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by

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SUMMARY

This report presents a classification of mid-seral black spruce ecosystems in the Boreal White and Black Spruce (BWBS) and Sub-boreal Spruce (SBS) zones of British Columbia. The classification is based on a total of 122 plots sampled during the summers of 1997 and 1998. We used multivariate and tabular methods to synthesize and classify ecosystems according to the Braun-Blanquet approach and the methods of biogeoclimatic ecosystem classification. The black spruce ecosystems were classified into 8 vegetation units (associations or subassociations) and the same number of site associations. We describe vegetation and environmental features of these vegetation and site units. Vegetation and environmental tables for individual plots are given in Appendices. In addition, we also present the relationships between site index of black spruce and direct and indirect measures of site quality.

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INTRODUCTION

Black spruce (*Picea mariana* (Mill.) B.S.P.) is a principal species of the Canadian boreal forest. While it is one of the major timber crop species in eastern Canada, in British Columbia (BC) it is considered a non- or less desirable (valuable) crop species, except on sites that are edaphically unsuitable for more desirable (valuable) crop species, such as white spruce (*Picea glauca* (Moench) Voss) and lodgepole pine (*Pinus contorta* var *latifolia* Dougl. ex Loud.). Its value as a crop species, however, cannot be debated in the absence of productivity data for pure and mixed-species stands of black spruce in BC. From over 2,000 reports on black spruce ecosystems published in Canada and the United States to date (TREE CD CABI, 1999), only a few have originated in the province. A better understanding of the ecology and growth of black spruce in BC is needed in anticipation of future demands for the timber resources of the boreal forest in BC.

In BC, late-seral and old-growth black spruce-dominated ecosystems have been investigated by Revel (1972), Wali and Krajina (1973), and Annas (1974). More recently, the Ecological Program Staff of the BC Ministry of Forests presented a general overview of the Boreal Black and White Spruce (BWBS) and Sub-Boreal Spruce (SBS) zones (Meidinger and Pojar (1991) and a site classification for black spruce and other ecosystems in these zones (*e.g.* DeLong *et al.* 1990; MacKinnon *et al.*, 1990; Banner et al. 1993). However, we still need additional information for a more complete understanding of these ecosystems. Therefore, we developed a classification as a complementary tool for further studies of black spruce ecosystems and as a means to relate them to other studies in the North American boreal forest. We aimed to develop a classification that organizes communities into groups in a way that shows the greatest number of vegetation and vegetation-environment relationships, is easily retained in memory, and is easily conveyed through instructions.

In addition, forest managers need productivity relationships integrated into ecosystem classification. In British Columbia, measures of climate, soil moisture, nutrients, and aeration conditions have been used to relate site index (the most commonly used index of forest productivity) to site quality (Chen *et al.* 1998; Kayahara *et al.* 1998; Kayahara *et al.* 1997; Kayahara and Pearson 1996; Wang and Klinka 1996; Klinka and Carter 1990).

To investigate black spruce ecosystems and their productivity, we carried out a study with the objectives of:

(1) classifying black spruce ecosystems;
(2) quantifying the relationships between black spruce site index and ecological measures of site quality; and evaluating the potential for predicting site index from easily field-estimated measures of site quality.

Other aspects of black spruce growth and boreal ecology, such as height/age and site index models, a characterization of understory plant diversity, humus forms, and soil nutrient conditions of black spruce ecosystems, and a comparison of these between black spruce and trembling aspen (*Populus tremuloides* Michx.) ecosystems will be discussed in other reports.

This report is available in full colour or B&W printed versions or in electronic format on Scientia Silvica CD-ROM. For further information or to order a copy visit www.forestry.ubc.ca/klinka or contact Karel Klinka, Forest Sciences Department, University of British Columbia, 3036-2424 Main Mall, Vancouver BC V6T 1Z4 (e-mail: klinka@interchange.ubc.ca).

METHODS

Study Area

The study area encompassed nearly the entire BWBS zone, and the northern portion of the SBS zone, of BC. Both zones are part of the Canadian Boreal Forest Region (Krajina 1969). The BWBS zone is influenced by a continental, montane boreal climate and subject to frequent outbreaks of arctic masses. The climate influencing the SBS zone is slightly less continental, with lower temperatures in summer, higher temperatures in winter and a slightly longer growing season. Forest fires are frequent in both the SBS and BWBS zones (except for the portion of the BWBS just east of the Rocky Mountains (BWBSwk subzone)), maintaining a large portion of the landscape in early and mid-seral stages.

The major species of these two zones are white spruce, hybrid white spruce (*Picea engelmannii x glauca*), black spruce, subalpine fir (*Abies lasiocarpa* (Hook.) Nutt., lodgepole pine, trembling aspen, balsam poplar (*Populus balsamifera* L.), paper birch (*Betula papyrifera* Marsh.), and Alaska paper birch (*Betula neoalaskana* Sarg.), with black spruce increasing in abundance with increasing latitude and with decreasing soil drainage. In mid-seral upland ecosystems, black spruce typically grows in mixtures with white spruce, hybrid white spruce, lodgepole pine, and trembling aspen. In wetlands, particularly ombotrophic wetlands, black spruce predominates and often associates with tamarack (*Larix laricina* (Du Roi) K. Koch). Upland soils are primarily Luvisols, Podzols, Brunisols, and Gleysols, while organic soils are associated with wetlands – bogs, fens, marshes, and swamps. More detailed information about the BWBS and SBS zones is given in Krajina (1969) and Meidinger and Pojar (1991).

Sampling

The ecosystem sampling was done during the summers of 1997 and 1998. In the first season, we (i) carried out a reconnaissance, (ii) located candidate ecosystems for sampling, and (iii) described and sampled about 70 plots. During the second season we completed the description and sampling of selected ecosystems and cut nearly 400 trees for stem analysis. Our data set includes vegetation and environmental information obtained from 122 plots.

The candidate ecosystems were located close to access roads branching from the Cassiar and Alaska Highways, around Tumbler Ridge, and north of Fort St. James (Figure 1). They were deliberately selected to obtain the (i) the widest possible range in environmental conditions (climate, soil moisture, soil nutrients, and soil aeration), and (ii) height growth data from trees without a history of suppression. Suitable stands were typically found on sites that had an obvious history of wildfire. We assumed that the original advance regeneration was destroyed by fire, and the subsequently established seedlings had developed under full light conditions, except during the earliest developmental stages (<1.3 m in height), in which the seedlings might have been affected by competing shrubs and tall herbs. All selected stands had a uniform single canopy layer dominated by black spruce, which was often associated with lodgepole pine, white spruce, hybrid spruce, or trembling aspen.

Figure 1. The native range of black spruce in British Columbia and the distribution of sample plots.

Sample plots, each 20 x 20 m (0.04 ha) in size, were located in naturally established, unmanaged, immature and early mature (>35 but <185 years at breast height), even-aged stands (the age range of all sampled trees was <20 years in each stand (Smith 1986)). Each sample plot was selected to represent an ecosystem that was relatively uniform in stand structure, floristic composition, and site attributes (*e.g.*, slope position, aspect, gradient, soils and ground cover). The biogeoclimatic subzone or variant was identified using biogeoclimatic maps for the Prince Rupert Region (BC Ministry of Forests 1998), and for the Prince George Region (BC Ministry of Forests, 1987). Latitude and longitude were determined from topographic maps, and elevation was measured with a Thommen pocket altimeter. Site, vegetation, and soil of each plot were described according to Luttmerding *et al.* (1990).

All plant species present within the plot were identified and their cover percentage was estimated. These cover values were converted to classes (+ to 9) of the Domin-Krajina scale of species significance. The plant nomenclature followed Qian and Klinka (1998). Unknown plants were collected and identified in the laboratory.

A soil pit was dug at each plot and soils were described and identified according to the Canadian Soil Classification System (Agriculture Canada Expert Committee on Soil Survey 1987). Humus samples were taken from each plot for a visual analysis and identification in the laboratory using the humus form classification of Green *et al.* (1993). The type of ground cover (forest floor, decaying wood, mineral soil, coarse fragments, and open water) was recorded. A more complete description of the field methods is given in Brooke *et al.* (1970) and Luttmerding *et al.* (1990).

Soil moisture and nutrient regimes were estimated in the field by a systematically guided evaluation of a selected number of topographic (slope, aspect, gradient, and position) and soil morphological properties (humus form, rooting depth, soil texture, coarse fragment content, soil aeration, soil mineralogy, and the presence and depth of the growing-season water table). This procedure is based on interpreting relationships between these properties, soil water-holding capacity, and available nutrient levels in the soil (Green and Klinka 1994). Field-estimates of SNRs were substantiated by soil nutrient analysis (Kayahara *et al.* 2000, submitted manuscript), while SMRs were only field-estimated and not directly measured. Using the criteria proposed by Klinka *et al.* (1989), we converted relative SMRs to actual SMRs by consulting Wang *et al.* (1994) for the SBSdk subzone and Banner *et al.* (1993) for the BWBSdk subzone. Conversion for the BWBmw and BWBSwk subzones was done on the basis of our environmental data, indicator plant analysis, correlation with the other subzones in this study, and with the estimates of actual SMRs for the SBS subzones given by Kayahara *et al.* (1995, unpublished report).

Classification

Our objective was to produce ecologically meaningful classes of ecosystems that could be identified and used as a framework for examining vegetation-environment relationships. Consistent with the methods of the biogeoclimatic ecosystem classification, the plots within each group had to represent communities that had affinities in floristic composition and physiognomy, and the groups of plots were required to 1) be floristically distinct, and 2) occupy a floristically defined segment of the edaphic and local climatic gradients. The classification was done in the following sequence: 1) vegetation classification, and 2) site classification using the results of the vegetation classification, spectral analysis, and the environmental data.

Vegetation Classification

We classified the ecosystems into vegetation units at three categorical levels (subassociation, association, and alliance) using the Braun-Blanquet approach (Mueller-Dombois and Ellenberg 1974: 177-210; Westhoff and van der Maarel 1980: 287-399). This method consists of grouping the plots in a way that each group is separated from all other groups by an exclusive diagnostic combination of species. These diagnostic species must be either **differential species**, which have a much higher presence (proportion of plots of a group that it occurs in) than in other groups, or a **dominant differential species**, which have higher species significance (percent cover) than in other groups. The exact criteria are as follows (Becking 1957):

differential species: species that may be associated with more than one vegetation unit in a hierarchy; presence class ≥ III (occurring in ≥ 40% of the plots of this unit) and at least two presence classes greater than in other units of the same hierarchical level within the same higher level unit.

dominant-differential species: species that may be associated with more than one vegetation unit in a hierarchy; presence class ≥ III, mean species significance ≥ 5 (≥ 10% cover) and two or more species significance classes greater than in other units of the same hierarchical level within the same higher level unit.

There is no universally accepted methodology for, nor agreement upon, the required composition of the diagnostic combination of species for a particular category (Becking 1957; Mueller-Dombois and Ellenberg 1974; Westhoff and van Maarel 1980). We used the principle of relative differentiation that allows delineation of a subassociation or association by an exclusive diagnostic combination of species that must include at least one differential species or dominant-differential species. However, a subassociation or association that represents the central concept, *i.e.* typic, of a higher circumscribing unit can be recognized without a diagnostic combination of species because it is differentiated by the absence or low occurrence of species that characterize other subassociations or associations of the same hierarchical level within the same higher level unit (Pojar *et al.* 1987: 131-132).

The major tool used to achieve this objective was a computer-aided program, VTAB-Ecosystem Reporter, Revision 19907a (Emanuel 1999), which produces the various tables required in the analysis and synthesis of vegetation data. It arranges columns (plots or groups of plots) and rows (species) according to the criteria specified by the user for each step of the tabular analysis and synthesis.

The following four analytical steps were used to synthesize the data:

Step 1 Plots were stratified into floristically similar groups using a two-way indicator species analysis (TWINSPAN, Hill 1979). This program divides the plots into two groups, then further subdivides each of these groups in subsequent steps. When all the plots in a group are relatively uniform according to predetermined criteria, subdivision of this group stops.

Step 2 For each of the groups obtained in step 1, a tentative vegetation plot table, which shows the species significance of each species in all plots of the group (*e.g.*, Appendices 3 through 9), was produced and examined for within-group similarities and differences. A tentative differentiated summary vegetation table (*e.g.*, Table 3), showing species presence and average species significance for each group, was used to examine floristic affinities and differences between groups.

Step 3 Tentative environmental plot tables, which show selected environmental characteristics for all plots within each group (*e.g.*, Appendices 10 through 16), were used to determine whether the floristically similar plots were also similar in environmental characteristics. Floristically and environmentally aberrant plots were reassigned to the group to which they were most closely related. After reassignment, the summary vegetation tables were inspected to determine to which extent the groups of plots could be differentiated from each other in a hierarchical manner. The groups that could not be differentiated were merged.

Steps 2 and 3 were repeated iteratively in a process of successive approximation (Poore 1962), in which the production of revised vegetation and environmental tables continued until there were no more plot re-assignments and group mergers.

Step 4 A tentative hierarchy of groups was then proposed, where each group was considered to be either an association or a subassociation depending on its relationship to the hierarchy. A preliminary diagnostic table showing the diagnostic combination of species for every group was produced.

Step 4 was repeated in a process of successive approximations in which the production of tentative diagnostic tables continued until exclusive diagnostic combinations of species were obtained for each group of the hierarchy. This process typically required changes in the structure of the hierarchy, and, occasionally, merging of some of the groups lacking a diagnostic combination of species.

Instead of using phytosociological nomenclature (Barkman *et al.* 1976) we used the scientific names without suffixes for naming vegetation units. Plant alliances and associations were named using the generic and specific names of two dominant species from the diagnostic combination of species for that association, *e.g.*, the Picea mariana – Cladina stellaris plant association. Plant subassociations were named by adding a colon (:) to the association name, followed either by the term 'typic' (to represent what we believed to be the central concept of that association) or the name of one diagnostic species, *e.g.*, the Picea mariana – Equisetum sylvaticum: Larix laricina plant subassociation. All units based on the synthesis of <10 sample plots were considered tentative.

Similarity Analysis

Using VTAB, we compared floristic similarities between each pair of vegetation units using Sørenson's index based on presence/absence of species (Equation 1, Magurran 1988), as well as on species cover (Equation 2, Qian *et al.* 1997). The presence/absence index is a simple but effective measure of the number of species shared between two vegetation units. Both indices enable the comparison of floristic similarity between vegetation units.

Equation 1. $SI = \frac{2c}{(a+b)}$, where a = the number of species in the first unit,
b = the number of species in the second unit,
c = the number of species common to both units.

Equation 2. $SI = \frac{2C}{(A+B)}$, where A = the cover sum of all species in the first unit,
B = the cover sum of all species in the second unit,
C = the sum of the lower of the two cover values for the species common to both units.

Life Form Spectral Analysis

To provide a simple means for characterizing the vegetation of a group of plots complementary to tabular analysis, VTAB-assisted 'spectral analysis' was carried out (Mueller-Dombois & Ellenberg 1974:315-319). In spectral analysis, species are grouped according to various criteria. For each vegetation unit, the cover proportion of these groups of species relative to all species of interest is calculated. This relative proportion is termed **relative frequency** hereafter.

Spectral analysis was performed on life forms (coniferous trees, broad-leaved trees, evergreen shrubs, deciduous shrubs, ferns, graminoids, herbs, mosses, liverworts, lichens and dwarf woody plants). A spectrum was constructed for each vegetation unit, representing the relative frequency of each life form in that vegetation unit. Relative frequencies were calculated using Equation 3 (Klinka *et al.* 1996). The plots were not standardized, *i.e.*, plots with a greater total vegetation cover contribute relatively more to the spectrum of the vegetation unit.

Equation 3. $F_j = \frac{\sum_{i=1}^{n} C_i}{\sum_{j=1}^{m}\sum_{i=1}^{n} C_{ij}}$, where F_j = relative frequency (%) of species group j (j = 1,2,3...m) for lifeform (m= 12), and

C_i = midpoint percent cover value of species i (i= 1,2,3...n).

Site Classification

A site is a portion of the landscape with relatively uniform climatic and edaphic characteristics. Similar sites will have similar vegetation potential and productivity, and will respond similarly to management. Therefore, an important purpose of ecosystem classification is to frame site units that (i) can form a framework in which to investigate site-productivity relationships and (ii) are easily identifiable in the field, even when they are not vegetated (*e.g.* clearcuts).

In addition to the ecological site characteristics, the vegetation at a site reflects the history of disturbance, the time since the last disturbance, the characteristics of the tree layer, and chance. Therefore, several different vegetation types can exist on similar sites, and vegetation units derived from different seral stages cannot form the basis of a convenient and stable framework for site classification. Of all seral stages, the old-growth vegetation is considered to best reflect site quality, and to be minimally influenced by disturbance history. We suggest that the vegetation of the mid-seral black spruce stands is similar enough to the old-growth stands that a site classification could be derived. In addition, site index is preferably derived from non-supressed trees in even-aged mid-seral stands.

The basic category of site classification is the site association. Sites that have, regardless of the actual vegetation, the same or equivalent environmental properties and, hence, similar vegetation and productivity potentials are grouped into a site association. In this study, site associations were derived from mid-seral plant associations and characterized by climate (biogeoclimatic subzones or variants), soil moisture regime (SMR), and soil nutrient regime (SNR). To create edaphically uniform classes of ecosystems, we divided site associations into site types according to one or more edaphic factors or properties that are thought to be important in affecting ecosystems.

We named site associations by the common names of one or two dominant tree species and an indicator plant species, or life form, which is expected to be nearly always present on the sites represented by the site association (*e.g.*, the SbSw – Common Mitrewort site association). Tree species names were abbreviated using the standard symbols of the BC Ministry of Forests (Pl = lodgepole pine; Sb = black spruce; Sw = white spruce; At = trembling Aspen; Lt = tamarack). The subdivisions of site association based on edaphic factors, *i.e.* the site types, were named by modifying the name of a site association by one or two diagnostic adjectives, *e.g.*, SbSw – Common Mitrewort/organic site type. We used the diagnostic adjective typic for the site type thought to represent the central edaphic concept of the site association, and other adjectives to denote aberrant edaphic properties, *i.e.* those differing from typic.

SNR and SMR Spectal Analysis

To characterize the soil moisture and nutrient status of each site association, a soil nutrient spectrum and a soil moisture spectrum were constructed. A spectrum presents the relative frequency of each indicator species group in that site association. Relative frequencies were calculated using Equation 3 (for the attribute SMR (m= 6), and SNR = (m= 3)). We used the mean relative frequency of the nitrogen-rich indicator species group to determine soil nutrient regime as follows: 1% for very poor SNR, 4% for poor SNR, 9% for medium SNR, 25% for rich SNR, and 38% for very rich SNR (Wang 1992).

Site Index Sampling and Analysis

In each sample plot, the three largest diameter and dominant trees without visible evidence of growth abnormalities and damage were felled for stem analysis. Total tree height was measured in the field after falling. Stem disks were cut at 0.3, 0.8 and 1.3 m above the ground surface, and then at 1-m intervals from 1.3 m to the top of the tree. In the laboratory, each disc was cut sliced transversely with a sharp knife, and, when necessary, zinc oxide powder was added to make the rings more visible. Rings were counted in two directions with the aid of a microscope. Particular attention was paid to abrupt changes in radial increment to detect possible suppression.

The raw stem analysis data were adjusted using Carmean's (1972) algorithm to calculate tree height corresponding to the age at each sectioned disk (Dyer and Bailey 1987). The height versus age curves for the three trees in each sample plot were examined for uniformity and the presence of suppression. If suppression was present or suspected, the three breast height disks were compared with each other for differences in the radial increment pattern. If a tree was considered suppressed, it was excluded and the remaining two trees per plot were used in further analysis. If more than one tree showed suppression, the plot was excluded from the analysis. Trees <50 years at breast height were also excluded. Of the 122 study plots, 82 were used for stem analysis; 36 were excluded due to suppression of trees, and 4 did not meet the minimum index age of 50 years at breast height.

Site index reflects the integrated effect of site factors on tree growth. Since the site index concept is applied at the stand scale (Monserud 1984; Nigh and Sit 1996; Chen *et al.* 1998), averaging was used to obtain a single height growth curve for each stand. Linear interpolation (Carmean 1975; Nigh 1996) was used to obtain an average height-age curve. Height-age data were averaged by plot for each selected age up to the youngest tree. The site index for each plot was calculated as the average top height of the sampled trees at breast height age 50 years.

Correlation analysis was perfomed to detect relationships between site index and elevation, latitude, longitude, and slope. Analysis of variance (ANOVA) was used to test for differences in mean site index between (1) the BWBS and SBS zone, and between

three subzones within the BWBS zone; (2) soil orders; (3) soil moisture regimes; (4) soil nutrient regimes; (5) aspect classes and (6) site associations. Tukey's test was used for multiple comparisons. In each ANOVA, only classes with more than one plot were included.

Multiple regression models with site index as the dependent variable were developed using the independent variables (1) elevation, (2) elevation and latitude; (3) soil order and elevation; (4) SMR and elevation; (5) SNR and elevation; (6) SMR, SNR, and elevation; and (7) site association and elevation. Additionally, the regressions using soil moisture and nutrient regimes together were tested with and without soil moisture by nutrient interactions. All regressions, except (1) and (2), were also tested without elevation as an independent variable. Dummy variables were used for the categorical variables of soil orders, soil moisture/nutrient regimes, and site associations. To make the regressions comparable, the four plots with a unique soil moisture/soil nutrient combination were excluded from this analysis, for N=78 plots. The mean site index for the combinations of soil moisture and nutrient regimes was calculated with corresponding confidence and prediction intervals.

RESULTS AND DISCUSSION

The Vegetation Classification

A list of all species found in the sample plots is given in Appendix 1. The list is representative of the flora of mid-seral black spruce ecosystems, but is not a complete list for black spruce ecosystems in general, as the early- and late-seral succession stages were not studied. All 122 sample plots were classified into a hierarchy of vegetation units that includes 3 alliances, 6 associations, and 4 subassociations (Table 1). These units were delineated according to floristic differences (diagnostic combinations of species) that are summarized in Table 2. Table 3 lists all species occurring in ≥ 41% of the plots in at least one vegetation unit (presence class ≥ III), while those species occurring in ≤ 40% of the plots of all vegetation units (presence class ≤ II) are listed in Appendix 2. Eight units, either associations or subassociations, were most fundamental, *i.e.* not further subdivided, and these eight units are referred to as the basic units hereafter. Vegetation plot tables, which show the species significance of each species in all sample plots of each basic unit (110 to 310) are given in Appendices 3 to 9.

All units, except the provisional Picea mariana – Betula nana (310) association, are thought to belong to the Picea glauca & mariana order that was proposed by Krajina (1969) to represent montane boreal ecosystems. He proposed *Picea glauca*, *P. mariana*, *Abies lasiocarpa*, *Larix laricina*, *Pinus banksiana*, *P. contorta*, and *Populus tremuloides* as the characteristic species of this order. All these species are present in our data set (Appendix 1), except for *Pinus banksiana* whose range is outside the study area.

Table 1. Synopsis of vegetation units delineated in mid-seral black spruce ecosystems indicating levels of generalization and relationships. The rows containing the names of associations are printed in bold fonts. Numerical codes indicate the position of a unit in the hierarchy; the same codes are used in the diagnostic and summary vegetation tables. An asterisk indicates an insufficiently sampled unit (<10 plots).

Code	Plant alliance **Plant association** Plant subassociation
100	Picea mariana – Vaccinium vitis-idea
110	**Picea mariana – Cladina stellaris* (5 plots)**
120	**Picea mariana – Vaccinium vitis-idaea (25 plots)**
130	**Picea mariana – Equisetum sylvaticum**
131	Picea mariana – Equisetum sylvaticum: typic (34 plots)
132	Picea mariana – Equisetum sylvaticum: Larix laricina (13 plots)
200	Picea glauca & mariana – Lonicera involucrata
210	**Picea glauca & mariana – Viburnum edule**
211	Picea glauca & mariana – Viburnum edule: Shepherdia canadensis (13 plots)
212	Picea glauca & mariana – Viburnum edule: Mitella nuda (28 plots)
220	**Picea glauca & mariana – Equisetum pratense* (3 plots)**
300	Betula nana
310	**Picea mariana – Betula nana* (1 plot)**

Table 2. Diagnostic combinations of species for the vegetation units in mid-seral black spruce ecosystems. The diagnostic combination of species for each vegetation unit is shaded in gray. Presence values ≥III are printed in bold fonts. An asterisk indicates an insufficiently sampled unit (<10 plots).

Vegetation unit code		110		120		131		132		211		212		220		310	
Number of plots		5		25		34		13		13		28		3		1	
Species	Diagnostic value[1]	**Species presence[2] and species significance[3]**															
100 Picea mariana – Vaccinium vitis-idea alliance																	
Dicranella palustris	(ic)[1]	II[2]	3[3]	II	h	I	+	**III**	+	I	h	I	+				
Empetrum nigrum	(ic)	II	4	**III**	3	II	2	II	2			I	h				
Ledum groenlandicum	(d)	**III**	1	**IV**	5	**V**	5	**IV**	6	I	+	II	4	**V**	4		
Peltigera membranacea	(ic)	**III**	4	**III**	2	**III**	+	I	h	I	1	II	+				
Pinus contorta	(ic)	**V**	7	**IV**	7	**III**	6	II	4	**III**	6	**III**	5				
Vaccinium scoparium	(ic)	II	2	II	2	I	3	I	h			I	+				
Vaccinium vitis-idaea	(d)	**V**	5	**IV**	5	**V**	5	**V**	4	I	h	**III**	3	II	h		
Vaccinium uliginosum	(ic)	I	1	I	h	I	+	II	2								
110 Picea mariana – Cladina stellaris association*																	
Arctostaphylos uva-ursi	(ic)	II	4			I	+										
Cladina stellaris	(d)	**V**	6	**III**	4	II	+	II	+	I	2	I	h	II	h		
Cladonia ecmocyna	(ic)	**III**	+	II	h	I	h	I	h	I	h	I	h	II	h		
Nephroma arcticum	(ic)	II	h	I	h												
Stereocaulon paschale	(ic)	II	5	I	h												
120 Picea mariana – Vaccinium vitis-idaea association																	
Orthilia secunda	(ic)			**III**	+	II	h	I	h	II	h	**III**	+	**IV**	+		
130 Picea mariana – Equisetum sylvaticum association																	
Equisetum sylvaticum	(d)			I	h	**III**	3	**IV**	4	II	+	II	h	II	5		
131 Picea mariana – Equisetum sylvaticum; typic subassociation																	
Peltigera membranacea	(d)	**III**	4	**III**	2	**III**	+	I	h	I	1	II	+				
Pinus contorta	(dd)	**V**	7	**IV**	7	**III**	6	II	4	**III**	6	**III**	5				
132 Picea mariana – Equisetum sylvaticum; Larix laricina subassociation																	
Aulacomnium palustre	(d)	I	2	I	+	II	1	**IV**	4			I	+	**IV**	5		
Dicranella palustris	(d)	II	3	II	h	I	+	**III**	+	I	h	I	+				
Larix laricina	(d)					I	4	**III**	5	I	+	I	4	II	h		
Rubus chamaemorus	(d)					I	+	**III**	4			I	t				
Rubus pedatus	(d)			I	h	I	h	**III**	1			II	3	II	+		
200 Picea glauca & mariana – Lonicera involucrata alliance																	
Arnica cordifolia	(ic)			II	+	I	h			**III**	1	II	+	II	h		
Aster ciliolatus	(ic)							I	h	**III**	2	II	h	II	h		
Delphinium glaucum	(ic)			I	t	I	t	I	h	I	h	II	h	II	+		
Heracleum maximum	(ic)									I	+	I	h	II	2		
Lonicera involucrata	(d)			II	h	I	h	I	3	**III**	2	**IV**	4	**V**	4		
Osmorhiza berteroi	(ic)			I	t	I	h			**III**	h	II	h	II	+		
Petasites frigidus	(ic)			**III**	1	**III**	2	II	1	**III**	2	**IV**	3	**V**	4		
Picea glauca	(d)	II	4	II	5	II	4	I	4	**V**	6	**IV**	7	**IV**	6		
Rosa acicularis	(d)	**III**	+	**III**	2	**III**	2	**III**	2	**V**	2	**V**	2	**IV**	4		
Ribes lacustre	(ic)			I	h	I	h	I	h	II	h	**III**	1	II	+		
Rubus pubescens	(ic)			I	h	I	+			**III**	3	**III**	2	**IV**	2	**V**	5
210 Picea glauca & mariana – Viburnum edule association																	
Abies lasiocarpa	(ic)			II	4	I	3	I	4	**III**	4	II	4				
Actaea rubra	(ic)							I	h	II	1	II	+				
Amelanchier alnifolia	(ic)									II	2	I	h				
Epilobium angustifolium	(d)	I	h	II	+	II	2	II	h	**V**	2	**IV**	2	II	+		
Fragaria virginiana	(ic)					I	h	I	h	**III**	+	II	h				
Galium boreale	(ic)			I	h	I	h	I	+	**III**	+	II	h				
Galium triflorum	(ic)									II	h	II	+				

Vegetation unit code		110	120	131	132	211	212	220	310
Number of plots		5	25	34	13	13	28	3	1
Species	Diagnostic value[1]	**Species presence[2] and species significance[3]**							
Pinus contorta	(d)	**V** 7	**IV** 7	**III** 6	II 4	**III** 6	**III** 5		
Populus tremuloides	(d)		I h	I 1	I 3	**III** 7	**III** 5		
Viburnum edule	(d)		II h	I h	I 2	**IV** 3	**IV** 2		
211 Picea glauca & mariana – Viburnum edule; Sheperdia canadensis subassociation									
Geocaulon lividum	(d)	II 1	**III** 2	II +	II h	**IV** 3	II h		
Maianthemum racemosum	(d)		I t			**III** +	I +		
Populus tremuloides	(dd)		I h	I 1	I 3	**III** 7	**III** 5		
Shepherdia canadensis	(d)	I h	II 3	I +	I +	**IV** 4	II 2		
212 Picea glauca & mariana – Viburnum edule; Mitella nuda subassociation									
Achillea millefolium	(d)		I h	I h	I h	I h	**III** h		
Mertensia paniculata	(d)	I +	II h	II +	I +	II +	**IV** 1	**V** 3	
Mitella nuda	(d)		I h	II h	I h	II h	**V** 1	**V** 1	
Vaccinium vitis-idaea	(d)	**V** 5	**IV** 5	**V** 5	**V** 4	I h	**III** 3	II h	
220 Picea glauca & mariana – Equisetum pratense association*									
Angelica genuflexa	(d)					I h		**V** 3	
Aulacomnium palustre	(d)	I 2	I +	II 1	**IV** 4		I +	**IV** 5	
Carex disperma	(d)		I t	I h	II 1		I +	**IV** 5	
Disporum hookeri	(d)					I h	I h	**IV** +	
Equisetum pratense	(d)		I t	II +	II 2	I h	II +	**V** 7	
Equisetum scirpoides	(d)		I h	II +	II h	I h	II 2	**IV** 1	
Geum macrophyllum	(d)							**IV** 3	
Impatiens noli-tangere	(ic)							II h	
Listera cordata	(d)		I t	I h	I h		II h	**IV** +	
Moneses uniflora	(d)	I h	I h	I h	I h		II h	**IV** +	
Oxycoccus oxycoccos	(d)		I h	I +	I 3		I +	**IV** +	
Parnassia palustris	(ic)			I t				II h	
Plagiochila aspleniformis	(ic)				I h			II +	
Ranunculus eschscholtzii	(ic)							II h	
Rhizomnium glabrescens	(d)				II 2		I t	**IV** 4	
Ribes triste	(d)		I h	I h	I h	I h	II +	**IV** +	
Salix glauca	(d)		I +	I 2	I 2		I 2	**IV** 3	
Senecio triangularis	(d)					I h		**IV** +	
Sphagnum girgensohnii	(d)			II 4	I 4		I t	**IV** 6	
310 Picea mariana – Betula nana association*									
Betula nana	(d)	I 1		I 1	II 3		I h		**V** 7
Comandra umbellata	(d)								**V** 5
Drepanocladus exannulatus	(d)								**V** +
Drepanocladus uncinatus	(d)		I t			I h	I t		**V** 4
Equisetum fluviatile	(d)				I h		I t		**V** 4
Eriophorum angustifolium	(d)								**V** 6
Eurhynchium pulchellum	(d)								**V** +
Menyanthes trifoliata	(d)								**V** 5
Plagiomnium ellipticum	(d)								**V** +
Sphagnum warnstorfii	(d)		I h	I +	I 3		I +	II h	**V** 7
Tomentypnum nitens	(d)				II 4		I h		**V** 6

1. Species diagnostic values: d = differential, dd = dominant differential, ic = important companion (Pojar *et al.* 1987).
2. Species presence classes (the percentage of plots in which the species occurs): I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%.
3. Species significance classes and the corresponding mid-point and range (in parentheses) of cover: t = 0.005 (0.001-0.009), h = 0.05 (0.01 - 0.099), + = 0.2 (0.1-0.299), 1 = 0.4 (0.3-0.499), 2 = 0.75 (0.5-0.999), 3 = 1.5 (1-1.999), 4 = 3.5 (2-4.999), 5 = 7.5 (5-9.999), 6 = 15 (10-19.999), 7 = 35 (20-49.999), 8 = 60 (50-69.999), 9 = 85 (70-100).

Table 3. Differentiated (in descending order from left to right) summary table of the vegetation units in mid-seral black spruce ecosystems. This table contains only plant species present in ≥41% of the plots in at least one vegetation unit (presence class ≥III). As most of these species were diagnostic (differential, dominant-differential, and important companion species, Table 2) for a vegetation unit, only non-diagnostic species are shaded in grey. Presence values ≥III are printed in bold fonts.

Vegetation unit code	**110**		**120**		**131**		**132**		**211**		**212**		**220**		**310**	
Number of sample plots	5		25		34		13		13		28		3		1	
Number of plant species	52		129		128		108		107		152		68		16	
Species	**Species presence[1] and species significance[2]**															
Cladonia ecmocyna	**III**	+	II	h	I	h	I	h	I	h	I	h	II	h		
Cladina stellaris	**V**	6	**III**	4	II	+	II	+	I	2	I	h	II	h		
Peltigera membranacea	**III**	4	**III**	2	**III**	+	I	h	I	1	II	+				
Ledum groenlandicum	**III**	1	**IV**	5	**V**	5	**IV**	6	I	+	II	4	**V**	4		
Pinus contorta	**V**	7	**IV**	7	**III**	6	II	4	**III**	6	**III**	5				
Vaccinium vitis-idaea	**V**	5	**IV**	5	**V**	5	**V**	4	I	h	**III**	3	II	h		
Linnaea borealis	**III**	+	**III**	1	**III**	1	II	1	**IV**	1	**IV**	4	II	2	**V**	3
Hylocomium splendens	**III**	6	**V**	7	**V**	7	**V**	7	**IV**	7	**V**	7	**V**	7		
Rosa acicularis	**III**	+	**III**	2	**III**	2	**III**	2	**V**	2	**V**	2	**IV**	4		
Picea mariana	**V**	7	**V**	7	**V**	7	**V**	7	**IV**	7	**V**	7	**V**	7	**V**	6
Pleurozium schreberi	**IV**	7	**V**	7	**V**	7	**V**	7	**V**	7	**V**	7	**V**	7	**V**	4
Empetrum nigrum	II	4	**III**	3	II	2	II	2			I	h				
Geocaulon lividum	II	1	**III**	2	II	+	II	h	**IV**	3	II	h				
Orthilia secunda			**III**	+	II	h	I	h	II	h	**III**	+	**IV**	+		
Peltigera aphthosa			**III**	3	**V**	3	**IV**	1	II	1	**III**	1	**II**	2		
Cornus canadensis	II	1	**V**	4	**IV**	5	**IV**	3	**V**	4	**V**	5	**II**	5		
Petasites frigidus			**III**	1	**III**	2	**II**	1	**III**	2	**IV**	3	**V**	4		
Ptilium crista-castrensis			**IV**	6	**IV**	5	**IV**	4	**III**	5	**IV**	6	**IV**	7		
Equisetum sylvaticum			I	h	**III**	3	**IV**	4	II	+	II	h	II	5		
Dicranella palustris	II	3	II	h	I	+	**III**	+	I	h	I	+				
Larix laricina					I	4	**III**	5	I	+	I	4	II	h		
Rubus chamaemorus					I	+	**III**	4			I	t				
Rubus pedatus			I	h	I	h	**III**	1			II	3	II	+		
Aulacomnium palustre	I	2	I	+	II	1	**IV**	4			I	+	**IV**	5		
Abies lasiocarpa			II	4	I	3	I	4	**III**	4	II	4				
Arnica cordifolia			II	+	I	h			**III**	1	II	+	II	h		
Aster ciliolatus							I	h	**III**	2	II	h	II	h		
Fragaria virginiana					I	h	I	h	**III**	+	II	h				
Galium boreale			I	h	I	h	I	+	**III**	+	II	h				
Maianthemum racemosum			I	t					**III**	+	I	+				
Osmorhiza berteroi			I	t	I	h			**III**	h	II	h	II	+		
Shepherdia canadensis	I	h	II	3	I	+	I	+	**IV**	4	II	2				
Epilobium angustifolium	I	h	II	+	II	2	II	h	**V**	2	**IV**	2	II	+		
Populus tremuloides			I	h	I	1	I	3	**III**	7	**III**	5				
Viburnum edule			II	h	I	h	I	2	**IV**	3	**IV**	2				
Lonicera involucrata			II	h	I	h	I	3	**III**	2	**IV**	4	**V**	4		
Picea glauca	II	4	II	5	II	4	I	4	**V**	6	**IV**	7	**IV**	6		
Rubus pubescens			I	h	I	+			**III**	3	**III**	2	**IV**	2	**V**	5
Achillea millefolium			I	h	I	h	I	h	I	h	**III**	h				
Ribes lacustre			I	h	I	h	I	h	II	h	**III**	1	II	+		
Mertensia paniculata	I	+	II	h	II	+	I	+	II	+	**IV**	1	**V**	3		
Mitella nuda			I	h	II	h	I	h	II	h	**V**	1	**V**	1		
Angelica genuflexa									I	h			**V**	3		
Carex disperma			I	t	I	h	II	1			I	+	**IV**	5		
Disporum hookeri									I	h	I	h	**IV**	+		
Equisetum pratense			I	t	II	+	II	2	I	h	II	+	**V**	7		
Equisetum scirpoides			I	h	II	+	II	h	I	h	II	2	**IV**	1		
Geum macrophyllum													**IV**	3		
Listera cordata			I	t	I	h	I	h			II	h	**IV**	+		
Moneses uniflora	I	h	I	h	I	h	I	h			II	h	**IV**	+		

Vegetation unit code	**110**	**120**	**131**	**132**	**211**	**212**	**220**	**310**
Number of sample plots	5	25	34	13	13	28	3	1
Number of plant species	52	129	128	108	107	152	68	16
Species	**Species presence[1] and species significance[2]**							
Oxycoccus oxycoccos		I h	I +	I 3		I +	**IV** +	
Rhizomnium glabrescens				II 2		I t	**IV** 4	
Ribes triste		I h	I h	I h	I h	II +	**IV** +	
Salix glauca		I +	I 2	I 2		I 2	**IV** 3	
Senecio triangularis					I h		**IV** +	
Sphagnum girgensohnii			II 4	I 4		I t	**IV** 6	
Betula nana	I 1		I 1	II 3		I h		**V** 7
Bryum spp.						I t		**V** +
Comandra umbellata								**V** 5
Drepanocladus exannulatus								**V** +
Drepanocladus uncinatus		I t			I h	I t		**V** 4
Equisetum fluviatile				I h		I t		**V** 4
Eriophorum angustifolium								**V** 6
Eurhynchium pulchellum								**V** +
Menyanthes trifoliata								**V** 5
Plagiomnium ellipticum								**V** +
Sphagnum warnstorfii		I h	I +	I 3		I +	II h	**V** 7
Tomentypnum nitens				II 4		I h		**V** 6

1. Species presence classes (the percentage of plots in which the species occurs): I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%.
2. Species significance classes and the corresponding mid-point and range (in parentheses) of cover: t = 0.005 (0.001-0.009), h = 0.05 (0.01 - 0.099), + = 0.2 (0.1-0.299), 1 = 0.4 (0.3-0.499), 2 = 0.75 (0.5-0.999), 3 = 1.5 (1-1.999), 4 = 3.5 (2-4.999), 5 = 7.5 (5-9.999), 6 = 15 (10-19.999), 7 = 35 (20-49.999), 8 = 60 (50-69.999), 9 = 85 (70-100).

While the constant occurrence of *Picea mariana* was a consequence of the sampling design, many other species, such as *Linnaea borealis*, *Hylocomium splendens*, *Pleurozium schreberi*, *Geocaulon lividum*, *Peltigera aphthosa*, *Cornus canadensis*, and *Ptilium crista-castrensis*, also occurred in all or nearly all groups (Table 3). This resulted in the somewhat poor floristic differentiation reflected by both the numerical and tabular analyses. Some other species that were used in diagnostic combinations of species had marginal differential values (*e.g. Rosa acicularis)* or could be used only as important companions, (*e.g. Empetrum nigrum,* an important companion for the Picea mariana – Vaccinium vitis-idaea alliance, or *Petasites frigidus*, an important companion species for the Picea glauca & mariana – Lonicera involucrata alliance) (Table 2).

One plot was very different from all others, and was tentatively placed as the Picea mariana – Betula nana association in the Betula nana alliance (Table 1). Among all other plots, a distinct subdivision was present and we considered these two groups to be alliances: Picea mariana – Vacinium vitis-idaea, and Picea glauca & mariana – Lonicera involucrata. The former is distinguished by the presence of ericaceous shrubs and is often found on nutrient poor soils, while the latter is distinguished by a higher presence of white spruce, deciduous shrubs, and herbs, and is often found on nutrient-medium and richer soils (Table 2).

The Picea mariana – Vacinium vitis-idaea alliance includes three associations, which are, in order of increasing soil moisture: Picea mariana – Cladina stellaris (110), Picea mariana – Vaccinium vitis-idaea (120), and Picea mariana – Equisetum sylvaticum (130) (Table 1). Of all vegetation units recognized in this report, the Picea mariana – Vaccinium vitis-idaea (120) association is most poorly differentiated from the others (Table 2) as it represents intermediate soil moisture (slightly dry) and poor soil nutrient conditions. Communities of the Picea mariana – Vaccinium vitis-idaea (120) association occur typically on zonal sites across the BWBS zone. Earlier successional stages are characterized by a higher presence of lodgepole pine and lichens; later successional stages are characterized by an increasing presence of *Equisetum sylvaticum*. Two subassociations of the Picea mariana – Equisetum sylvaticum (130) association were delineated: (i) typic, often including lodgepole pine, and (ii) *Larix laricina*, often including tamarack (Table 3).

The Picea glauca & mariana – Lonicera involucrata alliance includes two associations which are, in order of increasing soil moisture: Picea glauca & mariana – Viburnum edule (210), and Picea glauca & mariana – Equisetum pratense (220) (Table 1). The Shepherdia canadensis (211) and Mitella nuda (222) subassociations of the Picea glauca & mariana – Viburnum (210) edule association signify differences in soil moisture, with the former occupying drier and warmer sites than the latter (Table 2). Communities of the Picea glauca & mariana – Lonicera involucrata (200) alliance are influenced by a fluctuating growing-season water table, which is typically found in fine-textured, lacustrine soils. Compared to the Picea mariana – Equisetum sylvaticum (130) association, communities of the tentative Picea glauca & mariana – Equisetum pratense (220) association are associated with nutrient-medium and richer organic soils.

The tentative Picea mariana – Betula nana (310) association represents ecosystems that are wetter than those included into the Picea mariana – Equisetum sylvaticum (130) and Picea glauca & mariana – Equisetum pratense (220) associations, and could be considered to be transitional between forested and non-forested ecosystems (Table 3). Since this association is represented by only one sample plot, the species significance values can be found in Table 3 and Appendix 2.

The floristic individuality of the vegetation units was described by two sets of similarity indices (Table 4). The tentative Picea mariana – Betula nana (310) association was most dissimilar to other units, followed by the Picea mariana – Cladina stellaris (110) and Picea glauca & mariana – Equisetum pratense (220) associations, two units with contrasting edaphic properties, the former drier and poorer, the latter wetter and richer than the majority of the units. All other units had relatively high similarities to each other according to both indices. Two pairs were consistently most similar: (i) the Picea mariana – Vaccinium vitis-idaea (120) association and the Picea mariana – Equisetum sylvaticum: typic (131) subassociation, and (ii) the Picea mariana – Equisetum sylvaticum: typic (131) subassociation and the Picea glauca & mariana – Viburnum edule: Mitella nuda (212) subassociation. Since the units of each of these two pairs were adjacent to each other on regional soil moisture or soil nutrient gradients, the floristic similarity of these units appears to be related to edaphic affinities.

Table 4. Matrix of floristic similarities for vegetation units delineated in mid-seral black spruce ecosystems. Higher values indicate a greater number of shared species and greater floristic similarity. Codes for vegetation units as in Table 1.

a. Sørenson's (coincidence) coefficient of floristic similarity based on species presence/absence.

Vegetation units	110	120	131	132	211	212	220	310
110	1.000							
120	0.514	1.000						
131	0.461	0.685	1.000					
132	0.395	0.574	0.686	1.000				
211	0.385	0.636	0.630	0.558	1.000			
212	0.349	0.619	0.686	0.623	0.679	1.000		
220	0.295	0.436	0.510	0.568	0.468	0.491	1.000	
310	0.114	0.083	0.083	0.113	0.081	0.119	0.119	1.000

b. Cover index (Sørenson modified) of floristic similarity based on cover values.

Vegetation units	110	120	131	132	211	212	220	310
110	1.000							
120	0.245	1.000						
131	0.176	0.741	1.000					
132	0.301	0.487	0.483	1.000				
211	0.363	0.492	0.377	0.543	1.000			
212	0.182	0.686	0.687	0.467	0.500	1.000		
220	0.381	0.162	0.148	0.321	0.296	0.157	1.000	
310	0.040	0.008	0.013	0.045	0.020	0.011	0.049	1.000

Floristic affinities between the vegetation units were also illustrated by the spectra presenting the life form profile for each unit (Figure 2). Except for the provisional Picea mariana – Betula nana (310) association, all other units have similar profiles, with coniferous trees (black spruce, white spruce, and lodgepole pine) and mosses (predominantly *Hylocomium splendens, Pleurozium schreberi*, and *Ptilium crista-castrensis*) representing over 60% of each spectrum. While the proportion of coniferous trees and mosses was relatively consistent, the relative frequency of broad-leaved trees, evergreen shrubs, deciduous shrubs, ferns and allies, graminoids, herbs, lichens, and dwarf woody plants varied from unit to unit.

Broad-leaved deciduous trees (predominantly aspen) had the highest relative frequency (5 to 10%) in the nutrient-richer communities of the Picea glauca & mariana – Viburnum edule (210) association. Although their proportion was small (about 5%), evergreen shrubs (predominantly *Ledum groenlandicum*) were characteristic of nutrient-poor communities included in the Picea mariana – Vaccinium vitis-idaea (120) and the Picea mariana – Equisetum sylvaticum (130) associations. As expected, a small proportion (about 5%) of ferns and allies (mainly *Equisetum* spp.) was present in the spectra of the Picea mariana – Equisetum sylvaticum (130) and the Picea glauca & mariana – Equisetum pratense (220) associations. Although each vegetation unit featured herbs, they had a higher relative frequency (5 to 20%) in the nutrient-richer units: the Picea glauca & mariana – Viburnum edule (210) and Picea glauca & mariana – Equisetum pratense (220) associations.

Lichens were most abundant in water-deficient communities of the Picea mariana – Cladina stellaris (110) association. Dwarf woody plants (such as *Linnaea borealis*, *Vaccinium scoparium*, and *V. vitis-idaea*) occurred with a low relative frequency (generally <10%) and were most characteristic of nutrient-poor communities of the Picea mariana – Vaccinium vitis-idaea (100) alliance.

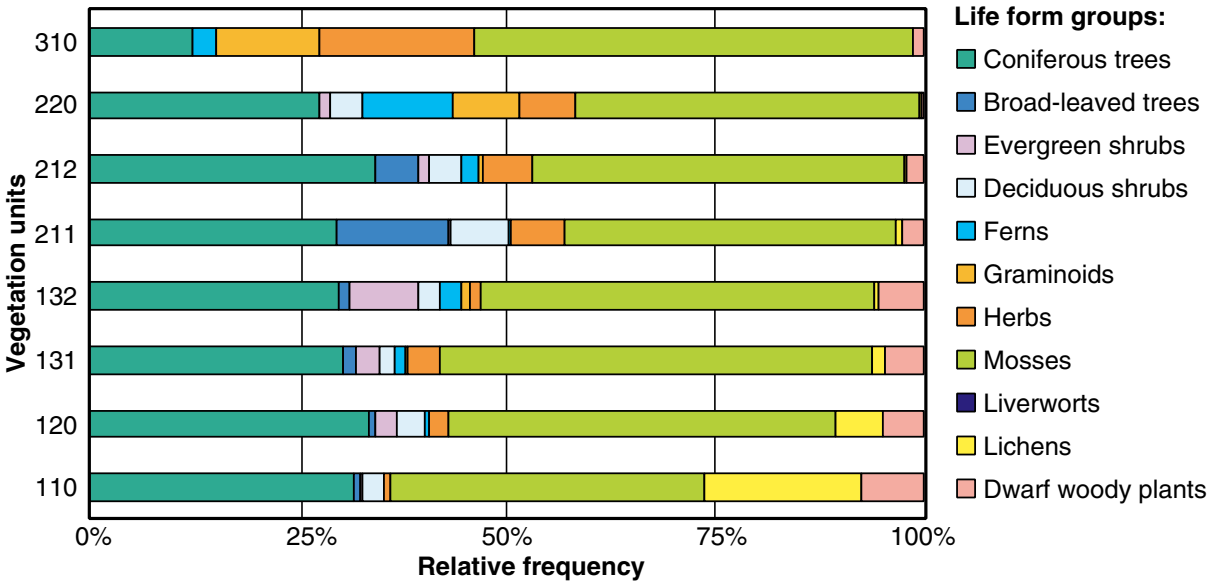

Figure 2. Life form spectra for the eight basic vegetation units delineated in mid-seral black spruce ecosystems by this study. Codes for vegetation units as in Table 1.

Description of Plant Associations

This section expands on the vegetation classification by emphasizing floristic and stand characteristics of the plant associations. As much of this information is presented in diagnostic, summary and plot vegetation tables, the description is brief and focused on the most salient features. We describe and illustrate each of the six plant associations, including their subassociations (if any). The associations are organized according to the order given in Table 1. We emphasize the habitat and vegetation-environment relationships in the next section on site classification.

110 Picea mariana – Cladina stellaris plant association

(References: Tables 2 and 3; Figures 2 and 3; Appendices 2 and 3)

This association represents low-productivity black spruce and lodgepole pine dominated communities that have developed on water-deficient, nutrient-poor sites throughout the BWBS zone and the northern portion of the SBS zone. Conifers, mosses, lichens, and dwarf woody plants are most prominent in the life form spectrum (Figure 2). The forest canopy is typically open, often discontinuous, enabling the growth of shade-intolerant species, such as *Arctostaphylos uva-ursi* and several lichen species in the understory (Tables 2 and 3). The cover of the other life forms decreases in order from the mosses to the shrubs to the herbs. The constant dominant species in the understory are: *Cladina stellaris* (also the most important diagnostic species) and *Vaccinium vitis-idaea*. Although sometimes occurring with high cover, *Hylocomium spendens* and *Pleurozium schreberi* may be occasionally absent. The complete absence of *Ptilium crista-castrensis* suggests that it is intolerant of water deficits and exposure. A greater number of samples would improve characterization of these lichen communities; however these communities are uncommon and, especially on the driest sites, slow to develop, making it difficult to avoid sampling earlier seral stages without black spruce.

Figure 3. An open-canopy, old-growth lodgepole pine community (in the foreground) and a mid-seral black spruce community (in the background) representing the Picea mariana – Cladina stellaris (110) association on a moderately dry, nutrient-poor site located on a water-shedding crest in the BWBSdk subzone.

120 Picea mariana – Vaccinium vitis-idaea plant association

(References: Tables 2 and 3; Figures 2 and 4; Appendices 2 and 4)

This association represents low- to- medium productivity black spruce communities with or without lodgepole pine as a dominant species in the tree layer. These communities occur on slightly water-deficient, nutrient-poor sites throughout the BWBS zone and the northern portion of the SBS zone. Conifers and mosses are the predominant life forms, with a minor proportion (<5%) of lichens, dwarf woody plants, evergreen shrubs, deciduous shrubs, and herbs. Shade-tolerant boreal mosses (*Hylocomium splendens*, *Pleurozium schreberii* and *Ptilium crista-castrensis*) dominate the understory. Forest canopies range from open to closed, and this variation appears to influence the presence and abundance of shade-intolerant species, such as lichens, in the forest understory.

Trees are distributed randomly or in clusters. Clusters are typical in pure black spruce stands because of the ability of the species to regenerate by layering. In comparison to the Picea mariana – Cladina stellaris (110) association, the presence of lichens was lower, although small patches of *Cladina stellaris* and *Cladina mitis* may occur among mosses. Usually, lichens form patches around or on stones, roots, or poorly decomposed wood. The presence of ericaceous shrubs (*e.g.*, *Ledum groelandicum*), some herbs, (*e.g.*, *Petasites frigidus*), and mosses (*e.g.*, *Hylocomium splendens* and *Ptilium crista-castrensis*) was higher (Tables 2 and 3). Within the Picea mariana – Vaccinium vitis-idaea (100) alliance, this association is virtually without a diagnostic combination of species (except for *Orthilia secunda* as an important companion), *i.e.*, it is differentiated by the absence of the species that are characteristic for the other associations of the alliance. Such poor differentiation is characteristic of the communities associated with intermediate (zonal) sites.

Figure 4. A semi-open canopy stand of black and white spruce in the understory reinitiation developmental stage. This stand represents the Picea mariana – Vaccinium vitis-idaea (120) association on a slightly dry, nutrient-poor mid-slope site in the BWBSdk subzone. Note the occasional clumps of trees, advance regeneration of black spruce and subalpine fir, and the lower cover of understory vegetation in patches with higher canopy closure.

To determine the magnitude of floristic differences that could be attributed to the influence of regional climate, we stratified the 25 plots of the Picea mariana – Vaccinium vitis-idaea (120) association according to subzones into 4 groups (BWBSdk, BWBSmw, BWBSwk, and combined SBS subzones). This comparison showed the presence of weak differences among the subzones (Table 5). *Cladina stellaris* and *Geocaulon lividum* appear to be more frequent in the driest climate (BWBSdk subzone) and *Menziesia ferruginea* and *Vaccinium mebranaceum* in the wettest climate (BWBSwk subzone), while no significance was attributed to a higher presence of *Equisetum arvense* in the BWBSmw subzone. The predominantly drier combined SBS subzones were well differentiated from the BWBS subzones by a number of species; however, few of them signify climatic differences (*e.g.*, *Spiraea betulifolia* indicating a warmer (milder) climate, and *Lonicera involucrata* and *Petasites frigidus* indicating a summer-wet climate).

Our findings are in rough concordance with Meidinger and Pojar (1991) who considered *Shepherdia canadensis* and *Geocaulon lividum* to be characteristic of the BWBSdk subzone, *Lathyrus ochroleucus*, *Mertensia paniculata*, *Galium boreale*, and *Mitella nuda* of the BWBSmw subzone, and *Abies lasiocarpa* and *Vaccinium membranaceum* of the BWBSwk subzone. The species underlined above were not differential, as they occurred either across several vegetation units, or were diagnostic of the units represented by the Picea glauca & mariana – Viburnum edule (200) alliance, *i.e.*, communities occurring on medium and richer sites. Nevertheless, this comparison suggests that according to the zonal concept, the Picea mariana – Vaccinium vitis-idaea (120) association could be further differentiated into several subassociations, each signifying differences in regional climate. However, we suggest that such a differentiation is inconsequential to our classification for the BWBS zone, particularly in view of (i) the small number of plots, (ii) the classification of mid-seral ecosystems, and (iii) the designation of slightly dry and nutrient poor sites as zonal sites. Even if the differentiation were implemented, it would not change the edaphic characteristics of the resulting subassociations, and hence their vegetation and productivity potentials.

Table 5. Potential diagnostic combinations of species for groups of plots of the Picea mariana - Vaccinium vitis-idaea (120) association stratified according to biogeoclimatic units. The diagnostic combination of species for each vegetation unit is shaded in gray.

Biogeoclimatic subzone		**BWBS dk**		**BWBS mw**		**BWBS wk**		**all SBS**	
Number of plots		8		5		5		7	
Species	**Diagnostic[1] value**	**Species presence[2] and significance[3]**							
BWBdk plots									
Cladina stellaris	(d)[1]	IV[2]	4[3]	II	4	II	6	II	h
Geocaulon lividum	(d)	V	4	I	1			III	h
BWBSmw plots									
Equisetum arvense	(d)	I	h	III	+	I	1	I	h
BWBSwk plots									
Abies lasiocarpa	(ic)	II	5			IV	5	III	4
Menziesia ferruginea	(d)					III	5		
Vaccinium membranaceum	(ic)			I	h	III	6	II	2
Northern SBS subzones									
Aster sibiricus	(d)							III	+
Goodyera oblongifolia	(d)	I	h					III	h
Linnaea borealis	(d)	III	+	II	2	II	1	V	1
Lonicera involucrata	(d)			I	+			IV	+
Nephroma arcticum	(d)							III	+
Peltigera malacea	(d)							III	+
Petasites frigidus	(d)	II	h	III	2	II	1	V	2
Rosa acicularis	(d)	II	1	II	2	I	1	IV	2
Rubus pubescens	(d)							III	+
Spiraea betulifolia	(d)							III	2

1, 2, 3 Diagnostic values and species presence and significance classes as defined in Table 2.

130 Picea mariana – Equisetum sylvaticum plant association

(References: Tables 2 and 3; Figures 2, 5 and 6; Appendices 2, 5, and 6)

This association represents low- to medium-productivity black spruce communities on nutrient-poor sites, usually with lodgepole pine as a minor species. Two subassociations were delineated: (i) 131 typic, which represents communities on fresh, moist, and very moist sites, and (ii) 132 Larix laricina, which represents communities on wet sites, with both occurring throughout the BWBS zone and the northern portion of the SBS zone. Location on flat terrain or in depressions combined with constrained drainage causes the water table to fluctuate during the growing season; *i.e.*, soil moisture conditions may vary from water surplus after snowmelt and spring thaw to water deficit in late spring to water surplus following major summer precipitation events. In addition, a frozen layer, which often persists into the growing season, may be present in very moist and wet soils.

Similar to the drier Picea mariana – Vaccinium vitis-idaea (120) association, conifers and mosses are the predominant life forms in this association, with a minor proportion (<5%) of evergreen shrubs, deciduous shrubs, herbs, and dwarf woody plants (Figure 2). The cover of the tree layer varies from 20 to 90%; however, most of the stands have open canopies, which allows better development of the shrub, herb, and moss layers. *Equisetum sylvaticum* is the only moderately strong differential species for the association, with its presence and cover increasing with increasing water surplus from the typic to the Larix laricina subassociation. A similar trend was observed for *Aulacomnium palustre*, the most characteristic species for the Larix laricina subassociation and a good indicator of a fluctuating water table. According to the cover-based Sørenson index, the typic (131) subassociation is floristically more similar to the intermediate Picea mariana – Vaccinium vitis-idaea (120) association than to the Larix laricina (132) subassociation (Table 4).

Figure 5. A nearly fully stocked, clumpy, pure black spruce stand representing the Picea mariana – Equisetum sylvaticum: typic (131) subassociation on a very moist, nutrient-poor site with a fluctuating water table in the BWBSdk subzone. Note the high cover of *Equisetum sylvaticum* in canopy gaps.

Figure 6. An open-canopy, clumpy, 109 year-old (@ bh) stand of pure black spruce representing the Picea mariana – Equisetum sylvaticum: Larix laricina (132) subassociation on a wet, nutrient-poor site in the BWBSdk subzone sample (plot 71).

210 Picea glauca & mariana – Viburnum edule plant association

(References: Tables 2 and 3; Figures 2, 7 and 8; Appendices 2, 7, and 8)

This association represents species-diverse, medium- to high-productivity white and black spruce communities on nutrient-medium and richer sites, usually with lodgepole pine and/or trembling aspen as occasional major or minor species. Two closely related subassociations were delineated: (i) Shepherdia canadensis (211), which represents communities on slightly water-deficient sites, and (ii) Mitella nuda (212), which represents communities on fresh, moist and very moist sites. Both associations occur throughout the BWBS and the northern portion of the SBS zone. As with their moisture-equivalent but nutrient-poorer counterparts (the Picea mariana – Vaccinium vitis-idaea (120) association and the Picea mariana – Equisetum sylvaticum: typic (131) subassociation), the water table will fluctuate during the growing season if these communities are located on flat terrain or in depressions with fine-textured soils and constrained drainage. Soil moisture conditions may change from water surplus after snowmelt and spring thaw to water deficit in late spring, to water surplus following major summer precipitation events.

Conifers and mosses are the predominant life forms; however, the proportion of deciduous trees (trembling aspen), deciduous shrubs (*e.g.*, *Lonicera involucrata* and *Viburnum edule*) and herbs (*e.g.*, *Arnica cordifolia*, *Aster ciliolatus*, and *Osmorhiza berteroi*) is markedly higher compared to the Picea mariana – Vaccinium vitis-idaea (100) alliance (Tables 2 and 3). The cover of the tree layer is generally high (over 50%), yet allows a moderate development of the herb layer. The Picea glauca & mariana – Viburnum edule (210) association is well differentiated from the wetter Picea glauca & mariana – Equisetum pratense (220) association by species including *Epilobium angustifolium*, *Galium boreale*, *G. triflorum*, and *Viburnum edule*; however, the Shepherdia canadensis (211) and Mitella nuda (212) subassociations are floristically quite similar (Table 4). *Shepherdia canadensis* is the most significant diagnostic (and indicator) species for the drier communities, with its presence and cover decreasing with increasing water surplus. *Mertensia paniculata* and *Mitella nuda* are considered important diagnostic species for the wetter communities, with their presence increasing with increasing water surplus.

Figure 7. A nearly closed-canopy black spruce stand representing the Picea glauca & mariana–Viburnum edule: Shepherdia canadensis (211) subassociation on a slightly dry, nutrient medium, mid-slope site in the BWBSmw subzone. Note the high cover of *Petasites frigidus*, a species characteristic of the Picea glauca & mariana – Viburnum edule alliance and of a fluctuating water table.

Figure 8. A nearly closed-canopy mixture of black spruce and white spruce representing the Picea mariana – Viburnum edule: Mitella nuda (212) subassociation on a fresh, nutrient-rich, mid-slope site in the BWBSdk subzone. Note the high cover of *Arnica cordifolia*, a companion species of the Picea glauca & mariana – Viburnum edule alliance.

220 Picea glauca & mariana – Equisetum pratense plant association

(References: Tables 2 and 3; Figures 2 and 9; Appendices 2 and 9)

This insufficiently sampled (3 plots), and therefore tentative, association represents low-productivity, black and white spruce dominated communities on wet, nutrient-medium and richer sites throughout the BWBS and the northern portion of the SBS zone. Occurrence on gentle slopes may result in good drainage, but occurrence on flat terrain or in depressions combined with constrained drainage results in a fluctuating water table during the growing season; *i.e.*, soil moisture conditions may change from water surplus after snowmelt and spring thaw to water deficit in late spring to water surplus following major summer precipitation events.

Conifers and mosses are the predominant life forms, but these communities also feature a higher proportion (>5%) of ferns and allies (*Equisetum pratense* and *E. scirpoides*), graminoids (mainly *Carex* spp.), and herbs than other units (Figure 2). The cover of the tree layer is generally low (about 50%). Compared to other vegetation units, this association is characterized by many differential species, several of which are indicators of easily available soil nitrogen (*e.g.*, *Angelica genuflexa*, *Geum macrophyllum*, and *Senecio triangularis*).

Figure 9. A nearly fully stocked, but clumpy, 99 year-old (@bh) pure black spruce stand representing the Picea glauca & mariana – Equisetum pratense (220) association on a wet, nutrient-medium site on flat terrain in the BWBSdk subzone.

310 Picea mariana – Betula nana plant association

(References: Tables 2 and 3; Figures 2 and 10; Appendix 2)

This insufficiently sampled (1 plot), tentative association represents low-productivity communities on very wet, nutrient-medium and richer sites, usually with both black and white spruce as the leading but scattered tree species. These communities could be considered transitional between forested and non-forested ecosystems throughout the BWBS and the northern portion of the SBS zone. Our single community sampled probably represents medium soil nutrient conditions considering the relatively low cover of ericaceous shrubs and *Sphagnum* spp. Plant communities on very wet, nutrient-poor sites will be expected to be ombotrophic, non-forested bogs dominated by *Ledum groelandicum* and *Sphagnum* spp., with scattered black spruce.

Figure 10. A poorly forested Picea mariana – Betula nana (310) community north of Smithers.

The Site Classification

We derived 8 site associations from 8 mid-seral vegetation units (plant associations or subassociations), thus there is 1:1 correspondence between vegetation units and site associations (Table 6). This good correspondence between vegetation and habitats was attributed to the small number of vegetation units, each with a nearly exclusive range of soil moisture and nutrient regimes. The edaphic individuality of site associations is illustrated on the edatopic grid (Figure 11) and in the summary environmental table (Table 7).

Table 6. Synopsis of site associations delineated in mid-seral black spruce ecosystems by this study, showing their relationships with the parent vegetation units.

Site association	Parent vegetation unit
100 SbPl – Lichens	110 Picea mariana – Cladina stellaris association
200 SbPl – Moss	120 Picea mariana – Vaccinium vitis-idaea association
300 Sb – Wood Horsetail	131 Picea mariana – Equisetum sylvaticum: typic subassociation
400 Sb – Tamarack	132 Picea mariana – Equisetum sylvaticum: Larix laricina subassociation
500 SbSw – Soopolallie	211 Picea glauca & mariana – Viburnum edule: Shepherdia canadensis subassociation
600 SbSw – Common Mitrewort	212 Picea glauca & mariana – Viburnum edule: Mitella nuda subassociation
700 SbSw – Meadow Horsetail	220 Picea glauca & mariana – Equisetum pratense plant association
800 (Sb) – Swamp Birch	310 Picea mariana – Betula nana plant association

From a climatic perspective, each site association includes ecosystems from nearly all BWBS variants and the northern subzones/variants of the SBS zone. If climate, as expressed by biogeoclimatic subzones/variants, has a strong influence on vegetation, then this climatic influence should be most strongly expressed on zonal sites. We considered the sites where the Picea mariana – Vaccinium vitis-idaea plant association occurred to be closest to zonal, and stratified the sample plots according to the membership in the subzones studied. As the vegetation analysis showed weak floristic differences between subzones (Table 5), we framed only one 'zonal' site association (SbPl – Moss) for the whole study area.

Since the floristic differences due to climate within other well-sampled site associations were generally minor, we concluded that it would be unnecessary to undertake additional floristic analysis within each of the site associations. It is more useful to describe apparent trends and divide each site association into site series according to biogeoclimatic subzones/variants. Each set of site series may reflect minor variations in vegetation and soil characteristics and, more importantly, differences in the distribution pattern of ecosystems imposed by regional climates. For example, ecosystems on the driest sites will be expected to be more frequent in the landscape in the driest subzones than in the wettest subzones, and will likely feature a higher and more consistent cover of xerophytic species.

One of the premises of plant ecology is that there are predictable, if inexact, relationships between vegetation patterns and environmental gradients. These relationships can be used to infer certain environmental conditions from the presence of a given plant community or, conversely, to predict the presence or development of plant communities given certain environmental conditions. The steepest gradients in forested ecosystems are usually climatic and edaphic (soil moisture, soil nutrients, and aeration). Other, usually indirect, environmental factors that affect plant communities (and can be used to predict their presence) include: aspect, slope gradient, slope position, parent material, soil texture, and soil drainage.

Table 7. Summary environmental table for the site associations in mid-seral black spruce ecosystems delineated in this study. Continuous properties are characterized by mean and range; categorical properties are described by the percentage of the sample plots in each class.

	Site association							
Property	**100 SbPl - Lichens**	**200 SbPl - Moss**	**300 Sb - Wood Horsetail**	**400 Sb - Tamarack**	**500 SbSw - Soopolallie**	**600 SbSw - Common Mitrewort**	**700 SbSw - Meadow Horsetail**	**800 Sb - Swamp Birch**
Number of plots	5	25	34	13	13	28	3	1
Subzone[1]	BWBSdk - 80 BWBSmw - 20	BWBSdk - 48 BWBSmw - 20 BWBSwk - 20 SBSdk - 4 SBSdw - 8	BWBSdk - 26 BWBSmw- 65 BWBSwk - 3 SBSmk - 6	BWBSdk - 8 BWBSmw- 84 BWBSwk - 8	BWBSdk - 23 BWBSmw - 8 SBSmk - 31 SBSdw - 38	BWBSdk - 19 BWBSmw - 67 SBSdk - 4 SBSdw - 4 SBSmk - 6	BWBSmw - 33 BWBSwk - 33 SBSdw - 34	BWBSdw - 100
Soil moisture regime[2]	2/MD - 80 3/SD - 20	3/SD - 28 4/SD - 68 5/F&M - 4	5/F&M - 50 6/VM - 50	6/VM - 8 7/W - 92	3/SD - 10 4/SD - 90	5/F&M - 71 6/VM - 29	7/W - 100	8/VW- 100
Soil nutrient regime[3]	VP - 60 P - 40	VP - 16 P - 80 M - 4	VP - 38 P - 56 M - 6	VP - 62 P - 38	P - 15 M - 46 R - 38	P - 4 M - 68 R - 18 VR - 11	M - 67 R - 33	M - 100
Elevation (m)	918 (840 - 1020)	933 (400 - 1190)	841 (350 - 1170)	646 (350 - 1160)	792 (390 - 955)	801 (340 - 1030)	950 (840 - 1020)	880
Slope gradient (%)	16 (2 - 40)	21 (0 - 82)	11 (0 - 36)	2 (0 - 16)	9 (0 - 32)	7 (0 - 31)	0	0
Slope aspect[4]	N - 40 E - 20 S - 40	N - 28 E - 16 S - 28 W - 8 F - 20	N - 15 E - 9 S - 18 W - 29 F - 29	W - 23 F - 77	N - 23 E - 15 S - 23 W - 8 F - 31	N - 25 E - 4 S - 14 W - 18 F - 39	F - 100	F - 100

Property	Site association 100 SbPl - Lichens	200 SbPl - Moss	300 Sb - Wood Horsetail	400 Sb - Tamarack	500 SbSw - Soopolallie	600 SbSw - Common Mitrewort	700 SbSw - Meadow Horsetail	800 Sb - Swamp Birch
Number of plots	5	25	34	13	13	28	3	1
Forest floor thickness (cm)	7 (5 - 10)	11 (4 - 30)	13 (8 - 23)	18 (12 - 30)	11 (2 - 40)	13 (9 - 23)	15 (9 - 24)	25
Generalized textural class[5]	L - 80 S - 20	L - 72 S - 24 O - 4	C - 6 L - 44 S - 6 O - 38	C - 8 L - 23 O - 69	C - 8 L - 70 S - 22	C - 22 L - 61 S - 4 O- 14	O - 100	C - 100
Potential rooting depth (cm)	53 (25 - 60)	50 (10 - 80)	49 (15 - 90)	49 (30 - 70)	52 (15 - 70)	48 (20 - 100)	53 (40 - 70)	70
Water table depth (cm)	N/A[6]	N/A or > 70	N/A or 15 - 70	5 - 50	N/A or > 70	N/A or 10 - 75	30 - 35	10
Soil drainage[7]	R - 40 W - 40 M - 20	R - 16 W - 36 M - 32 I - 16	W - 6 M - 12 I - 29 P - 53	P - 54 V - 46	R - 8 W - 31 M - 54 I - 8	W - 7 M - 7 I - 68 P - 18	P - 33 V - 67	V - 100
Stand age (years@ bh)[7]	96 (54 - 151)	98 (37 - 176)	102 (48 - 185)	107 (69 - 151)	90 (44 - 108)	95 (54 - 157)	158 (144 - 172)	77
Site index (m @50yrs bh age)[8]	9.0(7.3 - 9.9)	9.7(7.3 - 13.3)	8.6(4.7 - 11.5)	9.6(6.9 - 11.6)	12.1(10.4 - 13.9)	11.2(7.8 - 14.0)	6.3	9.2
Tree layer cover (%)	41 (20 - 70)	50 (15 - 90)	54 (20 - 96)	47 (22 - 86)	69 (45 - 90)	63 (30 - 90)	53 (50 - 60)	10
Shrub layer cover (%)	14 (1 - 48)	16 (0 - 66)	16 (0 - 44)	30 (0 - 80)	12 (0 - 51)	13 (0 - 68)	13 (6 - 23)	46
Herb layer cover (%)	1 (0 - 2)	3 (0 - 13)	7 (0 - 33)	7 (1 - 17)	10 (0 - 24)	11.4 (0 - 55)	26 (5- 62)	25
Moss layer cover (%)	68 (38 - 97)	88 (45 - 100)	90 (52 - 100)	82 (32 - 100)	61 (1 - 97)	76 (0 - 100)	68 (40 - 93)	46

1 Subzones of the Boreal Black and White Spruce Zone: BWBSdk - Dry Cool BWBS, BWBSmw - Moist Warm BWBS, BWBSwk - Wet Cool BWBW; and the Sub-Boreal Spruce Zone: SBSdk - Dry Cool SBS, SBSdw - Dry Warm SBS, SBSmk - Moist Cool SBS.

2 Relative/actual moisture regime: 2/MD-subxeric/moderately dry, 3/SD-submesic/slightly dry, 4/SD-mesic/slightly dry, 5/F&M-subhygric/fresh and moist, 6/VM-hygric/very moist, 7/W-subhydric/wet, 8/VW-hydric/very wet, f - fluctuating water table

3 VP-very poor, P-poor, M-medium, R-rich, VR-very rich

4 N-north, E-east, S-south, W-west, F-flat

5 S-sandy, L-loamy, C-clayey, O-organic (See Table 8 for definitions)

6 N/A - not applicable; N/D - not determined

7 R-rapid, W-well, M- moderately well, I-imperfect, P-poor, V-very poor

8 Site Index and stand age data are missing for some plots. See Appendices 10 - 16 for details.

In this study, the variation along regional soil moisture and nutrient gradients was sufficient for the exclusive differentiation of site associations. Thus, regardless of the vegetation present on the site (or the stage in stand development), any site within the studied edaphic range can be identified, *i.e.*, assigned to one of the 8 site associations based on an estimate of soil moisture and nutrient conditions of the site (Figure 11). The edaphic limits of some site associations have been extended to include the soil moisture and nutrient conditions where we expect similar plant communities to develop.

There are two sets of site associations: the nutrient poorer ones (100 - 400) with SNRs ranging from very poor to poor, and the nutrient-richer ones (500 - 600), with SNRs ranging from medium to rich (occasionally very rich). The difference in SNRs between these two sets is supported by soil chemical analysis (Kayahara *et al.* 2000, submitted manuscript) and by a distinctly higher (15-27%) relative frequency of nitrogen-rich plant indicators in the soil nutrient spectra of the SbSw – Soopolallie, SbSw – Common Mitrewort, and SbSw – Meadow Horsetail site associations (Figure 12). A relative frequency of nitrogen-rich indicators exceeding 9% was considered to be diagnostic for medium and richer SNRs (Wang, 1992). However, the field-identified SNRs showed some overlap between these two sets of site associations (Table 7). This is due to the fact that the assessment of soil nutrient regime using soil properties reflects the nutrient status throughout the soil profile, while indicator plant analysis primarily reflects the nutrient status of the forest floor.

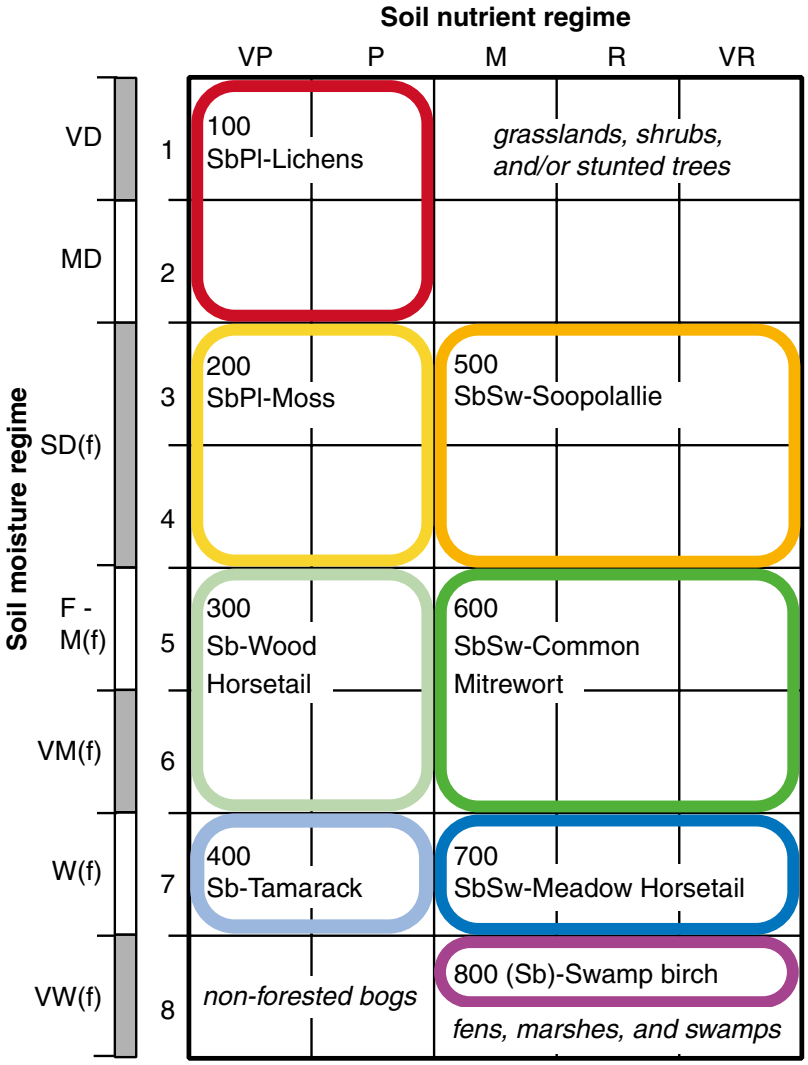

Figure 11. Edatopic grid showing the generalized relationships of the eight site associations to soil moisture and soil nutrient regimes. Numerical codes for site associations as in Table 6.

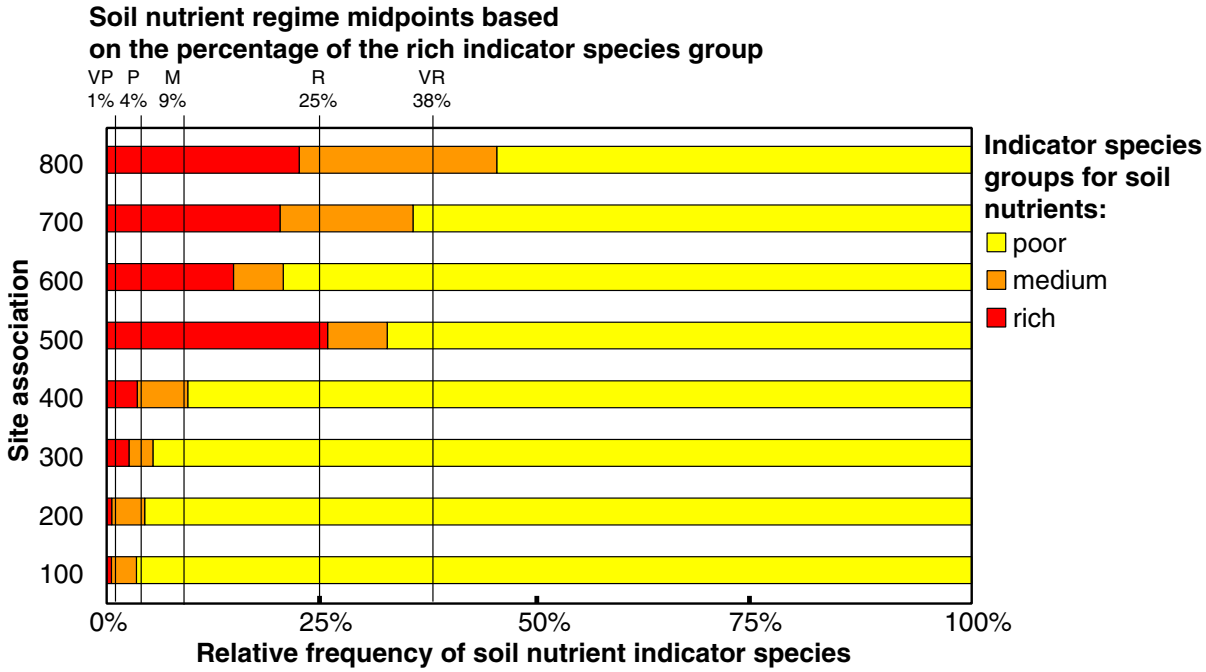

Figure 12. Soil nutrient spectra for the eight site associations showing the frequency of plants indicating various soil nutrient conditions relative to all soil nutrient indicator species. Numerical codes for site associations are listed in Table 6. Mid-points of rich indicators from Wang (1992).

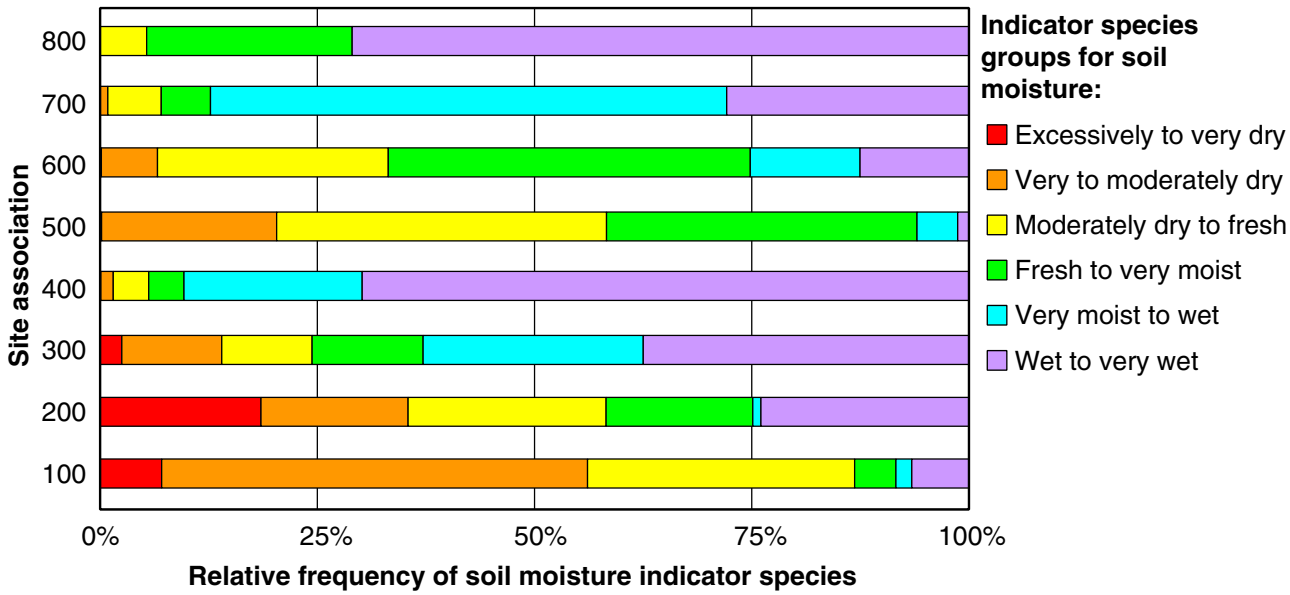

Figure 13. Soil moisture spectra for the eight site associations showing the frequency of plants indicating various soil moisture conditions relative to all soil moisture indicator species. Numerical codes for site associations are listed in Table 6.

Similarly, the indicator plant analysis supported differentiation of site associations into 5 sets of soil moisture conditions: (1) very dry to moderately dry (2) slightly dry, (3) fresh to very moist, (4) wet, and (5) very wet (Figure 13). However, we did not sample the very dry, nutrient-medium and richer sites, which support grasslands and low-vigour trembling aspen ecosystems (Banner *et al.* 1993), or, except for the one plot in the 800 (Sb) – Swamp birch site association, the very wet sites, which support poorly forested and non-forested bogs, fens, marshes, and swamps (DeLong *et al.* 1990; MacKinnon *et al.* 1990; Banner *et al.* 1993). In order from very dry to wet sites, the soil moisture spectra showed a consistent decrease in the relative frequency of the indicators species groups of moisture-deficient soils, and a consistent increase in the relative frequency of the indicator groups of water-surplus soils in both the nutrient-poorer and nutrient-richer sites. These trends suggests that the separation of site associations according to these soil moisture sets reflects a natural pattern in black spruce ecosystems because the differences in edaphic conditions between site associations are well reflected by the floristic composition of understory vegetation.

We propose that for this study area a distinction should be made between two sets of soil moisture conditions: (i) with a groundwater table which exhibits no or relatively minor fluctuations (typically associated with no or minor soil drainage constraints), and (ii) with a strongly fluctuating water table (typically associated with imperfectly and poorly drained soils). While the 'standard' (from very dry to very wet) SMRs are to used with first set, the adjective fluctuating (f) should be used with the second set to indicate significant changes in soil moisture during the growing season. A strongly fluctuating water table can be expected to occur on flat terrain or in depressions when the associated soils are fine-textured, poorly structured, have a low content of coarse fragments, have a compacted, root-restricting layer close to the ground surface, and feature a gleyed (occasionally) soil layer/horizon. Under such conditions, soil moisture conditions may change from water surplus after snowmelt and spring thaw to water deficit in late spring and again to water surplus following major summer precipitation events. For example, the slightly dry fluctuating SMR may be characterized by growing-season soil moisture conditions ranging from very moist to slightly dry, with slightly dry conditions being most frequent during the growing season.

When describing site associations, we proposed potential site types using one or two edaphic adjectives indicative of aberrant properties in relation to the majority of the sample plots in a particular site association (the typic site type) (Table 8). We do not expect floristic difference between site types; however, if they occur, they probably reflect edaphic differences. For example a shallow site type will be expected to be drier compared to moderately deep and deep sites; a gleyed site type will be expected to be associated with a strongly fluctuating water table, and a slope-skeletal site type will be expected to be associated with unconstrained soil drainage.

Table 8. Definitions of the diagnostic edaphic properties used to frame site types in the site classification of mid-seral black spruce ecosystems. These properties can represent the central concept (i.e. typic) of a site type, or when used as an adjective on the site association name, it can describe the aberrant properties of a site type.

Adjective	Definition
Type and degree of expression of soil horizons	
Gleyed	A soil that has a horizon(s) formed under poor drainage (wet and partly anaerobic) conditions which results in the reduction of iron and other elements and in gray colours and/or mottles; the soil belongs to the gleyed subgroups of Brunisols, Luvisols, Podzols, or Regosols.
Gleysolic	A soil that belongs to the Gleysolic order (Orthic or Humic Gleysols).
Organic	A soil that belongs to the Organic order (Folisols, Fibrisols, Mesisols, or Humisols).
Particle size	
Sandy	Texture of the fine earth is sand or loamy sand, but not loamy very fine sand or very fine sand; coarse fragments make up <35% by volume.
Loamy	Texture of the fine earth is loamy very fine sand, very fine sand, or finer, but the amount of clay is <35%; coarse fragments are <35% by volume.
Clayey	Fine earth contains ≥35% clay by weight, and coarse fragments are <35% by volume.
Skeletal	Coarse fragments make up ≥35% by volume with enough fine earth to fill interstices larger than 1 mm; this adjective is used together with the particle size classes defined above (sandy, loamy, and clayey).
Rooting depth	
Shallow	A soil that has a rooting depth of <30 cm.
Moderately deep	A soil that has a rooting depth of ≥30 cm but <100 cm.
Deep	A soil that has a rooting depth of ≥100 cm.
Landform characteristics	
Slope	A site that has a slope gradient of ≥35% but <80%.
Steep-slope	A site that has a slope gradient of ≥80%.

Description of Site Associations

This section expands on the site classification by emphasizing the important environmental (habitat) features of each site association. As much of this information is presented in summary and plot environmental tables (Table 7, Appendices 10 to 16), the descriptions are brief and focus on the most salient features. We describe each of the eight site associations delineated in this study and give potential site types (according to the major edaphic differences between sample plots within a site association). Site associations are organized in the same order as in Table 6.

Considering the large number of site series and site types, the number of sample plots in this study was not sufficient to conduct a meaningful analysis of the vegetation-environment data for each of these categories. Ideally, each site association should also be characterized by a generalized chronosequence of all vegetation units that may develop on the sites in the process of secondary succession; however, this also could not be done in the present study.

The potential site series derived from the delinated site associations can be easily framed by prefixing the biogeoclimatic unit (subzone or variant) symbol to the name of the site association. For example, the site series which can be derived from the SbPl – Lichens site association are (1) BWBSdk1/SbPl – Lichens, (2) BWBSdk2/SbPl – Lichens, (3) BWBSmw1/SbPl – Lichens, (4) BWBSmw2/SbPl – Lichens, (5) BWBSwk1/SbPl – Lichens, and (6) BWBSwk2/SbPl – Lichens.

100 SbPl – Lichens site association

(References: Tables 6 and 7; Figures 11, 12, 13, and 14; Appendix 10)

Submontane to montane, very dry and moderately dry, nutrient-very poor and poor, well-aerated soils on water shedding sites

The SbPl – Lichens site association was derived from the Picea mariana – Cladina stellaris (110) plant association, which is most common in drier BWBS subzones (Table 7). The central edaphic concept (typic site type) is represented by moderately deep, coarse-skeletal Humo-Ferric Podzols that have formed on crests, mid-slopes, and flat terrain. The associated humus forms are thin Mors, predominantly Hemimors. The potential aberrant site types are shallow and slope (Appendix 10).

The SbPl – Lichen site association represents a complex of azonal sites with low-productivity that are marginally suitable for timber production, with a site index (50 yrs @ bh) for black spruce of <9 m. A growing-season water deficit and severe nitrogen deficiency are the fundamental growth constraints. Spectral analysis showed that the soil moisture spectrum is dominated by the indicators of very dry and moderately dry SMRs (Figure 13), and the soil nutrient spectrum is dominated almost entirely by the indicators of very low availability of soil nitrogen (Figure 12). Wind strongly influences the vegetation on crests and upper slopes: it removes organic particles, affects crown development and is the cause of frequent windthrow. Fire disturbance may result in the establishment of predominantly lodgepole pine stands or mixtures of lodgepole pine and black spruce, depending on the composition of the original stands. Depending on the history of fire, regeneration, and windthrow, these azonal sites may lack a continuous vegetation cover, and they often contain patches of exposed mineral soil. Since the canopy is generally open, lodgepole pine may regenerate in larger gaps and form a significant component in late-seral stages (Figure 14).

Figure 14. An open-canopy, clumpy mosaic of old-growth lodgepole pine cohorts on a SbPl – Lichen site. The soil parent materials of this site are sand dune deposits. Note the high cover of lichens in the open and the regeneration of lodgepole pine and black spruce close to the clumps.

200 SbPl – Moss site association

(References: Tables 6 and 7; Figures 11, 12, 13, and 15; Appendix 11)

Submontane to montane, slightly dry (infrequently with a fluctuating water table), nutrient-very poor and -poor, well to adequately aerated soils on more or less zonal sites

The SbPl – Moss site association was derived from the Picea mariana – Vaccinium vitis-idaea (120) plant association, which is considered to represent zonal sites throughout the BWBS zone (Table 6). Compared to other sites, these moss sites are floristically indistinct and best characterized in advanced stages of stand development by a high and continuous cover of mosses, mostly *Pleurozium schreberi*, *Hylocomium splendens*, and *Ptilium crista-castrensis*. The central edaphic concept (typic site type) is represented by moderately deep, loamy-skeletal Brunisols, Luvisols or Humo-Ferric Podzols that have developed on a variety of terrain. The associated humus forms are Mors, predominantly Hemimors or Rhizomors. The potential aberrant site types are shallow, slope, steep-slope, gleyed, and organic (Appendix 11).

The SbPl – Moss site association represents a complex of low- to medium-productivity sites, with a black spruce site index (50 yrs @ bh) ranging from 9 to 13 m. However, the black spruce site index was <9 m on organic and gleyed soils and high-elevation (>1,100 m) sites. Cool soils and soil nitrogen deficiency are thought to be the principal growth constraints. The soil moisture spectrum of this site association features about the same proportion of all soil moisture indicator groups (except of the very moist to wet group) (Figure 13). The presence of the wet to very wet indicator species group on these upland sites is misleading as it reflects the presence of *Ledum groelandicum*. This species is used in cool temperate and mesothermal climates as the indicator of waterlogged sites, but is commonly found on drier upland sites in boreal climates. The indicators of a very low soil nitrogen availability dominate the soil nutrient spectrum almost entirely (Figure 12).

Figure 15. The development and persistence of high density stands is typical for black spruce, particularly on intermediate sites, such as those represented by the SbPl – Moss or SbSw – Soopolallie site associations.

300 Sb – Wood Horsetail site association

(References: Tables 6 and 7; Figures 11, 12, 13, and 16; Appendix 12)

Submontane to montane, fresh, moist, and very moist (frequently with a fluctuating water table and restricted aeration), nutrient-very poor and -poor soils on water-receiving sites.

The Sb – Wood Horsetail site association was derived from the Picea mariana – Equisetum sylvaticum: typic (131) plant subassociation, which is distributed predominantly on lower slopes throughout the BWBS zone. The central edaphic concept (typic site type) is represented by moderately deep, loamy-skeletal Brunisols, Luvisols, or Humo-Ferric Podzols, without a growing-season water deficit or with the water table >60 cm deep. The associated humus forms are Mors, predominantly Hemimors. The potential aberrant site types are slope, gleyed, gleysolic, and organic, with the latter two typically associated with flat terrain and depressions (Appendix 12).

The SbPl – Wood Horsetail site association represents a complex of low- to medium-productivity sites, with the black spruce site index (50 yrs @ bh) typically ranging from 8 to 10 m. The site index decreases with increasing elevation and decreasing depth of the water table; values of <8 m are characteristic of very moist organic soils. The very moist to wet and wet to very wet indicator species groups predominate in the soil moisture spectrum, while the presence of water-deficient indicator species groups is indicative of fluctuating soil moisture conditions (Figure 13). As in all other site associations on nutrient poor sites, the indicators of a low availability of soil nitrogen dominate the soil nutrient spectrum almost entirely (Figure 12). Cool soils, often with a frozen layer that persists into the growing season in the very moist and wet soils, deficient aeration, and nitrogen deficiency are thought to be the principal growth constraints. A long-lasting snow cover, restricted outflow of excess groundwater, and the presence of fine organic materials result in a fluctuating and, if not stagnant, very slowly moving groundwater table. Accumulation of organic materials on these sites progresses at a greater rate than their decomposition, which results in the development of a thick forest floor soon after disturbance.

Figure 16. A dense stand of black spruce in the stem exclusion developmental stage on a very moist, nutrient poor Sb – Wood Horsetail site. Note the random distribution pattern of individual trees that is characteristic of moist and very moist, but not wet sites.

400 Sb – Tamarack site association

(References: Tables 6 and 7; Figures 11, 12, 13, and 17; Appendix 13)

Submontane to montane, wet (infrequently with a fluctuating water table), nutrient-very poor and -poor, and poorly aerated soils on water-collecting sites.

The Sb – Tamarack site association was derived from the Picea mariana – Equisetum sylvaticum: Larix laricina (132) plant subassociation, which is distributed throughout the BWBS zone. The central edaphic concept (typic site type) is represented by organic soils (Fibrisols, Mesisols, and Humisols), with the growing-season water table <30 cm deep. The associated humus forms are Mors, predominantly Fibrimor (Table 7). The potential aberrant site type is gleysolic, which may be associated with flat terrain or very gentle slopes (Appendix 13).

The Sb – Tamarack site association represents low- to medium-productivity sites, with a black spruce site index (50 yrs @ bh) ranging from 9 to 11 m. Site index decreases with increasing elevation and decreasing aeration. When accounting for 'low-productivity' sample plots within the SbPl – Moss and Sb – Wood Horsetail site associations, the growth performance of black spruce on these sites and tamarack sites is approximately within the same range - between 9 and 11 m. This suggests that neither a moderate water deficit nor water surplus have a significant influence on black spruce growth. A long-lasting snow cover and somewhat restricted outflow of excess groundwater result in a very slowly moving groundwater table. Accumulation of organic materials in these sites progresses at a greater rate than their decomposition, which results in the development of a thick forest floor soon after disturbance.

The wet to very wet indicator species group predominates in the soil moisture spectrum, while the presence of water-deficient indicator species groups, which is considered to be indicative of fluctuating soil moisture conditions, is minor (Figure 13). As in all other site associations on nutrient poor sites, the indicators of a low availability of soil nitrogen (Figure 12) dominate the soil nutrient spectrum almost entirely.

Figure 17. A dense stand of black spruce in the stem exclusion developmental stage on a wet, nutrient poor Sb – Tamarack site. Note the random group (cluster) tree distribution pattern that is characteristic of wet sites.

500 SbSw – Soopolallie site association

(References: Tables 6 and 7; Figures 11, 12, 13, and 18; Appendix 14)

Submontane to montane, slightly dry (infrequently with a fluctuating water table), nutrient-medium and richer, well aerated to adequately aerated soils on water shedding sites

The SbSw – Soopolallie site association, a nutrient-richer counterpart to the SbPl – Moss site association (Figure 11), was derived from the Picea glauca & mariana – Viburnum edule: Shepherdia canadensis (211) plant subassociation, which was found to be distributed in the BWBS zone and in the SBSdk and SBSdw subzones. Compared to the SbPl – Moss site association, the Soopolallie sites are distinguished by a higher proportion of deciduous trees (*Populus tremuloides*), deciduous shrubs (*e.g.*, *Shepherdia canadensis* and *Viburnum edule*), and herbs. The central edaphic concept (typic site type) is represented by moderately deep, loamy-skeletal Brunisols or Luvisols, which have developed on mid- and lower slopes, and occasionally on flat terrain. The associated humus forms are Mors (Hemimors) or Moders (Mormoders and Leptomoders). The potential aberrant site types are shallow and gleyed (Appendix 14).

The SbSw – Soopolallie site association represents generally medium- to high-productivity sites for growth of lodgepole pine, white spruce, black spruce, and trembling aspen, with the black spruce site index (50 yrs @ bh) ranging from 10 to 14 m. Apart from climatic constraints, cool soils are thought to be the principal growth constraint. The soil moisture spectrum of this site association is dominated by the moderately dry to fresh and fresh to very moist indicator species groups; however, the very dry to moderately dry group is also well represented (Figure 13). This combination suggests slightly dry soil moisture conditions. The soil nutrient spectrum shows that the nitrogen-rich indicator species group is well represented (>5% relative frequency) signifying a rich SNR (Figure 12).

Figure 18. A semi-open canopy of a lodgepole pine and black spruce mixture on a SbSw – Soopolallie site in the SBSdw subzone (sample plot 89). Although the black spruce site index (50 yrs @ bh) of 11.2 m is unimpressive, note that at the breast height age of about 85 years, black spruce trees have developed into the upper canopy.

600 SbSw – Common Mitrewort site association

(References: Tables 6 and 7; Figures 11, 12, 13, 19 and 20; Appendix 15)

Submontane to montane, fresh, moist, and very moist (frequently with a fluctuating water table and restricted aeration), nutrient-medium and richer soils on water-receiving sites.

The SbSw – Common Mitrewort site association, a nutrient-richer counterpart to the Sb – Wood Horsetail site association, was derived from the Picea glauca & mariana – Viburnum edule: Mitella nuda (212) plant subassociation. It is found predominantly in the BWBSmw subzone, but is not limited to this subzone. The central edaphic concept (typic site type) is represented by moderately deep, fine loamy-skeletal, gleyed Brunisols or Luvisols that have developed on gentle (<5%) lower slopes or on flat terrain. The associated humus forms are Mors (Hemimors and Rhizomors) or Moders (Mormoders). The potential aberrant site types are clayey (sandy clay, clay, silty clay), gleysolic, and organic (Appendix 15).

Compared to the Sb – Wood Horsetail site association, these common mitrewort sites are distinguished by a higher proportion of deciduous trees (*Populus trichocarpa* and *P. tremuloides*), deciduous shrubs (*e.g.*, *Lonicera involucrata* and *Viburnum edule*), and herbs (*e.g.*, *Epilobium angustifolium*, *Mertensia paniculata*, and *Mitella nuda*). The soil moisture spectrum of this site association is dominated by the moderately dry to fresh and fresh to very moist indicator species groups; however, the very moist to wet and wet to very wet groups are also well represented (Figure 13). The soil nutrient spectrum shows that the nitrogen-rich indicator species group is represented with a mean relative frequency of >9%, which signifies a medium SNR (Figure 12). The SbSw – Common Mitrewort site association represents generally medium- to high-productivity sites for the growth of lodgepole pine, white spruce, black spruce, balsam poplar, and trembling aspen. The black spruce site index (50 yrs @ bh) ranges from 8 to nearly 14 m. Apart from climatic constraints, cool soils are thought to be the principal growth constraint. Site index decreases with increasing elevation and decreasing depth of the water table; the values <9 m are characteristic of very moist organic soils.

Figure 19. A fully stocked, 78 year-old (@ bh) black spruce stand in the early understory reinitiation developmental stage on a moist, nutrient medium SbSw – Common mitrewort site in the BWBSmw subzone (sample plot 111). Note the larger cover of deciduous shrubs and herbs underneath a less dense canopy.

Figure 20. A canopy profile of a 70 year-old (@ bh) black spruce stand in the early understory reinitiation developmental stage on a moist, nutrient medium SbSw – Common mitrewort site in the SBSdk subzone. Note the development of club-like crown tops.

700 SbSw – Meadow Horsetail site association

(References: Tables 6 and 7; Figures 11, 12, 13 and 21; Appendix 16)

Submontane to montane, wet (infrequently with a fluctuating water table), poorly aerated, and nutrient-medium and richer soils on water-collecting sites

The SbSw – Meadow Horsetail site association, a nutrient-richer counterpart to the Sb – Tamarack site association (Figure 11), was derived from the Picea glauca & mariana – Equisetum pratense (220) plant association, and is found predominantly in the BWBSmw and BWBSwk subzones. The central edaphic concept is represented by organic soils that have developed on flat terrain and in depressions. The associated humus forms are primarily Moders (Saprimoders). No potential aberrant site types have been distinguished.

Vegetation of the azonal meadow horsetail sites displays a distinct mound-depression pattern. The discontinuous and clumpy forest canopy is due to the presence of small water pools inhibiting the establishment of terrestrial vegetation, and due to windthrow. Successful regeneration and productive growth of trees is confined to drier, raised mounds of organic materials, which originated from stumps and uprooted trees. Compared to the Sb – Tamarack site association, the meadow horsetail sites are distinguished by a higher proportion of deciduous shrubs (*Salix* spp.), ferns and allies (*Equisetum* spp), graminoids (*Carex* spp.), and herbs (*e.g.*, *Angelica genuflexa*, *Mertensia paniculata*, and *Mitella nuda*).

The soil moisture spectrum of these meadow horsetail sites is dominated by the very moist to wet and wet to very wet indicator species groups (Figure 13), and is indicative of a high (about 30 cm deep) growing-season water table. The soil nutrient spectrum shows that the nitrogen-rich indicator species group is represented with the mean frequency of approximately 20%, signifiying a medium to rich SNR (Figure 12). The SbSw – Meadow Horsetail site association represents low-productivity sites for growth of white spruce, tamarack, and black spruce. The black spruce site index (50 yrs @ bh) is probably higher than 6.3 m (likely comparable to tamarack sites) but it was measured in only one of the three sampled plots. Cool soils (possibly with permafrost lenses) are thought to be the principal edaphic growth constraint. A long-lasting snow cover and somewhat restricted outflow of excess groundwater result in a nearly stagnant groundwater table.

Figure 21. A dense 95 year-old (@ bh) black spruce stand in the late stem exclusion developmental stage on a wet, nutrient-medium SbSw – Meadow Horsetail site in the BWBSmw subzone. Due to very low light conditions, the understory vegetation is poorly developed.

800 (Sb) – Swamp Birch site association

(References: Tables 6 and 7; Figures 11, 12, and 13)

Submontane to montane, very wet, very poorly aerated, nutrient-medium and richer soils on water-collecting sites

The (Sb) – Swamp Birch site association was derived from the insufficiently sampled, tentative Picea mariana – Betula nana (310) plant association. Our sample was located in the SBSdk subzone in a depression that featured a waterlogged Humisol, with a Saprimoder. Values of the other environmental characteristics are found in Table 7. The (Sb) – Swamp Birch association represents low-productivity sites for the growth of black spruce. The Black spruce site index (50 yrs @ bh) was 9, which was within the range of the closely related the Sb – Tamarack site association. The wet to very wet indicator species group predominated in the soil moisture spectrum (Figure 13); the frequency of nitrogen-rich indicator species was >20 %, signifying a medium to rich SNR (Figure 12). Since this tentative site association was only represented by one plot, it was not compared to site series recognized by the Ecological Program Staff of the BC Ministry of Forests.

Site Index in Relation to Ecological Measures of Site Quality

For all samples, the range of black spruce site index extended from 4.7 to 14.0 m (Table 9). Even when grouped according to various ecological measures of site quality, the within-group range of site index was wide. Analysis of variance indicated a lack of significant differences ($P > 0.05$) in mean site index between (1) the BWBS zone and the SBS study subzones, and (2) the three subzones of the BWBS zone (Table 9). The lack of difference between the means of subzones, or even between the BWBS and SBS zone suggests that (1) climate and its variability in the studied biogeoclimatic units is similar, and (2) the precipitation difference between the subzones and zones is not likely an important growth factor. Of all other climate-related measures (elevation, latitude, longitude, aspect, and slope), only elevation was significantly, albeit weakly, related to site index ($r^2 = 0.07$, $P < 0.05$, Eq. [1], Figure 22). A multiple linear regression showed that black spruce site index decreased 0.4 m with every 100 m increase in elevation, and 0.3 m with every one degree increase in latitude (Eq. [2], Table 10); however, although significant, this equation accounted for little of the variation about the mean ($R^2 = 0.13$).

Table 9. Summary of the black spruce site index data stratified according to selected categorical variables: biogeoclimatic zone, slope aspect, slope position, actual soil moisture regime, soil nutrient regime, and site association.

Category	Class	Abbreviation	Number of plots	Mean site index (range)
Biogeoclimatic zone	Boreal Black and White Spruce	BWBS	60	9.8 (4.7 - 14.0)
	Sub-boreal Spruce	SBS	22	10.2 (8.6 - 13.2)
Aspect	North (slope > 3%, azimuth 315°- 45°)	N	13	10.1 (7.8 - 12.7)
	East (slope > 3%, azimuth 45°-135°)	E	6	10.1 (6.1 - 13.9)
	South (slope > 3%, azimuth 135°-225°)	S	10	9.8 (7.0 - 13.5)
	West (slope > 3%, azimuth 225°-315°)	W	13	8.7 (4.7 - 11.6)
	Flat (slopes ≤ 3%)	F	40	10.2 (5.2 - 14.0)
Slope	Flat (≤ 3%)	F	40	10.2 (5.2 - 14.0)
	Gentle (3.1 - 10%)	GL	24	9.7 (4.7 - 13.9)
	Moderate (10.1 - 15%)	MD	8	9.7 (7.0 - 13.5)
	Steep (>15%)	ST	10	9.4 (7.2 - 12.2)
Soil order	Brunisolic	BRUN	8	11.3 (8.6 - 13.9)
	Podzolic	PODZ	17	10.0 (7.4 - 14.0)
	Gleysolic	GLEY	6	11.9 (9.5 - 13.8)
	Luvisolic	LUV	30	10.1 (6.1 - 14.0)
	Organic	ORG	21	8.4 (4.7 - 11.0)
Actual Soil Moisture Regime (SMR)	Moderately Dry	MD	3	8.6 (7.3 - 9.4)
	Slightly Dry	SD	21	10.4 (7.3 - 13.9)
	Fresh and Moist	F/M	30	10.3 (7.0 - 14.0)
	Very Moist	VM	20	9.0 (4.7 - 14.0)
	Wet	W	7	9.5 (6.3 - 11.6)
	Very wet	VW	1	9.2
Soil nutrient Regime (SNR)	Very poor	VP	18	8.8 (4.7 - 13.2)
	Poor	P	33	9.2 (6.1 - 13.5)
	Medium	MED	21	11.3 (9.1 - 14.0)
	Rich	R	9	10.7 (6.3 - 14.0)
	Very rich	VR	1	11.6
Site association	SbPl - Lichens	SA100	4	8.9 (7.3 - 9.9)
	SbPl - Moss	SA200	15	9.7 (7.3 - 13.5)
	Sb - Wood Horsetail	SA300	25	8.6 (4.7 - 11.5)
	Sb - Tamarack	SA400	7	9.6 (6.9 - 11.6)
	SbSw - Soopalallie	SA500	6	12.1 (10.4 - 13.9)
	SbSw - Common Mitrewort	SA600	23	11.2 (7.8 - 14.0)
	SbSw - Meadow Horsetail	SA700	1	6.3
	(Sb) - Swamp Birch	SA800	1	9.2

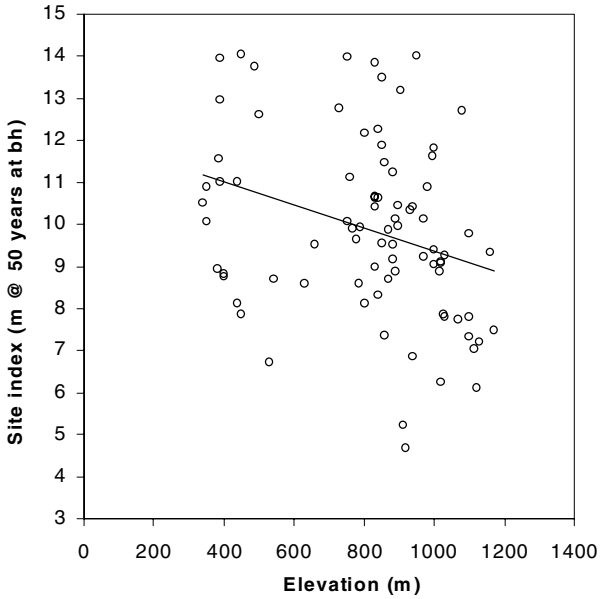

Figure 22. Black spruce site index in relation to elevation. The fitted regression line is Site Index = 12.08 - 0.2683 (elevation); $R^2 = 0.07$, standard error of estimates 2.03 m, P <0.01.

Table 10. Regression models for predicting black spruce site index from climatic and edaphic variables (n = 78). The abbreviations for the variables are: SI = site index; ELEV = elevation (100 m); LAT = latitude; SEE = standard error of the estimate.

	Factors	Model	P	adj-R^2	SEE
[1]	elevation	SI = 12.08 - 0.2683(ELEV)	0.0068	0.07	2.03
[2]	elevation, latitude	SI = 33.3999 - 0.3510(LAT) - 0.4261(ELEV)	0.0028	0.12	1.99
[3]	soil order	SI = 8.45 + 2.83(BRUN) + 3.45(GLEY) + 1.56(LUV) + 1.76(PODZ)	0.0006	0.19	1.91
[4]	soil order, elevation	SI = 10.81 + 2.85 (BRUN) + 2.65(GLEY) 2.19(LUV) + 2.40(PODZ) - 0.33(ELEV)	0.0001	0.28	1.79
[5]	SNR	SI = 8.84 + 0.43(P) + 2.65(MED) + 2.45(R)	0.0001	0.25	1.83
[6]	SNR, elevation	SI = 10.80 + 0.77(P) + 2.69(MED) + 2.79(R) - 0.27(ELEV)	0.0001	0.33	1.73
[7]	SMR	SI = 9.25 +1.19(SD) + 1.02(F/M) - 0.28(VM) + 0.84(W)	0.1772	0.03	2.09
[8]	SMR, elevation	SI = 13.32 + 0.58(SD) + 0.44(F/M) - 1.45(VM) - 1.13(W) - 0.40(ELEV)	0.0010	0.19	1.91
[9]	SMR, SNR	SI = 9.25 - 0.22(SD) - 0.82(F/M) - 1.22(VM) + 0.62(W) + 0.45(P) + 3.05(MED) + 2.34(R)	0.0001	0.31	1.76
[10]	SMR, SNR, elevation	SI = 12.51 - 0.44(SD) -1.33(F/M) - 2.24(VM) - 1.12(W) + 0.76(P) + 2.87(MED) + 2.45(R) - 0.33(ELEV)	0.0001	0.40	1.63
[11]	SMR, SNR, SMR×SNR	SI = 9.25 + 1.35(SD) - 0.97(F/M) - 1.70(VM) + 0.34(W) - 1.10(P) + 2.54(MED) + 0.98(R) + 2.16(F/M×P) + 0.35(F/M×MED) + 1.75(F/M×R) + 1.92(VM×P) + 1.91(VM×MED) + 2.10(W×P)	0.0003	0.30	1.77
[12]	SMR, SNR, SMR×SNR, elevation	SI = 13.00 + 1.01(SD) - 2.27(F/M) - 2.82(VM) - 1.89(W) - 1.18(P) +1.25(MED) + 0.61(R) + 3.38(F/M×P) + 2.10(F/M×MED) + 3.01(F/M×R) + 2.18(VM×P) + 2.98(VM×MED) + 3.01(W×P)- 0.37(ELEV)	0.0001	0.42	1.59
[13]	site association	SI = 9.46 + 0.23(SA200) - 0.83(SA300) + 0.17(SA400) + 2.61(SA500) + 1.75(SA600)	0.0001	0.26	1.82
[14]	site association, elevation	SI = 12.08 + 0.06(SA200) - 1.25(SA300) - 0.87(SA400) + 2.02(SA500) + 1.28(SA600) - 0.27(ELEV)	0.0001	0.34	1.72

Analysis of variance detected significant differences (P <0.05) in site index between soil orders (Figure 23). Site index of black spruce increased in order from Organics to Podzols to Luvisols to Brunisols to Gleysols, with Brunisols and Gleysols having significantly higher site index than Organics (Table 9). Site index of black spruce on Organics (typically poorly aerated, water-surplus soils) was 1.8 m lower, and on Gleysols (typically non-water deficient and nutrient-richer sites) 1.7 m higher, than the mean of the other soil orders combined. These relationships are complex because several edaphic factors such as soil moisture (drainage), nutrients, aeration, and temperature are integrated into soil orders.

The black spruce site index did not differ significantly along the soil moisture gradient (which was confounded with the soil nutrient gradient). Examination of the trend of black spruce site index along the soil nutrient gradient (albeit confounded with the soil moisture gradient) showed an increase from the very poor to poor to medium sites (Figure 24). Significant differences occurred only between medium and very poor sites, while poor and rich sites were not significantly different from either very poor or medium sites. The site index on sites with a medium SNR was 1.6 m higher than the mean site index for all other SNRs combined. The lack of significant differences in site index between soil moisture regimes suggests that within a boreal climate shallow-rooted black spruce is not growth-sensitive to soil moisture. The narrow range in site index between very poor and rich sites suggests that black spruce is marginally growth-sensitive to an increasing supply of soil nutrients within a boreal climate. The pattern of predicted site index placed on the edatopic gird (Table 11) emphasized the relatively small differences in site index between soil moisture and nutrient conditions. This suggests that one or more factors not measured in this study has an overriding influence on tree growth.

Among the five site associations that could be tested, significant differences (P <0.05) in site index were detected only between the Sb - Wood Horsetail association (mean site index of 8.6 m) and the SbSw - Soopolallie and SbSw - Common Mitrewort associations (mean site index of 12.1 and 11.2 m, respectively); there were no significant differences in site index between the SbPl - Lichens, SbPl - Moss, and Sb - Tamarack associations (Table 9, Figure 25). Black spruce site index on the SbSw - Soopolallie sites was 3 m higher, and on the SbSw - Common Mitrewort sites 2.1 m higher, than the mean of all other site associations combined. Regardless of moisture, site index appeared to increase from nutrient-poorer to -richer sites as illustrated by comparing moisture-equivalent associations: SbPl - Moss *versus* SbSw - Soopolallie and Sb - Wood Horsetail *versus* SbSw - Common Mitrewort site associations. The Sb - Wood Horsetail site association reflects adverse soil moisture, nutrient, aeration, and temperature conditions, while the SbSw - Soopolallie site association reflects the optimum soil aeration, temperature, and nutrient conditions for black spruce growth.

In addition to the two climate models, twelve regression models using a combination of variables related to soil conditions (with or without elevation) were developed to quantify site index-site quality relationships, and to determine the precision of the predictions of black spruce site index (Eqs. [3] to [14], Table 10). Except for model [7], which used only SMRs, the remaining models were significant at P <0.01. The addition of elevation into the models decreased the SEE and increased the R^2 in all cases (compare equations [3] and [4]; [5] and [6]; [7] and [8]; [9] and [10]; [11] and [12]; [13] and [14]). There were three groupings of precision: models [10] and [12] had the lowest SEE and highest R^2; followed by models [6] and [14]. Finally, models [9], [11], and [13] are at the limits of acceptable precision. As the average site index for the edatopic grid is around 10 m, the SEE from our best regression of 1.59 m is about 16% of the average site index. The mean site index predicted by equation [9] (Table 10) for combinations of soil moisture and nutrient regimes and the confidence and prediction intervals were placed on the edatopic grid of the BEC system (Table 11).

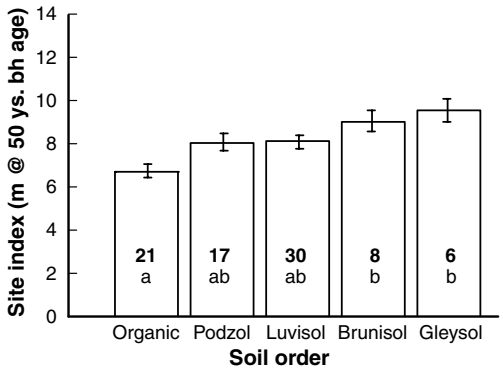

Figure 23. Black spruce site index in relation to soil orders. Error bars are one standard error of the mean; the numbers in bars are numbers of sample plots; bars with the same lowercase letter are not significantly different ($P < 0.05$; Tukey's test).

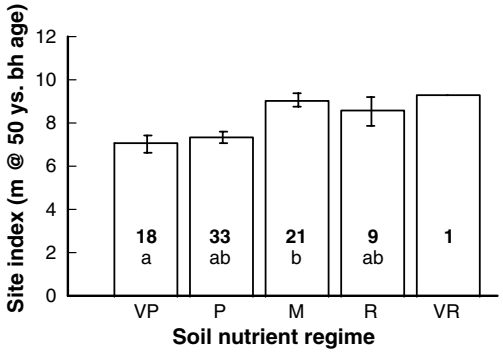

Figure 24. Black spruce site index in relation to soil nutrient regime (SNR). Abbreviations for SNRs as in Table 1. Error bars are one standard error of the mean; the numbers in bars are numbers of sample plots; bars with the same lowercase letter are not significantly different ($P < 0.05$; Tukey's test).

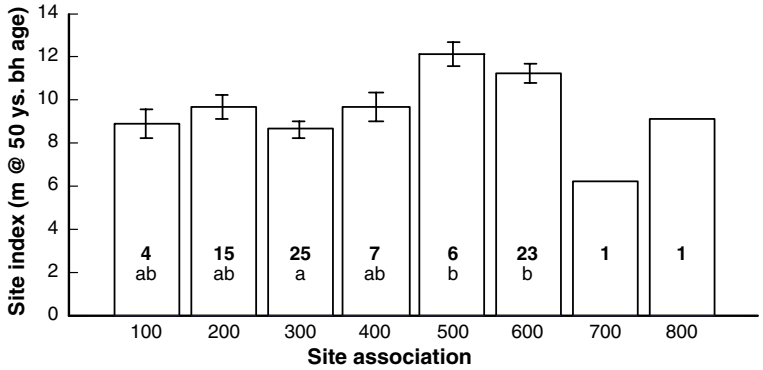

Figure 25. Black spruce site index in relation to site associations. Abbreviations for site associations as in Table 1. Error bars are one standard error of the mean; the numbers in bars are numbers of sample plots; bars with the same lowercase letter are not significantly different ($P < 0.05$; Tukey's test).

The use of soil moisture and nutrient regimes for quantifying site index relationships has once again shown to be useful. In the case of the BWBS zone however, elevation appears to be a useful surrogate for climate, reflecting an increase in site index with increasing temperature. Although the coefficients of determination for the regression models for black spruce are lower compared to other to cool temperate and mesothermal tree species, this was probably simply due to the small range of mean site index. The smallest predicted site index for any cell on the edtopic grid was 8.03 m and the largest site index was 12.53 m (Table 11). This range is very small when compared to coastal Douglas-fir (*Pseudotsuga menziesii*), for example, in comparable SMRs and SNRs site index ranges from 20 to 40 (Klinka and Carter 1990). However, our SEE is relatively large compared to other regression models developed for other species of BC. Generally, the SEEs are in the range of 10% of the average site index for the respective edatopic grids, whereas for black spruce the SEE is 16% of the average site index. The prediction intervals are rather large, thus limiting the applicability of the models in predicting the future site index of a given stand based on soil moisture and nutrient regime. However, the model describes the mean site index well across the edatopic grid.

Two other studies, by Krajina (1969) and the BC Ministry of Forests (1997), have quantified site index across the edatopic grid in the BWBS zone. The values in this study are close to those of Krajina (1969), who also suggested very low site index values. The highest site index for black spruce in the BWBS zone was 15 m in 100 years, which is reasonable compared to our 50 year base age site index values. However, Krajina (1969) proposed that the largest mean site index value would occur on very moist/poor sites, whereas this study suggests the largest site index occurs on slightly dry/medium sites. Direct comparisons with BC Ministry of Forests SIBEC data is difficult, since we used actual SMRs as opposed to the relative SMRs used by the Ministry of Forests, and our site associations differ from theirs. However, the SIBEC site index values for the BWBSdk1 and 2 variants are generally in the low range (around 10), while the site index values of 15 for the BWBSmw1 and 2 variants seem too high. The site index values of the BWBS zone for black spruce are rated as having low reliability; therefore we suggest that the site index values of 15 be replaced with our highest estimates for site index of 12.

Regional differences in black spruce site index have been attributed to climatic factors, and differences within regions to soil moisture and soil nutrients (Viereck and Johnston 1990). Jeglum (1974) found site index to be predominantly related to the moisture-aeration regime, and on waterlogged organic soils, water movement and chemistry appear to be most important growth determinants (Heinselman 1970). However, this study suggests that neither climate, soil moisture regime, nor soil nutrient regime accounts satisfactorily for differences in site index on different sites. It is likely that soil temperature is the most influential growth factor in the BWBS zone, and this requires further investigation.

Table 11. Mean site index (m @ 50 years breast height age), 95% confidence interval (m), 95% prediction interval (in parentheses), and sample size for each combination of SMR and SNR for black spruce in the BWBS zone using equation [9] (See Table 10).

Actual Soil moisture regime	Soil nutrient regime: very poor	poor	medium	rich
moderately dry	**9.25** ±2.49 (±4.31) n = 2			
slightly dry	**9.47** ±1.16 (±3.71) n = 4	**9.92** ±0.88 (±3.63) n = 11	**12.53** ±1.18 (±3.71) n = 2	**11.81** ±1.35 (±3.77) n = 4
fresh - moist	**8.43** ±1.20 (±3.72) n = 2	**8.88** ±0.88 (±3.63) n = 10	**11.49** ±0.85 (±3.62) n = 13	**10.77** ±1.35 (±3.77) n = 4
very moist	**8.03** ±1.05 (±3.67) n = 7	**8.48** ±0.95 (±3.64) n = 8	**11.09** ±1.11 (±3.69) n = 5	
wet	**9.87** ±1.54 (±3.84) n = 3	**10.32** ±1.54 (±3.84) n = 3		

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APPENDICES

Appendix 1. List of all plant species (arranged alphabetically) found in the mid-seral black spruce ecosystems in northern British Columbia sampled in this study. Scientific nomenclature follows Qian and Klinka (1998).

Scientific name	Common name	Authority
Abies lasiocarpa	subalpine fir	(Hook.) Nutt.
Achillea millefolium	yarrow	L.
Actaea rubra	baneberry	(Ait.) Willd.
Agrostis mertensii	northern bentgrass	Trin.
Alectoria sarmentosa	common witch's hair	(Ach.) Ach.
Alnus incana (=Alnus tenuifolia)	gray alder	(L.) Moench
Alnus viridis	green alder	(Vill.) Lam & D.C.
Amblystegium riparium		(Hedw.) Schimp
Amelanchier alnifolia	saskatoon	(Nutt.) Nutt. ex M. Roemer
Anemone parviflora	northern anemone	Michx.
Angelica genuflexa	kneeling angelica	Nutt.
Antennaria racemosa	racemose pussytoes	Hook.
Aquilegia formosa	red columbine	Fisch. ex DC.
Aralia nudicaulis	wild sarsaparilla	L.
Arctostaphylos alpina	alpine bearberry	(L.) Spreng.
Arctostaphylos uva-ursi	kinnikinnick	(L.) Spreng.
Arnica cordifolia	heart-leaved arnica	Hook.
Aster ciliolatus	Lindley's aster	Lindl.
Aster conspicuus	showy aster	Lindl.
Aster modestus	great northern aster	Lindl.
Aster sibiricus	arctic aster	L.
Aulacomnium palustre	glow moss	(Hedw.) Schwaegr.
Barbilophozia hatcheri		(Evans) Loeske
Barbilophozia kunzeana		(Hub.) Gams.
Betula nana (=Betula glandulosa)	swamp birch	L.
Betula papyrifera	paper birch	Marsh.
Brachythecium spp.	ragged moss	
Bryum spp.		
Calamagrostis canadensis	bluejoint	(Michx.) Beauv.
Calamagrostis rubescens	pinegrass	Buckl.
Calliergon cordifolium		(Hedw.) Kindb.
Calliergon giganteum	giant water moss	(Schimp.) Kindb.
Calliergon stramineum		(Brid.) Kindb.
Calypso bulbosa	fairyslipper	(L.) Oakes
Campylium stellatum		(Hedw.) C. Jens.
Carex concinna	low northern sedge	R. Br.
Carex disperma	soft-leaved sedge	Dewey
Carex rossii	Ross' sedge	Boott
Carex spectabilis	showy sedge	Dewey
Carex spp.	sedge	
Castilleja miniata	scarlet paintbrush	Dougl. ex Hook.
Cetraria ericetorum	icelandmoss	Opiz
Cinna latifolia	nodding wood-reed	(Trev. ex Goepp.) Griseb.
Cladina arbuscula		(Wallr.) Hale & Culb.
Cladina rangiferina	grey reindeer lichen	(L.) Nyl.
Cladina stellaris		(Opiz) Brodo
Cladonia cenotea	powdered pixie-funnel	(Ach.) Schaerer
Cladonia cervicornis		(Ach.) Flotow
Cladonia chlorophaea	peppered pixie-cup	(Färke ex Sommerf.) Sprengel
Cladonia cornuta	greater pixie stick	(L.) Hoffm.
Cladonia crispata		(Ach.) Flotow
Cladonia ecmocyna	orange-footed pixie	Leighton
Cladonia gracilis		(L.) Willd.
Cladonia multiformis	slotted pixie-cup	G. Merr.
Cladonia phyllophora		Hoffm.
Cladonia sulphurina	sulphur cladonia	(Michaux) Fr.
Cladonia uncialis		(L.) F. H. Wigg.
Clintonia uniflora	queen's cup	(Menzies ex J.A. & J.H. Schultes) Kunth
Coeloglossum viride	long-bracted frog orchid	(L.) Hartman

Scientific name	Common name	Authority
Comandra umbellata	California comandra	(L.) Nutt.
Coptis trifolia	three-leaved goldthread	(L.) Salisb.
Corallorhiza trifida	yellow coralroot	Chatelain
Cornus canadensis	bunchberry	L.
Cornus stolonifera	red-osier dogwood	Michx.
Cystopteris montana	mountain bladder fern	(Lam.) Bernh. ex Desv.
Delphinium glaucum	tall larkspur	S. Wats.
Dicranella palustris		(Dicks.) Crundw. ex Warb.
Dicranum affine		Funck
Dicranum fuscescens	curly heron's-bill moss	Turn.
Dicranum polysetum	wavy-leaved moss	Sw.
Dicranum scoparium	broom moss	Hedw.
Dicranum spp.		
Disporum hookeri	Hooker's fairybells	(Torr.) Nichols.
Distichium capillaceum		(Hedw.) Bruch & Schimp.
Drepanocladus exannulatus		(Schimp.) Warnst.
Drepanocladus uncinatus	sickle moss	(Hedw.) Warnst.
Drosera rotundifolia	round-leaved sundew	L.
Elliottia pyroliflorus (=Cladothamnus pyroliflorus)	copperbush	(Bong.) S.W. Brim & P.F. Stevens
Elymus glaucus	blue wildrye	Buckl.
Elymus repens	quackgrass	(L.) Gould
Empetrum nigrum	crowberry	L.
Epilobium angustifolium	fireweed	L.
Epilobium ciliatum	purple-leaved willowherb	Raf.
Epilobium glaberrimum	smooth willowherb	Barbey
Equisetum arvense	common horsetail	L.
Equisetum fluviatile	swamp horsetail	L.
Equisetum pratense	meadow horsetail	Ehrh.
Equisetum scirpoides	dwarf scouring-rush	Michx.
Equisetum sylvaticum	wood horsetail	L.
Eriophorum angustifolium	narrow-leaved cotton-grass	Honckeny
Eurhynchium pulchellum		(Hedw.) Jenn.
Evernia mesomorpha	spruce moss	Nyl.
Festuca altaica	Altai fescue	Trin.
Festuca occidentalis	western fescue	Hook.
Flavocetraria nivalis	ragged snow	(L.) Kärnefelt & Thell
Fragaria virginiana	wild strawberry	Duchesne
Frangula purshiana (=Rhamnus purshiana)	cascara	(D.C.) Cooper
Galium bifolium	thin-leaved bedstraw	S. Wats.
Galium boreale	northern bedstraw	L.
Galium triflorum	small bedstraw	L.
Gentianella amarella	northern gentian	(L.) Boerner
Geocaulon lividum	bastard toad-flax	(Richards.) Fern.
Geum macrophyllum	large-leaved avens	Willd.
Goodyera oblongifolia	rattlesnake-plantain	Raf.
Goodyera repens	dwarf rattlesnake orchid	(L.) R. Br. ex Ait. f.
Gymnocarpium dryopteris	oak fern	(L.) Newman
Heracleum maximum	cow-parsnip	Bartr.
Hylocomium splendens	step moss	(Hedw.) Schimp.
Hypogymnia austerodes	powdered bone	(Nyl.) Räsänen
Hypogymnia physodes	monk's-hood	(L.) Nyl.
Icmadophila ericetorum	spraypaint	(L.) Zahlbr.
Impatiens noli-tangere	common touch-me-not	L.
Jungermannia leiantha		Grolle
Juniperus communis	common juniper	L.
Larix laricina	tamarack	(Du Roi) K. Koch
Lathyrus nevadensis	purple peavine	S. Wats.
Lathyrus ochroleucus	creamy peavine	Hook.
Ledum groenlandicum	Labrador tea	Oeder
Leymus innovatus	fuzzy-spiked wildrye	(Beal) Pilger
Linnaea borealis	twinflower	L.
Listera cordata	heart-leaved twayblade	(L.) R. Br. ex Ait. f.
Lonicera involucrata	black twinberry	(Richards.) Banks ex Spreng.
Lonicera utahensis	Utah honeysuckle	S. Wats.

Scientific name	Common name	Authority
Lupinus arcticus	arctic lupine	S. Wats.
Luzula parviflora	small-flowered woodrush	(Ehrh.) Desv.
Lycopodium annotinum	stiff clubmoss	L.
Lycopodium complanatum	ground-cedar	L.
Lycopodium dendroideum	ground-pine	Michx.
Lysichiton americanum	skunk cabbage	Hult. & St. John
Maianthemum canadense	wild lily-of-the-valley	Desf.
Maianthemum racemosum (=Smilacina racemosa)	False Solomon's seal	(L.) Link
Maianthemum stellatum (=Smilacina stellata)	star-flowered false Solomon's seal	(L.) Link
Maianthemum trifolium (=Smilacina trifolia)	three-leaved false Solomon's seal	(L.) Sloboda
Malaxis brachypoda		(Gray) Fern.
Menyanthes trifoliata	buckbean	L.
Menziesia ferruginea	false azalea	Sm.
Mertensia paniculata	tall bluebells	(W. Ait.) G. Don
Mitella nuda	common mitrewort	L.
Mnium spinulosum	Menzies' red-mouthed mnium	Bruch & Schimp. in B.S.G.
Moneses uniflora	single delight	(L.) A. Gray
Nephroma arcticum	green light	(L.) Torss.
Orthilia secunda	one-sided wintergreen	(L.) House
Oryzopsis asperifolia	rough-leaved ricegrass	Michx.
Osmorhiza berteroi (=Osmorhiza chilensis)	mountain sweet-cicely	D.C.
Oxycoccus oxycoccos	bog cranberry	(L.) MacM.
Parmelia sulcata	waxpaper	Taylor
Parnassia palustris	northern grass-of-Parnassus	L.
Pedicularis bracteosa	bracted lousewort	Benth.
Pedicularis labradorica	Labrador lousewort	Wirsing
Peltigera aphthosa	freckle pelt	(L.) Willd.
Peltigera malacea	apple pelt	(Ach.) Funck
Peltigera membranacea	greater dog pelt	(Ach.) Nyl.
Peltigera neopolydactyla	greater frog pelt	(Gyelnik) Gyelnik
Peltigera praetextata	born-again pelt	(Färke ex Sommerf.) Zopf
Peltigera scabrosa	toad pelt	Th. Fr.
Pentaphylloides floribunda (=Potentilla fruticosa)	Shrubby cinqfoil	(Pursh.) A. Löve
Petasites frigidus	sweet coltsfoot	(L.) Fries
Petasites sagittatus	arrow-leaved coltsfoot	(Banks ex Pursh) A. Gray
Phleum alpinum	alpine timothy	L.
Picea glauca	white spruce	(Moench) Voss
Picea mariana	black spruce	(P. Mill.) B.S.P.
Pinus contorta	lodgepole pine	Dougl. ex Loud.
Plagiochila aspleniformis		Schust.
Plagiomnium ciliare		(C. Müll.) Kop.
Plagiomnium ellipticum		(Brid.) T. Kop.
Platanthera obtusata	one-leaved rein orchid	(Banks ex Pursh) Lindl.
Platanthera orbiculata	large round-leaved rein orchid	(Pursh) Lindl.
Pleurozium schreberi	red-stemmed feathermoss	(Brid.) Mitt.
Poa spp.	bluegrass	
Pohlia spp.		
Polemonium caeruleum	tall Jacob's-ladder	L.
Polytrichum commune		Hedw.
Polytrichum juniperinum	juniper haircap moss	Hedw.
Polytrichum piliferum	awned haircap moss	Hedw.
Polytrichum strictum	bog haircap moss	Brid.
Populus balsamifera	balsam poplar	L.
Populus tremuloides	trembling aspen	Michx.
Ptilidium pulcherrimum		(G. Web.) Hampe
Ptilium crista-castrensis		(Hedw.) De Not.
Pulsatilla patens(=Anemone patens)	prairie crocus	(L.) P. Mill
Pyrola asarifolia	pink wintergreen	Michx.
Pyrola chlorantha	green wintergreen	Sw.
Pyrola elliptica	white wintergreen	Nutt.
Pyrola minor	lesser wintergreen	L.
Ranunculus eschscholtzii	subalpine buttercup	Schlecht.
Rhizomnium glabrescens	fan moss	(Kindb.) T. Kop
Rhizomnium pseudopunctatum		(Bruch & Schimp.)T. Kop.

Scientific name	Common name	Authority
Rhytidiadelphus triquetrus	electrified cat's-tail moss	(Hedw.) Warnst.
Ribes hudsonianum	northern blackcurrant	Richards.
Ribes lacustre	black gooseberry	(Pers.) Poir.
Ribes triste	red swamp currant	Pallas
Rosa acicularis	prickly rose	Lindl.
Rubus chamaemorus	cloudberry	L.
Rubus idaeus	red raspberry	L.
Rubus parviflorus	thimbleberry	Nutt.
Rubus pedatus	five-leaved bramble	Sm.
Rubus pubescens	trailing raspberry	Raf.
Salix bebbiana	Bebb's willow	Sarg.
Salix glauca	grey-leaved willow	L.
Salix lucida	shining willow	Muhl.
Salix myrtillifolia	bilberry willow	Anderss.
Salix scouleriana	Scouler's willow	Barratt ex Hook.
Salix spp.	willow	
Sambucus racemosa	red elderberry	L.
Sanguisorba canadensis	Sitka burnet	L.
Senecio triangularis	arrow-leaved groundsel	Hook.
Shepherdia canadensis	soopolallie	(L.) Nutt.
Solidago spathulata	spike-like goldenrod	DC.
Solorina crocea	chocolate chip	(L.) Ach.
Sorbus scopulina	western mountain-ash	Greene
Sphagnum capillifolium	small red peat moss	(Ehrh.) Hedw.
Sphagnum fuscum	rusty peat moss	(Schimp.) Klinggr.
Sphagnum girgensohnii	white-toothed peat moss	Russ.
Sphagnum magellanicum	midway peat moss	Brid.
Sphagnum palustre		L.
Sphagnum rubellum		Wils.
Sphagnum spp.	Peat moss	
Sphagnum squarrosum	Spread-leaved peat moss	Crome
Sphagnum warnstorfii	Warnstorf's peat moss	Russ.
Spiraea betulifolia	birch-leaved spirea	Pallas
Spiraea douglasii	hardhack	Hook.
Spiraea pyramidata	pyramid spirea	Greene
Splachnum sphaericum		Hedw.
Stellaria calycantha	northern starwort	(Ledeb.) Bong.
Stereocaulon paschale	cottontail coral	(L.) Hoffm.
Stereocaulon tomentosum	woolly coral	Fr.
Streptopus amplexifolius	clasping twistedstalk	(L.) DC.
Symphoricarpos albus	common snowberry	(L.) Blake
Thalictrum occidentale	western meadowrue	A. Gray
Thamnolia vermicularis	rockworm	(Sw.) Ach. ex Schaerer
Tiarella trifoliata	three-leaved foamflower	L.
Tomentypnum nitens	golden fuzzy fen moss	(Hedw.) Loeske
Torreyochloa pallida	Fernald's false-manna	(Torr.) Church
Trientalis europaea	European starflower	L.
Trimorpha acris (=Erigeron acris)	bitter fleabane	(L.) Neeson
Trisetum cernuum	nodding trisetum	Trin.
Trisetum spicatum	spike trisetum	(L.) Richter
Tritomaria exsectiformis		(Breidl.) Loeske
Usnea spp.	witches' hair	
Vaccinium caespitosum	dwarf blueberry	Michx.
Vaccinium membranaceum	black huckleberry	Dougl. ex Torr.
Vaccinium scoparium	grouseberry	Leib. ex Coville
Vaccinium uliginosum	bog blueberry	L.
Vaccinium vitis-idaea	lingonberry	L.
Veratrum viride	Indian hellebore	Ait.
Veronica beccabunga	American speedwell	L.
Viburnum edule	highbush-cranberry	(Michx.) Raf.
Viola canadensis	Canada violet	L.
Viola orbiculata	rounded-leaved violet	Geyer ex Holz.
Viola palustris	marsh violet	L.
Viola renifolia	kidney-leaved violet	A. Gray
Zigadenus elegans	mountain death-camas	Pursh

Appendix 2. Summary table of vegetation units. This table presents only the plant species (in alphabetical order) occurring in ≤40% of plots in all vegetation units (presence class ≤II). Weak diagnostic species (usually important companion species) used in the diagnostic combinations of species (Table 2) are shaded in gray.

Vegetation unit Code	**110**	**120**	**131**	**132**	**211**	**212**	**220**	**310**
Number of plant species	52	129	128	108	107	152	68	16
Number of sample plots	5	25	34	13	13	28	3	1
Species	**Species presence and significance[1]**							
Actaea rubra				I h	II 1	II +		
Agrostis mertensii						I t		
Alectoria sarmentosa			I t					
Alnus incana		I t	I +	II 4	I +	II 2	II 4	
Alnus viridis	I 5	I 2	I 2	I 2	I 3	I 2		
Amblystegium riparium				I h				
Amelanchier alnifolia					II 2	I h		
Anemone parviflora			I t	II h	I h		II h	
Antennaria racemosa		I t						
Aquilegia formosa					I h			
Aralia nudicaulis						I h		
Arctostaphylos alpina		I +	I +	I +	I h			
Arctostaphylos uva-ursi	II 4		I +					
Aster conspicuus				I h	II 3	I h		
Aster modestus						I t		
Aster sibiricus		I h	I h		I h	II h		
Barbilophozia hatcheri		I t						
Barbilophozia kunzeana	I h							
Betula papyrifera			I +	I 2		I 1		
Brachythecium spp.		I 4						
Calamagrostis canadensis		I t	I +	II h	I h	II +	II 6	
Calamagrostis rubescens		I t						
Calliergon cordifolium						I +		
Calliergon giganteum			I +					
Calliergon stramineum				I h			II h	
Calypso bulbosa			I t			I t		
Campylium stellatum						I h		
Carex concinna						I t		
Carex rossii						I h	II h	
Carex spectabilis			I t					
Carex spp.						I +		
Castilleja miniata					I h			
Cetraria ericetorum		I h						
Cinna latifolia			I h		I h	I h		
Cladina arbuscula	I 2	I 4	I 1	I h	I h	I h		
Cladina rangiferina	I 1	I +						
Cladonia cenotea		I t						
Cladonia cervicornis			I t					
Cladonia chlorophaea		I h						
Cladonia cornuta		I h	I t					
Cladonia crispata	I 3	I h				I t		
Cladonia gracilis	II h	I t	I t		I h	I t		
Cladonia multiformis	I h							
Cladonia phyllophora	I h	I h						
Cladonia sulphurina	I h	I t	I t					
Cladonia uncialis	I 3	I 1						
Clintonia uniflora		I t		I h	II 2			
Coeloglossum viride				I h			II h	
Coptis trifolia		I t	I t					
Corallorhiza trifida						I t		
Cornus stolonifera					I 2	I 2		
Cystopteris montana						I t		
Delphinium glaucum		I t	I t	I h	I h	II h	II +	
Dicranum affine	I h	I t				I h		

Vegetation unit Code	**110**	**120**	**131**	**132**	**211**	**212**	**220**	**310**
Number of plant species	52	129	128	108	107	152	68	16
Number of sample plots	5	25	34	13	13	28	3	1
Species	**Species presence and significance[1]**							
Dicranum fuscescens	I h	I h	I h		I h			
Dicranum polysetum			I h			I h		
Dicranum scoparium		I h	I t		I h	I h	II h	
Dicranum spp.				I h				
Distichium capillaceum			I t					
Drosera rotundifolia				I h				
Elliottia pyroliflorus				I 2				
Elymus glaucus	I +			I h	II h			
Elymus repens			I t			I t		
Epilobium ciliatum							II h	
Epilobium glaberrimum				I h				
Equisetum arvense		II +	I 2	II 4	I h	I 3		
Evernia mesomorpha		I t						
Festuca altaica	I h	I h	II +		I h	I h		
Festuca occidentalis					II h	I h		
Flavocetraria nivalis		I h						
Frangula purshiana						I t		
Galium bifolium						I t	II h	
Galium triflorum					II h	II +		
Gentianella amarella			I t			I t		
Goodyera oblongifolia		I h			II h	I h		
Goodyera repens		II h	I h	I h	II h	II h		
Gymnocarpium dryopteris					I h	I h		
Heracleum maximum					I +	I h	II 2	
Hypogymnia austerodes						I t		
Hypogymnia physodes		I t						
Icmadophila ericetorum		I t		I 2				
Impatiens noli-tangere							II h	
Jungermannia leiantha						I t		
Juniperus communis	I h							
Lathyrus nevadensis		I h	I h	I h	I h	I h		
Lathyrus ochroleucus			I h	I h	II +	I +		
Leymus innovatus	I +	I t	I h	I 3	I h	I 2		
Lonicera utahensis		I t						
Lupinus arcticus	I +	I t	I h					
Luzula parviflora				I h		I t		
Lycopodium annotinum		II 2	II 1	I +	I +	I 4		
Lycopodium complanatum		I h	I h		I +			
Lycopodium dendroideum		I t						
Lysichiton americanum				I h				
Maianthemum canadense						I h		
Maianthemum stellatum		I t			I h	I t		
Maianthemum trifolium			I +	II 1			II +	
Malaxis brachypoda						I t		
Menziesia ferruginea		I 3						
Mnium spinulosum		I t			I +			
Nephroma arcticum	II h	I h						
Oryzopsis asperifolia		I h			I h			
Pentaphylloides floribunda			I +					
Parmelia sulcata		I t						
Parnassia palustris			I t				II h	
Pedicularis bracteosa			I t					
Pedicularis labradorica		I t	I t	I h				
Peltigera malacea		I h	I h		I h	I t		
Peltigera neopolydactyla						I t		
Peltigera praetextata	I h	I h	I t		I h	I h	II h	
Peltigera scabrosa		I +	I h		I +	I h		
Petasites sagittatus				I h			II +	
Phleum alpinum						I t		
Plagiochila asplenioformis				I h			II +	
Plagiomnium ciliare				I h		I t		

Vegetation unit Code	110		120		131		132		211		212		220		310
Number of plant species	52		129		128		108		107		152		68		16
Number of sample plots	5		25		34		13		13		28		3		1
Species	**Species presence and significance[1]**														
Platanthera obtusata			I	t	I	h	I	h	I	h	II	h	II	h	
Platanthera orbiculata					I	t	I	h	I	h	I	h			
Poa spp.					I	h	I	h			I	h			
Poa spp.											I	t			
Pohlia spp.			I	t							I	t			
Polemonium caeruleum					I	t									
Polytrichum commune	I	h	I	+	II	1	II	+			I	4	II	h	
Polytrichum juniperinum					I	h					I	t			
Polytrichum piliferum			I	h	I	h	I	h							
Polytrichum strictum	I	+			I	h									
Populus balsamifera			I	h	I	3	I	2	I	2	II	4			
Ptilidium pulcherrimum			I	h							I	t			
Pulsatilla patens									I	h					
Pyrola asarifolia			I	t	I	t			I	h	I	h			
Pyrola chlorantha									I	h	I	t			
Pyrola elliptica			I	t	I	t	I	h	I	h	I	h			
Pyrola minor			I	h							I	h			
Ranunculus eschscholtzii													II	h	
Rhizomnium pseudopunctatum					I	t	I	h							
Rhytidiadelphus triquetrus			I	+			I	h	II	2	I	h			
Ribes hudsonianum					I	h	I	h			I	h	II	h	
Rubus idaeus					I	+									
Rubus parviflorus									I	+	I	3			
Salix bebbiana	I	2	I	2	I	+			I	+	I	+			
Salix lucida			I	h	I	t					I	+			
Salix myrtillifolia	I	1	I	+	I	1	II	3							
Salix scouleriana	I	2	I	3	II	3			I	+	I	1			
Salix spp.											I	+			
Sambucus racemosa											I	t			
Sanguisorba canadensis					I	1									
Solidago spathulata					I	t	I	h			I	h			
Solorina crocea			I	h											
Sorbus scopulina					I	t			II	1	I	h			
Sphagnum capillifolium					I	+	I	2			I	+	II	3	
Sphagnum fuscum					I	3	I	5							
Sphagnum magellanicum							I	2							
Sphagnum palustre					I	t									
Sphagnum rubellum			I	h											
Sphagnum squarrosum							I	+							
Sphagnum spp.							I	4							
Spiraea betulifolia	I	h	I	+					II	2					
Spiraea douglasii									I	+					
Spiraea pyramidata			I	h							I	t			
Splachnum sphaericum			I	h											
Stellaria calycantha									I	h					
Stereocaulon paschale	II	5	I	h											
Stereocaulon tomentosum			I	3	I	h					I	h			
Streptopus amplexifolius					I	h									
Symphoricarpos albus									I	h					
Thalictrum occidentale					I	t			II	1	I	h			
Thamnolia vermicularis	I	h	I	t	I	h	I	h							
Tiarella trifoliata											I	t			
Torreyochloa pallida											I	t			
Trientalis europaea							I	h							
Trimorpha acris									I	h					
Trisetum cernuum			I	t	I	h			I	h	I	h			
Trisetum spicatum			I	t											
Tritomaria exsectiformis			I	t											
Usnea spp.			I	h											
Vaccinium caespitosum	I	2	II	3	I	2	I	h	II	4	I	h			
Vaccinium membranaceum	I	4	II	4	I	1			II	4	I	t	II	h	

Vegetation unit Code	110	120	131	132	211	212	220	310
Number of plant species	52	129	128	108	107	152	68	16
Number of sample plots	5	25	34	13	13	28	3	1
Species	**Species presence and significance[1]**							
Vaccinium scoparium	II 2	II 2	I 3	I h		I +		
Vaccinium uliginosum	I 1	I h	I +	II 2				
Veratrum viride						I t		
Veronica beccabunga							II h	
Viola canadensis						I t		
Viola orbiculata			I t					
Viola palustris				I h		I h	II h	
Viola renifolia					I h	I h		
Zigadenus elegans					I h			

1. Species presence and significance classes as defined in Table 2.

Appendix 3. Plot vegetation table for the Picea mariana - Cladina stellaris plant association, showing species significance in all plots of this plant association. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	1	2	3	4	5
Species	**Species significance[2]**				
Cladina stellaris	6	5	4	7	+
Picea mariana	6	7	6	7	6
Pinus contorta	5	6	7	7	6
Vaccinium vitis-idaea	4	3	5	6	3
Pleurozium schreberi	7	7	7		9
Cladonia ecmocyna		2	+		+
Hylocomium splendens	6	8	6		
Ledum groenlandicum	3	+			+
Linnaea borealis		+	+		+
Peltigera membranacea		3	5	6	
Rosa acicularis		+		2	+
Arctostaphylos uva-ursi				6	+
Cladonia gracilis	+				+
Cornus canadensis	3				+
Dicranella palustris		5		+	
Empetrum nigrum				5	4
Geocaulon lividum			+		3
Nephroma arcticum	+				+
Picea glauca		5			5
Stereocaulon paschale			+	7	
Vaccinium scoparium	3			3	
Alnus viridis			7		
Aulacomnium palustre	4				
Betula nana	3				
Barbilophozia kunzeana	+				
Cladina arbuscula					4
Cladina rangiferina	3				
Cladonia crispata	5				
Cladonia multiformis					+
Cladonia phyllophora	+				
Cladonia sulphurina	+				
Cladonia uncialis	5				
Dicranum affine	+				
Dicranum fuscescens	1				
Elymus glaucus	2				
Epilobium angustifolium					+
Festuca altaica		+			
Juniperus communis					+
Leymus innovatus				2	
Lupinus arcticus		2			
Mertensia paniculata		2			
Moneses uniflora				+	
Peltigera praetextata					+
Polytrichum commune		+			
Polytrichum strictum	2				
Salix bebbiana				4	
Salix myrtillifolia	3				
Salix scouleriana	4				
Shepherdia canadensis					+
Spiraea betulifolia				+	
Thamnolia vermicularis			+		
Vaccinium caespitosum	4				
Vaccinium membranaceum				6	
Vaccinium uliginosum	3				

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 4. Plot vegetation table for the Picea mariana - Vaccinium vitis-idea plant association, showing species significance in all plots of this plant association. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Species	**Species significance[2]**																								
Hylocomium splendens		7	7	9	7	+	9	9	9	7	8	7	7	7	7	7	7	5	6	7	5	+	6	6	8
Picea mariana	7	9	7		7	6	7	6	7	9	7	7	6	7	8	7	7	7	7	7	7	6	6	7	7
Pleurozium schreberi	9	7	8	7	7	9	6	7		8	6	7	5	8	8	8	7	6	7	4	9	7	9	9	7
Cornus canadensis	2	3	4	3		5		6	4	3	5	2	3	3	2	5	4	2	3	5	+	+	+	+	2
Pinus contorta	8				6	6		6	6	6	7	7	7		7	7	7	7	5	6	6	7		6	5
Vaccinium vitis-idaea				4		4	2	3	3	+	4	7	4	7	5	6	5	4	1	6	+			+	+
Ledum groenlandicum		2			4	3	+	6	2	+	6		3		6	7	5	5		6	+		3	+	+
Ptilium crista-castrensis		5	+	5		+		5	2	6				5		5	7		8	5	6	9	+	4	6
Linnaea borealis	+	3				2	+	2	+		4				+	2			2		+	+	+	+	+
Peltigera aphthosa			+	4	4	2		4		4		4	4	4	3	4	3		+	5					
Petasites frigidus	+	4				+			+		3			+	3	3			+			+	+	+	+
Geocaulon lividum		+	3	6	+	+	3	3	+	+	3											+		+	
Cladina stellaris		+			5	+	3	+	5		5		5					7		7	+				
Empetrum nigrum				4		3	+	5				2	6			2		1		4	2				+
Orthilia secunda	+		+	+	+			+						+			+		3				+	+	+
Peltigera membranacea		4			3	+			+	3		2	1	3		2	1			4					
Rosa acicularis	4	2	3				+		3		4				2					3		2	+		2
Abies lasiocarpa		4	7					3									5	3	6	6		2			6
Vaccinium scoparium	+											2	4		2	6	2					4		+	+
Epilobium angustifolium	+			3		+					2				2							+		+	+
Shepherdia canadensis	4				+	3		3			3											5		6	3
Arnica cordifolia	+		+	3											+				+					+	
Cladonia ecmocyna			+									+	+	+					+	+					
Dicranella palustris	+			+								+	2			+		+							
Equisetum arvense		+			+						+	+		+						3					
Goodyera repens			+	+			+	+								+			+						
Lonicera involucrata	+	2													2							+	+		+
Lycopodium annotinum	+			6				3				+	1			+									
Mertensia paniculata			+					+		+									+				+		+
Picea glauca				7			4	6						7					7		6				
Vaccinium caespitosum	+	+			6	+										5		6							
Vaccinium membranaceum	1														+	6	5	7				4			
Viburnum edule			2			2																+	+	+	+
Dicranum scoparium									+			+		+						+	+				
Salix bebbiana		4									5	4						1						+	
Salix scouleriana				3			6	4					3							4					
Cladina arbuscula												5						7		6				+	
Dicranum fuscescens			+									+								+				+	
Equisetum scirpoides		2			+		+																+		
Festuca altaica	+					+							3	+											
Goodyera oblongifolia	+	+	+																			+			
Moneses uniflora			+														+		+				+		
Peltigera malacea																						+	2	+	+
Polytrichum commune						+						+				3	2								
Polytrichum piliferum						+							2					+		2					
Rubus pubescens	+	+																				+	+		
Stereocaulon tomentosum				+								5						4		6					
Alnus viridis									5	4									4						
Achillea millefolium									+													+	+		
Arctostaphylos alpina					+		+		4																
Aster sibiricus		+																				2		+	
Cladonia cornuta				+														+		+					
Lycopodium complanatum		+						+																+	
Menziesia ferruginea																	7	2		3					
Nephroma arcticum																					+			+	2
Pyrola minor				+													+						+		

Plot number[1]	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Species	**Species significance[2]**																								
Rubus pedatus					+				+								+								
Salix myrtillifolia							4		+														3		
Spiraea betulifolia	4	+																				+			
Aulacomnium palustre					3		3																		
Cladina rangiferina					4															4					
Cladonia chlorophaea			+																	+					
Cladonia crispata					+													+							
Cladonia phyllophora					1	+																			
Equisetum sylvaticum					+									+											
Galium boreale																						+	+		
Mitella nuda									+														+		
Oryzopsis asperifolia		2																				+			
Peltigera praetextata																					+		+		
Peltigera scabrosa								+			4														
Populus balsamifera			3																				+		
Populus tremuloides			3			2																			
Ribes lacustre											+													+	
Ribes triste				+				+																	
Salix glauca																			3				3		
Salix lucida																							+	+	
Alnus incana																							+		
Antennaria racemosa																						+			
Brachythecium spp.			8																						
Barbilophozia hatcheri			+																						
Calamagrostis canadensis											+														
Calamagrostis rubescens																								+	
Carex disperma																			+						
Cetraria ericetorum																				1					
Cladonia cenotea					+																				
Cladonia gracilis						+																			
Cladonia sulphurina						+																			
Cladonia uncialis																		5							
Clintonia uniflora																						+			
Coptis trifolia									+																
Delphinium glaucum																							+		
Dicranum affine					+																				
Drepanocladus uncinatus			+																						
Equisetum pratense							+																		
Evernia mesomorpha										+															
Flavocetraria nivalis												1													
Hypogymnia physodes							+																		
Icmadophila ericetorum												+													
Lathyrus nevadensis																						3			
Leymus innovatus															+										
Listera cordata		+																							
Lonicera utahensis																						+			
Lupinus arcticus																						+			
Lycopodium dendroideum	+																								
Maianthemum racemosum																						+			
Maianthemum stellatum		+																							
Mnium spinulosum			+																						
Osmorhiza berteroi		+																							
Oxycoccus oxycoccos																	2								
Pohlia spp.				+																					
Parmelia sulcata							+																		
Pedicularis labradorica								+																	
Platanthera obtusata																			+						

Plot number[1]	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Species	**Species significance[2]**																								
Ptilidium pulcherrimum												1													
Pyrola asarifolia																							+		
Pyrola elliptica				+																					
Rhytidiadelphus triquetrus			4																						
Solorina crocea																3									
Sphagnum rubellum					3																				
Sphagnum warnstorfii					3																				
Spiraea pyramidata																						2			
Splachnum sphaericum										1															
Stereocaulon paschale													1												
Thamnolia vermicularis														+											
Trisetum cernuum																			+						
Trisetum spicatum																						+			
Tritomaria exsectiformis				+																					
Usnea spp.										3															
Vaccinium uliginosum													2												

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 5. Plot vegetation table for the Picea mariana - Equisetum sylvaticum: typic plant subassociation, showing species significance in all plots of this plant subassociation. Species are arranged first in order of decreasing presence, then alphabetically.

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Plot number[1]	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Species	**Species significance[2]**																																	
Picea mariana	7	8	7	7	7	7	8	9	8	7	8	8	7	7	7	6	6	7	7	7	8	8	8	7	7	7	6	6	6	6	9	7	7	8
Pleurozium schreberi	9	7	7	6	5	7	7	7	7	7	6	7	6	9	9	7	9	6	7	7	8	8	8	9	8	7	7	9	8	7	7	7	7	7
Hylocomium splendens	6	7	8	8	9	8	7	8	7	8	9	9	9	5	7	7	6	9	7	8	7	7	7	6		8	6	5	7	8	7	7	8	7
Ledum groenlandicum	6	7	4	4		7	2		2	7	6	2	2	+	3	2	5		3	+			4	+	2	4	5	+	5	6	+	3	+	+
Peltigera aphthosa	3	+	4	+	3	5	2	2	3	4		+	4		+		3	3	3	3	3	3	2	3	4		5			3	5	4	4	+
Vaccinium vitis-idaea	6		2		7	2	+		+	+	+	+	3		+	7	3		3	4	6	6	5	+	6	6	6		4	2	5	4	3	+
Cornus canadensis		6			5	4	2	2		6	+			+	5	7	5	+	2	5	5	2	4	4	6	6	4	6	4	4	2			2
Ptilium crista-castrensis		5	6		4	6	7	5					5	6		6	4	3	2	2	5	6	7	5	6	6			1	7	2	5	5	6
Petasites frigidus			3	2					2				+	+	+	3			+	4	1	4		2		4		4	+	+	2	3	4	+
Rosa acicularis			2	+	+		3		3	3	3			+				+	2	+	2			+	2		+	+		+		+	3	5
Pinus contorta					7			5							6	8	6		7		6	6	6	7	6	7	6	5	7	6	5	5	4	
Equisetum sylvaticum		6	6			4	+	+	2	2	2	+							+			5	+	+	+			+	2				3
Linnaea borealis			+		3			+						+	+				3	+	+		+	+	+		+	2	3	3		2	2	
Peltigera membranacea	+	+	+	2				2			2		+				+			2	+	+	2	+	4					2				
Cladina stellaris		+		4						+	+		+				+		3	2		+	+						+		2		+	
Lycopodium annotinum					+										+	1	+			3			+	3	+		2		+			+	5	
Mertensia paniculata			2	+					2					3	+		+			3	+							3		+		+	+	
Equisetum scirpoides	+	+	+	5		+			+				+	+	+		+													+				
Orthilia secunda	+		+	+	+			+						+	+		+				+							+		2				
Empetrum nigrum	4	3							2							3			+		2	3							5		4		+	
Equisetum pratense										+				3	2					+	+				+		+	+				3	+	
Festuca altaica																	3		2	4	+		+			+	+		+		+	+		
Picea glauca		6			4			6						3		5	3											6		7		5	6	
Polytrichum commune													+			4	3		+			5			3	+	2			2		+	
Aulacomnium palustre	5		2	2		3							3				+		+													+	2
Epilobium angustifolium				+											5		+			3	+					4		5			+	+	
Geocaulon lividum	+	3													+		+							2	+		+	+			2		
Salix scouleriana		4		2												1	3	5		2		4	3								6		
Mitella nuda		+				2		+						+	+															+			+	
Sphagnum girgensohnii						4	2		7				4		+							4									2			7
Abies lasiocarpa					2		6		4		5					2														6			3	
Dicranella palustris				4	+								4						2					+			+				+			
Goodyera repens	+						+	+																+		+				+		+		
Salix glauca			6											+					3								2	5				4	4	
Vaccinium scoparium																4								+	7		2	5	4	1				
Vaccinium uliginosum													5				+		2	+							+		+			+	
Alnus viridis					5		2			3	4									2										6				
Betula nana													5		+	+												+	4				4	
Cinna latifolia						+	+		+	+											+											+	
Salix bebbiana														+	3		3		4	3												3	
Vaccinium caespitosum			3													+			2							6	3				+		

Plot number[1]	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Vaccinium membranaceum																+							5	+	+				+	5				
Cladina arbuscula	+														+		+								1		6							
Ribes triste			+											+														+					3	+
Rubus pedatus				+									+						+	+													+	
Arnica cordifolia																					+			+		2				+				
Carex disperma		+																												+	+			+
Cladonia ecmocyna				+													+		+								+							
Equisetum arvense	6			+																						+							4	
Larix laricina						6			6																	6								7
Leymus innovatus																+					+			2	+									
Listera cordata								+								+					+									+				
Oxycoccus oxycoccos	+									+					5													2						
Rubus chamaemorus	+								+	4																					+			
Shepherdia canadensis															4											+		+				4		
Viburnum edule						3								+										2						2				
Arctostaphylos alpina	4	+		4																														
Betula papyrifera					2		4	2																										
Calamagrostis canadensis										4																		+						+
Fragaria virginiana		+												+	+																			
Galium boreale														+						+								+						
Lonicera involucrata														+														3		+				

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 6. Plot vegetation table for the Picea mariana - Equisetum sylvaticum: Larix laricina plant subassociation, showing species significance in all plots of this plant subassociation. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	65	66	67	68	69	70	71	72	73	74	75	76	77
Species	**Species significance[2]**												
Picea mariana	7	8	7	9	7	5	7	7	7	7	7	7	7
Hylocomium splendens	8	7	9	9	6	7	7	6	7	8	9		7
Pleurozium schreberi	6	7	5	6	6	9	7	5	7	7	+		5
Vaccinium vitis-idaea	4	+	6	4	4	4	5	6		2	5	4	
Aulacomnium palustre	2	3	4			+	2	3	+		+	7	4
Ledum groenlandicum	7	+	6		6		7	8	6	6	6		4
Cornus canadensis	3	2		4	4	2			2	+	3		4
Equisetum sylvaticum	5		+	+	4	+			3	6	5	4	
Ptilium crista-castrensis	+	4	6	5	5	2		4	6		3		
Peltigera aphthosa	2		3	+		2			+	+	3	+	
Dicranella palustris	+		1		3	2	+	+			+		
Larix laricina							5	5	5	6		5	8
Rosa acicularis			2	5			+		+	+	2		
Rubus chamaemorus		+						7	3	2	3	4	
Rubus pedatus			+		4	3	2		+				+
Carex disperma	+			+				2			+		4
Linnaea borealis	2		4		3				+		+		
Maianthemum trifolium		+					+		2			3	3
Petasites frigidus			3	+		3	+				2		
Calamagrostis canadensis		+		+		+						+	
Cladina stellaris	+					2	+				+		
Equisetum arvense						+	5	4			6		
Equisetum scirpoides	+		+				+		+				
Polytrichum commune				+	3	+					+		
Tomentypnum nitens	6						2	6			+		
Alnus incana	2								6				7
Anemone parviflora									+		+	+	
Betula nana						6					+	2	
Empetrum nigrum					4	4					3		
Epilobium angustifolium	+			+		2							
Equisetum pratense			2	+						5			
Geocaulon lividum							+			+	+		
Pinus contorta				3	5	7							
Rhizomnium glabrescens									2		+		5
Salix myrtillifolia	+		6				4						
Vaccinium uliginosum					5	2	+						
Alnus viridis										2			5
Abies lasiocarpa					7	+							
Achillea millefolium			+				+						
Arctostaphylos alpina							4				+		
Betula papyrifera	5											+	
Epilobium glaberrimum						+		+					
Listera cordata			+								+		
Lycopodium annotinum					3	+							
Orthilia secunda					2						+		
Oxycoccus oxycoccos					6		+						
Peltigera membranacea	2	+											
Picea glauca			7								4		
Sphagnum spp.	7												6
Shepherdia canadensis	2		2										
Sphagnum fuscum							6	9					
Sphagnum girgensohnii									6			7	
Sphagnum warnstorfii								6					3
Viburnum edule				5					+				
Actaea rubra				+									
Amblystegium riparium													+

Plot number[1]	65	66	67	68	69	70	71	72	73	74	75	76	77
Species	**Species significance[2]**												
Aster ciliolatus			2										
Aster conspicuus			+										
Calliergon stramineum													+
Cladina arbuscula											+		
Cladonia ecmocyna			+										
Clintonia uniflora								2					
Coeloglossum viride							+						
Dicranum spp.											+		
Delphinium glaucum			2										
Drosera rotundifolia							+						
Elliottia pyroliflorus												5	
Elymus glaucus						2							
Equisetum fluviatile								+					
Fragaria virginiana			+										
Galium boreale			3										
Goodyera repens											+		
Icmadophila ericetorum								5					
Lathyrus nevadensis				+									
Lathyrus ochroleucus	+												
Leymus innovatus			6										
Lonicera involucrata			6										
Luzula parviflora						+							
Lysichiton americanum									+				
Mertensia paniculata			3										
Mitella nuda			+										
Moneses uniflora											+		
Poa spp.						+							
Pedicularis labradorica							+						
Petasites sagittatus											+		
Plagiochila aspleniformis													+
Plagiomnium ciliare													+
Platanthera obtusata											+		
Platanthera orbiculata				+									
Polytrichum piliferum						+							
Populus balsamifera				5									
Populus tremuloides				6									
Pyrola elliptica	+												
Rhizomnium pseudopunctatum											1		
Rhytidiadelphus triquetrus	+												
Ribes hudsonianum									+				
Ribes lacustre			2										
Ribes triste				+									
Salix glauca			5										
Solidago spathulata			2										
Sphagnum capillifolium							5						
Sphagnum magellanicum								5					
Sphagnum squarrosum													4
Trientalis europaea		+											
Thamnolia vermicularis			+										
Vaccinium caespitosum						1							
Vaccinium scoparium						+							
Viola palustris							+						

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 7. Plot vegetation table for the Picea mariana - Viburnum edule: Sheperdia canadensis plant subassociation, showing species significance in all plots of this plant subassociation. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	78	79	80	81	82	83	84	85	86	87	88	89	90
Species	**Species significance[2]**												
Picea glauca	6		6	7	5	6	7	6	5	7	5	5	7
Pleurozium schreberi	+	7		5	+	6	5	7	7	7	9	7	7
Rosa acicularis	+	2	+	3	+	+	+	+	1		4	1	4
Cornus canadensis	+	+		5	+	2	4		2	5	2	3	5
Epilobium angustifolium	+	+	+		3	+		3	1	+	5	+	+
Hylocomium splendens	3	9	9	9			8	7	8	8		7	7
Linnaea borealis	+	2	+	3		2	+		+	+	+		1
Picea mariana	7	6	7	6			6		8	7	7	6	5
Geocaulon lividum	+			6		+	+		+	+	+	4	
Shepherdia canadensis	+			3	2	7		4		+		1	4
Viburnum edule	+					5	+		4	+	4	3	5
Abies lasiocarpa	+				5			2		6	4	4	5
Arnica cordifolia		+		4	+	+				+		+	+
Galium boreale	+		+					+	+		+	+	3
Petasites frigidus	3							+	4	4	3	+	2
Pinus contorta		7	6			5			6	6	6	8	
Ptilium crista-castrensis		4	+				5		6	5	2	7	
Aster ciliolatus	4							2	1	+		+	3
Fragaria virginiana	+		+	+					1		3		2
Lonicera involucrata	2					+			4	+	3	3	
Maianthemum racemosum	+				3	+		+		+			3
Osmorhiza berteroi	+					+		+	+			+	+
Populus tremuloides	7				9	8	7	8					7
Rubus pubescens	+							+	4		3	+	6
Elymus glaucus	+		+					+	+		+		
Mertensia paniculata	+	+		3				+	+				
Mitella nuda	+							+	+	+			+
Orthilia secunda		+		+	+	+				+			
Rhytidiadelphus triquetrus					+			+			+	2	5
Spiraea betulifolia	+									+	+	5	+
Vaccinium caespitosum	+				7	6				4	+		
Vaccinium membranaceum					7	5				+	+	4	
Amelanchier alnifolia	4										+	3	3
Aster conspicuus	3										6	+	4
Clintonia uniflora						+				+	5	3	
Festuca occidentalis	+				+	+				+			
Goodyera oblongifolia	+									+	+	+	
Goodyera repens				+		+	+					+	
Lathyrus ochroleucus									+		3	+	+
Sorbus scopulina					4						+	+	+
Thalictrum occidentale	+								4		3	+	
Actaea rubra								1				+	4
Equisetum sylvaticum								+	3	+			
Galium triflorum						+		+				+	
Peltigera aphthosa			4			2					+		
Ribes lacustre						+		+				+	
Alnus incana	3				3								
Alnus viridis		6											3
Cladina arbuscula					+						+		
Cladonia ecmocyna		+	+										
Cornus stolonifera									+				5
Dicranella palustris		+										+	
Dicranum fuscescens				+	+								
Dicranum scoparium		+		+									
Drepanocladus uncinatus				+						+			
Equisetum pratense				+				+					

Plot number[1]	78	79	80	81	82	83	84	85	86	87	88	89	90
Species	**Species significance[2]**												
Lathyrus nevadensis	+												+
Ledum groenlandicum		4		+									
Lycopodium complanatum					3		+						
Maianthemum stellatum												2	+
Oryzopsis asperifolia	+											+	
Peltigera membranacea									3			4	
Peltigera praetextata	+							+					
Platanthera obtusata								+					2
Rubus parviflorus										3		+	
Salix bebbiana	3											3	
Salix scouleriana					2			3					
Trisetum cernuum												+	+
Vaccinium vitis-idaea		2		+									
Achillea millefolium	+												
Anemone parviflora			+										
Angelica genuflexa								+					
Aquilegia formosa			+										
Arctostaphylos alpina		2											
Aster sibiricus											+		
Calamagrostis canadensis													+
Castilleja miniata	+												
Cinna latifolia													+
Cladina stellaris		5											
Cladonia gracilis					+								
Delphinium glaucum								+					
Disporum hookeri											+		
Equisetum arvense									+				
Equisetum scirpoides				+									
Festuca altaica									+				
Gymnocarpium dryopteris										+			
Heracleum maximum									4				
Larix laricina			4										
Leymus innovatus		+											
Lycopodium annotinum								3					
Mnium spinulosum				3									
Pulsatilla patens			+										
Peltigera malacea					+								
Peltigera scabrosa			4										
Platanthera orbiculata							+						
Populus balsamifera				5									
Pyrola asarifolia								2					
Pyrola chlorantha				+									
Pyrola elliptica													+
Ribes triste													2
Senecio triangularis								+					
Spiraea douglasii	3												
Stellaria calycantha			+										
Symphoricarpos albus													+
Trimorpha acris			+										
Viola renifolia										+			
Zigadenus elegans			2										

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 8. Plot vegetation table for the Picea mariana - Viburnum edule: Mitella nuda plant subassociation, showing species significance in all plots of this plant subassociation. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Species	**Species significance[2]**																											
Picea mariana	7	8	7	7	8	8	7	7	7	7	7	6	7	6	6	7		7	6	6	6	6	6	7	7	7	8	7
Cornus canadensis		4	4	+	6	3	5	4	4	8	+	4	3	4	6	5		2	+	2	5	4	+	3	6	4	6	5
Hylocomium splendens	9	7	8	9	8	7	7	7	7	7	6	7	6	8	7	7		8	9	7	8	9	6		7	6	7	9
Mitella nuda	+		+	+	+	+	+	1	+	+	+	+	+	2	4	3	+	+			2	+	+	+	+	+		2
Pleurozium schreberi		9	7	7	7	7	7	6	7	8	9	7	8	7	6	7		7	4	7	6		7			7	8	6
Rosa acicularis	2		4	+	4	+	+	2	+		+	+	+	2	2	2		+	+		3	3	+	3	4	3		+
Linnaea borealis	3			+		+	2	6	+		+	+	+	3	7	5		2	+		2	3	+	+	2	+	2	+
Petasites frigidus	1		5			2	3	3	+	+		+	2	3	3	3	2	+			2	+	+	+	+	4	5	+
Picea glauca				8	7	7	6	7	6	7	6	6	6		8	7	5		8	7	8	7	5	7	7	7		7
Lonicera involucrata	3		5		4		2	6	3	3	+	+	+	+	6	+	5	3					+		5	3	5	+
Ptilium crista-castrensis		5	6	4	6	7		5	7	5	4	7	7	6	7	7			4	6	7				6		5	3
Mertensia paniculata		+	+		+		1	3			+	+	+	3	1	2	+		+			+	+	+	1		4	1
Viburnum edule				+	4	+			2	2	+	+	+	2	3		5				+	+	+	+	4	3	4	1
Epilobium angustifolium			+		1		1	+	+	+		+	+	+	3		4	5	+		+		+		+	+	2	
Rubus pubescens	1					+		1	+		+	4	3	+	3		+	2			4	4	3		+	2		2
Orthilia secunda	+		+		+			+			+		+		+	+		+	+		+			+	+	+	+	+
Ribes lacustre					2					4		+	+	2	+	1	4					+	+	+	+	+	3	
Peltigera aphthosa			3		3	3	2		2				+	2	3	3		2	+	3								+
Pinus contorta		6	7		4			6	6	6	+	+		8				5		2			5			6		
Populus tremuloides			5				6	5	5			+			5		8		6	3	5	4		5		7		
Achillea millefolium							+			+		+		+		+		+			+	+	+		+	+		+
Vaccinium vitis-idaea		2				2	+	5	4		+	+		+	5	6					+				2			
Populus balsamifera	4														+		5			5	6	4	5	4	5		7	6
Fragaria virginiana								1		+				+	+			+				+	+		2	+		+
Equisetum pratense					+		+			+	2	3								+					2	4	+	
Equisetum scirpoides	6				+							+	+			+						+	+			+		+
Ledum groenlandicum					7				5	+	+	2		+		6						+					2	
Shepherdia canadensis								+						3	2							+	6		4	+	3	1
Abies lasiocarpa					6					6	+	5		5		5	5							+				
Arnica cordifolia			3		3	+				+			+	+		+									+		
Aster sibiricus	2						+			+		+	+					+					+					+
Galium boreale	+						+				+				+			+			+		+					+
Geocaulon lividum	+								+	+		+						2	+				+					+
Goodyera repens				+	+			+	+			+			+												+	+
Actaea rubra						+				+			+	+	2		3											+
Calamagrostis canadensis								2	+						2			+					+			2		+
Galium triflorum		2								+					+		+					+				+	3	
Listera cordata			+	+	+				+				+												+		+	

Plot number[1]	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Species	**Species significance[2]**																											
Peltigera membranacea				2		2	2		+					2	2													+
Ribes triste					2			2						+	2	2					+				2			
Rubus pedatus					7	+	2			3		+			+						+							
Alnus incana	4										+	+					6				2	3						
Aster ciliolatus															1		+	+			+					+		+
Delphinium glaucum										+			+										+		+		+	+
Equisetum sylvaticum			+			+		+		+		+			2													
Moneses uniflora														+						+	+		+	+				+
Osmorhiza berteroi										+							+						+		+	+	2	
Platanthera obtusata									+		+		+	+												+		+
Alnus viridis		5		+		4													4		2							
Aulacomnium palustre	+						4									+		3				+						
Betula papyrifera									4						2					3	3			3				
Dicranella palustris			3												+	+									3	+		
Polytrichum commune		+				4		6	3						7													
Pyrola asarifolia					3		+	+															+		+			
Pyrola minor								+			+			+							+		+				
Vaccinium scoparium								2			1			3				+									4	
Cladonia ecmocyna							+	+	+					+														
Equisetum arvense	7							+						+							+							
Lathyrus nevadensis							+								1							+			+			
Lathyrus ochroleucus							4								2										2			2
Lycopodium annotinum					6			7			+															+		
Platanthera orbiculata									+	+								+						+				
Pyrola elliptica								+																		+	+	+
Solidago spathulata														+							+				+		+	
Trisetum cernuum								+						+	+	+												
Viola palustris															+							+				+	+	
Amelanchier alnifolia													+	+			3											
Carex disperma	4															+										4		
Cladina stellaris							3							+					+									
Dicranum scoparium														3	+											+		
Disporum hookeri	+								2			+																
Heracleum maximum															2										2		2	
Leymus innovatus								6						+											4			
Rhytidiadelphus triquetrus	3													+												2		
Salix bebbiana							4		3						3													
Salix scouleriana						4									4		4											
Sorbus scopulina										+		+					2											
Aster conspicuus								+									+											
Cinna latifolia	+														+													
Cladina arbuscula											+										+							
Cornus stolonifera																	6	3										
Festuca altaica			+																								+	
Festuca occidentalis										+								+										

Plot number[1]	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Species	**Species significance[2]**																											
Goodyera oblongifolia											+															+		
Gymnocarpium dryopteris										3	2																	
Larix laricina																				7		7						
Maianthemum racemosum												+					5											
Maianthemum canadense									+												+							
Oxycoccus oxycoccos											+	4																
Poa spp.							+	+																				
Peltigera praetextata											+	+																
Peltigera scabrosa															+											2		
Ribes hudsonianum										2																1		
Salix spp.											+															4		
Salix glauca	6																	2										
Thalictrum occidentale	2																	3										
Vaccinium caespitosum								2																			2	
Viola renifolia												+											+					
Agrostis mertensii																												+
Aralia nudicaulis																					2							
Aster modestus																										+		
Betula nana								2																				
Bryum spp.	+																											
Carex spp.												4																
Calliergon cordifolium																									4			
Calypso bulbosa									+																			
Campylium stellatum	1																											
Carex concinna													+															
Carex rossii	3																											
Cladonia crispata																					+							
Cladonia gracilis																					+							
Corallorhiza trifida															+													
Cystopteris montana												+																
Dicranum affine																									3			
Dicranum polysetum														2														
Drepanocladus uncinatus																									+			
Elymus repens																		+										
Empetrum nigrum																2												
Equisetum fluviatile	+																											
Frangula purshiana																								+				
Galium bifolium	+																											
Gentianella amarella																							+					
Hypogymnia austerodes														+														
Jungermannia leiantha																										+		
Luzula parviflora												+																
Maianthemum stellatum	+																											
Malaxis brachypoda	+																											
Poa spp.																												+

Plot number[1]	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Species	**Species significance[2]**																											
Pohlia spp.																									+			
Peltigera malacea									+																			
Peltigera neopolydactyla									+																			
Phleum alpinum																												+
Plagiomnium ciliare	+																											
Polytrichum juniperinum																											+	
Ptilidium pulcherrimum														+														
Pyrola chlorantha																												+
Rhizomnium glabrescens										+																		
Rubus chamaemorus															+													
Rubus parviflorus																	7											
Salix lucida																		5										
Sambucus racemosa															+													
Sphagnum capillifolium																									4			
Sphagnum girgensohnii											+																	
Sphagnum warnstorfii	5																											
Spiraea pyramidata																		+										
Stereocaulon tomentosum																					1							
Tiarella trifoliata										+																		
Tomentypnum nitens	1																											
Torreyochloa pallida	+																											
Vaccinium membranaceum																	+											
Veratrum viride	+																											
Viola canadensis																	+											

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2.* Species significance classes as defined in Table 2.

Appendix 9. Plot vegetation table for the Picea glauca & mariana - Equisetum pratense plant association, showing species significance in all plots of this plant association. Species are arranged first in order of decreasing presence, then alphabetically.

Plot number[1]	119	120	121
Species	**Species significance[2]**		
Angelica genuflexa	+	+	4
Equisetum pratense	7	5	6
Hylocomium splendens	+	7	7
Ledum groenlandicum	+	3	5
Lonicera involucrata	3	4	5
Mertensia paniculata	1	4	3
Mitella nuda	+	+	2
Petasites frigidus	+	+	5
Picea mariana	8	7	7
Pleurozium schreberi	7	6	6
Aulacomnium palustre		5	6
Carex disperma	6		3
Disporum hookeri		1	+
Equisetum scirpoides		+	2
Geum macrophyllum	3		4
Listera cordata	+		+
Moneses uniflora	+	+	
Orthilia secunda	+		+
Oxycoccus oxycoccos	+		+
Picea glauca		6	7
Ptilium crista-castrensis		8	6
Rhizomnium glabrescens		5	+
Ribes triste		+	+
Rosa acicularis	3		5
Rubus pubescens	2		3
Salix glauca	4		3
Senecio triangularis	+	+	
Sphagnum girgensohnii	7		+
Alnus incana			5
Anemone parviflora		+	
Arnica cordifolia		+	
Aster ciliolatus	+		
Calamagrostis canadensis			7
Calliergon stramineum	+		
Carex rossii	+		
Cladina stellaris			+
Cladonia ecmocyna			+
Coeloglossum viride		+	
Cornus canadensis			6
Delphinium glaucum			2
Dicranum scoparium			+
Epilobium angustifolium	2		
Epilobium ciliatum	+		
Equisetum sylvaticum			6
Galium bifolium			+
Heracleum maximum			3
Impatiens noli-tangere			+
Larix laricina			+
Linnaea borealis		3	
Maianthemum trifolium			2
Osmorhiza berteroi		2	
Parnassia palustris	+		
Peltigera aphthosa			3
Peltigera praetextata	+		

Plot number[1]	119	120	121
Species	**Species significance[2]**		
Petasites sagittatus			2
Plagiochila asplenioformis		1	
Platanthera obtusata		+	
Polytrichum commune			+
Ranunculus eschscholtzii	+		
Ribes hudsonianum			+
Ribes lacustre			2
Rubus pedatus		2	
Sphagnum capillifolium		4	
Sphagnum warnstorfii	+		
Vaccinium membranaceum	+		
Vaccinium vitis-idaea		+	
Veronica beccabunga			+
Viola palustris			+

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
2. Species significance classes as defined in Table 2.

Appendix 10. Selected environmental characteristics for plots of the SbPl - Lichens site association derived from the Picea mariana - Cladina stellaris plant association (110).

Plot number[1]	1	2	3	4	5
Zonal unit	BWBS dk1	BWBS dk2	BWBS dk2	BWBS mw1	BWBS dk1
Soil moisture regime*	2/MD	2/MD	2/MD	2/MD	2/MD
Soil nutrient regime*	VP	P	P	VP	VP
Elevation (m)	870	860	840	1000	1020
Slope gradient (%)	10	5	24	40	2
Aspect*	E	S	N	S	N
Forest floor thickness (cm)	10	7	6	6	5
Generalized textural class*	L	L	L	S	L
Potential rooting depth (cm)	60	60	60	60	25
Water table depth (cm)	N/A	N/A	N/A	N/A	N/A
Soil drainage*	W	M	W	R	R
Soil Great Group	R	HFP	HFP	HFP	HFP
Stand age (years@bh)	64	142	54	71	151
Site index (m)	9.9	7.3	N/D	9.6	9.1
Tree layer cover (%)	20	40	70	50	25
Shrub layer cover (%)	11	1	5	48	5
Herb layer cover (%)	2	1	0	1	1
Moss layer cover (%)	70	97	38	55	83

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.

* Abbrevations as defined in Table 7.

Appendix 11. Selected environmental characteristics for plots of the SbPl - Moss site association derived from the Picea mariana - Vaccinium vitis idaea plant association (120).

Plot number[1]	6	7	8	9	10	11	12	13	14	15	16	17	18
Zonal unit	SBS dk	SBS dw3	BWBS dk1	BWBS dk1	BWBS dk1	BWBS dk1	BWBS dk1	BWBS dk1	BWBS dk2	BWBS dk2	BWBS mw2	BWBS mw2	BWBS mw2
Soil moisture regime*	3/SD	4/SD	3/SD	4/SD	4/SD	4/SD	5/F&M	4/SD	4/SD	4/SD	4/SD	4/SD	4/SD
Soil nutrient regime*	P	P	P	P	M	P	P	P	P	P	P	P	P
Elevation (m)	890	890	1000	990	805	810	840	850	830	750	400	1100	1190
Slope gradient (%)	0	0	27	6	31	24	16	27	0	11	0	11	16
Aspect*	F	F	S	E	E	S	S	S	F	S	F	E	W
Forest floor thickness (cm)	5	8	13	16	30	4	14	11	11	10	6	12	11
Generalized textural class*	L	L	S	S	L	L	O	L	S	L	L	L	L
Potential rooting depth (cm)	40	50	60	60	60	30	55	40	50	35	65	60	60
Water table depth (cm)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	70	N/A	N/A	N/A	N/A
Soil drainage*	W	W	W	M	M	M	I	M	I	W	M	I	M
Soil Great Group	HFP	HFP	EB	EB	EB	EB	H	HFP	DYB	HFP	HFP	HFP	GL
Stand age (years@bh)	N/D	95	N/D	N/D	43	37	62	82	129	135	72	59	81
Site index (m)	N/D	8.6	N/D	N/D	N/D	N/D	8.3	13.5	N/D	10.1	8.8	7.8	N/D
Tree layer cover (%)	70	72	57	30	50	31	33	36	45	83	50	60	35
Shrub layer cover (%)	7	6	3	2	12	6	15	29	6	0	30	24	19
Herb layer cover (%)	2	3	5	7	1	5	1	13	3	1	7	1	2
Moss layer cover (%)	80	78	90	95	75	81	92	97	96	95	77	70	45

Plot number	19	20	21	22	23	24	25	26	27	28	29	30
Zonal unit	BWBS mw2	BWBS mw1	BWBS wk1	BWBS wk1	BWBS wk1	BWBS wk1	BWBS wk1	BWBS dk1	SBS dw3	BWBS dk1	BWBS dk1	BWBS dk1
Soil moisture regime*	4/SD	4/SD	3/SD	3/SD	3/SD	4/SD	3/SD	3/SD	4/SD	4/SD	4/SD	4/SD
Soil nutrient regime*	P	P	VP	P	P	P	P	VP	P	VP	VP	P
Elevation (m)	1100	1000	1100	1130	1080	1050	1025	1015	785	895	905	895
Slope gradient (%)	51	5	11	60	16	82	0	30	10	23	14	60
Aspect*	S	S	W	N	N	N	F	N	N	N	E	N
Forest floor thickness (cm)	14	8	12	11	4	10	11	11	7	19	11	7
Generalized textural class*	L	L	S	L	S	L	L	S	L	L	L	L
Potential rooting depth (cm)	60	60	70	70	60	50	50	15	15	50	10	80
Water table depth (cm)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Soil drainage*	I	M	W	W	R	W	R	R	M	W	W	R
Soil Great Group	GL	HFP	HFP	HFP	HFP	HFP	HFP	HFP	EB	M	HFP	HFP
Stand age (years@bh)	134	84	N/D	136	63	72	160	149	109	93	80	176
Site index (m)	7.3	9.0	N/D	N/D	12.7	N/D	7.9	8.9	8.6	10.5	13.2	10.0
Tree layer cover (%)	55	90	50	60	41	77	50	40	36	15	45	45
Shrub layer cover (%)	25	18	66	40	39	2	26	0.8	13	6	13	2
Herb layer cover (%)	2	2	5	4	1	3	6	0	3	1	1	1
Moss layer cover (%)	99	91	100	92	80	90	94	98	90	96	98	100

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
* Abbrevations as defined in Table 7.

Appendix 12. Selected environmental characteristics for plots of the Sb - Wood Horsetail. Sb site association derived from the Picea mariana - Equisetum sylvaticum: typic plant subassociation (131).

Plot number[1]	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Zonal unit	BWBS dk1	BWBS dk1	BWBS dk1	BWBS dk2	BWBS mw2	BWBS dk2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS dk1	SBS mk1	BWBS mw2	BWBS dk1
Soil moisture regime*	6/VM	6/VM	6/VM	5/F&M	5/F&M	6/VM	6/VM	6/VM	6/VM	6/VM	6/VM	5/F&M	6/VM	5/F&M	5/F&M	6/VM	5/F&M
Soil nutrient regime*	VP	VP	P	VP	P	P	VP	VP	VP	VP	VP	VP	VP	P	P	VP	P
Elevation (m)	920	910	800	870	660	530	630	640	540	540	440	450	1020	880	930	1170	860
Slope gradient (%)	10	5	0	0	16	0	10	10	0	0	10	0	0	13	8	27	11
Aspect*	W	S	F	F	S	F	W	W	F	F	W	F	F	N	S	W	S
Forest floor thickness (cm)	14	12	23	12	9	10	14	9	15	15	14	16	12	13	10	16	11
Generalized textural class*	O	O	O	O	C	O	O	O	O	O	O	O	O	O	S	CL	L
Potential rooting depth (cm)	50	35	60	40	60	90	45	40	50	40	60	50	45	70	40	40	60
Water table depth (cm)	55	35	70	42	20	70	45	20	50	40	45	N/A	50	N/A	N/A	40	N/A
Soil drainage*	P	P	I	P	I	P	P	P	P	P	P	I	P	M	W	P	M
Soil Great Group	M	M	M	M	G	M	F	M	F	M	M	F	M	M	HFP	GL	DYB
Stand age (years@bh)	185	151	118	99	135	141	130	137	122	71	134	72	48	87	103	86	71
Site index (m)	4.7	5.2	8.1	8.7	9.5	6.7	8.6	N/D	N/D	8.7	8.1	7.9	N/D	9.5	10.3	7.5	11.5
Tree layer cover (%)	20	60	35	40	69	50	74	96	77	31	58	50	40	26	40	79	21
Shrub layer cover (%)	23	23	19	16	31	37	2	0	3	44	16	1	17	11	10	25	9
Herb layer cover (%)	11	22	16	6	5	8	1	1	2	13	1	0	0	3	13	21	7
Moss layer cover (%)	100	96	93	82	80	99	81	99	91	98	91	95	94	95	90	83	95

Plot number	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Zonal unit	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw1	BWBS mw2	SBS mk1	BWBS mw2	BWBS wk1	BWBS mw2	BWBS dk1	BWBS dk1	BWBS mw2
Soil moisture regime*	6/VM	5/F&M	5/F&M	5/F&M	6/VM	5/F&M	5/F&M	6/VM	5/F&M	5/F&M	5/F&M	6/VM	5/F&M	6/VM	5/F&M	5/F&M	6/VM
Soil nutrient regime*	P	P	P	P	P	P	M	P	P	P	P	P	M	VP	P	P	VP
Elevation (m)	390	1100	1070	1115	1120	1130	840	830	980	1010	930	1170	1080	1120	800	760	350
Slope gradient (%)	0	11	31	31	16	36	11	0	16	11	8	5	29	16	20	11	0
Aspect*	F	E	W	S	E	W	S	F	W	N	E	N	N	N	W	W	F
Forest floor thickness (cm)	15	13	14	14	12	13	11	15	12	8	18	12	15	15	8	11	12
Generalized textural class*	C	L	L	L	CL	L	L	L	L	L	S	L	L	L	L	L	L
Potential rooting depth (cm)	55	60	40	50	40	60	30	30	48	46	15	60	45	60	60	40	60
Water table depth (cm)	45	44	40	55	40	N/A	N/A	15	N/A	45	N/A	48	45	45	N/A	N/A	43
Soil drainage*	P	I	P	I	P	I	I	P	I	P	W	I	M	P	M	I	P
Soil Great Group	G	GL	GL	GL	GL	GL	GL	GL	GL	GL	HFP	GL	GBL	GL	EB	GL	GL
Stand age (years@bh)	77	62	61	128	124	117	99	92	57	53	92	100	N/D	122	118	72	106
Site index (m)	11.0	9.8	7.7	7.0	6.1	7.2	10.7	9.0	10.9	N/D	10.5	N/D	N/D	N/D	8.1	11.1	10.1
Tree layer cover (%)	40	40	40.5	70	70	60	80	45	80	30	25	45	80	75	65	33	80
Shrub layer cover (%)	5	9	5	11	14	14	1	36	28	17	13	22	21	10	22	10	6
Herb layer cover (%)	0	2	13	7	6	3	5	11	13	5	33	4	4	1	2	9	2
Moss layer cover (%)	97	79	98	97	99	91	92	76	95	52	86	81	97	82	87	97	100

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
* Abbrevations as defined in Table 7.

Appendix 13. Selected environmental characteristics for plots of the Sb - Tamarack site association derived from the Picea mariana - Equisetum sylvaticum: Larix laricina plant subassociation (132).

Plot number[1]	65	66	67	68	69	70	71	72	73	74	75	76	77
Zonal unit	BWBS mw2	BWBS mw2	BWBS mw1	BWBS mw2	BWBS wk1	BWBS mw2	BWBS mw2	BWBS mw1	BWBS mw2	BWBS mw2	BWBS dk1	BWBS mw2	BWBS mw2
Soil moisture regime*	7/W	7/W	6/VM	7/W	7/W	7/W	7/W	7/W	7/W	7/W	7/W	7/W	7/W
Soil nutrient regime*	P	VP	P	P	VP	P	VP	VP	VP	VP	P	VP	VP
Elevation (m)	385	400	940	350	1120	1160	380	990	360	520	910	440	440
Slope gradient (%)	0	0	16	0	0	5	0	0	0	0	11	0	0
Aspect*	F	F	W	F	F	W	F	F	F	F	W	F	F
Forest floor thickness (cm)	13	16	20	14	12	12	29	30	14	19	12	20	20
Generalized textural class*	C	O	O	L	L	L	O	O	O	O	O	O	O
Potential rooting depth (cm)	55	35	60	30	50	30	60	50	60	40	50	70	50
Water table depth (cm)	25	25	20	15	10	25	20	20	10	30	50	10	5
Soil drainage*	P	P	P	P	P	V	V	V	V	P	V	V	P
Soil Great Group	G	F	M	GL	GBL	GL	M	H	F	F	H	F	F
Stand age (years@bh)	73	73	129	108	151	83	109	N/D	147	124	149	74	69
Site index (m)	11.6	8.8	6.9	10.9	N/D	9.3	9.0	N/D	N/D	N/D	N/D	11.0	N/D
Tree layer cover (%)	35	60	50	86	55	28	35	45	45	51	22	25	75
Shrub layer cover (%)	25	0	54	12	39	23	50	80	27	11	18	12	33
Herb layer cover (%)	7	1	15	4	8	2	6	4	2	15	17	3	7
Moss layer cover (%)	100	94	90	100	32	93	91	100	100	70	93	50	48

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
* Abbrevations as defined in Table 7.

Appendix 14. Selected environmental characteristics for plots of the SbSw - Soopalallie site association derived from the Picea glauca & mariana - Viburnum edule: Sheperdia canadensis plant subassociation (211).

Plot number[1]	78	79	80	81	82	83	84	85	86	87	88	89	90
Zonal unit	SBS dw3	BWBS dk2	BWBS dk2	BWBS dk1	SBS mk1	SBS mk1	BWBS mw2	SBS mk1	SBS dw3	SBS mk1	SBS dw3	SBS dw3	SBS dw3
Soil moisture regime*	4/SD	4/SD	4/SD	4/SD	3/SD	3/SD	4/SD	4/SD	4/SD	4/SD	4/SD	3/SD	4/SD
Soil nutrient regime*	R	M	M	P	P	M	M	M	R	M	R	R	R
Elevation (m)	730	840	680	910	955	850	390	840	830	800	740	880	850
Slope gradient (%)	2	10	0	11	0	0	10	32	5	18	8	10	5
Aspect*	N	W	F	S	F	F	E	S	E	N	S	F	N
Forest floor thickness (cm)	9	8	5	13	2	6	9	40	16	7	6	10	16
Generalized textural class*	C	L	L	S	L	L	L	L	L	L	L	L	L
Potential rooting depth (cm)	30	60	70	70		45	60	55	60	40	15	60	60
Water table depth (cm)	N/A	N/A	70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Soil drainage*	I	M	M	M	R	W	M	W	W	M	M	W	M
Soil Great Group	GL	GL	R	EB	DYB	DYB	DYB	HR	EB	DYB	GL	DYB	EB
Stand age (years@bh)	98	N/D	44	N/D	N/D	N/D	108	N/D	100	79	94	98	96
Site index (m)	12.8	N/D	N/D	N/D	N/D	N/D	13.9	N/D	10.4	12.2	8.1	11.2	11.9
Tree layer cover (%)	55	65	53	45	82	75	90	72	75	70	48	72	89
Shrub layer cover (%)	6	5	0	3	26	51	0	5	8	4	8	12	26
Herb layer cover (%)	6	1	2	19	23	11	3	3	12	6	24	6	16
Moss layer cover (%)	1	97	95	96	0	11	70	41	81	85	71	83	65

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
* Abbrevations as defined in Table 7.

Appendix 15. Selected environmental characteristics for plots of the SbSw - Common Mitrewort site association derived from the Picea glauca & mariana - Viburnum edule; Mitella nuda plant subassociation (212).

Plot number[1]	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Zonal unit	SBS dw3	BWBS dk2	BWBS mw1	BWBS mw2	BWBS mw1	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	SBS mk1	BWBS dk1	BWBS dk1	BWBS dk1	BWBS mw1
Soil moisture regime*	6/VM	5/F&M	5/F&M	5/F&M	5/F&M	5/F&M	5/F&M	5/F&M	5/F&M	5/F&M	6/VM	5/F&M	5/F&M	5/F&M
Soil nutrient regime*	M	M	M	M	R	VR	M	M	R	R	P	M	M	M
Elevation (m)	890	750	1000	390	1030	970	830	830	840	790	780	970	1030	940
Slope gradient (%)	5	5	16	5	20	0	5	0	0	3	15	17	23	31
Aspect*	S	S	N	W	N	F	S	F	F	N	N	N	W	W
Forest floor thickness (cm)	10	9	13	12	13	20	17	14	11	16	14	14	12	11
Generalized textural class*	O	L	L	C	L	L	L	L	L	L	O	O	L	L
Potential rooting depth (cm)	40	100	40	40	70	50	60	50	40	25	30	35	40	60
Water table depth (cm)	38	N/A	N/A	45	70	N/A	N/A	35	30	75	40	60	N/A	N/A
Soil drainage*	P	W	I	I	M	I	I	P	I	I	I	I	I	I
Soil Great Group	H	HFP	GL	G	GBL	GBL	GL	GL	GL	GBL	FO	H	GL	GL
Stand age (years@bh)	94	134	84	69	157	54	60	114	100	126	105	102	98	84
Site index (m)	10.1	14.0	11.8	13.0	7.8	N/D	13.8	10.7	12.3	9.9	9.7	10.2	9.3	10.4
Tree layer cover (%)	43	75	75	80	83	88	55	60	53	60	40	30	50	70
Shrub layer cover (%)	15	1	8	0	65	5	4	28	11	6	1	6	2	5
Herb layer cover (%)	38	4	5	0	23	2	13	36	4	55	2	9	3	7
Moss layer cover (%)	87	95	97	98	96	94	64	65	92	75	98	90	100	100

Plot number	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Zonal unit	BWBS mw2	BWBS mw1	SBS mk1	SBS mk1	BWBS mw2	BWBS mw2	BWBS mw2	BWBS mw2	BWBS dk1	BWBS mw2	BWBS mw1	SBS dk	BWBS mw1	BWBS mw2
Soil moisture regime*	5/F&M	6/VM	5/F&M	5/F&M	6/VM	5/F&M	6/VM	6/VM	5/F&M	6/VM	5/F&M	5/F&M	5/F&M	6/VM
Soil nutrient regime*	M	M	R	M	M	M	M	M	M	M	R	M	VR	VR
Elevation (m)	830	1020	940	765	500	340	450	490	970	450	950	890	995	800
Slope gradient (%)	0	16	15	0	0	0	0	0	7	10	5	0	11	0
Aspect*	F	N	S	F	F	F	F	F	W	E	N	F	W	F
Forest floor thickness (cm)	15	16	12	11	9	15	12	10	14	15	11	12	15	23
Generalized textural class*	L	L	S	L	C	C	C	C	L	C	L	O	L	L
Potential rooting depth (cm)	60	46	30	20	60	30	60	60	25	60	60	40	60	60
Water table depth (cm)	45	46	N/A	N/A	25	N/A	20	10	N/A	30	N/A	N/A	50	23
Soil drainage*	I	I	W	I	I	I	P	P	M	P	I	I	I	I
Soil Great Group	GBL	GBL	DYB	GBL	G	DYB	GBL	G	GBL	GBL	GL	H	GL	GBL
Stand age (years@bh)	115	153	N/D	75	76	117	62	77	99	64	83	N/D	85	N/D
Site index (m)	10.6	9.1	N/D	9.9	12.6	10.5	14.0	13.8	9.2	N/D	14.0	N/D	11.6	N/D
Tree layer cover (%)	71	65	77	45	73	58	77	65	30	78	55	70	90	60
Shrub layer cover (%)	43	27	68	4	0	0	6	6	12	1	17	8	14	1
Herb layer cover (%)	17	7	7	11	1	1	7	4	2	2	17	11	17	11
Moss layer cover (%)	77	81	0	92	75	91	91	70	30	21	47	32	75	81

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.
* Abbrevations as defined in Table 7.

Appendix 16. Selected environmental characteristics for plots of the SbSw - Meadow Horsetail site association derived from the Picea glauca & mariana - Equisetum pratense plant association (220).

Plot number[1]	119	120	121
Zonal unit	SBS dw3	BWBS wk1	BWBS mw1
Soil moisture regime*	7/W	7/W	7/W
Soil nutrient regime*	M	R	M
Elevation (m)	840	1020	990
Slope gradient (%)	0	0	0
Aspect*	F	F	F
Forest floor thickness (cm)	11	9	24
Generalized textural class*	O	O	O
Potential rooting depth (cm)	50	40	70
Water table depth (cm)	35	30	35
Soil drainage*	V	P	V
Soil Great Group	H	H	H
Stand age (years@bh)	N/D	172	144
Site index (m)	N/D	6.3	N/D
Tree layer cover (%)	60	50	50
Shrub layer cover (%)	10	6	23
Herb layer cover (%)	5	10	62
Moss layer cover (%)	40	93	72

1. Plot numbers have been simplified in this report. See Appendix 17 for original plot codes.

* Abbrevations as defined in Table 7.

Appendix 17. Converstion of the plot numbers used in this report to the plot codes used in the original data set (SbKK.MDB) on file with the British Columbia Ministry of Forests, Research Branch, in the VENUS data base.

plot number	plot code
1	97-079
2	97-095
3	97-112
4	97-184
5	98-123
6	97-001
7	97-014
8	97-046
9	97-053
10	97-062
11	97-064
12	97-075
13	97-085
14	97-114
15	97-118
16	97-148
17	97-149
18	97-160
19	97-162
20	97-176
21	97-180
22	97-182
23	97-183
24	97-188
25	97-189
26	98-124
27	98-133
28	98-139
29	98-141
30	98-142
31	97-039
32	97-044
33	97-071
34	97-115
35	97-141
36	97-122
37	97-123
38	97-124
39	97-125
40	97-126
41	97-131

plot number	plot code
42	97-132
43	97-153
44	98-140
45	98-136
46	97-157
47	97-078
48	97-145
49	97-150
50	97-151
51	97-154
52	97-156
53	97-161
54	97-166
55	97-169
56	97-179
57	97-152
58	98-137
59	97-159
60	97-187
61	97-155
62	97-070
63	97-087
64	97-135
65	97-144
66	97-146
67	97-172
68	97-136
69	97-181
70	97-158
71	97-142
72	97-175
73	97-147
74	97-128
75	97-035
76	97-134
77	97-133
78	98-132
79	97-113
80	97-092
81	97-043
82	98-122

plot number	plot code
83	98-117
84	97-138
85	98-118
86	97-022
87	98-112
88	98-131
89	97-006
90	97-016
91	97-013
92	97-119
93	97-178
94	97-143
95	97-186
96	97-163
97	97-165
98	97-168
99	97-170
100	98-113
101	98-126
102	98-127
103	98-128
104	97-171
105	97-167
106	97-185
107	98-121
108	98-116
109	97-140
110	97-137
111	97-130
112	97-139
113	98-125
114	97-129
115	97-173
116	97-002
117	97-177
118	97-164
119	98-119
120	97-190
121	97-174
122	97-012