



Vegetation Composition and Structure: Baseline Monitoring in the Southwest Alaska Network

2008 Annual Summary Report

Natural Resource Technical Report NPS/SWAN/NRTR—2009/213



ON THE COVER

Vegetation monitoring plot in white spruce woodland (Plot LACL-2008-02-048), August 2008, Twin Lakes, Lake Clark National Park and Preserve. Photograph by Amy Miller, Southwest Alaska Network.

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Contents

	Page
Figures.....	iv
Tables.....	v
Appendices.....	vi
Abstract.....	vii
Acknowledgements.....	vii
Introduction.....	1
Methods.....	1
Study Area	1
Field Methods	1
Analysis.....	5
Results and Discussion	5
Species cover and frequency.....	5
Stand structure	9
Tree and shrub mortality.....	12
Interannual variability in species cover	16
Modifications to sampling design and sampling methods.....	16
Recommendations and Conclusions	17
Literature Cited.....	19
Appendices.....	21

Figures

	Page
Figure 1. GRTS plots established in 2007-2008, Lake Clark NPP.....	2
Figure 2. Mid-elevation white spruce and dwarf birch communities, Lake Clark NPP.....	4
Figure 3. Frequency of vascular species recorded in monitoring plots.	6
Figure 4. Mean species richness recorded in monitoring plots.....	9
Figure 5. Structural attributes of two mid-elevation spruce woodland plots.	11
Figure 6. Relationship between tree and seedling density in spruce woodland plots.....	11
Figure 7. White spruce infected with spruce needle rust, Lake Clark NPP (2007)	12
Figure 8. Winter temperature profiles for Port Alsworth, Alaska, 2001-2008	13
Figure 9. Frost damage on dwarf shrubs at sites near Snipe and Square Lakes (2007)....	14
Figure 10. Changes in dwarf shrub cover associated with frost damage in 2007.....	15

Tables

Table 1. Summary of monitoring plots established in Lake Clark NPP (2007-2008).....	2
Table 2. Mean percent cover by growth form and ground cover classes, among plots, for three vegetation types, Lake Clark NPP (2007-2008).	7
Table 3. Mean percent cover by species, among plots, for three vegetation types, Lake Clark NPP.	8
Table 4. Stand characteristics for spruce woodland and forest ecotone sites, Lake Clark NPP (2007-2008).....	10
Table 5. Frost damage in dwarf and low shrub species, Lake Clark NPP (2007).	14
Table 6. Interannual variability in species cover and percent cover by growth form, Lake Clark NPP	16
Table 7. Panel design for vegetation monitoring in the Southwest Alaska Network	17

Appendices

Appendix 1. Mean percent cover by growth form and ground cover class, within plots, for three vegetation types, Lake Clark NPP (2007-2008)	21
Appendix 2. Mean percent cover by species and height class for a subset of species, within plots, for three vegetation types, Lake Clark NPP (2007-2008).....	25
Appendix 3. Frequency data, within plots, for species recorded in three vegetation types, Lake Clark NPP (2007-2008)	29

Abstract

Landscape-scale monitoring vegetation monitoring will be conducted for all park units in the Southwest Alaska Network (SWAN) using a combination of remote-sensing products. Community-scale monitoring will be conducted in three parks (Lake Clark, Katmai, Kenai Fjords) using ground-based sampling in permanent monitoring plots. This report summarizes the results of baseline sampling in Lake Clark National Park and Preserve (2007-2008) and discusses refinements to the current sampling design.

In 2007-2008, fifteen randomly-located 0.25 hectare vegetation plots were sampled for species cover, species occurrence, and structural attributes (e.g., tree height and density) in mid-elevation areas of interior Lake Clark NPP. Major vegetation types sampled included dwarf birch and white spruce woodland communities. Plot variables were summarized within and across sites for three of the major vegetation classes (dry dwarf birch, moist dwarf birch, and white spruce woodland). Trees in spruce woodland sites ranged from 60-125 years in age and tree mortality was low. Widespread infection of white spruce by spruce needle rust (*Chrysomyxa ledicola*) was observed in 2007. Frost damage to evergreen dwarf shrubs was also extensive in 2007, but the vegetation appeared to have mostly recovered by 2008.

Estimates of within- and among-plot variance in species occurrence, species cover, and cover by growth form were used in simulations to refine estimates of sample size and sampling frequency. A rotating panel design, in which twelve plots per elevation band and vegetation class will be monitored in a given park each year, will be revisited at an interval of every five years. Monitoring efforts in 2009 will focus on the completion of up to three panels (36-40 plots) in low (0-450 m), mid- (450-900 m) and high (>900 m) elevation bands in Lake Clark NPP. Data loggers to measure soil temperature were installed at two sites in 2008, and will be installed at an additional three to five sites in 2009. One or more monitoring plots will also be collocated with the Snipe Lake RAWS weather station.

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Introduction

In addition to its intrinsic ecological value (primary production, habitat, forage), vegetation is a sensitive indicator of environmental conditions. In the Southwest Alaska Network (SWAN), vegetation will be monitored at two scales. Landscape-scale monitoring of vegetation will be conducted for all park units in the using a combination of remote-sensing products. Community-scale monitoring, the focus of this report, will be conducted in three parks (Lake Clark, Katmai, Kenai Fjords) using ground-based sampling in permanent monitoring plots. Monitoring objectives are to document trends in the structure (e.g., height, density), composition (e.g., species richness and diversity), and demography (e.g., mortality and species turnover) of selected vegetation classes. We are interested in the direct response of vegetation to environmental change, and thus have focused on late-successional communities that have not experienced recent stand-level disturbance. This report summarizes the results of baseline sampling in Lake Clark National Park and Preserve (2007-2008) and discusses refinements to the current sampling design.

Methods

Study Area

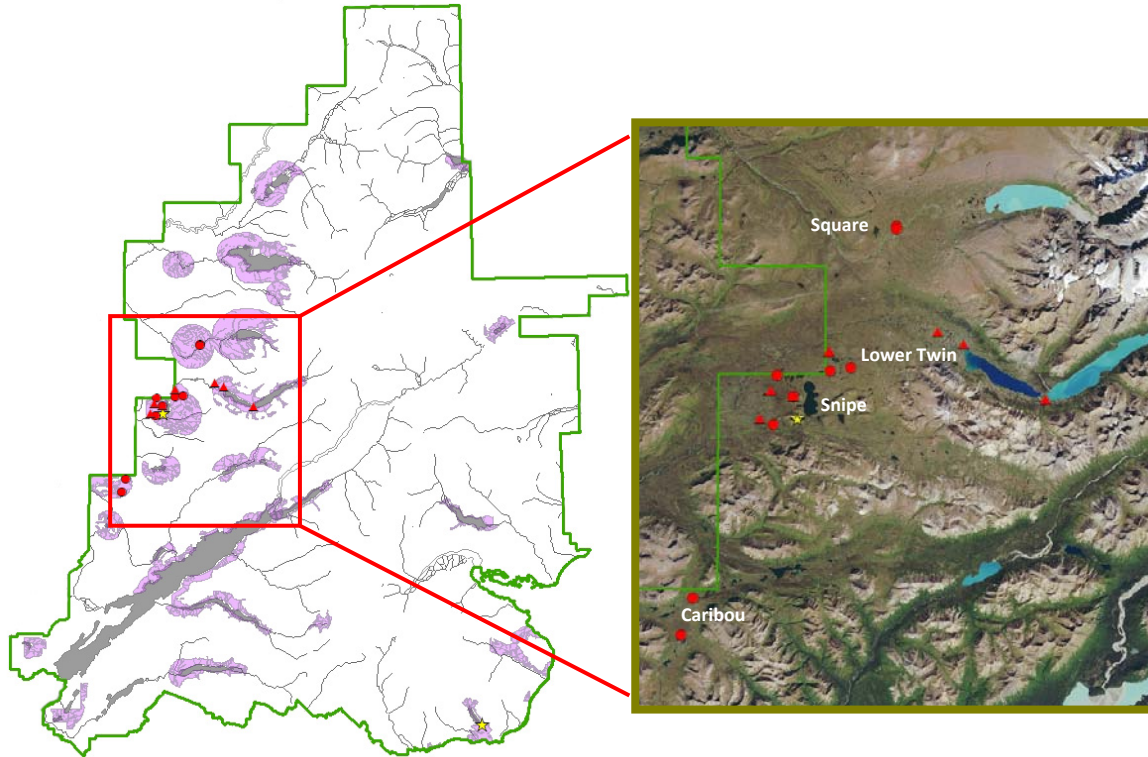
We initiated baseline sampling at fifteen mid-elevation (450-900 m) sites in Lake Clark NPP in 2007 and 2008 (Fig. 1; Table 1). Sampling was conducted between June 17-June 25, 2007; August 8-14, 2007; and June 24-July 1, 2008, using the sampling design and methods outlined in Miller et al. (2009). Briefly, we used a generalized random-tessellation stratified (GRTS, Stevens 1997; Stevens and Olsen 2004) design to select potential monitoring plots from three elevation bands (0-450 m, >450-900 m, >900 m) within an access layer (GIS) developed for Lake Clark NPP (Fig. 1; Mortenson and Miller 2008). Sites chosen for monitoring occurred low in the selection order of the GRTS sample (e.g., sample numbers 1-62) and were clustered within the accessible areas around Square, Snipe, Lower Twin, and Caribou Lakes. Square Lake occurs west of Turquoise Lake, in the headwaters of the Mulchatna River. Snipe and Lower Twin Lakes occur in the headwaters of the Chilikadrotna River, and the Caribou Lakes comprise the headwaters of the Koksetna River, which likewise drains in to the Chilikadrotna. All sites occur within the Western Lake and Till Plains subsection of the Lime Hills Ecoregion (Spencer 2001). The subsection is characterized by low relief and small-scale glacial features including eskers, pothole lakes and lateral and terminal moraines. Vegetation consists primarily of low shrub and ericaceous/lichen tundra, often dominated by dwarf birch (*Betula glandulosa*), dwarf Labrador tea (*Ledum palustre* ssp. *decumbens*), and/or crowberry (*Empetrum nigrum*), with scattered white spruce (*Picea glauca*) in well-drained areas. Treeline occurs at approximately 700 m elevation. Seasonal frost occurs at 0.2-0.5 m depth into late June-early July at most sites.

Field Methods

At each site, we established a 50 m × 50 m (0.25 ha) monitoring plot and intensively sampled the inner 30 m × 30 m (0.09 hectare), which was divided into three 30-m transects (Miller et al. 2009). We measured species occurrence (presence/absence) within fifteen 4-m² nested quadrats (0.25 m²; 1 m²; 4 m²) located at 7-m intervals along each transect, and species cover by point-intercept at 0.5 m intervals along each transect. Species cover was recorded within each of four

height classes (<0.5 m; 0.5-1.0 m; >1-4 m; >4 m). Species present in the 30 m × 30 m plot but not recorded in the nested

Figure 1. GRTS plots established in 2007-2008, Lake Clark NPP. Mid-elevation plots sampled in 2007 (circles) and 2008 (triangles) were accessed via floatplane and foot travel. The weather station near the southwest end of Snipe Lake is indicated in yellow. Access areas developed using slope, elevation, land ownership, and hydrology layers (GIS) are indicated in purple on the park overview map.



frequency quadrats were documented separately. Percent cover by plant growth form and substrate type was recorded using ocular estimates in the 4-m² quadrats in 1% increments up to 10%, and in 5% increments thereafter. Sampled vegetation types included white spruce woodland and low and dwarf shrub communities (Viereck et al. 1992; Table 1; Fig. 2). Plots that could not be accessed due to unanticipated barriers (e.g., dangerous stream crossings) were rejected.

Where applicable, we counted saplings in the 30 m × 30 m (0.09 hectare) inner plot and measured the diameter and height of all trees ≥ 12 cm diameter at breast height (DBH). We cored the four largest trees in the outer 10-m buffer surrounding the 30 m × 30 m plot and estimated canopy cover at the center of the plot using a spherical densiometer. Trees were cored at approximately 10-30 cm above the root crown to provide tree age. We calculated basal area for trees within the 0.09 hectare as follows:

$$\text{Basal area (cm)} = \pi \times (\text{DBH}/2)^2$$

We estimated aboveground biomass using allometric equations derived for *Picea glauca* (Harding and Grigal 1985):

$$\text{Dry mass (kg)} = 0.069 \times (\text{DBH (cm)})^{2.324} \times (\text{height (m)})^{0.210}$$

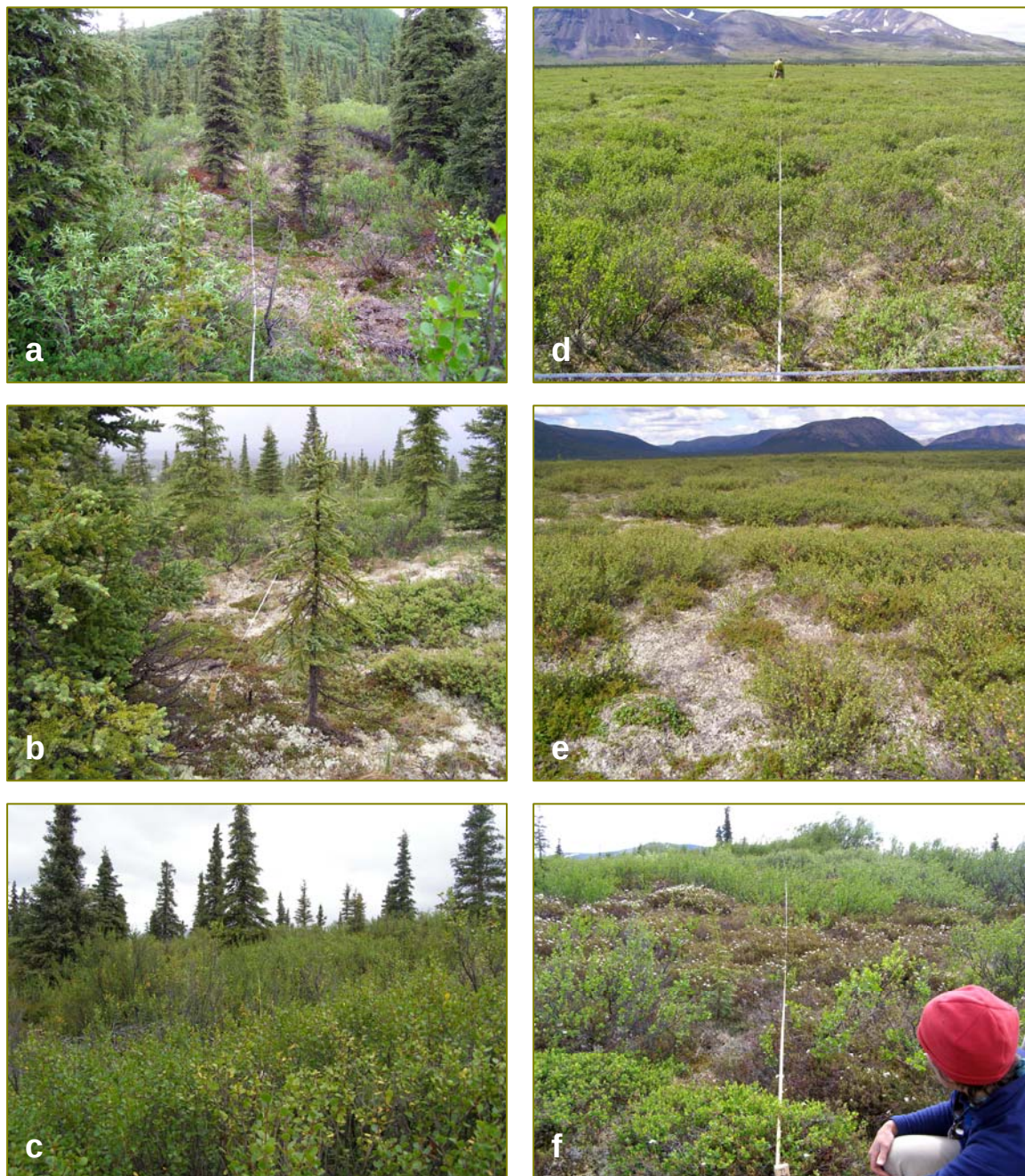
In addition, we recorded attributes related to forest condition (insects, pathogens, mortality) and site characteristics (slope, aspect, drainage). We measured one plot established in June 2007 (LACL-2007-02-006) again in June 2008, in order to estimate interannual variability. In 2009, we will re-measure several plots, including LACL-2007-02-006, to better characterize this source of temporal variation.

In 2008, we installed two HOBO Pro v1 data loggers to 10 cm depth at sites near Snipe Lake (Plots 2007-02-006; 2008-02-014). Soil temperature (°C) will be monitored continuously, year-round at 1-hour intervals. The data loggers will be downloaded every 1-2 years, but 2008-2009 data were not available for this report.

Table 1. Plot locations and major community types sampled in 2007-2008. Site elevations are rounded to the nearest 5 m. ‡Plot 2007-02-014 was located in a sedge meadow-spruce woodland transition. †Plot 2008-02-062 was located in a dwarf shrub-spruce woodland transition, on a moraine.

Plot no.	Location	Elevation (m)	Year established	Latitude/Longitude
Dwarf birch - dry				
02-002	Snipe Lake	615	2007	60.64863 N; 154.26604 W
02-006	Snipe Lake	630	2007	60.62798 N; 154.32708 W
02-006	Snipe Lake	535	2008	60.61016 N; 154.38164 W
02-007	Caribou Lakes	595	2007	60.43611 N; 154.50830 W
02-042	Snipe Lake	600	2008	60.66457 N; 154.26753 W
02-049	Lower Twin Lake	600	2008	60.68030 N; 154.08876 W
Dwarf birch - moist				
02-003	Square Lake	730	2007	60.76543 N; 154.15679 W
02-015	Snipe Lake	630	2007	60.65119 N; 154.23210 W
02-016	Square Lake	725	2007	60.76260 N; 154.15755 W
White spruce woodland				
02-005	Snipe Lake	540	2007	60.60531 N; 154.35904 W
02-014	Snipe Lake	545	2008	60.63263 N; 154.36351 W
02-017	Snipe Lake	580	2007	60.64522 N; 154.35295 W
02-048	Lower Twin Lake	620	2008	60.62562 N; 153.91125 W
Other				
02-014	Caribou Lakes‡	525	2007	60.46538 N; 154.48966 W
02-062	Lower Twin Lake†	630	2008	60.67026 N; 154.04574 W

Figure 2. Mid-elevation white spruce (*Picea glauca*) (a-c) and dry dwarf birch (*Betula glandulosa*; d-f) communities, Lake Clark NPP: a) LACL-2007-02-005 – Snipe Lake; b) LACL-2008-02-048 – Lower Twin Lake; c) LACL-2007-02-017 – Snipe Lake; d) LACL-2008-02-049 – Lower Twin Lake; e) LACL-2007-02-007 – Caribou Lakes; f) LACL-2008-02-006 – Snipe Lake.



Analysis

Plot variables (species occurrence; species cover; cover by growth form and height class) were summarized within and across sites using PROC SURVEYMEANS in SAS (SAS Institute, Cary, NC). The relationship between tree, sapling, and seedling densities in well-drained spruce woodland plots was explored using regression analysis.

Results and Discussion

Species cover and frequency

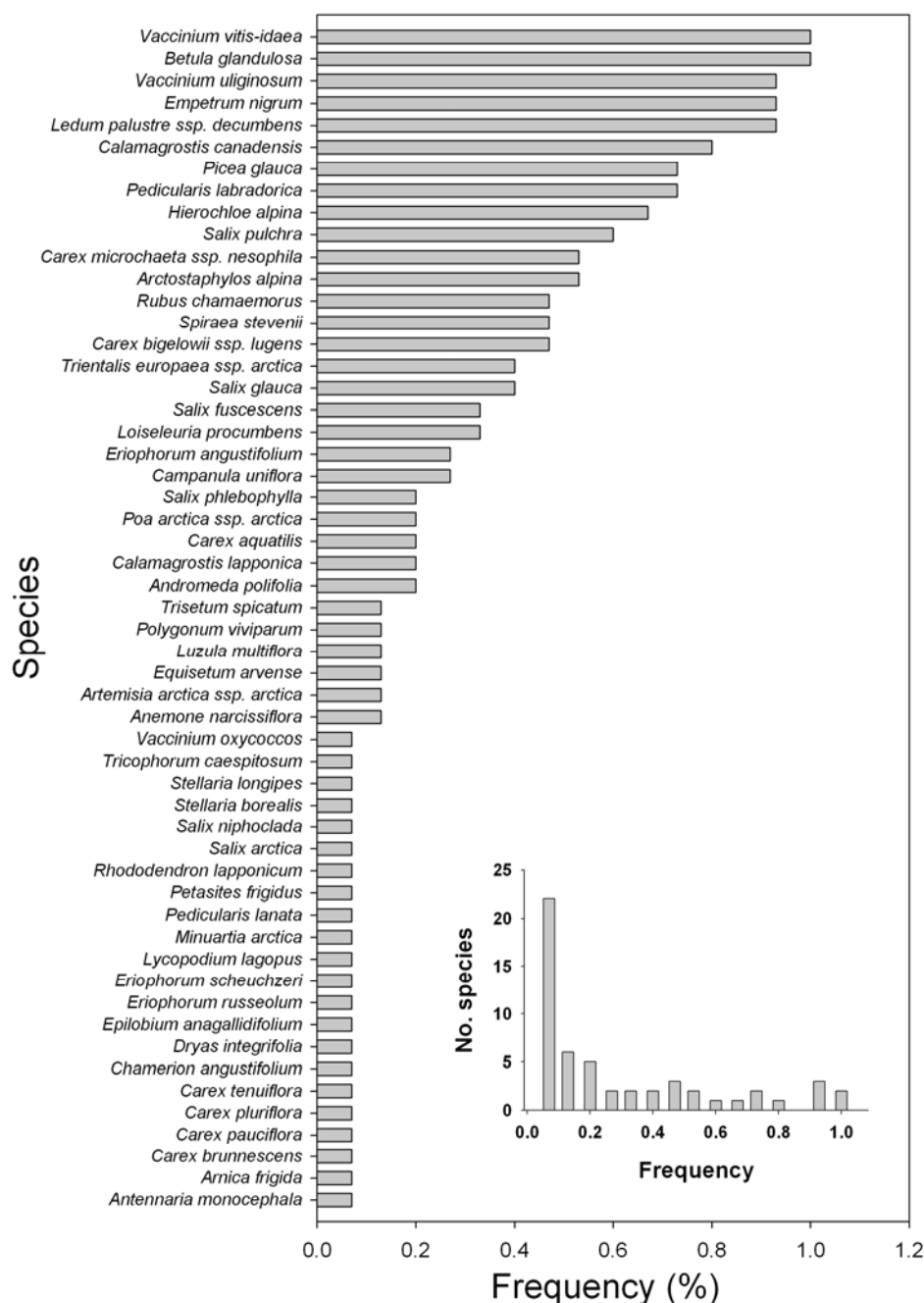
The communities we sampled shared many of the same species but differed in overall species composition and structural characteristics. Across sites, dry dwarf birch communities were characterized by high shrub (25-41%) and dwarf shrub cover (<1-26%), and by a large non-vascular component in the understory (lichen 5-43%; moss 12-72%; Table 2; Appendix 1). White spruce woodland communities were similar in understory composition to dry dwarf birch communities, having high shrub (10-40%), dwarf shrub (14-22%), lichen (11-52%) and moss cover (17-65 %; Appendix 1), but having a more complex, layered overstory (Table 3). Moist dwarf birch communities also showed high shrub cover (22-28%), as well as measurable graminoid (grass and sedge) cover (2-20%) and high variance in dwarf shrubs (2-40%; Table 2; Appendix 1).

Across all community types, a few species (e.g., *Betula glandulosa*, *Ledum palustre* ssp. *decumbens*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*) were characterized by high mean percent cover, low variance, and low coefficients of variation (CV) (Table 3; Appendix 2). In contrast, species that were less abundant, less broadly distributed (e.g., occurring only in one community type), or more variable in their distribution (e.g., occurring only in one or two plots across community types) showed low percent cover values, high variance across sites, and high CVs (e.g., *Arctostaphylos alpina*, *Salix fuscenscens*, *Carex aquatilis*, *Carex bigelowii* ssp. *lugens*, *Calamagrostis canadensis*; Table 3; Appendix 2).

Species occurrence, recorded in nested frequency quadrats, showed that most species, including widespread vascular species such as *Carex microchaeta* ssp. *nesophila*, *Arctostaphylos alpina*, *Anemone narcissiflora*, and *Salix glauca*, occurred at low frequency across a broad range of sites (Fig. 3; Appendix 3). Fewer species (e.g., *Betula glandulosa*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, *Empetrum nigrum*, *Ledum palustre* ssp. *decumbens*) occurred at high frequency across all sites.

Broadly-distributed species and/or growth forms characterized by low CVs in percent cover are expected to be good candidates for monitoring, since low sampling variance will increase our power to detect a trend through time. Similarly, for species that occur at high frequencies across one or more community types (Fig. 3), we may be able to detect changes in relative abundance. The frequency data should also enable us to track species turnover and changes in species richness within and across plots, through time, assuming that we can accurately quantify detection probabilities. For perennial plants, this should be relatively straightforward, given that we sample at a time of year when all species are identifiable (e.g., late June-late August).

Figure 3. Frequency of vascular species recorded in monitoring plots, Lake Clark NPP (2007-2008). Percentages (1.0 = 100%) reflect the number of plots, out of a total of fifteen, in which a species was recorded. Twenty-two species were found at one of fifteen sites (inset figure), whereas only two species (*Betula glandulosa*; *Vaccinium vitis-idaea*) were recorded at all sites.



The frequency data show a total of 33 vascular species recorded in the dry dwarf birch communities ($n = 6$); 29 species in the moist dwarf birch communities ($n = 3$); and 25 species in the spruce woodland communities ($n = 4$; Appendix 3). We do not have comparable numbers for non-vascular species, as we recorded only the most abundant bryophyte (moss, liverwort) and lichen species at each plot (Appendix 3).

Table 2. Percent cover by cover class and spruce seedling counts/quadrat for mid-elevation dry dwarf birch, moist dwarf birch, and white spruce woodland communities sampled in Lake Clark NPP (2007-2008). Mean seedling counts in 4-m² quadrats were converted to seedling densities (stems/ha) reported in the text. Cover was estimated visually in 4-m² quadrats arrayed along 30-m transects (n = 15); mean percent cover ($\pm$ 1 S.E.) and coefficient of variation (CV) are shown for each cover class within the broader community types. Total cover >100% is due to layering within community type. Dry dwarf birch and spruce woodland showed high constancy (CV $\leq$ 0.35; highlighted in boldface) in shrub, dwarf shrub, lichen, and moss components. Moist dwarf birch had a relatively rich graminoid component, and high constancy in shrub, forb, and moss components.

Cover class	Dwarf birch – dry (n = 6)		Dwarf birch – moist (n = 3)		White spruce woodland (n = 4)	
	% Cover	CV	% Cover	CV	% Cover	CV
Tree	1.9 (1.2)	0.61	<0.0 (0.0)	1.00	3.9 (0.7)	0.18
Shrub	31.5 (2.6)	0.08	25.8 (1.9)	0.07	24.2 (6.0)	0.25
Dwarf shrub	13.4 (3.6)	0.27	16.1 (12.2)	0.76	19.3 (1.9)	0.10
Forb	0.6 (0.4)	0.69	0.1 (0.0)	0.21	0.3 (0.2)	0.63
Graminoid	1.8 (1.0)	0.58	9.4 (5.3)	0.56	0.6 (0.2)	0.42
Lichen	21.3 (6.3)	0.29	3.6 (2.0)	0.56	30.9 (8.6)	0.28
Moss	42.9 (7.8)	0.18	31.7 (10.2)	0.32	45.2 (10.1)	0.22
Cryptobiotic crust	1.4 (0.7)	0.50	0.8 (0.6)	0.79	0.6 (0.3)	0.49
Tree seedlings (no. stems)	0.31 (0.14)	0.46	0.07 (0.07)	1.00	0.58 (0.13)	0.23
Gravel	0.9 (0.9)	1.04	<0.1 (0.0)	1.00	<0.1 (0.0)	1.00
Cobble	<0.1 (0.0)	1.04	0.1 (0.1)	1.00	0.0 (0.0)	-
Bedrock	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
Bare soil	0.15 (0.14)	0.97	0.0 (0.0)	-	0.0 (0.0)	-
Litter	18.4 (7.2)	0.39	34.0 (10.4)	0.31	14.8 (2.9)	0.20
Downed wood	<0.1 (0.0)	1.04	0.0 (0.0)	-	0.2 (0.2)	0.91
Standing dead	1.2 (0.4)	0.35	<0.1 (0.0)	1.00	0.5 (0.1)	0.19

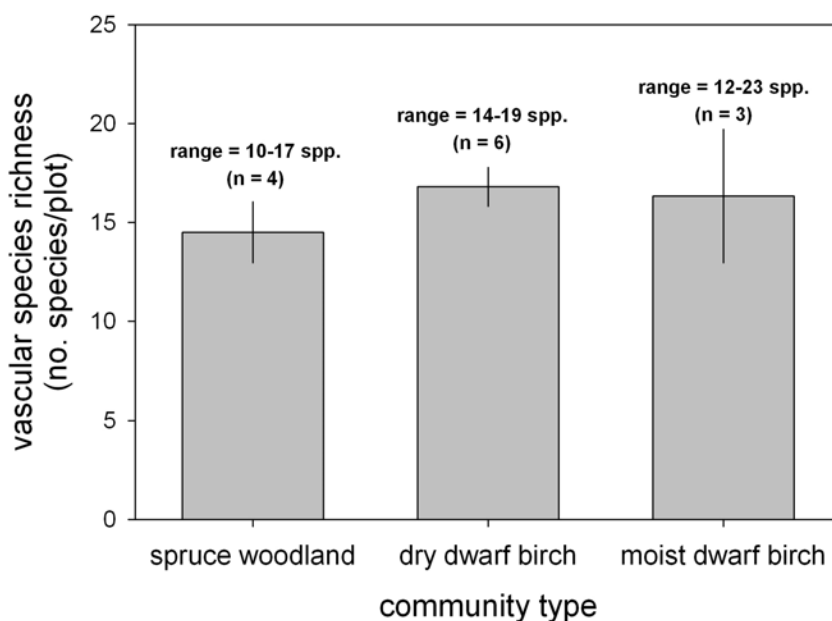
Table 3. Percent cover by species for mid-elevation dry dwarf birch, moist dwarf birch, and white spruce woodland communities sampled in Lake Clark NPP (2007-2008). Cover was estimated by point-intercept at 0.5-m intervals along 30-m transects; mean percent cover ($\pm$ 1 S.E.) and coefficient of variation (CV) are shown for a subset of species within each community type. Total cover >100% is due to layering within community type. Cover by height class (<0.5 m; 0.5-1.0

m; >1.0-4.0 m) is shown for white spruce (*Picea glauca*) and dwarf birch (*Betula glandulosa*). Species with CVs $\leq 35\%$ are highlighted in boldface (e.g., *Betula glandulosa*, *Ledum palustre* ssp. *decumbens*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*).

Species	Dwarf birch – dry (n = 6)		Dwarf birch – moist (n = 3)		Spruce woodland (n = 4)	
	% Cover	CV	% Cover	CV	% Cover	CV
Tree						
<i>Picea glauca</i> (<0.5 m)	0.4 (0.4)	1.04	0.0 (0.0)	-	3.4 (1.1)	0.31
<i>P. glauca</i> (0.5-1.0 m)	0.6 (0.4)	0.70	0.0 (0.0)	-	4.5 (1.0)	0.22
<i>P. glauca</i> (>1.0-4.0 m)	0.4 (0.3)	0.79	0.0 (0.0)	-	4.9 (2.1)	0.43
Shrub						
<i>Betula glandulosa</i> (<0.5 m)	25.7 (8.4)	0.33	26.9 (9.7)	0.36	15.7 (4.3)	0.27
<i>B. glandulosa</i> (0.5-1.0 m)	5.2 (2.8)	0.54	0.0 (0.0)	-	9.6 (3.6)	0.38
<i>B. glandulosa</i> (>1.0-4.0 m)	0.5 (0.5)	1.04	0.0 (0.0)	-	1.3 (0.5)	0.38
<i>Ledum palustre</i> ssp. <i>decumbens</i>	22.2 (5.1)	0.23	17.7 (8.5)	0.48	15.2 (4.2)	0.28
<i>Salix fuscescens</i>	0.0 (0.0)	-	2.1 (2.1)	1.00	0.1 (0.1)	1.00
<i>Vaccinium uliginosum</i>	12.3 (2.8)	0.23	21.5 (0.6)	0.03	16.0 (2.5)	0.15
Dwarf shrub						
<i>Arctostaphylos alpina</i>	0.6 (0.4)	0.63	0.2 (0.2)	1.00	0.3 (0.3)	1.00
<i>Empetrum nigrum</i>	20.0 (6.8)	0.34	17.3 (12.5)	0.72	26.6 (3.2)	0.12
<i>Vaccinium vitis-idaea</i>	9.7 (2.6)	0.27	7.7 (3.1)	0.40	4.7 (1.3)	0.28
Graminoid						
<i>Calamagrostis canadensis</i>	1.1 (0.6)	0.55	0.6 (0.6)	1.00	0.1 (0.1)	1.00
<i>Carex aquatilis</i>	0.0 (0.0)	-	12.1 (7.6)	0.63	0.0 (0.0)	-
<i>Carex bigelowii</i> ssp. <i>lugens</i>	4.4 (3.7)	0.84	2.4 (2.2)	0.89	0.0 (0.0)	-
Lichen	33.9 (6.1)	0.18	18.6 (9.1)	0.49	38.0 (8.4)	0.22
Moss	30.9 (7.4)	0.24	29.2 (4.2)	0.15	37.7 (7.9)	0.21

Vascular species richness (number of species per plot) was low and relatively constant among the three communities, averaging approximately 15-17 species/plot (Fig. 4; Appendix 3). Not surprisingly, species richness increased in the ecological transitions between communities, or ecotones (e.g., sedge meadow-spruce woodland: 25 species/plot; dwarf birch-spruce woodland: 27 species/plot). The two transitional sites accounted for approximately 65% of the vascular species that occurred at low frequency ($\leq 20\%$) across all plots (Fig. 3; Appendix 3). We found no non-native species, and no species of conservation concern (i.e., species that are tracked as rare on a statewide basis by the Alaska Natural Heritage Program) in the plots that we sampled.

Figure 4. Mean vascular species richness (± 1 S.E.) recorded in white spruce woodland, dry dwarf birch, and moist dwarf birch communities, Lake Clark NPP (2007-2008). Range in values for richness refers to the number of vascular species recorded in individual monitoring plots.



Stand structure

We used estimates of species cover by height class to provide information regarding stand structure. Across all community types, dwarf birch (*Betula glandulosa*) cover in height classes ≥ 0.5 m was relatively low, indicating that most dwarf birch measured was under 50 cm tall. That said, 5-10% of *Betula* cover in dry dwarf birch and spruce woodland communities was comprised of shrubs between 0.5 m and 1.0 m tall, and 1% of cover in spruce woodland consisted of shrubs >1.0 m tall (Table 3; Appendix 2). These results suggest the potential for more widespread increases in the height of dwarf birch, particularly in the spruce woodland communities. Whether increasing height in *Betula* leads to greater shading of the ground layer, and perhaps associated changes in species composition (e.g., loss of lichen and/or vascular species with high light requirements; cf. Chapin et al. 1995) cannot be determined from our data at this time. We will, however, monitor changes in both the structure of the forest understory (e.g., proportion of shrub species in each height class) and in the lower stature vegetation (e.g., species frequency, cover, and overall species richness), as both components could have far-

reaching effects on ecosystem processes. Increasing shrub cover or increased shrub height, for example, could lead to increasing surface roughness, increased albedo and evapotranspiration (e.g., Beringer et al. 2005). Plant height and density can also influence snowpack, with forests and tall shrubs providing increased protection from wind and thus greater snow depths than adjacent, low-stature vegetation (e.g., Kershaw and McCulloch 2007).

In the dry dwarf birch communities, white spruce (*Picea glauca*) was present in one-third of plots. *Picea* cover was evenly distributed across height classes (<0.5 m; ≥0.5-1.0 m; 1.0-4.0 m) in these plots, but averaged less than 1% in each layer. Nevertheless, the presence of spruce in taller height classes (e.g., widely scattered saplings and trees) indicates that the sites can support trees and suggests that spruce cover could increase in the future.

In the spruce woodland communities, tree densities ranged from 44-189 stems/ha (Table 4; Fig. 5) and *Picea* cover was weighted toward individuals ≥0.5 m tall (Table 3). Not surprisingly, mean spruce seedling densities in woodland communities were two to ten times greater than in moist or dry dwarf birch communities (spruce woodland: 1462 stems/ha; dry dwarf birch: 780 stems/ha; moist dwarf birch: 167 stems/ha; Appendix 1).

Table 4. Stand characteristics for white spruce woodland plots sampled in 2007-2008. Basal area and aboveground biomass estimates are based on tree (DBH >12 cm) measurements and do not include sapling counts. Seedling, sapling and tree densities are expressed as live stems/hectare. Mean tree age was determined for the largest diameter trees within the outer 50 × 50 m plot (n = 4). Canopy cover (%) was determined using a spherical densiometer at plot center.

Plot code	Basal area (m ² /ha)	Aboveground biomass (kg/ha)	Seedling density	Sapling density (stems/ha)	Tree density	Mean tree age (years)	Canopy cover (%)
2007-02-005	5.5	2103	2175	222	178	89	23
2007-02-017	2.0	698	1175	178	89	103	16
2008-02-014	4.7	1504	675	189	189	125	15
2008-02-048	0.9	258	1825	300	44	72	2

The greatest mean seedling densities were in forest ecotone plots (6162 stems/ha; Appendix 1), where high light conditions, low shrub cover, and proximity to seed source likely enhanced seedling establishment. Within the woodland and forest ecotone communities, seedling densities (675-6825 stems/ha; Table 4; Appendix 1) appeared to decrease at sites with higher tree densities. The best-fit regression line between tree and seedling density was described by a quadratic equation, suggesting that factors other than tree density (e.g., soils, shrub cover, or microclimate) also control seedling recruitment (Fig. 6; $df = 2$; $F=6.3$; $P>N.S.$). We found no relationship between tree and sapling densities in the plots sampled.

Figure 5. Three-dimensional plots of stand structure for two spruce woodland plots sampled in 2008. Trees ≥ 12 cm DBH are shown, with tree height indicated on the vertical axis. Larger diameter (>20 cm DBH) trees and greater tree density in Plot 2008-02-014 resulted in greater canopy cover. However, seedling and sapling densities (not shown) were greater in Plot 2008-02-048.

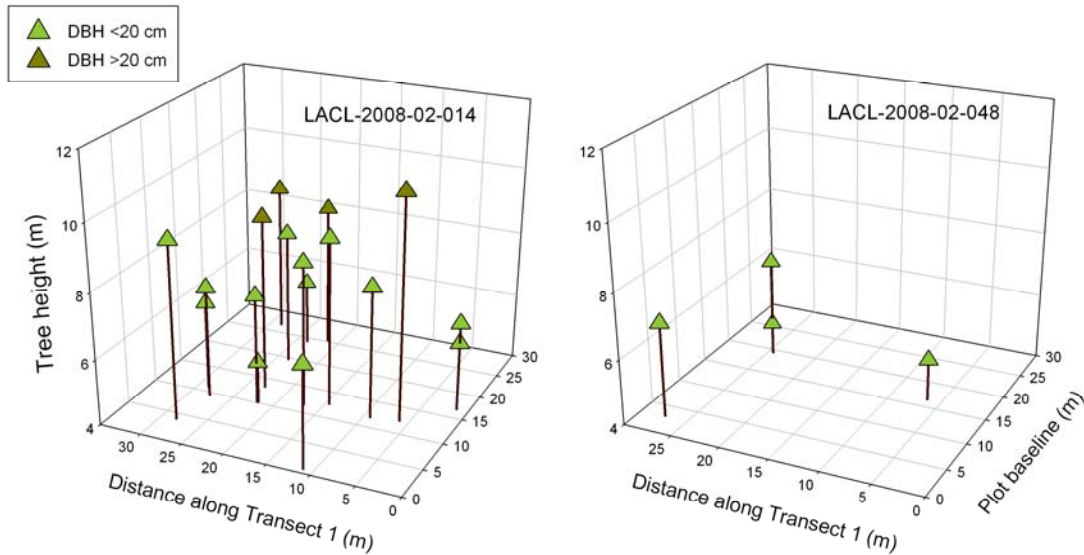
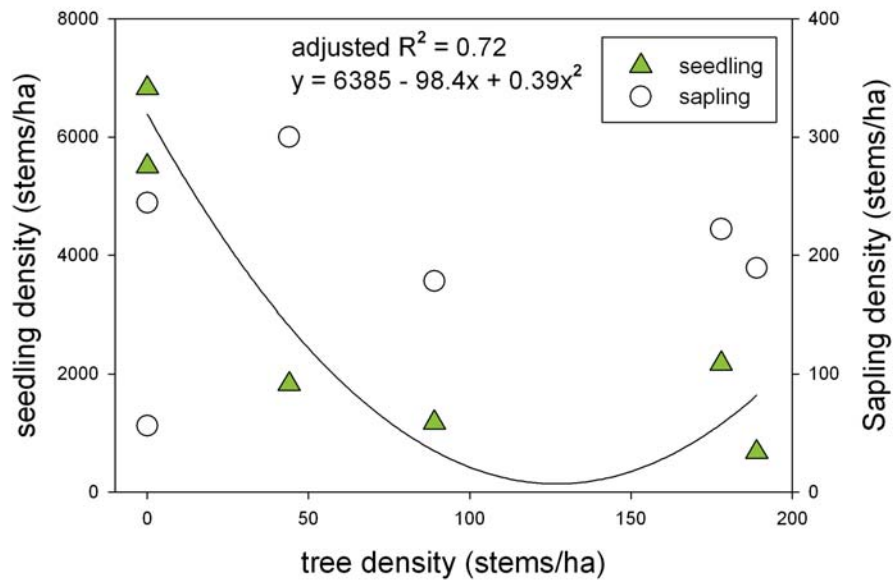


Figure 6. Relationship between overstory tree density and understory spruce seedling and sapling densities in mid-elevation white spruce woodland and forest ecotone plots. High light conditions (low tree densities) and proximity to seed source may support greater seedling densities in the ecotone plots.



Tree and shrub mortality

Roughly 1% of cover in dry dwarf birch plots consisted of standing dead material (Table 2), primarily dead branches of *Betula glandulosa* and/or frost-killed portions of *Ledum palustre* ssp. *decumbens*. We found similar damage in spruce woodland plots, although at less than 1% cover. The source of damage to the *Betula* stems was unclear; in some cases, the dead stems were on shrubs ≥ 1.0 m tall, suggesting that the individuals were growing old and decadent. In other cases, the damage may have been due to exposure (freezing), although we found little evidence for this when we recorded frost damage in 2007 (see below).

We recorded no tree mortality and only limited (<5%) sapling mortality across sites. In 2007, most trees sampled were infected with spruce needle rust (*Chrysomyxa ledicola*; Fig. 7), in agreement with reports from southeast Alaska where the fungus was recorded at epidemic levels (Snyder et al. 2008). Outbreaks are thought to be triggered by specific weather events that coincide with the emergence of new needles in May (Snyder et al. 2008), and the disease does not typically occur at high levels in successive years. In 2008, the fungus appeared to have returned to background levels.

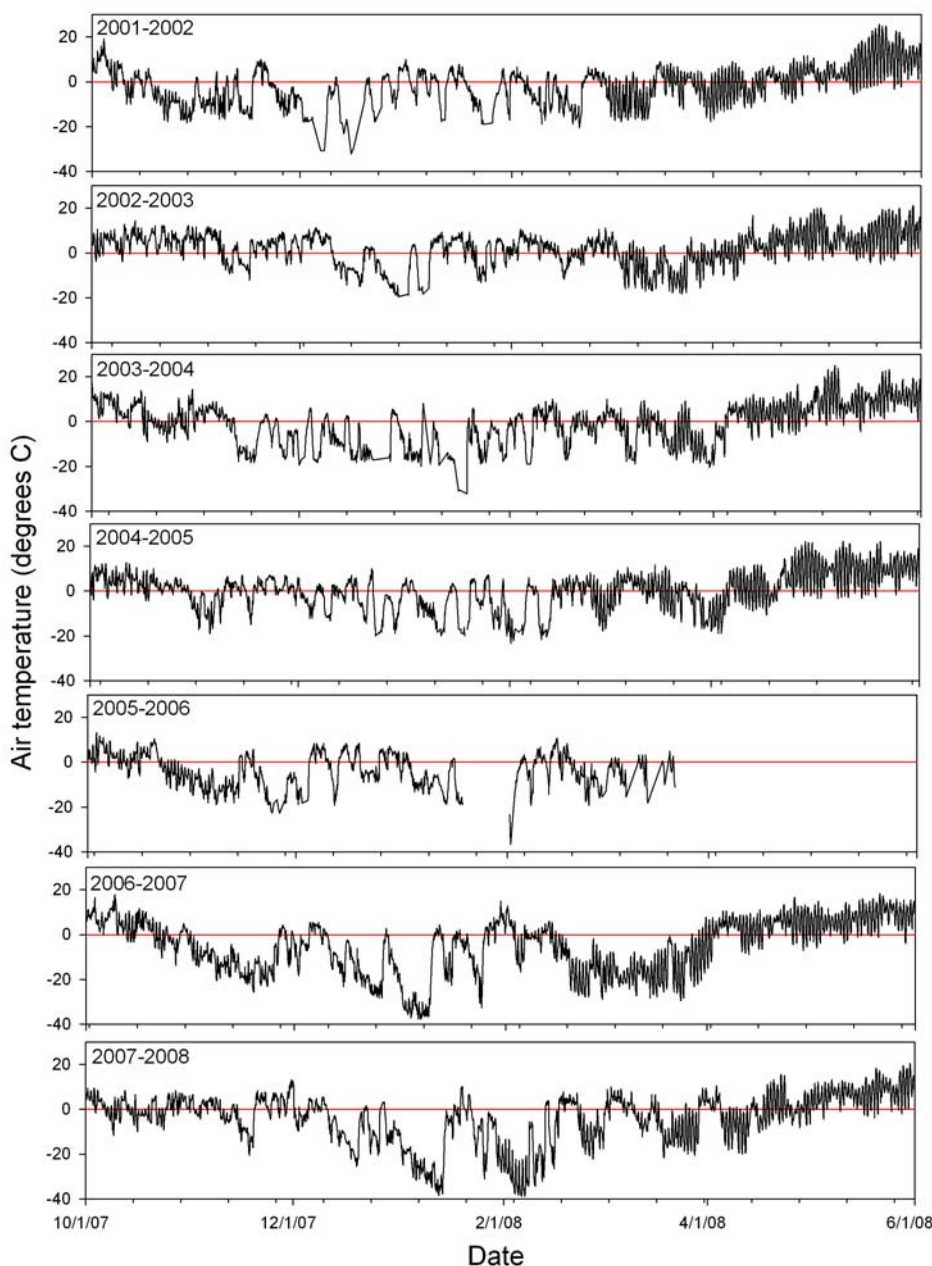


Figure 7. White spruce infected with spruce needle rust (*Chrysomyxa ledicola*), August 2007, Lake Clark NPP.

The fungus also infects Labrador tea (*Ledum* spp.), its alternate host. In 2007, the fungus occurred at the highest levels on record in southeast Alaska. In 2008, infection rates appeared to be much lower.

A mid-winter thaw and resultant loss of snow in 2006-2007 (Fig. 8) resulted in widespread frost damage, particularly to evergreen low and dwarf shrub species. We quantified this damage at a subset of sites (August 2007) and found that large areas of crowberry (*Empetrum nigrum*), Labrador tea (*Ledum palustre* ssp. *decumbens*) and lowbush cranberry (*Vaccinium vitis-idaea*) had been affected (Table 5; Fig. 9). Deciduous shrubs, including lowbush blueberry (*Vaccinium uliginosum*) and dwarf birch (*Betula glandulosa*), did not appear to have been damaged. Evidence of stem damage and/or death was still visible in 2008 and may partly explain the decreases in cover observed for *Empetrum* and *Ledum* at one site (LACL-2007-02-006) between years (Fig. 10).

Figure 8. Winter temperature profiles (2001-2008) for Port Alsworth, Alaska. The winter of 2006-2007 was characterized by a lengthy mid-winter thaw that resulted in a loss of snow cover, followed by more than a month of below-freezing temperatures.

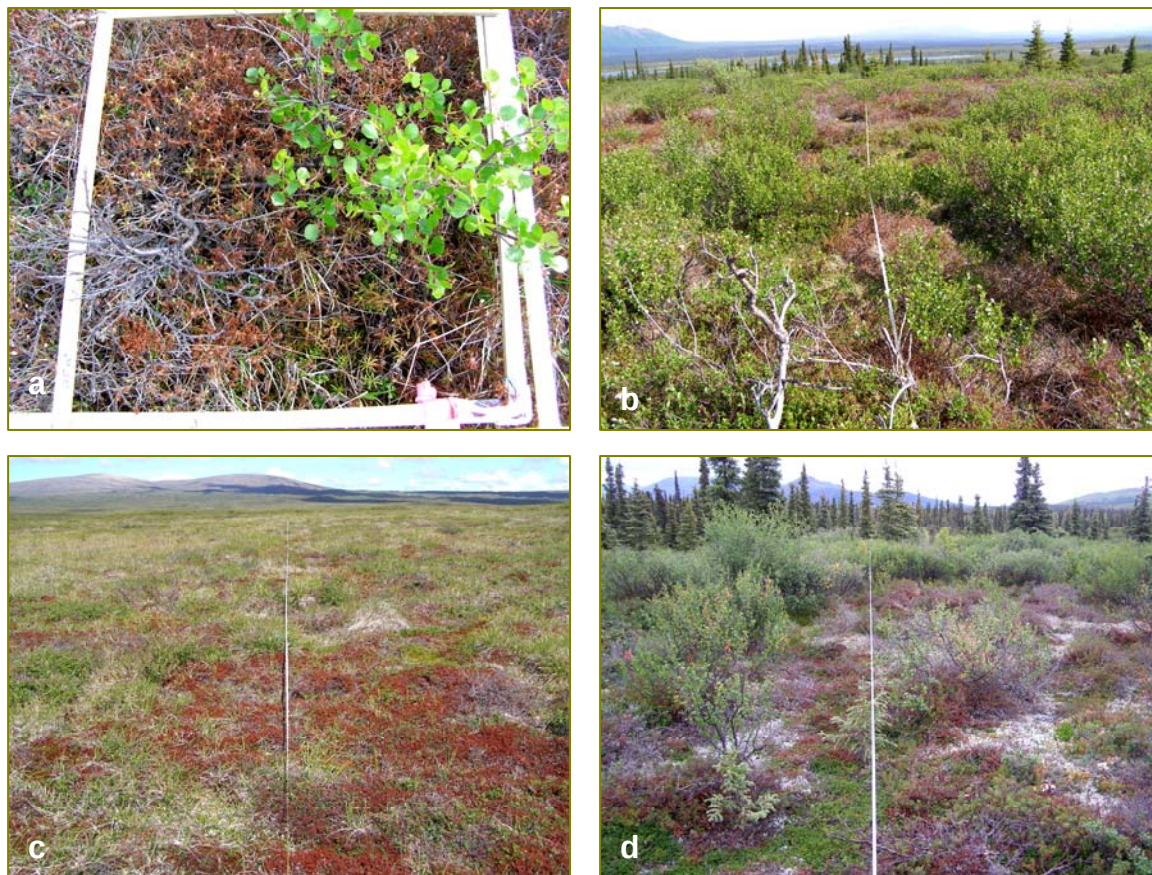


The mid-winter warming that occurred in 2007 resulted in twenty days of above-zero temperatures (1/25-2/3/07 and 2/6-2/17/08; maximum temperature 15 °C; RAWs hourly data; <http://www.raws.dri.edu>, accessed 5/4/09). Warm temperatures and high winds led to snow loss in wind-exposed areas, and widespread frost damage to dwarf shrubs during the ensuing cold period (2/17-3/29/07; minimum temperatures -28 °C). In most other years, the mid-winter thaw has been short-lived and/or has been followed by near-zero temperatures, extending into snowmelt.

Table 5. Frost damage to dwarf and low shrub species in a subset of plots sampled in August 2007, Lake Clark NPP. Percent cover by species and percent damage within species were recorded by point-intercept along the 30-m transects. Total cover affected ranged from 2-33% in *Empetrum* and from <1-8% in *Ledum*. Damage to *Vaccinium* comprised $\leq 1\%$ of cover.

Plot code	Community type	<i>Empetrum nigrum</i>		<i>Ledum palustre</i> ssp. <i>decumbens</i>		<i>Vaccinium vitis-idaea</i>	
		% cover	% damage	% cover	% damage	% cover	% damage
2007-02-006	dry dwarf birch	41.5	34.7	33.1	23.1	9.3	9.1
2007-02-016	dry dwarf birch	42.4	77.3	14.1	12.0	7.9	21.4
2007-02-003	moist dwarf birch	4.0	71.4	5.1	11.1	2.3	50.0
2007-02-017	spruce woodland	32.2	5.3	27.7	0.0	7.9	0.0

Figure 9. Frost damage, as indicated by reddened leaves, at sites near Snipe and Square Lakes, August 2007. (a) Frost damage in Labrador tea (*Ledum palustre* ssp. *decumbens*) sampled in a 0.25-m² quadrat (LACL-2007-02-006 - Snipe Lake); (b) damaged *Ledum* hummocks shown with undamaged dwarf birch (*Betula glandulosa*; LACL-2007-02-006 - Snipe Lake); (c) frost damage in crowberry (*Empetrum nigrum*; LACL-2007-02-016 - Square Lake); (d) frost damage in *Ledum* and *Empetrum* at a spruce woodland site (LACL-2007-02-017 - Snipe Lake).

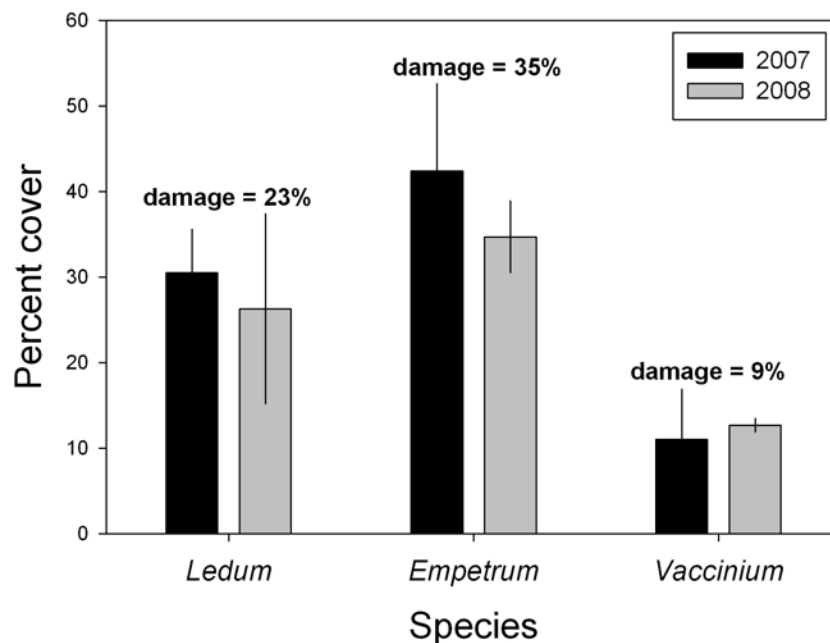


Short-term variation in species cover due to extreme weather or other localized events is unlikely to lead to long-term reductions in cover, unless the damage is very extensive, severe enough to kill belowground portions of the plants, or the disturbance (in this case, freezing associated with loss of snow cover) recurs over several successive years. A recent warming experiment in a

subarctic heath community has shown that a set of related species, *Empetrum hermaphroditum* and two species of *Vaccinium* (*V. myrtillus*, *V. vitis-idaea*), showed delayed bud development and up to 80% reductions in berry production in response to a 1-week extreme winter warming event (Bokhorst et al. 2008). However, the response among species varied: *V. myrtillus* and *Empetrum* were negatively affected by the winter warming treatment, whereas *V. vitis-idaea* showed a slight increase in growth. The experimental results above are consistent with our observations of *Empetrum nigrum*, which showed extensive frost damage in 2007, and *Vaccinium vitis-idaea*, which was less severely affected (Fig. 10).

Although mid-winter thaw events are not unusual, an increase in the frequency of these events, and thus repeated damage without a sufficient recovery period, could have major effects on community structure and productivity. Species most susceptible to frost damage (e.g., *Empetrum*, *Ledum*) may decline in abundance and/or be replaced by more frost-tolerant species, particularly if reproduction is affected. Growth in *E. hermaphroditum* has been found to be relatively insensitive to snowmelt date (Bär et al. 2008), but earlier melt-out dates could likewise lead to increased frost damage if newly exposed plants experience repeated freeze-thaw cycles. Thinner snowpacks and earlier snowmelt dates have already resulted in more than a decade of increased bud mortality in three high elevation species in Colorado, likely reducing seed production and seedling recruitment at the site, as well (Inouye 2008).

Figure 10. Changes in species cover (2007-2008) associated with frost damage in 2007. Data are from dry dwarf birch (LACL-2007-02-006, Snipe Lake). Mean cover (± 1 S.E.) was estimated by point-intercept in late June of both years. Percent damage shown over bars for each species refers to the proportion of that species that exhibited frost damage in August 2007 (Table 4). *Empetrum nigrum*, which showed the most extensive damage in 2007, showed a measurable decrease in cover in 2008.



Interannual variability in species cover

Interannual variability in percent cover estimates for individual species and cover classes (e.g., tree, shrub, etc.) ranged from 0-240%, with abundant species and cover classes showing the lowest variation (Table 6). Graminoids (grasses and sedges) and forbs showed the greatest variation in cover due to phenology. Whereas woody growth forms (shrubs, dwarf shrubs, trees) have relatively stable morphologies and may be less affected by year-to-year environmental variation, herbaceous species (grasses, sedges, forbs) may produce more or less biomass in a given year, depending on climatic conditions. For example, the low percent cover value for *Carex bigelowii* ssp. *lugens* in 2008 was due to later snowmelt and delayed emergence of the new leaves in that year, and thus was an artifact of our sampling date. Note that estimated interannual variation cannot be separated from other sources of error, as transects were re-established and re-measured in two consecutive years. In 2009, we will quantify observer error and error associated with re-measurement of transects on a single sampling date.

Table 6. Interannual variability in percent cover for a subset of species and cover classes measured in a dry dwarf birch community (Plot LACL-2007-02-006). Cover by species was recorded by point-intercept along 30-m transects. Cover by growth form was recorded using ocular estimates. Percent cover values are plot means for 2007 and 2008.

Species	% Cover		% Variation
	2007	2008	
<i>Betula glandulosa</i>	11.0	13.6	23
<i>Carex bigelowii</i> ssp. <i>lugens</i>	12.7	5.1	150
<i>Empetrum nigrum</i>	42.4	34.8	21
<i>Louisleuria procumbens</i>	5.9	3.4	75
<i>Salix pulchra</i>	0.9	0.9	0
<i>Vaccinium uliginosum</i>	16.1	15.3	6
<i>Vaccinium vitis-idaea</i>	11.0	12.7	15
Growth form			
Tree	7.2	7.0	3
Shrub	30.5	31.5	3
Dwarf shrub	13.0	17.4	34
Forb	0.2	0.4	79
Graminoid	2.6	0.8	240
Lichen	7.8	7.8	<1
Moss	36.5	49.1	34

Modifications to the sampling design and sampling methods

In addition to describing baseline conditions, we have used results of the pilot sampling to quantify variability in several common vegetation classes (spruce woodland, dry and moist dwarf birch). Based on the sample variances (CVs; e.g., Tables 2-3) and estimated interannual variability (Table 6), we have used simulations to evaluate minimum sample size and sample frequency required to detect long-term trends in vegetation parameters. The simulations investigated the minimum level of total change that could be detected with 95% confidence under a rotating panel design for populations subjected to different levels of true total change (30%, 40%, and 50%) over a 31-year period (Miller et al. 2009). We used our estimates of interannual variability and rates of change reported in the literature to assign a minimum detectable total change of 20% for a true total change of 40%. To accomplish this using the split

panel design outlined in Table 7, we will attempt to sample 12 plots per vegetation class $\times$ elevation band $\times$ park (total = 36 plots per year in a single park) every five years. In addition, we will sample a subset of plots for two consecutive years every four years to provide continuous estimates of interannual variability.

Table 7. Panel design for vegetation monitoring in the SWAN. A panel represents a group of plots that is sampled during the same year (McDonald 2003). Each X in panels 1-5 represents 36 plots, or three vegetation class $\times$ elevation band $\times$ park combinations. In Panel 6, which is sampled for 2 consecutive years beginning every 5th year, each X represents 4-6 plots.

Panel	Year																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	X					X					X					X					
2		X					X					X					X				
3			X					X					X					X			
4				X					X					X					X		
5					X					X					X					X	
6					X	X				X	X				X	X				X	X

To a large extent, our sampling methods at the plot level follow those of the Central Alaska Network (CAKN; Roland et al. 2004). However, based on our pilot sampling in 2007-2008, we have made several modifications. First, we have added descriptors to the species data collected along point-intercept transects that indicate whether plants are frost damaged or include standing dead material. Following our observations of frost damage in 2007, we included this new field with the hope that it may enable us to track long-term damage associated with extreme weather events. Second, we have begun to map trees in the plot in a way that enables us to plot stand structure in three-dimensional space (e.g., Fig.5). In this way, we can quantify changes in the density and spatial array of trees in different size classes, as well as increases in mortality, if they occur. We have aggregated the height classes used by the CAKN from ten to four vertical strata (for species cover estimates along point-intercept transects), and have limited our frequency estimations for non-vascular species to the most common species, to save time. In 2008, we began collecting samples of feather moss (*Hylocomium splendens*) at all sites to analyze for airborne contaminants, including heavy metals and nutrients (N and S).

Recommendations and Conclusions

Pilot sampling conducted in 2007-2008 was limited to mid-elevation (450-900 m) sites in interior Lake Clark NPP, and our ability to sample multiple sites was constrained by a lack of personnel. In 2009, we have hired a crew of one term biological technician with expertise in non-vascular plants, a seasonal biological technician, and a student intern. With this expanded staffing, we expect to complete between 36-40 plots over the course of the field season. With the addition of a lichen specialist, we also hope to increase our ability to sample the non-vascular component.

We will continue to sample in the mid-elevation band in 2009, due to its importance as a transitional zone for vegetation (e.g., treeline), but will also sample in the low (0-450 m) and high (>900 m) elevation bands. A subset of sites in the low elevation band will be in the

headwaters of the Chulitna River, near Lake 423 (as indicated on the 1:63,000 USGS quads). This area is upstream of the proposed Pebble mine site, and may provide useful baseline data with respect to contaminant loads (e.g., as measured in *Hylocomium splendens*). In 2010, we plan to begin sampling in all elevation bands in Katmai National Park and Preserve.

Because of the importance of snowpack and timing of snowmelt to vegetation development, we will continue to monitor soil temperature at the two sites established in 2008, and at an additional six to eight sites in Lake Clark NPP. Soil temperature provides a good proxy for snow cover and snowmelt date, as soil temperatures stabilize once a snowpack develops and begin to increase rapidly once the sites are snow-free. We will establish at least one site in close proximity (within 0.5 km) of the RAWS weather station at Snipe Lake. Ambient (air) temperature is currently monitored at this station, and in 2009 a Campbell datalogger and soil thermistors will be installed at 10 cm and 50 cm depths. Time and funds permitting, we may also install a camera at one or more sites to document the timing of snowpack development, snowmelt, and phenological metrics (leaf out, senescence). The temperature data could then be cross-referenced to known melt-out dates, thus improving interpretation.

We will continue to revisit a subset of plots in consecutive years (cf. Table 7) to estimate interannual variability. An understanding of the inherent variability in the system is essential to our interpretation of longer-term, decadal-scale changes in vegetation. For example, it may enable us to distinguish between the effects of an episodic event (e.g., a mid-winter thaw period, late snowmelt, or anomalies in summer precipitation for a given year) and longer-term, directional change.

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Appendix 1. Mean percent cover (± 1 S.E.) by growth form and ground cover class, and mean number of tree seedlings/4-m² quadrat, for monitoring plots sampled in Lake Clark NPP (2007-2008). Seedling densities reported in text were converted to stems/hectare by multiplying mean seedling counts by 2500. Coefficients of variation (CV) are expressed as percentages (1.00 = 100%). Plot summaries are organized by community type (white spruce woodland; dry dwarf birch; moist dwarf birch; other).

White spruce woodland			Plot code					
Cover class	LACL_2007_02_005		LACL_2007_02_017		LACL_2008_02_014		LACL_2008_02_048	
	% Cover	CV	% Cover	CV	% Cover	CV	% Cover	CV
Tree	5.7 (2.8)	0.50	2.8 (2.6)	0.92	2.7 (2.2)	0.78	4.3 (2.9)	0.68
Shrub	23.7 (3.9)	0.17	39.7 (5.2)	0.13	23.0 (0.6)	0.03	10.3 (2.2)	0.21
Dwarf shrub	19.7 (4.3)	0.22	22.5 (4.1)	0.18	21.3 (6.6)	0.31	13.8 (2.0)	0.15
Forb	0.4 (0.3)	0.89	< 0.1 (0.0)	0.25	< 0.1 (0.0)	0.58	0.9 (0.6)	0.60
Graminoid	0.6 (0.3)	0.53	0.3 (0.1)	0.38	0.2 (0.1)	0.83	1.3 (0.5)	0.42
Lichen	33.7 (7.3)	0.22	26.3 (3.5)	0.13	11.1 (5.1)	0.46	52.3 (9.3)	0.18
Moss	53.3 (9.3)	0.30	45.0 (5.3)	0.12	65.0 (6.2)	0.10	17.4 (5.0)	0.29
Cryptogamic crust	0.2 (0.1)	0.52	0.2 (0.2)	1.00	0.5 (0.3)	0.48	1.4 (0.7)	0.48
Tree seedlings (no. stems)	0.87 (0.48)	0.55	0.47 (0.37)	0.80	0.27 (0.07)	0.25	0.73 (0.35)	0.48
Gravel	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00
Cobble	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Bedrock	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Bare Soil	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Litter	22.0 (6.4)	0.29	13.1 (0.7)	0.05	8.0 (0.9)	0.11	16.0 (2.1)	0.13
Downed wood	0.8 (0.67)	0.77	0.0 (0.0)	0.00	<0.1 (0.1)	1.00	0.0 (0.0)	0.00
Standing dead	0.5 (0.4)	0.71	0.45 (0.2)	0.48	0.6 (0.0)	0.01	0.2 (0.1)	0.52

Appendix 1. (continued)

Dry dwarf birch		Plot code											
		LACL_2007_02_002		LACL_2007_02_006		LACL_2007_02_007		LACL_2008_02_006		LACL_2008_02_042		LACL_2008_02_049	
Cover class		% Cover	CV	% Cover	CV	% Cover	CV	% Cover	CV	% Cover	CV	% Cover	CV
Tree		< 0.1 (0.0)	1.00	4.8 (4.7)	0.98	0.0 (0.0)	0.00	3.4 (2.8)	0.83	< 0.1 (0.0)	0.58	< 0.1 (0.0)	0.58
Shrub		26.1 (4.1)	0.16	25.4 (6.5)	0.26	41.3 (5.8)	0.14	31.0 (3.5)	0.11	28.3 (0.9)	0.03	39.3 (3.7)	0.09
Dwarf shrub		12.3 (4.5)	0.36	12.6 (4.1)	0.32	26.4 (4.6)	0.18	2.7 (2.1)	0.76	20.9 (5.7)	0.27	0.4 (.23)	0.59
Forb		< 0.1 (0.0)	0.29	3.5 (3.3)	0.93	0.3 (0.3)	0.97	0.1 (<0.1)	0.43	0.0 (0.0)	0.00	< 0.1 (0.0)	0.07
Graminoid		1.1 (0.7)	0.67	9.0 (6.5)	0.72	0.4 (<0.1)	0.14	0.2 (<0.1)	0.38	0.3 (0.1)	0.38	1.0 (0.2)	0.22
Lichen		43.3 (2.6)	0.06	5.2 (3.8)	0.73	29.7 (2.3)	0.08	29.1 (6.2)	0.21	14.8 (3.3)	0.22	20.7 (1.2)	0.06
Moss		34.1 (16.4)	0.48	28.0 (9.1)	0.32	11.8 (1.4)	0.41	58.9 (9.8)	0.17	53.0 (6.7)	0.13	72.3 (3.2)	0.04
Cryptogamic crust		3.8 (2.0)	0.53	1.7 (1.2)	0.72	0.3 (0.3)	0.97	0.0 (0.0)	0.00	1.0 (0.2)	0.20	< 0.1 (0.0)	0.40
Tree seedlings (no. stems)		0.00 (0.00)	0.00	0.27 (0.13)	0.50	0.00 (0.00)	0.00	1.07 (0.70)	0.65	0.27 (0.13)	0.50	0.20 (0.12)	0.58
Gravel		6.0 (6.0)	1.00	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Cobble		0.0 (0.0)	0.00	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Bedrock		0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Bare Soil		1.0 (0.6)	0.58	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Litter		11.7 (1.8)	0.15	68.3 (12.7)	0.19	11.5 (1.4)	0.12	8.1 (1.2)	0.14	7.7 (0.4)	0.05	11.0 (0.6)	0.05
Downed wood		< 0.1 (0.0)	0.77	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.00	0.00
Standing dead		< 0.1 (0.0)	1.0	0.4 (4.7)	0.53	0.2 (<0.1)	0.50	2.5 (1.3)	0.50	2.8 (2.1)	0.76	0.8 (0.2)	0.23

Appendix 1. (continued)

Moist dwarf birch			Plot code			
	LACL_2007_02_003		LACL_2007_02_015		LACL_2007_02_016	
Cover class	% Cover	CV	% Cover	CV	% Cover	CV
Tree	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00	0.0 (0.0)	0.00
Shrub	41.3 (5.8)	0.14	27.7 (2.3)	0.08	22.0 (0.6)	0.03
Dwarf shrub	1.7 (0.3)	0.16	6.2 (1.8)	0.27	40.3 (5.7)	0.14
Forb	0.2 (0.1)	0.60	0.1 (0.1)	0.44	< 0.1 (0.0)	0.68
Graminoid	19.7 (9.3)	0.47	6.0 (1.1)	0.18	2.4 (0.6)	0.27
Lichen	< 0.1 (0.0)	0.26	7.1 (3.3)	0.47	3.7 (1.1)	0.29
Moss	21.1 (9.0)	0.43	52.0 (9.5)	0.18	22.0 (3.6)	0.16
Cryptogamic crust	0.0 (0.0)	0.00	2.0 (1.0)	0.50	0.3 (0.3)	0.97
Tree seedlings (no. stems)	0.00 (0.00)	0.00	0.20 (0.20)	1.00	0.00 (0.00)	0.00
Gravel	0.0 (0.0)	0.00	0.0 (0.0)	0.00	< 0.1 (0.0)	1.00
Cobble	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.4 (0.3)	0.75
Bedrock	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Bare Soil	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Litter	43.0 (11.9)	0.28	45.7 (4.7)	0.10	13.2 (5.7)	0.43
Downed wood	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Standing dead	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.13	1.00

Appendix 1. (continued)

Other	Plot code			
	LACL_2007_02_014 (Sedge meadow-spruce woodland)		LACL_2008_02_062 (Dwarf birch-spruce woodland)	
Cover class	% Cover	CV	% Cover	CV
Tree	2.2 (1.5)	0.67	12.3 (6.3)	0.52
Shrub	27.0 (3.0)	0.11	18.4 (7.2)	0.39
Dwarf shrub	12.4 (1.4)	0.12	3.2 (1.4)	0.45
Forb	2.0 (0.8)	0.37	< 0.1 (0.0)	0.19
Graminoid	5.7 (1.4)	0.24	< 0.1 (0.0)	0.14
Lichen	< 0.1 (0.0)	0.13	59.7 (9.8)	0.16
Moss	80.3 (1.9)	0.02	20.9 (9.2)	0.44
Cryptogamic crust	< 0.1 (0.0)	0.87	2.1 (1.9)	0.89
Tree seedlings (no. stems)	2.73 (0.94)	0.34	2.20 (1.01)	0.46
Gravel	0.0 (0.0)	0.00	12.7 (6.4)	0.51
Cobble	0.0 (0.0)	0.00	0.2 (0.2)	0.91
Bedrock	0.0 (0.0)	0.00	1.4 (0.2)	0.16
Bare Soil	< 0.1 (0.0)	0.58	0.0 (0.0)	0.00
Litter	15.7 (2.9)	0.18	5.5 (1.3)	0.23
Downed wood	0.0 (0.0)	0.00	0.7 (0.6)	0.85
Standing dead	0.2 (0.1)	0.38	0.4 (<0.1)	0.02

Appendix 2. Mean percent cover (± 1 S.E.) for a subset of species in monitoring plots in Lake Clark NPP (2007-2008). Plot summaries are organized by community type (white spruce woodland; dry dwarf birch; moist dwarf birch; other). Cover was estimated by point-intercept at 0.5-m intervals along 30-m transects. Mean percent cover (± 1 S.E.) and coefficient of variation (CV) are shown for a subset of species within each community type. Total cover >100% is due to layering within community type. Cover by height class (<0.5 m; 0.5-1.0 m; >1.0-4.0 m) is shown for white spruce (*Picea glauca*) and dwarf birch (*Betula glandulosa*). Coefficients of variation (CV) are expressed as percentages (1.00 = 100%).

White spruce woodland	Plot code							
	LACL_2007_02_005		LACL_2007_02_017		LACL_2008_02_014		LACL_2008_02_048	
Species	% cover	CV	% cover	CV	% cover	CV	% cover	CV
Tree								
<i>Picea glauca</i> (<0.5 m)	4.0 (2.5)	0.62	<1.0 (0.6)	1.00	3.4 (2.6)	0.76	5.6 (2.3)	0.40
<i>P. glauca</i> (0.5-1.0 m)	7.3 (1.5)	0.20	2.8 (1.5)	0.53	3.4 (1.0)	0.29	4.5 (2.8)	0.63
<i>P. glauca</i> (>1.0-4.0 m)	11.3 (3.4)	0.30	2.3 (1.5)	0.66	2.8 (0.6)	0.20	3.4 (3.4)	1.00
Shrub								
<i>Betula glandulosa</i> (<0.5 m)	10.7 (2.5)	0.23	21.5 (6.0)	0.28	6.2 (2.5)	0.40	24.3 (2.8)	0.12
<i>B. glandulosa</i> (0.5-1.0 m)	4.5 (2.3)	0.50	20.3 (7.4)	0.36	6.2 (1.5)	0.24	7.3 (4.4)	0.60
<i>B. glandulosa</i> (>1.0-4.0 m)	1.1 (1.1)	1.00	2.3 (2.3)	1.00	1.7 (1.7)	1.00	0.0 (0.0)	0.00
<i>Ledum palustre</i> ssp. <i>decumbens</i>	11.3 (4.6)	0.41	27.7 (4.4)	0.16	11.4 (4.3)	0.38	10.2 (7.6)	0.75
<i>Salix fuscescens</i>	<1.0 (0.6)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Vaccinium uliginosum</i>	14.7 (1.5)	0.10	22.6 (4.0)	0.18	15.8 (3.7)	0.23	10.7 (9.9)	0.92
Dwarf shrub								
<i>Arctostaphylos alpina</i>	1.1 (1.1)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Empetrum nigrum</i>	27.7 (4.8)	0.17	32.2 (4.3)	0.13	28.8 (3.4)	0.12	17.5 (2.8)	0.16
<i>Vaccinium vitis-idaea</i>	4.0 (2.0)	0.52	7.9 (3.1)	0.40	5.1 (1.7)	0.33	1.7 (1.7)	1.00
Graminoid								
<i>Calamagrostis canadensis</i>	<1.0 (0.0)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Carex aquatilis</i>	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Carex bigelowii</i> ssp. <i>lugens</i>	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Lichen	45.8 (3.5)	0.08	27.1 (4.9)	0.18	21.5 (4.5)	0.21	57.6 (5.6)	0.09
Moss	50.3 (5.6)	0.11	42.4 (6.0)	0.14	43.5 (3.7)	0.09	14.7 (6.2)	0.42

Appendix 2. (continued)

Species	Plot code											
	LACL_2007_02_002			LACL_2007_02_006			LACL_2007_02_007			LACL_2008_02_006		
	% cover	CV	% cover	CV	% cover	CV	% cover	CV	% cover	CV	% cover	CV
Dry dwarf birch												
Tree												
<i>Picea glauca</i> (<0.5 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	2.8 (1.5)	0.53	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>P. glauca</i> (0.5-1.0 m)	0.0 (0.0)	0.00	<0.1 (0.6)	1.00	0.0 (0.0)	0.00	2.8 (2.0)	0.72	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>P. glauca</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	2.3 (2.3)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Shrub												
<i>Betula glandulosa</i> (<0.5 m)	15.3 (2.6)	0.17	10.7 (2.5)	0.23	32.8 (11.0)	0.34	25.4 (6.8)	0.27	17.5 (5.4)	0.31	67.8 (3.5)	0.05
<i>B. glandulosa</i> (0.5-1.0 m)	0.0 (0.0)	0.00	<1.0 (0.6)	1.00	4.5 (4.5)	1.00	19.2 (4.0)	0.21	9.0 (2.5)	0.27	0.0 (0.0)	0.00
<i>B. glandulosa</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	3.4 (3.4)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Ledum palustre</i> ssp. <i>decumbens</i>	19.2 (4.6)	0.24	22.0 (9.0)	0.41	23.2 (4.0)	0.17	46.0 (12.8)	0.28	23.2 (1.5)	0.06	0.0 (0.0)	0.00
<i>Salix fuscescens</i>	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Vaccinium uliginosum</i>	11.9 (2.6)	0.22	13.0 (3.1)	0.24	6.2 (1.5)	0.24	17.5 (1.5)	0.09	16.9 (2.0)	0.12	0.0 (0.0)	0.00
Dwarf shrub												
<i>Arctostaphylos alpina</i>	1.1 (1.1)	1.00	<1.0 (0.6)	1.00	0.0 (0.0)	0.00	2.8 (2.0)	0.72	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Empetrum nigrum</i>	1.7 (1.0)	0.58	28.8 (14.8)	0.51	39.5 (4.0)	0.10	7.3 (2.0)	0.28	28.8 (2.6)	0.09	0.0 (0.0)	0.00
<i>Vaccinium vitis-idaea</i>	22.6 (6.5)	0.29	7.3 (5.0)	0.68	9.1 (0.5)	0.06	12.4 (1.1)	0.09	5.1 (1.0)	0.19	1.1 (1.1)	1.00
Graminoid												
<i>Calamagrostis canadensis</i>	0.0 (0.0)	0.00	2.8 (2.8)	1.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	<1.0 (0.6)	1.00	4.5 (1.5)	0.33
<i>Carex aquatilis</i>	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Carex bigelowii</i> ssp. <i>lugens</i>	<1.0 (0.6)	1.00	26.0 (13.7)	0.53	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Lichen												
	64.4 (3.9)	0.06	22.6 (11.7)	0.52	41.8 (8.0)	0.19	29.9 (5.0)	0.17	20.9 (4.6)	0.22	31.1 (2.0)	0.07
Moss												
	24.3 (9.2)	0.38	24.3 (5.4)	0.22	14.1 (2.0)	0.14	32.8 (12.5)	0.38	35.2 (5.6)	0.16	68.9 (2.5)	0.04

Appendix 2. (continued)

Moist dwarf birch			Plot code			
Species	LACL_2007_02_003		LACL_2007_02_015		LACL_2007_02_016	
	% Cover	CV	% Cover	CV	% Cover	CV
Tree						
<i>Picea glauca</i> (<0.5 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>P. glauca</i> (0.5-1.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>P. glauca</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Shrub						
<i>Betula glandulosa</i> (<0.5 m)	46.3 (2.0)	0.04	15.8 (2.5)	0.16	18.6 (4.5)	0.24
<i>B. glandulosa</i> (0.5-1.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>B. glandulosa</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Ledum palustre</i> ssp. <i>decumbens</i>	5.1 (2.6)	0.51	33.9 (2.6)	0.08	14.1 (2.0)	0.14
<i>Salix fuscescens</i>	6.2 (3.1)	0.51	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Vaccinium uliginosum</i>	22.0 (2.9)	0.13	20.3 (6.0)	0.29	22.0 (4.3)	0.19
Dwarf shrub						
<i>Arctostaphylos alpina</i>	0.0 (0.0)	0.00	<1.0 (0.6)	1.00	0.0 (0.0)	0.00
<i>Empetrum nigrum</i>	4.0 (1.5)	0.38	5.6 (1.5)	0.26	42.4 (2.6)	0.06
<i>Vaccinium vitis-idaea</i>	2.3 (1.1)	0.50	13.0 (5.9)	0.45	7.9 (2.0)	0.26
Graminoid						
<i>Calamagrostis canadensis</i>	1.7 (0.0)	0.00	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Carex aquatilis</i>	26.0 (9.3)	0.36	10.2 (1.7)	0.17	0.0 (0.0)	0.00
<i>Carex bigelowii</i> ssp. <i>lugens</i>	6.8 (6.8)	1.00	<1.0 (0.6)	1.00	0.0 (0.0)	0.00
Lichen						
	<1.0 (0.6)	1.00	29.4 (6.0)	0.20	26.0 (3.7)	0.14
Moss						
	28.8 (7.1)	0.24	36.7 (4.6)	0.13	22.0 (4.3)	0.19

Appendix 2. (continued)

Other	Plot code			
	LACL_2007_02_014 (Sedge meadow-spruce woodland)		LACL_2008_02_062 (Dwarf shrub-spruce woodland)	
Species	% cover	CV	% cover	CV
Tree				
<i>Picea glauca</i> (<0.5 m)	0.0 (0.0)	0.00	17.5(4.1)	0.23
<i>P. glauca</i> (0.5-1.0 m)	<1.0 (0.6)	1.00	<1.0 (0.6)	1.00
<i>P. glauca</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	<1.0 (0.6)	1.00
Shrub				
<i>Betula glandulosa</i> (<0.5 m)	37.3 (4.9)	0.13	31.6 (3.4)	0.11
<i>B. glandulosa</i> (0.5-1.0 m)	0.0 (0.0)	0.00	<1.0 (0.6)	1.00
<i>B. glandulosa</i> (>1.0-4.0 m)	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Ledum palustre</i> ssp. <i>decumbens</i>	2.8 (2.8)	1.00	1.7 (1.7)	1.00
<i>Salix fuscescens</i>	10.7 (3.7)	0.35	0.0 (0.0)	0.00
<i>Vaccinium uliginosum</i>	13.6 (5.9)	0.43	5.6 (1.4)	0.72
Dwarf shrub				
<i>Arctostaphylos alpina</i>	0.0 (0.0)	0.00	0.0 (0.0)	0.00
<i>Empetrum nigrum</i>	22.6 (2.5)	0.11	2.3 (2.3)	1.00
<i>Vaccinium vitis-idaea</i>	2.8 (0.6)	0.20	13.0 (5.7)	0.44
Graminoid				
<i>Calamagrostis canadensis</i>	4.0 (2.5)	0.69	0.0 (0.0)	0.00
<i>Carex aquatilis</i>	12.4 (8.5)	0.62	0.0 (0.0)	0.00
<i>Carex bigelowii</i> ssp. <i>lugens</i>	<1.0 (0.6)	1.00	0.0 (0.0)	0.00
Lichen	1.1 (0.6)	0.50	62.1 (9.8)	0.16
Moss	68.4 (1.5)	0.02	24.3 (9.8)	0.40

Appendix 3. Frequency of species in monitoring plots sampled in Lake Clark NPP (2007-2008). Multiply values by 100 to express as percentages (1.00 = 100%). Plot summaries are organized by community type (white spruce woodland; dry dwarf birch; moist dwarf birch; other). Determinations for non-vascular species collected in 2008 are in progress.

White spruce woodland				
Vascular species	Plot code			
	LACL_2007_02_005	LACL_2007_02_017	LACL_2008_02_014	LACL_2008_02_048
<i>Anemone narcissiflora</i>				0.47
<i>Arctostaphylos alpina</i>	0.13			
<i>Artemisia arctica</i> ssp. <i>arctica</i>				0.73
<i>Betula glandulosa</i>	1.00	1.00	1.00	1.00
<i>Calamagrostis canadensis</i>	0.13	0.20		0.07
<i>Campanula uniflora</i>				0.40
<i>Carex bigelowii</i> ssp. <i>lugens</i>		0.07	0.47	
<i>Carex microchaeta</i> ssp. <i>nesophila</i>		0.53		0.80
<i>Empetrum nigrum</i>	1.00	1.00	1.00	0.67
<i>Epilobium anagallidifolium</i>		0.07		
<i>Festuca altaica</i>	0.27	0.20		0.67
<i>Hierochloa alpina</i>	0.53	0.80		0.60
<i>Ledum palustre</i> ssp. <i>decumbens</i>	0.93	1.00	1.00	0.60
<i>Loiseleuria procumbens</i>	0.07			
<i>Pedicularis labradorica</i>	0.07		0.07	0.27
<i>Picea glauca</i>	0.47	0.27	0.33	0.40
<i>Poa arctica</i> ssp. <i>arctica</i>				0.07
<i>Rubus chamaemorus</i>		0.20	0.13	
<i>Salix fuscescens</i>	0.13			
<i>Salix glauca</i>		0.13		0.67
<i>Salix pulchra</i>	0.13	0.07		
<i>Spiraea stevenii</i>		0.47	0.07	
<i>Trientalis europaea</i> ssp. <i>arctica</i>	0.07			0.20
<i>Vaccinium uliginosum</i>	0.93	1.00	0.73	0.47
<i>Vaccinium vitis-idaea</i>	1.00	1.00	1.00	0.93
Nonvascular species				
<i>Cladina arbuscula</i> ssp. <i>beringiana</i>		0.40		
<i>Hylocomium splendens</i>	0.87	0.07	0.73	0.33
<i>Sphagnum russowii</i>		0.13	0.33	
<i>Stereocaulon paschale</i>	0.47	0.60		

Appendix 3. (continued)

Dry dwarf birch						
Vascular species	Plot code					
	LACL_2007_02_002	LACL_2007_02_006	LACL_2007_02_007	LACL_2008_02_042	LACL_2008_02_049	LACL_2008_02_006
<i>Anemone narcissiflora</i>	0.27					
<i>Arctostaphylos alpina</i>	0.60	0.10	0.20			0.20
<i>Artemisia arctica</i> ssp. <i>arctica</i>			0.07			
<i>Betula glandulosa</i>	0.87	0.80	1.00	1.00	1.00	0.60
<i>Calamagrostis canadensis</i>	0.07	0.30	0.13	0.73	0.93	
<i>Calamagrostis lapponica</i>		0.27	0.47	0.47		
<i>Campanula uniflora</i>	0.13				0.60	
<i>Carex bigelowii</i> ssp. <i>lugens</i>		0.65	0.07			0.07
<i>Carex microchaeta</i> ssp. <i>nesophila</i>	0.80		0.67	0.87	1.00	
<i>Empetrum nigrum</i>	0.27	0.90	1.00	1.00		0.33
<i>Festuca altaica</i>	0.20		0.07	0.07	1.00	0.13
<i>Hierochloa alpina</i>	0.60	0.35	0.80	0.40	0.87	
<i>Ledum palustre</i> ssp. <i>decumbens</i>	1.00	0.90	1.00	1.00		1.00
<i>Loiseleuria procumbens</i>	0.27	0.15		0.07		
<i>Luzula multiflora</i>					0.47	
<i>Lycopodium lagopus</i>		0.07				
<i>Pedicularis labradorica</i>	0.07	0.05	0.07			0.07
<i>Pedicularis lanata</i>	0.07					
<i>Petasites frigidus</i>		0.05				
<i>Picea glauca</i>	0.07	0.25		0.20	0.20	0.40
<i>Poa arctica</i> ssp. <i>arctica</i>		0.05			0.33	
<i>Rubus chamaemorus</i>		0.55				0.13
<i>Salix fuscescens</i>			0.07			
<i>Salix glauca</i>	0.27			0.07		0.20
<i>Salix niphoclada</i>					0.33	
<i>Salix phlebophylla</i>	0.13		0.07			
<i>Salix pulchra</i>	0.20	0.30	0.20	0.27		
<i>Spiraea stevenii</i>		0.05	0.20	0.13		0.20
<i>Stellaria longipes</i>					0.20	
<i>Trientalis europaea</i> ssp. <i>arctica</i>			0.07		0.73	
<i>Trisetum spicatum</i>						0.60
<i>Vaccinium uliginosum</i>	0.80	1.00	0.53	0.93		0.87
<i>Vaccinium vitis-idaea</i>	1.00	0.70	1.00	0.93	0.73	0.67

Appendix 3. (continued)

Dry dwarf birch						
Non-vascular species	Plot code					
	LACL_2007_02_002	LACL_2007_02_006	LACL_2007_02_007	LACL_2008_02_042	LACL_2008_02_049	LACL_2008_02_006
<i>Cetraria islandica</i>		0.15				
<i>Cladina arbuscula</i> ssp. <i>beringiana</i>		0.65	0.13			
<i>Flavocetraria cucullata</i>			0.73			
<i>Hylocomium splendens</i>	0.20	0.65	0.07	0.67		0.33
<i>Nephroma arcticum</i>		0.15	0.20			
<i>Pleurozium schreberi</i>		0.25	0.93			
<i>Polytrichum</i> sp.		0.65				
<i>Ptilium crista-castrensis</i>			0.80			
<i>Sphagnum</i> sp.		0.25		0.07		0.13
<i>Stereocaulon paschale</i>	1.00	0.25	0.93			
<i>Thamnia vermicularis</i>		0.15				

Appendix 3. (continued)

Moist dwarf birch			
Vascular species	LACL_2007_02_003	Plot code	
		LACL_2007_02_015	LACL_2007_02_016
<i>Andromeda polifolia</i>	0.07	0.07	
<i>Arctostaphylos alpina</i>		0.13	0.07
<i>Artemisia arctica</i> ssp. <i>arctica</i>			0.07
<i>Betula glandulosa</i>	0.93	1.00	1.00
<i>Calamagrostis canadensis</i>	0.20	0.07	
<i>Carex aquatilis</i>	0.93	1.00	
<i>Carex bigelowii</i> ssp. <i>lugens</i>	0.33		
<i>Carex microchaeta</i> ssp. <i>nesophila</i>			1.00
<i>Carex tenuiflora</i>	0.20		
<i>Empetrum nigrum</i>	0.67	0.60	1.00
<i>Equisetum arvense</i>	0.47		
<i>Eriophorum angustifolium</i>	0.40		
<i>Eriophorum angustifolium</i> ssp. <i>angustifolium</i>		0.07	
<i>Eriophorum scheuchzeri</i>	0.47		
<i>Festuca altaica</i>			0.20
<i>Hierochloa alpina</i>		0.13	
<i>Ledum palustre</i> ssp. <i>decumbens</i>	0.87	1.00	1.00
<i>Luzula multiflora</i> ssp. <i>kobayashii</i>	0.27		
<i>Pedicularis labradorica</i>	0.13	0.07	0.07
<i>Poa pratensis</i> ssp. <i>alpigena</i>	0.27		
<i>Pedicularis</i> sp.	0.07		
<i>Polygonum viviparum</i> = <i>Bistorta vivipara</i>	0.20		0.27
<i>Rubus chamaemorus</i>	0.60	0.67	
<i>Salix fuscescens</i>	0.93	0.13	
<i>Salix pulchra</i>	0.60		0.20
<i>Stellaria borealis</i>	0.07		
<i>Trichophorum caespitosum</i> = <i>Scirpus caespitosus</i>	0.13		
<i>Vaccinium uliginosum</i>	1.00	0.93	1.00
<i>Vaccinium vitis-idaea</i>	0.93	1.00	1.00

Appendix 3. (continued)

Moist dwarf birch			
Non-vascular species	Plot code		
	LACL_2007_02_003	LACL_2007_02_015	LACL_2007_02_016
<i>Cladina arbuscula</i> ssp. <i>beringiana</i>	0.53	1.00	0.33
<i>Flavocetraria cucullata</i>			0.27
<i>Hylocomium splendens</i>			0.27
<i>Peltigera aphthosa</i>			0.80
<i>Polytrichum</i> sp.		0.53	
<i>Ptilium crista-castrensis</i>			0.93
<i>Sphagnum girgensohnii</i>	0.13	0.07	
<i>Stereocaulon paschale</i>		0.13	0.93
<i>Thamnia vermicularis</i>		0.07	0.80

Appendix 3. (continued)

Other			
Sedge meadow-spruce woodland transition		Dwarf shrub-spruce woodland transition	
Vascular species	Plot code LACL_2007_02_014	Vascular species	Plot code LACL_2008_02_062
<i>Andromeda polifolia</i>	0.33	<i>Arctostaphylos alpina</i>	0.40
<i>Betula glandulosa</i>	1.00	<i>Arnica frigida</i>	0.47
<i>Carex aquatilis</i>	0.27	<i>Antennaria monocephala</i> ssp. <i>monocephala</i>	0.27
<i>Carex brunnescens</i>	0.73	<i>Betula glandulosa</i>	0.93
<i>Calamagrostis canadensis</i>	0.60	<i>Betula glandulosa</i> × <i>B. papyrifera</i>	0.07
<i>Carex bigelowii</i> ssp. <i>lugens</i>	0.87	<i>Calamagrostis canadensis</i>	0.07
<i>Carex pauciflora</i>	0.13	<i>Carex microchaeta</i> ssp. <i>nesophila</i>	0.40
<i>Carex pluriflora</i>	0.07	<i>Campanula uniflora</i>	0.53
<i>Empetrum nigrum</i>	0.93	<i>Chamerion angustifolium</i>	0.07
<i>Equisetum arvense</i>	0.73	<i>Dryas integrifolia</i>	0.40
<i>Eriophorum angustifolium</i>	0.07	<i>Empetrum nigrum</i>	0.07
<i>Eriophorum angustifolium</i> ssp. <i>angustifolium</i>	0.53	<i>Festuca altaica</i>	0.20
<i>Eriophorum russeolum</i>	0.20	<i>Festuca brachyphylla</i>	0.07
<i>Ledum palustre</i> ssp. <i>decumbens</i>	0.47	<i>Hierochloa alpina</i>	0.40
<i>Pedicularis labradorica</i>	0.53	<i>Ledum palustre</i> ssp. <i>decumbens</i>	0.60
<i>Picea glauca</i>	0.73	<i>Loiseleuria procumbens</i>	0.07
<i>Rubus chamaemorus</i>	1.00	<i>Minuartia arctica</i>	0.07
<i>Salix fuscescens</i>	0.87	<i>Picea glauca</i>	0.80
<i>Salix pulchra</i>	0.47	<i>Poa arctica</i> ssp. <i>arctica</i>	0.13
<i>Spiraea stevenii</i>	0.33	<i>Rhododendron lapponicum</i>	0.20
<i>Trientalis europaea</i> ssp. <i>arctica</i>	0.27	<i>Salix arctica</i>	0.40
<i>Vaccinium oxycoccus</i> = <i>Oxycoccus microcarpus</i>	0.73	<i>Salix glauca</i>	0.07
<i>Vaccinium uliginosum</i>	0.60	<i>Salix phlebophylla</i>	0.40
<i>Vaccinium vitis-idaea</i>	0.93	<i>Trientalis europaea</i> ssp. <i>arctica</i>	0.20
Non-vascular species		<i>Trisetum spicatum</i>	0.20
<i>Aulacomnium palustre</i>	0.53	<i>Vaccinium uliginosum</i>	0.60
<i>Calliergon stramineum</i>	0.93	<i>Vaccinium vitis-idaea</i>	0.67
<i>Cladina arbuscula</i> ssp. <i>beringiana</i>	0.60	Non-vascular species	
<i>Flavocetraria cucullata</i>	1.00	<i>Cladina arbuscula</i> ssp. <i>beringiana</i>	0.07
<i>Polytrichum commune</i> var. <i>commune</i>	0.53	<i>Hylocomium splendens</i>	0.13
<i>Sphagnum russowii</i>	0.67	<i>Pleurozium schreberi</i>	0.60

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