563 ± 516	747 ± 176	-	1,979 ± 651	3,545 ± 1,189
Tall shrub	-	-	-	-	1,871 ± 1,171	-
Seedling	103 ± 49	350 ± 228	1,225 ± 866	82 ± 58	1,218 ± 556	97 ± 36
Low shrub	2,463 ± 450	7,404 ± 1,799	10,223 ± 1,866	6,099 ± 969	5,825 ± 1,227	8,845 ± 1,367
Herb	1 ± 1	265 ± 123	30 ± 23	229 ± 70	838 ± 326	67 ± 35
Bryophyte	2,381 ± 495	2,337 ± 427	3,781 ± 922	2,478 ± 373	2,663 ± 301	1,914 ± 555
Total community	72,909 ± 20,627	46,043 ± 7,163	38,614 ± 9,297	33,651 ± 7,256	21,168 ± 4,837	15,395 ± 2,531

Pm - *Picea mariana*, Pb - *Pinus banksiana*

Table 2.3. Environmental and vegetation characteristics of the plant communities in L632.

	Open bog - *Ledum/Chamaedaphne* (7)	Open bog - *Carex oligosperma* (8)
Surface water		
pH mean	4.05	4.30
range	3.65 - 4.70	3.85 - 4.95
K_{corr} (µS cm^{-1}) mean	40.5	26.5
range	20.5 - 65.0	21.5 - 38.5
Microtopography	hummock and hollow	lawn
Density (ha^{-1})		
Tree	2,250	-
Sapling and tall shrub	2,143	-
Biomass (± s.e. kg ha^{-1})		
Tree	27,181 ± 10,705	-
Sapling	2,376 ± 495	-
Tall shrub	-	-
Seedling	34 ± 34	-
Low shrub	8,983 ± 1,560	2,133 ± 567
Herb	184 ± 128	964 ± 223
Bryophyte	2,626 ± 592	4,047 ± 924
Total community	41,384 ± 10,780	7,189 ± 924

Community 8 Open bog - *Carex oligosperma*

Community 8 occurred in three separate areas of L632. All were areas of groundwater discharge, near the small inflow stream, on the south side of the basin, and near the small outflow stream. It was treeless. The cover of low shrubs was the lowest among communities. *Chamaedaphne calyculata* and *Myrica gale* together provided 33% cover. *Carex oligosperma* had a cover of 16% in the herb layer and the ground layer was dominated by *Sphagnum angustifolium/fallax* (64% cover).

The surface water in the communities of both sites had low pH and conductivity values. The pH ranged from 3.45 to 4.95, and conductivity, expressed as total ions minus H^+ (K_{corr}) ranged from 20.5 to 90.5 $\mu S\ cm^{-1}$ (Tables 2.2 & 2.3). The communities with a lawn microtopography (Bubier *et al.* 1995) and a higher water-table tended to have a higher mean pH. However, there were no significant differences in either pH and conductivity among the communities of L979 and L632 according to ANOVA. The Low density *Pinus banksiana - Ledum* shrub (6) community had the highest conductivity value.

2.3.1 Multivariate statistical analysis

The ordinations resulting from correspondence analysis of cover data for both sites show differences in species composition, but not a complete separation of plot scores among community types (Figs. 2.3 & 2.4). In the ordination of L979 data, the plot scores of the same community type tend to clump together but overlap among communities. The greatest variation in the L979 data, summarized by the first CA axis, corresponds with a mire margin - mire expanse gradient (Sjörs 1948, 1950). The mire expanse, Open bog - *Chamaedaphne* shrub (3, see Fig. 2.1) community plots are on the left side of the ordination and the mire margin, High density *Picea mariana - Ledum* shrub (1) plots on the right (Fig. 2.3). At the mire expanse end of the gradient, plots are associated with the centroids of *Myrica gale* (Mg) and *Sphagnum fuscum* (Sf). The mire margin plots are characterized by *Picea mariana* (Pm_t) and *Pleurozium schreberi* (Ps).

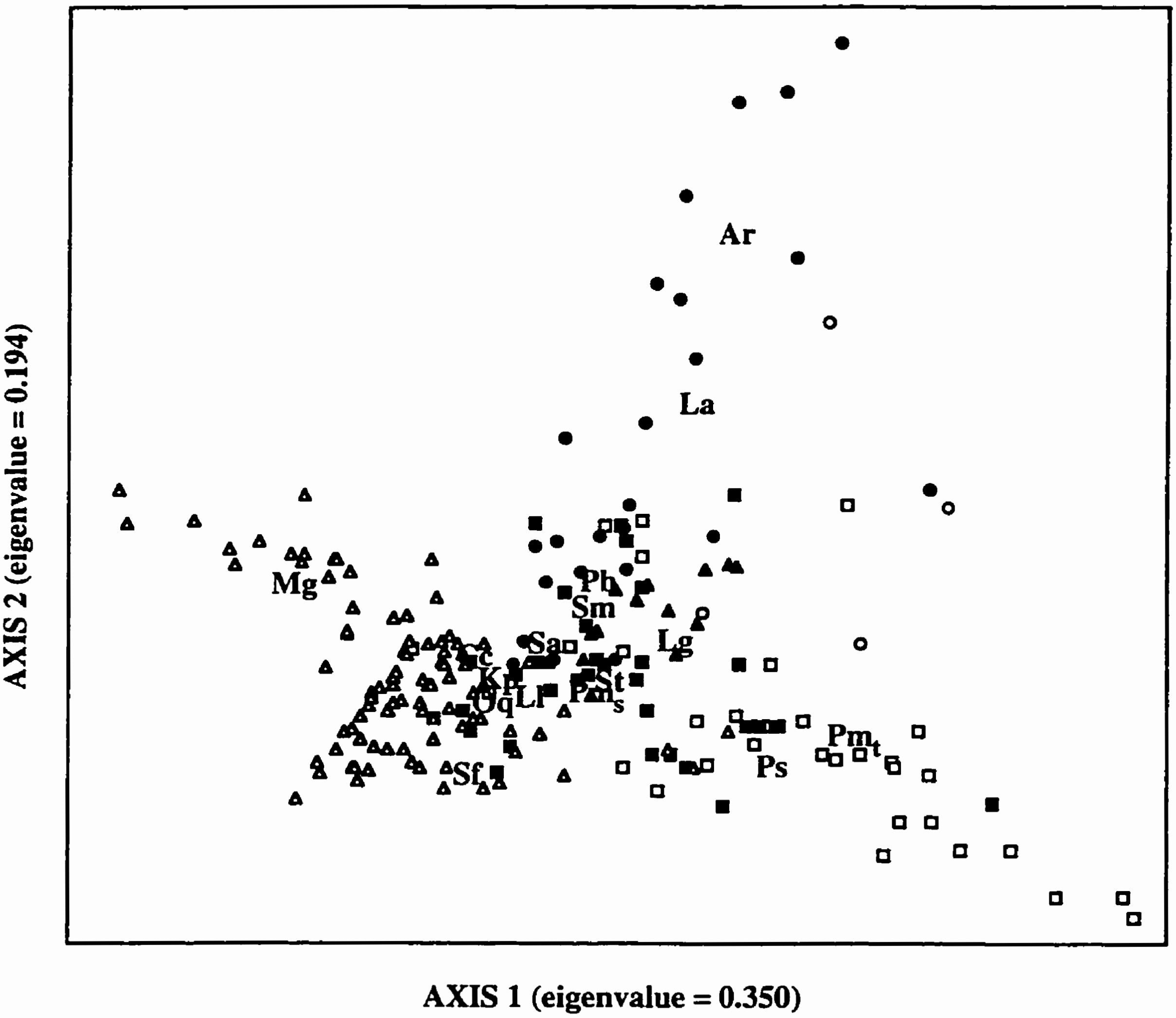

Figure 2.3. Ordination of plot scores and species centroids resulting from correspondence analysis of L979 data. Species centroids are represented by the letters assigned in Table 2.1. ▫High density *Picea mariana* - *Ledum* shrub (1); ▪Medium density *Picea mariana* - *Ledum* shrub (2); ▵ Open bog - *Chamaedaphne* shrub (3); ○Medium density *Picea mariana* - *Alnus* shrub (4); ●Open bog - *Alnus* shrub (5); ▲Low density *Pinus banksiana* - *Ledum* shrub (6).

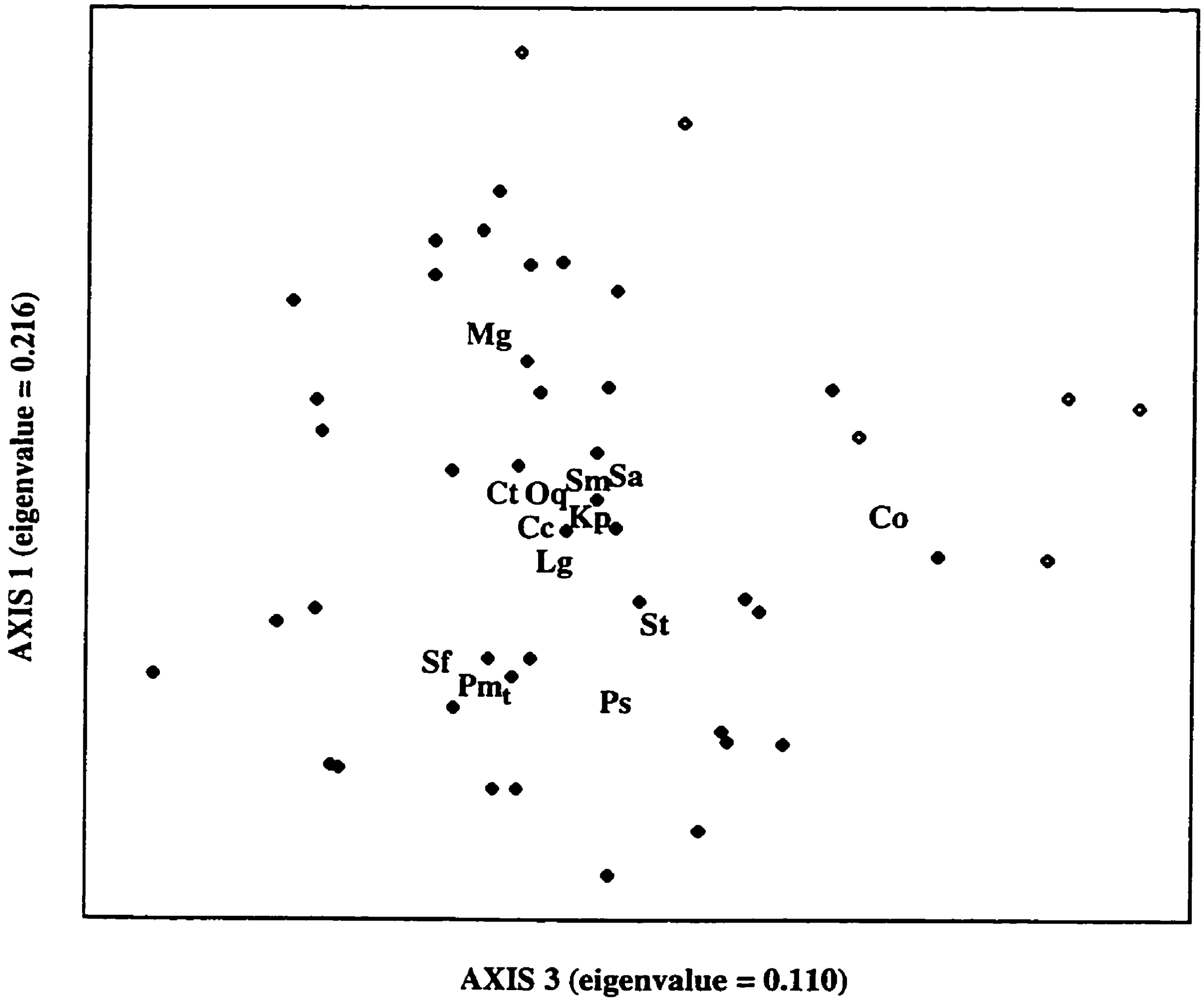

Figure 2.4. Ordination of plot scores and species centroids resulting from correspondence analysis of L632 cover data. Species centroids are represented by the letters assigned in Table 2.1. • Open bog - *Ledum/Chamaedaphne* shrub (7); ◦ Open bog - *Carex oligosperma* (8).

This gradient relates to the density and shading of the overstory trees, saplings and tall shrubs. It varies from the open community on the left side of the ordination with a relatively low density of saplings and/or tall shrubs, characterized by the low shrubs *Chamaedaphne calyculata* (Cc) and *Myrica gale*, and *Sphagnum fuscum* hummocks, to the densely treed bog community on the right, characterized by a relatively dense overstory of *Picea mariana* trees, and the co-dominance of *Pleurozium schreberi* in the ground layer. The other communities lie in between the extremes of this gradient. The Medium density *Picea mariana - Ledum* shrub (2), Medium density *Picea mariana - Alnus* shrub (4) and Low density *Pinus banksiana - Ledum* shrub (6) communities had intermediate cover of trees and the Open bog - *Alnus* community (5) lacked tree cover but had an overstory of tall shrubs.

As the density and cover of *Picea mariana* increased, the cover of *Chamaedaphne calyculata* in the communities of the main basin of L979 decreased, from 49% in the Open bog - *Chamaedaphne* shrub (3) community to 18% in the Medium density *Picea mariana - Ledum* shrub (2) community to 7% in the High density *Picea mariana - Ledum* shrub (1) community. At the same time the cover of *L. groenlandicum* increased from 7 to 39 to 50%.

The second CA axis in the L979 ordination emphasizes the difference in species composition between the communities of the north-east sub-basin (Medium density *Picea mariana - Alnus* shrub (4) and Open bog - *Alnus* shrub (5)) and those of the main basin. The north-east sub-basin plots are characterized by the presence of *Lycopodium annotinum* (La) and a layer of *Alnus rugosa* (Ar), both absent from the communities of the main basin.

Univariate analysis of variance (ANOVA) of the plot scores along the first three axes resulting from CA of L979 data showed significant differences in species composition at the alpha = 0.05 level along each of these axes (Table 2.4). The relatively high chi-square values associated with the first two canonical variates indicate that they were the most important in summarizing the difference in species composition in the L979 data set

(Table 2.5). Ordination of the spherized plot scores resulting from CVA shows separation of the 95% confidence circles and thus a difference in species composition of all communities except the Medium density *Picea mariana - Ledum* shrub (2) and Low density *Pinus banksiana - Ledum* shrub (6) communities (Fig. 2.5). The first CA axis was most important in the discrimination among communities in L979 data along the first CVA axis, as indicated by the high correlation of CA axis 1 and CV 1 (Table 2.6). This indicates that the first CA axis summarizing the most variation in species composition in the data set was highly correlated with the first CVA axis which exhibits maximum separation of the communities based on species composition.

In the CA ordination of L632 cover data, plot scores for the Open bog - *Carex oligosperma* (8) community lie on the upper and right side. They are characterized by *Carex oligosperma* (Co) and *Myrica gale* (Mg) (Fig. 2.4). The poor separation in plot scores between the two communities in L632 was probably due to the small sample size (n = 6) collected from the Open bog - *Carex oligosperma* (8) community. CA axis 1 may be interpreted as corresponding to a gradient in hydrology, with species found in drier habitats, *Picea mariana* (Pm_t), *Pleurozium schreberi* (Ps) and *Sphagnum fuscum* (Sf) towards the bottom of the ordination, and *M. gale*, a species that can survive long periods of flooding (Sjörs 1991), towards the top. Also, *Picea mariana*, *Pleurozium schreberi* and *Sphagnum fuscum* are species that are indicative of nutrient-poor conditions, whereas *M. gale* is usually associated with slightly more minerotrophic conditions (Sjörs 1961; Vitt and Bayley 1984).

Further analysis via ANOVA showed that the species composition of L632 significantly differs between the two communities along the first and third CA axes. It was most different along the third axis, as it had the largest associated F-ratio (Table 2.4). The CVA axis, exhibiting maximum separation among the communities of L632, was most highly correlated with the third CA axis with a value of 0.815. The third CA axis emphasizes the difference between the plots characterized by *Carex oligosperma* on the

Table 2.4. Results of univariate analysis of variance (ANOVA) performed on plot scores along the first three CA axes for L979 and L632 species composition data.

Variable	F-ratio	P-value	Correlation with corresponding canonical variate
L979 ($df^{*}_{5,189}$)			
CA axis 1	65.484	<0.001	0.930
CA axis 2	28.765	<0.001	0.874
CA axis 3	2.704	0.017	0.962
L632 ($df_{1,44}$)			
CA axis 1	5.801	0.020	0.496
CA axis 2	1.259	0.268	0.242
CA axis 3	20.156	<0.001	0.815

* df = degrees of freedom

Table 2.5. Results of chi-square tests with successive canonical variates removed for L979 and L632 data.

Canonical variate removed	Chi-square	Degrees of freedom	P-value
L979			
0	329.61	15	<0.001
1	122.13	8	<0.001
2	6.08	3	not significant
L632			
0	27.26	3	<0.001

Table 2.6. Correlation of CA axes with canonical variates (CV) in L979 and L632 data.

CA axis	CV_1	CV_2	CV_3
L979			
1	0.930	-0.355	-0.091
2	0.344	0.874	0.344
3	-0.127	-0.242	0.962
L632			
1	0.496		
2	0.242		
3	0.815		

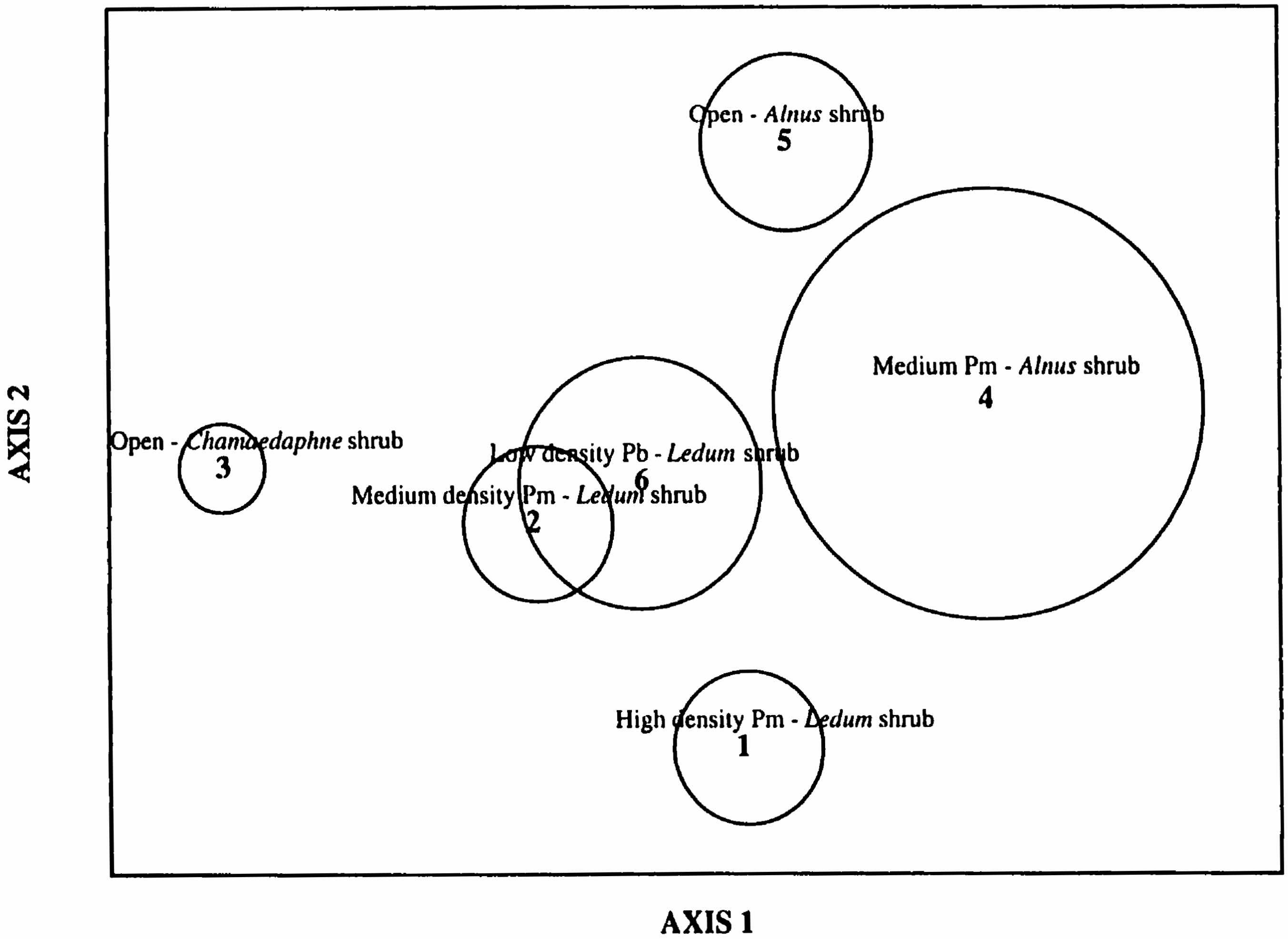

Figure 2.5. Ordination of L979 canonical variates analysis results with 95% confidence circles around the centroids. Centroids are represented by the numbers assigned to each community type in Fig. 2.1. Pb - *Pinus banksiana*, Pb - *Picea mariana*

right side of the CA ordination (Fig. 2.4) and the rest of the plots in L632.

2.3.2 Community biomass

The estimates of total aboveground biomass for the communities in L979 and L632 ranged from 7,189 ± 924 kg ha^{-1} (± s.e.) in the Open bog - *Carex oligosperma* (8) community of L632 to 72,909 ± 20,627 kg ha^{-1} in the High density *Picea mariana - Ledum* shrub (1) community of L979 (Tables 2.2 & 2.3). The lowest community biomass estimated in L979, 15,395 ± 2,531 kg ha^{-1}, was for the Low density *Pinus banksiana - Ledum* shrub (6) community which burned 12 years earlier.

The community with the highest estimate of total biomass, the High density *Picea mariana - Ledum* shrub (1) community, also had the highest estimate of tree biomass, 66,506 ± 20,613 kg ha^{-1} (Table 2.2). As the density of trees in the communities of the main basin in L979 decreased, low shrub biomass increased, from 2,463 ± 450 kg ha^{-1} in the High density *Picea mariana - Ledum* shrub (1) community to 10,223 ± 1,866 kg ha^{-1} in the Open bog - *Chamaedaphne* shrub (3) community. The biomass of other understory strata also followed this trend.

The Low density *Pinus banksiana - Ledum* shrub (6) community had the highest estimate of sapling biomass at 3,545 ± 1,189 kg ha^{-1} and the second largest estimate, 2,376 ± 495 kg ha^{-1} was for the Open - *Chamaedaphne/Ledum* shrub (7) community. The Open bog - *Alnus* shrub (5) community had the highest estimate of tall shrub biomass at 1,871 ± 1,171, while the Open bog - *Chamaedaphne* shrub (3) community had the largest estimate for tree and tall shrub seedlings at 1,225 ± 866 kg ha^{-1}. There is no estimate for tall shrubs in the Medium density *Picea mariana - Alnus* shrub (4) community because no tall shrubs occurred in the randomly distributed sapling and tall shrub density plots. Herb biomass was, in general, low, but was highest in the Open bog - *Alnus* shrub (5) community, at 838 ± 326 kg ha^{-1}, and Open bog - *Carex oligosperma* (8) community, at 964 ± 223 kg ha^{-1}. The mean biomass of bryophytes reached a maximum of

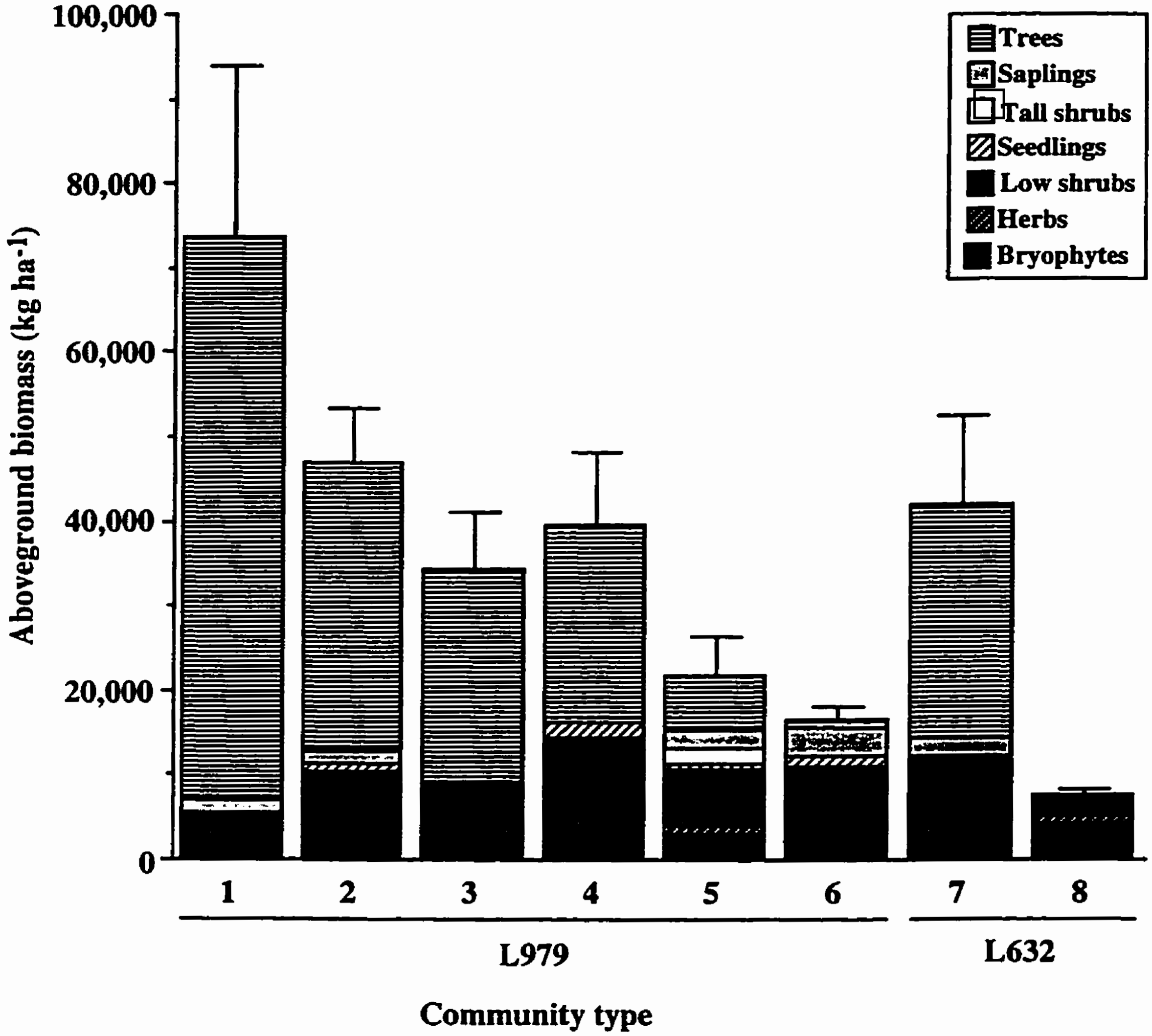

Figure 2.6. The aboveground biomass of trees, saplings, tall shrubs, tree and tall shrub seedlings, low shrubs, herbs and bryophytes in the communities of L979 and L632. The error bars represent the standard error associated with the estimate of total community biomass.

approximately 4,000 ± 900 kg ha^{-1} in the two most open communities, the Open bog - *Chamaedaphne* shrub (3) community of L979 and Open bog - *Carex oligosperma* (8) community of L632. The standard error ranged from 13 to 28% and averaged 21% of total community biomass.

2.4 DISCUSSION

2.4.0 Species composition

The species composition of the communities delineated in L979 and L632 generally agrees with the description of bog communities in the literature from the Low Boreal wetland region (Dansereau and Segadas-Vianna 1952; Segadas-Vianna 1955; Heinselman 1970; Reader and Stewart 1972; Jeglum *et al.* 1974; Glaser *et al.* 1981, 1990; Glaser 1983, 1987, 1992; Vitt and Bayley 1984; Kenkel 1987; Swanson and Grigal 1991). The communities of L979 and L632 were characterized by either an absence of tree cover, or the presence of *Picea mariana* with an occasional *Larix laricina* in medium to high densities, except in the area that burned 12 years earlier where there was a low density of *Pinus banksiana*. The communities of the north-east sub-basin of L979 had a sparse tall shrub layer dominated by *Alnus rugosa*. The ericaceous low shrub layer of all communities was dominated by *Chamaedaphne calyculata* or *Ledum groenlandicum*, with *Kalmia polifolia* and *Oxycoccus quadripetalus* as common species. *Myrica gale* was a common low shrub in both communities of L632. *Smilacina trifolia* was common in the herb layer of most communities. *Carex oligosperma* was common in the Open bog - *Carex oligosperma* (8) community and *Carex trisperma* in the Open bog - *Chamaedaphne/Ledum* shrub (7) community of L632. *Sphagnum angustifolium*, *S. fallax* and *S. magellanicum* predominated in the ground layer, except in the High density *Picea mariana - Ledum* shrub (1) community where *Pleurozium schreberi* was co-dominant with *S. angustifolium/fallax*. *Sphagnum fuscum* was prominent on the tops of hummocks in the Open bog - *Chamaedaphne* (3) shrub community of L979.

2.4.1 Variation in species composition

There was a significant difference in the species composition of the communities which had been delineated in L979 and L632 using aerial photos. Water chemistry is not likely to play a major role in these differences. The pH and conductivity did not significantly differ among the community types of L979 and L632. Glaser *et al.* (1981), Vitt and Bayley (1984) and Glaser (1987) also found that water chemistry did not play a significant role in the variation in species composition among bog communities they studied in northern Minnesota and north-western Ontario. Instead, they found that the depth to water-table, degree of shading and the 'mire margin - mire expanse gradient' were important factors in the variation in species composition among bog communities. This agrees with the CA ordination of L979 species composition data. The first axis emphasized the importance of the mire margin - mire expanse gradient. This gradient was described by Sjörs (1948, 1950) and is largely governed by hydrology. The mire margin and mire expanse are floristically and physiognomically distinct. The mire margin receives water inputs from the upland that have been in contact with mineral soil and is therefore slightly more minerotrophic than other areas of the bog. Also, the water-table is lower and more stable than in the mire expanse. This creates better conditions for tree growth (Damman and Dowhan 1981; Malmer 1986; Jeglum 1991; Cooper and Andrus 1994) The water-table is closer to the peatland surface in the mire expanse than in the mire margin and fluctuates throughout the growing season in response to the level of the central water body. A high water-table creates more anoxic soil conditions (Ingram 1983) and an unfavorable environment for tree establishment and growth.

The density of the overstory was correlated with changes in species composition in the understory. In the mire expanse of L979 (Open bog - *Chamaedaphne* shrub (3) community) with a lack of continuous tree cover, *C. calyculata* dominated the low shrub cover, in large part due to its ability to tolerate a wide spectrum of environmental conditions such as variation in water-table levels (Segadas-Vianna 1955), and *Sphagnum fuscum* was a significant presence in the ground layer. In the mire margin (High density *Picea mariana* - *Ledum* shrub (1) community), with a high density tree cover, *L. groenlandicum* dominated the low shrub cover. *Ledum groenlandicum* occurs in areas that are drier, more shaded and have less extreme water-table fluctuations (Dansereau and Segadas-Vianna 1952). *Sphagnum* was co-dominant with *Pleurozium schreberi*, which is typically predominant in dense *Picea mariana* stands (Heinselman 1970; Reader and Stewart 1972; Jeglum 1973).

The second CA axis in the ordination of L979 data emphasized the difference in species composition between the north-east sub-basin and the main basin. Both communities in the north-east sub-basin had a tall shrub layer of *Alnus rugosa* with *Lycopodium annotinum* in the herb layer. These species are indicators of minerotrophic conditions, and were absent from the main basin. This difference is due to the greater influence of minerotrophic upland run-off in the sub-basin. There is water movement out of the main basin through the outflow but the water-table of the sub-basin is higher and more stagnant. Also the peat in the sub-basin which reaches a maximum of 1.5 m in depth is shallower than in the main basin where it reaches a maximum of 9.1 m.

The difference in species composition between the Open bog - *Chamaedaphne/Ledum* shrub (7) and Open bog - *Carex oligosperma* (8) communities of L632 was again primarily related to hydrology. The portions covered by Open bog - *Carex oligosperma* (8) vegetation were areas of groundwater upwelling or discharge, whereas Open bog - *Chamaedaphne/Ledum* shrub (7) vegetation covered areas of groundwater recharge (Branfireun *et al.* 1996). The groundwater discharge inhibits the establishment of trees, and creates conditions favorable for *Myrica gale* and *Carex oligosperma*. Cooper and Andrus (1994) also describe groundwater discharge as an important factor in the vegetation patterns of fens in Wyoming.

Glaser *et al.* (1981) and Glaser (1983, 1987) describe *Carex oligosperma* as the characteristic species of non-forested openings and bog drains where the water-table is near the surface in patterned mires and bogs of northern Minnesota. They found that these openings are not discernibly different in water chemistry from *Picea mariana* forested communities characterized by the presence of *C. trisperma*, *Vaccinium vitis-idaea*, *Smilacina trifolia* and/or *Pleurozium schreberi* and the absence of *C. oligosperma*. The species composition of communities in L632 also fit these criteria. *Carex oligosperma* was largely restricted to the Open bog - *Carex oligosperma* (8) community which lacked trees, and *C. trisperma* and *P. schreberi* were restricted to the Open bog - *Chamaedaphne/Ledum* shrub (7) community.

2.4.2 Community biomass

The total biomass estimates for communities in L979 and L632 fall well within the range of 5,546 to 101,975 kg ha^{-1} reported for bog communities in the Low Boreal region and north-central Minnesota (Reader and Stewart 1972; Grigal *et al.* 1985; Swanson and Grigal 1991). The total biomass of 7,189 ± 924 kg ha^{-1} estimated for the Open bog - *Carex oligosperma* (8) community of this study was similar to biomass estimates for open bog communities of 9,400 kg ha^{-1} (Swanson and Grigal 1991) and 5,546 kg ha^{-1} (Reader and Stewart 1972). Estimates of tree biomass for the undisturbed communities of L979 and L632, which ranged from 6,556 ± 4,207 to 66,506 ± 20,613 kg ha^{-1} were well within literature estimates of tree biomass in other bog communities in the region which range from 3,678 kg ha^{-1} for a sparsely treed community in southeastern Manitoba (Reader and Stewart 1972) to 100,730 kg ha^{-1} for a densely treed community in north-central Minnesota (Grigal *et al.* 1985). The low shrub biomass of communities in this study, which reached a maximum of 10,223 ± 1,866 kg ha^{-1} in the Open bog - *Chamaedaphne* shrub (3) community of L979, was higher than the estimates of low shrub biomass in the literature, where the maximum low shrub estimate is 4,500 kg ha^{-1} for a treed bog community (Grigal *et al.* 1985). The bryophyte biomass estimates for communities in this study were slightly higher than those of Reader and Stewart (1972) which range from 937 to 2,000 kg ha^{-1}, but are approximately half those reported for bog communities in Swanson and Grigal (1991). These differences may be due in part to the methods used to estimate low shrub and bryophyte biomass. In this study, estimates were based on 0.25 m^2 harvested samples, while Reader and Stewart (1972) harvested 0.06 m^2 samples, and Grigal *et al.* (1985) and Swanson and Grigal (1991) used allometric regression equations. Also the plant material may have been clipped at different depths.

The estimated biomass of 7,939 kg ha^{-1} for a subarctic low density *Picea mariana* bog community in northern Manitoba (Sims and Stewart 1981) is less than that of comparable bog communities in the Low Boreal wetland region, while biomass estimates of open bog communities in Maine at 4,710 to 5,270 kg ha^{-1} are similar (Wallen and Malmer 1992). Botkin and Simpson (1990) estimate the tree and shrub biomass of boreal forests in north-western Ontario to be 63,400 ± 36,700 kg ha^{-1}, which is similar to the estimated biomass of medium and high density *Picea mariana* communities in this study. The estimated biomass of the High density *Picea mariana* - *Ledum* shrub (1) mire margin community, however, is approximately half the 141,313 kg ha^{-1} estimated for upland *Picea mariana* - feather moss communities in Minnesota (Ohmann and Grigal 1985).

The ordinations of L979 cover data indicate that the species composition of these bog communities varied in relation to gradients in the cover of trees along the first axis and tall shrubs along the second axis. Total community biomass also varied along a gradient in overstory cover strongly correlated with tree biomass (Fig. 2.7), and thus was strongly related to gradients in environmental conditions such as hydrology and to a lesser degree minerotrophy that influence the presence and density of tree cover along the mire expanse - mire margin gradient. In the absence of trees and tall shrubs more resources such as sunlight and nutrients are available to the understory plants resulting in the higher biomass values for low shrubs and bryophytes in the Open bog - *Chamaedaphne* shrub (3) and Open bog - *Carex oligosperma* (8) communities. From the mire margin High density *Picea mariana* - *Ledum* shrub (1) to the intermediate Medium density *Picea mariana* - *Ledum*

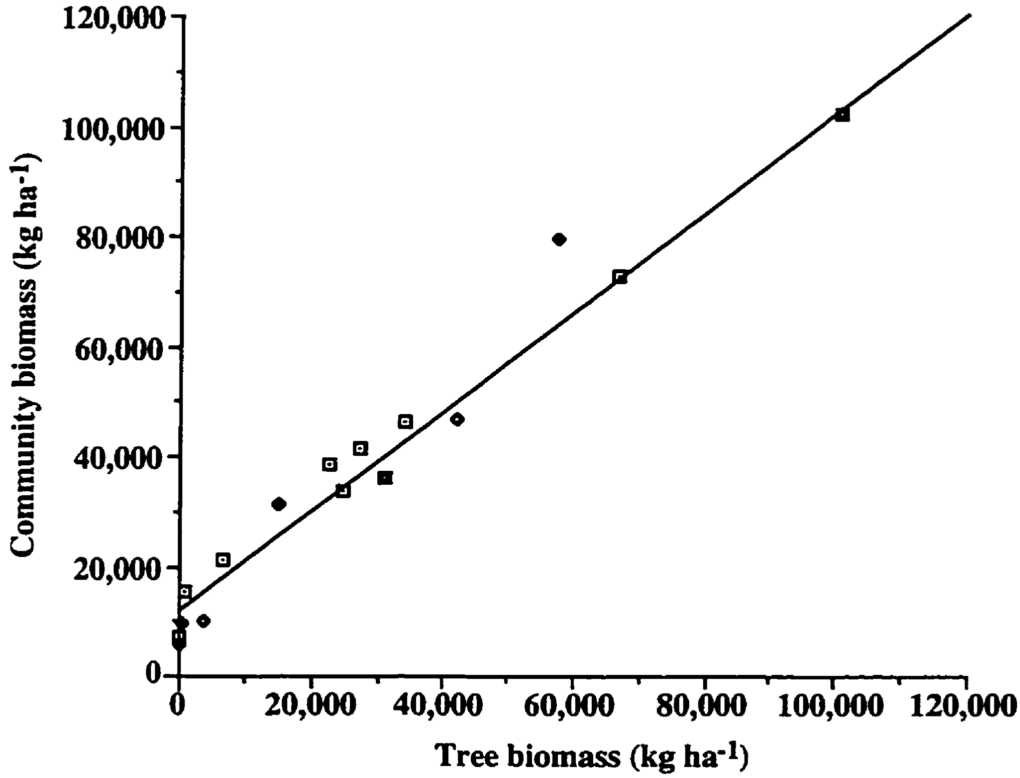

Figure 2.7. The relationship between total aboveground community biomass and aboveground tree biomass estimated for bog communities in the Low Boreal region and north-central Minnesota. ◆ Reader and Stewart (1972), ■ Grigal *et al.* (1985), ● Swanson and Grigal (1991) and ▣ the present study. Y = 11,345 + 0.96 * X, R^2 = 0.96.

shrub (2) and mire expanse Open - *Chamaedaphne* shrub (3) communities tree biomass decreased from 66,506 to 33,978 to 22,600 kg ha^{-1}, while low shrub biomass increased from 2,463 to 7,404 to 10,223 kg ha^{-1} (Fig. 2.6). Bryophyte biomass increased from 2,381 to 3,781 kg ha^{-1}.

The biomass estimates of Reader and Stewart (1972) and Swanson and Grigal (1991) also exhibit a strong relationship between total community and tree biomass. These data combined with the biomass data from this study form a highly correlated linear regression relationship with an R^2 of 0.96 (Fig. 2.7). This implies that a rough estimate of the total biomass of a bog community in the Low Boreal region and north-central Minnesota may be predicted from the biomass of the tree stratum.

Few studies of the biomass in bog communities provide measures of variability. Those that do, show that variability can be high, e.g. in a study of low shrub biomass the standard deviation among biomass samples of low shrub components in some cases exceeds the actual biomass estimate (Schwintzer 1983). In communities with higher tree biomass, a source of increased variability is the clumped distribution of trees due to 'layering', where lower branches in contact with the bog surface may root and develop into separate individuals (Walsh and Wickware 1991). The distribution of low shrubs and herbs is also somewhat clumped as they tend to occur on the drier habitats of the *Sphagnum* hummocks, providing another source of variability.

The dominance of *Pinus banksiana* in the overstory of the Low density *Pinus banksiana* - *Ledum* shrub (6) community was the most obvious effect of the 1980 fire. Otherwise the species composition of this community was similar to the composition of the remainder of the main basin of L979. Community biomass was lower than the other communities due to the small size of the few *P. banksiana* that had reached ≥10 cm CBH since the fire. Litter biomass, however, was over 2,000 kg ha^{-1} greater than in other communities. The mean K_{corr} of surface water indicated that it was slightly richer than other communities.

2.4.3 Conclusions

The communities of L979 and L632 were open, or treed with low to high densities of *Picea mariana*, except in the community that burned in 1980 where *Pinus banksiana* dominated the low density tree stratum. There was a tall shrub layer dominated by *Alnus rugosa* in the communities of the L979 north-east sub-basin. *Chamaedaphne calyculata* and *Ledum groenlandicum* dominated the low shrub layers and *Myrica gale* was important in L632. *Carex oligosperma* was characteristic of areas of groundwater upwelling in L632. *Sphagnum angustifolium/fallax*, *S. fuscum*, and *S. magellanicum* were important in the ground layer. *Pleurozium schreberi* was characteristic in the mire margin High density *Picea mariana - Ledum* shrub (1) community of L979.

The species composition and biomass of the bog communities varied along a continuum related to the mire margin - mire expanse gradient in L979 and groundwater discharge in L632. These are both a result of environmental factors that relate to hydrology, such as the influx of minerotrophic run-off, water-table level, groundwater discharge, and the magnitude, frequency and duration of water-table fluctuations. Hydrology is a determining factor in the establishment and density of tree cover, which in turn influences the species composition and biomass of the understory by affecting the availability of light and nutrients.

The physiognomic delineation of community types based on the relative cover of trees was a simple, yet effective method of distinguishing bog communities that significantly differed in species composition and biomass. This agrees with the conclusions of Sims *et al.* (1982) who used physiognomy to classify fen community types and Swanson and Grigal (1991) who found that the classification of vegetation into physiognomic groups provided reasonable estimates of total aboveground biomass. Therefore, despite the gradients in species composition and biomass variation in bogs, the results of this study show that physiognomically distinguishable communities exist along these gradients which have a characteristic species and biomass composition that allows typification (Okland 1990).

Chapter 3. Aboveground biomass and carbon content of vegetation in two basin bogs in the Experimental Lakes Area, north-western Ontario

3.0 INTRODUCTION

The standing crop or biomass of a plant community is an important measure of ecosystem function (Doucet *et al.* 1976). On a gross scale it represents a balance between carbon accumulation and decomposition, and the influence of environmental factors such as nutrient availability, soil moisture and climate. It is an important variable in the contribution of vegetation to the nutrient and carbon cycles of an ecosystem. For the purposes of modeling these cycles on an ecosystem scale, biomass estimates for all components of the plant community are needed and an estimate of the associated variation is desirable (Grigal 1991; Shay *et al.* 1991).

This research is part of the Experimental Lakes Area Reservoir Project (ELARP). The ELARP study involves the flooding of an experimental basin bog in north-western Ontario to simulate a hydroelectric reservoir. Postflood changes in concentrations of the greenhouse gases CO_2 and CH_4, and methyl mercury will be compared with those of a reference bog and modeled. The objective of this component of the project is to estimate the preflood biomass and carbon pool in aboveground vegetation in the experimental and reference bogs.

Few studies have attempted to measure or estimate the biomass of all components of bog plant communities in North American sites. None of these include estimates of associated variation. Estimates of the vegetative carbon pool for bog communities are also lacking.

Szumigalski and Bayley (1996a) show that the productivity of bog vegetation in North America decreases with latitude. Biomass estimates of treed bog communities also exhibit this trend. The estimated aboveground biomass for a subarctic (56°21'N) treed bog community, 7,939 kg ha^{-1} (Sims and Stewart 1981), is lower than the 9,950 kg ha^{-1}

estimated for a comparable community in the low boreal region (49°53'N) (Reader and Stewart 1972). These estimates are much lower than the estimates of 35,920 (excluding bryophytes) (Grigal *et al.* 1985) and 31,300 kg ha^{-1} (Swanson and Grigal 1991) for low density treed bog communities in north-central Minnesota (47 to 48°N), although the species composition of these sites is similar. Tree biomass, mainly *Picea mariana*, accounts for 29 (in the subarctic bog) to 49% (in north-central Minnesota) of community biomass. Low shrub biomass contributes 3 to 50% and is predominantly *Chamaedaphne calyculata* and *Ledum groenlandicum* with small amounts of *Kalmia polifolia* and *Vaccinium vitis-idaea*. Herb biomass, mostly *Carex* spp., reaches a maximum of 6% in the subarctic bog. Bryophytes account for 4 to 16% of community biomass and are dominated by *Sphagnum fuscum*.

3.1 METHODS

Six community types were present in L979 and two in L979 (Table 3.1). For study area and community type descriptions, and the methods used in sampling tree, sapling and tall shrub density and the biomass of all strata, see Chapter 2.

3.1.0 Carbon content

The carbon content of certain species and biomass categories was estimated from the data of McCullogh and Shay (in Bodaly *et al.* 1987). To provide an estimate of the carbon concentration for species or categories not analyzed by McCullogh and Shay (in Bodaly *et al.* 1987), randomly selected subsamples of sapling, tall shrub, low shrub and herb biomass, collected, sorted and dried by the methods reported above, were ground and sieved. The samples were analyzed with an elemental analyzer at the Freshwater Institute, Winnipeg, MB. Carbon estimates of the various tissue types and species in each community were calculated by multiplying the carbon concentration by the biomass

Table 3.1. Classification of community types in L979 and L632 (Riley and Michaud 1994).

Community type	Formation/Subformation	Physiognomic group	Dominance/Site type
L979			
1	High density TREED BOG^{43†}	Low shrub^{60}	*Picea mariana*^{37*}-*Ledum groenlandicum*^{50}-*Pleurozium schreberi*^{27}/*Sphagnum angustifolium/fallax*^{27}
2	Medium density TREED BOG^{25}	Low shrub^{74}	*P. mariana*^{17}-*L. groenlandicum*^{39}-*S. angustifolium/fallax*^{53}
3	OPEN BOG^{3}	Low shrub^{81}	*Chamaedaphne calyculata*^{49}-*S. angustifolium/fallax*^{36}
4	Medium density TREED BOG^{54}	Tall shrub^{10}	*P. mariana*^{54}- *Alnus rugosa*^{10}-*L. groenlandicum*^{56}
5	OPEN BOG^{0}	Tall shrub^{14}	*A. rugosa*^{14}-*C. calyculata*^{27}/*L. groenlandicum*^{26}-*S. angustifolium/fallax*^{45}
6	Low density TREED BOG^{11}	Low shrub^{78}	*Pinus banksiana*^{9}-*Ledum groenlandicum*^{63}-*Sphagnum magellanicum*^{26}
L632			
7	OPEN BOG^{0}	Low shrub^{43}	*Chamaedaphne calyculata*^{18}-*Sphagnum angustifolium/fallax*^{64}
8	OPEN BOG^{9}	Low shrub^{81}	*Ledum groenlandicum*^{29}/*Chamaedaphne calyculata*^{26} -*Sphagnum angustifolium/fallax*^{37}

† Sum of mean species cover (%) for stratum in formation/subformation and physiognomic group classifications.
* Mean species cover (%) in the dominance/site type classification.

estimate. Standard errors associated with the biomass and carbon estimates were calculated using Grigal (1991).

3.2 RESULTS

3.2.0 Sapling and tall shrub biomass regression

Of the regression models and combinations of predictor variables tested, the allometric model with diameter as the single predictor variable provided the best fit based on a comparison of R^2 values, standard errors and F-ratios. High R^2 values, which ranged from 0.96 to 0.99, and F-ratios (236 to 777) indicate a significant and highly predictable relationship between total aboveground sapling and tall shrub biomass, and diameter (Table 3.2, Fig. D.1).

Leaf, branch and stem biomass as a percentage of total biomass varied among species. Of the total biomass of the deciduous species *Alnus rugosa*, *Betula papyrifera* and *Larix laricina*, approximately 12 to 15% was leaf, 20 to 32% branch and 61 to 63% stem material. In the evergreen species *Picea mariana* and *Pinus banksiana*, however, leaf biomass constituted 30 and 25%, respectively. Branch biomass was 32% of total biomass for *P. mariana* and 18% for *P. banksiana*, and stem biomass 38 and 57%, respectively.

3.2.1 Strata and species biomass

Trees were absent from the Open bog - *Carex oligosperma* (8) community of L632. In L979 total aboveground tree biomass ranged from 24,750 ± 7,184 (s.e.) to 66,506 ± 20,613 kg ha^{-1} in the medium and high density *Picea mariana* (1, 2 & 4) communities (Table 3.3). Relatively high tree biomass figures of 22,600 ± 9,200 in the Open bog - *Chamaedaphne* (3) shrub and 27,181 ± 10,705 kg ha^{-1} in the Open bog - *Chamaedaphne/Ledum* (7) shrub community were also estimated. The regenerating Low density *Pinus banksiana - Ledum* shrub (6) community had the lowest total tree biomass estimate at 898 ± 1,726 kg ha^{-1}. Tree foliage made significant contributions of

Table 3.2. Statistics summary of allometric regression analysis on the relationship between aboveground sapling and tall shrub biomass (kg) and diameter (cm). $Y = a * b^X$, where Y = biomass and X = diameter at 15 cm above ground level.

Species	R^2	s*	df†	F-ratio	Regression coefficients		Diameter (cm)		n‡
					a	b	Range	Mean	
Alnus rugosa	0.97	0.13	28	479	0.02	3.06	2.10 - 4.87	2.72	30
Betula papyrifera	0.99	0.05	8	777	0.09	1.86	1.52 - 3.95	2.49	10
Larix laricina	0.99	<0.01	8	283	0.05	2.27	1.61 - 2.57	2.08	10
Picea mariana	0.97	0.05	27	441	0.09	2.24	1.49 - 3.84	2.27	29
Pinus banksiana	0.96	0.13	19	236	0.08	2.05	1.56 - 3.78	2.30	21

* s = standard error of the estimate, † df = degrees of freedom, ‡ n = sample size

Table 3.3. The estimated biomass and carbon per unit area in the communities of L979 and L632. Pm - *Picea mariana*.

Species and tissue type		High density Pm - *Ledum* shrub (1)		Medium density Pm - *Ledum* shrub (2)		Open bog - *Chamaedaphne* shrub (3)		Medium density Pm - *Alnus* shrub (4)	
		(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Tree									
Larix laricina	- leaf	204	105	36	18	384	197	-	-
	- branch	495	249	85	43	790	397	-	-
	- stem	3,076	1,490	529	256	5,000	2,421	-	-
Picea mariana	- leaf	3,304	1,383	1,791	750	986	413	1,620	678
	- branch	8,022	3,749	4,282	2,001	2,031	949	3,063	1,431
	- stem	49,874	25,214	26,515	13,405	12,853	6,502	19,656	9,943
Total leaf		3,508 ± 2,038	1,487 ± 872	1,827 ± 943	768 ± 401	1,370 ± 1,224	610 ± 547	1,620 ± 956	678 ± 403
Total leaf, branch and stem		66,506 ± 20,613	32,189 ± 8,835	33,978 ± 7,051	16,473 ± 3,487	22,600 ± 9,200	10,880 ± 4,605	24,750 ± 7,184	12,053 ± 4,165
Sapling and tall shrub									
Larix laricina	- leaf	2	1	-	-	-	-	-	-
	- branch	5	3	-	-	-	-	-	-
	- stem	10	5	-	-	-	-	-	-
Picea mariana	- leaf	430	180	467	196	223	93	-	-
	- branch	458	214	498	233	238	111	-	-
	- stem	549	276	598	301	286	144	-	-
Total		1,454 ± 458	678 ± 242	1,563 ± 516	729 ± 270	747 ± 176	348 ± 101	-	-

Table 3.3 cont'd.

Species and tissue type	High density Pm - *Ledum* shrub (1)		Medium density Pm - *Ledum* shrub (2)		Open bog - *Chamaedaphne* shrub (3)		Medium density Pm - *Alnus* shrub (4)	
	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Seedling								
Picea mariana - leaf	39	16	170	71	623	261	45	19
- branch and stem	65	30	180	84	602	281	37	17
Total	103 ± 49	46 ± 22	350 ± 228	155 ± 102	1,225 ± 866	542 ± 384	82 ± 58	36 ± 26
Low shrubs								
Andromeda glaucophylla - leaf	-	-	42	22	13	7	68	36
- branch and stem	-	-	129	64	28	14	266	132
Chamaedaphne calyculata - leaf	65	35	430	232	1,116	603	391	211
- branch and stem	311	151	3,437	1,667	7,210	3,497	1,855	900
Gaultheria hispidula	-	-	-	-	-	-	10	5
Kalmia polifolia - leaf	8	4	117	62	98	52	22	12
- branch and stem	43	21	456	227	388	193	80	40
Ledum groenlandicum - leaf	660	271	1,033	423	340	139	815	334
- branch and stem	1,325	625	1,602	756	826	390	2,440	1,152
Oxycoccus quadripetalus	51	26	157	79	203	102	119	60

Table 3.3 cont'd.

Species and tissue type	High density Pm - *Ledum* shrub (1)		Medium density Pm - *Ledum* shrub (2)		Open bog - *Chamaedaphne* shrub (3)		Medium density Pm - *Alnus* shrub (4)	
	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Vaccinium angustifolium								
- leaf	-	-	-	-	-	-	6	3
- branch and stem	-	-	-	-	-	-	26	12
Total	2,463 ± 450	1,133 ± 220	7,404 ± 1,799	3,532 ± 876	10,223 ± 1,866	4,996 ± 905	6,099 ± 969	2,896 ± 475
Herbs								
Cyperaeceae	-	-	148	64	9	4	14	6
Drosera rotundifolia	-	-	-	-	-	-	2	1
Lycopodium annotinum	-	-	96	47	-	-	212	103
Smilacina trifolia	1	1	21	11	22	11	-	-
Total	1 ± 1	1 ± 1	265 ± 123	121 ± 57	30 ± 23	15 ± 12	229 ± 70	110 ± 34
Bryophytes	2,381 ± 495	960 ± 201	2,337 ± 427	942 ± 174	3,781 ± 922	1,524 ± 374	2,478 ± 373	999 ± 153
Litter	5,246 ± 421	2,156 ± 243	1,749 ± 280	719 ± 128	3,354 ± 1,125	1,379 ± 475	4,055 ± 651	1,667 ± 298

Table 3.3 cont'd. Pb - *Pinus banksiana*.

Species and tissue type		Open bog - *Alnus* shrub (5)		Low density Pb - *Ledum* shrub (6)		Open bog - *Cham/Ledum* shrub (7)		Open bog - *Carex oligosperma* (8)	
		(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Tree									
Betula papyrifera	- leaf	31	15	-	-	-	-	-	-
	- branch	50	24	-	-	-	-	-	-
	- stem	312	115	-	-	-	-	-	-
Larix laricina	- leaf	-	-	3	2	102	52	-	-
	- branch	-	-	6	3	180	91	-	-
	- stem	-	-	25	12	1,151	557	-	-
Picea mariana	- leaf	452	189	5	2	1,816	760	-	-
	- branch	733	342	8	4	3,202	1,496	-	-
	- stem	4,582	2,319	37	19	20,423	10,333	-	-
Pinus banksiana	- leaf	29	14	69	34	-	-	-	-
	- branch	46	24	116	60	-	-	-	-
	- stem	290	144	510	253	-	-	-	-
Total leaf		512 ± 595	218 ± 254	77 ± 248	37 ± 120	1,918 ± 1,535	812 ± 652	-	-
Total leaf, branch and stem		6,556 ± 4,207	3,186 ± 2,085	898 ± 1,726	389 ± 868	27,181 ± 10,705	13,290 ± 5,503	-	-
Saplings and tall shrubs									
Alnus rugosa	- leaf	221	94	-	-	-	-	-	-

Table 3.3 cont'd.

Species and tissue type		Open bog - *Alnus* shrub (5)		Low density Pb - *Ledum* shrub (6)		Open bog - *Cham/Ledum* shrub (7)		Open bog - *Carex oligosperma* (8)	
		(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Alnus rugosa									
	- branch	478	249	-	-	-	-	-	-
	- stem	1,172	566	-	-	-	-	-	-
Betula papyrifera	- leaf	14	7	3	1	6	3	-	-
	- branch	19	9	4	2	8	4	-	-
	- stem	63	21	12	4	27	9	-	-
Larix laricina	- leaf	-	-	-	-	5	3	-	-
	- branch	-	-	-	-	12	6	-	-
	- stem	-	-	-	-	22	11	-	-
Picea mariana	- leaf	563	236	-	-	687	287	-	-
	- branch	600	280	-	-	731	342	-	-
	- stem	720	362	-	-	878	442	-	-
Pinus banksiana	- leaf	-	-	873	426	-	-	-	-
	- branch	-	-	638	328	-	-	-	-
	- stem	-	-	2,015	986	-	-	-	-
Total		3,851 ± 1,340	1,824 ± 747	3,545 ± 1,189	1,747 ± 610	2,376 ± 495	1,106 ± 231	-	-
Seedlings									
Alnus rugosa - leaf		308	131	-	-	-	-	10	4
- branch and stem		456	238	-	-	-	-	36	19

Table 3.3 cont'd.

Species and tissue type	Open bog - *Alnus* shrub (5)		Low density Pb - *Ledum* shrub (6)		Open bog - *Cham/Ledum* shrub (7)		Open bog - *Carex oligosperma* (8)	
	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Picea mariana - leaf	313	131	33	14	19	8	-	-
- branch and stem	141	66	43	20	15	7	-	-
Pinus banksiana - leaf	-	-	13	6	-	-	-	-
- branch and stem	-	-	8	4	-	-	-	-
Total	1,218 ± 556	566 ± 264	97 ± 36	44 ± 16	34 ± 34	15 ± 11	46 ± 37	23 ± 19
Low shrubs								
Andromeda glaucophylla								
- leaf	6	3	-	-	-	-	6	3
- branch and stem	9	4	-	-	-	-	5	2
Chamaedaphne calyculata - leaf	507	274	118	64	812	438	225	122
- branch and stem	3,112	1,510	922	447	3,639	1,765	613	297
Gaultheria hispidula	7	4	3	2	8	4	-	-
Kalmia polifolia - leaf	26	14	7	4	162	85	61	32
- branch and stem	125	62	15	7	748	372	125	62
Ledum groenlandicum - leaf	615	252	1,279	524	505	207	22	9
- branch and stem	1,407	664	6,249	2,950	605	285	21	10

Table 3.3 cont'd.

Species and tissue type	Open bog - *Alnus* shrub (5)		Low density Pb - *Ledum* shrub (6)		Open bog - *Cham/Ledum* shrub (7)		Open bog - *Carex oligosperma* (8)	
	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Myrica gale - leaf	-	-	-	-	409	210	77	40
-branch and stem	-	-	-	-	1,779	854	845	406
Oxycoccus quadripetalus	10	5	251	126	280	141	133	67
Vaccinium angustifolium								
- leaf	-	-	-	-	14	7	-	-
- branch and stem	-	-	-	-	24	12	-	-
Total	5,825 ± 1,227	2,792 ± 597	8,845 ± 1,367	4,124 ± 689	8,983 ± 1,560	4,379 ± 759	2,133 ± 567	1,049 ± 275
Herbs								
Cyperaeceae	217	93	28	12	174	75	889	382
Equisetum sylvaticum	5	2	-	-	-	-	-	-
Lycopodium annotinum	607	295	-	-	-	-	41	20
Smilacina trifolia	9	5	40	21	10	5	34	18
Total	838 ± 326	392 ± 155	67 ± 35	33 ± 16	184 ± 128	80 ± 55	964 ± 223	420 ± 96
Bryophytes	2,663 ± 301	1,073 ± 125	1,914 ± 555	771 ± 225	2,626 ± 592	1,071 ± 243	4,047 ± 924	1,651 ± 380

Table 3.3 cont'd.

Species and tissue type	Open bog - *Alnus* shrub (5)		Low density Pb - *Ledum* shrub (6)		Open bog - *Cham/Ledum* shrub (7)		Open bog - *Carex oligosperma* (8)	
	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})	(kg ha^{-1})	(kg C ha^{-1})
Litter	3,277 ± 1,089	1,347 ± 460	7,664 ± 2,848	3,150 ± 1,197	3,570 ± 1,742	1,467 ± 725	1,181 ± 548	485 ± 229

approximately 1,400 to 3,500 kg ha^{-1} in communities 1, 2, 3, 4 and 7. It represented 5% of total tree biomass in the medium and high density *P. mariana* communities (1, 2 & 4) to a maximum of 9% in the Low density *Pinus banksiana - Ledum* shrub (6) community. *Picea mariana* contributed the most to tree biomass in these communities except in community 6 where *P. banksiana* was the largest contributor. *Larix laricina* was a substantial contributor in communities 1, 2 and 7. It made the largest contribution among tree species in community 3.

Saplings and tall shrubs were absent from the Open bog - *Carex oligosperma* (8) community. In contrast their biomass was highest in the Open bog - *Alnus* shrub (5) (3,851 ± 1,340 kg ha^{-1}) and Low density *Pinus banksiana - Ledum* shrub (6) (3,545 ± 1,189 kg ha^{-1}) communities. In community 5, the largest component of this stratum was *A. rugosa*, whereas in community 6 it was saplings of *P. banksiana*. The High density *Picea mariana - Ledum* shrub (1), Medium density *Picea mariana - Ledum* shrub (2) and Open bog - *Chamaedaphne/Ledum* (7) shrub communities also had substantial estimates of sapling biomass, which ranged from 1,454 to 2,376 kg ha^{-1}, composed mostly of *P. mariana*. No sapling and tall shrub biomass was estimated for the Medium density *Picea mariana - Alnus* shrub (4) community because there were none present in the small number of density samples.

Tree and tall shrub seedling biomass was generally low but contributed about 1,200 kg ha^{-1}, to the Open bog - *Chamaedaphne* shrub (3) and Open bog - *Alnus* shrub (5) communities. Seedling biomass was dominated by *Picea mariana* in community 3, and *A. rugosa* in community 5.

Estimates of low shrub biomass were lowest for the Open bog - *Carex oligosperma* (8), 2,133 ± 567 kg ha^{-1}, and High density *Picea mariana - Ledum* shrub (1), 2,463 ± 450 kg ha^{-1}, communities. The highest low shrub biomass was estimated for the Open bog - *Chamaedaphne* shrub (3) community at 10,223 ± 1,866 kg ha^{-1}, but was also quite high for the Low density *Pinus banksiana - Ledum* shrub (6) and Open bog -

Chamaedaphne/Ledum shrub (7) communities at 8,845 and 8,983 kg ha^{-1}, respectively (Table 3.3).

In general, *Chamaedaphne calyculata* and *Ledum groenlandicum* contributed the most towards low shrub biomass, with the biomass of *C. calyculata* dominant in the more open, wetter communities (Open bog - *Chamaedaphne* shrub (3) and Open bog - *Chamaedaphne/Ledum* shrub (7)) and *L. groenlandicum* in the drier Medium density *Picea mariana* - *Alnus* shrub (4) and Low density *Pinus banksiana* - *Ledum* shrub (6) communities. *Myrica gale* made a substantial contribution to low shrub biomass in both communities of L632.

The contribution of leaves to the low shrub biomass averaged 21%, but this varied among species. For *Chamaedaphne calyculata*, leaf biomass was an average of 16% of total *C. calyculata* biomass, but was double this figure, 32%, for *Ledum groenlandicum*. *Myrica gale* leaves were 19% of its total biomass in the Open bog - *Chamaedaphne/Ledum* shrub (7) community but only 8% in the Open bog - *Carex oligosperma* (8) community.

Herb biomass was a relatively insignificant component of community biomass. However, its estimates reached 838 ± 326 kg ha^{-1} for the Open bog - *Alnus* shrub (5) community and 964 ± 223 kg ha^{-1} for the Open bog - *Carex oligosperma* (8) community. *Lycopodium annotinum* was the most substantial component of herb biomass in community 5 but in community 8 it was the Cyperaceae.

Estimates of bryophyte biomass varied from 1,914 ± 555 kg ha^{-1} for the Low density *Pinus banksiana* - *Ledum* shrub (6) community to 4,047 ± 924 kg ha^{-1} for the Open bog - *Carex oligosperma* (8) community. The estimates were similar in the high and medium density *Picea mariana* communities (1, 2 & 4), and the Open bog - *Chamaedaphne/Ledum* shrub (7) community, ranging from 2,337 to 2,663 kg ha^{-1}, and were slightly higher in the Open bog - *Chamaedaphne* (3) shrub community at 3,781 ± 922 kg ha^{-1}.

The Open bog - *Carex oligosperma* (8) community had the lowest amount of litter, 1,181 ± 548 kg ha^{-1} and the lowest community biomass estimate. The highest amount of litter, 7,664 ± 2,848 kg ha^{-1}, was found in the regenerating Low density ***Pinus banksiana* - *Ledum*** shrub (6) community.

3.2.2 Carbon content

Among woody species, leaves had a higher carbon concentration, 513 to 540 mg C g^{-1}, than branches and stems with 480 to 503 mg C g^{-1} (Table 3.4). Cyperaceae had the lowest carbon concentration among species and categories at 430 mg C g^{-1}. The carbon content of *Oxycoccus quadripetalus* was approximately 50% of dry mass, while that of *Lycopodium annotinum* was slightly lower at 485 mg C g^{-1} and *Smilacina trifolia* slightly higher at 522 mg C g^{-1}. Standard errors associated with the carbon measurements were low, approximately 1% of the mean.

Carbon in tree foliage per unit area was 42 and 43% of tree foliage biomass with minor differences. When branches and stems were included, total tree carbon per unit area as a percentage of total tree biomass averaged 48 and 49% except in community 6 where it was 43%. These percentages were similar for sapling, tall shrub and low shrub components, 46 to 49%, but were 40 and 41% for bryophytes and litter. Despite these differences, the range of community carbon per unit area as a percentage of biomass among communities was relatively low, 44 to 48%. It was lowest in the Open bog - *Carex oligosperma* (8) community where the largest proportion of Cyperaeceae and bryophyte biomass was found.

3.2.3 Community carbon pool

Estimates of the community carbon pool (excluding litter) in the aboveground vegetation of the communities in L979 and L632 ranged from approximately 2,140 ± 480 to 35,010 ± 8,840 kg C ha^{-1}. The relative contributions of trees, saplings and tall shrubs,

Table 3.4. Carbon content of species and tissue types analyzed, expressed as mg C g^{-1} dry weight (n = 4).

Species and tissue type	Mean C content ± s.e.	Range
Chamaedaphne calyculata - leaf	540 ± 5	531 - 555
- branch and stem	485 ± 5	475 - 497
Cyperaeceae	430 ± 4	422 - 440
Kalmia polifolia - leaf	524 ± 4	513 - 533
- branch and stem	497 ± 1	494 - 499
Larix laricina - leaf	513 ± 3	507 - 522
- branch	503 ± 6	489 - 514
- stem	484 ± 3	480 - 493
Lycopodium annotinum	485 ± 4	475 - 495
Myrica gale - leaf	514 ± 4	506 - 524
- branch and stem	480 ± 3	475 - 488
Oxycoccus quadripetalus	502 ± 2	499 - 505
Smilacina trifolia	522 ± 4	514 - 529

tree and tall shrub seedlings, low shrubs, herbs, and bryophytes to the carbon pool for each community were similar to their relative contributions to community biomass (Figs. 2.6 & 3.1). Trees contributed 92% to the total carbon in the High density *Picea mariana - Ledum* shrub (1) community, and 75% to the Medium density *Picea mariana - Ledum* shrub (2) and Medium density *Picea mariana - Alnus* shrub (4) communities. They contributed 69, 67 and 32% to the open bog communities (3, 5 & 7).

Understory contributions to the carbon pool were greater in communities with few trees. Saplings and tall shrubs made the largest contribution in the Open bog - *Alnus* shrub (5) community, with 19%, and in the regenerating Low density *Pinus banksiana - Ledum* shrub (6) community, with 25%. Tree and tall shrub seedlings only contributed <1 to 6%. The carbon contribution of low shrubs increased from 3% in the mire margin High density *Picea mariana - Ledum* shrub (1), to 16% in the intermediate Medium density *Picea mariana - Ledum* shrub (2) and 27% in the mire expanse Open bog - *Chamaedaphne* shrub (3) communities of the main basin of L979. The largest contribution of low shrubs, 58%, was in the Low density *Pinus banksiana - Ledum* shrub (6) community. The herb contribution was low except in the Open bog - *Carex oligosperma* (8) community where it was 13%.

Bryophytes contributed from 3 to 11% to the carbon pool except in the Open bog - *Carex oligosperma* (8) community where they contributed 53%. When litter is considered a component of the total carbon per unit area, it made contributions similar to bryophytes, except in the Low density *Pinus banksiana - Ledum* shrub (6) community and community 8. Litter contributed 3 to 9% to the total carbon pool in the medium and high density *Picea mariana* (1, 2 & 4), Open bog - *Chamaedaphne* (3) and *Chamaedaphne/Ledum* shrub (7) communities with a hummock-hollow microtopography. It contributed 12 and 13% in the Open bog - *Alnus* shrub (5) and Open bog - *Carex oligosperma* (8) communities with a lawn microtopography. It made the largest contribution of 31% in the regenerating Low density *Pinus banksiana - Ledum* shrub (6) community.

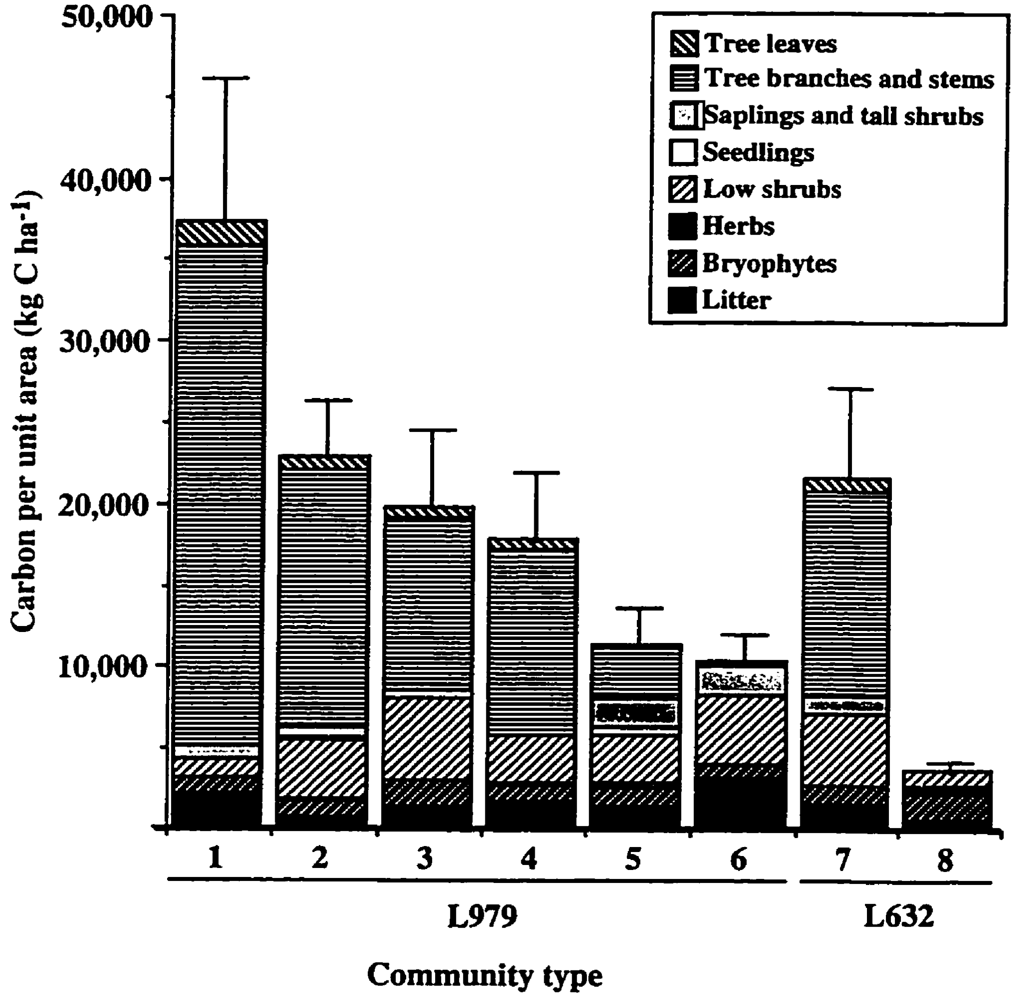

Figure 3.1. Carbon content of the aboveground biomass of trees, saplings, tall shrubs, tree and tall shrub seedlings, low shrubs, herbs, bryophytes and litter of the communities in L979 and L632. The error bars represent the standard error associated with the aboveground community carbon pool estimate.

While the standard errors associated with mean carbon concentrations were low, the standard errors associated with community carbon per unit area were relatively high because of high standard errors associated with the community biomass per unit area. In communities 1, 3, 4, 5 and 7, the standard errors were 24 to 28% of community carbon per unit area estimates. These figures were lower, 15 to 18%, in communities 2, 6 and 8 (Fig. 3.1).

3.3 DISCUSSION

3.3.0 Sapling and tall shrub biomass regression

The allometric regression model has been found to be the most suitable model for the prediction of tree and tall shrub biomass by many (e.g. Grigal and Kernik 1984; Buech and Rugg 1995), and is widely accepted and used (Ohmann *et al.* 1976; Ohmann and Grigal 1985).

The results of this study show that it is possible to develop reasonably precise biomass regression equations with R^2 values of 0.96 to 0.99 for tree and tall shrub species in bog habitats from a relatively small sample size of 10 to 30 individuals. This agrees with the results of Ohmann *et al.* (1976), Grigal and Kernik (1984), Buech and Rugg (1995), and Szumigalski and Bayley (1996a) .

Foliage as a percentage of total *Alnus rugosa* biomass collected in L979 was 12%, agreeing with the 11 and 12% from *A. rugosa* dominated sites in New York (Tilton and Bernard 1975) and northern Michigan (Parker and Schneider 1975), respectively. Branch biomass, however, at 26% was slightly higher than literature values of 16 and 21%, and stem biomass, at 63%, slightly lower. The proportion of total biomass in the foliage of *Picea mariana* and *Pinus banksiana* was higher, being 30 and 25% respectively. The differences in biomass proportions among woody species tissue types in addition to different carbon concentrations result in differences in the relative contribution of tree, sapling and tall shrub components to the available carbon pool of the experimental reservoir.

3.3.1 Strata and species biomass

The total aboveground biomass estimated for the communities of L979 and L632 ranged from 7,189 ± 924 kg ha^{-1} to 72,909 ± 20,627 kg ha^{-1} which is well within the range of community biomass estimated for other bogs of the Low Boreal wetland region and north-central Minnesota of 5,546 kg ha^{-1} (Reader and Stewart 1972) to 101,975 kg ha^{-1} (including vascular species only) (Grigal *et al.* 1985).

When the biomass of individual species is reported for bog communities in the Low Boreal wetland region in the literature, *Picea mariana* is the only tree species named. In L979, estimates of *P. mariana* biomass ranged from approximately 24,000 to 61,000 kg ha^{-1} for the treed communities dominated by *P. mariana*, with 1,370 to 2,726 trees ha^{-1} and 7.1 to 11.5 m^2 ha^{-1} at breast height. The *P. mariana* biomass in a mature bog forest community with a high density of 7,829 trees ha^{-1} in south-east Manitoba, estimated at 41,860 kg ha^{-1}, falls within this range (Reader and Stewart 1972). *Picea mariana* biomass estimates of 100,730 kg ha^{-1} and 30,980 kg ha^{-1} are reported for the tree strata of perched bogs with 2,800 trees ha^{-1} and basal area of 27 m^2 ha^{-1}, and raised bogs, with 4,200 trees ha^{-1} and basal area of 10 m^2 ha^{-1} in north-central Minnesota (Grigal *et al.* 1985). Swanson and Grigal (1991) suggest *Larix laricina* may constitute a portion of the tree cover in stands dominated by *P. mariana* but do not indicate the biomass of each species in their total tree biomass estimates of 57,500 kg ha^{-1} for high density treed bog communities, 15,200 kg ha^{-1} for low density treed bog communities and 500 kg ha^{-1} for open bog communities in north and central Minnesota. While *P. mariana* dominated the biomass of the tree, sapling and seedling strata in most of the bog communities in L979 and L632, *L. laricina* made an important contribution to the high and medium density *P. mariana* (1, 2 & 4) and open bog communities of the main basin of L979 (3) and L632 (7) (Table 3.3).

Biomass of the Open bog - *Alnus* shrub (5) community dominated by *A. rugosa*, estimated at 20,950 ± 4,675 kg ha^{-1}, was slightly lower than that of *A. rugosa* dominated communities in northern Michigan (31,000 kg ha^{-1}) (Parker and Schneider 1975) and New York (27,520 kg ha^{-1}) (Tilton and Bernard 1975). The maximum low shrub biomass for communities in L979 and L632 was 10,223 ± 1,866 kg ha^{-1}, approximately twice that of the maximum low shrub biomass, 4,540 kg ha^{-1} (Grigal *et al.* 1985), estimated for low boreal bog communities in the literature. The difference may be due to the method of biomass estimation. In this study estimates were based on 0.25 m^2 harvested samples, while Reader and Stewart (1972) harvested 0.06 m^2 samples, and Grigal *et al.* (1985) and Swanson and Grigal (1991) used allometric regression equations. As in our study *Chamaedaphne calyculata* and *Ledum groenlandicum* are the largest contributors to low shrub biomass in the bog communities of Grigal *et al.* (1985) and Reader and Stewart (1972) with *L. groenlandicum* dominating *Picea mariana* forested communities. *Chamaedaphne calyculata* dominated the biomass in the open bog communities in L979 and L632, however there was approximately equal biomass of *C. calyculata* and *L. groenlandicum* in the open bog community of Reader and Stewart (1972).

The average percentage leaf biomass for *Chamaedaphne calyculata* in the communities of L979 and L632 was 16%, and 32% for *Ledum groenlandicum*. Grigal *et al.* (1985) also found that *C. calyculata* tends to have a lower percentage of foliage biomass than *L. groenlandicum* but the averages of 22% for *C. calyculata* and 35% for *L. groenlandicum* are higher than in L979 and L632. The percentage *C. calyculata* leaf biomass in an open *Myrica gale* dominated bog in central Massachusetts (Schwintzer 1983) is similar to the average percentage in L979 and L632, but the percentage *M. gale* foliage biomass, 24%, is higher than the 19 and 8% in L632.

Bryophyte biomass estimates for the communities of L979 and L632, which ranged from 1,914 ± 555 to 4,047 ± 924 kg ha^{-1}, are approximately twice those of Reader and Stewart (1972), being 937 to 2,000 kg ha^{-1}, but approximately half those reported in

Swanson and Grigal (1991). These differences are again likely due to the methods used to estimate the biomass of this stratum.

3.3.2 Carbon content

Carbon as a percentage of dry weight varied up to 11% among tissue types and species in this study. This resulted in variation in carbon as a percentage of biomass among communities dominated by different species and for certain biomass components within the same community. For example in bryophytes and litter, carbon content was 40 and 41% of biomass but was 46 to 49% for all other components of the communities. Malmer and Nihlgard (1980) also found that the carbon content of bryophytes is lower than in the woody species of a subarctic ombrotrophic bog. Their carbon content estimates for current, one- and two-year old shoots of the ericaceous low shrub *Empetrum hermaphroditum*, were 57 and 58%, slightly higher than for the ericaceous low shrubs in our study. Overall, however, in L979 and L632, the range in carbon as a percentage of community biomass was low, being 44 to 48%.

3.3.3 Community carbon pool

The total carbon pool of aboveground vegetation varied from approximately 2,140 ± 480 to 35,010 ± 8,840 kg C ha^{-1} (excluding litter). The relative contributions of trees, saplings and tall shrubs, tree and tall shrub seedlings, low shrubs, herbs and bryophytes to the aboveground community carbon pool and associated standard errors were similar to their relative contributions to aboveground community biomass. For the purpose of estimating the carbon pool of aboveground vegetation that is a potential source of carbon in the production of CO_2 and CH_4 in the experimental reservoir it was assumed that carbon in litter would be available but that of tree trunks and branches would not.

In the relatively dry High density *Picea mariana - Ledum* shrub (1) community of L979, 92% of the aboveground community carbon pool was contributed by trees. Tree foliage was 23% of the available carbon pool (including litter and excluding tree branches and trunks), slightly more than the 18% contributed by low shrubs, but less than the 33% contributed by litter (Fig. 3.1).

In the Medium density *Picea mariana - Ledum* shrub (2) community of the main basin of L979 and Medium density *Picea mariana - Alnus* shrub (4) community of the north-east sub-basin, contributions to the available carbon pool of most of strata were similar, 11% was contributed by tree foliage, 51 and 45% by low shrubs, and 14 and 16% by bryophytes, respectively. They differed in that there was a small amount of carbon contributed by *P. mariana* saplings and approximately half the litter in community 2. Low shrubs, dominated by *Chamaedaphne calyculata* biomass in community 2 and *L. groenlandicum* biomass in community 4, contributed the most to the available carbon pool of these communities.

Low shrubs, dominated by *Chamaedaphne calyculata* biomass, also contributed the most (53%) to the available carbon pool of the wetter Open bog - *Chamaedaphne* shrub (3) community of L979. Litter contributed about the same amount as bryophytes, 15 and 16% respectively, and tree and tall shrub seedlings contributed the same amount as tree foliage (6%).

The sapling and tall shrub stratum, dominated by *Alnus rugosa*, contributed 22% to the available carbon pool in the Open bog - *Alnus* shrub (5) community, and 18%, dominated by *Pinus banksiana*, in the Low density *Pinus banksiana - Ledum* shrub (6) community. Low shrubs again contributed the most to the available carbon pool of these communities, 34% in community 5 and 42% in community 6. Low shrub biomass was dominated by *Chamaedaphne calyculata* biomass in the wetter habitat of community 5 and *L. groenlandicum* in the drier habitat of community 6. Herbs, dominated by *Lycopodium annotinum*, constituted 5% of the available carbon pool of community 5. The contribution of bryophytes to the available carbon pool of community 6, at 8%, was the lowest among communities. The contribution of litter in this community at 32%, along with that of the

High density *Picea mariana - Ledum* shrub (1) community at 33%, was among the highest. The bryophyte and litter components of community 5 contributed similar amounts of 13 and 16%, respectively.

In the Open bog - *Chamaedaphne/Ledum* shrub (7) community of L632, tree foliage contributed 9% to the available carbon pool, and saplings and tall shrubs 12%. Low shrubs contributed 49%, with approximately twice the carbon coming from *C. calyculata* compared with *L. groenlandicum*, even though they had approximately the same mean percent cover. Litter made a slightly larger contribution of 16% than bryophytes at 12%. The Open bog - *Carex oligosperma* (8) community is the only community in which bryophytes made the largest contribution to the available carbon pool (46%). Low shrubs, with approximately equal amounts of *C. calyculata* and *Myrica gale*, made the second largest contribution at 29%. Herbs, dominated by Cyperaceae biomass, and litter made similar contributions of 12 and 13%.

3.3.4 Available carbon pool in vegetation of the experimental bog

In L979, the low density treed bog (6) (9,907 ± 1,531 kg C ha^{-1}), and open bog (3 & 5) (9,413 ± 1,281 and 8,212 ± 1,140 kg C ha^{-1}) communities had the highest estimates of available carbon per unit area (Table 3.5). The medium and high density *Picea mariana* communities had estimates of 6,386 ± 709 to 6,966 ± 1,017 kg C ha^{-1}. The associated standard errors were approximately 11 to 15%.

If we multiply the available carbon per unit area by the area occupied by the respective communities and sum these figures we obtain an estimate of the dry mass of carbon contributed by aboveground vegetation to the experimental bog, L979 (Table 3.5). Of the 117,100 kg C total carbon pool in the aboveground vegetation, more than half, or 62,132 kg C, was contributed by the Open bog - *Chamaedaphne* shrub (3) community. A large portion of the carbon contributed by this community (44%) originated from *C. calyculata* biomass.

Table 3.5. Estimate of the available aboveground carbon pool in vegetation (excluding tree branches and trunks, and including litter) for the experimental bog, L979.

Community type	Available community carbon (kg C ha^{-1})	Area (ha)	Total available carbon (x 10^3 kg C)
High density Pm - *Ledum* shrub	6,462	2.25	14.5
Medium density Pm - *Ledum* shrub	6,966	2.23	15.5
Open bog - *Chamaedaphne* shrub	9,413	6.60	62.1
Medium density Pm - *Alnus* shrub	6,386	0.27	1.7
Open bog - *Alnus* shrub	8,212	1.72	14.1
Low density Pb - *Ledum* shrub	9,907	0.91	9.0
		Total	117.1

Pm - *Picea mariana*
Pb - *Pinus banksiana*

Although few studies of peatland biomass include estimates of litter biomass, litter made a significant contribution to the available carbon pool of the experimental bog. Litter contributed 10 to 16% in the Medium density *Picea mariana - Ledum* shrub (2) and open bog communities (3 & 5), and about 30% in the High density *Picea mariana - Ledum* shrub (1), Medium density *Picea mariana - Ledum* shrub (4) and regenerating low density *Pinus banksiana* (6) communities. More tree needles in communities 1, 4 and 6, and the fire damaged moss layer in the low density *P. banksiana* community resulted in higher litter biomass in these communities.

Since we have an estimate of the amount of carbon contributed by each tissue type of each species in the communities of the experimental bog, the contribution of aboveground vegetation may be accounted for in the model of CO_2 and CH_4 flux in the experimental reservoir using the decomposition rates of these tissue types (Moore 1994).

3.3.5 Conclusions

The carbon concentration in leaves of the woody bog species analyzed ranged from 513 to 540 mg C g^{-1} (51 to 54%), and 480 to 503 mg C g^{-1} (48 to 50%) in branches and stems. The carbon concentration of herbaceous species ranged from 430 to 522 mg C g^{-1} (43 to 52%). Overall, the range of community carbon per unit area as a percentage of community biomass among the communities of L979 and L632 was 44 to 48%.

The relative contributions of trees, saplings and tall shrubs, tree and tall shrub seedlings, low shrubs, herbs and bryophytes to the community carbon pool and associated standard errors were similar to their relative contributions to community biomass. Trees, including foliage, branches and stems, contributed the most towards the community carbon pool of the medium and high density *Picea mariana* (1, 2 & 4) and Open bog - *Chamaedaphne* (3) and Open bog - *Chamaedaphne/Ledum* shrub (7) communities, and was dominated by *P. mariana* biomass. In the Open bog - *Alnus* shrub (5) community, trees dominated by *P. mariana* biomass and low shrubs, dominated by *C. calyculata* made similar contributions to the community carbon pool. In the Low density *Pinus banksiana - Ledum* shrub (6) community, low shrubs, dominated by *L. groenlandicum* biomass made the largest contribution, and in the Open bog - *Carex oligosperma* (8) community, bryophytes made the largest contribution.

Litter made the largest contribution to the available community carbon pool in the High density *Picea mariana - Ledum* shrub (1) community. Low shrubs made the largest contribution, and were dominated by *C. calyculata* in the Medium density *Picea mariana - Ledum* (2), Open bog - *Chamaedaphne* (3) and Open bog - *Alnus* shrub (5) communities, and *L. groenlandicum* in the Medium density *Picea mariana - Alnus* (4) and Low density *Pinus banksiana - Ledum* shrub (6) communities. Litter is often ignored in studies which estimate the biomass of peatland communities, however, the present study showed that it made a significant contribution to the available carbon pool of the experimental bog.

Although the number of biomass samples was limited, the available carbon pool in aboveground vegetation of the experimental reservoir L979 was estimated with reasonable precision. This figure was estimated to be 1.17×10^5 kg C, approximately 8% of the carbon pool in the peat of L979, estimated by Bubier *et al.* (1993) to be 1.43×10^6 kg C. Since the species composition and biomass of these communities are typical of the Low Boreal wetland region these data could be applied to potential reservoir sites in this region.

Chapter 4. Summary

4.0 Species composition

Six community types were delineated with the use of aerial photos in the experimental bog L979, and two in the reference bog L632. Tree cover of these eight communities was open, or ranged from low to high cover and density (11 to 54% cover, 362 to 2,726 trees ha^{-1}). All were dominated by *Picea mariana*, except the burned area in L979 dominated by *Pinus banksiana*. Tall shrubs were present in only two communities of the north-east sub-basin in L979 which had a sparse but well-developed (10 and 14%) tall shrub layer (Jeglum *et al.* 1974) of *Alnus rugosa*. A well-developed low shrub stratum (43 to 81% cover) was present in all communities, dominated or co-dominated by *Chamaedaphne calyculata* or *Ledum groenlandicum*. Herb cover in L979 was sparse (4 to 8%), primarily *Lycopodium annotinum* in the north-east sub-basin and *Smilacina trifolia* in the main basin. In L632, herb cover was 9% in the community where herb cover was co-dominated by *Carex trisperma* and *S. trifolia*, and 27% where dominated by *Carex oligosperma*. The ground layer was predominantly *Sphagnum* spp. (*S. angustifolium/fallax* and *S. magellanicum*) except in the community with the highest density of trees where *Pleurozium schreberi* was co-dominant with *Sphagnum*. Species with a mean cover ≥5% in both bogs included *Picea mariana, Chamaedaphne calyculata, Kalmia polifolia, Ledum groenlandicum, Myrica gale, Oxycoccus quadripetalus, Smilacina trifolia, Pleurozium schreberi, Sphagnum angustifolium/fallax., Sphagnum fuscum*, and *Sphagnum magellanicum*.

The pH and conductivity of surface water in both sites was low. The pH ranged from 3.45 to 4.95, and conductivity, expressed as total ions minus H^+ (K_{corr}) ranged from 20.5 to 90.5 $\mu S\ cm^{-1}$. There was no significant difference in either surface water pH or conductivities among the communities in L979 and L632.

Species composition significantly differed among the communities within each bog according to canonical variates analysis (CVA). The mire expanse - mire margin gradient, which is largely governed by hydrology, was interpreted as the most important factor in explaining the variation in species composition in L979 based on the results of correspondence analysis (CA). Important hydrologic variables relating to the mire expanse - mire margin gradient are depth to the water-table, the magnitude, frequency and duration of water-table fluctuations and the influx of groundwater from the upland at the mire margin that has been in contact with mineral soil (minerotrophic). The mire expanse end of the gradient, with a relatively high water-table and more frequent water fluctuations, was characterized by *Myrica gale* and *Sphagnum fuscum*. The mire margin end of the gradient has a relatively low, stable water-table influenced by minerotrophic water and was characterized by *Picea mariana* and *Pleurozium schreberi*. This relates to a change in physiognomy. As the density and percentage cover of *Picea mariana* increased from the mire expanse to the mire margin, the cover of *Chamaedaphne calyculata* decreased and the cover of *Ledum groenlandicum* increased.

The second most important factor in explaining the variation in species composition of L979 according to CA, was the influence of upland run-off on the north-east sub-basin. Because there is a greater edge effect in the sub-basin (a higher edge to peat surface ratio) there is a greater minerotrophic influence. Also the peat in the north-east sub-basin is shallower than in the main basin. These conditions are favorable for *Alnus rugosa* and *Lycopodium annotinum* which were absent from the main basin.

The variation in species composition in L632 summarized by CA can also be interpreted in relation to hydrology. Species associated with drier bog habitat conditions (*Picea mariana*, *Pleurozium schreberi* and *Sphagnum fuscum*) were on one side of the ordination and *Myrica gale* and *Chamaedaphne calyculata* in areas of groundwater upwelling, on the other.

4.1 Aboveground biomass

The allometric model with diameter as the estimator variable provided the best fit for regression equations developed from harvested saplings and tall shrubs for estimating aboveground sapling and tall shrub biomass. The high R^2 values and F-ratios indicated a significant and highly predictable relationship between total aboveground sapling and tall shrub biomass and diameter even though the sample sizes of 10 to 30 individuals were relatively small.

Estimates of total aboveground biomass ranged from 7,189 ± 924 kg ha^{-1} (s.e.) in the Open bog - *Carex oligosperma* community of L632 to 72,909 ± 20,627 kg ha^{-1} in the High density - *Picea mariana* community of L979. The biomass data of this study in addition to biomass estimates for Low Boreal and north-central Minnesota bog communities in the literature, exhibit a strong relationship between total community and tree biomass ($R^2 = 0.96$). This implies that a rough estimate of the total biomass of a bog community in this region may be predicted from the biomass of the tree stratum.

There were no trees in the Open bog - *Carex oligosperma* community of L632. Tree biomass of the other communities ranged from 898 ± 1,726 kg ha^{-1} in the Low density *Pinus banksiana* - *Ledum* shrub community to 66,506 ± 20,613 kg ha^{-1} in the High density *Picea mariana* - *Ledum* shrub community. Tree foliage, representing the portion of total tree biomass important to the carbon model of the reservoir, was 5 to 9% of total tree biomass. Sapling and tall shrub biomass was highest in the Open bog - *Alnus* shrub community at 3,851 ± 1,340 kg ha^{-1}, and the Low density *Pinus banksiana* community at 3,545 ± 1,189 kg ha^{-1}. In general, tree and tall shrub seedling biomass was low but made a significant contribution, of about 1,200 kg ha^{-1} in the open bog communities of L979.

Low shrub biomass ranged from 2,133 ± 567 kg ha^{-1} in the Open bog - *Carex oligosperma* community to 10,223 ± 1,866 kg ha^{-1} in the Open bog - *Chamaedaphne* shrub community. Herb biomass was relatively insignificant, 1 to 964 kg ha^{-1} and highest in the Open bog - *Carex oligosperma* community. Bryophyte biomass ranged from 1,914 ± 555 kg ha^{-1} in the Low density *Pinus banksiana - Ledum* shrub community to 4,047 ± 924 kg ha^{-1} in the Open bog - *Carex oligosperma* community. Its estimates for high and medium density *Picea mariana* communities and the Open bog - *Chamaedaphne/Ledum* shrub community were similar, but were slightly higher in the Open bog - *Chamaedaphne* shrub community. Litter biomass was lowest in the Open bog - *Carex oligosperma* community and highest in the regenerating Low density *Pinus banksiana - Ledum* shrub community.

4.2 Carbon content of aboveground vegetation

Carbon concentrations ranged from 430 ± 4 to 540 ± 5 mg C g^{-1} among species and tissue types analyzed. Among woody species, leaves had a higher carbon concentration than branch and stem tissue. Cyperaeceae had the lowest carbon concentration. In bryophytes, carbon was 40% and in litter 41% of biomass. This was lower than the 46 to 49% for all other components of the community. Overall, the range of total community carbon as a percentage of total community biomass in L979 and L632 was relatively small, 44 to 48%.

In the communities of L979 and L632, the community carbon pool of aboveground vegetation varied from 3,140 ± 480 to 35,010 ± 8,840 kg C ha^{-1} (excluding litter). The contributions of trees, saplings and tall shrubs, tree and tall shrub seedlings, low shrubs, herbs and bryophytes to the carbon pool for each community were proportional to their contributions to community biomass. If litter is considered a component of total community carbon it's contribution was similar to that of bryophytes, except in the Low density *Pinus banksiana - Ledum* shrub community where the amount of litter was almost four times that of bryophytes.

4.3 Available carbon pool in vegetation of the experimental bog

Tree trunks and branches were not included when estimating the carbon pool in aboveground vegetation that would be an available source of carbon in the production of

CO_2 and CH_4 in the experimental reservoir, but litter was included. The Low density *Pinus banksiana - Ledum* shrub, Open bog - *Chamaedaphne* shrub and Open bog - *Alnus* shrub communities contributed the highest amount of available carbon per unit area to the reservoir with 9,907 ± 1,531, 9,413 ± 1,281 and 8,212 ± 1,140 kg C ha^{-1}, respectively.

Over half the available aboveground carbon pool of 117,100 kg C in the experimental bog, L979, was contributed by the mire expanse Open bog - *Chamaedaphne* shrub community. Forty-four percent of this originated from *C. calyculata* biomass. The available carbon pool in aboveground vegetation in the experimental bog was approximately 8% of the carbon pool in the peat estimated by Bubier *et al.* (1993) to be 1.43×10^6 kg C. Since the species composition and biomass of these communities are typical of the Low Boreal wetland region these data are applicable to potential reservoir sites in this region.

4.4 Application to future studies

This study was restricted to two sites that were pre-selected by the Experimental Lakes Area Reservoir Project (ELARP). Future sampling in replicate bog communities in other sites of the region would increase the validity of these data in application to a broader area.

The approximate average aboveground plant biomass per unit area (excluding litter and weighted by the area occupied by each community type) in L979, 41,500 kg ha^{-1}, is similar to that of L632, at 35,332 kg ha^{-1}. The approximate average carbon content per unit area in the two sites is also similar (19,760 kg C ha^{-1} in L979 and 16,967 kg C ha^{-1} in L632). However, differences in the hydrology, physiognomy and species composition of plant communities between these sites point to the importance of considering the vegetation when choosing experimental and reference sites for multidisciplinary studies such as the ELARP. The sites differ in hydrology in that L979 is a flow-through system with a higher flow-through rate than L632, which is a headwater system. The latter is manifest by differences in species composition, including (1) a narrow zone of minerotrophic vegetation surrounding the central water body of L632, (2) sedge meadows in areas of groundwater upwelling that are absent in L979, and (3) the presence of *Myrica gale* as a common shrub throughout L632, *M. gale* is an indicator of minerotrophic conditions (Vitt and Bayley 1984; Sjörs 1961). These differences suggest that L632 is a slightly more minerotrophic system than L979. Also, the L632 site was approximately one fourth the size of L979 and thus perhaps a less than optimal reference for the experimental site, L979.

Since the existence of plant species and communities in a particular area is dependent in large part on the environmental conditions in that area, vegetation is an important indicator of these conditions (Bubier 1995, Bubier *et al.* 1995) and thus an important component of baseline data for such studies.

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APPENDIX A. Species lists

Appendix A.1.

Species and taxa observed within sample plots in L979

Trees

Betula papyrifera Marsh.*
Larix laricina (Du Roi) Koch
Picea mariana (Mill.) BSP.
Pinus banksiana Engelm.

Tall shrubs

Alnus rugosa (Du Roi) Spreng.
Salix pyrifolia Anderss.
Salix spp. L.

Low shrubs

Andromeda glaucophylla Link
Chamaedaphne calyculata (L.) Moench
Gaultheria hispidula (L.) Muhl.
Kalmia polifolia Wang.
Ledum groenlandicum Oeder
Myrica gale L.
Oxycoccus quadripetalus Gilib.
Rubus idaeus L.
Vaccinium angustifolium Ait.
V. vitis-idaea L.

Graminoids and herbs

Calamagrostis canadensis (Michx.) Nutt.
Carex spp. L.
Carex limosa L.
C. michauxiana Boeckl.
C. oligosperma Michx.
C. paupercula Michx.
C. rostrata Stokes
C. trisperma Dewey
Cornus canadensis L.
Drosera rotundifolia L.
Equisetum sylvaticum L.
Eriophorum vaginatum ssp. *spissum* (Fern.) Hult.
Eriophorum spp. L.
Hypericum virginicum L.
Listera cordata (L.) R. Br.
Lycopodium annotinum L.
Lycopus uniflorus Michx.
Monotropa uniflora L.

* Nomenclature follows Scoggan (1978-79) for vascular species, Anderson (1990) for *Sphagnum* spp. and Anderson *et al.* (1990) for other mosses, and Brodo (1981) for lichens.

Muhlenbergia asperifolia (Nees & Meyen) Parodi
Sarracenia purpurea L.
Smilacina trifolia (L.) Desf.
Solidago canadensis L.
Viola nephrophylla Greene

Bryophytes and lichens

Aulacomnium palustre (Hedw.) Schwaegr.
Ceratodon purpureus (Hedw.) Brid.
Cladina mitis (Sandst.) Hale & W. Culb.
C. rangiferina (L.) Nyl.
Cladonia spp.
Dicranum spp. Hedw.
Hylocomium splendens (Hedw.) Schimp. in B.S.G.
Mylia anomala (Hook.) S. Gray
Pleurozium schreberi (Brid.) Mitt.
Pohlia sphagnicola (Bruch & Schimp.) Lindb. & Arnell
Polytrichum commune Hedw.
P. strictum Brid.
Ptilidium ciliare (L.) Hampe
Ptilium crista-castrensis (Hedw.) De Not.
Sphagnum angustifolium (C. Jens. *ex* Russ.) C. Jens. *in* Tolf
S. capillifolium (Ehrh.) Hedw.
S. fallax (Klinggr.) Klinggr.
S. fuscum (Schimp.) Klinggr.
S. magellanicum Brid.
S. rubellum Wils.
S. subsecundum Nees *ex* Sturm

Species observed outside sample plots in L979

Amelanchier alnifolia Nutt.
Betula glandulosa Michx.
Carex lasiocarpa Ehrh.
Drepanocladus uncinatus (Hedw.) Warnst.
Eriophorum angustifolium Honckeny
Glyceria canadensis (Nash) Batch.
Iris versicolor L.
Menyanthes trifoliata L.
Sphagnum girgensohnii Russ.

Appendix A.2.

Species and taxa observed within sample plots in L632

Trees

Picea mariana (Mill.) BSP.
Larix laricina (Du Roi) Koch

Tall shrubs

Alnus rugosa (Du Roi) Spreng.

Low shrubs

Andromeda glaucophylla Link
Chamaedaphne calyculata (L.) Moench
Gaultheria hispidula (L.) Muhl.
Kalmia polifolia Wang.
Ledum groenlandicum Oeder
Myrica gale L.
Oxycoccus quadripetalus Gilib.
Vaccinium angustifolium Ait.
V. vitis-idaea L.

Graminoids and herbs

Calamagrostis canadensis (Michx.) Nutt.
Carex spp. L.
C. oligosperma Michx.
C. pauciflora Lightf.
C. paupercula Michx.
C. rostrata Stokes
C. trisperma Dewey
Cornus canadensis L.
Drosera rotundifolia L.
Eriophorum spp. L.
Hypericum virginicum L.
Lycopodium annotinum L.
Lycopus uniflorus Michx.
Melampyrum lineare Desr.
Sarracenia purpurea L.
Smilacina trifolia (L.) Desf.
Trientalis borealis Raf.

Bryophytes and lichens

Aulacomnium palustre (Hedw.) Schwaegr.
Cladina mitis (Sandst.) Hale & W. Culb.
C. rangiferina (L.) Nyl.
Cladonia spp.
Dicranum spp. Hedw.
Mylia anomala (Hook.) S. Gray
Pleurozium schreberi (Brid.) Mitt.
Pohlia sphagnicola (Bruch & Schimp.) Lindb. & Arnell
Polytrichum commune Hedw.
P. juniperinum Hedw.
P. strictum Brid.
Ptilium crista-castrensis (Hedw.) De Not.

Sphagnum angustifolium (C. Jens. *ex* Russ.) C. Jens. *in* Tolf
S. capillifolium (Ehrh.) Hedw.
S. fallax (Klinggr.) Klinggr.
S. fuscum (Schimp.) Klinggr.
S. magellanicum Brid.
S. papillosum Lindb.
S. pulchrum (Lindb. *ex* Braithw.) Warnst.
S. rubellum Wils.

Species observed outside sample plots in L632

Acer rubrum L.
Betula papyrifera Marsh.
Botrychium virginianum (L.) Sw.
Carex canescens L.
C. interior Bailey
C. lasiocarpa Ehrh.
C. limosa L.
Drosera intermedia Hayne
Dryopteris austriaca var. *spinulosa* (Muell.) Fiori
D. cristata (L.) Gray
Eriophorum angustifolium Honckeny
E. vaginatum ssp. *spissum* (Fern.) Hult.
Juncus brevicaudatus (Engelm.) Fern.
Monotropa uniflora L.
Potentilla palustris (L.) Scop.
Rhynchospora alba (L.) Vahl
Rubus idaeus L.
Scheuchzeria palustris L.
Scirpus cyperinus (L.) Kunth
Sphagnum majus (Russ.) C. Jens.
Xyris montana Ries

APPENDIX B. Species composition data.

Table B.1. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the High density *Picea mariana* - *Ledum* shrub (1) community of L979 (n=32).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Dead wood	0	0	2.5	0	0	0	0	0
Litter	12.5	7.5	20	t	3	1	25	5
Open water	0	0	5	0	0	0	0	0
Trees (≥ 10 cm CBH)								
Larix laricina	80	0	90	0	0	0	0	0
Picea mariana	0	0	0	10	25	0	15	0
Salix pyrifolia	0	0	0	0	0	0	t	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	10	0	0	0	5	2.5	0	0
Salix sp.	0	0	5	0	0	0	0	0
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	25	65	5.5	0	0	20	15	10
Gaultheria hispidula	0	0	0	0	15	0	0	0
Kalmia polifolia	3	12.5	0	t	0	2.5	2.5	0
Ledum groenlandicum	15	0.5	40	85	30	25	60	45
Oxycoccus quadripetalus	20	t	t	0	0	3	1	0.5
Seedlings and Herbs								
Calamagrostis canadensis	0	1	0	1	0	0	0	0
Carex trisperma	0	12.5	0	0	15	3	0	0
Carex sp.	0	0	0	0	0	1	0	0
Equisetum sylvaticum	0	0	0	0	0	2.5	0	0
Lycopodium annotinum	0	0	0	0	20	10	0	0
Picea mariana	5	0	0	0	0	0	0	0
Smilacina trifolia	0	0	0	0	0	2.5	3	10
Bryophytes and Lichens								
Aulacomnium palustre	2.5	0	0	0	0	0	0	0
Cladina mitis	0	0	0	0	0	0	0	3
Dicranum spp.	0	0	0	0	0	0	0.5	0
Pleurozium schreberi	0	0	0	0	0	0	1	32.5
Pohlia sphagnicola	0.5	0	1	0	1	1	t	5.5
Polytrichum strictum	0	0	0	0	t	25	0	10
Sphagnum angustifolium/fallax	65	95	15.3	95	5	30	5	20
S. fuscum	5	0	5	0	0	0	65	30
S. magellanicum	15	0	50	2.5	95	35	1	0

t - trace, <1%

Table B.1 cont'd.

Species and taxa	Plot No. 9	10	11	12	13	14	15	16
Dead wood	0	5	10	0	5	0	0	0
Litter	3	55	10	5.5	0	15	2.5	t
Trees (≥ 10 cm CBH)								
Picea mariana	55	10	5	20	100	0	100	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	20	0	0	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	0	0	12.5	0	0
Chamaedaphne calyculata	0	0	0	0	0	3	0	5
Gaultheria hispidula	0	0	3	30	t	20.5	0	10
Kalmia polifolia	0	0	0	0	0	3	0	7.5
Ledum groenlandicum	60	65	60	55	25	80	45	30
Oxycoccus quadripetalus	7.5	1	0	t	0	t	0	10
Seedlings and Herbs								
Carex sp.	0	0	0	0	0	t	0	t
Carex trisperma	0	0	0	0	0	0	0	2.5
Eriophorum sp.	0	0	0	0	0	0	0	5
Lycopodium annotinum	0	0	0	0	0	17.5	0	7.5
Monotropa uniflora	0	0	0	0	0	0	t	0
Smilacina trifolia	2.5	7.5	0	12.5	7.5	0	2.5	5
Bryophytes and Lichens								
Cladina mitis	0	t	2.5	0	0	0	0	0
Cladonia spp.	2.5	5	0	0	t	0	0	0
Dicranum spp.	t	3	35	5	t	0	0	0
Pleurozium schreberi	60	20	30	5	90	t	45	2.5
Pohlia sphagnicola	t	5	0	0	0	t	0	5
Polytrichum strictum	3	0	0	0	0	0	0	5
Ptilidium ciliare	0	t	0	0	5	0	0	0
Ptilium crista-castrensis	0	0	0	0	t	0	0	0
Sphagnum angustifolium/fallax	20	10	15	35	7.5	55	55	20
S. fuscum	17.5	15	0	10	0	5	0	0
S. magellanicum	t	2.5	0	27.5	0	25	0	70

t - trace, < 1%

Table B.1 cont'd.

Species and taxa	Plot No. 17	28	29	20	21	22	23	24
Dead wood	0	0	0	0	0	0	0	3
Litter	25	22.5	65	7.5	25	30	3	5.5
Trees (≥ 10 cm CBH)								
Picea mariana	100	40	85	50	15	100	50	50
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	25	2.5	0	0	0
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	0	t	15	t	17.5	0	0	2.5
Kalmia polifolia	0	0	2.5	0	1	0	0	0
Ledum groenlandicum	60	70	55	30	55	15	75	25
Oxycoccus quadripetalus	0	t	t	t	t	1	5	t
Seedlings and Herbs								
Picea mariana	0	0	0	45	t	0	0	0
Smilacina trifolia	25	15.3	0	25	7.5	1	7.5	5
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	t	0	0	0	0
Cladina mitis	5.3	0	0	0	0	0	0	0
Dicranum spp.	22.5	2.5	2.5	2.5	0	t	0	0
Pleurozium schreberi	22.5	t	7.5	60	22.5	60	45	35
Pohlia sphagnicola	t	0	0	t	2.8	t	2.8	2.5
Sphagnum angustifolium/fallax	22.5	70	20	20	0	5.5	3	35
S. fuscum	2.5	0	0	0	30	2.5	0	0
S. magellanicum	0	1	2.5	2.5	25	10.5	47.5	20

t - trace, < 1%

Table B.1 cont'd.

Species and taxa	Plot No. 25	26	27	28	29	30	31	32
Dead wood	t	0	20	0	0	15	0	15
Litter	5.5	5	12.5	15	45	45	20	20
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	15	0	0	0	0	0
Picea mariana	100	90	85	15	5	0	0	50
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	17.5	0	0	55	5.3	30	30
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	2.5	0	0	0	0	0
Chamaedaphne calyculata	0	0	0	5.5	t	t	15	7.5
Gaultheria hispidula	0	0	0	0	0	10.3	0	0
Kalmia polifolia	0	0	2.5	0	t	2.5	5	0
Ledum groenlandicum	40	55	55	90	80	35	65	65
Oxycoccus quadripetalus	0	t	2.5	3	t	10.5	3	2.5
Seedlings and Herbs								
Eriophorum sp.	0	0	0	0	0	5	0	0
Smilacina trifolia	5	0	5	0	0	2.5	7.5	15
Bryophytes and Lichens								
Cladonia spp.	0	0	0	0	0	0	0	2.5
Dicranum spp.	5	0	5.3	t	t	t	10	30
Hylocomium splendens	t	0	0	0	0	0	0	0
Pleurozium schreberi	90	100	30	45	17.5	t	40	15
Pohlia sphagnicola	0	0	0	0	5	t	t	15.3
Polytrichum strictum	0	0	0	0	0	0	15	t
Ptilidium ciliare	t	0	2.8	0	0	0	0	0
Ptilium crista-castrensis	1	0	0	0	0	0	0	0
Sphagnum angustifolium/fallax	0	2.5	25	25	40	50	3	5
S. fuscum	0	0	0	0	0	2.5	0	0
S. magellanicum	0	0	2.5	5	5.5	t	20	0

t - trace, <1%

Table B.1 cont'd.

Species and taxa	Mean (n=32)
Dead wood	2
Litter	16
Open water	t
Trees (≥ 10 cm CBH)	
Larix laricina	6
Picea mariana	37
Salix pyrifolia	1
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs	
Picea mariana	6
Salix sp.	t
Low shrubs (≤ 1.5 m)	
Andromeda glaucophylla	t
Chamaedaphne calyculata	7
Gaultheria hispidula	3
Kalmia polifolia	1
Ledum groenlandicum	50
Oxycoccus quadripetalus	2
Seedlings and Herbs	
Calamagrostis canadensis	t
Carex trisperma	1
Carex sp.	t
Equisetum sylvaticum	t
Eriophorum sp.	t
Lycopodium annotinum	2
Monotropa uniflora	t
Picea mariana	2
Smilacina trifolia	5
Bryophytes and Lichens	
Aulacomnium palustre	t
Cladina mitis	t
Cladonia spp.	t
Dicranum spp.	4
Hylocomium splendens	t
Pleurozium schreberi	27
Pohlia sphagnicola	2
Polytrichum strictum	2
Ptilidium ciliare	t
Ptilium crista-castrensis	t
Sphagnum angustifolium/fallax	27
S. fuscum	6
S. magellanicum	15

t - trace, <1%

Table B.2. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Medium density *Picea mariana - Ledum* shrub (2) community of L979 (n=32).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Litter	1	5	1	22.5	1	t	5.5	t
Trees (≥ 10 cm CBH)								
Picea mariana	0	0	0	0	2.5	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	65	0	0	30	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	10	1	t	10	0	0
Chamedaphne calyculata	3	5.5	60	1	t	22.5	20	5
Kalmia polifolia	10	7.5	5	7.5	7.5	10.5	7.5	7.5
Ledum groenlandicum	55	65	2.5	85	75	25	40	35
Oxycoccus quadripetalus	12.5	5	5	2.5	5	5	t	3
Seedlings and Herbs								
Carex trisperma	0	0	0	0	0	0	t	t
Carex sp.	t	0	1	1	1	t	t	t
Drosera rotundifolia	0	0	0	2.5	0	0	0	t
Eriophorum sp.	0	10	7.5	2.8	1	5.5	2.5	0
Lycopodium annotinum	10	0	20	0	30	5	10	10
Picea mariana	0	0	0	0	0	0	30	0
Smilacina trifolia	t	50	7.5	0	12.5	15	30	20
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	0	2.5	0
Pleurozium schreberi	0	0	0	0	0	0	2.5	0
Pohlia sphagnicola	t	0	0	0	1	0	3	t
Polytrichum strictum	0	0	0	0	5	0	0	0
Sphagnum angustifolium/fallax	50	90	95	65	15	90	30	65
S. fuscum	0	5	0	2.5	0	0	0	0
S. magellanicum	50	t	2.8	12.5	25	t	50	27.5

t - trace, <1%

Table B.2 cont'd.

Species and taxa	Plot No. 9	10	11	12	13	14	15	16
Dead wood	0	0	0	0	0	0	25	0
Litter	7.5	35	5.5	2.8	5	5	2.8	t
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	70	100	5	0	0	0
Picea mariana	100	5	0	0	75	0	100	5
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	0	52.5	0	0	0	0	0	0
Picea mariana	0	0	0	0	0	t	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	5	10.5	5	0	0	t	t
Chamedaphne calyculata	40	2.5	7.5	10	7.5	20	t	12.5
Kalmia polifolia	t	7.5	5	10	5	2.8	0	12.5
Ledum groenlandicum	50	95	75	80	85	20	30	15
Oxycoccus quadripetalus	7.5	25.5	2.5	5	t	10.5	2.5	12.5
Seedlings and Herbs								
Carex trisperma	0	0	0	0	0	0	t	0
Carex sp.	0	0	t	0	0	0	t	3
Eriophorum sp.	10.5	0	t	t	0	2.5	2.5	0
Sarracenia purpurea	7.5	0	0	0	0	7.5	0	0
Smilacina trifolia	2.5	2.5	10	5	0	7.5	5	15
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	t	5	0
Pleurozium schreberi	0	0	2.5	0	0	t	50	0
Pohlia sphagnicola	1	t	2.5	0	0	3	5	t
Polytrichum strictum	0	t	0	0	0	2.5	0	0
Sphagnum angustifolium/fallax	75	40	45	95	90	50	35	70
S. fuscum	0	0	0	0	0	5	0	t
S. magellanicum	17.5	10.5	50	0	5	30	0	25

t - trace, <1%

Table B.2 cont'd.

Species and taxa	Plot No. 17	18	19	20	21	22	23	24
Dead wood	0	0	t	0	5	5	0	0
Litter	5	t	20	t	5	3	7.5	7.5
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	55	0	0	0	0	0
Picea mariana	55	35	0	40	0	20	10	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	0	20	30	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	7.5	7.5	12.5	12.5	10	0	3	0
Chamedaphne calyculata	7.5	7.5	15	20	7.5	0	12.5	5.5
Kalmia polifolia	10	10	7.5	5	2.5	7.5	10	15
Ledum groenlandicum	20	15	17.5	15	35	40	50	85
Oxycoccus quadripetalus	7.5	12.5	27.5	7.5	12.5	t	t	t
Seedlings and Herbs								
Carex limosa	0	0	0	0	0	0	0	t
Carex trisperma	0	0	0	0	0	2.5	0	0
Carex sp.	1	t	t	0	t	t	0	t
Drosera rotundifolia	0	0	0	2.5	0	0	t	0
Eriophorum spissum	0	0	0	0	7.5	0	0	0
Eriophorum sp.	5	3	t	0	0	0	t	t
Listera chordata	0	0	0	0	0	0	0	t
Picea mariana	0	0	0	0	0	0	t	0
Sarracenia purpurea	0	15.5	0	0	0	0	0	0
Smilacina trifolia	20	7.5	5	0	10	0	2.5	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	5	0	0	0
Pleurozium schreberi	0	0	0	5	5	0	2.5	0
Pohlia sphagnicola	1	0	2.5	t	3	2.5	2.5	0
Polytrichum strictum	0	0	20	2.5	t	0	2.5	0
Sphagnum angustifolium/fallax	45	60	20	70	70	65	90	95
S. fuscum	30	15	t	12.5	0	0	5	0
S. magellanicum	15	5.5	20.5	7.5	2.5	25	3	3

t - trace, <1%

Table B.2 cont'd.

Species and taxa	Plot No. 25	26	27	28	29	30	31	32
Litter	5.3	7.5	65	5	7.5	3	7.5	15
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	0	10	0	0	0	0
Picea mariana	0	0	0	0	40	0	70	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	5	0	0	0	0	0	0	0
Picea mariana	50	0	0	0	50	0	t	t
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	2.5	0	2.5	3	2.5	3	3
Chamedaphne calyculata	30	65	80	35	2.5	25	10	35
Kalmia polifolia	0	5	2.5	2.5	5	15	3	5
Ledum groenlandicum	25	10	12.5	20	12.5	10	40	15
Oxycoccus quadripetalus	5	17.5	17.5	10	3	20	35	25
Vaccinium vitis-idaea	0	0	0	0	0	0	0	t
Seedlings and Herbs								
Carex sp.	t	t	t	t	t	t	0	0
Drosera rotundifolia	0	t	0	0	0	2.5	t	2.8
Eriophorum sp.	2.5	t	0	0	5	0	t	0
Picea mariana	10	0	0	0	0	0	0	t
Smilacina trifolia	15	7.5	2.5	10	25	20	20	15
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	2.5	0	t	0
Dicranum spp.	0	0	0	0	0	0	0	t
Mylia anomala	0	0	0	0	0	0	0	2.5
Pleurozium schreberi	0	0	0	5	5	0	15.5	t
Pohlia sphagnicola	3	t	0	t	5	t	3	3
Polytrichum commune	0	0	0	0	0	0	t	t
P. strictum	5	5	0	15	0	12.5	2.5	5
Ptilium crista-castrensis	0	0	0	0	0	0	t	0
Sphagnum angustifolium/fallax	0	25	20	2.5	20	35	50	15.5
S. fuscum	75	40	0	55	0	37.5	30	70
S. magellanicum	0	3	0	15	60	10	t	10.3

t - trace, <1%

Table B.2 cont'd.

Species and taxa	Mean (n=32)
Dead wood	1
Litter	8
Trees (≥ 10 cm CBH)	
Larix laricina	8
Picea mariana	17
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs	
Larix laricina	2
Picea mariana	8
Low shrubs (≤ 1.5 m)	
Andromeda glaucophylla	4
Chamedaphne calyculata	18
Kalmia polifolia	7
Ledum groenlandicum	39
Oxycoccus quadripetalus	10
Vaccinium vitis-idaea	t
Seedlings and Herbs	
Carex limosa	t
C. trisperma	t
Carex sp.	t
Drosera rotundifolia	t
Eriophorum spissum	t
Eriophorum sp.	1
Listera chordata	t
Lycopodium annotinum	3
Picea mariana	1
Sarracenia purpurea	1
Smilacina trifolia	11
Bryophytes and Lichens	
Aulacomnium palustre	t
Dicranum spp.	t
Mylia anomala	t
Pleurozium schreberi	3
Pohlia sphagnicola	1
Polytrichum commune	t
Polytrichum strictum	2
Ptilium crista-castrensis	t
Sphagnum angustifolium/fallax	53
S. fuscum	12
S. magellanicum	15

t - trace, <1%

Table B.3. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Open bog - *Chamaedaphne* shrub (3) community of L979 (n=91).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Dead wood	t	2.5	0	0	0	0	0	3
Litter	45	45	70	15	20	45	45	7.5
Open water	0	0	90	0	0	25	10	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	0	0	0	2.5	0	0	0	0
Low shrubs (≤ 1.5 m)								
Chamedaphne calyculata	30	45	5	70	40	5.3	20	70
Kalmia polifolia	5.5	0	0	10	10	0	0	5
Ledum groenlandicum	15	0	0	0	0	0	0	5
Myrica gale	20	45	80	35	10	30	15	0
Oxycoccus quadripetalus	t	t	0	t	0	0	0	7.5
Seedlings and Herbs								
Carex rostrata	0	3	0	0	10.5	20	30	0
Carex trisperma	0	0	0	t	0	0	0	0
Carex sp.	12.5	0	5.5	t	0	0	0	t
Drosera rotundifolia	0	0	0	0	0	0	7.5	0
Picea mariana	0	0	0	0	0	0	0	2.5
Pinus banksiana	0	0	0	0	0	0	2.5	0
Smilacina trifolia	0	0	0	2.5	2.5	0	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	t	0	0	0	0	0	0
Cladina mitis	0	0	0	0	0	0	0	2.5
Cladonia spp.	0	0	0	0	0	0	2.5	0
Pleurozium schreberi	0	0	0	0	0	0	0	22.5
Pohlia sphagnicola	2.5	0	0	0	0	0	0	t
Polytrichum strictum	0	0	0	0	0	0	0	15
Sphagnum angustifolium/fallax	30	55	0	65	75	30	35	45
S. fuscum	0	0	0	0	0	0	0	2.5
S. magellanicum	45	t	0	25	t	0	5	2.8
S. rubellum	0	0	0	0	0	0	5	0
S. subsecundum	0	0	30	0	0	0	0	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 9	10	11	12	13	14	15	16
Litter	12.5	1	17.5	12.5	10	40	20	1
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	0	0	0	60	0	10
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	0	0	0	0	0	2.5	0	0
Picea mariana	0	0	t	0	0	0	5	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	t	7.5	0	10	0
Chamedaphne calyculata	80	75	70	50	70	15	75	40
Gaultheria hispidula	0	0	0	0	0	0	0	0
Kalmia polifolia	5	7.5	7.5	3	5	2.5	2.5	5
Ledum groenlandicum	15	17.5	20	25	0	40	5	5
Myrica gale	0	0	0	7.5	0	0	0	0
Oxycoccus quadripetalus	3	2.5	5.3	10	10	5	35	5
Seedlings and Herbs								
Carex sp.	t	2.8	0	0	0	0	0	1
Drosera rotundifolia	0	0	2.5	t	t	0	0	0
Eriophorum sp.	0	0	0	t	0	0	0	t
Picea mariana	2.5	0	0	t	0	0	0	0
Smilacina trifolia	0	2.5	0	0	0	2.5	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	2.8	t	10	0	0
Cladonia spp.	0	0	0	t	0	0	0	0
Mylia anomala	t	0	0	t	0	0	0	0
Pleurozium schreberi	0	0	t	0	0	10	20	0
Pohlia sphagnicola	t	0	5	3	t	1	0	t
Polytrichum strictum	t	5	3	0	3	20	35	t
Sphagnum angustifolium/fallax	35	95	35	15	35	20	25	95
S. fuscum	40	0	55	30	20	0	0	0
S. magellanicum	12.5	3	t	20	25	10	0	5

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 17	18	19	20	21	22	23	24
Litter	3	5.3	2.8	65	3	3	22.5	15
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	0	95	0	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	10	0	10	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	15	25	10	3	5	t	7.5	t
Chamedaphne calyculata	45	20	30	100	40	60	70	60
Kalmia polifolia	7.5	7.5	7.5	17.5	10	7.5	12.5	12.5
Ledum groenlandicum	0	0	2.5	0	0	0	0	0
Oxycoccus quadripetalus	7.5	45	25	25	12.5	3	12.5	25
Seedlings and Herbs								
Carex trisperma	0	0	0	t	0	0	0	0
Carex sp.	t	0	0	0	t	t	t	0
Drosera rotundifolia	2.5	t	t	0	t	0	t	t
Eriophorum sp.	0	12.5	10.3	t	3	0	0	0
Smilacina trifolia	20	0	1	0	5	15	0	7.5
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	t	0	0	0
Pleurozium schreberi	15	0	0	0	t	0	0	0
Pohlia sphagnicola	5	t	1	t	1	t	t	5
Polytrichum strictum	15	t	5.5	0	0	0	10	t
Sphagnum angustifolium/fallax	12.5	30	5.5	25	90	85	50	t
S. fuscum	50	65	90	0	0	0	20	95
S. magellanicum	1	2.8	0	0	t	12.5	t	t

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 25	26	27	28	29	30	31	32
Litter	1	3	15	3	15	25	5.5	2.8
Open water	0	0	t	0	0	0	0	0
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	0	0	0	0	0	45
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	15	0	0	0	0	0	0	0
Picea mariana	0	10	0	0	2.5	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	25	5.5	5	5	0	t	5	0
Chamedaphne calyculata	40	40	22.5	75	55	90	55	80
Kalmia polifolia	10	5	15	7.5	10	7.5	3	7.5
Ledum groenlandicum	0	0	t	0	0	0	25	0
Oxycoccus quadripetalus	5	30	5	0	15	5.5	12.5	2.5
Seedlings and Herbs								
Carex rostrata	0	0	2.5	0	0	0	0	0
Carex trisperma	0	0	2.5	0	0	0	0	0
Carex sp.	0	0	0	t	0	0	0	0
Drosera rotundifolia	3	2.5	0	3	5.5	t	7.5	2.5
Equisetum sylvaticum	0	0	5	0	0	0	0	0
Eriophorum sp.	2.5	0	t	0	0	0	0	0
Sarracenia purpurea	0	0	0	0	5	0	2.5	0
Smilacina trifolia	0	7.5	0	10	0	10	5	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	t	0	0	0	0	0
Cladonia spp.	0	0	t	0	0	0	0	0
Dicranum spp.	0	0	t	0	0	0	0	0
Mylia anomala	0	0	10	0	0	0	0	0
Pleurozium schreberi	0	20	0	0	0	0	0	0
Pohlia sphagnicola	5	5	5	1	3	t	7.5	1
Polytrichum strictum	15	10	0	0	t	0	0	0
Sphagnum angustifolium/fallax	30	5.3	60	70	7.5	45	12.5	55
S. fuscum	35	55	5	30	75	2.8	80	25
S. magellanicum	10	10	25	3	5	50	1	7.5

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 33	34	35	36	37	38	39	40
Bare ground	0	0	0	0	0	0	0	5
Litter	30	7.5	25	15.5	7.5	5.5	30	12.5
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	0	0	0	0	75
Pinus banksiana	0	0	0	0	20	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	2.5	5	2.5	t	0	0	10.3	0
Chamedaphne calyculata	65	85	55	65	25	45	55	22.5
Kalmia polifolia	2.5	7.5	5	t	0	7.5	5.5	2.5
Ledum groenlandicum	0	0	0	0	0	0	0	25
Myrica gale	0	0	0	0	70	0	35	0
Oxycoccus quadripetalus	0	5	15	20	0	15	t	t
Seedlings and Herbs								
Calamagrostis canadensis	0	0	0	0	3	0	t	0
Carex rostrata	0	0	0	0	7.5	0	0	0
Carex sp.	t	0	0	0	t	0	0	0
Drosera rotundifolia	0	2.5	2.5	t	0	3	0	t
Eriophorum sp.	15.3	0	0	0	t	0	0	0
Hypericum virginicum	0	0	0	0	3	0	t	0
Lycopus uniflorus	0	0	0	0	0	0	t	0
Picea mariana	0	0	0	t	0	0	0	0
Sarracenia purpurea	0	0	0	2.5	0	10	0	0
Smilacina trifolia	0	7.5	0	0	0	0	0	5
Viola nephrophylla	0	0	0	0	5	0	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	0	t	0
Cladonia spp.	t	0	t	0	0	0	0	10.5
Mylia anomala	t	0	0	0	0	0	0	0
Pleurozium schreberi	0	10	5	0	0	0	t	0
Pohlia sphagnicola	t	t	1	t	3	5	t	1
Polytrichum strictum	t	10	15	1	0	0	0	30
Sphagnum angustifolium/fallax	15.3	30	12.5	t	60	0	20	3
S. fuscum	0	40	40	90	0	95	0	15
S. magellanicum	25	0	0	t	25	0	50	35
S. rubellum	0	0	0	0	0	0	15	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 41	42	43	44	45	46	47	48
Litter	7.5	20	5.5	15	5.5	1	3	5
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	75	0	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	2.5	0	0	7.5	3	5	0	0
Chamedaphne calyculata	50	30	25	60	65	20	50	35
Kalmia polifolia	5	5	7.5	5.5	7.5	7.5	3	10
Ledum groenlandicum	0	0	0	0	0	0	3	0
Myrica gale	0	5	0	0	0	10	20	0
Oxycoccus quadripetalus	0	0	5.3	10	3	12.5	3	5
Seedlings and Herbs								
Carex rostrata	7.5	10	0	0	t	0	0	0
Carex sp.	1	3	t	0	5	5	0	0
Drosera rotundifolia	0	0	5	3	5	3	t	2.5
Eriophorum spissum	0	0	0	0	0	0	0	2.5
Eriophorum sp.	3	5	0	0	0	2.5	0	2.5
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	0	t	0
Cladonia spp.	0	0	0	2.5	0	0	0	0
Mylia anomala	0	0	0	0	2.5	0	0	0
Pleurozium schreberi	0	0	0	0	0	0	10.3	0
Pohlia sphagnicola	0	t	t	1	t	t	t	1
Polytrichum strictum	0	0	0	0	2.5	0	0	0
Sphagnum angustifolium/fallax	75	75	50	20.5	20	55	55	80
S. fuscum	5	5.5	30	60	70	10	20	10
S. magellanicum	5	t	15.3	2.5	5	25	3	3
S. rubellum	0	2.5	0	0	0	0	0	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 49	50	51	52	53	54	55	56
Litter	10	15	45	7.5	25	5	1	10
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	5	10	40	0	0	25	0	25
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	2.5	1	1	1	5	0	5	t
Chamedaphne calyculata	40	50	30	75	40	65	45	60
Kalmia polifolia	2.5	10	5	5	15	5.3	15	15
Ledum groenlandicum	0	0	0	0	0	15	10	0
Oxycoccus quadripetalus	15	40	20	5	12.5	15	15	15
Seedlings and Herbs								
Carex sp.	3	0	0	t	t	0	t	0
Drosera rotundifolia	2.5	t	t	0	3	0	t	t
Eriophorum sp.	5	0	0	7.5	10	0	0	0
Picea mariana	0	0	0	0	2.5	0	0	0
Sarracenia purpurea	2.5	10	0	0	0	0	0	0
Smilacina trifolia	0	0	0	0	0	2.5	30	t
Bryophytes and Lichens								
Aulacomnium palustre	t	0	0	0	0	0	0	0
Mylia anomala	0	0	t	0	0	0	0	0
Pohlia sphagnicola	t	t	t	t	t	1	t	t
Polytrichum strictum	0	0	t	0	5	50	0	0
Sphagnum angustifolium/fallax	15	20	5	85	1	30	75	5.5
S. fuscum	75	60	60	0	70	7.5	15	90
S. magellanicum	0	t	t	3	1	10.3	7.5	0
S. rubellum	0	0	0	t	t	0	0	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 57	58	59	60	61	62	63	64
Litter	10.5	1	5	20	12.5	35	7.5	3
Trees (≥ 10 cm CBH)								
Picea mariana	0	0	0	0	0	0	50	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	35	0	0	10	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	t	t	0	0	0	10	15	0
Chamedaphne calyculata	45	60	75	60	50	30	15	85
Kalmia polifolia	2.8	5	5	17.5	12.5	12.5	t	7.5
Ledum groenlandicum	0	0	0	7.5	25	25	60	0
Myrica gale	0	0	0	0	0	25	0	0
Oxycoccus quadripetalus	20	12.5	7.5	5.3	3	20	30	7.5
Seedlings and Herbs								
Carex oligosperma	0	5	0	0	0	0	0	0
Carex trisperma	0	0	0	0	0	0	45	0
Carex sp.	t	t	t	t	0	0	0	t
Drosera rotundifolia	t	0	0	0	0	0	0	0
Eriophorum spissum	0	0	0	0	0	0	0	5.5
Eriophorum sp.	0	5	0	0	0	0	0	0
Picea mariana	0	0	0	0	0	0	2.5	0
Smilacina trifolia	20	0	10	0	0	2.5	2.5	0
Bryophytes and Lichens								
Aulacomnium palustre	t	0	0	0	0	0	0	0
Cladina mitis	1	0	0	0	5	0	0	0
C. rangiferina	0	0	0	0	5	0	0	0
Cladonia spp.	t	0	0	0	0	0	0	0
Dicranum spp.	t	0	0	0	0	0	0	0
Mylia anomala	t	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	0	45	2.5	0	t	17.5
Pohlia sphagnicola	1	2.5	t	t	t	2.8	5	0
Polytrichum strictum	1	5	0	15	10	2.8	2.8	20
Sphagnum angustifolium/fallax	2.5	45	75	0	25	20	55	22.5
S. fuscum	80	30	12.5	20	40	5	t	40
S. magellanicum	1	2.5	10.5	5	2.5	25	5.3	0
S. rubellum	0	15	0	0	0	0	0	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 65	66	67	68	69	70	71	72
Litter	5.5	15	15	25	3	5.5	15	3
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	10	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	20	30	t	0	0	2.5	0	0
Chamedaphne calyculata	22.5	65	80	65	60	80	70	65
Kalmia polifolia	7.5	20	5	0	1	15	15	7.5
Ledum groenlandicum	10	15	22.5	25.5	0	0	0	0
Myrica gale	12.5	7.5	0	0	0	0	0	0
Oxycoccus quadripetalus	60	70	7.5	1	5.5	2.8	30	7.5
Seedlings and Herbs								
Carex trisperma	0	2.5	0	0	0	0	0	0
Carex sp.	t	0	0	0	t	2.5	t	0
Drosera rotundifolia	0	0	t	t	0	0	0	2.5
Eriophorum sp.	t	0	t	0	0	0	0	0
Picea mariana	0	0	0	t	0	0	0	t
Sarracenia purpurea	0	0	0	0	0	0	0	15
Smilacina trifolia	0	5	0	0	10	0	10	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	0	1	0
Cladonia spp.	t	0	0	t	0	0	0	0
Mylia anomala	0	0	0	10	0	0	0	t
Pleurozium schreberi	40	0	0	10	0	0	0	0
Pohlia sphagnicola	3	0	3	2.8	0	t	5	t
Polytrichum strictum	22.5	0	0	t	0	0	0	10
Sphagnum angustifolium/fallax	15	50	32.5	7.5	100	65	55	2.5
S. fuscum	t	5	50	65	0	27.5	t	85
S. magellanicum	t	45	t	2.5	t	5.3	25	2.5

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 73	74	75	76	77	78	79	80
Dead wood	0	0	2.5	0	0	0	0	0
Litter	5	20	10	15	5	25	2.8	40
Open water	0	0	0	0	25	0	0	0
Trees (≥ 10 cm CBH)								
Picea mariana	0	0	45.3	0	0	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	5	47.5	10	0	0	0	0	20
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	0	2.5	0	0	0
Chamedaphne calyculata	70	25.3	20	40	45	35	65	65
Kalmia polifolia	5	5	t	7.5	2.5	0	t	3
Ledum groenlandicum	12.5	25	35	7.5	0	50	45	7.5
Myrica gale	0	0	0	0	35	0	0	0
Oxycoccus quadripetalus	7.5	17.5	1	7.5	0	25	2.8	35
Seedlings and Herbs								
Carex sp.	0	0	0	3	t	0	0	0
Drosera rotundifolia	0	2.8	0	0	0	0	0	t
Eriophorum sp.	0	0	0	0	5.5	0	0	t
Picea mariana	0	0	t	15	0	7.5	0	0
Sarracenia purpurea	10	0	0	0	0	0	0	0
Smilacina trifolia	0	0	7.5	0	0	10	15	7.5
Bryophytes and Lichens								
Aulacomnium palustre	0	0	t	0	t	1	0	2.8
Cladina mitis	0	0	0	0	2.5	0	0	0
Cladonia spp.	0	0	0	2.5	t	0	0	0
Dicranum spp.	0	0	2.5	0	0	0	0	0
Mylia anomala	0	0	0	0	0	0	0	2.5
Pleurozium schreberi	0	0	2.5	0	t	45	0	t
Pohlia sphagnicola	5.5	t	1	5	0	t	t	7.5
Polytrichum strictum	5	5	2.5	5	0	10	2.8	0
Sphagnum angustifolium/fallax	70	40	7.5	45	45	15	90	t
S. fuscum	5	35.3	60	15	0	0	2.5	60
S. magellanicum	10	t	10.5	15	15.5	0	3	15.5
S. rubellum	0	0	0	0	t	0	0	0

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 81	82	83	84	85	86	87	88
Dead wood	0	0	5	2.5	0	0	0	0
Litter	55	1	t	40	25	7.5	3	0
Open water	0	0	0	0	0	0	0	70
Trees (≥ 10 cm CBH)								
Larix laricina	0	0	0	0	t	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	10.3	0	0	0	0	0	0	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	7.5	2.5	0	3	0
Chamedaphne calyculata	35	65	75	15	10	40	60	15
Gaultheria hispidula	0	0	t	0	0	0	0	0
Kalmia polifolia	t	7.5	7.5	10	5	5	7.5	0
Ledum groenlandicum	5	3	10	0	0	0	0	0
Myrica gale	45	0	5	15	25	15	10	40
Oxycoccus quadripetalus	25	3	7.5	0	0	12.5	17.5	0
Seedlings and Herbs								
Carex rostrata	0	0	0	0	2.5	15.5	12.5	30
Carex trisperma	0	0	0	t	0	0	0	0
Carex sp.	0	0	t	t	15	3	0	10
Cornus canadensis	0	0	0	2.5	0	0	0	0
Drosera rotundifolia	t	2.5	0	0	0	0	t	0
Equisetum sylvaticum	0	0	0	0	0	0	0	7.5
Eriophorum sp.	0	0	0	15.5	3	t	0	1
Hypericum virginicum	0	0	0	3	0	0	0	0
Picea mariana	0	0	0	2.5	0	0	0	0
Sarracenia purpurea	0	0	2.5	20	0	0	0	0
Smilacina trifolia	0	0	20	0	0	25	0	0
Solidago canadensis	0	0	0	2.5	0	0	0	0
Viola nephrophylla	0	0	0	0	t	0	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	0	t	0	0	0	0	0
Mylia anomala	7.5	0	0	0	0	0	0	0
Pleurozium schreberi	10	0	0	0	0	0	0	0
Pohlia sphagnicola	2.5	3	5	0	0	0	t	2.8
Polytrichum strictum	0	t	0	0	0	0	0	0
Sphagnum angustifolium/fallax	0	65	7.5	35	10	75	20	30
S. fuscum	35	35	45	0	0	0	47.5	0
S. magellanicum	5	3	5	0	0	12.5	35	0
S. subsecundum	0	0	0	0	55	0	0	5

t - trace, <1%

Table B.3 cont'd.

Species and taxa	Plot No. 89	90	91	Mean (n=91)
Bare ground	0	0	0	t
Dead wood	0	0	0	t
Litter	45	40	40	16
Open water	30	50	2.5	3
Trees (≥ 10 cm CBH)				
Larix laricina	0	0	0	2
Picea mariana	0	0	0	1
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs				
Larix laricina	0	0	0	t
Picea mariana	0	0	0	5
Pinus banksiana	0	0	0	t
Low shrubs (≤ 1.5 m)				
Andromeda glaucophylla	0	0	0	3
Chamedaphne calyculata	27.5	7.5	20	49
Gaultheria hispidula	0	0	0	t
Kalmia polifolia	0	0	0	6
Ledum groenlandicum	0	0	0	7
Myrica gale	40	25	30	8
Oxycoccus quadripetalus	0	0	0	11
Vaccinium vitis-idaea	0	0	0	t
Seedlings and Herbs				
Calamagrostis canadensis	0	0	0	t
Carex rostrata	10	30	20	2
Carex trisperma	0	0	0	1
Carex sp.	3	0	0	1
Cornus canadensis	0	0	0	t
Drosera rotundifolia	0	0	0	1
Equisetum sylvaticum	15	0	12.5	t
Eriophorum spissum	0	0	0	t
Eriophorum sp.	1	5	t	1
Hypericum virginicum	0	0	0	t
Lycopus uniflorus	0	0	0	t
Picea mariana	0	0	0	t
Pinus banksiana	0	0	0	t
Sarracenia purpurea	0	0	0	1
Smilacina trifolia	0	0	0	3
Solidago canadensis	0	0	0	t
Viola nephrophylla	0	0	0	t

Table B.3 cont'd.

Species and taxa	Plot No. 89	90	91	Mean (n=91)
Bryophytes and Lichens				
Aulacomnium palustre	0	0	0	t
Cladina mitis	0	0	0	t
Cladina rangiferina	0	0	0	t
Cladonia spp.	0	0	0	t
Dicranum spp.	0	0	0	t
Hylocomium splendens	0	0	0	t
Mylia anomala	0	0	0	t
Pleurozium schreberi	0	0	0	3
Pohlia sphagnicola	t	0	0	2
Polytrichum strictum	0	0	0	4
Sphagnum angustifolium/fallax	20	0	60	36
S. fuscum	0	0	0	27
S. magellanicum	0	t	1	8
S. rubellum	0	2.5	0	t
S. subsecundum	10	20	7.5	1

t - trace, <1%

Table B.4. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Medium density *Picea mariana - Alnus* shrub (4) community of L979 (n=4).

Species and taxa	Plot No. 1	2	3	4	Mean (n=4)
Bare ground	0	40	0	0	10
Dead wood	5	2.5	0	0	2
Litter	35	7.5	45	10.5	25
Trees (≥ 10 cm CBH)					
Picea mariana	0	85	40	90	54
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs					
Alnus rugosa	0	0	40	0	10
Low shrubs (≤ 1.5 m)					
Andromeda glaucophylla	0	12.5	t	0	3
Chamaedaphne calyculata	15	10.5	7.5	15	12
Gaultheria hispidula	0	5.5	0	0	1
Kalmia polifolia	2.5	0.3	2.5	t	1
Ledum groenlandicum	75	75	40	35	56
Oxycoccus quadripetalus	0	t	0	5	1
Vaccinium angustifolium	5	0	0.8	2.5	2
Seedlings and Herbs					
Carex sp.	0	0	1	t	t
Lycopodium annotinum	1	10	20	15	12
Bryophytes and Lichens					
Aulacomnium palustre	t	0	0	0	t
Pleurozium schreberi	15	0	0	10	6
Pohlia sphagnicola	0.8	0	0	0.8	0
Polytrichum commune	3	0	0	0	1
P. strictum	0	0	0	2.5	1
Sphagnum angustifolium/fallax	15	5	45	5	18
S. magellanicum	25	35	t	70	33

t - trace, <1%

Table B.5. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Open bog - *Alnus* shrub (5) community of L979 (n=24).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Bare ground	0	0	0	0	t	15	0	0
Dead wood	5	10	2.5	5	t	3	0	3
Litter	20	12.5	25	7.5	15	15	15	17.5
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Alnus rugosa	10	50	7.5	0	12.5	10	80	35
Picea mariana	0	0	0	15	0	2.5	15	0
Salix planifolia	0	0	0	0	0	7.5	0	0
Low shrubs (≤ 1.5 m)								
Chamedaphne calyculata	25	20	45	25	65	5	0	0
Gaultheria hispidula	0	0	0	5	0	0	0	2.5
Kalmia polifolia	5	t	t	5	0	0	0	0
Ledum groenlandicum	30.5	2.5	2.5	15	10	60	30	40
Oxycoccus quadripetalus	0	0	3	3	0	t	0	0
Seedlings and Herbs								
Alnus rugosa	30	0	0	5	0	0	0	0
Calamagrostis canadensis	0	0	t	t	1	t	5	3
C. trisperma	0	0	t	15	0	2.5	0	0
Carex sp.	0	0	t	1	0	2.8	t	0
Equisetum sylvaticum	0	0	0	0	12.5	2.5	t	t
Lycopodium annotinum	0	50	0	0	17.5	30	7.5	60
Picea mariana	0	0	0	2.5	0	0	0	0
Smilacina trifolia	2.5	0	0	0	0	0	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	t	t	0	t	0	0	0
Pleurozium schreberi	0	0	0	10	0	0	0	0
Pohlia sphagnicola	0	t	3	1	0	0	0	0
Polytrichum strictum	0	0	0	0	0	t	t	t
Sphagnum angustifolium/fallax	5.5	40	20.5	55	15	20	7.5	10.5
S. magellanicum	75	40	40	25	40	35	75	12.5
S. rubellum	t	0	2.5	0	0	t	t	0

t - trace, <1%

Table B.5 cont'd.

Species and taxa	Plot No. 9	10	11	12	13	14	15	16
Bare ground	2.5	0	0	0	0	0	0	5
Dead wood	0	30	5.5	0	0	0	2.5	0
Litter	20	7.5	3	50	t	0	3	27.5
Open water	0	5	0	0	0	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Alnus rugosa	t	25	40	65	0	0	0	0
Betula papyrifera	0	0	0	0	0	0	5	0
Picea mariana	0	0	0	0	0	15.5	5	30
Salix planifolia	0	0	0	0	20	5	2.5	0
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	0	0	0	2.5	0
Chamedaphne calyculata	0	25	12.5	15	20	35	10	40
Gaultheria hispidula	10	0	0	0	0	0	0	0
Kalmia polifolia	0	0	10	10	0	t	3	0
Ledum groenlandicum	10	10	35	30	2.5	0	75	15
Oxycoccus quadripetalus	0	t	5.5	15	t	t	15	t
Rubus sp.	0	0	0	0	0	t	0	0
Vaccinium angustifolium	15	0	0	0	0	0	0	0
Seedlings and Herbs								
Calamagrostis canadensis	0	0	0	0	0	t	t	0
Carex michauxiana	0	0	0	0	0	t	0	0
C. trisperma	t	15	0	0	0	t	0	0
Carex sp.	t	0	7.5	0	1	2.5	0	0
Equisetum sylvaticum	0	0	2.5	0	0	0	0	25
Lycopodium annotinum	7.5	t	0	30	0	0	5	7.5
Smilacina trifolia	0	25	0	0	12.5	25	t	2.5
Bryophytes and Lichens								
Aulacomnium palustre	t	t	0	0	0	0	t	5
Cladina rangiferina	t	0	0	0	0	0	0	0
Cladonia spp.	t	0	0	0	0	0	0	0
Pleurozium schreberi	30.5	0	0	0	0	0	0	0
Pohlia sphagnicola	0	t	t	1	0	0	0	0
Polytrichum commune	0	t	0	0	25	2.8	3	5
P. strictum	t	0	0	t	0	0	0	t
Ptilidium ciliare	t	0	0	0	0	0	0	0
Ptilium crista-castrensis	t	0	0	0	0	0	0	0
Sphagnum angustifolium/fallax	t	50	15	15	65	80	70	40
S. capillifolium	t	0	0	0	0	0	0	0
S. magellanicum	0	20	80	15.3	5	10	25	10
S. rubellum	45	15	0	0	0	0	0	0

t - trace, <1%

Table B.5 cont'd.

Species and taxa	Plot No. 17	18	19	20	21	22	23	24
Dead wood	0	0	10	0	0	0	t	0
Litter	5	t	3	20	3	15.5	0	t
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	20	0	0	3	27.5	0	7.5
Salix planifolia	0	0	0	0	0	0	0	5
Low shrubs (≤ 1.5 m)								
Chamedaphne calyculata	65	0	40	50	60	30	40	12.5
Gaultheria hispidula	0	0	0	t	t	0	0	0
Kalmia polifolia	t	0	5	12.5	2.5	2.5	7.5	7.5
Ledum groenlandicum	30	70	35	20	30	25	40	15
Oxycoccus quadripetalus	10.5	0	0	0	t	t	3	5
Seedlings and Herbs								
Calamagrostis canadensis	0	t	0	0	0	0	0	0
Carex trisperma	0	0	3	t	0	0	0	0
Carex sp.	15	t	t	1	3	t	0	1
Equisetum sylvaticum	0	0	0	0	5.5	0	0	0
Eriophorum sp.	0	0	0	0	0	0	0	2.5
Lycopodium annotinum	10	5.5	15	7.5	3	5	15	0
Picea mariana	0	0	0	5	0	0	2.5	2.5
Smilacina trifolia	0	0	2.5	0	0	0	10	25
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	0	t	0	0
Dicranum spp.	0	t	0	0	0	0	0	0
Pohlia sphagnicola	0	t	t	0	0	0	0	0
Polytrichum commune	0	50	0	0	5.5	7.5	t	7.5
P. strictum	0	0	0	t	0	0	0	0
Sphagnum angustifolium/fallax	75	40	85	75	85	40	85	85
S. magellanicum	22.5	10.5	7.5	5	7.5	20	7.5	10

t - trace, <1%

Table B.5 cont'd.

Species and taxa	Mean (n=24)
Bare ground	1
Dead wood	3
Litter	12
Open water	t
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs	
Alnus rugosa	14
Betula papyrifera	t
Picea mariana	6
Salix planifolia	2
Low shrubs (≤ 1.5 m)	
Andromeda glaucophylla	t
Chamedaphne calyculata	27
Gaultheria hispidula	1
Kalmia polifolia	3
Ledum groenlandicum	26
Oxycoccus quadripetalus	3
Rubus sp.	t
Vaccinium angustifolium	1
Seedlings and Herbs	
Alnus rugosa	1
Calamagrostis canadensis	1
Carex michauxiana	t
C. trisperma	2
Carex sp.	2
Equisetum sylvaticum	2
Eriophorum sp.	t
Lycopodium annotinum	12
Picea mariana	1
Smilacina trifolia	4
Bryophytes and Lichens	
Aulacomnium palustre	t
Cladina rangiferina	t
Cladonia spp.	t
Dicranum spp.	t
Mylia anomala	t
Pleurozium schreberi	2
Pohlia sphagnicola	t
Polytrichum commune	4
P. strictum	t
Ptilidium ciliare	t
Ptilium crista-castrensis	t
Sphagnum angustifolium/fallax	45

t - trace, <1%

Table B.5 cont'd.

Species and taxa	Mean (n=24)
S. capillifolium	t
S. magellanicum	25
S. rubellum	3

t - trace, <1%

Table B.6. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Low density *Pinus banksiana* - *Ledum* shrub (6) community of L979 (n=12).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Dead wood	t	20	65	25	0	2.5	7.5	7.5
Litter	t	30	65	20	45	30	30	5.5
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Pinus banksiana	0	0	0	0	15	50	0	0
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	0	20	0	15	5	t	5	0
Kalmia polifolia	0	0	0	t	0	t	2.5	0
Ledum groenlandicum	80	30	65	50	75	90	75	65
Oxycoccus quadripetalus	0	0	5	5	7.5	7.5	5	7.5
Seedlings and Herbs								
Carex sp.	0	0	0	0	0	0	2.5	0
Carex trisperma	2.5	25	2.5	7.5	0	0	0	0
Picea mariana	2.5	2.5	0	0	0	0	0	0
Pinus banksiana	0	0	0	0	7.5	2.8	3	0
Smilacina trifolia	10	15	7.5	15	35	5.5	10	15
Bryophytes and Lichens								
Ceratodon purpureus	0	t	0	0	0	0	0	0
Cladonia spp.	0	7.5	0	0	2.5	t	2.5	0
Dicranum spp.	0	0	0	0	5.3	2.5	0	0
Pleurozium schreberi	0	5	0	0	0	0	0	5
Pohlia sphagnicola	3	t	t	5	t	10	t	t
Polytrichum commune	0	0	0	0	0	t	7.5	0
P. strictum	t	30	7.5	0	0	0	0	0
Sphagnum angustifolium/fallax	20	5	5	25	25	10	35	10
S. fuscum	0	0	0	0	7.5	15	0	15
S. magellanicum	80	10	15	45	15	45	30	60

t - trace, <1%

Table B.6 cont'd.

Species and taxa	Plot No. 9	10	11	12	Mean (n=12)
Dead wood	25	25	5	5	16
Litter	65	50	25	10	31
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs					
Picea mariana	0	0	0	27.5	2
Pinus banksiana	25	20	3	0	9
Low shrubs (≤ 1.5 m)					
Chamaedaphne calyculata	0	0	2.5	50	8
Gaultheria hispidula	0	0	0	5	t
Kalmia polifolia	0	0	0	10	1
Ledum groenlandicum	75	65	45	35	63
Oxycoccus quadripetalus	0	15.5	5	15	6
Seedlings and Herbs					
Carex sp.	t	0	0	0	t
Carex trisperma	0	0	0	0	3
Eriophorum sp.	t	0	0	0	t
Picea mariana	0	0	0	0	t
Pinus banksiana	0	0	0	0	1
Smilacina trifolia	35	25	2.5	7.5	15
Bryophytes and Lichens					
Ceratodon purpureus	0	0	0	0	t
Cladonia spp.	5	5.5	0	0	2
Dicranum spp.	0	0	0	0	1
Pleurozium schreberi	0	0	t	0	1
Pohlia sphagnicola	0	t	2.8	2.5	2
Polytrichum commune	15.3	3	0	0	2
P. strictum	0	0	t	2.8	3
Sphagnum angustifolium/fallax	t	2.5	30.5	85	21
S. fuscum	0	5	35	0	6
S. magellanicum	0	0	10	0	26

t - trace, <1%

Table B.7. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Open bog - *Chamaedaphne/Ledum* shrub (7) community of L632 (n=40).

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
Deadwood	0	2.5	0	0	0	0	0	0
Litter	55	50	1	45	15.1	5.5	35	5
Trees (≥ 10 cm CBH)								
Picea mariana	55	0	0	0	0	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	0	5	0	0	2.5
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	0	17.5	25	0	20	20	40	0
Gaultheria hispidula	0	0	0	0	0	0	0	1
Kalmia polifolia	0	10	15	15	10.5	7.5	t	2.5
Ledum groenlandicum	85	35	30	30	40	15	0	30
Myrica gale	20	40	0	32.5	0	50	0	2.5
Oxycoccus quadripetalus	7.5	0	3	20	t	5.5	7.5	t
Vaccinium angustifolium	5	15	0	0	0	0	0	15
Seedlings and Herbs								
Carex oligosperma	0	0	0	7.5	0	0	0	7.5
C. pauciflora	0	0	15	0	0	0	0	0
C. trisperma	15	10	7.5	0	3	0	2.5	5
Carex sp.	0	t	t	0	0	t	t	0
Drosera rotundifolia	0	0	0	0	0	t	0	t
Lycopodium annotinum	0	0	0	0	0	0	0	1
Melampyrum lineare	t	0	0	0	0	0	0	0
Picea mariana	0	0	0	0	0	t	2.5	0
Smilacina trifolia	0	0	20	15	10	2.5	2.5	0
Bryophytes and Lichens								
Aulacomnium palustre	t	0	2.5	0	0	t	0	t
Cladina mitis	0	0	0	0	0	0	0	3
C. rangiferina	12.5	0	0	0	0	0	0	20
Cladonia spp.	3	0	0	0	0	0	t	0
Dicranum spp.	t	0	0	0	5.5	0	0	2.6
Pleurozium schreberi	3	t	15	0	65	0	5	15.5
Pohlia sphagnicola	t	0	t	t	t	2.6	0	0
Polytrichum commune	7.5	0	0	0	0	0	7.5	0
P. juniperinum	10.5	0	0	0	0	0	10.5	0
Sphagnum angustifolium/fallax	0	0	75	25	20.5	30	2.5	t
S. capillifolium	0	0	0	0	0	5.5	0	0
S. fuscum	25	0	0	0	0	0	0	0
S. magellanicum	7.5	0	2.5	t	t	60	5	35

Table B.7 cont'd.

Species and taxa	Plot No. 1	2	3	4	5	6	7	8
S. pulchrum	25	15	0	25	0	0	25	15
S. rubellum	10	55	0	0	0	0	2.5	t

t - trace, <1%

Table B.7 cont'd.

Species and taxa	Plot No. 9	10	11	12	13	14	15	16
Dead wood	0	0	2.5	0	0	0	0	0
Litter	1	60	20	7.5	25	55	12.5	10
Trees (≥ 10 cm CBH)								
Picea mariana	15	10	60	25	55	0	40	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Larix laricina	0	2.5	0	0	0	0	0	0
Picea mariana	0	0	0	10	0	0	0	25
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	3	17.5	30	0	25	5	50	55
Gaultheria hispidula	0	0	2.5	1	t	0	0	0
Kalmia polifolia	7.5	5	10	0	2.5	0	0	0
Ledum groenlandicum	40	30	70	65	50	30	25	5.5
Myrica gale	0	40	0	0	0	65	0	15
Oxycoccus quadripetalus	1	2.5	3	1	0.1	0	0	0
Vaccinium angustifolium	0	0	0	5	0	0	0	0
Seedlings and Herbs								
Carex trisperma	25	0	0	15	2.5	t	2.5	40
Carex sp.	t	0	0	0	0	0	0	0
Lycopodium annotinum	2.5	0	0	0	0	0	0	0
Picea mariana	0	0	0	0	0	0	0	5
Smilacina trifolia	35	0	20	25	10	0	2.5	10
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	0	t	0	0	0
Cladina rangiferina	0	0	0	0	t	0	0	0
Dicranum spp.	0	0	0	0	t	t	5.5	0
Pleurozium schreberi	0	0	0	50	30	t	3	10
Pohlia sphagnicola	0	2.6	t	0	t	0	0	0
Ptilium crista-castrensis	0	0	0	10	0	0	0	0
Sphagnum angustifolium/fallax	85	40	50	5	45	17.5	75	75
S. capillifolium	0	10	0	0	0	0	0	2.5
S. fuscum	12.5	10	30	2.5	0	37.5	5	0
S. magellanicum	0	0	0	t	0	0	0	0
S. rubellum	0	2.5	0	15	0	0	0	2.5

t - trace, <1%

Table B.7 cont'd.

Species and taxa	Plot No. 17	18	19	20	21	22	23	24
Dead wood	0	0	0	0	0	0	0	5
Litter	5.5	5.5	2.6	12.5	3	22.5	20	35.5
Trees (≥ 10 cm CBH)								
Picea mariana	40	0	0	0	0	0	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	5	0	t	0	10	30	25
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	0.1	0	0	0	27.5
Chamaedaphne calyculata	25	7.5	15	35	t	12.5	50	7.5
Gaultheria hispidula	2.5	t	2.5	0	t	0	0	0
Kalmia polifolia	5	3	15	1	t	0	t	0
Ledum groenlandicum	45	45	5	25	75	7.5	25	20
Myrica gale	0	0	0	0	0	35	30	0
Oxycoccus quadripetalus	t	t	3	0	7.5	30	40	3
Vaccinium angustifolium	0	0	2.5	0	15	0	0	0
V. vitis-idaea	0	0	0	0	0	2.5	0	0
Seedlings and Herbs								
Carex oligosperma	2.5	1	t	3	0	2.5	0	0
Carex trisperma	0	0	0	0	10	2.5	40	15
Carex sp.	0	0	t	0	t	0	0	t
Drosera rotundifolia	0	2.6	5	0	2.5	0	0	0
Lycopodium annotinum	0	0	0	0	0	2.5	0	15
Sarracenia purpurea	0	0	7.5	0	0	0	0	0
Smilacina trifolia	15	0	10	15	35	5	10	10
Bryophytes and Lichens								
Aulacomnium palustre	0	0	0	t	0	0	0.1	0
Cladonia spp.	0	0	0	0	0	0	0	2.5
Pleurozium schreberi	25	5	0	45	10	0	5.1	2.5
Pohlia sphagnicola	0	t	0	0	1	0	t	t
Sphagnum angustifolium/fallax	65	22.5	0	30	60	15	40	40
S. capillifolium	0	42.5	95	10	0	0	0	0
S. fuscum	7.5	27.5	7.5	2.5	20.5	10	40	5.5
S. pulchrum	0	0	0	0	0	55	0	0
S. rubellum	0	0	0	0	5	0	0	0

t - trace, <1%

Table B.7 cont'd.

Species and taxa	Plot No. 25	26	27	28	29	30	31	32
Litter	12.5	25	5.5	15	7.5	10	10.1	5
Standing water	0	0	5	0	0	0	0	0
Trees (≥ 10 cm CBH)								
Picea mariana	0	5	0	0	0	60	0	0
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs								
Picea mariana	0	0	0	0	0	0	0	50
Low shrubs (≤ 1.5 m)								
Andromeda glaucophylla	0	0	0	0	5	0	0	2.5
Chamaedaphne calyculata	15	45	10	25	7.5	17.5	35	25
Gaultheria hispidula	t	0	0	0	7.5	0	7.5	3
Kalmia polifolia	12.5	5	7.5	0	3	10	7.5	2.5
Ledum groenlandicum	55	7.5	35	40	55	30	15	25
Myrica gale	2.5	0	90	5	0	0	0	0
Oxycoccus quadripetalus	15	2.5	0	7.5	t	15	10	5
Vaccinium angustifolium	t	0	0	t	0	0	0	0
Seedlings and Herbs								
Carex oligosperma	0	t	0	0	5	0	0	0
C. rostrata	0	2.6	0	0	0	0	0	0
C. trisperma	25	10	0	0	0	12.5	0	0
Carex sp.	0	t	0	0	t	0	0	t
Cornus canadensis	0	0	0	10.5	0	0	0	0
Drosera rotundifolia	0	0	0	0	5	t	15	0
Larix laricina	0	0	0	t	0	0	0	0
Melampyrum lineare	t	0	0	0	0	0	0	0
Picea mariana	0	0	0	0	0	t	2.5	0
Smilacina trifolia	12.5	7.5	0	0	5	15	40	10
Bryophytes and Lichens								
Cladina mitis	0	0	0	0	0	0	t	0
Pleurozium schreberi	t	0	0	t	50	5	20	2.5
Pohlia sphagnicola	0	2.5	0	t	t	t	0	t
Polytricum strictum	0	0	0	0	0	0	2.5	0
Sphagnum angustifolium/fallax	80	70	50	50	7.5	55	3	5
S. capillifolium	0	0	0	10	35	15	65	85
S. fuscum	7.5	17.5	40	20	2.5	20	5	5.5

t - trace, <1%

Table B.7 cont'd.

Species and taxa	Plot No. 33	34	35	36	37	38	39	40
Litter	1	15	30	20	5	12.5	12.5	5.5
Low shrubs (≤ 1.5 m)								
Chamaedaphne calyculata	65	40	85	20	40	55	55	30
Gaultheria hispidula	0	0	0	0	0	0	0	t
Kalmia polifolia	3	10	0	7.5	5	10	10	7.5
Ledum groenlandicum	20	5	0	5	2.5	25	7.5	3
Myrica gale	80	35	0	7.5	20	0	35	0
Oxycoccus quadripetalus	7.5	5.5	2.6	7.5	1	7.5	30.5	3
Vaccinium angustifolium	0	0	0	0	0	0	0	7.5
Seedlings and Herbs								
Calamagrostis canadensis	0	0	0	t	0	0	0	0
Carex oligosperma	t	0	1	15.5	0	0	0	0
C. rostrata	0	0	0	10	0	0	0	0
C. trisperma	30	15.5	0	0	12.5	0	17.5	15
Carex sp.	0	t	1	5	t	1	5.5	t
Drosera rotundifolia	0	2.6	t	3	0	t	0	t
Hypericum virginicum	0	0	0	2.6	0	0	0	3
Lycopus uniflorus	0	0	0	0	0	0	0	5
Picea mariana	2.5	0	0	3	0	t	0	0
Bryophytes and Lichens								
Aulacomnium palustre	0	t	2.5	t	0	t	2.5	0
Cladonia spp.	0	0	0	0	0	2.5	t	0
Pohlia sphagnicola	0	2.5	t	t	t	5	0	0
Polytricum strictum	0	0	0	0	0	5.1	0	t
Ptilium crista-castrensis	0	0	0	0	0	0	0	0
Sphagnum angustifolium/fallax	50	22.5	t	35	70	20.1	60	75
S. capillifolium	0	40	40	5	0	50	0	0
S. fuscum	50	30	2.5	50	20	5.1	0	15.5
S. rubellum	0	0	25	0	2.6	0	0	0

t - trace, <1%

Table B.7 cont'd.

Species and taxa	Mean (n=40)
Dead wood	t
Litter	18
Standing water	t
Trees (≥ 10 cm CBH)	
Larix laricina	t
Picea mariana	9
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs	
Picea mariana	4
Low shrubs (≤ 1.5 m)	
Andromeda glaucophylla	1
Chamaedaphne calyculata	26
Gaultheria hispidula	1
Kalmia polifolia	5
Ledum groenlandicum	29
Myrica gale	15
Oxycoccus quadripetalus	6
Vaccinium angustifolium	2
V. vitis-idaea	t
Seedlings and Herbs	
Calamagrostis canadensis	
Carex oligosperma	1
C. pauciflora	t
C. rostrata	t
C. trisperma	8
Carex sp.	t
Cornus canadensis	t
Drosera rotundifolia	1
Hypericum virginicum	t
Larix laricina	t
Lycopodium annotinum	1
Lycopus uniflorus	t
Melampyrum lineare	t
Picea mariana	t
Sarracenia purpurea	t
Smilacina trifolia	9
Bryophytes and Lichens	
Aulacomnium palustre	t
Cladina mitis	t
Cladina rangiferina	1
Cladonia spp.	t
Dicranum spp.	t

Table B.7 cont'd.

Species and taxa	Mean (n=40)
Pleurozium schreberi	9
Pohlia sphagnicola	1
Polytrichum commune	t
Polytrichum juniperinum	1
Polytricum strictum	t
Sphagnum angustifolium/fallax	37
S. capillifolium	13
S. fuscum	16
S. magellanicum	t
S. pulchrum	4
S. rubellum	3

t - trace, <1%

Table B.8. Percent cover of species and taxa in 1 m x 0.5 m plots (the mean of two adjacent 0.5 m x 0.5 m quadrats) sampled in the Open bog - *Carex oligosperma* (8) community of L632 (n=6).

Species and taxa	Plot No. 1	2	3	4	5	6	Mean (n=6)
Dead wood	0	0	0	0	0	2.5	t
Litter	15	15	5.3	t	2.8	3	7
Standing water	2.5	0	0	0	7.5	0	2
Saplings (< 10 cm CBH, > 1.5 m tall) and Tall shrubs							
Alnus rugosa	5	0	0	0	0	0	1
Picea mariana	0	0	5	0	0	0	1
Low shrubs (≤ 1.5 m)							
Andromeda glaucophylla	0	0	t	0	0	0	t
Chamaedaphne calyculata	5	17.5	15	55	10	7.5	18
Kalmia polifolia	7.5	10	3	5	0	0	4
Ledum groenlandicum	t	15	2.8	0	0	0	3
Myrica gale	5	15	0	0	25	45	15
Oxycoccus quadripetalus	10	0	3	7.5	0	0	3
Vaccinium angustifolium	0	0	5	0	0	0	1
Seedlings and Herbs							
Calamagrostis canadensis	5	0	0	0	0	0	1
Carex oligosperma	28	30	40.3	11	1	t	18
C. rostrata	0	0	0	0	7.5	5.5	2
Carex sp.	0	0	0	2.5	7.5	t	2
Drosera rotundifolia	0	0	5	0	0	0	1
Lycopodium annotinum	2.5	7.5	0	0	0	0	2
Picea mariana	0	0	5	0	0	0	1
Smilacina trifolia	20	20	5	10	0	0	9
Trientalis borealis	2.5	0	0	0	0	0	t
Bryophytes and Lichens							
Pohlia sphagnicola	3	0	3	0	0	0	1
Sphagnum angustifolium/fallax	30	35	30	100	95	95	64
S. fuscum	0	0	30	0	0	0	5
S. magellanicum	25	50	35	0	0	0	18
S. papillosum	0	0	0	0	2.5	0	t
S. pulchrum	25	0	0	0	t	0	4

t - trace, <1%

APPENDIX C. Tree and tall shrub density data.

Table C.1. Point quarter data collected in the High density *Picea mariana* - *Ledum* shrub (1) community of L979 (n=16 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	3.50	24.7
	P. mariana	3.12	34.6
	Larix laricina	2.26	41.5
	L. laricina	2.69	32.4
2	*Picea mariana*	1.95	32.6
	P. mariana	1.89	35.3
	P. mariana	6.65	10.4
	P. mariana	1.55	13.3
3	*P. mariana*	1.34	22.7
	P. mariana	2.69	38.4
	P. mariana	1.10	36.5
	P. mariana	1.66	18.5
4	*P. mariana*	1.11	18.6
	P. mariana	1.06	13.2
	P. mariana	1.39	34.6
	P. mariana	1.26	15.1
5	*P. mariana*	1.67	41.7
	P. mariana	3.92	38.6
	P. mariana	4.02	13.2
	P. mariana	0.69	21.2
6	*P. mariana*	2.07	50.4
	P. mariana	3.53	27.4
	Larix laricina	5.18	15.2
	Picea mariana	4.98	40.3
7	*P. mariana*	2.12	55.7
	P. mariana	5.14	23.1
	P. mariana	2.61	14.6
	P. mariana	3.12	34.0
8	*P. mariana*	1.51	14.7
	P. mariana	1.46	14.0
	P. mariana	2.04	17.7
	P. mariana	3.11	46.1
9	*P. mariana*	1.82	14.8
	P. mariana	1.22	33.4
	P. mariana	3.74	26.9
	P. mariana	4.90	20.3

Table C.1 cont'd.

Point	Species	Distance (m)	Circumference (cm)
10	*P. mariana*	4.40	42.5
	P. mariana	2.16	25.5
	P. mariana	3.13	33.2
	P. mariana	3.17	36.0
11	*P. mariana*	0.87	30.0
	P. mariana	2.26	12.4
	Larix laricina	0.94	10.7
	Picea mariana	2.67	28.4
12	*P. mariana*	2.37	25.6
	P. mariana	3.91	10.0
	P. mariana	3.08	41.5
	P. mariana	3.85	31.4
13	*P. mariana*	1.39	33.6
	P. mariana	2.42	13.8
	P. mariana	1.36	18.9
	P. mariana	3.66	23.0
14	*P. mariana*	0.69	20.2
	P. mariana	1.15	10.5
	P. mariana	1.45	17.8
	P. mariana	0.67	10.4
15	*P. mariana*	1.09	37.9
	P. mariana	1.39	15.5
	P. mariana	1.77	11.1
	P. mariana	1.20	53.0
16	*P. mariana*	2.92	53.3
	P. mariana	3.98	20.6
	P. mariana	3.71	22.0
	P. mariana	1.35	43.2

Table C.2. Point quarter data collected in the Medium density *Picea mariana* - *Ledum* shrub (2) community of L979 (n=16 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	1.26	26.5
	P. mariana	4.30	38.5
	P. mariana	2.00	26.0
	P. mariana	3.34	15.5
2	*P. mariana*	5.30	39.0
	P. mariana	1.98	33.5
	P. mariana	1.00	29.5
	P. mariana	0.85	20.5
3	*P. mariana*	2.85	42.5
	P. mariana	1.55	25.0
	P. mariana	1.44	17.5
	P. mariana	2.23	31.5
4	*Larix laricina*	2.54	21.0
	Picea mariana	1.77	17.3
	Larix laricina	3.30	13.0
	Picea mariana	1.24	16.2
5	*P. mariana*	2.79	12.8
	P. mariana	5.35	35.8
	P. mariana	1.99	26.0
	P. mariana	2.77	11.5
6	*P. mariana*	4.02	20.0
	P. mariana	3.71	46.0
	P. mariana	2.92	35.0
	P. mariana	2.87	18.5
7	*P. mariana*	1.97	32.5
	P. mariana	4.10	40.0
	P. mariana	3.30	44.0
	P. mariana	3.13	24.7
8	*P. mariana*	0.98	20.2
	P. mariana	5.61	59.0
	P. mariana	2.78	44.2
	P. mariana	4.50	48.0
9	*P. mariana*	2.79	42.5
	P. mariana	2.73	17.0
	P. mariana	2.95	17.5
	P. mariana	2.52	24.7
10	*P. mariana*	2.04	49.0
	P. mariana	2.62	23.5

Table C.2 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	P. mariana	2.16	43.0
	P. mariana	3.70	20.8
11	*P. mariana*	1.92	16.0
	P. mariana	1.29	11.5
	P. mariana	4.34	23.0
	P. mariana	1.60	29.0
12	*P. mariana*	1.22	20.0
	P. mariana	1.97	21.8
	P. mariana	4.33	48.0
	P. mariana	5.40	39.2
13	*P. mariana*	1.74	14.0
	P. mariana	2.32	15.3
	P. mariana	2.50	43.5
	P. mariana	3.75	48.8
14	*P. mariana*	1.40	27.5
	P. mariana	4.12	19.5
	P. mariana	2.25	12.5
	P. mariana	2.82	13.8
15	*P. mariana*	1.45	23.2
	P. mariana	2.72	26.0
	P. mariana	3.23	30.0
	P. mariana	4.42	12.5
16	*P. mariana*	1.93	18.5
	P. mariana	2.00	26.0
	P. mariana	5.40	13.6
	P. mariana	5.34	15.7

Table C.3. Point quarter data collected in the Open bog - *Chamaedaphne* shrub (3) community of L979 (n=21 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	3.09	18.9
	P. mariana	2.37	13.6
	Larix laricina	3.37	37.4
	Picea mariana	2.34	20.2
2	*P. mariana*	2.12	31.8
	P. mariana	3.57	15.4
	Larix laricina	3.09	23.9
	L. laricina	3.13	23.0
3	*Picea mariana*	1.26	14.7
	P. mariana	2.07	39.5
	P. mariana	3.64	23.9
	P. mariana	2.84	18.3
4	*P. mariana*	2.29	13.5
	P. mariana	2.74	10.5
	P. mariana	2.58	18.4
	P. mariana	1.40	30.1
5	*P. mariana*	1.85	21.5
	P. mariana	1.31	21.1
	P. mariana	3.02	13.7
	P. mariana	1.88	35.9
6	*P. mariana*	1.09	28.3
	P. mariana	3.11	33.9
	P. mariana	0.83	23.4
	P. mariana	0.75	13.1
7	*P. mariana*	1.21	18.4
	P. mariana	1.62	28.3
	P. mariana	1.41	14.8
	P. mariana	1.39	31.6
8	*P. mariana*	1.71	14.3
	P. mariana	3.89	16.3
	P. mariana	1.39	30.5
	P. mariana	3.02	11.3
9	*P. mariana*	1.52	28.6
	P. mariana	2.99	14.6
	P. mariana	2.25	23.5
	P. mariana	1.39	26.3
10	*P. mariana*	1.34	41.2
	P. mariana	1.57	24.6

Table C.3 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	P. mariana	1.83	12.0
	P. mariana	1.17	28.1
11	*P. mariana*	1.17	18.7
	P. mariana	3.14	13.9
	P. mariana	2.20	16.9
	P. mariana	2.29	13.2
12	*Larix laricina*	2.45	11.2
	Picea mariana	2.67	29.5
	P. mariana	0.78	18.3
	P. mariana	2.56	17.4
13	*P. mariana*	2.17	19.7
	P. mariana	3.19	29.4
	P. mariana	3.03	19.4
	P. mariana	1.37	28.1
14	*P. mariana*	0.88	15.4
	P. mariana	1.94	17.2
	Larix laricina	1.33	24.1
	Picea mariana	4.95	22.5
15	*P. mariana*	1.32	12.2
	P. mariana	1.60	31.5
	P. mariana	3.84	25.8
	P. mariana	4.45	17.6
16	*P. mariana*	2.13	16.0
	Larix laricina	8.59	30.0
	L. laricina	4.67	25.8
	L. laricina	13.11	20.4
17	*L. laricina*	8.09	16.8
	L. laricina	8.10	18.5
	L. laricina	16.84	38.0
	Picea mariana	8.53	18.2
18	*Larix laricina*	5.62	10.0
	L. laricina	4.43	18.5
	L. laricina	3.38	13.6
	L. laricina	10.16	23.0
19	*L. laricina*	4.35	23.9
	L. laricina	9.34	24.3
	L. laricina	2.75	25.3
	L. laricina	7.23	24.9

Table C.3 cont'd.

Point	Species	Distance (m)	Circumference (cm)
20	*L. laricina*	11.47	17.4
	L. laricina	22.73	32.5
	L. laricina	19.12	26.6
	Picea mariana	29.81	27.5
21	*P. mariana*	22.37	12.5
	P. mariana	10.95	15.9
	P. mariana	8.87	12.9
	P. mariana	4.69	14.8

Table C.4. Point quarter data collected in the Medium density *Picea mariana* - *Ledum* shrub (4) community of L979 (n=4 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	3.33	19.0
	P. mariana	3.09	33.7
	P. mariana	3.55	24.3
	P. mariana	1.00	24.4
2	*P. mariana*	2.10	25.3
	P. mariana	3.21	17.1
	P. mariana	3.39	37.4
	P. mariana	4.10	27.0
3	*P. mariana*	1.13	35.0
	P. mariana	1.97	18.8
	P. mariana	4.08	27.9
	P. mariana	2.06	18.3
4	*P. mariana*	1.37	25.9
	P. mariana	3.01	22.4
	P. mariana	2.48	28.2
	P. mariana	4.20	21.4

Table C.5. Point quarter data collected in the Open bog - *Alnus* shrub (5) community of L979 (n=12 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	1.72	33.9
	P. mariana	2.76	11.2
	P. mariana	3.28	10.6
	P. mariana	6.06	38.2
2	*P. mariana*	1.43	13.8
	P. mariana	12.89	39.9
	P. mariana	3.24	10.5
	P. mariana	2.89	10.7
3	*P. mariana*	2.39	12.3
	Pinus banksiana	1.22	10.9
	Betula papyrifera	4.61	12.1
	Pinus banksiana	5.84	15.2
4	*Picea mariana*	1.75	11.4
	P. mariana	2.04	10.3
	P. mariana	3.35	13.9
	P. mariana	4.62	10.0
5	*P. mariana*	1.55	10.1
	P. mariana	1.16	15.1
	P. mariana	3.34	14.8
	P. mariana	5.30	10.3
6	*P. mariana*	2.92	10.2
	P. mariana	8.94	12.6
	Pinus banksiana	8.73	15.7
	Picea mariana	10.92	11.5
7	*P. mariana*	1.95	27.7
	Pinus banksiana	1.94	22.5
	Alnus rugosa	3.27	10.3
	Picea mariana	2.62	13.3
8	*P. mariana*	6.11	12.6
	P. mariana	5.96	14.5
	P. mariana	2.07	11.8
	P. mariana	7.52	10.2
9	*P. mariana*	1.34	13.2
	P. mariana	3.23	10.6
	P. mariana	4.86	11.2
	P. mariana	7.19	14.4
10	*P. mariana*	2.79	32.6
	Betula papyrifera	5.68	12.6

Table C.5 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	Picea mariana	1.87	10.0
	P. mariana	4.40	34.5
11	*P. mariana*	1.58	19.7
	P. mariana	2.22	15.3
	Betula papyrifera	14.38	10.0
	Picea mariana	3.39	13.8
12	*P. mariana*	0.91	10.7
	P. mariana	1.64	13.1
	P. mariana	1.05	19.0
	P. mariana	5.10	18.1

Table C.6. Point quarter data collected in the Low density *Pinus banksiana* - *Ledum* shrub (6) community of L979 (n=6 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Pinus banksiana*	4.06	12.0
	P. banksiana	9.50	11.2
	P. banksiana	5.45	11.0
	P. banksiana	8.80	10.6
2	*P. banksiana*	11.53	11.2
	P. banksiana	11.57	15.7
	Larix laricina	19.32	12.4
	Pinus banksiana	5.68	10.0
3	*P. banksiana*	8.86	11.2
	P. banksiana	1.72	12.3
	Picea mariana	7.90	18.3
	Pinus banksiana	7.84	10.2
4	*P. banksiana*	1.16	11.9
	P. banksiana	2.16	11.7
	P. banksiana	7.01	10.0
	P. banksiana	1.38	10.0
5	*P. banksiana*	11.75	11.5
	P. banksiana	3.99	11.6
	P. banksiana	8.03	10.4
	P. banksiana	6.88	10.7
6	*P. banksiana*	2.15	10.1
	P. banksiana	3.68	11.0
	P. banksiana	9.88	14.5
	P. banksiana	6.33	11.0

Table C.7. Point quarter data collected in the Open bog - *Chamaedaphne/Ledum* shrub (7) community of L632 (n=46 points).

Point	Species	Distance (m)	Circumference (cm)
1	*Picea mariana*	3.09	18.9
	P. mariana	2.37	13.6
	Larix laricina	3.37	37.4
	Picea mariana	2.34	20.2
2	*P. mariana*	2.12	31.8
	P. mariana	3.57	15.4
	Larix laricina	3.09	23.9
	L. laricina	3.13	23.0
3	*Picea mariana*	1.26	14.7
	P. mariana	2.07	39.5
	P. mariana	3.64	23.9
	P. mariana	2.84	18.3
4	*P. mariana*	2.29	13.5
	P. mariana	2.74	10.5
	P. mariana	2.58	18.4
	P. mariana	1.40	30.1
5	*P. mariana*	1.85	21.5
	P. mariana	1.31	21.1
	P. mariana	3.02	13.7
	P. mariana	1.88	35.9
6	*P. mariana*	1.09	28.3
	P. mariana	3.11	33.9
	P. mariana	0.83	23.4
	P. mariana	0.75	13.1
7	*P. mariana*	1.21	18.4
	P. mariana	1.62	28.3
	P. mariana	1.41	14.8
	P. mariana	1.39	31.6
8	*P. mariana*	1.71	14.3
	P. mariana	3.89	16.3
	P. mariana	1.39	30.5
	P. mariana	3.02	11.3
9	*P. mariana*	1.52	28.6
	P. mariana	2.99	14.6
	P. mariana	2.25	23.5
	P. mariana	1.39	26.3
10	*P. mariana*	1.34	41.2
	P. mariana	1.57	24.6

Table C.7 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	P. mariana	1.83	12.0
	P. mariana	1.17	28.1
11	*P. mariana*	1.17	18.7
	P. mariana	3.14	13.9
	P. mariana	2.20	16.9
	P. mariana	2.29	13.2
12	*Larix laricina*	2.45	11.2
	Picea mariana	2.67	29.5
	P. mariana	0.78	18.3
	P. mariana	2.56	17.4
13	*P. mariana*	2.17	19.7
	P. mariana	3.19	29.4
	P. mariana	3.03	19.4
	P. mariana	1.37	28.1
14	*P. mariana*	0.88	15.4
	P. mariana	1.94	17.2
	Larix laricina	1.33	24.1
	Picea mariana	4.95	22.5
15	*P. mariana*	1.32	12.2
	P. mariana	1.60	31.5
	P. mariana	3.84	25.8
	P. mariana	4.45	17.6
16	*P. mariana*	3.00	15.0
	P. mariana	2.61	11.1
	P. mariana	8.32	18.3
	P. mariana	7.28	11.6
17	*P. mariana*	0.87	10.3
	P. mariana	4.03	15.9
	P. mariana	5.80	12.2
	P. mariana	1.63	10.4
18	*P. mariana*	3.65	21.1
	P. mariana	7.15	21.2
	P. mariana	4.06	11.1
	P. mariana	3.22	10.0
19	*P. mariana*	1.36	31.9
	P. mariana	2.27	14.9
	P. mariana	2.28	45.7
	P. mariana	4.89	31.2

Table C.7 cont'd.

Point	Species	Distance (m)	Circumference (cm)
20	*P. mariana*	3.73	10.3
	P. mariana	3.42	36.3
	P. mariana	1.15	15.2
	P. mariana	3.54	27.2
21	*P. mariana*	7.69	21.9
	P. mariana	3.02	20.2
	P. mariana	8.10	15.6
	P. mariana	5.32	23.5
22	*P. mariana*	11.32	13.9
	P. mariana	3.62	11.1
	P. mariana	4.51	25.9
	P. mariana	3.55	10.3
23	*P. mariana*	1.67	20.7
	P. mariana	1.06	17.7
	P. mariana	3.59	34.2
	P. mariana	1.67	20.3
24	*P. mariana*	0.78	19.6
	P. mariana	1.19	20.8
	P. mariana	2.15	12.4
	P. mariana	1.76	28.8
25	*P. mariana*	0.93	12.9
	P. mariana	1.79	21.3
	P. mariana	0.95	22.2
	P. mariana	2.37	15.3
26	*P. mariana*	1.27	27.9
	P. mariana	1.16	25.7
	P. mariana	1.30	24.7
	P. mariana	1.84	33.5
27	*P. mariana*	1.65	32.5
	P. mariana	1.57	29.3
	P. mariana	1.74	10.1
	P. mariana	2.44	18.6
28	*Larix laricina*	1.20	16.7
	Picea mariana	2.18	25.5
	P. mariana	1.49	15.3
	P. mariana	2.18	14.7
29	*P. mariana*	1.44	20.3
	P. mariana	2.74	10.9
	P. mariana	1.47	11.7

Table C.7 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	P. mariana	3.43	23.8
30	*P. mariana*	3.02	17.6
	P. mariana	2.16	16.2
	P. mariana	2.56	18.5
	P. mariana	3.13	29.9
31	*P. mariana*	2.90	12.2
	P. mariana	3.06	36.3
	P. mariana	3.67	25.4
	P. mariana	1.62	19.9
32	*Larix laricina*	0.99	10.0
	Picea mariana	1.47	10.7
	P. mariana	1.40	23.7
	P. mariana	2.11	13.6
33	*P. mariana*	3.17	26.2
	P. mariana	2.43	15.3
	P. mariana	2.50	21.6
	P. mariana	2.48	16.7
34	*Larix laricina*	2.84	10.5
	Picea mariana	2.98	10.6
	P. mariana	1.42	29.8
	P. mariana	1.70	10.6
35	*P. mariana*	0.84	26.6
	P. mariana	1.12	18.5
	Larix laricina	1.86	16.6
	Picea mariana	1.85	10.6
36	*P. mariana*	1.33	14.2
	P. mariana	1.45	19.4
	P. mariana	2.74	23.8
	P. mariana	1.96	15.9
37	*P. mariana*	0.89	12.9
	P. mariana	1.23	29.9
	P. mariana	1.29	18.0
	P. mariana	3.57	19.5
38	*Larix laricina*	2.35	13.8
	Picea mariana	1.22	19.3
	P. mariana	1.03	16.8
	P. mariana	2.89	14.6
39	*P. mariana*	3.05	18.8

Table C.7 cont'd.

Point	Species	Distance (m)	Circumference (cm)
	P. mariana	4.66	14.4
	P. mariana	2.30	19.9
	P. mariana	3.75	13.4
40	*P. mariana*	0.77	36.9
	P. mariana	2.60	25.1
	P. mariana	2.15	10.5
	P. mariana	2.16	12.1
41	*P. mariana*	1.40	16.3
	P. mariana	3.73	31.0
	P. mariana	3.89	16.0
	P. mariana	2.24	36.5
42	*P. mariana*	1.57	22.3
	P. mariana	4.12	13.3
	P. mariana	0.70	28.2
	P. mariana	2.05	18.6
43	*P. mariana*	3.12	12.4
	P. mariana	2.19	23.1
	P. mariana	1.04	15.5
	P. mariana	1.96	17.0
44	*P. mariana*	2.43	31.8
	P. mariana	3.30	10.1
	Larix laricina	2.61	12.0
	Picea mariana	3.11	31.8
45	*P. mariana*	2.52	20.4
	P. mariana	2.44	24.6
	P. mariana	2.82	19.0
	P. mariana	2.60	22.6
46	*P. mariana*	4.47	21.2
	P. mariana	3.19	12.8
	P. mariana	2.18	10.3
	P. mariana	2.70	29.9

Table C.8. The density of saplings and tall shrubs in 4 m x 4 m plots in the High density *Picea mariana* - *Ledum* shrub (1) community in L979 (n=8). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

		Plot No.							
Species	Stem class	1	2	3	4	5	6	7	8
Larix laricina	2	0	0	0	0	0	1	0	0
Picea mariana	2	0	2	1	0	0	0	0	1
	3	1	1	3	0	0	0	0	4
	4	1	1	1	0	0	0	1	0
Total		2	4	5	0	0	1	1	5

Table C.9. The density of saplings and tall shrubs in 4 m x 4 m plots in the Medium density *Picea mariana* - *Ledum* shrub (2) community in L979 (n=8). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

		Plot No.							
Species	Stem class	1	2	3	4	5	6	7	8
Picea mariana	2	0	0	1	1	1	0	0	0
	3	0	5	0	1	0	2	0	3
	4	0	1	0	1	1	0	1	0
Total		0	6	1	3	2	2	1	3

Table C.10. The density of saplings and tall shrubs in 4 m x 4 m plots in the Open bog - *Chamaedaphne* shrub (3) community in L979 (n=23). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

		Plot No.							
Species	Stem class	1	2	3	4	5	6	7	8
Picea mariana	2	0	0	0	0	0	0	0	0
	3	0	0	1	0	0	1	1	3
	4	0	0	0	0	2	0	1	1
Total		0	0	1	0	2	1	2	4

		Plot No.							
Species	Stem class	9	10	11	12	13	14	15	16
Picea mariana	2	0	0	0	0	0	1	1	0
	3	1	1	0	0	0	1	0	0
	4	0	1	0	0	0	0	0	0
Total		1	2	0	0	0	2	1	0

		Plot No.						
Species	Stem class	17	18	19	20	21	22	23
Picea mariana	2	0	0	0	0	0	0	0
	3	2	0	0	2	1	0	1
	4	1	0	0	0	0	0	0
Total		3	0	0	2	1	0	1

Table C.11. The density of saplings and tall shrubs in 2 m x 2 m plots in the Open bog - *Alnus* shrub (5) community in L979 (n=18). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

		Plot No.							
Species	Stem class	1	2	3	4	5	6	7	8
Alnus rugosa	1	2	7	8	4	7	7	0	0
	2	5	0	0	1	1	9	4	0
	3	1	0	0	0	0	1	1	0
	4	0	0	0	1	0	1	0	0
Betula papyrifera	3	0	1	0	0	0	0	0	0
Picea mariana	2	1	0	2	0	1	0	0	0
	3	0	0	0	1	1	0	0	0
	4	0	0	0	0	0	0	0	0
Total		9	8	10	7	10	18	5	0

		Plot No.							
Species	Stem class	9	10	11	12	13	14	15	16
Alnus rugosa	1	3	0	0	0	0	0	7	1
	2	4	0	0	0	0	0	1	0
	3	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
Betula papyrifera	3	0	0	0	0	0	0	0	0
Picea mariana	2	0	0	0	3	1	0	0	0
	3	1	1	0	2	0	0	0	0
	4	0	0	1	0	0	0	0	1
Total		8	1	1	5	1	0	8	2

Table C.11 cont'd.

Species	Stem class	Plot No. 17	18
Alnus rugosa	1	2	0
	2	5	0
	3	4	0
	4	0	0
Betula papyrifera	3	0	0
Picea mariana	2	0	1
	3	0	0
	4	0	0
Total		11	1

Table C.12. The density of saplings and tall shrubs in 4 m x 4 m plots in the Low density *Pinus banksiana - Ledum* shrub (6) community in L979 (n=3). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

		Plot No.		
Species	Stem class	1	2	3
Betula papyrifera	1	0	0	1
Pinus banksiana	1	0	1	11
	2	1	5	8
	3	0	3	1
	4	0	3	3
Total		1	12	24

Table C.13. The density of saplings and tall shrubs in 4 m x 4 m plots in the Open bog - *Chamaedaphne/Ledum* shrub (7) community in L632 (n=21). Stem class is the stem diameter 15 cm above ground level rounded to the nearest cm.

Species	Stem class	Plot No. 1	2	3	4	5	6	7	8
Picea mariana	2	0	0	8	0	0	4	1	0
	3	0	4	0	0	0	0	4	1
	4	0	0	0	4	0	4	2	3
Larix laricina	2	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0
Betula papyrifera	3	0	0	0	0	0	0	0	0
Total		0	4	8	4	0	8	7	4

Species	Stem class	Plot No. 9	10	11	12	13	14	15	16
Picea mariana	2	1	0	0	1	0	0	0	0
	3	0	1	3	1	2	0	0	2
	4	1	0	0	2	1	0	0	1
Larix laricina	2	0	1	0	0	0	0	0	0
	3	2	0	0	0	0	0	0	0
Betula papyrifera	3	0	0	0	0	0	0	2	0
Total		4	2	3	4	3	0	2	3

Species	Stem class	Plot No. 17	18	19	20	21
Picea mariana	2	2	1	1	0	0
	3	2	3	1	1	0
	4	0	3	1	1	0
Larix laricina	2	0	0	0	0	0
	3	0	0	0	0	0
Betula papyrifera	3	0	0	0	0	0
Total		4	7	3	2	0

APPENDIX D. Biomass data.

Table D.1. The aboveground dry mass, circumference, height and canopy area of harvested *Alnus rugosa* shrubs (n=30).

Component	Sample No. 1	2	4	5	6	7	8
Biomass (kg)							
Leaf	0.0198	0.1014	0.0227	0.0131	0.0036	0.0064	0.0051
Branch	0.0329	0.2505	0.0291	0.0561	0.0061	0.0233	0.0102
Stem	0.0615	0.3101	0.0811	0.1536	0.0352	0.0601	0.0367
Total	0.1142	0.6620	0.1329	0.2228	0.0449	0.0898	0.0520
Circumference (cm)	4.0	9.2	5.5	6.0	3.8	4.4	3.7
Height (m)	2.00	3.00	2.10	2.60	1.70	1.77	1.57
Canopy area (cm^2)	4200	14950	1400	2750	576	2900	1575

Component	Sample No. 9	10	11	12	13	14	15
Biomass							
Leaf	0.0175	0.0163	0.0082	0.0051	0.3114	0.0727	0.0418
Branch	0.0486	0.0745	0.0423	0.0179	0.1588	0.0406	0.7584
Stem	0.0936	0.1195	0.0939	0.0632	0.0217	0.0877	1.0606
Total	0.1597	0.2103	0.1444	0.0862	0.4919	0.2010	1.8608
Circumference (cm)	5.4	7	6.9	4.6	7.8	5.5	13.9
Height (m)	2.23	1.81	1.72	1.7	3.16	2.15	3.75
Canopy area (cm^2)	4200	4125	5000	3500	15600	4914	30000

Table D.1 cont'd.

Component	Sample No. 16	21	23	24	25	26	27
Biomass							
Leaf	0.0057	0.0081	0.0457	0.0464	0.0154	0.0191	0.0175
Branch	0.0031	0.0833	0.3527	0.2681	0.1849	0.0495	0.0580
Stem	0.0393	0.2333	0.8605	1.4390	0.8780	0.1130	0.1534
Total	0.0481	0.3247	1.2589	1.7535	1.0783	0.1816	0.2289
Circumference (cm)	3.9	7.9	11.4	13.1	12.2	9.0	6.0
Height (m)	1.75	2.60	4.20	4.87	4.80	2.31	2.90
Canopy area (cm^2)	1880	3150	14700	10500	13140	9384	12000

Component	Sample No. 28	29	30	31	32	33	35
Biomass							
Leaf	0.0159	0.0164	0.0167	0.9292	0.0187	0.0146	0.0111
Branch	0.0631	0.0274	0.0328	0.2883	0.0415	0.1682	0.1310
Stem	0.1334	0.0815	0.0813	0.8914	0.1185	0.5344	0.3708
Total	0.2124	0.1253	0.1308	2.1089	0.1787	0.7172	0.5129
Circumference (cm)	6.7	4.6	5.1	13.1	6.2	10.3	9.4
Height (m)	3.13	2.20	2.11	3.95	2.10	3.20	2.85
Canopy area (cm^2)	10350	5170	2912	20000	5395	18125	16250

Component	Sample No. 36	37
Biomass		
Leaf	0.0549	0.0310
Branch	0.2287	0.6129
Stem	0.4160	0.7580
Total	0.6996	1.4019
Circumference (cm)	9.9	13.0
Height (m)	3.45	4.00
Canopy area (cm^2)	17100	21750

Table D.2. The aboveground dry mass, circumference, height and canopy area of harvested *Betula papyrifera* saplings (<10 cm CBH and >1.5 m in height) (n=10).

Component	Sample No. 93/46	93/47	93/30	93/31	18	19	20
Biomass (kg)							
Leaf	0.0090	0.0149	0.0049	0.0724	0.0569	0.0517	0.0548
Branch	0.0098	0.0181	0.0082	0.0092	0.1307	0.1542	0.2026
Stem	0.0443	0.0464	0.0328	0.0590	0.5316	0.5396	0.4475
Total	0.0631	0.0794	0.0459	0.1406	0.7192	0.7455	0.7049
Circumference (cm)	2.9	3.7	2.8	3.8	9.9	9.3	8.9
Height (m)	1.680	1.648	1.524	1.610	3.130	3.950	3.280
Canopy area (cm^2)	3760	2475	3894	1672	7225	10925	13750

Component	Sample No. 22	34	93/45
Biomass (kg)			
Leaf	0.0681	0.0637	0.0095
Branch	0.1661	0.2171	0.0139
Stem	0.4231	0.7617	0.0421
Total	0.6573	1.0425	0.0655
Circumference (cm)	9.5	11.8	3.1
Height (m)	2.7	3.68	1.68
Canopy area (cm^2)	9000	12075	2772

Table D.3. The aboveground dry mass, circumference, height and canopy area of harvested *Larix laricina* saplings (<10 cm CBH and >1.5 m in height) (n=10).

Component	Sample No. 38	39	40	41	42	43	93/52
Biomass (kg)							
Leaf	0.0410	0.0314	0.0752	0.0472	0.0533	0.0491	0.0635
Branch	0.0891	0.0895	0.2421	0.0829	0.1027	0.1579	0.1345
Stem	0.1143	0.1990	0.4281	0.1516	0.2315	0.6586	0.2957
Total	0.2444	0.3199	0.7454	0.2817	0.3875	0.8656	0.4937
Circumference (cm)	7.7	7.9	10.8	7.2	8.7	11.5	8.5
Height (m)	1.650	2.130	2.560	1.900	2.350	2.570	2.326
Canopy area (cm^2)	12600	6750	8500	5810	5950	13560	6640

Component	Sample No. 93/53	93/54	93/55
Biomass (kg)			
Leaf	0.0856	0.0178	0.0347
Branch	0.1533	0.0440	0.1101
Stem	0.2624	0.0904	0.1410
Total	0.5013	0.1522	0.2858
Circumference (cm)	8.7	4.9	5.9
Height (m)	2.044	1.606	1.674
Canopy area (cm^2)	12996	7656	9408

Table D.4. The aboveground dry mass, circumference, height and canopy area of harvested *Picea mariana* saplings (<10 cm CBH and >1.5 m in height) (n=29).

Component	Sample No. 93/1	93/2	93/3	93/4	93/5	93/6	93/7
Biomass							
Leaf	0.0726	0.1730	0.1716	0.0605	0.0747	0.1208	0.2071
Branch	0.0476	0.2703	0.1244	0.0321	0.0367	0.0732	0.1217
Stem	0.0966	0.4909	0.3547	0.0846	0.1495	0.1511	0.4027
Total	0.2168	0.9342	0.6507	0.1772	0.2609	0.3451	0.7315
Circumference (cm)	5.6	11.0	8.6	5.0	6.5	6.4	8.6
Height (m)	1.56	2.62	2.45	1.72	1.86	1.76	2.80
Canopy area (cm^2)	4248	14577	6106	2842	3953	4824	3290

Component	Sample No. 93/8	93/9	93/34	93/35	93/36	93/37	93/38
Biomass							
Leaf	0.1386	0.3198	0.2192	0.1153	0.1287	0.2254	0.1749
Branch	0.0391	0.1116	0.4059	0.1766	0.1736	0.3067	0.4143
Stem	0.0812	0.1132	0.3048	0.1966	0.3575	0.3490	0.3479
Total	0.2589	0.5446	0.9299	0.4885	0.6598	0.8811	0.9371
Circumference (cm)	5.7	8.3	8.9	7.0	8.2	9.8	9.0
Height (m)	2.04	2.68	2.01	1.68	2.38	2.07	1.79
Canopy area (cm^2)	2585	5976	16002	12192	7462	17024	21870

Component	Sample No. 93/39	93/40	93/41	93/42	93/43	93/44	93/48
Biomass							
Leaf	0.1753	0.1409	0.1317	0.0941	0.4671	0.3619	0.1560
Branch	0.1918	0.2297	0.0758	0.0720	0.4012	0.2966	0.1191
Stem	0.2514	0.2844	0.0931	0.1156	0.7682	0.8130	0.1069
Total	0.6185	0.6550	0.3006	0.2817	1.6365	1.4715	0.3820
Circumference (cm)	8.3	8.1	5.5	5.3	11.0	11.4	5.9
Height (m)	1.78	1.78	1.56	1.93	3.84	3.42	1.49
Canopy area (cm^2)	8211	7050	4560	8091	16240	9010	8568

Table D.4 cont'd.

Component	Sample No. 93/49	93/50	93/51	93/56	93/57	93/58	93/59
Biomass							
Leaf	0.3925	0.4144	0.2003	0.4405	0.3461	0.3120	0.5459
Branch	0.4503	0.2835	0.1592	0.4459	0.5706	0.4495	0.4914
Stem	0.5294	0.5828	0.1696	0.9039	0.5784	0.5357	0.6233
Total	1.3722	1.2807	0.5291	1.7903	1.4951	1.2972	1.6606
Circumference (cm)	12.0	8.5	6.5	10.9	11.5	10.9	11.5
Height (m)	2.40	2.70	1.67	3.34	2.64	2.50	2.77
Canopy area (cm^2)	16200	11413	6204	18408	15805	16356	14351

Component	Sample No. 93/60
Biomass	
Leaf	0.2948
Branch	0.5317
Stem	0.4870
Total	1.3135
Circumference (cm)	10.9
Height (m)	2.36
Canopy area (cm^2)	19840

Table D.5. The aboveground dry mass, circumference, height and canopy area of harvested *Pinus banksiana* saplings (<10 cm CBH and >1.5 m in height) (n=21).

Component	Sample No. 93/1	93/2	93/3	93/4	93/5	93/6	93/7
Biomass							
Leaf	0.0726	0.1730	0.1716	0.0605	0.0747	0.1208	0.2071
Branch	0.0476	0.2703	0.1244	0.0321	0.0367	0.0732	0.1217
Stem	0.0966	0.4909	0.3547	0.0846	0.1495	0.1511	0.4027
Total	0.2168	0.9342	0.6507	0.1772	0.2609	0.3451	0.7315
Circumference (cm)	5.6	11.0	8.6	5.0	6.5	6.4	8.6
Height (m)	1.56	2.62	2.45	1.72	1.86	1.76	2.80
Canopy area (cm^2)	4248	14577	6106	2842	3953	4824	3290

Component	Sample No. 93/8	93/9	93/10	93/11	93/12	93/13	93/14
Biomass							
Leaf	0.0812	0.1132	0.0515	0.3375	0.1712	0.0479	0.0094
Branch	0.0391	0.1116	0.0319	0.3191	0.1492	0.0286	0.0598
Stem	0.1386	0.3198	0.1008	0.7500	0.5857	0.1547	0.1683
Total	0.2589	0.5446	0.1842	1.4066	0.9061	0.2312	0.2375
Circumference (cm)	5.7	8.3	5.0	11.2	9.2	5.5	5.9
Height (m)	2.04	2.68	1.73	3.18	3.78	2.32	1.85
Canopy area (cm^2)	2585	5976	2688	8930	5200	2530	3550

Component	Sample No. 93/15	93/16	93/17	93/21	93/22	93/23	93/24
Biomass							
Leaf	0.2460	0.1269	0.1972	0.0335	0.0152	0.0302	0.0145
Branch	0.2244	0.1417	0.2124	0.0157	0.0062	0.0162	0.0063
Stem	0.7100	0.5339	0.5229	0.0711	0.0326	0.0519	0.0423
Total	1.1804	0.8025	0.9325	0.1203	0.0540	0.0983	0.0631
Circumference (cm)	11.6	11.6	10.0	4.1	2.9	3.7	3.4
Height (m)	3.46	2.96	2.88	1.89	1.62	1.65	1.59
Canopy area (cm^2)	12960	6720	5850	2652	1504	3808	720

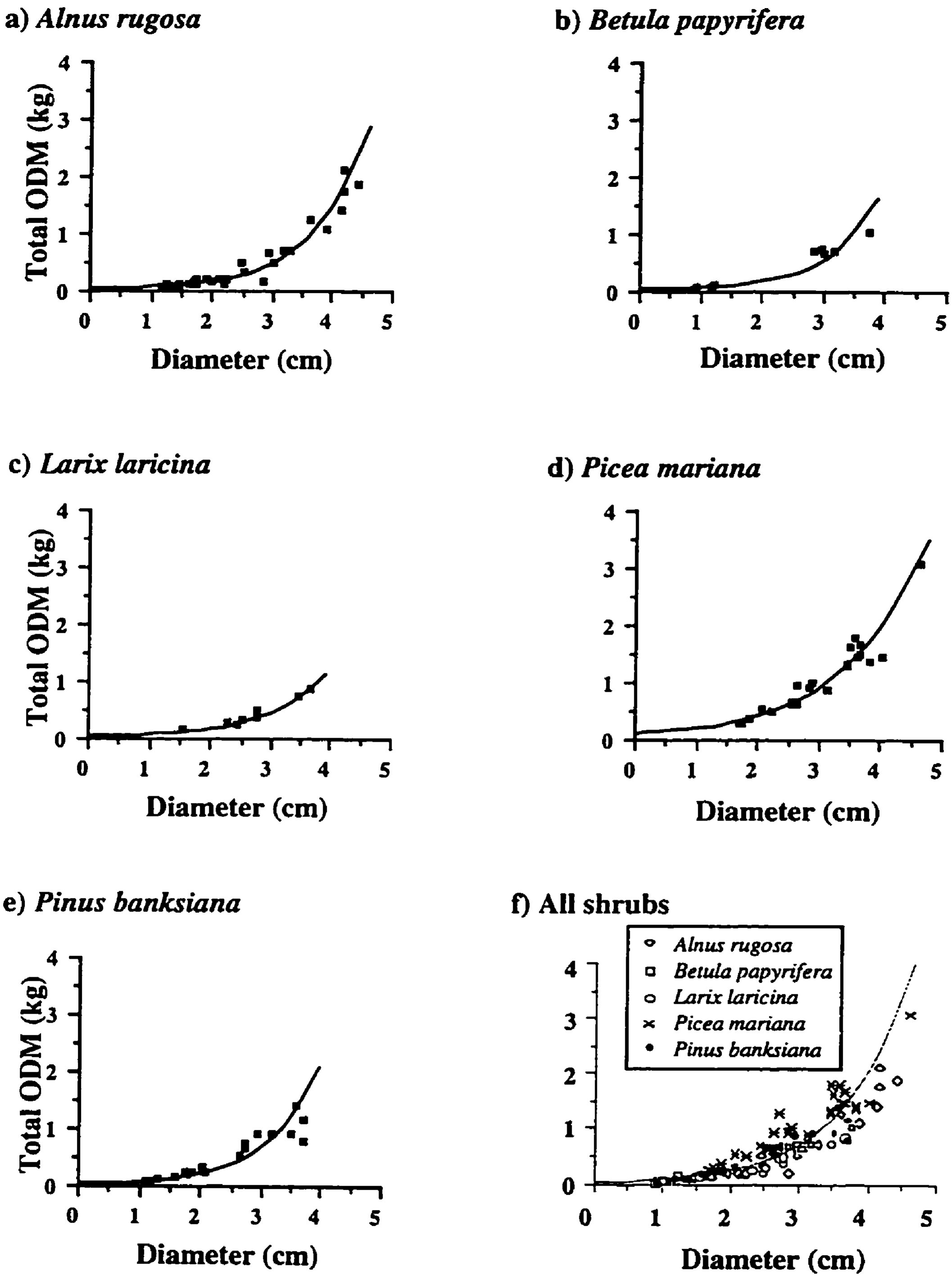

Figure D.1. The allometric ($Y = a * b^X$) relationship between sapling and tall shrub oven dry mass (ODM) and stem diameter in (a) *Alnus rugosa* (n=30), (b) *Betula papyrifera* (n=10), (c) *Larix laricina* (n=10), (d) *Picea mariana* (n=29), (e) *Pinus banksiana* (n=21) and (f) all shrubs together (n=100).

Table D.6. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the High density *Picea mariana* - *Ledum* shrub (1) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Chamaedaphne calyculata						
- leaf	0.60	0	0	7.51	0	1.62
- branch and stem	8.43	0	7.90	22.13	0.36	7.76
Kalmia polifolia						
- leaf	0.29	0	0.33	0.41	0	0.21
- branch and stem	0.69	0	0.74	3.98	0	1.08
Ledum groenlandicum						
- leaf	14.95	17.75	23.82	1.83	24.17	16.50
- branch and stem	20.26	33.95	53.07	4.49	53.86	33.13
Oxycoccus quadripetalus	0.93	0	0.30	3.48	1.68	1.28
Picea mariana						
- leaf	0	1.24	0	3.60	0	0.97
- branch and stem	0	3.82	0	4.27	0	1.62
Smilacina trifolia	0	0	0.18	0	0	0.04
Bryophytes	54.62	43.94	29.11	67.99	101.98	59.53
Litter	166.84	124.57	117.50	140.73	106.15	131.16

Table D.7. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Medium density *Picea mariana* - *Ledum* shrub (2) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Andromeda glaucophylla						
- leaf	2.34	2.11	0	0.82	0	1.05
- branch and stem	9.32	5.45	0	1.41	0	3.24
Chamaedaphne calyculata						
- leaf	7.93	2.69	1.59	13.03	28.49	10.75
- branch and stem	50.08	15.43	3.86	118.21	242.03	85.92
Cyperaceae	0	4.91	10.43	0.52	2.63	3.70
Kalmia polifolia						
- leaf	2.23	3.89	6.67	0.17	1.73	2.94
- branch and stem	11.59	20.83	12.90	1.15	10.53	11.40
Ledum groenlandicum						
- leaf	29.97	38.41	30.91	11.09	18.71	25.82
- branch and stem	59.97	42.82	38.49	23.30	35.72	40.06
Lycopodium annotinum	0	0	12.02	0	0	2.40
Oxycoccus quadripetalus	0	1.29	0.30	5.45	12.59	3.93
Picea mariana						
- leaf	0	19.74	0	1.51	0	4.25
- branch and stem	0	21.10	0	1.39	0	4.50
Smilacina trifolia	0	0.30	1.13	0.48	0.72	0.53
Bryophytes	66.09	66.84	71.53	71.62	16.01	58.42
Litter	46.71	67.46	24.30	40.58	39.59	43.73

Table D.8. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Open bog - *Chamaedaphne* shrub (3) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Andromeda glaucophylla						
- leaf	0	0	1.68	0	0	0.34
- branch and stem	0	0	2.12	0	1.44	0.71
Chamaedaphne calyculata						
- leaf	7.95	40.57	39.31	19.50	32.20	27.91
- branch and stem	72.42	259.13	136.01	129.17	304.48	180.24
Cyperaceae	0	0.81	0.29	0	0	0.22
Kalmia polifolia						
- leaf	0	3.68	8.29	0	0.33	2.46
- branch and stem	0.38	11.44	28.49	4.78	3.44	9.71
Ledum groenlandicum						
- leaf	0	0	7.62	29.68	5.20	8.50
- branch and stem	0	0	14.68	72.78	15.76	20.64
Oxycoccus quadripetalus	7.06	13.80	2.21	2.00	0.25	5.06
Picea mariana						
- leaf	77.91	0	0	0	0	15.58
- branch and stem	75.21	0	0	0	0	15.04
Smilacina trifolia	0	2.70	0	0	0	0.54
Bryophytes	176.50	107.01	53.81	49.64	85.72	94.54
Litter	32.64	74.37	105.38	180.47	26.43	83.86

Table D.9. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Medium density *Picea mariana* - *Alnus* shrub (4) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Andromeda glaucophylla						
- leaf	0.19	7.91	0	0	0.42	1.70
- branch and stem	0.22	33.07	0	0	0	6.66
Chamaedaphne calyculata						
- leaf	20.26	1.61	9.31	7.58	10.16	9.78
- branch and stem	71.54	0	47.13	28.89	84.30	46.37
Cyperaceae	0.24	0	0.91	0.66	0	0.36
Drosera rotundifolia	0	0	0	0.29	0	0.06
Gaultheria hispidula	0.33	0.42	0.20	0.36	0	0.26
Kalmia polifolia						
- leaf	0.73	0	0.90	0.94	0.19	0.55
- branch and stem	3.84	0	1.47	4.13	0.56	2.00
Ledum groenlandicum						
- leaf	28.79	34.98	12.27	13.05	12.80	20.38
- branch and stem	67.25	116.45	18.07	37.65	65.55	60.99
Lycopodium annotinum	10.95	7.10	1.76	1.81	4.89	5.30
Oxycoccus quadripetalus	0	1.20	11.71	1.94	0	2.97
Picea mariana						
- leaf	0	0	5.67	0	0	1.13
- branch and stem	0	0	4.57	0	0	0.91
Vaccinium angustifolium						
- leaf	0.78	0	0	0	0	0.16
- branch and stem	3.21	0	0	0	0	0.64
Bryophytes	70.70	82.29	70.05	59.06	27.62	61.94
Litter	99.60	160.07	67.68	74.84	104.72	101.38

Table D.10. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Open bog - *Alnus* shrub (5) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Alnus rugosa						
- leaf	26.35	0	0	11.94	0.22	7.70
- branch and stem	49.48	0	0	7.00	0.53	11.40
Andromeda glaucophylla						
- leaf	0	0	0.71	0	0	0.14
- branch and stem	0	0	1.07	0	0	0.21
Chamaedaphne calyculata						
- leaf	21.32	5.70	31.55	0	4.75	12.66
- branch and stem	124.49	115.95	125.67	0	22.95	77.81
Cyperaceae	0	0	0.71	15.98	10.47	5.43
Equisetum sylvaticum	0	0.58	0	0	0	0.12
Gaultheria hispidula	0	0	0	0.93	0	0.19
Kalmia polifolia						
- leaf	1.88	0	1.43	0	0	0.66
- branch and stem	4.68	0	11.00	0	0	3.14
Ledum groenlandicum						
- leaf	22.73	3.81	20.94	29.44	0	15.38
- branch and stem	41.52	23.03	48.02	63.29	0	35.17
Lycopodium annotinum	18.32	12.13	3.55	41.91	0	15.18
Oxycoccus quadripetalus	0	0.84	0.42	0	0.03	0.26
Picea mariana						
- leaf	0	0	39.07	0	0	7.81
- branch and stem	0	0	17.67	0	0	3.53
Smilacina trifolia	0	0	0	0	1.12	0.22
Bryophytes	76.98	62.55	74.36	38.92	80.08	66.58
Litter	174.17	108.48	40.95	64.32	21.71	81.92

Table D.11. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Low density *Pinus banksiana* - *Ledum* shrub (6) community in L979 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Chamaedaphne calyculata						
- leaf	4.40	0	9.16	0.68	0.50	2.95
- branch and stem	24.85	0	86.15	2.73	1.58	23.06
Cyperaceae	3.47	0	0	0	0	0.69
Gaultheria hispidula	0	0	0	0	0.43	0.09
Kalmia polifolia						
- leaf	0	0.60	0.32	0	0	0.18
- branch and stem	0	0.74	0.57	0.53	0	0.37
Ledum groenlandicum						
- leaf	63.85	43.48	14.80	20.62	17.16	31.98
- branch and stem	202.68	237.02	83.93	112.13	145.43	156.24
Oxycoccus quadripetalus	8.15	0.63	15.00	0	7.58	6.27
Picea mariana						
- leaf	0.30	0	0	0.74	3.10	0.83
- branch and stem	0.72	0	0	1.11	3.56	1.08
Pinus banksiana						
- leaf	0.48	0	0.53	0.65	0	0.33
- branch and stem	0.19	0	0.35	0.42	0	0.19
Smilacina trifolia	0	0.32	0.85	0.72	3.08	0.99
Bryophytes	72.19	6.85	63.30	22.54	74.35	47.85
Litter	185.68	464.84	97.87	142.42	67.25	191.61

Table D.12. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Open bog - *Chamaedaphne/Ledum* shrub (7) community in L632 (n=5).

Category	Sample No. 1	2	3	4	5	Mean
Chamaedaphne calyculata						
- leaf	31.51	26.72	26.85	10.49	5.89	20.29
- branch and stem	184.18	72.53	111.44	71.16	15.52	90.97
Cyperaceae	0	0.99	3.17	16.91	0.72	4.36
Gaultheria hispidula	0	0.34	0.60	0	0	0.19
Kalmia polifolia						
- leaf	15.87	0	3.93	0	0.40	4.04
- branch and stem	82.67	0	10.18	0	0.60	18.69
Ledum groenlandicum						
- leaf	0	13.64	26.62	2.63	20.18	12.61
- branch and stem	0	29.57	28.50	2.56	14.98	15.12
Myrica gale						
- leaf	9.37	5.16	0	11.46	25.14	10.23
- branch and stem	47.32	18.68	0	45.62	110.79	44.48
Oxycoccus quadripetalus	19.44	11.68	3.66	0.11	0.17	7.01
Picea mariana						
- leaf	0	0	0	2.38	0	0.48
- branch and stem	0	0	0	1.88	0	0.38
Smilacina trifolia	0	0.3	0	0.96	0	0.25
Vaccinium angustifolium						
- leaf	0	1.73	0	0	0	0.35
- branch and stem	0	3.06	0	0	0	0.61
Bryophyte	13.12	92.94	91.55	75.28	55.32	65.64
Litter	252.51	84.01	11.38	80.65	17.7	89.25

Table D.13. The aboveground dry mass (g) of plant material harvested in 0.5 m x 0.5 m quadrats in the Open bog - *Carex oligosperma* shrub (8) community in L632 (n=5).

Categories	Sample No. 1	2	3	4	5	Mean
Alnus rugosa						
- leaf	1.26	0	0	0	0	0.25
- branch and stem	4.48	0	0	0	0	0.90
Andromeda glaucophylla						
- leaf	0	0	0	0	0.72	0.14
- branch and stem	0	0	0	0	0.60	0.12
Chamaedaphne calyculata						
- leaf	4.83	13.51	0	0	9.81	5.63
- branch and stem	17.42	36.68	0	0	22.47	15.31
Cyperaceae	32.14	23.50	35.17	5.95	14.37	22.23
Kalmia polifolia						
- leaf	5.07	0.53	0	0	1.99	1.52
- branch and stem	11.04	1.28	0	0	3.29	3.12
Ledum groenlandicum						
- leaf	1.48	0.83	0	0	0.49	0.56
- branch and stem	1.75	0.54	0	0	0.39	0.54
Lycopodium annotinum	5.16	0	0	0	0	1.03
Myrica gale						
- leaf	1.18	0	5.56	2.87	0	1.92
- branch and stem	7.49	0	45.17	52.97	0	21.13
Oxycoccus quadripetalus	10.73	5.02	0	0	0.89	3.33
Smilacina trifolia	0.32	1.32	0	0	2.57	0.84
Bryophytes	61.14	187.77	62.88	103.07	91.01	101.17
Litter	12.16	15.20	28.89	82.62	8.75	29.52

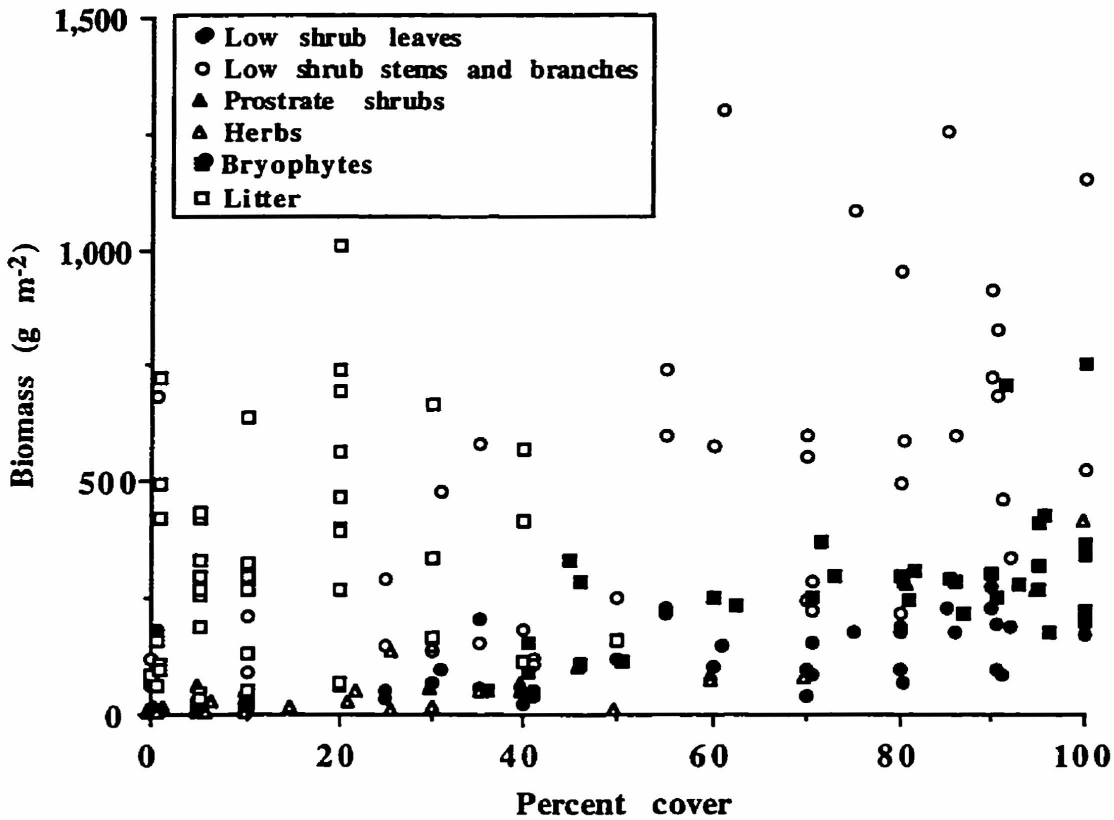

Figure D.2. The relationship between biomass and percent cover for the components of 0.5 m x 0.5 m harvested samples.

APPENDIX E. Carbon content data.

Table E.1. The carbon content of species and tissue types analyzed.

Tissue type	Sample No.	mg C g^{-1}
Chamaedaphne calyculata		
leaves	1	534
	2	539
	3	531
	4	555
C. calyculata		
branches	1	486
	2	480
	3	475
	4	497
Cyperaceae		
	1	432
	2	424
	3	422
	4	440
Kalmia polifolia		
leaves	1	526
	2	524
	3	533
	4	513
K. polifolia		
branches	1	499
	2	495
	3	498
	4	494
Larix laricina		
leaves	1	511
	2	507
	3	512
	4	522
L. laricina		
branches	1	513
	2	489
	3	496
	4	514

Table E.1 cont'd.

Tissue type	Sample No.	mg C g^{-1}
L. laricina		
stems	1	482
	2	480
	3	493
	4	482
Lycopodium annotinum		
	1	495
	2	487
	3	481
	4	475
Myrica gale		
leaves	1	506
	2	515
	3	512
	4	524
M. gale		
branches	1	479
	2	475
	3	477
	4	488
Oxycoccus quadripetalus		
	1	504
	2	499
	3	505
	4	499
Smilacina trifolia		
	1	529
	2	528
	3	514
	4	517

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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