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

2010 Annual Summary Report

Natural Resource Technical Report NPS/SWAN/NRTR—2011/449

ON THE COVER
Dwarf shrub tundra on Tanalian Mountian, Lake Clark National Park and Preserve, August 2010.
Photograph by: Amy Miller, Southwest Alaska Network.

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

2010 Annual Summary Report

Natural Resource Technical Report NPS/SWAN/NRTR—2011/449

Amy E. Miller, James K. Walton, Andrew Shulstad, and Claudette Moore

National Park Service
Southwest Alaska Network
240 W. 5th Ave.
Anchorage, AK 99501

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Executive Summary

This report summarizes the results of baseline vegetation sampling in Lake Clark National Park and Preserve (LACL) in 2010 and draws comparisons with a subset of woodland and forested sites sampled in Katmai National Park and Preserve (KATM) in 2009. The sites will be revisited every five years, with a subset sampled for two consecutive years.

During the 2010 field season, we established and/or resampled thirty-seven 0.25 hectare plots that included four vegetation types in low (0-450 m), mid- (450-900 m) and high (>900 m) elevation areas of LACL. Vegetation types included low and mid-elevation white spruce woodland, low elevation mature closed spruce forest, mid-elevation low shrub communities, and high elevation dwarf shrub tundra. Nine plots were collocated with the RAWS weather station above Snipe Lake (elevation 695 m; mid-elevation band). An automated time-lapse camera was also installed at the Snipe Lake RAWS in 2010 to monitor changes in phenology (e.g., leaf-out and senescence) and snowpack.

Four low elevation closed spruce plots were established in areas of spruce beetle damage near Lake Clark (Tlikakila, Currant Creek) and Upper Tazimina Lake. Two additional closed spruce plots showing little or no beetle activity were established at Upper Two Lakes and Lachbuna Lake. All but the Upper Tazimina sites had been cored in 2005 as part of a separate study examining historic spruce beetle activity. Additional tree cores were collected in 2010 to describe age and size-class structure of the stands, and to relate climate variables to growth characteristics (e.g., growth suppression) that preceded the recent spruce beetle outbreak. Soil temperature loggers were installed at six of the eight closed spruce sites, and at 1-2 sites in each additional vegetation type (twelve sites total). The temperature loggers will be used to monitor the timing and duration of freeze-thaw periods, snowpack development, and snowmelt.

Plot variables were summarized within and across sites for the four vegetation types (closed spruce forest, spruce woodland, low shrub, dwarf shrub). Species richness was highest at high elevations (>900 m). Nonvascular species richness, as measured in nested frequency plots, was up to three times greater than for vascular species at a given site.

Trees in spruce forest and spruce woodland sites ranged from less than 50 years to greater than 300 years in age. The oldest trees were found in mature closed forest, including stands on the north shore of Upper Two Lakes in LACL (350 years) and the Valley of 10,000 Smokes Road in KATM (310 years). Tree mortality ranged from 0%-50% in low elevation spruce woodland sites, and from 5%-95% in the closed spruce sites, based on basal area. Snag densities, coarse woody debris (CWD) and fine fuel loads were highest in the closed forest/beetle-kill plots, as was seedling regeneration. Seedling densities in low elevation spruce woodland were three to ten times greater in KATM than in LACL, suggesting an ongoing southern expansion of the spruce forest.

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Introduction

Vegetation composition and structure has been targeted for monitoring in the Southwest Alaska Network (SWAN) due to its intrinsic ecological value (primary production, habitat, forage) and because vegetation is a sensitive indicator of environmental conditions. 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 late-successional vegetation types in the three largest parks in the SWAN (Lake Clark NPP (LACL), Katmai NPP (KATM), Kenai Fjords NP (KEFJ)). This report summarizes the results of baseline sampling in LACL (2010) and draws comparisons with a subset of woodland and forested sites sampled in KATM (2009).

Methods

Sampling design and site selection

We established and/or re-sampled monitoring plots at 17 low elevation (0-450 m), 12 mid-elevation (450-900 m), and 6 high elevation (>900 m) sites in LACL in 2010 (Table 1; Figure 1). Nine of the plots had been established during a pilot phase in 2007-2008 and were revisited in 2010. Another nine plots were collocated (≤ 5 km) with the Snipe Lake remote area weather station (RAWS). Baseline sampling at all sites was conducted between 21 June and 25 August 2010, following methods outlined in Miller et al. (2010a). This report describes preliminary results for the first five elevation × vegetation class combinations shown in Table 1 (low elevation spruce woodland; low elevation mature closed spruce; mid-elevation spruce woodland; mid-elevation low/dwarf shrub tundra; high elevation dwarf shrub tundra).

Our sampling design requires that we sample a minimum of eight plots from each elevation × vegetation class combination in a given year (Miller et al. 2010a). Prior to the start of the field season, we drew sites from a generalized random-tesselation stratified (GRTS, Stevens 1997; Stevens and Olsen 2004) sample established for three elevation bands (0-450 m, >450-900 m, >900 m) within an access layer (GIS) developed for LACL (Figure 1; Mortenson and Miller 2008).

Following a field reconnaissance in early June, 2010 (Appendix 1), we selected 26 GRTS points for monitoring in low and mid-elevation spruce woodland, mid-elevation low shrub, and mid- and high elevation dwarf shrub tundra community types (Viereck et al. 1992; Table 1; Figure 2). Plots that could not be accessed due to unanticipated barriers (e.g., dangerous stream crossings) were rejected (Appendix 1). A limited number of high elevation areas met criteria for accessibility (e.g., slope and distance from access point) and thus the GRTS sample for sites >450 m in elevation was highly constrained. To ensure greater spatial dispersion, we split the high elevation GRTS sample into two populations, north and south of Turquoise Lake, with pixel sizes of 25 m and 50 m, respectively (Miller et al. 2010a). In addition, we sampled two representative high elevation areas (Tanalian Mountain, LACL-2010-03S-099; Lachbuna, LACL-2010-03S-098; Table 1) that fell outside of the established access layer (Mortenson and Miller 2008). Camp locations and site access (LACL 2010) are described in Appendix 6.

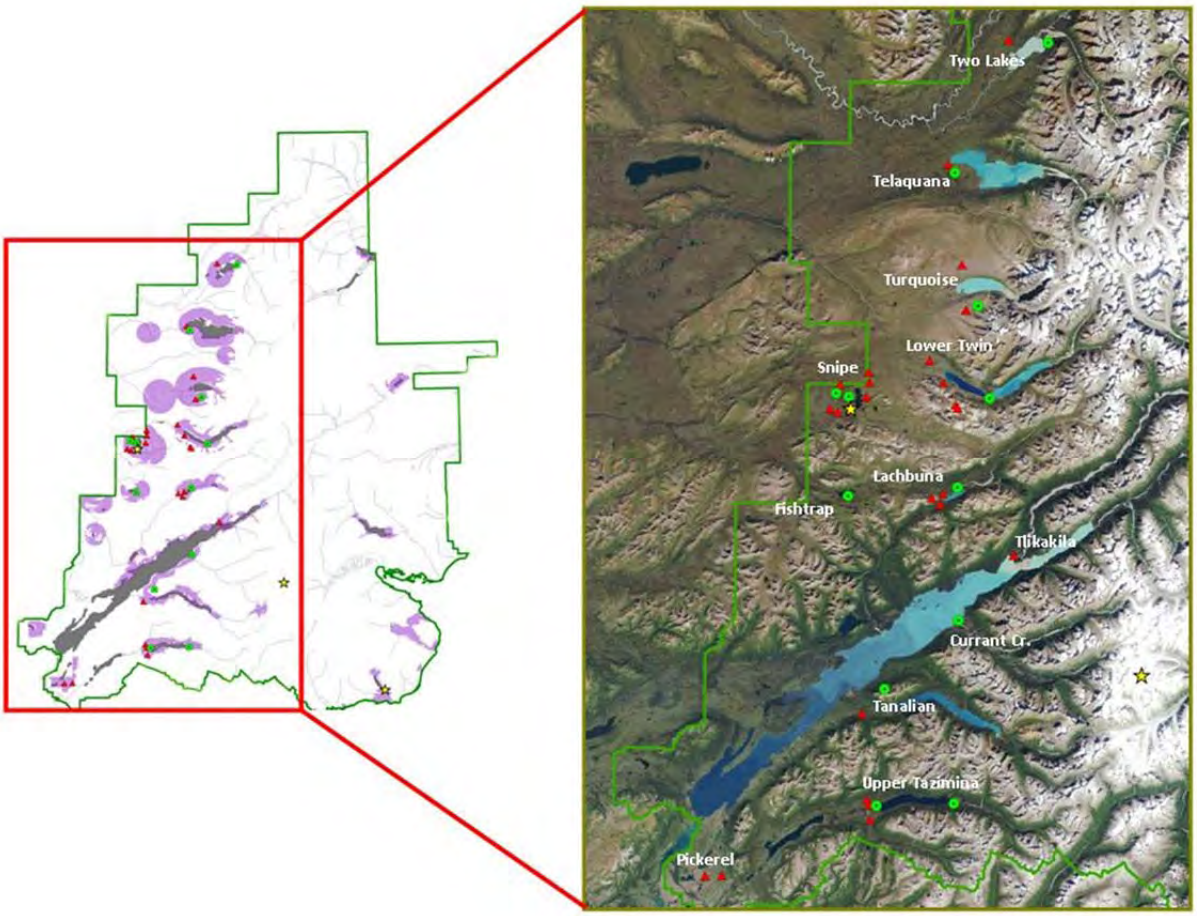

Figure 1. Long-term vegetation monitoring plots sampled in 2010 in LACL. Access areas developed using slope, elevation, land ownership, and hydrology layers (GIS) are indicated in purple on the park overview map (left). Sites with temperature loggers are indicated in green on the inset map (right). All other sites are indicated in red. The RAWS weather stations at Snipe Lake and in the Chigmit Mountains are shown by yellow stars. Nine monitoring plots were collocated with the RAWS station at Snipe Lake.

In order to monitor the long-term effects of forest disturbance, we also established six sites in representative stands of low-elevation, mature white spruce that had been impacted to varying degrees by recent spruce beetle (*Dendroctonus ruffipenis*) activity (Table 1; Figure 2). These sites were not part of the GRTS sample, but were randomly located in closed-canopy spruce stands, four of which had been cored in 2005 as part of a separate project examining historic spruce beetle disturbance (Sherriff et al. 2011).

Study area

Sites identified for monitoring occurred in proximity to a number of the major lakes in the interior of the park (Two Lakes, Telaquana, Turquoise, Lower Twin, Lachbuna, Fishtrap, Lake Clark, Upper Tazimina). Sites established in 2008 near Square Lake were not revisited in 2010. The lakes visited in 2010 span four ecological subsections (Spencer 2001) and feed four major river drainages: the Stony, Mulchatna, and Chilikondrotna to the north, and the Newhalen to the south (Figure 1).

Table 1. Plot locations and major vegetation types sampled in LACL (2010). Site elevations are rounded to the nearest 5 m. Datum = NAD83. Sites at which a soil temperature logger was installed are indicated with a dagger (†). Collections of stairstep moss (*Hylocomium splendens*) for analysis of airborne contamints were made at sites indicated by (§). Sites established previously (2007 & 2008) and remeasured in 2010 are indicated with an asterisk (*). Nine sites fall within approximately 5 km of the RAWS weather station at Snipe Lake.

Site ID	Location	Elevation (m)	Latitude/Longitude
	Low elevation (0-450 m) white spruce woodland		
LACL-2010-01-009	Upper Tazimina§	245	60.01867 N; -154.2580 W
LACL-2010-01-014	Pickerel	190	59.93636 N; -154.6881 W
LACL-2010-01-024	Upper Tazimina§	230	60.03927 N; -154.2622 W
LACL-2010-01-026	Lachbuna§	395	60.47177 N; -154.0569 W
LACL-2010-01-027	Pickerel	120	59.93548 N; -154.7360 W
LACL-2010-01-030	Two Lakes	435	61.14088 N; -153.8517 W
LACL-2010-01-038	Upper Tazimina§	275	60.04722 N; -154.2688 W
LACL-2010-01-051	Telaquana	365	60.96145 N; -154.0338 W
LACL-2010-01-088	Tanalian River	225	60.17091 N; -154.2833 W
LACL-2010-01-105	Telaquana†§	375	60.95015 N; -154.0139 W
LACL-2010-01-S94	Lachbuna	400	60.49604 N; -154.0097 W
	Low elevation (0-450 m) closed white spruce forest		
LACL-2010-01-S93	Currant Creek†§	80	60.30519 N; -154.0020 W
LACL-2010-01-S95	Upper Tazimina†§	225	60.03830 N; -154.2407 W
LACL-2010-01-S96	Tlikakila River	80	60.39818 N; -153.8410 W
LACL-2010-01-S97	Upper Tazimina†§	225	60.04188 N; -154.0166 W
LACL-2010-01-S98	Lachbuna†§	400	60.49587 N; -154.0056 W
LACL-2010-01-S99	Two Lakes†§	350	61.13662 N; -153.7335 W
	Mid-elevation (450-900 m) white spruce woodland		
LACL-2007-02-005	Snipe§*	540	60.60531 N; -154.3590 W
LACL-2007-02-017	Snipe§*	580	60.64522 N; -154.3529 W
LACL-2008-02-014	Snipe†§*	545	60.63264 N; -154.3635 W
LACL-2008-02-048	Lower Twin†§*	620	60.62562 N; -153.9113 W
LACL-2010-02-005	Lower Twin§	630	60.64820 N; -154.0478 W
LACL-2010-02-092	Fishtrap†§	510	60.48361 N; -154.3276 W
	Mid-elevation (450-900 m) low shrub tundra		
LACL-2007-02-002	Snipe*	615	60.64863 N; -154.2660 W
LACL-2007-02-006	Snipe†§*	630	60.62798 N: -154.3271 W
LACL-2008-02-006	Snipe§*	535	60.61016 N; -154.3816 W
LACL-2008-02-049	Lower Twin*	600	60.68030 N; -154.0888 W
LACL-2008-02-042-2	Snipe§	615	60.66349 N; -154.2683 W
LACL-2010-02-016	Snipe§	595	60.62768 N; -154.2747 W
LACL-2010-02-099	Snipe§	695	60.61011 N; -154.3220 W
	High elevation (>900 m) dwarf shrub tundra		
LACL-2010-03N-006	Turquoise	1010	60.81792 N; -153.9930 W
LACL-2010-03S-001	Turquoise†	1250	60.75841 N; -153.9449 W
LACL-2010-03S-008	Turquoise	1185	60.75272 N; -153.9806 W
LACL-2010-03S-097	Lower Twin	1010	60.61190 N; -154.0062 W
LACL-2010-03S-098	Lachbuna	1005	60.48045 N; -154.0819 W
LACL-2010-03S-099	Tanalian Mt. †	945	60.20597 N; -154.2186 W
LACL-2010-03S-121	Lower Twin	950	60.61669 N; -154.0112 W

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. Eighteen sites, clustered in mid- and high elevation areas near Turquoise, Lower Twin, and Snipe Lake, were established 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 nana*), 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. Four low-elevation sites near Two Lakes and Telaquana were established within the Stony River Morainal Valley subsection of the Alaska Range Ecoregion. Four mid- and high elevation sites were located on or near ridges in the Lower Twin and Lachbuna area in the Rounded Volcanic Hills subsection, and eleven low-elevation sites were established near Lake Clark, Pickerel Lakes, and Upper Tazimina, in the Lake Clark Pass and Moraines subsection, both of the Lime Hills Ecoregion.

Low and mid-elevation white spruce woodland occur on well-drained terraces, ridges and moraines throughout the study area (Figure 2a-b). Mid-elevation low and dwarf shrub tundra sites were established on well-drained rolling ridges and valleys between Turquoise and Snipe Lakes. Extensive defoliator damage was observed on dwarf birch (*Betula nana*) near Snipe Lake early in the summer of 2010 (see *Results and Discussion*). Dwarf shrub cover ranged from 35-45% and included crowberry, alpine bearberry (*Arctostaphylos alpina*), arctic willow (*Salix arctica*) and alpine azalea (*Loiseleuria procumbens*). Lichen cover (e.g., *Cetraria islandica* ssp. *crispiformis*, *Cladonia arbuscula* ssp. *beringiana*) was often 25% or greater (Figure 2c-d).

Mature closed spruce occurred on well-drained, mesic loamy to sandy soils in the low elevation band. We sampled four sites affected by spruce beetle, located at the mouth of the Tlikakila River and Currant Creek, and at two sites on Upper Tazimina Lake. An additional two sites showed little to no beetle activity and were located at the north end of Two Lakes and on the northeast side of Lachbuna Lake. Canopy cover ranged from 40-80% across the sites. Cottonwood (*Populus trichocarpa*) was a common associate, and bluejoint (*Calamagrostis canadensis*) was a frequent dominant in the understory (Figure 2e-f). Understory shrubs included high-bush cranberry (*Viburnum edule*), wood rose (*Rosa acicularis*), and occasional willows (e.g., *Salix pulchra*, *S. barclayi*). Four of the six sites (Two Lakes, Currant Creek, Upper Tazimina) had recent windthrow, likely from storms in 2008-2009.

Field sampling

Field methods are described in detail in Miller et al. (2010a). At each field 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. We measured vascular and nonvascular species occurrence using nested quadrats (0.25 m^2; 1 m^2; 4 m^2) at 7-m intervals along each transect (n = 5 quadrats/transect), and vascular species cover by point-intercept at 0.5 m intervals along each transect (n = 59 intercepts/transect). Species cover was recorded in each of four height classes (<0.5 m; 0.5-1.0 m; >1-4 m; >4 m). Vascular species present in the 30 m × 30 m plot but not recorded in the nested frequency quadrats were documented separately. Percent cover by plant growth form (tree, shrub, dwarf shrub, forb, graminoid, lichen, moss) and substrate type was recorded using ocular estimates in the 4-m^2 quadrats. Tree seedling counts were also recorded in 4-m^2 quadrats.

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), and the diameter only of saplings. We cored the four largest trees in the outer 10-m of the 30 m × 30 m plot and estimated canopy cover at the plot center and four corners using a spherical

Figure 2. Representative low and mid-elevation white spruce (*Picea glauca*), low and dwarf shrub tundra communities sampled in LACL (2010). Low elevation spruce woodland: a) LACL-2010-01-030, Two Lakes; b) LACL-2010-01-014, Pickerel; mid-elevation low shrub tundra: c) LACL-2007-02-002, Snipe; d) LACL-2010-02-016, Snipe; low elevation closed spruce forest: e) LACL-2010-01-S95, Upper Tazimina; f) LACL-2010-01-S98, Lachbuna; high-elevation dwarf shrub tundra: g) LACL-2010-03S-001, Turquoise; h) LACL-2010-03S-099, Tanalian Mountain.

densiometer. Trees were cored at approximately 10-30 cm above the root crown for estimation of tree age. In a subset of plots, we cored all trees and saplings ≥2.5 cm DBH to characterize age structure at the site (Table 4).

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 live and dead biomass (trees and saplings) using allometric equations derived for *Picea glauca* (Manning et al. 1984; Harding and Grigal 1985):

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

In 2009, we began quantifying coarse woody debris (CWD) loads using the line-intersect method (Van Wagner 1968, Brown 1974), and assuming a specific gravity of 0.34 g/cm^3 for white spruce (Taylor et al. 1982):

$$\text{Volume of wood per unit area (m}^3\text{/ha)} = V = [\pi^2 \times \Sigma\ (\text{diameter (m)})^2]/[8 \times (\text{transect length (m)})]$$

$$\text{Weight per unit area (kg/ha)} = V \times \text{specific gravity (kg/m}^3\text{)}$$

At each site, we recorded attributes related to forest condition (insects, pathogens, mortality) and site characteristics (slope, aspect, drainage). We measured the thickness of the litter, living mat (vegetation), and organic horizons, and depth to seasonal frost, where applicable. In 2010, we began measuring DBH on all saplings, as outlined for CAKN (Roland et al. 2004).

Soil temperature logger installations and data downloads – KATM and LACL

In 2010, we installed soil temperature loggers (HOBO Pro v2; Onset Computer Corporation, Bourne, MA) to a depth of 10 cm at 2-5 sites per vegetation type and elevation band (12 sites total; Table 1). Soil temperature loggers (HOBO Pro v2) installed in LACL (2008) and KATM (2009) were downloaded in July and September 2010. Data were downloaded at 2 sites at Snipe Lake in LACL, and at 8 of 11 sites at KATM: Lake Brooks, Naknek, E Colville, Upper Colville (2), Emerald, Hammersly, Malone (cf. Miller et al. 2010). The logger at Malone was damaged and not replaced. We could not locate loggers at two sites (Dumpling, Nonvianuk), and we did not revisit one site in KATM (Kulik). New and/or replacement loggers were installed at three sites in KATM: Valley of 10K Road (new site), Dumpling (replacement), and Nonvianuk (replacement).

Time-lapse camera installations – LACL and KATM

Time-lapse cameras (Canon EOS 1000D) were installed at one RAWS station in LACL (Snipe) and two stations in KATM (Contact, Upper Colville) in August and September 2010. The cameras use a focal length of 18 mm-24 mm and are oriented to the north (NNE-NNW) at a height of approximately 2.5 m. They were programmed to take four photos per day at 1-h intervals spanning 12:00 p.m. (11 a.m., 12 p.m., 1 p.m., 2 p.m.). The photos are intended to capture start- and end-of-season dates, and the timing of snowpack development and snowmelt. A camera installed in Pt. Alsworth (2010) likewise records daily snow depth.

Moss collections – KATM and LACL

We collected approximately 5-7 g dry weight of stair-step moss (*Hylocomium splendens*) at 21 of the 37 sites in LACL (2010) for analysis of nitrogen (N), sulfur (S) and heavy metals (Table 1). Samples from the current year's collections were submitted for analysis in September 2010. Contaminants analysis for previously collected *Hylocomium* samples from LACL (2008) and KATM (2009) is ongoing, and results will be included in a future report.

Analysis

Plot variables (species occurrence in 4-m^2 quadrats; species cover; cover by growth form and height class) were summarized within and across sites using PROC SURVEYMEANS in SAS (SAS Institute, Cary, NC; Miller et al. 2010a). Relationships between elevation and species richness across all vegetation types, and site productivity (standing biomass), canopy cover, and seedling densities in low-elevation forested types, were explored using regression analysis.

Nonmetric multidimensional scaling (NMS) in PC-ORD (McCune and Mefford 2009) was used to ordinate plots in species space using the nested frequency data from LACL (2010) and KATM (2009). Prior to analysis, we removed species found in fewer than 5% of plots to reduce noise from rare or inadequately sampled taxa. We used the Sørenson index (Beals 1984) to calculate the distance matrix for the ordination. The significance of the best fit was evaluated using a Monte Carlo test that compared final axes to those calculated from 250 runs of randomized data. The ordination was rigidly rotated to load the strongest environmental variable onto a single axis. An arbitrary cut-off value of $r^2 \geq 0.30$ was used when assessing correlations of environmental variables and diversity estimates with the ordination axes. Indicator species analysis (Dufrêne & Legendre 1997, using default settings as implemented in McCune & Mefford 2009) was used to calculate indicator values for all species encountered within major vegetation types. The species indicator value is a combination of species relative frequency and abundance within a given vegetation type, and reflects the faithfulness of a species to a particular type. Indicator values range between 0 (no indication) to 100 (perfect indication), and were tested for significance using a Monte Carlo randomization test.

Results and Discussion

Species composition

The communities shared many species in common but differed in overall species composition and structural characteristics. Visual estimates of cover by growth form classes (tree, shrub, dwarf shrub, graminoid, forb, lichen, moss) were used to describe broad patterns in community structure. Shrub cover ranged from 15-45% in all but the high elevation (dwarf shrub tundra) sites (Table 2). Species cover, recorded by point-intercept along transects, showed variation in the abundance of major vascular species across vegetation types and height classes (Table 3; Appendix 2). In spruce woodland and closed spruce (beetle kill) plots, live white spruce (*Picea glauca*) was recorded in all four height classes and comprised 15-20% of cover in closed spruce stands (Table 3; Figure 3; Appendix 2). This was in contrast to beetle-affected stands in KATM (2009), which showed close to 100% mortality in some sites and averaged less than 5% live cover in each layer (Miller et al. 2010b; Figure 3).

Table 2. Percent cover by cover class and spruce seedling counts/quadrat for vegetation types sampled in LACL (2010). Cover was estimated visually in 4-m^2 quadrats arrayed along 30-m transects (n = 15 per plot); mean percent cover (± 1 S.E.) and coefficient of variation (CV) are shown for each cover class within the broader vegetation types. Total cover >100% is due to layering within vegetation type. Mean seedling counts in 4-m^2 quadrats were converted to seedling densities (stems/ha) reported in the text. Cover classes showing high constancy (CV ≤ 35%) are in boldface.

	Low elevation spruce woodland (n=9)		**Low elevation closed spruce forest (n=6)**		**Mid-elevation spruce woodland (n=6)**		**Mid-elevation low shrub tundra (n=7)**		**High elevation alpine dwarf shrub tundra (n=5)**	
Cover class	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**
Tree	***6.7 (2.1)***	***0.32***	***33.0 (5.5)***	***0.17***	***3.6 (0.9)***	***0.24***	3.8 (1.8)	0.46	0.0 (0.0)	-
Shrub	***45.4 (2.5)***	***0.05***	***15.2 (2.4)***	***0.16***	***33.9 (4.4)***	***0.13***	***43.1 (5.7)***	***0.13***	3.8 (1.6)	0.41
Dwarf shrub	***15.9 (3.1)***	***0.19***	***18.4 (4.0)***	***0.22***	***24.4 (2.4)***	***0.09***	13.5 (6.9)	0.51	***34.9 (3.6)***	***0.10***
Forb	0.4 (0.3)	*0.72*	14.3 (5.4)	0.38	0.3 (0.2)	*0.79*	***0.1 (0.0)***	***0.34***	0.7 (0.3)	0.42
Graminoid	0.2 (0.1)	*0.46*	6.0 (3.0)	0.49	0.4 (0.2)	*0.49*	1.2 (0.4)	0.37	***0.7 (0.1)***	***0.19***
Lichen	***24.0 (3.3)***	***0.14***	0.8 (0.6)	0.71	***25.4 (5.7)***	***0.22***	***22.1 (5.9)***	***0.27***	***34.7 (5.6)***	***0.16***
Moss	***44.3 (9.5)***	***0.15***	***54.8 (9.4)***	***0.17***	***39.2 (5.7)***	***0.15***	***40.1 (10.4)***	***0.26***	***1.0 (0.2)***	***0.19***
Cryptobiotic crust	0.0 (0.0)	-	0.0 (0.0)	-	<0.1 (0.0)	0.93	<0.1 (0.0)	0.83	0.1 (0.1)	0.43
Tree seedlings (no. stems/quadrat)	0.3 (0.1)	0.46	1.7 (0.6)	0.38	***0.4 (0.1)***	***0.21***	0.3 (0.2)	0.53	0.0 (0.0)	-
Gravel	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	<0.1 (0.0)	0.77	16.4 (6.9)	0.42
Cobble	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	<0.1 (0.0)	0.83	***6.1 (0.7)***	***0.12***
Bedrock	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	1.8 (1.0)	0.56
Bare soil	0.1 (0.1)	0.80	0.0 (0.0)	-	<0.1 (0.0)	0.59	<0.1 (0.0)	0.41	***4.7 (0.9)***	***0.18***
Litter	***6.0 (0.7)***	***0.11***	***27.5 (6.7)***	***0.25***	***4.7 (0.4)***	***0.09***	***6.1 (2.0)***	***0.32***	***2.6 (0.7)***	***0.26***
Downed wood	***0.6 (0.2)***	***0.28***	***5.0 (0.6)***	***0.12***	<0.1 (0.0)	0.84	0.0 (0.0)	-	0.0 (0.0)	-
Standing dead	***2.5 (0.3)***	***0.12***	1.0 (0.4)	0.40	***2.7 (0.5)***	***0.17***	***5.3 (1.6)***	***0.31***	0.4 (0.2)	0.49

Table 3. Percent cover by species and height class for vegetation types sampled in LACL (2010). 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 vegetation type. Total cover >100% is due to layering within vegetation type. Cover by height class (<0.5 m; 0.5-1.0 m; >1.0-4.0 m; >4.0 m) is shown for tree species. Cover for all other species is shown for the ground layer (<0.5 m). Species showing high constancy (CV ≤35%) are in boldface. See Appendix 2 for plot-level summaries.

	Low elevation spruce woodland (n=9)		**Low elevation closed spruce forest (n=6)**		**Mid-elevation spruce woodland (n=6)**		**Mid-elevation low shrub tundra (n=7)**		**High elevation alpine dwarf shrub tundra (n=5)**	
Species	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**	**% Cover**	**CV**
Tree										
Picea glauca (<0.5 m)	***0.8 (0.3)***	***0.35***	1.1 (0.5)	0.47	***4.0 (0.1)***	***0.23***	0.3 (0.2)	0.50	0.0 (0.0)	-
P. glauca (0.5-1.0 m)	***2.4 (0.6)***	***0.28***	1.1 (0.5)	0.43	***5.4 (1.3)***	***0.24***	0.9 (0.6)	0.72	0.0 (0.0)	-
P. glauca (>1.0-4.0 m)	***3.6 (1.3)***	***0.36***	***15.3 (2.7)***	***0.18***	***5.9 (1.3)***	***0.22***	1.3 (1.0)	0.80	0.0 (0.0)	-
P. glauca (>4.0 m)	1.1 (0.4)	0.46	***21.8 (3.8)***	***0.17***	2.8 (1.1)	0.40	0.2 (0.2)	1.00	0.0 (0.0)	-
Betula neoalaskana (<0.5 m)	0.2 (0.2)	1.00	<0.1 (0.0)	1.00	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
B. neoalaskana 0.5-1.0 m)	0.5 (0.5)	1.00	0.2 (0.2)	1.00	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
B. neoalaskana (>1.0-4.0 m)	<0.1 (0.0)	1.00	2.5 (1.7)	0.70	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
B. neoalaskana (>4.0 m)	0.0 (0.0)	-	5.1 (5.1)	1.00	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
Shrub										
Alnus viridis ssp. *sinuata*	0.0 (0.0)	-	0.8 (0.8)	1.00	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
Betula nana	***9.3 (2.4)***	***0.26***	0.0 (0.0)	-	***14.3 (1.3)***	***0.09***	25.6 (18.3)	0.72	0.2 (0.2)	0.69
Ledum palustre ssp. *decumbens*	***40.7 (3.4)***	***0.08***	2.4 (2.4)	1.00	***25.0 (6.1)***	***0.24***	19.6 (10.5)	0.54	2.5 (1.0)	0.41
Salix glauca	0.1 (0.0)	0.52	0.2 (0.2)	1.00	0.6 (0.4)	0.68	0.4 (0.4)	1.00	0.0 (0.0)	-
Salix pulchra	0.5 (0.3)	0.58	0.2 (0.1)	0.63	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-
Spiraea stevensii	0.4 (0.2)	0.40	<0.1 (0.0)	1.00	<0.1 (0.0)	1.00	0.2 (0.2)	1.00	0.0 (0.0)	-
Vaccinium uliginosum	***14.9 (2.5)***	***0.16***	0.9 (0.8)	0.89	***21.9 (3.3)***	***0.15***	12.9 (6.5)	0.50	7.6 (3.5)	0.46
Dwarf shrub										
Arctostaphylos alpina	1.6 (1.0)	0.60	0.0 (0.0)	-	0.5 (0.4)	0.78	3.0 (2.7)	0.91	0.6 (0.3)	0.49
Empetrum nigrum	***17.4 (5.9)***	***0.34***	***5.8 (2.0)***	***0.34***	***31.5 (4.8)***	***0.15***	18.1 (14.3)	0.79	2.7 (1.1)	0.41
Louisleuria procumbens	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	1.1 (1.1)	1.00	7.4 (3.3)	0.45
Salix arctica	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	0.7 (0.5)	0.69
Vaccinium vitis-idaea	***19.2 (1.9)***	***0.10***	7.9 (4.4)	0.56	10.4 (1.2)	0.64	12.4 (5.2)	0.42	***1.4 (0.4)***	***0.27***
Graminoid										
Calamagrostis canadensis	1.3 (0.5)	0.37	15.3 (6.7)	0.44	0.3 (0.3)	1.00	0.9 (0.9)	1.00	0.0 (0.0)	-
Carex microchaeta	0.0 (0.0)	-	0.0 (0.0)	-	0.0 (0.0)	-	0.3 (0.3)	1.00	***4.2 (0.8)***	***0.20***
Festuca altaica	2.5 (2.5)	1.00	0.0 (0.0)	-	2.9 (2.6)	0.89	5.1 (2.9)	0.58	0.2 (0.1)	0.64
Anthoxanthum monticola ssp. *alpinum*	1.0 (1.0)	1.00	0.0 (0.0)	-	1.8 (0.8)	0.44	2.3 (0.9)	0.38	***1.7 (0.3)***	***0.19***
Lichen	***47.5 (6.2)***	***0.13***	1.6 (1.3)	0.80	***57.1 (5.4)***	***0.09***	***48.0 (10.0)***	***0.21***	***64.0 (7.0)***	***0.11***
Moss	***48.6 (8.9)***	***0.18***	***58.9 (7.6)***	***0.13***	***59.6 (4.1)***	***0.07***	***61.4 (14.9)***	***0.24***	***3.0 (0.7)***	***0.23***

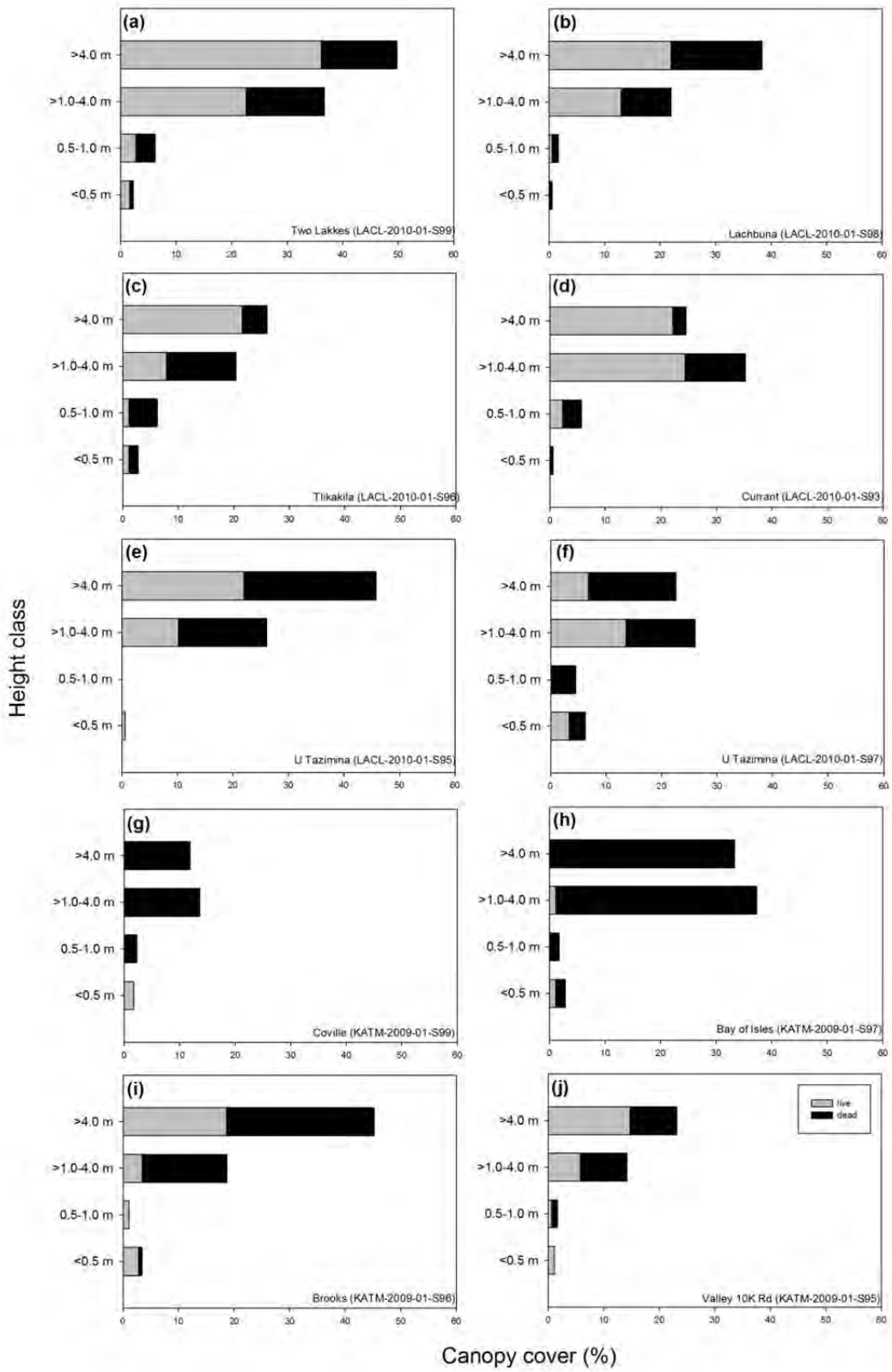

Figure 3. White spruce (*Picea glauca*) cover by height class in low elevation, mature forest plots in LACL and KATM. Stacked bars show canopy cover contributed by live (gray) and dead (black) trees, as estimated by point-intercept. Stands in southern LACL (e-f) and KATM (**g-j)** had the highest levels of beetle-related mortality.

Species occurrence, measured in nested frequency quadrats, indicated that the majority of species occurred at low frequency within a vegetation type, but that the distribution of frequencies varied across elevation and vegetation types (Appendix 3). A small number of species (e.g., *Anemone narcissiflora*, *Anthoxanthum monticola* ssp. *alpinum* (=*Hierochlöe alpina*)) occurred at low frequency across all vegetation types. A second set of species, including *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, *Cladonia arbuscula* ssp. *beringiana*, *Dicranum scoparium*, *Polytrichum commune* ssp. *commune*, and *Hylocomium splendens* occurred in a high proportion of plots (≥20% frequency) across vegetation types. These latter, widespread and relatively common species are expected to be good candidates for detecting changes in community composition through time, due to their high abundance and low sample variance.

Species richness, or number of species per plot, was estimated from the frequency data. Species richness increased with elevation and was highest in high elevation (74-124 species/plot) and mid-elevation dwarf shrub sites (52-78 species/plot) and lowest in closed forest-beetle kill sites (27-63 species/plot; Figure 4; Appendix 3). The richness estimates are conservative and the number of species present is likely higher at most sites, particularly for the nonvascular taxa. Although our results are constrained by our selection of vegetation types for monitoring, a similar pattern of increasing richness with elevation has been reported by the Central Alaska Network, which samples systematically across the elevation gradient using a two-stage grid (C. Roland, *personal communication*). Ordination results, discussed in the next section, suggested that the increase in richness with elevation is likely due to greater spatial heterogeneity (e.g., greater number of microsites) at higher elevations, rather than to elevation-related variables, per se.

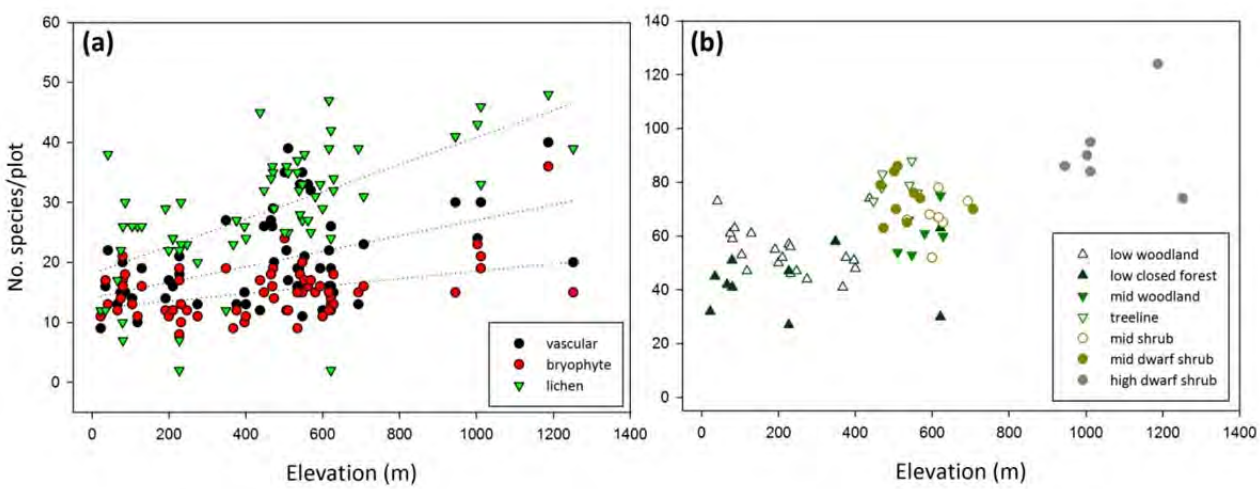

Figure 4. Vascular and nonvascular species richness as a function of elevation and vegetation type in LACL and KATM. (a) Number of species per functional group (vascular, bryophyte, lichen) per plot as estimated from nested frequency plots sampled in 2009-2010. (b) Total number of species (vascular + nonvascular) per plot, grouped by vegetation type. Low woodland and closed forest were sampled at elevations between 0-450 m. Treeline spruce, shrub, and dwarf shrub tundra were sampled between 450-900 m. A subset of high elevation dwarf shrub sites were sampled >900 m in LACL in 2010. Sampling of high elevation and treeline sites will continue in both parks in 2011.

Nonvascular species were an important component of each vegetation type and in most cases comprised ≥65% of the taxa recorded in 1-m^2 quadrats (Figure 5; Appendix 3). Low and mid-elevation spruce woodland sites, and mid-elevation dwarf and low shrub sites, in particular, were

characterized by low vascular species richness but a relatively high number of nonvascular species (Figure 5).

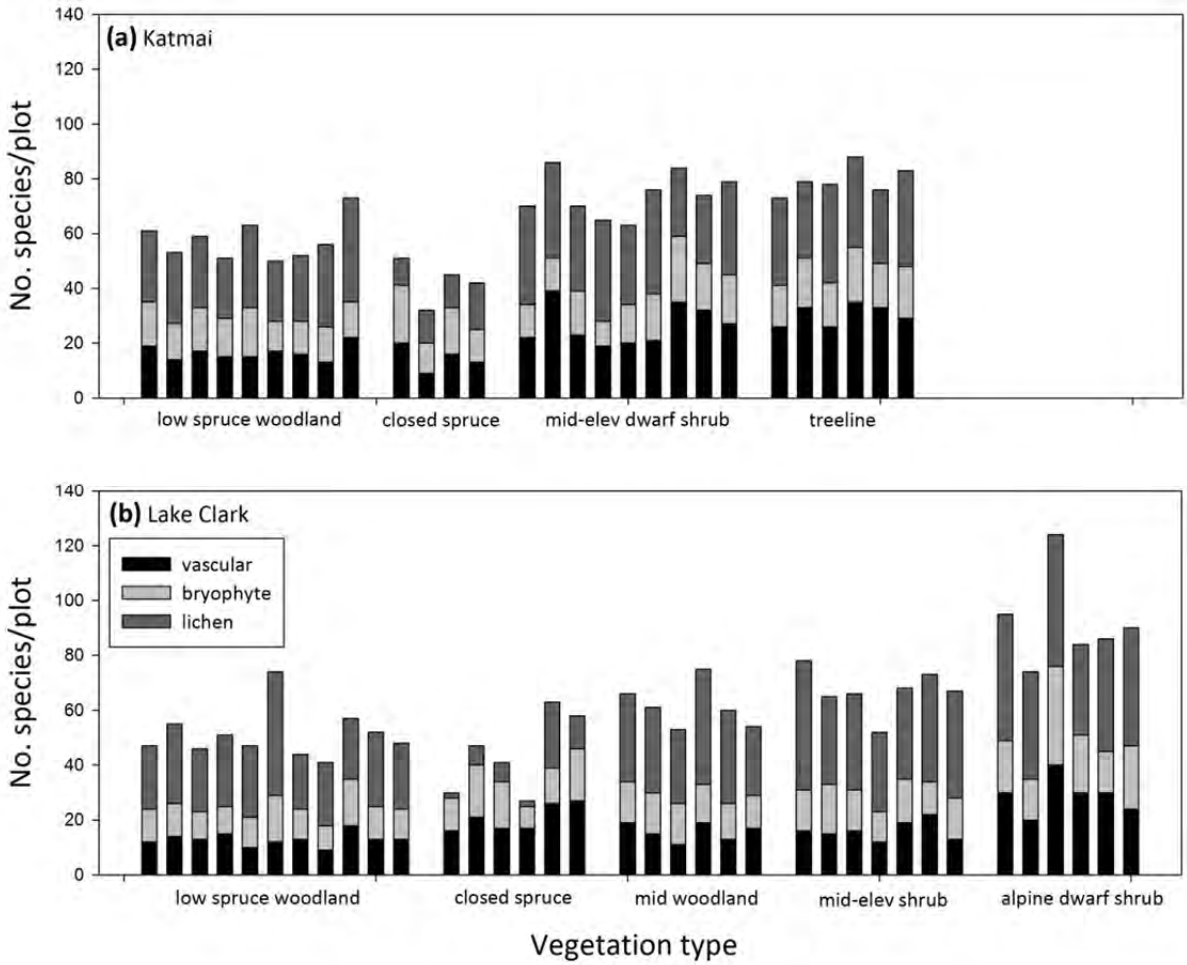

Figure 5. Contribution of vascular and nonvascular (bryophyte, lichen) taxa to overall species richness in sampled vegetation types, in (a) KATM and (b) LACL. Low spruce woodland and closed spruce (0-450 m) were sampled in both parks. Mid-elevation dwarf shrub and treeline sites (>450-900 m) were sampled in KATM only. Mid-elevation spruce woodland and low shrub (>450-900 m) , and alpine dwarf shrub (>900 m) were sampled in LACL. The contribution of nonvascular taxa to overall species richness was relatively constant across vegetation types, with the exception of low elevation closed spruce, in which nonvascular richness was relatively low. Total species richness increased with elevation in both parks.

Nested frequency data were used to characterize understory species composition across LACL and KATM (Figure 6). Ordination by NMS yielded two axes that explained 90.2% of the variance in the frequency data, with the first axis accounting for 80.1% of the community variation. Species most strongly positively correlated with Axis 1 were *Salix phlebophylla* (r = 0.73), *Anthoxanthum monticola* ssp. *alpinum* (r = 0.73), *Cladonia arbuscula* subsp. *beringiana* (r = 0.72), *Anemone narcissiflora* (r = 0.71), *Carex microchaeta* (r = 0.71), *Flavocetraria nivalis* (r = 0.70), *Sphaerophorus globosus* (r = 0.69), and *Cladonia borealis* (r = 0.69), many of which are found primarily in non-forested environments at higher elevations. Lichen richness, elevation, and percent cover of bare soil and cobble were also positively correlated with this axis. Species most strongly negatively correlated with Axis 1 were *Hylocomium splendens* (r = -0.73),

Calamagrostis canadensis (*r* = -0.69), *Ptilium crista-castrensis* (*r* = -0.69), *Picea glauca* (*r* = -0.61), and *Linnaea borealis* (*r* = -0.58), all of which are found in closed spruce forest at lower elevations. Percent cover of downed wood, tree, moss, and forb were also negatively correlated with this axis.

Axis 1 partially characterizes a mineral substrate gradient, because plots with a high percentage of exposed mineral surfaces (e.g., bare soil, gravel, cobble, etc.) clustered at the positive end. Similarly, topographic position (elevation) was associated with Axis 1. Plots of low elevation, expansive moss-carpeted forest clustered at the negative end of the axis, while high elevation dwarf shrub tundra plots with heterogeneous soil types (e.g., well-drained gravels and soil microsites) and microtopography (e.g., due to frost pockets and solifluction) clustered at the positive end (Figure 6). Low elevation closed forest and high elevation dwarf shrub tundra likewise included a number of taxa that emerged as 'indicators' (Appendix 5). Species with high indicator values (IV) in low elevation closed spruce forest included the forbs *Linnaea borealis* and *Orthilia secunda*, the foliose lichen, *Peltigera praetextata*, and a moss, *Rhytidiadelphus triquetrus*. Indicators in high elevation dwarf shrub tundra sites were numerous and included alpine dwarf shrubs (*Diappensia lapponica*, *Dryas octopetala*); lichens (*Alectoria ochroleuca*, *Bryocaulon divergens*, *Cetraria nigricans*, *Dactylina ramulosa*, *Gowardia nigricans*, *Melanelia hepatizon*) and bryophytes (*Polytrichum piliferum*, *Pogonatum urnigerum*; Appendix 5).

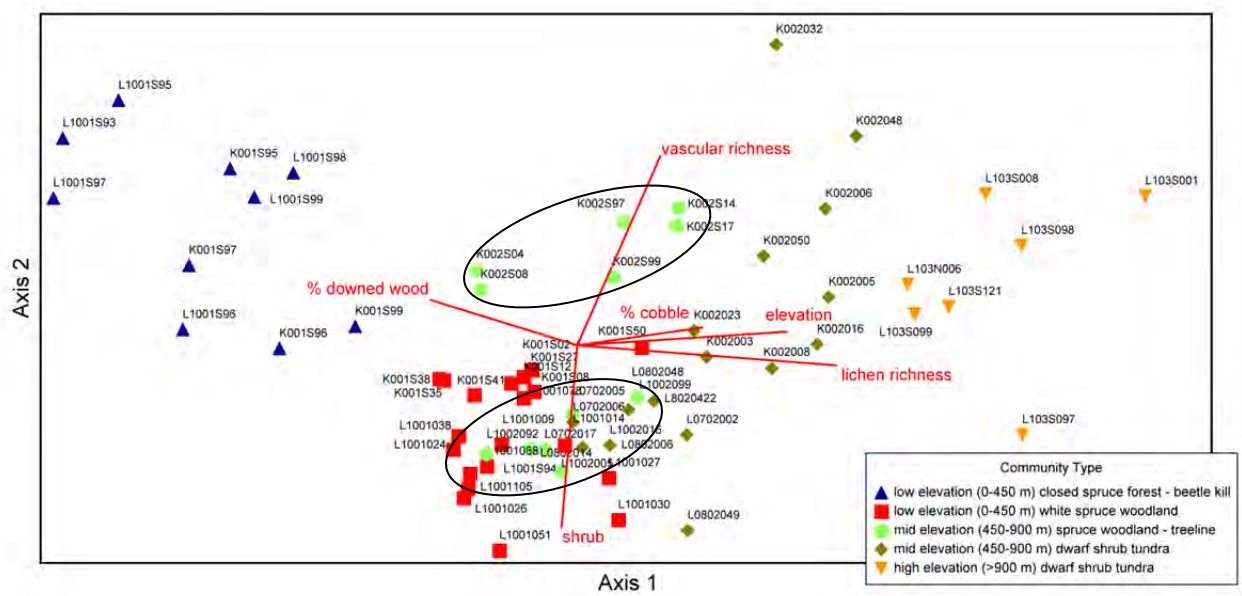

Figure 6. NMS ordination for communities sampled in KATM (2009) and LACL (2010). Sites are depicted as symbols and lines represent joint plots of environmental variables (r^2 cutoff = 0.30). Mid-elevation spruce woodland types were divided into treeline sites in KATM (upper group, circled), characterized by low cover of white spruce and relatively high understory species richness, and woodland sites in LACL (lower group, circled), characterized by higher cover of spruce, high cover of dwarf birch in the understory, and low understory species richness.

The second axis represented 10.1% of community variation and was positively correlated with vascular and bryophyte species richness. Species positively correlated with this axis included *Rhodiola integrifolia* (*r* = 0.53), *Racomitrium lanuginosum* (*r* = 0.46), *Salix arctica* (*r* = 0.46), and *Polygonum viviparum* (*r* = 0.44). Species negatively correlated with this axis included

Cladonia gracilis subsp. *vulnerata* (*r* = -0.76), *Cladonia stygia* (*r* = -0.72), *Betula nana* (*r* = -0.71), *Tuckermannopsis sepinicola* (*r* = -0.70), *Vaccinium vitis-idaea* (*r* = -0.68), *Ledum palustre* subsp. *decumbens* (*r* = -0.66), and *Peltigera aphthosa* (*r* = -0.66).

The NMS plot shows that mature closed spruce, low elevation spruce woodland, and high elevation sites were comparable across parks. In contrast, mid-elevation spruce woodland sites separated into relatively young treeline sites (KATM), characterized by low productivity but high species richness, and older, more productive but species-poor woodland sites (LACL) (Figure 6, circled). Mid-elevation dwarf and low shrub communities were also arrayed along a productivity gradient, from crowberry-dominated sites in KATM (low biomass), to dwarf birch-dominated sites in LACL (high biomass). The difference in mid-elevation woodland sites between parks is due to differences in the distribution of spruce across latitudinal and elevation gradients: In LACL, the upper limit of treeline (overstory spruce cover <1%) is at approximately 700 m. In KATM, white spruce appears to be actively expanding, but the upper limit of treeline is lower, located between approximately 575-600 m. We plan to establish treeline sites in LACL in 2011, analogous to those already sampled in KATM.

Stand age, structure and fuel loads in low elevation, closed spruce forest

Low elevation, closed white spruce stands (undisturbed and beetle-related mortality) account for less than 1% of vegetated land cover in LACL and KATM, and less than 5% when grouped with closed mixed forest. In spite of its low frequency on the landscape, closed spruce forest areas provide some of the only mature forest habitat in the interior of the parks. Sampled stands ranged in age from 109-178 years, as estimated from tree cores collected in 2005-2010 (Figure 7; Table 4; R. Sherriff, *unpublished data*). In LACL, most trees established between AD 1820-1850 (Figure 7a-d), whereas in KATM, most established later, between AD 1850-1910 (Figure 7e-h). Two cohorts of trees, aged approximately 95 years and 215 years, were found in a stand near the Valley of 10,000 Smokes Road (KATM-2009-01-S95; Figure 7h). A similar bimodal distribution in tree age was seen at the Tlikakila site (LACL-2010-01-S96; Figure 7c), with minor cohorts at 150 years and 215 years. The oldest trees we cored were from the Valley 10K Road site (KATM-2009-01-S95; Figure 7h) and Two Lakes (LACL- 2010-01-S99; Figure 7a) and and ranged from approximately 310 years to 350 years, respectively (Sherriff et al. 2011; *data not shown*).

We established monitoring plots in ten closed white spruce stands in KATM (n = 4; 2009) and LACL (n = 6; 2010) that had been affected to varying degrees by spruce beetle (Figure 8). Spruce mortality ranged from 5%-95% and was most severe at the southern end of the gradient; i.e., sites in northern LACL showed little or no spruce beetle damage (Two Lakes, Lachbuna), whereas sites in southern LACL (e.g., Tlikakila, Currant Creek, Upper Tazimina) and KATM (Coville, Bay of Isles, Brooks, Valley 10K Road) were severely damaged. Although most of the mortality has occurred within the last ten years, some of this damage is >20 years old, e.g., near Lake Brooks (Manski 1986, *unpublished report*) and Lake Clark Pass (Holsten 1993, *unpublished report*).

Aerial surveys conducted by Alaska State and Private Forestry (USFS-DNR) recorded a decrease in spruce beetle activity in LACL and the Lake Iliamna area in 2010, but an increase in KATM (13,760 ha; USFS 2011). In total, the region accounted for 75% of recorded spruce beetle-

caused mortality in the state in the last year, with activity centered on Naknek, Grosvenor, and Lake Brooks in KATM, and Tazimina, Kontrashibuna and Lake Clark in LACL (USFS 2011). Approximately 45,325 ha and 57,715 ha of forest are currently affected in KATM and LACL, respectively.

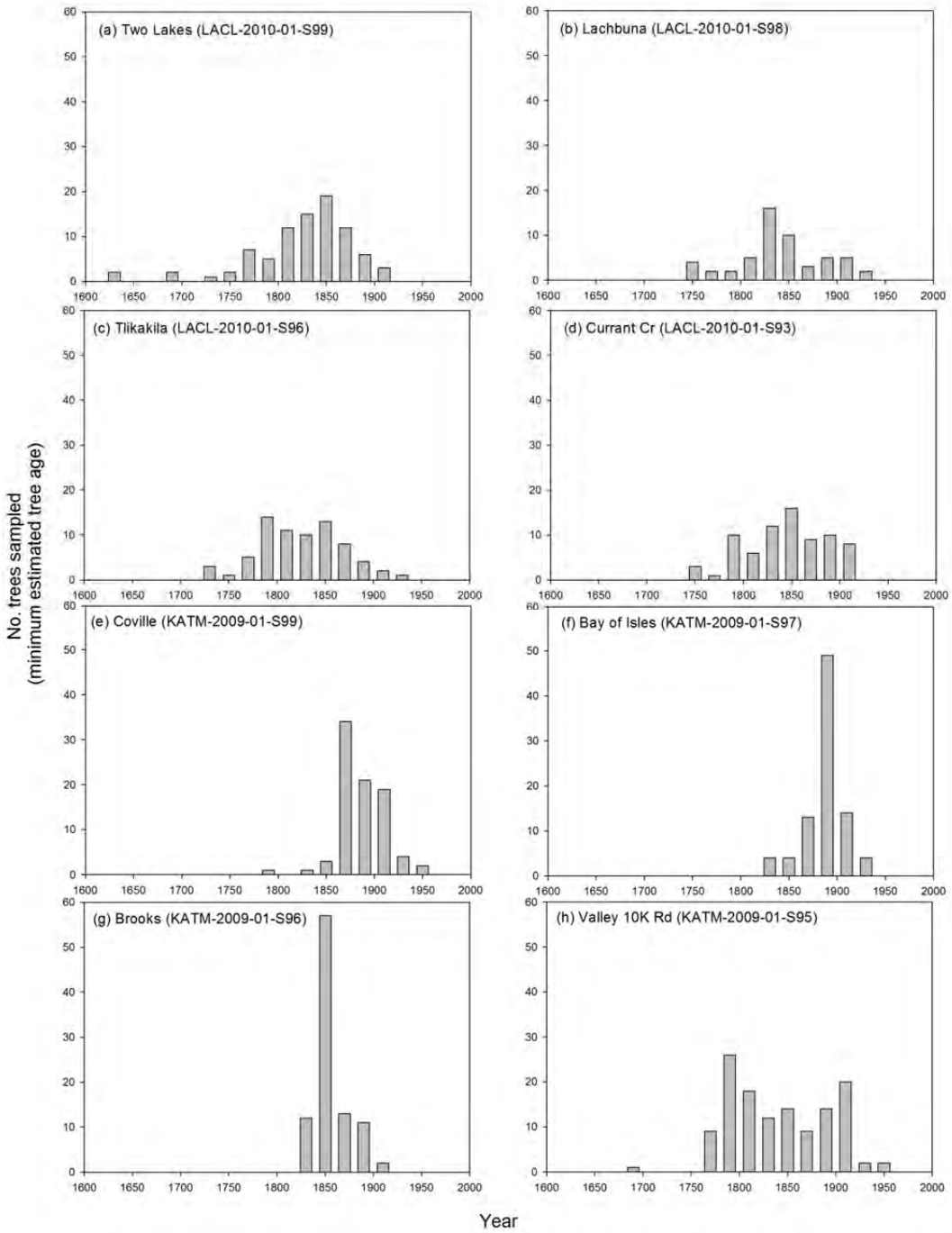

Figure 7. Age structure for low elevation closed spruce (beetle kill) stands cored in 2005 and 2007 in LACL (a-d) and KATM (e-h; R. Sherriff, unpublished data). Monitoring plots were subsequently established in closed spruce sites in KATM (2009) and LACL (2010). Two additional sites were established at Upper Tazimina, LACL (2010), in beetle kill not sampled previously. The oldest trees dated from 1650-1696 and were found at Two Lakes (LACL) and a site along the Valley 10K Road (KATM).

Table 4. Stand attributes for low elevation spruce woodland and closed forest (beetle kill) sites in LACL and KATM. Stand age and seedling counts are based on site means for white spruce (± 1 SE; Figure 8). For closed spruce sites, stand age is interpreted from tree core data collected between 2005-2010. Sites in which all trees and saplings were cored for determination of age structure (2009-2010) are indicated with a dagger (†). Biomass estimates and stem densities for trees and saplings (Picea glauca; P. mariana) are scaled up from plot-level inventories. TBD = to be determined.

Park	Site ID	Forest type	Stand age (y)	All trees	Snags	CWD	Tree	Sapling	Seedling
				---------- biomass (t/ha) ----------			---------- density (stems/ha) ----------		
LACL	01-009	woodland	149.5 (29.3)	9.86	4.41	1.47	156	222	0 (0)
LACL	01-014	woodland	78.8 (5.4)	0.62	0.00	1.24	11	811	333 (137)
LACL	01-024†	woodland	TBD	22.29	11.42	ND	267	222	667 (547)
LACL	01-026†	woodland	TBD	13.73	0.66	1.56	167	33	0 (0)
LACL	01-027	woodland	50.0 (7.0)	0.99	0.00	0.44	33	11	167 (137)
LACL	01-030	woodland	40.7 (3.9)	3.83	0.00	0.77	11	1677	2333 (761)
LACL	01-038	woodland	136.8 (35.8)	8.10	1.19	1.82	111	311	0 (0)
LACL	01-051	woodland	78.5 (20.1)	2.75	0.00	2.36	78	111	ND
LACL	01-088†	woodland	TBD	9.96	0.00	1.43	144	44	167 (137)
LACL	01-105†	woodland	TBD	9.18	0.17	1.98	133	1833	833 (493)
LACL	01-S94†	woodland	TBD	21.65	0.29	4.52	178	211	3667 (2608)
KATM	01-S35†	woodland	225.8 (8.6)	2.21	0.71	0.93	267	1367	2500 (1170)
KATM	01-S38	woodland	153.3 (16.3)	3.24	1.45	3.28	289	1100	2167 (875)
KATM	01-S41	woodland	113.3 (17.5)	1.21	0.00	0.43	189	833	2667 (861)
KATM	01-078	woodland	52.5 (1.6)	0.09	0.00	0.47	33	367	2667 (1130)
KATM	01-S02†	woodland	126.8 (2.8)	2.52	0.33	2.74	356	467	8167 (2993)
KATM	01-S08	woodland	113.0 (22.8)	1.02	0.00	0.30	89	444	2500 (880)
KATM	01-S12	woodland	129.5 (34.6)	1.32	0.02	0.70	122	444	2833 (1141)
KATM	01-S50	woodland	75.3 (4.3)	0.28	0.00	0.93	33	867	3167 (928)
KATM	01-S27†	woodland	160.3 (10.0)	1.50	0.06	3.37	222	500	2333 (826)
LACL	01-S93†	closed	158.9 (4.7)	28.78	1.95	0.31	433	1222	1667 (831)
LACL	01-S95†	closed	143.5 (12.4)	24.73	17.08	1.61	589	156	333 (273)
LACL	01-S96†	closed	174.8 (5.1)	22.30	1.52	3.77	433	178	1167 (493)
LACL	01-S97†	closed	TBD	18.57	16.89	18.89	711	756	2833 (1215)
LACL	01-S98†	closed	161.1 (7.5)	28.81	2.46	3.07	944	589	9000 (5461)
LACL	01-S99†	closed	177.9 (5.8)	18.22	0.87	6.40	922	978	9833 (2122)
KATM	01-S95†	closed	164.2 (4.3)	20.74	7.49	6.10	633	89	167 (167)
KATM	01-S96†	closed	151.4 (1.8)	22.47	13.95	4.31	1500	1122	17833 (4397)
KATM	01-S97†	closed	108.9 (2.3)	16.03	16.03	4.62	989	367	2833 (1579)
KATM	01-S99†	closed	114.9 (2.6)	12.38	12.21	4.73	667	122	1500 (476)

Old (median age >140 years), large-diameter (≥ 20 cm) white spruce comprised between 50% and 90% of basal area in the closed spruce stands (*data not shown*). In KATM, resin birch (*Betula neoalaskana*) comprised between 0-40% of the canopy, and tall shrubs (*Salix barclayi*, *S. pulchra*) were understory dominants (Miller et al. 2010b). In LACL, birch was less common (0-10%), and cottonwood (*Populus trichocarpa*) comprised up to 20% of the canopy in sites where birch was absent (Appendix 2). Bluejoint (*Calamagrostis canadensis*) and shrubs (e.g., *Ribes triste*, *Rosa acicularis*, *Viburnum edule*) were common in the understory (Appendix 3).

Large CWD (1000-h) fuel loads measured on transects were generally low. However, stands with a high percentage of beetle-kill had a high proportion of standing dead (snag) biomass (Table 4; Figure 9), suggesting that CWD could increase at these sites in the next 5-10 years. Recent (≤5 years) windthrow was localized, but measurable at several sites in both LACL (Two Lakes, Currant Creek, Upper Tazimina) and KATM (Bay of Isles). Whole-plot estimates of large-diameter (1000-h) CWD volumes were relatively high at both the Valley 10K Road (7.1 m^3/ha) and Bay of Isles (6.9 m^3/ha) sites in KATM and, due to recent windthrow, nearly an order

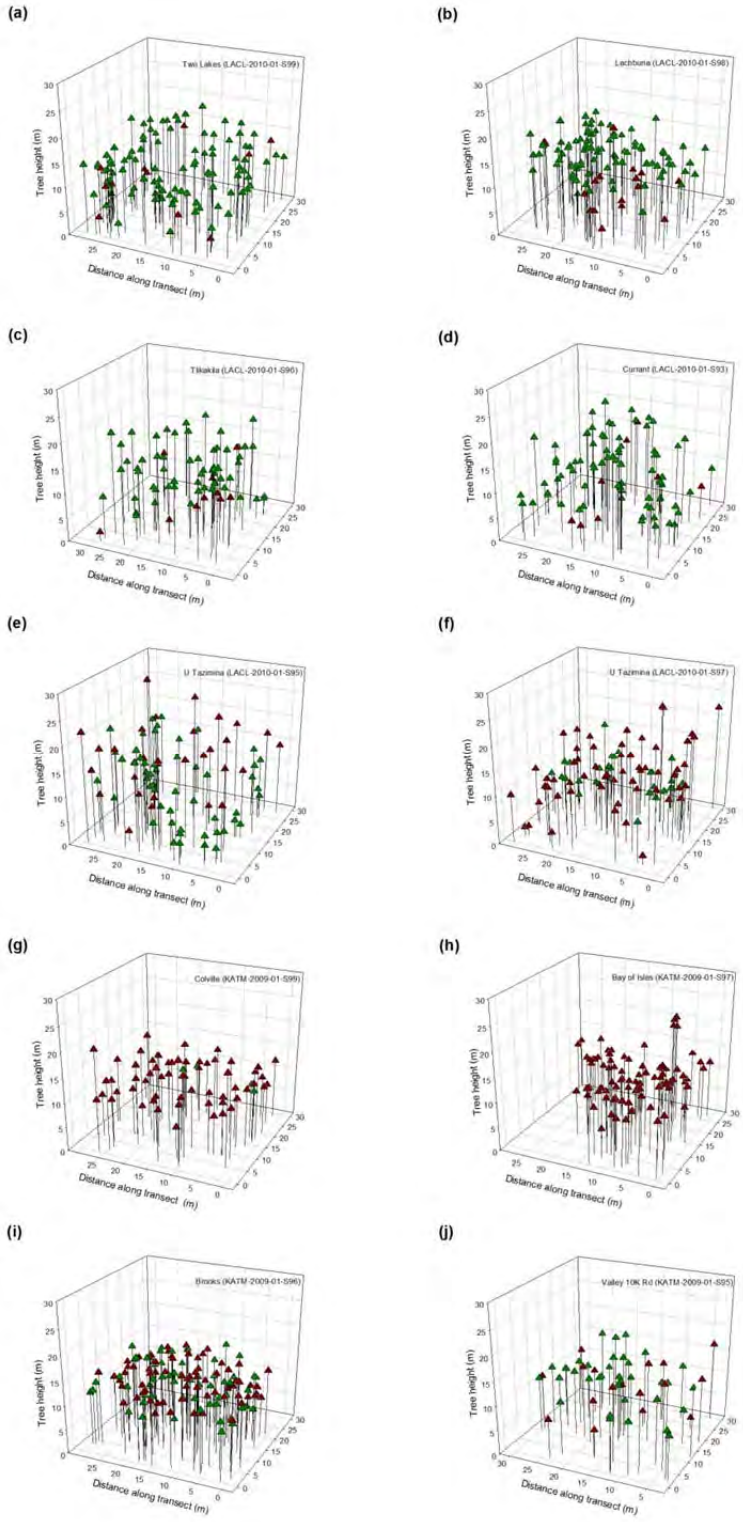

Figure 8. Three-dimensional stem plots for low elevation, mature closed spruce sites sampled along a 300-km north-south gradient, from northern LACL (a-f) to central KATM (g-j). Tree height for live (green) and dead (red) trees is shown on the vertical axis. Stands in southern LACL (e-f) and KATM (g-j) showed the highest beetle-related mortality, whereas stands in northern LACL (a-b) were undisturbed by beetle and had little standing dead. Recent windthrow was found in LACL (a, d, f).

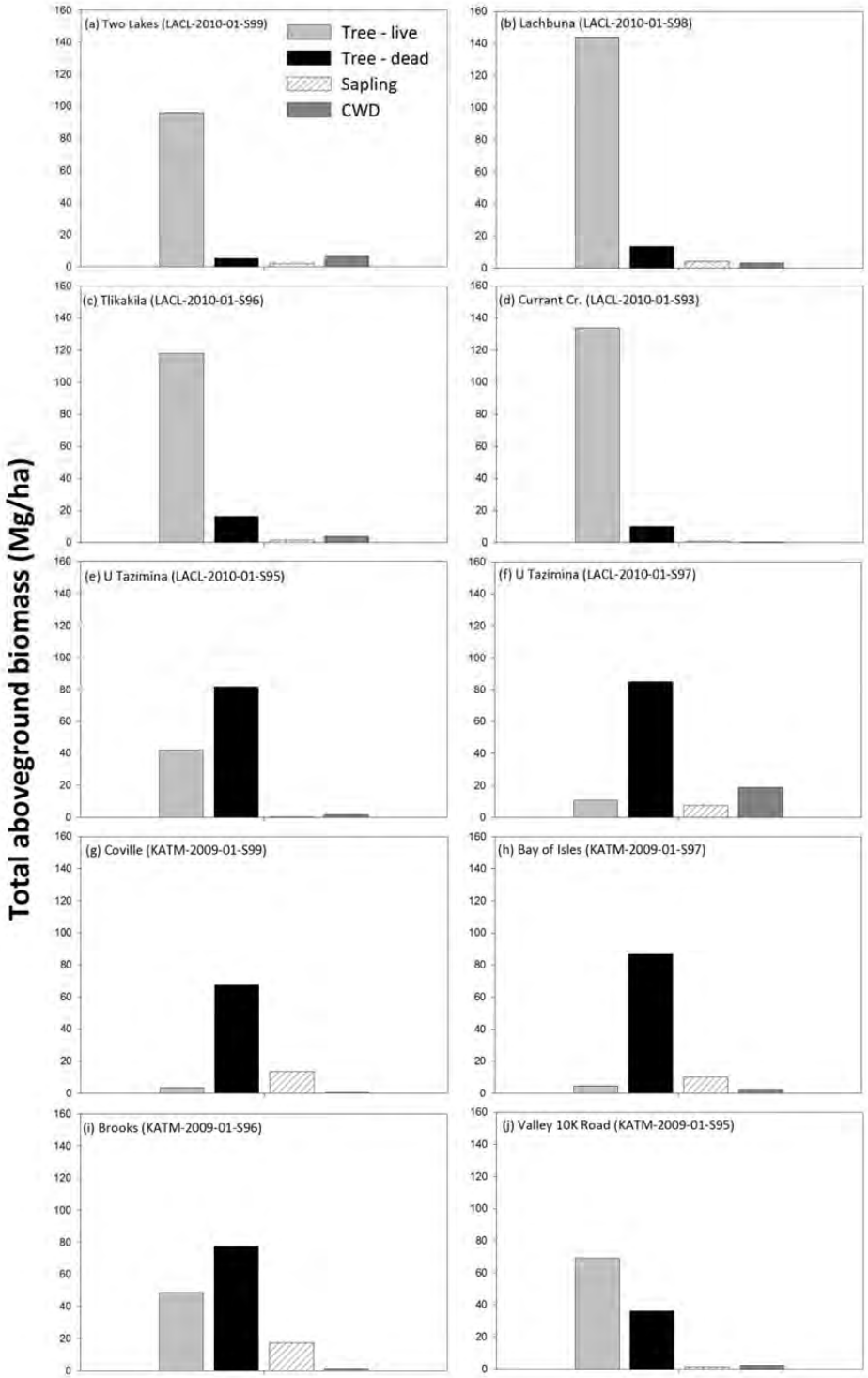

Figure 9. Total aboveground biomass in standing live and dead trees (DBH ≥ 12 cm), saplings (DBH < 12 cm), and coarse woody debris (CWD) loads in low-elevation, mature closed forest. Sites in LACL (a-e) and KATM (f-j) are as in Fig. 6.

of magnitude higher at some sites in LACL (e.g., Upper Tazimina, LACL-2010-01-S97; 55.5 m^3/ha; *data not shown*). Thousand-hour fuels (> 7.6 cm diameter) include large downed branches, logs, and tree stumps, and burn only under prolonged dry conditions or when sufficiently preheated by adjacent fuels. Although they can serve as natural firebreaks under some conditions, they can also burn for days after ignition, creating air quality and re-burn hazards (Pyne et al. 1996). As the logs decompose, they are expected to provide nursery habitat for new seedlings (Boggs et al. 2008). Decay rates for CWD on the western Kenai have been estimated at approximately 70 years (Harmon et al. 2005) and should be roughly comparable in LACL and KATM.

Small-diameter ground fuels (1 h-100 h) comprised the majority of the fuel loads and were an order of magnitude higher in closed spruce-beetle kill than in other sites. One-hour fuels (< 0.625 cm diameter) are the most important fuels for carrying surface fires, and their moisture content governs fire behavior. Ten-hour fuels (0.625 - 2.5 cm diameter) include small branches and woody stems that can carry hot fires and help ignite larger (100- and 1000-hour) fuels.

Seedling densities in low elevation closed spruce sites ranged from roughly 100-10,000 stems/ha, with the exception of one site in KATM that had exceptionally high densities (Brooks, KATM-2009-01-S96; Table 4; Figure 10b). Outside of the site at Lake Brooks, seedling densities were greatest in the undisturbed (non-beetle kill) sites in LACL (≥9000 stems/ha). On the Kenai Peninsula, spruce beetle-related mortality has resulted in increased cover of bluejoint and fireweed (*Chamerion angustifolium*) over a 15-year period, but no measurable reduction in spruce seedling regeneration (Boucher and Mead 2006). In contrast, Boggs et al. (2008) found that seedling survival was negatively correlated with bluejoint litter, although seedling regeneration overall was sufficient to restock stands to pre-outbreak densities. In LACL bluejoint ranged from 2%-46% cover in the understory, and in KATM, from 0%-15% cover. In both parks, seedling densities appeared to be high enough to maintain existing tree densities (782 ± 101 stems/ha) at most sites. Seedling density did not appear to be affected by standing biomass (live and dead trees ≥12 cm DBH), overstory cover (e.g., tree canopy or shrub cover), stand age, graminoid cover, or moss thickness (*data not shown*).

Structural characteristics of low elevation white spruce woodland

Spruce woodland is mapped as 2%-5% of vegetated land cover in the parks, and when aggregated with open spruce comprises closer to 5%-10% of land cover. Low elevation spruce woodland in LACL and KATM varies structurally and compositionally across the north-south gradient but retains several general attributes: cover of white spruce ranges from 10%-25%, understory species composition is dominated by low and/or dwarf shrubs, lichen and bryophyte cover is high, and species richness is low. At the north end of the gradient, in LACL (Stony River Morainal Valley subsection), white and black spruce (*Picea mariana*) co-occurred at some woodland sites (e.g., Two Lakes, Telaquana). Sites sampled in the southern half of Lake Clark (Rounded Volcanic Hills and Lake Clark Pass & Moraines subsections; PMR 1998) were dominated by white spruce, and some appeared to be recently established (e.g., Pickerel Lakes). Stand age has not yet been determined for some sites in LACL, as the cores are still being processed. Dwarf birch (*Betula nana*) and Labrador tea (*Ledum palustre* ssp. *decumbens*) were dominant understory species at all sites in LACL, and ranged in height from less than 0.5 m to >1 m tall. In KATM (Lakes Region Spruce Covered Moraines and Lowland Outwash & Drift

Deposits subsections; Boggs et al. 2003), sampled stands tended to be older than in LACL (Table 4). We found evidence of heart rot at some sites, and a high incidence of trees with broken tops due to wind damage (Miller et al. 2010b). At one site (Long Lake; KATM-2009-01-S12), we were unable to get good ages for the largest trees due to decay in the heartwood. At most sites, the trees appeared stressed, as evidenced by narrow growth rings and dead branches in the lower one-third to one-half of the canopy. Understory species composition was fairly uniform across KATM, and was dominated by low ericaceous shrubs (*Vaccinium uliginosum, V. vitis-idaea, Ledum palustre* ssp. *decumbens*) and fruticose lichens (e.g., *Cladonia* spp.). Dwarf birch (≤0.5 m height) occurred at low frequency (3%-14% cover) or was absent from sites in KATM. Sub-dominants included low- to mid-stature willows, such as *Salix glauca* (0-3%) and *S. pulchra* (0-6%), and spiraea (*Spiraea beauverdiana* (0-3%)).

Seedling densities in KATM ranged from roughly 2000-4000 stems/ha and were consistently four to ten times greater than in comparable woodland sites in LACL (Table 4; Figure 10a). It is unclear what factors are controlling seedling establishment (see previous section), although lower reproduction and dispersal, greater understory shrub cover (and thus lower light availability), and/or fewer favorable microsites in LACL are possible explanations. The relatively high seedling densities in woodland sites in KATM suggest that white spruce is thriving and that we may see continued forest establishment, and perhaps expansion, at the southern end of its range.

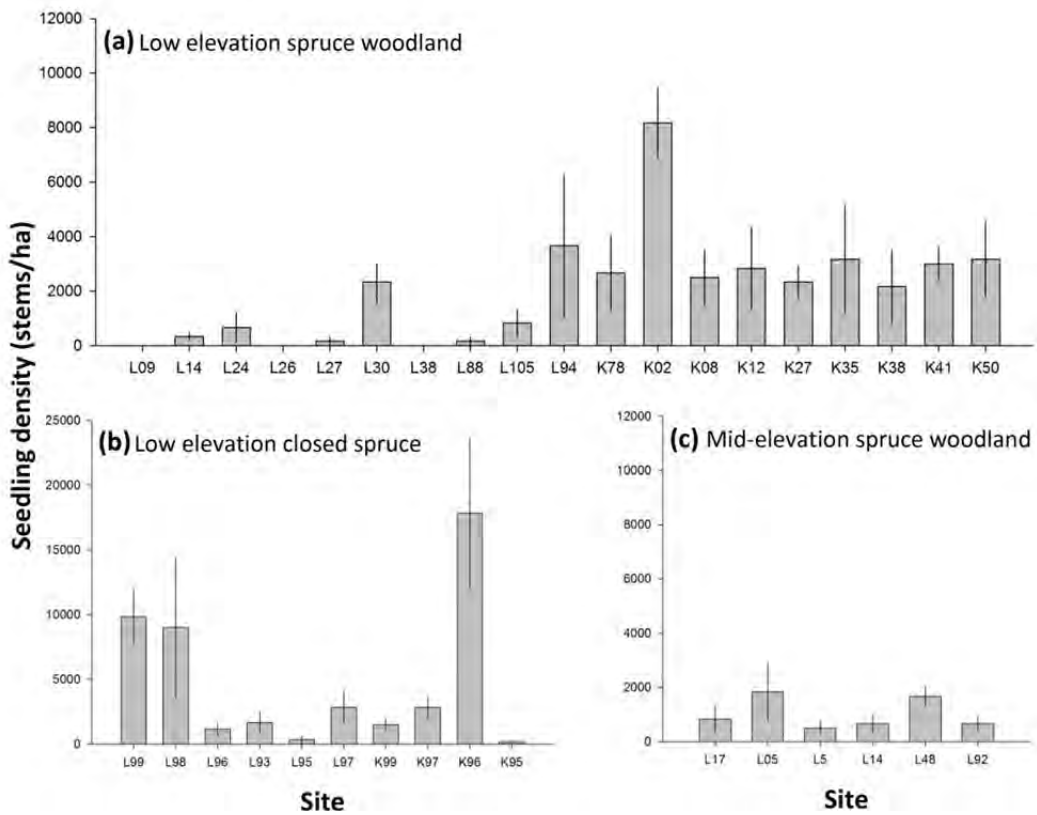

Figure 10. Seedling densities (stems/ha) for (a) low elevation white spruce woodland and (b) low elevation, mature closed spruce in KATM ('K' sites; 2009) and LACL ('L' sites; 2010) National Parks and Preserves; and (c) mid-elevation spruce woodland stands in LACL (2010). Closed spruce sites at Two Lakes and Lachbuna (LACL) and Lake Brooks (KATM) showed the highest seedling densities. Seedling densities were lowest in mid-elevation spruce woodland in LACL.

Windthrow appeared to be a common source of disturbance at woodland sites in KATM, and was evident at a number of plots (Miller et al. 2010b). In LACL, in contrast, most sites were relatively undisturbed and trees appeared to be growing relatively rapidly. A ring-width analysis is pending for tree cores collected in LACL and KATM and should provide more quantitative information regarding annual growth rates. Tree mortality was relatively low in LACL, with the exception of woodland sites at Upper Tazimina, which had been affected by the spruce beetle (Table 4).

Defoliator damage on shrubs in interior LACL

Defoliation of shrubs by at least three unidentified taxa was observed early in the growing season, in mid-late June, in interior LACL (Figure 11a-b). The damage was most pronounced on dwarf birch (*Betula nana*), but was also evident on a range of other species, including Labrador tea (*Ledum palustre* ssp. *decumbens*) and willow (*Salix* spp.). Episodic increases in defoliator populations have apparently occurred in the area before, with the last one perhaps 10 years ago (J. Branson and G. Alsworth, *pers. comm.*). The 2010 outbreak was extensive, but it's unclear whether it affected a greater area than previous outbreaks, as there appears to be no documentation for those earlier events. The 2010 damage ranged from the Bonanza Hills to the northwest, to the little Mulchatna River, to the southeast (G. Alsworth, *pers. comm.*).

At the request of NPS, State and Private Forestry (USFS-ADF) aerial survey mappers collected larvae at Snipe Lake in early July 2010 that resulted in five viable pupae, although the pupae never emerged (K. Zogas, *pers. comm.*). More than 50% of the resulting pupae appeared to be parasitized. We do not yet know the identity of the defoliators, but according to entomologists at USFS-ADF, they do not appear to be related to the Geometrid moth (larvae = looper caterpillars) outbreak that occurred in the Anchorage Bowl during the same time period (e.g., autumnal moths *Epirrita autumnata*, *Eulithis distinata*, *Eulithis propulsata*). USFS-ADF personnel will return to Snipe in 2011 to collect both plant material and larvae. There appeared to be at least two to three different defoliators in the area, or one or more species with high variability in larval instars, as we found larvae that were both black (Figure 11c) and green (not shown). Unfortunately, USFS-ADF was unable to map the extent of the damage in 2010, but indicated that at the time of their visit (late June) it extended west from Snipe, discontinuously along the Chilikondrotna and Mulchatna Rivers (K. Zogas, *pers. comm.*).

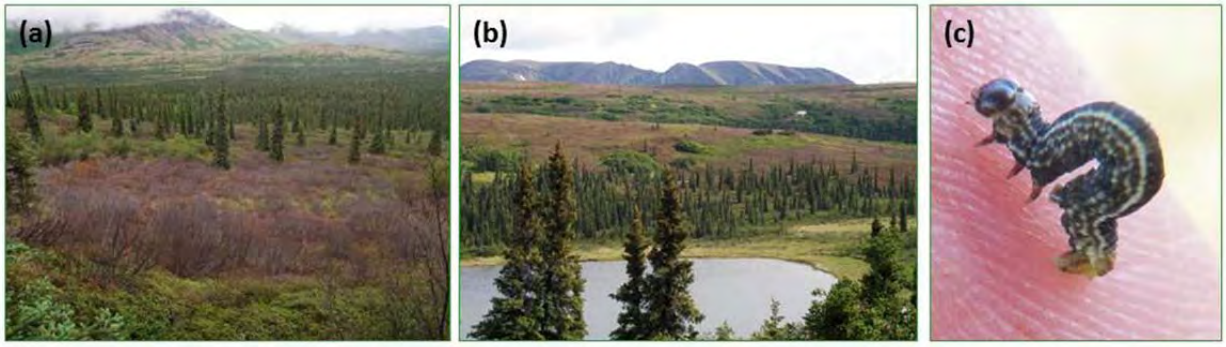

Figure 11. Widespread defoliator damage on dwarf birch (*Betula nana*; reddish-brown in photos) and willows (*Salix* spp.) near Snipe Lake (a-b); larvae of one of several unidentified defoliators, collected near Snipe Lake, June, 2010 (c). Defoliation occurred within a month of leaf-out (mid-late June, 2010), and shrubs had not produced a second flush of leaves as of late July.

Soil temperature

Soils in low elevation, mature closed spruce stands stay cold later into the growing season and have fewer degree growing days than well-drained, higher elevation tundra sites in the same vicinity. In water year (WY) 2010 (October 1-September 30), soils in closed forest sites in KATM froze between December 11-15 and thawed (reached 0 °C) between May 26-31 (Figure 12c-d). Maximum soil temperatures were recorded in August-early September, approximately one month later than nearby sites that were 400-500 m higher (Table 5a). Soils at the two forested sites are deeper and finer-textured than soils at the higher elevation sites, have a higher organic content, are shaded by an overstory canopy (20%-80% cover), and are insulated by a layer of moss ranging from 5-10 cm. Depth to the frost layer was approximately 75 cm at the time of sampling, in mid-August, 2009. The low forested sites had roughly one-third to one-half the number of growing degree days as the higher elevation, non-forested sites (Table 5b).

Although forested soils were cooler than non-forested soils during the growing season, they remained warmer (-2 to -1 °C) over most of the winter. In contrast, higher elevation, non-forested soils showed one or more dips in mid-winter temperature, to -10 °C or lower, likely due to lower soil water content and/or a lack of insulative snow cover. At two sites on the RAWS ridge above Lake Coville (WY 2010), soils froze on November 17 and thawed between May 15-22 (Figures 12e, h), resulting in a longer period of below-zero temperatures than the adjacent forested site at Coville (Figure 12d). The site at Emerald (Figure 12f) is located in a basin, rather than on a ridgeline, and warmer soils, mid-winter, are likely the result of a deeper snowpack than at the other non-forested sites. Likewise, a comparison of forested and non-forested sites near the Snipe Lake RAWS (WY 2009-2010; Figure 12a-b) showed fewer mid-winter fluctuations in soil temperature in the woodland site, likely due to a deeper, insulative snowpack. Beginning in 2011, we hope to characterize the relationship between snowmelt date, as captured by the time-lapse cameras installed at the RAWS, and soil temperature as determined from dataloggers. A correlation between the two should enable us to model snowmelt dates at other sites for which we have soil temperature data.

Species of conservation concern

Three species of conservation concern, or species that are tracked as rare by the states and/or by the International Union for Conservation of Nature (IUCN), were collected in the park during the 2010 field season. The collections will be archived at the National Park Service Regional Office (Herbarium) and/or the University of Alaska Fairbanks Museum of the North (ALA). No exotic species were encountered in 2010.

Douglasia alaskana (Coville & Standley ex Hultén**)** S. Kelso, or Alaska douglasia, is an Alaska-Yukon endemic found in rocky tundra and alpine scree between 0-2000 m (Figure 13a). It is considered rare (G3 S3) in Alaska and the Yukon Territory (Douglas et al. 1981), where it is known from roughly 40 records from the St. Elias Mountains, Chugach Mountains, Kenai Mountains, Alaska Range, Aleutian Range, Kodiak Archipelago, Ahklun Mountains, Nulato Hills, Kilbuk-Kuskokwim Mountains, and Seward Peninsula (ALA 2010). The 2010 collection was from a monitoring plot established on the ridge to the north of Lachbuna, at 1005 m a.s.l. (A. Miller, Accession # LACL-00343, Catalog # LACL 5042; Plot No. LACL-2010-03S-098; Table 1).

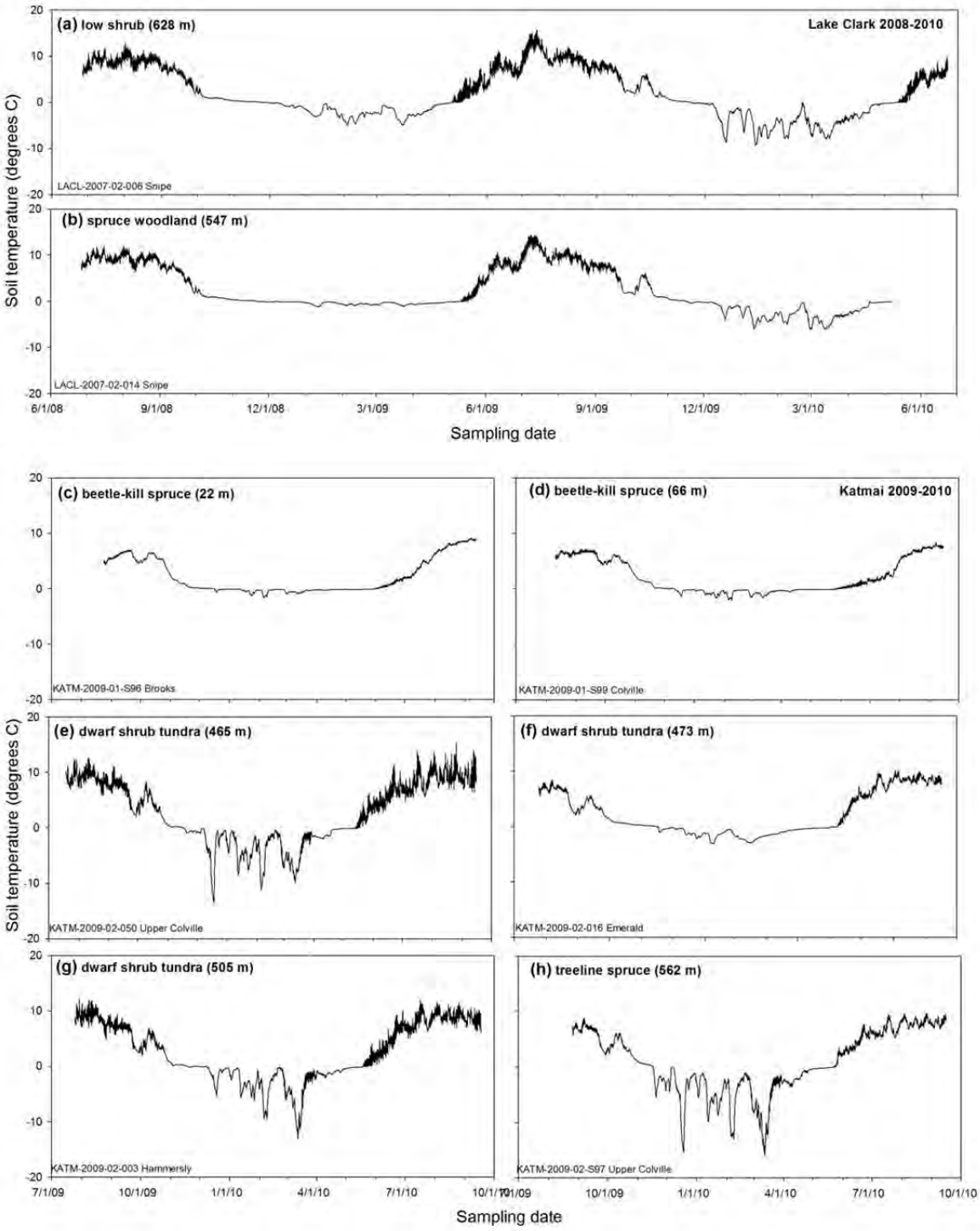

Figure 12. Hourly soil temperature (°C) recorded at 10 cm depth at low and mid-elevation sites in LACL (a-b) and KATM (c-h).

Table 5a. Coldest and warmest 7-day periods (based on mean daily value) for continuous soil temperature measurements at 10 cm depth, summarized by by water year (WY; October 1 – September 30). Data are means ± 1 SD. Canopy cover (tree) was averaged across the plot and rounded to the nearest 5%. ND = no data.

Site	Elevation (m)	Drainage	Canopy cover (%)	Coldest 7-day Period	Soil Temperature (°C)	Warmest 7-day Period	Soil Temperature (°C)
KATM – WY 2010							
2009-02-016	473	High	0	March 13 – 19	-2.83 (0.16)	August 1 – 7	9.09 (0.40)
2009-02-003	505	High	0	March 9 – 15	-10.26 (1.67)	July 31 – August 6	9.82 (0.53)
2009-02-050	465	High	0	December 13 – 19	-8.34 (2.37)	July 29 – August 4	10.47 (1.03)
2009-02-S97	562	High	<5	March 9 – 15	-12.71 (1.39)	July 30 – August 5	8.59 (0.70)
2009-01-S99	66	Moderate	85	February 3 – 9	-1.45 (0.31)	*September 4 – 9	7.76 (0.10)
2009-01-S96	22	Moderate	20	February 3 – 9	-1.09 (0.30)	*Aug 29 – Sept 4	8.57 (0.05)
LACL							
WY 2008							
2008-02-006	628	High	1	ND	ND	July 30 – August 5	10.46 (0.51)
2008-02-014	547	High	20	ND	ND	July 30 – August 5	10.55 (0.36)
WY 2009							
2008-02-006	628	High	1	March 18 – 24	-4.29 (0.82)	July 7 – 13	13.17 (0.71)
2008-02-014	547	High	20	January 7 – 13	-1.00 (0.20)	July 7 – 13	12.91 (0.69)
WY 2010							
2008-02-006	628	High	1	January 11 – 17	-7.30 (1.40)	ND	ND
2008-02-014	547	High	20	March 11 – 17	-5.58 (0.46)	ND	ND

*indicates warmest period to date of collection

Table 5b. Monthly growing degree day totals (4.4°C) by water year (WY) based on soil temperature measured at 10 cm depth in low- and mid-elevation vegetation plots, LACL and KATM. Temperature loggers in LACL were installed in June-July 2008. Loggers in KATM were installed June-August 2009. ND = no data (not yet available).

	LACL		KATM					
	2008-02-006	**2008-02-014**	**2009-02-016**	**2009-02-003**	**2009-02-050**	**2009-02-S97**	**2009-01-S99**	**2009-01-S96**
WY 2008								
Jul-08	142.5	159.2	-	-	-	-	-	-
Aug-08	152.1	152.6	-	-	-	-	-	-
Sep-08	50.3	55.7	-	-	-	-	-	-
WY 2009								
Oct-08	0.0	0.0	-	-	-	-	-	-
Nov-08	0.0	0.0	-	-	-	-	-	-
Dec-08	0.0	0.0	-	-	-	-	-	-
Jan-09	0.0	0.0	-	-	-	-	-	-
Feb-09	0.0	0.0	-	-	-	-	-	-
Mar-09	0.0	0.0	-	-	-	-	-	-
Apr-09	0.0	0.0	-	-	-	-	-	-
May-09	2.58	0.0	-	-	-	-	-	-
Jun-09	86.0	95.9	-	-	-	-	-	-
Jul-09	203.1	201.4	-	-	-	-	-	-
Aug-09	141.5	141.7	-	-	-	-	-	-
Sep-09	55.9	53.1	52.7	57.1	70.4	54.1	53.3	48.1
WY 2010								
Oct-09	5.7	5.3	4.3	9.8	17.1	8.8	19.8	30.8
Nov-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jan-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Feb-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mar-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apr-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
May-10	5.3	3.6	0.0	0.0	0.0	0.0	0.0	0.0
June-10	ND	ND	7.3	30.9	45.3	20.4	0.0	0.0
July-10	ND	ND	80.3	110.8	109.6	71.1	0.8	10.0
Aug-10	ND	ND	133.1	148.1	162.3	114.4	68.4	102.5
Sept-10	ND	ND	ND	ND	ND	ND	45.3	ND

Hypogymnia pulverata (Nyl. ex Crombie) Elix, is an epiphytic foliose macrolichen considered common in the southern hemisphere but rare in North America (S1 in Oregon; Figure 13b). The species is known currently from three wide-ranging locations in Quebec, Oregon, and Alaska, and was collected at a number of locations in KATM during the 2009 field season (Miller et al. 2010). Four collections of *H. pulverata* were made in black spruce woodland near a small unnamed lake in the southwest corner of LACL, during a site reconnaissance in June 2010 (*J. Walton 13577*, NPS Accession # LACL-00343, Catalog # LACL 6205; *J. Walton 13581*, NPS Accession # LACL-00343, Catalog # LACL 6207; *J. Walton 13582*, NPS Accession # LACL-00343, Catalog # LACL 6208; J. Walton *13583*, NPS Accession # LACL-00343, Catalog # LACL 6206).

Schistostega pennata (Hedw.) Web. & Mohr, is a moss previously known from eight sites in southeast Alaska and one site near Fairbanks (Figure 13c). Recently a significant state range extension was collected at Nonvianuk Lake in KATM (Miller et al. 2010b). Within western North America, the species is considered rare to uncommon (S1 in Montana and Idaho, S2 in Oregon and Washington State). Two populations from LACL were discovered on damp mineral soil in the hollows of overturned white spruce rootwads near Lachbuna Lake and Two Lakes (*J. Walton 13788*, NPS Accession # LACL-00343, Catalog # LACL 13788; J. Walton 13847, NPS Accession # LACL-00343, Catalog # 6078, Plot No. LACL-2010-01-S99; J. Walton 13847, NPS Accession # LACL-00343, Catalog # LACL 6271).

Figure 13. Rare taxa found in LACL (2010): a) *Douglasia alaskana*; b) *Hypogymnia pulverata*; c) *Schistostega pennata*.

Modifications to the sampling design and methods

We have used the baseline data from KATM (2009) and LACL (2008; 2010) to examine variability in plot attributes for four representative vegetation types (low elevation spruce woodland, low elevation closed forest, mid-elevation treeline spruce, mid-elevation dwarf shrub tundra). Low sample variances (CVs) for a number of attributes, including cover by growth form, species cover, and frequency indicate that our estimated minimum sample size of eight plots per vegetation type (Thompson et al., *in press*) will be sufficient to detect long-term trends in vegetation parameters (minimum detectable total change of 25% over 31 years, for a true change of 50%; Thompson et al, *in press*). In addition, we find that the sample variances for targeted vegetation types (closed spruce-beetle kill; treeline spruce) are sufficiently low to detect change with fewer than eight replicates. In 2011, we plan to resample four to six plots in LACL and KATM (i.e., up to two plots per vegetation type in low elevation spruce woodland, mid-

elevation treeline spruce, and mid-elevation dwarf shrub tundra) to estimate interannual variability for the period 2009-2011.

In 2010, we used a crew consisting of a term biotech (GS-7), a seasonal biotech (GS-6), and a M.S. student intern supervised by the UAF Herbarium. Crew size ranged from 3-4 persons, including the PI, and was supplemented by intermittent help from SWAN staff. As in 2009, we measured fuels at forested and woodland sites, following the line-intersect methods of Van Wagner (1968) and Brown (1974), and conducted full-plot inventories of CWD in mature, closed forest plots. We continued to use descriptors adopted in 2008 to delineate between current-year frost damage ('FD') and dead branches in low-stature woody vegetation (shrubs and dwarf shrubs), but refined the definition of 'standing dead' to differentiate between dead branches on live trees ('standing dead on live' (SDL)) and standing dead trees ('standing dead' (SD)). We added a new descriptor for insect damage ('ID'), which in this case applied to caterpillar defoliation on dwarf birch and willow in interior LACL. Dead branches on live plants other than trees (e.g., annual dieback on shrubs or herbaceous species) were not counted as 'standing dead.' In 2010, we began to record DBH on all saplings in a plot, as per the CAKN protocol (Roland et al. 2004). We also began recording moss thickness at each of the four corners of the plot, in roughly the same location that we measured depth to frost layer.

As indicated in the Methods, we parsed the GRTS sample for Elevation Band 3 into two populations, north and south of Turquoise, to ensure greater dispersion of high elevation sites in the southern half of the park. As in KATM in 2009, we were unable to locate enough GRTS sites at treeline to provide adequate replication. The problem with treeline is twofold: (1) the landcover map does not accurately capture treeline, so many 'spruce' GRTS points identified as high elevation spruce were in fact dwarf shrub tundra (Appendix 1); and (2) upper treeline is by definition discontinuous and patchy, reducing the probability that a GRTS point will land in a location occupied by spruce. We surveyed a number of potential treeline sites in 2010 and will establish plots in 2011. In all cases, we will attempt to establish sites in relatively close proximity to a GRTS point, thus maintaining spatial dispersion to the extent possible. However, because the treeline sites will be subjectively chosen, we will treat the entire sample as targeted, and thus limit our area of inference accordingly.

Recommendations and Conclusions

Baseline sampling conducted in 2010 was limited to low (0-450 m) and mid-elevation (450-900 m) sites in interior LACL. We were unable to complete a full replicate of high elevation sites (>900 m) in LACL due to time constraints and inclement weather. The establishment of high elevation plots in KATM was postponed until 2011.

In 2011, we will base the crew out of Anchorage and resume plot establishment in high elevation sites in both parks. Areas to be sampled in LACL will include high elevation ridges near Turquoise Lake, Caribou Lakes, and Upper Tazimina, and mid-elevation treeline sites near Snipe, Lachbuna, and Upper Tazimina. In KATM, high elevation areas above Pfaff Mine, Hammersly Lake, Mirror Lake and Contact Creek will be sampled. We also plan to re-measure four to six plots established in 2009-2010 in each park, including at least one site from each elevation band.

In 2010, we surveyed sites 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*). We did not establish plots using the GRTS points from this area because they did not include any of the targeted vegetation types. However, we recommend expanding the sampling frame to include black spruce (*Picea mariana*) woodland, a dominant type in this area and in other sections of the park.

We will continue to monitor soil temperature across the two parks, as outlined in Miller et al. (2010b) and will begin to use image dates derived from time-lapse cameras to estimate the timing of snowpack development and snowmelt, leaf out, and senescence.

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Appendix 1. Site reconnaissance for LACL (2010). Up to121 sites were surveyed in each stratum. Closed spruce sites (01-S93 through 01-S99) and a subset of high elevation sites (03S-097 through 03S-099) were targeted sites, independent of the GRTS population.

1a. GRTS – all classes, including spruce (0-450 m): target vegetation = white spruce woodland

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
1-001	1	15	1	60.008513	-154.684663	Pickerel Lakes	reject	access - too far
1-002	3	8	1	60.358969	-154.054731	Lake Clark	reject	not target veg
1-003	2	11	1	60.125934	-152.691242	Tuxedni Bay	reject	not target veg
1-004	2	6	1	60.420805	-153.807206	Lake Clark	reject	not target veg
1-005	0	7	1	60.953634	-154.015179	Lake Telaquana	reject	not target veg
1-006	1	8	1	60.993319	-154.059154	Lake Telaquana	reject	not target veg
1-007	3	15	1	59.946725	-154.701165	Pickerel Lakes	reject	not target veg
1-008	2	7	1	60.049755	-154.238525	Upper Tazimina Lake	*unconfirmed*	*evaluation needed*
1-009	2	6	1	60.018599	-154.259359	Upper Tazimina Lake	**accept**	
1-010	2	14	1	60.947235	-154.251869	Lake 21 (Telaquana River)	reject	not target veg
1-011	1	6	1	60.222518	-154.444622	Lake Clark	reject	not target veg
1-012	3	7	1	59.94583	-154.811605	Pickerel Lakes	reject	not target veg
1-013	1	15	1	59.935421	-154.756945	Pickerel Lakes	reject	not target veg
1-014	2	7	1	59.936865	-154.688566	Pickerel Lakes	**accept**	
1-015	2	5	1	60.50141	-153.990308	Lachbuna Lake	reject	not target veg
1-016	2	10	1	60.233782	-154.232255	Lake Clark	reject	not target veg
1-017	2	14	1	60.952416	-154.200785	Lake 21 (Telaquana River)	reject	access - unsafe
1-018	0	15	1	60.794422	-152.770272	Summit Lake	reject	not target veg
1-019	3	6	1	59.942373	-154.712386	Pickerel Lakes	reject	not target veg
1-020	3	8	1	60.395342	-153.821559	Lake Clark	reject	not target veg
1-021	2	11	1	60.086282	-152.81242	Johnson River (Tuxedni Bay)	reject	not target veg
1-022	3	11	1	59.925637	-154.731412	Pickerel Lakes	reject	not target veg
1-023	2	19	1	60.940237	-154.265146	Lake 21 (Telaquana River)	reject	not target veg
1-024	3	7	1	60.039249	-154.262223	Upper Tazimina Lake	**accept**	
1-025	0	13	1	61.010498	-153.996277	Lake Telaquana	reject	not target veg

1a. GRTS – all classes, including spruce (0-450 m): target vegetation = white spruce woodland

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
1-026	3	6	1	60.472162	-154.057112	Lachbuna Lake	**accept**	
1-027	2	7	1	59.935541	-154.735401	Pickerel Lakes	**accept**	
1-028	1	16	1	60.942447	-154.229054	Lake 21 (Telaquana River)	reject	not target veg
1-029	0	25	1	61.147518	-152.938939	Kenibuna Lake	reject	not target veg
1-030	2	7	1	61.141043	-153.851482	Two Lakes	**accept**	
1-031	3	7	1	60.038712	-154.262218	Upper Tazimina Lake	reject	<100 m from est. plot
1-032	4	25	1	60.959022	-153.740049	Lake Telaquana	reject	not target veg
1-033	1	7	1	59.94373	-154.80401	Pickerel Lakes	*unconfirmed*	*evaluation needed*
1-034	0	20	1	60.404813	-153.023767	Crescent Lake	reject	not target veg
1-035	2	19	1	60.983657	-154.071374	Lake Telaquana	reject	not target veg
1-036	1	19	1	60.077096	-152.805177	Johnson River (Tuxedni Bay)	reject	not target veg
1-037	8	15	1	60.087413	-154.905467	Lake 423	reject	not target veg
1-038	2	7	1	60.047283	-154.268772	Upper Tazimina Lake	**accept**	
1-039	1	15	1	59.938862	-154.765104	Pickerel Lakes	reject	not target veg
1-040	1	19	1	60.985017	-153.997949	Lake Telaquana	reject	not target veg
1-041	5	15	1	59.931626	-154.715386	Pickerel Lakes	reject	not target veg
1-042	3	6	1	60.074207	-154.874271	Lake 423	reject	not target veg
1-043	2	6	1	60.978311	-154.015746	Lake Telaquana	reject	not target veg
1-044	1	15	1	59.935131	-154.760709	Pickerel Lakes	reject	not target veg
1-045	2	19	1	61.002719	-154.013532	Lake Telaquana	reject	not target veg
1-046	2	25	1	60.312196	-154.17397	Lake Clark	reject	not target veg
1-047	3	6	1	60.988766	-154.042456	Lake Telaquana	reject	not target veg
1-048	0	6	1	60.398846	-153.83465	Lake Clark	reject	not target veg
1-049	0	19	1	59.939509	-154.792055	Pickerel Lakes	reject	not target veg
1-050	1	19	1	60.105909	-154.907601	Lake 423	reject	not target veg
1-051	1	19	1	60.960336	-154.03408	Lake Telaquana	**accept**	
1-052	0	7	1	60.509187	-153.975506	Lachbuna Lake	reject	not target veg
1-053	3	7	1	61.145343	-153.859289	Two Lakes	reject	not target veg
1-054	1	8	1	60.940223	-154.011284	Lake Telaquana	reject	not target veg

1a. GRTS – all classes, including spruce (0-450 m): target vegetation = white spruce woodland

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
1-055	1	19	1	60.992514	-154.060266	Lake Telaquana	reject	not target veg
1-056	0	8	1	60.948534	-154.03629	Lake Telaquana	reject	not target veg
1-057	0	25	1	60.387255	-153.793207	Lake Clark	reject	not target veg
1-058	1	8	1	59.948992	-154.728695	Pickerel Lakes	reject	not target veg
1-059	2	19	1	60.49846	-153.993596	Lachbuna Lake	reject	not target veg
1-060	1	19	1	60.971381	-154.248723	Lake 21 (Telaquana River)	reject	access - unsafe
1-061	0	20	1	61.155585	-152.941466	Kenibuna Lake	reject	not target veg
1-062	1	22	1	60.782092	-152.801703	Summit Lake	reject	not target veg
1-063	2	2	1	60.251525	-154.340057	Lake Clark	reject	not target veg
1-064	1	19	1	59.926068	-154.79658	Pickerel Lakes	reject	not target veg
1-065	1	6	1	59.936354	-154.781206	Pickerel Lakes	reject	not target veg
1-066	2	5	1	60.23635	-154.396431	Lake Clark	reject	not target veg
1-067	2	4	1	60.919084	-154.244987	Lake 21 (Telaquana River)	reject	not target veg
1-068	2	6	1	60.422948	-153.805554	Lake Clark	reject	not target veg
1-069	1	11	1	60.076228	-152.798175	Johnson River (Tuxedni Bay)	reject	not target veg
1-070	3	6	1	60.35576	-154.021447	Lake Clark	reject	not target veg
1-071	1	19	1	60.959519	-154.067985	Lake Telaquana	reject	not target veg
1-072	1	20	1	61.157804	-152.916221	Kenibuna Lake	reject	not target veg
1-073	1	8	1	60.370011	-152.861596	Crescent Lake	reject	not target veg
1-074	0	6	1	60.221491	-154.430481	Lake Clark	reject	not target veg
1-075	1	19	1	60.992795	-153.995723	Lake Telaquana	reject	not target veg
1-076	1	19	1	59.94639	-154.807846	Pickerel Lakes	reject	not target veg
1-077	4	13	1	60.247242	-154.202444	Lake Clark	reject	not target veg
1-078	0	20	1	60.398632	-153.022313	Crescent Lake	reject	not target veg
1-079	1	6	1	60.313308	-154.303105	Kijik Lake (Lake Clark)	reject	not target veg
1-080	1	8	1	60.949742	-154.194655	Lake 21 (Telaquana River)	reject	not target veg
1-081	3	6	1	60.109498	-154.892537	Lake 423	reject	not target veg
1-082	19	5	1	60.40309	-153.799116	Lake Clark	reject	not target veg
1-083	1	6	1	60.309089	-153.98982	Lake Clark	reject	not target veg

1a. GRTS – all classes, including spruce (0-450 m): target vegetation = white spruce woodland

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
1-084	0	19	1	60.960057	-154.064651	Lake Telaquana	reject	not target veg
1-085	3	11	1	60.08835	-152.833994	Johnson River (Tuxedni Bay)	reject	not target veg
1-086	1	8	1	60.924428	-154.256132	Lake 21 (Telaquana River)	reject	not target veg
1-087	4	7	1	60.934116	-154.238437	Lake 21 (Telaquana River)	reject	not target veg
1-088	2	6	1	60.174104	-154.29748	Lake Clark	**accept**	
1-089	2	7	1	61.128215	-153.903507	Two Lakes	reject	not target veg
1-090	1	7	1	60.10322	-154.908609	Lake 423	reject	not target veg
1-091	1	7	1	60.403421	-153.847193	Lake Clark	reject	not target veg
1-092	0	19	1	60.312953	-154.207209	Lake Clark	reject	not target veg
1-093	2	6	1	60.495774	-153.967297	Lachbuna Lake	reject	access - unsafe
1-094	2	11	1	60.132923	-152.69259	Tuxedni Bay	reject	not target veg
1-095	0	19	1	60.313229	-154.202308	Lake Clark	reject	not target veg
1-096	1	7	1	60.9539	-154.031851	Lake Telaquana	reject	not target veg
1-097	3	25	1	60.364013	-152.984056	Crescent Lake	reject	not target veg
1-098	1	7	1	60.313636	-154.27532	Kijik Lake (Lake Clark)	reject	not target veg
1-099	1	7	1	60.952025	-154.012955	Lake Telaquana	reject	not target veg
1-100	1	20	1	60.415658	-153.03984	Crescent Lake	reject	not target veg
1-101	2	11	1	60.067721	-152.748184	Johnson River (Tuxedni Bay)	reject	not target veg
1-102	1	19	1	60.942858	-154.295167	Lake 21 (Telaquana River)	reject	not target veg
1-103	4	11	1	60.047611	-152.693271	Johnson River (Tuxedni Bay)	reject	not target veg
1-104	2	7	1	60.987162	-154.010188	Lake Telaquana	reject	not target veg
1-105	1	19	1	60.950147	-154.01351	Lake Telaquana	**accept**	

1b. GRTS – all classes, including spruce (450-900 m): target vegetation = white spruce woodland; dwarf shrub - low shrub tundra

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
2-001	4	23	2	60.657612	-154.217677	Snipe Lake	reject	not target veg
2-002	1	18	2	60.437421	-154.508812	Caribou Lakes	reject	not target veg
2-003	1	19	2	60.771225	-154.071456	Turquoise Lake	reject	not target veg
2-004	1	19	2	60.681318	-153.695443	Upper Twin Lake	reject	not target veg
2-005	3	19	2	60.648122	-154.046963	Lower Twin Lake	**accept**	
2-006	1	14	2	60.610311	-154.381762	Snipe Lake	**accept**	
2-007	4	12	2	60.458318	-154.347143	Fishtrap Lake	reject	not target veg
2-008	1	14	2	60.599705	-154.19805	Snipe Lake	reject	access - too far
2-009	2	7	2	60.475861	-154.301882	Fishtrap Lake	reject	not target veg
2-010	2	15	2	60.74301	-154.13875	Square Lake	reject	access - unsafe
2-011	3	14	2	60.736655	-154.265129	Square Lake	reject	access - unsafe
2-012	10	14	2	60.463429	-154.341176	Fishtrap Lake	reject	not target veg
2-013	1	14	2	60.663995	-154.249663	Snipe Lake	reject	not target veg
2-014	1	14	2	60.632625	-154.363318	Snipe Lake	**accept**	
2-015	2	19	2	60.607465	-154.210742	Snipe Lake	reject	not target veg
2-016	3	13	2	60.627736	-154.27469	Snipe Lake	**accept**	
2-017	1	14	2	60.641785	-154.218671	Snipe Lake	reject	access - too far
2-018	3	6	2	60.490093	-154.399525	Fishtrap Lake	reject	not target veg
2-019	1	16	2	60.762523	-154.19463	Square Lake	reject	not target veg
2-020	2	14	2	60.728979	-154.205465	Square Lake	reject	access - unsafe
2-021	1	15	2	60.863365	-153.79901	Lake Telaquana	reject	not target veg
2-022	2	19	2	60.604244	-154.212371	Snipe Lake	reject	access - too far
2-023	3	13	2	60.754597	-154.068658	Turquoise Lake	reject	not target veg
2-024	2	13	2	60.769788	-154.177545	Square Lake	reject	not target veg
2-025	0	25	2	60.683192	-153.693772	Upper Twin Lake	reject	not target veg
2-026	2	7	2	60.482357	-154.274558	Fishtrap Lake	*unconfirmed*	*evaluation needed (sw)*
2-027	2	8	2	60.730265	-154.239138	Square Lake	reject	access - unsafe
2-028	1	25	2	60.770353	-153.846559	Turquoise Lake	reject	not target veg
2-029	2	7	2	60.491238	-154.259294	Fishtrap Lake	reject	not target veg

1b. GRTS – all classes, including spruce (450-900 m): target vegetation = white spruce woodland; dwarf shrub - low shrub tundra

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
2-030	2	14	2	60.752415	-154.120566	Square Lake	reject	access - unsafe
2-031	2	14	2	60.741819	-154.227078	Square Lake	*unconfirmed*	*evaluation needed (ds)*
2-032	4	15	2	60.643558	-153.94293	Lower Twin Lake	reject	not target veg
2-033	1	19	2	60.761017	-154.097949	Turquoise Lake	reject	not target veg
2-034	1	15	2	60.671528	-154.237051	Snipe Lake	reject	not target veg
2-035	1	15	2	60.741123	-154.148127	Square Lake	reject	access - unsafe
2-036	1	14	2	60.444875	-154.523699	Caribou Lakes	reject	not target veg
2-037	1	19	2	60.67629	-154.028271	Lower Twin Lake	reject	not target veg
2-038	1	7	2	60.636164	-154.342997	Snipe Lake	*unconfirmed*	*evaluation needed (sw)*
2-039	1	20	2	60.478099	-154.372544	Fishtrap Lake	reject	not target veg
2-040	1	15	2	60.767719	-154.101837	Turquoise Lake	reject	not target veg
2-041	2	25	2	60.769817	-153.846561	Turquoise Lake	reject	not target veg
2-042	0	14	2	60.664498	-154.267292	Snipe Lake	**accept**	
2-043	3	15	2	60.771781	-153.999068	Turquoise Lake	reject	not target veg
2-044	1	19	2	60.462358	-154.637831	Caribou Lakes	reject	not target veg
2-045	1	14	2	60.618076	-154.276808	Snipe Lake	reject	not target veg
2-046	2	8	2	60.685936	-154.061347	Lower Twin Lake	reject	not target veg
2-047	4	15	2	60.670123	-154.019452	Lower Twin Lake	reject	not target veg
2-048	2	15	2	60.625302	-153.911057	Lower Twin Lake	**accept**	
2-049	0	15	2	60.680288	-154.088888	Lower Twin Lake	**accept**	
2-050	4	15	2	60.583382	-154.169931	Snipe Lake	reject	not target veg*
2-051	3	15	2	60.75769	-154.197915	Square Lake	*unconfirmed*	*evaluation needed (ds)*
2-052	0	14	2	60.626921	-154.279634	Snipe Lake	reject	not target veg
2-053	1	6	2	60.485838	-154.386874	Fishtrap Lake	*unconfirmed*	*evaluation needed (sw)*
2-054	1	16	2	60.784649	-154.04274	Turquoise Lake	reject	not target veg
2-055	2	19	2	60.72315	-154.1497	Square Lake	reject	access - unsafe
2-056	1	6	2	60.599139	-154.347002	Snipe Lake	reject	not target veg
2-057	1	6	2	60.635877	-154.350698	Snipe Lake	reject	not target veg
2-058	1	6	2	60.629409	-154.362181	Snipe Lake	*unconfirmed*	*evaluation needed (sw)*

1b. GRTS – all classes, including spruce (450-900 m): target vegetation = white spruce woodland; dwarf shrub - low shrub tundra

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
2-059	2	14	2	60.647458	-154.192287	Snipe Lake	reject	not target veg
2-060	3	7	2	60.458741	-154.607659	Caribou Lakes	reject	not target veg
2-061	3	16	2	60.805116	-154.229737	Square Lake	reject	not target veg
2-062	1	15	2	60.670117	-154.044241	Lower Twin Lake	reject	not target veg
2-063	2	14	2	60.758081	-154.073637	Turquoise Lake	reject	not target veg
2-064	3	20	2	60.389517	-154.549025	Caribou Lakes	reject	not target veg
2-065	1	15	2	60.765229	-154.176967	Square Lake	*unconfirmed*	*evaluation needed (ds)*
2-066	0	19	2	60.484788	-154.378646	Fishtrap Lake	reject	not target veg
2-067	1	15	2	60.755351	-154.136594	Turquoise Lake	reject	access - unsafe
2-068	1	14	2	60.618412	-154.362058	Snipe Lake	reject	not target veg
2-069	1	19	2	60.672604	-154.234856	Snipe Lake	reject	not target veg
2-070	3	20	2	60.792112	-154.120714	Turquoise Lake	reject	not target veg
2-071	1	14	2	60.450648	-154.486038	Caribou Lakes	reject	not target veg
2-072	2	16	2	60.657233	-154.066799	Lower Twin Lake	reject	not target veg
2-073	4	14	2	60.607749	-154.200298	Snipe Lake	reject	not target veg
2-074	3	19	2	60.639496	-154.294602	Snipe Lake	reject	not target veg
2-075	1	25	2	60.782706	-153.860319	Turquoise Lake	reject	not target veg
2-076	1	14	2	60.766308	-154.172	Square Lake	*unconfirmed*	*evaluation needed (ds)*
2-077	2	14	2	60.349693	-154.578902	Caribou Lakes	reject	not target veg
2-078	2	6	2	60.599614	-154.370093	Snipe Lake	reject	not target veg
2-079	3	14	2	60.593591	-154.156246	Snipe Lake	reject	access - too far
2-080	1	14	2	60.7943	-154.056577	Turquoise Lake	*unconfirmed*	*evaluation needed (ds)*
2-081	0	16	2	60.776338	-154.022832	Turquoise Lake	reject	not target veg
2-082	1	15	2	60.667152	-154.077836	Lower Twin Lake	reject	not target veg
2-083	0	14	2	60.783155	-154.208575	Square Lake	*unconfirmed*	*evaluation needed (ds)*
2-084	3	6	2	60.641234	-154.353508	Snipe Lake	*unconfirmed*	*evaluation needed (sw)*
2-085	1	25	2	60.736252	-154.183432	Square Lake	reject	access - unsafe
2-086	1	14	2	60.604005	-154.192579	Snipe Lake	reject	access - too far
2-087	1	6	2	60.449137	-154.653987	Caribou Lakes	reject	not target veg

1b. GRTS – all classes, including spruce (450-900 m): target vegetation = white spruce woodland; dwarf shrub - low shrub tundra

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
2-088	2	16	2	60.639702	-154.17518	Snipe Lake	reject	access - too far
2-089	1	19	2	60.770146	-154.082505	Turquoise Lake	reject	not target veg
2-090	2	7	2	60.597076	-154.312904	Snipe Lake	reject	not target veg
2-091	1	15	2	60.764092	-154.220605	Square Lake	reject	not target veg
2-092	2	6	2	60.48358	-154.327695	Fishtrap Lake	**accept**	

*check for suitability as treeline site in 2011

1c. GRTS – dwarf shrub tundra (> 900 m): target vegetation = dwarf shrub tundra - fellfield

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
3N-001	2	15	3	60.854235	-153.791865	Turquoise Lake	reject	access - too far
3N-002	1	25	3	60.852079	-153.785231	Turquoise Lake	reject	access - too far
3N-003	1	23	3	60.83052	-153.981904	Turquoise Lake	reject	not target veg
3N-004	2	16	3	60.808231	-154.087028	Turquoise Lake	reject	not target veg
3N-005	1	23	3	60.828904	-154.04612	Turquoise Lake	reject	not target veg
3N-006	3	17	3	60.817915	-153.992979	Turquoise Lake	**accept**	
3S-001	4	16	3	60.758358	-153.944384	Turquoise Lake	**accept**	
3S-002	3	16	3	60.753269	-154.032757	Turquoise Lake	reject	not target veg
3S-003	5	16	3	60.749506	-153.943295	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-004	3	16	3	60.568841	-154.210491	Snipe Lake	reject	access - too far
3S-005	3	14	3	60.564276	-154.213756	Snipe Lake	reject	access - too far
3S-006	3	25	3	60.749512	-154.042141	Turquoise Lake	reject	not target veg
3S-007	2	18	3	60.759692	-153.928915	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-008	5	16	3	60.752736	-153.987471	Turquoise Lake	**accept**	
3S-009	3	16	3	60.747902	-154.044348	Turquoise Lake	reject	not target veg
3S-010	2	15	3	60.738786	-154.02943	Turquoise Lake	reject	not target veg
3S-011	2	16	3	60.759166	-153.953221	Turquoise Lake	reject	not target veg
3S-012	1	15	3	60.733156	-154.015627	Turquoise Lake	reject	not target veg
3S-013	3	15	3	60.733692	-154.017283	Turquoise Lake	reject	not target veg
3S-014	5	16	3	60.737977	-154.044886	Turquoise Lake	reject	not target veg

1c. GRTS – dwarf shrub tundra (> 900 m): target vegetation = dwarf shrub tundra - fellfield

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
3S-015	3	16	3	60.753529	-153.941079	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-016	3	16	3	60.743348	-153.984714	Turquoise Lake	reject	not target veg
3S-017	4	17	3	60.733693	-153.988582	Turquoise Lake	reject	not target veg
3S-018	3	16	3	60.745226	-154.013976	Turquoise Lake	reject	not target veg
3S-019	1	16	3	60.754334	-153.942182	Turquoise Lake	reject	not target veg
3S-020	5	16	3	60.768807	-153.920607	Turquoise Lake	reject	not target veg
3S-021	4	16	3	60.754078	-153.991336	Turquoise Lake	reject	not target veg
3S-022	4	7	3	60.563997	-154.220343	Snipe Lake	reject	access - too far
3S-023	2	15	3	60.735033	-154.019491	Turquoise Lake	reject	not target veg
3S-024	4	16	3	60.754882	-153.985261	Turquoise Lake	reject	not target veg
3S-025	3	16	3	60.748172	-154.035513	Turquoise Lake	reject	not target veg
3S-026	5	16	3	60.743885	-153.985266	Turquoise Lake	reject	not target veg
3S-027	3	16	3	60.567183	-154.239583	Snipe Lake	reject	access - too far
3S-028	4	25	3	60.568863	-154.195665	Snipe Lake	reject	access - too far
3S-029	5	16	3	60.754345	-153.986365	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-030	6	16	3	60.426764	-154.558401	Caribou Lakes	**accept**	
3S-031	3	16	3	60.754074	-154.032206	Turquoise Lake	reject	not target veg
3S-032	1	15	3	60.575529	-154.22152	Snipe Lake	reject	access - too far
3S-033	4	16	3	60.747371	-154.01729	Turquoise Lake	reject	not target veg
3S-034	3	16	3	60.569126	-154.198961	Snipe Lake	reject	access - too far
3S-035	3	16	3	60.757553	-153.942176	Turquoise Lake	*reject*	*175 m from est. plot - redundant*
3S-036	2	16	3	60.747097	-154.045451	Turquoise Lake	reject	not target veg
3S-037	2	18	3	60.75326	-153.939975	Turquoise Lake	*reject*	*redundant with 3S-015*
3S-038	3	16	3	60.751396	-153.993546	Turquoise Lake	reject	not target veg
3S-039	1	16	3	60.425957	-154.558934	Caribou Lakes	reject	<100 m from est. plot
3S-040	3	17	3	60.743884	-153.983057	Turquoise Lake	reject	not target veg
3S-041	7	15	3	60.752464	-154.037174	Turquoise Lake	reject	not target veg
3S-042	4	16	3	60.757819	-153.938862	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-043	2	16	3	60.757825	-153.954327	Turquoise Lake	*unconfirmed*	*evaluation needed*

1c. GRTS – dwarf shrub tundra (> 900 m): target vegetation = dwarf shrub tundra - fellfield

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
3S-044	2	16	3	60.734496	-154.018387	Turquoise Lake	reject	not target veg
3S-045	4	16	3	60.565595	-154.226943	Snipe Lake	reject	access - too far
3S-046	15	25	3	60.34556	-154.603917	Caribou Lakes	reject	access - too far
3S-047	1	15	3	60.735837	-154.021148	Turquoise Lake	reject	not target veg
3S-048	4	25	3	60.757017	-153.945491	Turquoise Lake	reject	not target veg
3S-049	4	16	3	60.733424	-154.017283	Turquoise Lake	reject	not target veg
3S-050	2	16	3	60.746293	-154.041032	Turquoise Lake	reject	not target veg
3S-051	14	17	3	60.758899	-153.956535	Turquoise Lake	reject	not target veg
3S-052	3	16	3	60.56532	-154.231333	Snipe Lake	reject	access - too far
3S-053	3	16	3	60.758626	-153.944384	Turquoise Lake	reject	<100 m from est. plot
3S-054	3	17	3	60.751925	-154.043249	Turquoise Lake	reject	not target veg
3S-055	16	16	3	60.436575	-154.585368	Caribou Lakes	**accept**	
3S-056	8	16	3	60.758615	-153.921737	Turquoise Lake	reject	not target veg
3S-057	4	15	3	60.752194	-154.043249	Turquoise Lake	reject	not target veg
3S-058	2	16	3	60.757826	-153.955432	Turquoise Lake	reject	not target veg
3S-059	2	16	3	60.564278	-154.212109	Snipe Lake	reject	access - too far
3S-060	2	16	3	60.755948	-153.955435	Turquoise Lake	reject	not target veg
3S-061	1	16	3	60.745488	-154.042136	Turquoise Lake	reject	not target veg
3S-062	3	16	3	60.749782	-154.035515	Turquoise Lake	reject	not target veg
3S-063	5	16	3	60.746031	-154.013424	Turquoise Lake	reject	not target veg
3S-064	3	16	3	60.747099	-154.036064	Turquoise Lake	reject	not target veg
3S-065	3	24	3	60.753806	-154.032758	Turquoise Lake	reject	not target veg
3S-066	3	14	3	60.572326	-154.211612	Snipe Lake	reject	access - too far
3S-067	3	16	3	60.760239	-153.952667	Turquoise Lake	reject	not target veg
3S-068	3	16	3	60.568245	-154.245632	Snipe Lake	reject	access - too far
3S-069	17	25	3	60.605657	-153.840741	Upper Twin Lake	*reject*	*evaluation needed*
3S-070	3	25	3	60.756212	-153.943283	Turquoise Lake	reject	not target veg
3S-071	4	16	3	60.755408	-153.944942	Turquoise Lake	reject	not target veg
3S-072	2	17	3	60.742543	-153.98361	Turquoise Lake	reject	not target veg

1c. GRTS – dwarf shrub tundra (> 900 m): target vegetation = dwarf shrub tundra - fellfield

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
3S-073	2	25	3	60.757017	-153.944939	Turquoise Lake	reject	not target veg
3S-074	3	16	3	60.748977	-154.036066	Turquoise Lake	reject	not target veg
3S-075	17	25	3	60.43717	-154.571706	Caribou Lakes	**accept**	
3S-076	3	16	3	60.566114	-154.237379	Snipe Lake	reject	access - too far
3S-077	4	18	3	60.569374	-154.212691	Snipe Lake	reject	access - too far
3S-078	3	16	3	60.75809	-153.944937	Turquoise Lake	reject	<100 m from est. plot
3S-079	4	16	3	60.758094	-153.956537	Turquoise Lake	*reject*	*redundant with 3S-043*
3S-080	5	15	3	60.742271	-154.038267	Turquoise Lake	reject	not target veg
3S-081	2	16	3	60.755948	-153.953778	Turquoise Lake	reject	not target veg
3S-082	5	15	3	60.755418	-153.98526	Turquoise Lake	*reject*	*redundant with 3S-029*
3S-083	6	16	3	60.751664	-153.994098	Turquoise Lake	reject	not target veg
3S-084	2	15	3	60.747365	-154.045451	Turquoise Lake	reject	not target veg
3S-085	4	16	3	60.570192	-154.20391	Snipe Lake	reject	access - too far
3S-086	4	16	3	60.758357	-153.94107	Turquoise Lake	*reject*	*redundant with 3S-042*
3S-087	3	16	3	60.757552	-153.941624	Turquoise Lake	*reject*	*redundant with 3S-042*
3S-088	1	25	3	60.574995	-154.219868	Snipe Lake	reject	access - too far
3S-089	12	16	3	60.758363	-153.957089	Turquoise Lake	*reject*	*redundant with 3S-043*
3S-090	2	16	3	60.76184	-153.933882	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-091	1	17	3	60.75729	-153.956538	Turquoise Lake	reject	not target veg
3S-092	3	16	3	60.746834	-154.020603	Turquoise Lake	reject	not target veg
3S-093	2	16	3	60.755948	-153.955987	Turquoise Lake	*reject*	*redundant with 3S-043*
3S-094	3	16	3	60.755943	-153.942731	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-095	1	15	3	60.736373	-154.023356	Turquoise Lake	reject	not target veg
3S-096	3	16	3	60.746563	-154.036063	Turquoise Lake	reject	not target veg
3S-097	3	17	3	60.752187	-153.940529	Turquoise Lake	reject	not target veg
3S-098	2	17	3	60.756485	-153.955986	Turquoise Lake	reject	not target veg
3S-099	4	14	3	60.570457	-154.206108	Snipe Lake	reject	access - too far
3S-100	3	16	3	60.75005	-154.035515	Turquoise Lake	reject	not target veg
3S-101	6	16	3	60.761582	-153.958741	Turquoise Lake	reject	not target veg

1c. GRTS – dwarf shrub tundra (> 900 m): target vegetation = dwarf shrub tundra - fellfield

GRTS	Slope	LC	Elev Band	Latitude (NAD83)	Longitude (NAD83)	General Location	Accept/Reject	Reason
3S-102	4	16	3	60.760239	-153.953772	Turquoise Lake	reject	not target veg
3S-103	2	14	3	60.741734	-154.037714	Turquoise Lake	reject	not target veg
3S-104	2	16	3	60.751121	-154.043247	Turquoise Lake	reject	not target veg
3S-105	6	16	3	60.760508	-153.954324	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-106	4	16	3	60.564542	-154.214856	Snipe Lake	reject	access - too far
3S-107	6	16	3	60.76024	-153.955429	Turquoise Lake	*reject*	*redundant with 3S-105*
3S-108	5	16	3	60.756754	-153.958195	Turquoise Lake	*unconfirmed*	*evaluation needed*
3S-109	4	25	3	60.757768	-153.866503	Turquoise Lake	reject	not target veg
3S-110	3	15	3	60.741736	-154.031089	Turquoise Lake	reject	not target veg
3S-111	4	25	3	60.575264	-154.219321	Snipe Lake	reject	access - too far
3S-112	3	16	3	60.751928	-154.03386	Turquoise Lake	reject	not target veg
3S-113	5	14	3	60.742271	-154.037163	Turquoise Lake	reject	not target veg
3S-114	5	16	3	60.743349	-154.004038	Turquoise Lake	reject	not target veg
3S-115	1	20	3	60.747364	-154.046555	Turquoise Lake	reject	not target veg
3S-116	2	16	3	60.755407	-153.942732	Turquoise Lake	reject	not target veg
3S-117	4	16	3	60.569375	-154.211593	Snipe Lake	reject	access - too far
3S-118	1	16	3	60.563735	-154.216498	Snipe Lake	reject	access - too far
3S-119	3	16	3	60.565852	-154.234083	Snipe Lake	reject	access - too far
3S-120	4	15	3	60.743347	-154.024465	Turquoise Lake	reject	not target veg
3S-121	6	25	3	60.615942	-154.011171	Lower Twin Lake	**accept**	

Appendix 2. Within-site variance in species cover for selected vegetation types in LACL (2011). Means (± 1 SE) are shown for a subset of species in each growth form. Cover is estimated by point-intercept along 30-m transects. Total cover >100% is due to layering within vegetation type. Cover by height class is shown only for white spruce (*Picea glauca*), but was recorded for all species. Species with high constancy in cover (CV ≤35%) are indicated in boldface.

2a. Low elevation (0-450 m) mature closed spruce

	Site ID					
Vascular species	**01-S93**	**01-S95**	**01-S96**	**01-S97**	**01-S98**	**01-S99**
Tree						
Picea glauca (<0.5 m)	0.0	0.6 (0.6)	1.1 (0.6)	3.4 (2.0)	0.0	1.7 (1.7)
P. glauca (0.5-1.0 m)	2.3 (1.5)	0.0	1.1 (1.1)	0.0	0.6 (0.6)	**2.8 (0.6)**
P. glauca (>1.0-4.0 m)	**24.4 (7.3)**	**10.2 (3.0)**	**07.9 (2.5)**	13.6 (8.4)	13.0 (5.4)	**22.6 (7.5)**
P. glauca (>4.0 m)	22.2 (8.3)	22.0 (8.4)	**21.5 (3.1)**	6.8 (4.5)	22.0 (11.0)	**36.2 (11.8)**
Betula neoalaskana (>1.0 m)	0.0	0.0	10.2 (4.5)	4.5 (4.5)	0.0	0.0
Populus trichocarpa (>1.0 m)	**18.8 (2.7)**	5.1 (5.1)	0.0	0.0	1.1 (1.1)	2.3 (2.3)
Shrub						
Alnus viridis ssp. *sinuata*	0.0	0.0	0.0	**4.5 (0.6)**	0.0	0.0
Betula nana	0.0	0.0	0.0	0.0	0.0	0.0
Cornus suecica	0.0	23.2 (8.0)	0.0	0.0	**16.4 (5.7)**	**12.4 (4.1)**
Ledum palustre ssp. *decumbens*	0.0	0.0	**14.7 (4.1)**	0.0	0.0	0.0
Salix barclayi	0.0	0.0	0.0	0.0	0.0	0.0
Salix bebbiana	0.0	0.0	0.0	0.0	0.0	0.0
Salix glauca	0.0	0.0	0.0	0.0	0.0	**1.1 (1.1)**
Salix pulchra	0.0	0.6 (0.6)	0.0	0.0	0.6 (0.6)	0.0
Spiraea stevenii	0.0	0.0	0.6 (0.6)	0.0	0.0	0.0
Vaccinium uliginosum	0.0	0.0	0.0	0.0	0.6 (0.6)	5.1 (2.0)
Dwarf shrub						
Arctostaphylos alpina	0.0	0.0	0.0	0.0	0.0	0.0
Diapensia lapponica	0.0	0.0	0.0	0.0	0.0	0.0
Dryas octapetala	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum nigrum	6.2 (6.2)	0.0	4.0 (2.0)	4.5 (3.0)	14.7 (7.9)	**5.6 (0.6)**
Louisleuria procumbens	0.0	0.0	0.0	0.0	0.0	0.0
Salix arctica	0.0	0.0	0.0	0.0	0.0	0.0
Salix reticulata	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea	0.0	0.0	**24.3 (2.5)**	1.1 (1.1)	2.8 (2.0)	19.2 (7.6)
Graminoid						
Calamagrostis canadensis	7.3 (4.8)	**45.8 (1.0)**	1.7 (1.0)	**21.5 (6.4)**	**10.2 (2.9)**	5.1 (1.7)
Carex lugens	0.0	0.0	0.0	0.0	0.0	0.0

Carex microchaeta	0.0	0.0	0.0	0.0	0.0	0.0
Festuca altaica	0.0	0.0	0.0	0.0	0.0	0.0

2a. Low elevation (0-450 m) mature closed spruce

	Site ID					
Vascular species	**01-S93**	**01-S95**	**01-S96**	**01-S1297**	**01-S98**	**01-S99**
Anthoxanthum montícola ssp. *alpinum*	0..0	0.0	0.0	0.0	0.0	0.0
Trisetum spicatum	0.0	0.0	0.0	0.0	0.0	0.0
Forb						
Artemisia arctica ssp. *arctica*	0.0	0.0	0.0	0.0	0.0	0.0
Arnica frigida	0.0	0.0	0.0	0.0	0.0	0.0
Campanula uniflora	0.0	0.0	0.0	0.0	0.0	0.0
Lichen	0.0	0.0	0.6 (0.6)	0.0	7.9 (4.0)	1.1 (0.6)
Moss	44.6 (0.6)	**63.3 (7.8)**	**58.8 (8.2)**	**31.1 (3.1)**	**74.0 (8.8)**	**81.9 (2.8)**

2b. Low elevation (0-450 m) spruce woodland

	Site ID										
Vascular species	**01-009**	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-038**	**01-051**	**01-088**	**01-105**	**01-S94**
Tree											
Picea glauca (<0.5 m)	0.0	2.3 (1.5)	1.1 (1.1)	0.6 (0.6)	0.0	0.0	0.0	0.0	0.0	0.0	1.1 (1.1)
P. glauca (0.5-1.0 m)	0.0	**5.1 (1.0)**	3.4 (1.7)	1.7 (1.0)	2.3 (1.5)	4.0 (2.0)	0.6 (0.6)	0.0	0.0	4.0 (2.3)	6.2 (2.5)
P. glauca (>1.0-4.0 m)	0.0	6.2 (3.1)	6.3 (2.4)	2.8 (2.0)	1.1 (1.1)	2.3 (1.5)	0.6 (0.6)	0.0	0.0	10.7 (3.7)	11.3 (5.4)
P. glauca (>4.0 m)	0.0	0.0	3.4 (1.7)	0.0	1.1 (1.1)	0.6 (0.6)	1.1 (1.1)	0.0	0.0	3.4 (2.0)	4.0 (4.0)
Betula neoalaskana (<0.5 m)	0.0	**2.3 (0.6)**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B. neoalaskana (0.5-1.0 m)	0.0	**5.1 (1.0)**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B. neoalaskana (>1.0-4.0 m)	0.0	0.6 (0.6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B. neoalaskana (>4.0 m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrub											
Alnus viridis ssp. *sinuata*	0.0	0.0	0.0	0.0	0.0	0.0		0.0			
Betula nana	11.9 (5.1)	1.7 (1.0)	**11.3 (0.6)**	7.3 (4.1)	5.6 (3.0)	5.1 (3.4)	**10.2 (2.6)**	**28.2 (6.5)**	4.0 (1.1)	**16.9 (1.0)**	0.0
Cornus suecica	0.0	0.0	1.1 (0.6)	0.0	0.0	0.0	**5.1 (1.0)**	0.0	0.0	0.0	0.0
Ledum palustre ssp. *decumbens*	41.2 (19.9)	**37.3 (9.0)**	**47.5 (8.7)**	**61.0 (5.9)**	**43.5 (6.3)**	**23.7 (7.8)**	**49.2 (6.0)**	**34.5 (11.3)**	**51.4 (4.1)**	**32.2 (5.2)**	**26.0 (7.4)**
Salix barclayi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix bebbiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix glauca	0.6 (0.6)	0.0	0.0	0.0	0.0	0.6 (0.6)	0.0	0.0	0.6 (0.6)	0.0	0.0
Salix pulchra	0.0	0.6 (0.6)	0.6 (0.6)	0.0	0.0	0.6 (0.6)	0.6 (0.6)	0.0	0.0	3.4 (2.0)	0.0
Spiraea stevenii	1.7 (1.0)	0.0	0.6 (0.6)	0.0	0.0	0.0	1.1 (0.6)	1.1 (0.6)	0.0	0.0	0.6 (0.6)
Therorhodion camtschaticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium uliginosum	15.3 (7.8)	19.8 (8.1)	**5.1 (1.0)**	**15.3 (5.1)**	**18.6 (1.7)**	**19.8 (4.4)**	**33.9 (2.6)**	9.6 (3.4)	**7.9 (1.1)**	**10.7 (3.4)**	7.9 (7.1)

2b. Low elevation (0-450 m) spruce woodland

	Site ID										
Vascular species	**01-009**	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Dwarf shrub											
Arctostaphylos alpina	1.1 (0.6)	8.5 (4.9)	0.0	0.0	7.9 (4.9)	0.6 (0.6)	0.0	0.0	0.0	0.0	0.0
Diapensia lapponica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dryas octapetala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum nigrum	22.0 (11.1)	**41.8 (4.8)**	16.9 (8.7)	4.5 (4.5)	**30.5 (3.9)**	0.0	**59.9 (2.0)**	0.0	13.0 (6.0)	0.0	2.3 (1.5)
Louisleuria procumbens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix arctica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix reticulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea	16.9 (9.3)	**22.0 (3.5)**	**25.4 (12.9)**	**14.7 (1.5)**	**23.7 (8.4)**	**14.7 (3.0)**	**22.0 (5.2)**	**27.1 (9.3)**	**15.3 (0.0)**	**24.3 (2.0)**	**5.1 (1.7)**
Graminoid											
Calamagrostis canadensis	0.0	0.0	1.1 (1.1)	3.4 (2.0)	0.0	0.0	1.1 (1.1)	3.4 (2.0)	0.0	**4.0 (1.1)**	1.1 (0.6)
Carex lugens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex microchaeta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Festuca altaica	27.7 (27.7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anthoxanthum montícola ssp. *alpinum*	11.3 (11.3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trisetum spicatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forb											
Artemisia arctica ssp. *arctica*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arnica frigida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campanula uniflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lichen	31.6 (16.9)	**76.3 (8.0)**	**27.1 (6.4)**	**26.0 (5.0)**	**84.2 (1.1)**	16.4 (6.9)	41.2 (16.8)	**40.7 (10.6)**	**46.3 (4.6)**	**41.2 (12.5)**	**33.9 (10.4)**
Moss	26.0 (13.3)	4.0 (2.3)	**73.4 (1.1)**	**91.0 (2.5)**	11.9 (5.4)	**74.0 (5.9)**	**45.8 (2.6)**	**68.4 (8.9)**	**58.8 (11.7)**	**65.5 (4.8)**	**74.0 (8.3)**

2c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
Vascular species	**02-005**	**02-017**	**02-014**	**02-048**	**02-005**	**02-092**
Tree						
Picea glauca (<0.5 m)	3.4 (2.0)	**1.7 (0.0)**	5.1 (2.0)	4.5 (3.0)	**7.3 (2.3)**	**3.4 (1.0)**
P. glauca (0.5-1.0 m)	8.5 (1.0)	0.0	5.6 (2.5)	2.8 (2.0)	**10.2 (2.6)**	3.4 (2.0)
P. glauca (>1.0-4.0 m)	**9.0 (3.1)**	2.3 (1.1)	**4.0 (0.6)**	4.0 (3.1)	**9.0 (1.1)**	7.9 (4.4)
P. glauca (>4.0 m)	6.2 (3.4)	0.6 (0.6)	1.1 (1.1)	0.6 (0.6)	**2.8 (0.6)**	6.3 (3.1)

2c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
Vascular species	**02-005**	**02-017**	**02-014**	**02-048**	**02-005**	**02-092**
Shrub						
Alnus viridis ssp. *sinuata*	0.0	0.0	0.0	0.0	0.0	0.0
Betula nana	**10.7 (3.1)**	15.3 (7.4)	**10.2 (1.0)**	16.9 (7.8)	**15.8 (5.0)**	**16.9 (2.9)**
Cornus suecica	0.0	0.0	0.0	0.0	0.0	0.0
Ledum palustre ssp. *decumbens*	17.5 (8.0)	**22.0 (5.4)**	**14.7 (3.0)**	11.3 (8.8)	**32.8 (6.0)**	**51.4 (4.0)**
Salix barclayi	0.0	0.0	0.0	0.0	0.0	0.0
Salix bebbiana	0.0	0.0	0.0	0.0	0.0	0.0
Salix glauca	0.0	0.0	0.0	**2.3 (0.6)**	**1.1 (0.6)**	0.0
Salix pulchra	0.0	0.0	0.0	0.0	0.0	0.0
Spiraea stevenii	0.0	0.6 (0.6)	0.0	0.0	0.0	0.0
Therorhodion camtschaticum	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium uliginosum	**19.8 (3.1)**	**29.9 (9.9)**	**18.1 (3.4)**	12.4 (10.0)	**33.3 (2.5)**	**18.1 (1.1)**
Dwarf shrub						
Arctostaphylos alpina	2.3 (1.5)	0.0	0.0	0.0	0.6 (0.6)	0.0
Diapensia lapponica	0.0	0.0	0.0	0.0	0.0	0.0
Dryas octapetala	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum nigrum	**28.2 (7.5)**	**35.0 (9.8)**	**40.1 (4.4)**	**17.5 (6.0)**	**20.3 (6.8)**	**48.0 (4.0)**
Louisleuria procumbens	0.0	0.0	0.0	0.0	0.0	0.0
Salix arctica	0.0	0.0	0.0	0.0	0.0	0.0
Salix reticulata	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea	**11.3 (4.0)**	**8.5 (2.9)**	**13.0 (3.0)**	4.5 (4.5)	**14.7 (3.4)**	**10.2 (2.6)**
Graminoid						
Calamagrostis canadensis	0.0	0.0	0.0	0.0	0.0	**1.7 (0.0)**
Carex lugens	0.0	0.0	0.0	0.0	0.0	0.0
Carex microchaeta	0.0	0.0	0.0	0.0	0.0	0.0
Festuca altaica	1.7 (1.7)	0.0	0.0	**15.8 (1.5)**	0.0	0.0
Anthoxanthum monticola spp. *alpinum*	1.7 (1.0)	1.1 (1.1)	0.0	5.1 (3.5)	2.8 (1.5)	0.0
Trisetum spicatum	0.0	0.0	0.0	0.0	0.0	0.0

2c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
Vascular species	**07-02-005**	**02-017**	**02-014**	**02-048**	**08-02-005**	**02-092**
Forb						
Artemisia arctica ssp. *arctica*	0.0	0.0	0.0	0.0	0.0	0.0
Arnica frigida	0.0	0.0	0.0	0.0	0.0	0.0
Campanula uniflora	0.0	0.0	0.0	0.0	0.0	0.0
Lichen	**65.0 (8.9)**	**46.9 (5.9)**	**41.2 (4.0)**	**77.4 (8.9)**	**52.0 (5.4)**	**60.5 (7.8)**
Moss	**72.9 (9.0)**	**66.1 (6.0)**	**62.7 (3.4)**	**58.8 (11.3)**	**52.0 (7.3)**	**45.2 (1.5)**

2d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID						
Vascular species	**02-002**	**07-02-006**	**08-02-006**	**02-049**	**02-042-2**	**02-016**	**02-099**
Tree							
Picea glauca (<0.5 m)	0.0	0.6 (0.6)	0.6 (0.6)	0.0	0.0	0.0	0.0
P. glauca (0.5-1.0 m)	0.0	0.6 (0.6)	2.3 (2.3)	0.0	0.0	0.0	0.0
P. glauca (>1.0-4.0 m)	0.0	0.6 (0.6)	3.4 (2.6)	0.0	0.0	0.0	0.0
P. glauca (>4.0 m)	0.0	0.0	0.6 (0.6)	0.0	0.0	0.0	0.0
Shrub							
Alnus viridis ssp. *sinuata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula nana	1.7 (1.0)	1.1 (0.6)	**14.1 (2.0)**	**61.6 (1.5)**	3.4 (1.7)	2.8 (2.0)	0.0
Cornus suecica	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ledum palustre ssp. *decumbens*	**26.6 (3.1)**	**22.6 (4.6)**	**36.2 (17.6)**	0.0	12.4 (4.9)	**22.6 (3.1)**	**17.5 (3.4)**
Salix barclayi	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix bebbiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix glauca	0.0	0.0	0.0	1.1 (0.6)	0.0	0.6 (0.6)	0.6 (0.6)
Salix pulchra	1.7 (1.0)	0.6 (0.6)	0.0	0.0	0.0	0.0	0.0
Spiraea stevenii	0.0	0.6 (0.6)	0.0	0.0	0.0	0.6 (0.6)	0.0
Therorhodion camtschaticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium uliginosum	**18.6 (3.9)**	19.8 (8.1)	**19.2 (0.6)**	0.0	**39.5 (3.4)**	**30.5 (2.9)**	**41.2 (0.6)**

2d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID						
Vascular species	**02-002**	**07-02-006**	**08-02-006**	**02-049**	**02-042-2**	**02-016**	**02-099**
Dwarf shrub							
Arctostaphylos alpina	**6.8 (1.0)**	0.6 (0.6)	8.5 (8.5)	0.0	0.0	0.6 (0.6)	2.3 (2.3)
Diapensia lapponica	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dryas octapetala	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum nigrum	1.7 (1.0)	**46.3 (4.8)**	7.9 (3.4)	0.0	**51.4 (2.0)**	1.1 (0.6)	**18.6 (6.0)**
Louisleuria procumbens	0.0	3.4 (2.0)	0.0	0.0	1.1 (0.6)	0.0	1.1 (0.6)
Salix arctica	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix reticulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea	**34.5 (2.3)**	**13.6 (3.5)**	**20.9 (3.1)**	**2.8 (0.6)**	**9.0 (2.8)**	5.1 (3.4)	**18.6 (4.5)**
Graminoid							
Calamagrostis canadensis	0.0	0.0	0.0	2.8 (2.8)	0.0	0.0	0.6 (0.6)
Carex lugens	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex microchaeta	0.0	0.0	0.0	**9.0 (1.1)**	0.0	0.0	0.0
Festuca altaica	1.7 (1.7)	0.0	**5.1 (1.7)**	**10.2 (2.9)**	0.0	0.0	0.0
Anthoxanthum monticola ssp. *alpinum*	6.8 (2.6)	3.4 (1.0)	0.6 (0.6)	2.8 (2.8)	0.0	**15.8 (2.5)**	2.3 (1.5)
Trisetum spicatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forb							
Artemisia arctica ssp. *arctica*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arnica frigida	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campanula uniflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lichen	**78.5 (1.5)**	**29.4 (3.4)**	**50.8 (9.3)**	**63.8 (4.9)**	41.8 (16.1)	**34.5 (11.3)**	**67.8 (6.4)**
Moss	**26.6 (2.0)**	**41.2 (4.0)**	**52.5 (4.5)**	**90.4 (1.1)**	14.7 (6.5)	**36.7 (4.4)**	**20.9 (6.9)**

2e. High-elevation (>900 m) dwarf shrub tundra

		Site ID						
Vascular species		**03N-006**	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Tree								
Picea glauca (<0.5 m)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. glauca (0.5-1.0 m)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. glauca (>1.0-4.0 m)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. glauca (>4.0 m)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrub								
Alnus viridis ssp. *sinuata*		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula nana		1.1 (1.1)	0.0	0.0	0.0	0.0	0.6 (0.6)	0.0
Cornus suecica		0.0	0.0	0.0	0.0	0.0	0.0	0.6 (0.6)
Ledum palustre ssp. *decumbens*		1.1 (1.1)	0.0	0.6 (0.6)	**4.0 (1.1)**	0.0	**6.8 (1.7)**	5.1 (2.0)
Salix barclayi		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix bebbiana		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix glauca		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix pulchra		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiraea stevenii		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Therorhodion camtschaticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Vaccinium uliginosum		0.6 (0.6)	0.0	2.8 (1.5)	**9.6 (3.1)**	0.0	**21.5 (6.2)**	**19.2 (4.9)**
Dwarf shrub								
Arctostaphylos alpina		0.0	0.0	0.0	1.1 (1.1)	0.0	1.1 (1.1)	1.7 (1.0)
Diapensia lapponica		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dryas octapetala		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empetrum nigrum		**5.6 (1.5)**	0.0	0.0	4.0 (1.5)	0.0	6.8 (4.3)	2.3 (1.5)
Louisleuria procumbens		**13.6 (2.9)**	2.8 (2.0)	1.1 (1.1)	**23.2 (1.1)**	0.0	0.0	11.3 (4.5)
Salix arctica		0.0	0.0	1.7 (1.0)	0.0	**3.4 (1.0)**	0.0	0.0
Salix reticulata		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea		2.8 (1.1)	1.1 (1.1)	**1.1 (0.6)**	2.3 (1.5)	0.0	1.7 (1.0)	0.6 (0.6)

2e. High-elevation (>900 m) dwarf shrub tundra

	Site ID						
Vascular species	**03N-006**	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Graminoid							
Calamagrostis canadensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex lugens	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex microchaeta	3.4 (2.0)	**7.9 (1.5)**	2.8 (1.5)	**3.4 (0.0)**	1.1 (0.6)	6.2 (3.0)	4.5 (2.5)
Festuca altaica	0.6 (0.6)	0.0	0.6 (0.6)	0.0	0.0	0.0	0.0
Anthoxanthum monticola ssp. *alpinum*	**2.8 (0.6)**	1.1 (0.6)	0.6 (0.6)	1.7 (1.7)	1.1 (0.6)	2.8 (2.8)	**1.7 (0.0)**
Trisetum spicatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forb							
Artemisia arctica ssp. arctica	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arnica frigida	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campanula uniflora	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lichen	**63.8 (5.0)**	**55.4 (5.4)**	**34.5 (3.0)**	**90.4 (1.5)**	**57.1 (2.8)**	**63.8 (6.9)**	**83.1 (2.0)**
Moss	2.8 (2.0)	**3.4 (1.0)**	**1.7 (0.0)**	4.0 (3.1)	6.2 (2.8)	2.3 (1.5)	0.6 (0.6)

Appendix 3. Within-site estimates of frequency for vascular and nonvascular species in Lake Clark National Park and Preserve, sampled in 2010. Frequencies were measured in 4-m^2 quadrats (n = 15) and are expressed as percent occurrence across quadrats, within a site (e.g., 1.00 = 100% occurrence). † indicates species with ≥ 20% frequency across all sites within an elevation × vegetation class combination. ‡ indicates species with ≤ 1% frequency across all sites in an elevation × vegetation class combination.

3a. Low elevation (0-450 m) mature closed spruce

	Site ID					
	01-S93	**01-S95**	**01-S96**	**01-S97**	**01-S98**	**01-S99**
Vascular species						
Aconitum delphiniifolium DC.		0.07			0.07	
Alnus incana (L.) Moench	0.20					
Alnus viridis (Chaix) DC. subsp. *sinuata* (Regel) A. Löve & D. Löve				0.67		
Anemone richardsonii Hook. ‡						0.07
Artemisia tilesii Ledeb.					0.07	0.47
Aster alpinus L.					0.20	
Betula nana L.					0.13	
Betula neoalaskana Sarg.			0.33	0.07		
Calamagrostis canadensis (Michx.) P. Beauv. †	1.00	1.00	0.60	0.93	0.87	0.93
Chamerion angustifolium (L.) Holub †		1.00	0.20	0.47	0.67	0.13
Chamerion latifolium (L.) Holub						0.20
Cornus suecica L. †		1.00		0.33	1.00	1.00
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy		0.13				
Empetrum nigrum L. †	0.27		0.33	0.27	0.40	0.80
Equisetum arvense L. †		1.00	0.53		0.27	1.00
Equisetum sylvaticum L.			0.20			
Festuca altaica Trin.					0.33	
Geocaulon lividum (Richardson) Fernald ‡			0.07			
Goodyera repens (L.) R. Br.	0.07		0.27		0.07	0.27
Gymnocarpium dryopteris (L.) Newman †		1.00		1.00		
Hedysarum alpinum L.						0.13

3a. Low elevation (0-450 m) mature closed spruce

	Site ID					
	01-S93	**01-S95**	**01-S96**	**01-S97**	**01-S98**	**01-S99**
Hierochlöe alpina = Anthoxanthum monticola ssp. alpinum (Sw. ex Willd.) Soreng ‡					0.07	
Huperzia selago (L.) Bernh. ex Schrank & Mart.	0.13					
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén			0.87			0.07
Linnaea borealis L. †	0.93	0.87	1.00	1.00	0.80	1.00
Lycopodium annotinum L.		0.07				0.07
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen‡			0.07			
Moneses uniflora (L.) A. Gray					0.13	0.07
Orthilia secunda (L.) House †	0.07		0.13	0.20	0.67	0.73
Petasites frigidus (L.) Fr. ‡					0.07	
Picea glauca (Moench) Voss †	0.53	0.20	0.33	0.60	0.40	0.87
Populus balsamifera L.	0.27	0.13		0.07	0.20	0.13
Pyrola grandiflora Radius	0.20	0.13		0.07	0.60	
Rhodiola integrifolia Raf. ‡						0.07
Ribes triste Pall. †	0.13	0.47	0.13	0.47		
Rosa acicularis Lindl. †	0.33	0.93	1.00		0.33	0.80
Rubus arcticus L. †		0.47			0.60	0.27
Rubus arcticus L. subsp. *arcticus* †		0.47			0.60	0.27
Rubus pedatus Sm.				0.27		
Salix glauca L. ‡						0.07
Salix pulchra Cham.		0.33			0.27	0.33
Salix reticulata L.						0.13
Saussurea angustifolia (Willd.) DC.						0.13
Solidago multiradiata Aiton					0.13	
Sorbus scopulina Greene‡	0.07					
Spiraea stevenii (C.K. Schneid.) Rydb. ‡		0.07				
Trientalis europaea L. subsp. *arctica* (Fisch. ex Hook.) Hultén †	0.40	0.20	0.60	0.93		
Vaccinium uliginosum L.					0.07	0.73
Vaccinium vitis-idaea L. †	0.07	0.47	1.00	0.13	0.87	1.00
Viburnum edule (Michx.) Raf. †	0.80	0.47		0.13		

3a. Low elevation (0-450 m) mature closed spruce

	Site ID					
	01-S93	**01-S95**	**01-S96**	**01-S97**	**01-S98**	**01-S99**
Lichens						
Cetraria islandica (L.) Ach. ssp. *crispiformis* (Rasanen) Karnefelt					0.07	
Cladonia cenotea (Ach.) Schaerer					0.07	
Cladonia arbuscula subsp. *beringiana* Ahti		0.07				
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.		0.07	0.13		0.27	0.13
Cladonia cornuta (L.) Hoffm. ssp. *cornuta*					0.13	0.20
Cladonia crispata (Ach.) Flotow var. *crispata*					0.13	
Cladonia cyanipes (Sommerf.) Nyl.			0.13			
Cladonia furcata (Huds.) Schrad.					0.33	0.07
Cladonia gracilis (L.) Willd. ssp. *elongata* (Jacq.) Vain.					0.07	
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti	0.07		0.07		0.07	
Cladonia gracilis (L.) Willd. ssp. *vulnerata* Ahti					0.07	
Cladonia pleurota (Flörke) Schaerer						0.07
Cladonia rangiferina (L.) F.H. Wigg.					0.13	
Cladonia scabriuscula (Delise) Nyl.					0.07	0.07
Cladina stygia (Fr.) Ahti					0.07	
Cladonia subulata (L.) F.H. Wigg.						0.13
Cladonia sulphurina (Michx.) Fr.					0.13	
Cladonia umbricola Tønsberg & Ahti		0.20	0.13			
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell					0.13	
Hypogymnia austerodes (Nyl.) Rasanen					0.07	
Hypogymnia bitteri (Lynge) Ahti			0.07			0.07
Hypogymnia physodes (L.) Nyl.					0.07	
Lobaria linita (Ach.) Rabenh.					0.13	
Nephroma bellum (Spreng.) Tuck.		0.07				
Nephroma parile (Ach.) Ach.					0.07	
Parmelia sulcata Taylor			0.07	0.07		
Parmeliopsis ambigua (Wulfen) Nyl.			0.07			
Peltigera aphthosa (L.) Willd.					0.07	0.13

3a. Low elevation (0-450 m) mature closed spruce

	Site ID					
	01-S93	01-S95	01-S96	01-S97	01-S98	01-S99
Peltigera canina (L.) Willd.					0.20	
Peltigera horizontalis (Huds.) Baumg.		0.07				
Peltigera leucophlebia (Nyl.) Gyel.	0.07		0.07		0.53	0.07
Peltigera malacea (Ach.) Funck					0.07	
Peltigera polydactylon (Neck.) Hoffm.		0.07				0.07
Peltigera praetextata (Flörke ex Sommerf.) Zopf		0.20				0.13
Tuckermannopsis sepincola (Ehrh.) Hale					0.07	
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai					0.20	0.33
Bryophytes						
Aulacomnium palustre (Hedw.) Schwägr.	0.07	0.07	0.20		0.33	0.20
Aulacomnium turgidum (Wahlenb.) Schwägr.					0.07	
Brachythecium erythrorrhizon Schimp.	0.47	0.60				
Brachythecium nelsonii Grout	0.07			0.40		
Brachythecium oedipodium (Mitt.) A. Jaeger		0.07				
Brachythecium salebrosum (F. Weber & D. Mohr) Schimp.			0.33			0.20
Campylophyllum sommerfeltii (Myrin) Hedenäs		0.07				
Ceratodon purpureus (Hedw.) Brid. var. *purpureus*			0.07			
Dichodontium pellucidum (Hedw.) Schimp.			0.07			
Dicranum fragilifolium Lindb.		0.07				0.07
Dicranum polysetum Sw.			0.53			0.07
Dicranum scoparium Hedw.		0.13			0.13	0.40
Dicranum tauricum Sapeh.		0.07	0.07		0.13	0.07
Dicranum undulatum Brid.	0.27	0.07				
Eurhynchiastrum pulchellum (Hedwig) Ignatov & Huttunen var. *pulchellum*	0.07	0.07				
Hylocomium splendens (Hedw.) Schimp. †	0.93	1.00	1.00	1.00	1.00	1.00
Hypnum plicatulum (Lindb.) A. Jaeger				0.07		0.07
Plagiomnium medium (Bruch & Schimp.) T. Kop.		0.07		0.33		0.13
Plagiothecium laetum Schimp.			0.07			
Pleurozium schreberi (Brid.) Mitt. †	0.20		0.80		0.27	

3a. Low elevation (0-450 m) mature closed spruce

	Site ID					
	01-S93	**01-S95**	**01-S96**	**01-S97**	**01-S98**	**01-S99**
Pohlia cruda (Hedw.) Lindb.			0.07			0.07
Pohlia nutans (Hedw.) Lindb.		0.07				
Pohlia proligera (Kindb. ex Breidl.) Lindb. ex Arnell						0.07
Polytrichum commune Hedw. var. *commune*			0.20	0.40	0.20	0.07
Polytrichum juniperinum Hedw.		0.07	0.07		0.33	
Polytrichum piliferum Hedw.						0.07
Polytrichum strictum Brid.					0.07	
Ptilidium ciliare (L.) Hampe	0.13	0.27	0.20		0.53	
Ptilium crista-castrensis (Hedw.) De Not. †	0.27	0.80	0.07	0.80	0.60	0.80
Rhizomnium pseudopunctatum (Bruch & Schimp.) T. Kop.						0.07
Rhytidiadelphus triquetrus (Hedw.) Warnst.	0.47	0.07	0.07		0.07	0.27
Rhytidium rugosum (Hedw.) Kindb.						0.07
Sanionia uncinata (Hedw.) Loeske	0.20	0.20	0.13	0.07	0.07	0.20
Schistostega pennata (Hedw.) F. Weber & D. Mohr.						0.07
Sphagnum girgensohnii Russow		0.07	0.07			
Timmia austriaca Hedw.	0.07	0.07		0.07		

3b. Low elevation (0-450 m) spruce woodland

	Site ID										
	01-009	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Vascular species											
Arctostaphylos alpina (L.) Spreng.	0.27	0.33			0.53	0.53					
Betula nana L. †	0.87	0.33	0.93	1.00	0.53	1.00	0.93	1.00	0.20	1.00	1.00
Betula nana L. x *Betula neoalaskana* Sarg.		0.20			0.20	0.27			0.07		
Betula neoalaskana Sarg.		0.07							0.20		
Calamagrostis canadensis (Michx.) P. Beauv. †	0.60		0.73	0.87			0.73	0.47	0.40	0.80	0.93
Campanula lasiocarpa Cham.										0.27	
Carex lugens T. Holm	0.33			0.20				0.93	0.13	0.33	
Chamerion angustifolium (L.) Holub	0.07	0.13	0.07								0.07

3b. Low elevation (0-450 m) spruce woodland

	Site ID										
	01-009	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Cornus suecica L.			0.67	0.07			1.00				0.13
Empetrum nigrum L. †	1.00	1.00	1.00	0.33	0.80		1.00		0.73	0.07	0.20
Equisetum sylvaticum L.									0.20		
Festuca altaica Trin.		0.20			0.07	0.13					
Geocaulon lividum (Richardson) Fernald						0.07			0.13		
Hierochlöe alpina (Sw. ex Willd.) Roem. & Schult.		0.07		0.07				0.27		0.07	0.13
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén †	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	1.00	0.87	0.87
Loiseleuria procumbens (L.) Desv. ‡				0.07							
Lupinus nootkatensis Donn ex Sims		0.67									
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen							0.07			0.13	
Orthilia secunda (L.) House‡							0.07				
Pedicularis labradorica Wirsing ‡						0.07					
Petasites frigidus (L.) Fr. ‡											0.13
Picea glauca (Moench) Voss		0.27	0.13	0.07	0.07	0.47	0.13		0.07	0.20	0.33
Picea mariana (Mill.) Britton, Sterns & Poggenb.						0.60			0.13	0.07	
Rosa acicularis Lindl. ‡									0.07		
Rubus chamaemorus L. †	0.20		0.60					0.73	0.13		0.53
Salix glauca L.	0.13	0.20			0.13	0.13			0.53		
Salix pulchra Cham.			0.27	0.07			0.27			0.53	
Spiraea stevenii (C.K. Schneid.) Rydb.	0.87		0.27	0.07			0.67	0.13	0.07		0.07
Vaccinium oxycoccos L.			0.07	0.07			0.07		0.07		
Vaccinium uliginosum L. †	1.00	0.93	0.60	0.80	0.93	1.00	0.93	0.60	1.00	0.67	0.73
Vaccinium vitis-idaea L. †	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67	1.00
Lichens											
Baeomyces placophyllus Ach. ‡						0.07					
Cetraria islandica (L.) Ach. subsp. *crispiformis* (Rasanen) Karnefelt †	0.67	0.53	0.33	0.13	0.33	0.40	0.73		0.40	0.13	0.13
Cetraria laevigata Rass. †	0.53	0.33	0.13	0.33	0.87			0.20	0.13	0.27	0.47
Cladonia amaurocraea (Flörke) Schaerer †		0.13			0.40	0.20		0.67		0.73	0.13

3b. Low elevation (0-450 m) spruce woodland

	Site ID										
	01-009	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Cladonia arbuscula subsp. *beringiana* Ahti †	0.80	0.93	0.87	0.53	1.00	1.00	0.67	0.47	0.87	0.80	0.60
Cladonia borealis S. Stenroos						0.13					
Cladonia carneola (Fr.) Fr.		0.07			0.07	0.07					
Cladonia cenotea (Ach.) Schaerer			0.07	0.07		0.33				0.20	
Cladonia cervicornis (Ach.) Flotow subsp. *verticillata* (Hoffm.) Ahti						0.13					
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.	0.20	0.13	0.33	0.20		0.47	0.13	0.07		0.07	0.20
Cladonia cornuta (L.) Hoffm. subsp. *cornuta* †	0.07	0.13	0.20	0.40	0.20	0.67	0.13	0.20	0.20	0.47	0.20
Cladonia crispata (Ach.) Flotow var. *crispata* †	0.13	0.33		0.07	0.33	0.73	0.20	0.07	0.13	0.20	0.07
Cladonia cyanipes (Sommerf.) Nyl.		0.07	0.07	0.07		0.33					
Cladonia deformis (L.) Hoffm.	0.07		0.20			0.47		0.07		0.07	
Cladonia furcata (Huds.) Schrad.		0.27				0.20			0.13		
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti			0.07	0.07		0.53				0.13	0.07
Cladonia gracilis (L.) Willd. subsp. *vulnerata* Ahti †	1.00	0.93	0.87	0.33	0.87	0.33	0.93	0.73	0.73	0.93	0.87
Cladonia macilenta Hoffm. ‡						0.07					
Cladonia macrophylla (Schaerer) Stenh.						0.27					
Cladonia nipponica Asah. ‡					0.07						
Cladonia phyllophora Hoffm.	0.07					0.27					
Cladonia pleurota (Flörke) Schaerer	0.07					0.33					
Cladonia pyxidata (L.) Hoffm.						0.20					
Cladonia rangiferina (L.) F. H. Wigg.				0.07		0.07	0.27			0.40	
Cladonia scabriuscula (Delise) Nyl.			0.07	0.13		0.20		0.13		0.13	
Cladonia squamosa (Scop.) Hoffm.				0.13			0.07				
Cladonia stellaris (Opiz) Pouzar & Vězda †	0.40	0.73	0.07	0.07	0.67	0.40	0.07		0.07		0.20
Cladonia stygia (Fr.) Ruoss †	0.87	0.93	0.87	0.60	0.93	0.33	0.60	0.80	0.80	0.93	0.73
Cladonia subfurcata (Nyl.) Arnold						0.13				0.13	
Cladonia sulphurina (Michx.) Fr.			0.20	0.13		0.13		0.13		0.13	
Cladonia umbricola Tønsberg & Ahti ‡									0.07		
Cladonia uncialis (L.) F.H. Wigg.	0.07	0.40			0.40	0.73			0.07		

3b. Low elevation (0-450 m) spruce woodland

	Site ID										
	01-009	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell	0.33	0.27			1.00	0.20			0.20		0.07
Flavocetraria nivalis (L.) Karnefelt & A. Thell		0.07			0.07						
Hypogymnia physodes (L.) Nyl.					0.13			0.07			
Lobaria linita (Ach.) Rabenh. ‡						0.07					
Melanohalea septentrionalis (Lynge) O. Blanco et al.		0.07		0.20				0.40		0.20	0.13
Nephroma arcticum (L.) Torss.	0.33	0.07	0.13		0.13	0.27	0.20			0.07	
Parmelia omphalodes (L.) Ach. subsp. *omphalodes* ‡								0.07			
Parmeliopsis ambigua (Wulfen) Nyl. †	0.67	0.27	0.80	0.93	0.20	0.27	0.47	0.60	0.33	0.73	0.67
Parmeliopsis hyperopta (Ach.) Arnold †	0.60	0.40	0.80	0.73	0.20	0.33	0.60	0.87	0.27	1.00	0.47
Peltigera aphthosa (L.) Willd. †	0.60	0.53	0.53	0.67	0.47	0.53	0.47	0.20	0.20	0.87	0.20
Peltigera extenuata (Vainio) Lojka						0.40					
Peltigera leucophlebia (Nyl.) Gyel.		0.07	0.07			0.13	0.27		0.27		0.27
Peltigera malacea (Ach.) Funck †		0.40		0.20	0.60	0.67	0.07	0.47	0.20	0.40	0.13
Peltigera neckeri Hepp ex Müll. Arg. ‡									0.07		
Peltigera neopolydactyla (Gyel.) Gyel.	0.07									0.20	
Peltigera polydactylon (Neck.) Hoffm.		0.20	0.20	0.07		0.07	0.07	0.20	0.07	0.47	0.13
Peltigera scabrosa Th. Fr. †	0.27	0.13	0.80	0.40	0.20		0.20	0.20	0.33	0.93	0.60
Psoroma hypnorum (Vahl) A. Gray						0.20					
Sphaerophorus globosus (Huds.) Vain.											0.13
Stereocaulon paschale (L.) Hoffm.	0.07	0.20		0.07	0.13	0.33		0.07			0.07
Stereocaulon tomentosum Fr.					0.07	0.40					
Stereocaulon vesuvianum Pers. ‡						0.07					
Thamnolia subuliformis (Ehrh.) W.L. Culb.						0.13					
Thamnolia vermicularis (Sw.) Ach. ex Schaerer ‡		0.07									
Tuckermannopsis sepincola (Ehrh.) Hale †	0.80	0.33	0.87	0.80	0.13	0.60	0.53	0.93	0.47	0.87	0.80
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai †	0.47	0.13	0.80	0.93	0.07	0.73	0.47	0.93	0.67	0.93	0.73
Bryophytes											
Aulacomnium palustre (Hedw.) Schwägr. †	0.33	0.20	0.87	0.87	0.07	0.13	0.53	0.27	0.47	0.53	0.73
Aulacomnium turgidum (Wahlenb.) Schwägr. †				0.27				0.93	0.07	1.00	0.60

3b. Low elevation (0-450 m) spruce woodland

	Site ID										
	01-009	**01-014**	**01-024**	**01-026**	**01-027**	**01-030**	**01-037**	**01-051**	**01-088**	**01-105**	**01-S94**
Brachythecium oedipodium (Mitt.) A. Jaeger						0.13		0.07			
Brachythecium salebrosum (F. Weber & D. Mohr) Schimp. ‡									0.07		
Ceratodon purpureus (Hedw.) Brid. var. *purpureus*						0.07	0.07				
Dicranum fuscescens Turner var. *fuscescens*			0.13							0.13	
Dicranum polysetum Sw.		0.07				0.13			0.13		
Dicranum scoparium Hedw.	0.73	0.27	0.07		0.33	0.20	0.20		0.13		0.13
Dicranum undulatum Brid.		0.27		0.07	0.20		0.07	0.13	0.13	0.20	0.13
Ditrichum heteromallum (Hedw.) E. Britton ‡						0.07					
Eurhynchiastrum pulchellum (Hedwig) Ignatov & Huttunen *var. pulchellum* ‡									0.07		
Hylocomium splendens (Hedw.) Schimp. †	0.93	0.20	0.80	0.47	0.07	0.07	0.73		0.33	1.00	0.60
Hypnum plicatulum (Lindb.) A. Jaeger	0.07		0.07		0.13						
Lophozia ventricosa (Dicks.) Dumort. var. *ventricosa* ‡	0.07										
Mylia anomala (Hook.) A. Gray ‡									0.07		
Oncophorus virens (Hedw.) Brid. ‡						0.07					
Plagiothecium laetum Schimp. ‡	0.07										
Pleurozium schreberi (Brid.) Mitt. †	0.67	0.33	1.00	0.87	0.20	0.33	0.87	0.93	1.00	0.80	0.73
Pohlia nutans (Hedw.) Lindb.	0.13			0.13	0.07	0.20	0.13		0.07	0.13	0.13
Polytrichum commune Hedw. var. *commune* †		0.20	0.80	0.67	0.33	0.20		0.53	0.07	0.93	0.67
Polytrichum juniperinum Hedw.						0.47				0.07	
Polytrichum piliferum Hedw.						0.33					
Polytrichum strictum Brid.	0.40	0.13	0.53	0.93	0.40		0.07	0.47	0.53	0.87	0.73
Ptilidium ciliare (L.) Hampe †	0.20	0.40			0.40	0.60		0.73	0.47		
Ptilium crista-castrensis (Hedw.) De Not.	0.53	0.27	0.53			0.07	0.07		0.27	0.33	0.07
Racomitrium lanuginosum (Hedw.) Brid.		0.07				0.07					
Sanionia uncinata (Hedw.) Loeske		0.07			0.13	0.27					
Sphagnum girgensohnii Russow †	0.40		0.40	0.67			0.13	0.07	0.13	0.40	0.33
Sphagnum warnstorfii Russow				0.13			0.07		0.07		

3c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
	07-02-005	07-02-017	08-02-014	08-02-048	10-02-005	10-02-092
Vascular species						
Andromeda polifolia L. ‡						0.07
Anemone narcissiflora L.				0.47		
Arctostaphylos alpina (L.) Spreng.	0.13				0.07	
Artemisia arctica Less. subsp. *arctica*	0.03			0.77		
Betula nana L. †	1.00	0.93	1.00	1.00	1.00	0.87
Calamagrostis canadensis (Michx.) P. Beauv.	0.13	0.10		0.07	0.13	0.33
Campanula lasiocarpa Cham.				0.27		
Carex lugens T. Holm †	0.03	0.33	0.43	0.37	0.73	0.33
Carex microchaeta T. Holm		0.27		0.40		
Chamerion angustifolium (L.) Holub	0.03	0.03		0.87		
Empetrum nigrum L. †	1.00	0.97	1.00	0.80	0.73	1.00
Epilobium anagallidifolium Lam.		0.03				
Festuca altaica Trin. †	0.20	0.63		0.77		
Hierochlöe alpina = *Anthoxanthum monticola* ssp. *alpinum* (Sw. ex Willd.) Soreng†	0.57	0.63		0.77	0.67	
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén †	0.90	0.97	1.00	0.60	0.93	0.93
Loiseleuria procumbens (L.) Desv.	0.03					
Lycopodium alpinum L. ‡						0.07
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen	0.23	0.37	0.23	0.03		0.13
Orthilia secunda (L.) House						0.13
Pedicularis labradorica Wirsing	0.03		0.07	0.23		
Petasites frigidus (L.) Fr.	0.13					
Picea glauca (Moench) Voss †	0.40	0.27	0.33	0.40	0.20	0.13
Populus balsamifera L. ‡				0.07		
Rubus arcticus L. ‡		0.27				
Rubus chamaemorus L. †		0.27	0.23		0.13	0.53
Salix fuscescens Andersson	0.20					
Salix glauca L.	0.03		0.13	0.23	0.33	

3c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
	07-02-005	**07-02-017**	**08-02-014**	**08-02-048**	**10-02-005**	**10-02-092**
Salix pulchra Cham.	0.13	0.10				0.33
Spiraea stevenii (C.K. Schneid.) Rydb.	0.10	0.30	0.03			0.80
Trientalis europaea L. subsp. *arctica* (Fisch. ex Hook.) Hultén	0.10			0.23		0.13
Vaccinium oxycoccos L. ‡						0.07
Vaccinium uliginosum L. †	0.90	0.97	0.83	0.37	0.80	0.93
Vaccinium vitis-idaea L. †	1.00	1.00	1.00	0.97	1.00	1.00
Lichens						
Cetraria islandica (L.) Ach. subsp. *crispiformis* (Rasanen) Karnefelt †	0.73	0.67	0.60	0.27	0.13	0.93
Cetraria laevigata Rass. †	0.33	0.07	0.27	0.60	0.80	
Cladonia amaurocraea (Flörke) Schaerer				0.47	0.40	
Cladonia arbuscula subsp. *beringiana* Ahti †	1.00	0.67	0.80	0.93	0.67	0.40
Cladonia bellidiflora (Ach.) Schaerer	0.07	0.20	0.07		0.13	
Cladonia borealis S. Stenroos				0.13	0.07	
Cladonia cenotea (Ach.) Schaerer					0.07	
Cladonia cervicornis (Ach.) Flotow subsp. *verticillata* (Hoffm.) Ahti				0.07		
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. †	0.47	0.17	0.27	0.53	0.40	0.07
Cladonia cornuta (L.) Hoffm. subsp. *cornuta* †	0.60	0.40	0.40	0.47	0.40	0.60
Cladonia crispata (Ach.) Flotow var. *crispata* †	0.60	0.47	0.33	0.33	0.27	0.33
Cladonia cyanipes (Sommerf.) Nyl.			0.07	0.07	0.27	0.07
Cladonia deformis (L.) Hoffm. †	0.33	0.20	0.13	0.53	0.20	0.07
Cladonia furcata (Huds.) Schrad.				0.07		
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti	0.20	0.40		0.07	0.07	
Cladonia gracilis (L.) Willd. subsp. *vulnerata* Ahti †	0.80	0.80	0.60	0.80	0.80	0.87
Cladonia macrophylla (Schaerer) Stenh.	0.13	0.13		0.07		
Cladonia phyllophora Hoffm.	0.20	0.13	0.13	0.07		
Cladonia pleurota (Flörke) Schaerer	0.27	0.27	0.20	0.20		0.20
Cladonia pyxidata (L.) Hoffm.		0.07		0.07		
Cladonia rangiferina (L.) F. H. Wigg.	0.13			0.07		
Cladonia scabriuscula (Delise) Nyl.	0.27	0.47		0.07		0.07

3c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
	07-02-005	**07-02-017**	**08-02-014**	**08-02-048**	**10-02-005**	**10-02-092**
Cladonia squamosa (Scop.) Hoffm.	0.13			0.07		
Cladonia stellaris (Opiz) Pouzar & Vězda †	0.47	0.20	0.13	0.53	0.07	0.20
Cladonia stygia (Fr.) Ruoss †	1.00	0.93	1.00	0.73	1.00	0.87
Cladonia subfurcata (Nyl.) Arnold		0.13				
Cladonia subulata (L.) F.H. Wigg.				0.07		
Cladonia sulphurina (Michx.) Fr.	0.27	0.07	0.33		0.13	0.07
Cladonia uncialis (L.) F.H. Wigg. †	0.67	0.33	0.40	0.67	0.13	
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell †	0.80			0.93	0.53	
Flavocetraria nivalis (L.) Karnefelt & A. Thell				0.40		
Hypogymnia austerodes (Nyl.) Rasanen					0.07	
Hypogymnia physodes (L.) Nyl.					0.07	
Lobaria linita (Ach.) Rabenh.				0.20		
Melanohalea septentrionalis (Lynge) O. Blanco et al.		0.07		0.07	0.20	
Nephroma arcticum (L.) Torss.	0.07		0.13	0.13	0.13	0.47
Nephroma expallidum (Nyl.) Nyl.				0.07		0.07
Parmeliopsis ambigua (Wulfen) Nyl. †	0.60	0.80	0.73	0.20	0.73	0.60
Parmeliopsis hyperopta (Ach.) Arnold †	0.67	0.80	0.73	0.13	0.47	0.87
Peltigera aphthosa (L.) Willd. †	0.80	0.60	0.73	0.33	0.73	0.80
Peltigera leucophlebia (Nyl.) Gyel.	0.13	0.07	0.13	0.07	0.60	0.07
Peltigera malacea (Ach.) Funck †	0.40	0.27	0.60	0.47	0.20	0.13
Peltigera polydactylon (Neck.) Hoffm. †	0.40	0.40	0.07	0.07	0.27	0.27
Peltigera scabrosa Th. Fr. †	0.60	0.40	0.53		0.60	0.53
Psoroma hypnorum (Vahl) A. Gray	0.07			0.33		
Stereocaulon paschale (L.) Hoffm. †	0.67	0.40	0.53	0.87	0.20	0.13
Thamnolia vermicularis (Sw.) Ach. ex Schaerer				0.40		
Tuckermannopsis sepincola (Ehrh.) Hale †	0.40	0.53	0.60	0.40	0.60	0.60
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai †	0.80	0.80	0.87	0.33	0.73	0.87
Bryophytes						
Anastrophyllum minutum (Schreb.) R.M. Schust. var. *minutum*			0.13			

3c. Mid-elevation (450-900 m) white spruce woodland

	Site ID					
	07-02-005	**07-02-017**	**08-02-014**	**08-02-048**	**10-02-005**	**10-02-092**
Aulacomnium palustre (Hedw.) Schwägr. †	0.20	0.40	0.33			0.73
Aulacomnium turgidum (Wahlenb.) Schwägr. †	0.47			0.07	0.93	
Brachythecium salebrosum (F. Weber & D. Mohr) Schimp.					0.07	
Calypogeia neesiana (C. Massal. & Carestia) Müll. Frib.			0.07			
Ceratodon purpureus (Hedw.) Brid. var. *purpureus*				0.07		
Dicranum fuscescens Turner var. *fuscescens*				0.20		
Dicranum groenlandicum Brid. †	0.53	0.20		0.47	0.27	
Dicranum scoparium Hedw. †	0.67	0.60	0.87	0.27	0.47	0.53
Dicranum undulatum Brid. †	0.53	0.40	0.53			
Hylocomium splendens (Hedw.) Schimp. †	0.47	0.53	0.67	0.47	0.47	0.87
Hypnum plicatulum (Lindb.) A. Jaeger	0.33	0.13		0.13	0.07	
Lophozia ventricosa (Dicks.) Dumort. var. *ventricosa*	0.07	0.20	0.20		0.07	0.13
Pleurozium schreberi (Brid.) Mitt. †	0.87	0.80	1.00	0.20	0.07	0.53
Pohlia nutans (Hedw.) Lindb. †	0.20	0.47	0.13	0.20	0.13	0.13
Polytrichum commune Hedw. var. *commune* †	1.00	0.80	1.00	0.87	0.67	0.67
Polytrichum piliferum Hedw.					0.07	
Polytrichum strictum Brid. †	0.47	0.87	0.53	0.20	0.33	0.20
Ptilidium ciliare (L.) Hampe	0.20	0.13	0.13			0.07
Ptilium crista-castrensis (Hedw.) De Not.	0.27	0.07	0.07	0.07		0.07
Racomitrium lanuginosum (Hedw.) Brid.				0.40		
Rhytidium rugosum (Hedw.) Kindb.				0.07		
Sphagnum girgensohnii Russow	0.07	0.07	0.13		0.13	0.20
Sphagnum warnstorfii Russow		0.13				0.07
Tritomaria scitula (Taylor) Jörg.			0.07			

3d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID					
	07-02-002	07-02-015	07-02-016	08-02-042-2	10-02-016	10-02-099
Vascular species						
Andromeda polifolia L.		0.07				
Anemone narcissiflora L.	0.23					0.13
Arctostaphylos alpina (L.) Spreng. †	0.57	0.13	0.07		0.20	0.53
Artemisia arctica Less. subsp. *arctica*			0.07			0.20
Betula nana L. †	0.87	1.00	1.00	1.00	1.00	0.93
Calamagrostis canadensis (Michx.) P. Beauv.	0.03	0.07				
Calamagrostis lapponica (Wahlenb.) Hartm.			0.20			0.20
Campanula lasiocarpa Cham.	0.07					
Carex aquatilis Wahlenb.		1.00				
Carex lugens T. Holm †	0.37			1.00	1.00	1.00
Carex microchaeta T. Holm	0.40		1.00			
Diapensia lapponica L.						0.07
Empetrum nigrum L. †	0.37	0.60	1.00	1.00	0.13	0.93
Eriophorum angustifolium Honck.		0.07				
Eriophorum angustifolium Honck. subsp. *angustifolium*		0.07				
Festuca altaica Trin.	0.10		0.20			0.20
Hierochlöe alpina = *Anthoxanthum monticola* ssp. *alpinum* (Sw. ex Willd.) Soreng †	0.77	0.13		0.20	1.00	0.93
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén †	0.97	1.00	1.00	1.00	1.00	1.00
Loiseleuria procumbens (L.) Desv.	0.17			0.27		0.13
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen	0.10		0.07	0.27		
Orthilia secunda (L.) House			0.07			
Oxytropis nigrescens (Pall.) Fisch. ex DC. var. *nigrescens*						0.07
Pedicularis labradorica Wirsing †	0.17	0.07	0.07	0.27	0.40	0.27
Pedicularis lanata Cham. & Schltdl.	0.03					
Petasites frigidus (L.) Fr.			0.20			0.13
Picea glauca (Moench) Voss	0.07			0.07	0.13	0.07
Poa arctica R. Br.			0.27			

3d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID					
	07-02-002	**07-02-015**	**07-02-016**	**08-02-042-2**	**10-02-016**	**10-02-099**
Poa arctica R. Br. subsp. *arctica*						0.07
Polygonum viviparum L.			0.27			0.07
Rubus chamaemorus L.		0.67	0.20			
Salix fuscescens Andersson		0.13				
Salix glauca L.	0.27		0.13			0.13
Salix phlebophylla Andersson	0.20					
Salix pulchra Cham. †	0.27		0.20	0.13	0.33	0.07
Spiraea stevenii (C.K. Schneid.) Rydb.			0.13			
Tephroseris yukonensis (A.E. Porsild) Holub			0.07			
Vaccinium oxycoccos L.				0.07		
Vaccinium uliginosum L. †	0.80	0.93	1.00	1.00	0.93	1.00
Vaccinium vitis-idaea L. †	1.00	1.00	1.00	1.00	0.87	1.00
Lichens						
Alectoria ochroleuca (Hoffm.) A. Massal.	0.20					
Arctoparmelia separata (Th. Fr.) Hale	0.07					
Bryocaulon divergens (Ach.) Karnefelt	0.40					
Cetraria islandica (L.) Ach. subsp. *crispiformis* (Rasanen) Karnefelt †	0.40			0.73	0.93	1.00
Cetraria kamczatica Savicz	0.47			0.07		0.13
Cetraria laevigata Rass. †	0.60			0.47		
Cladonia amaurocraea (Flörke) Schaerer †	0.47				0.13	0.40
Cladonia arbuscula subsp. *beringiana* Ahti †	1.00			0.87	0.87	1.00
Cladonia bellidiflora (Ach.) Schaerer †	0.33			0.40	0.13	0.20
Cladonia borealis S. Stenroos	0.07					
Cladonia botrytes (K. Hagen) Willd.						0.20
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. †	1.00			0.47	0.47	0.67
Cladonia cornuta (L.) Hoffm. subsp. *cornuta* †	0.47			0.07	0.47	0.40
Cladonia crispata (Ach.) Flotow var. *crispata* †	0.73			0.87	0.53	0.87
Cladonia cyanipes (Sommerf.) Nyl.					0.13	0.20
Cladonia deformis (L.) Hoffm.	0.27			0.13	0.20	0.13

3d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID					
	07-02-002	07-02-015	07-02-016	08-02-042-2	10-02-016	10-02-099
Cladonia furcata (Huds.) Schrad.					0.07	
Cladonia gracilis (L.) Willd. subsp. *elongata* (Jacq.) Vain.				0.07		0.53
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti †	0.13			0.33	0.13	0.40
Cladonia gracilis (L.) Willd. subsp. *vulnerata* Ahti †	0.93			0.73	1.00	0.60
Cladonia macroceras (Delise) Hav.						0.07
Cladonia macrophylla (Schaerer) Stenh.	0.20			0.07		
Cladonia metacorallifera Asah.	0.33					
Cladonia phyllophora Hoffm.	0.33			0.27	0.07	
Cladonia pleurota (Flörke) Schaerer †	0.20			0.47	0.13	0.13
Cladonia pyxidata (L.) Hoffm.	0.07					
Cladonia rangiferina (L.) F. H. Wigg.	0.13				0.13	0.33
Cladonia scabriuscula (Delise) Nyl. †	0.13			0.13	0.40	0.13
Cladonia squamosa (Scop.) Hoffm.	0.33			0.20		0.07
Cladonia stellaris (Opiz) Pouzar & Vězda	0.53			0.80		0.33
Cladonia stygia (Fr.) Ruoss †	1.00			0.93	0.60	0.80
Cladonia subfurcata (Nyl.) Arnold	0.13			0.27		
Cladonia sulphurina (Michx.) Fr.	0.07			0.07	0.27	0.27
Cladonia uncialis (L.) F.H. Wigg. †	0.80			0.67	0.60	0.87
Dactylina arctica (Richardson) Nyl.						0.13
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell †	0.87			0.73	1.00	0.93
Flavocetraria nivalis (L.) Karnefelt & A. Thell †	0.40			0.40		0.20
Lobaria linita (Ach.) Rabenh.	0.13			0.07		0.07
Melanelia stygia (L.) Essl.	0.07					
Melanohalea septentrionalis (Lynge) O. Blanco et al.	0.33				0.20	
Nephroma arcticum (L.) Torss.				0.20	0.13	0.20
Nephroma parile (Ach.) Ach.	0.07					
Parmeliopsis ambigua (Wulfen) Nyl.				0.13	0.07	
Parmeliopsis hyperopta (Ach.) Arnold	0.07			0.13	0.07	
Peltigera aphthosa (L.) Willd. †	0.33			0.27	0.53	0.33

3d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID					
	07-02-002	07-02-015	07-02-016	08-02-042-2	10-02-016	10-02-099
Peltigera leucophlebia (Nyl.) Gyel. †				0.27	0.33	0.20
Peltigera malacea (Ach.) Funck	0.27			0.07		0.27
Peltigera polydactylon (Neck.) Hoffm. †	0.20			0.27	0.40	0.13
Peltigera scabrosa Th. Fr. †	0.07			0.47	0.27	0.27
Pseudephebe pubescens (L.) M. Choisy	0.07					
Psoroma hypnorum (Vahl) A. Gray	0.07			0.07	0.07	0.07
Sphaerophorus globosus (Huds.) Vain.	0.47			0.07		0.13
Stereocaulon paschale (L.) Hoffm. †	1.00			0.87	0.53	1.00
Thamnolia vermicularis (Sw.) Ach. ex Schaerer †	0.93			0.80	0.47	0.87
Tuckermannopsis sepincola (Ehrh.) Hale †	0.47			0.33	0.07	0.20
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai	0.07			0.13	0.33	0.20
Bryophytes						
Anastrophyllum minutum (Schreb.) R.M. Schust. var. *minutum*				0.07		
Aulacomnium palustre (Hedw.) Schwägr.	0.07			0.13	0.20	
Aulacomnium turgidum (Wahlenb.) Schwägr. †	0.20			0.67	0.67	0.47
Dicranum fuscescens Turner var. *fuscescens*					0.33	
Dicranum groenlandicum Brid. †	0.87			0.60	0.47	0.67
Dicranum scoparium Hedw. †	0.73			0.87	0.53	0.93
Dicranum undulatum Brid.				0.07	0.40	0.07
Hylocomium splendens (Hedw.) Schimp. †				0.87	0.13	0.40
Hypnum plicatulum (Lindb.) A. Jaeger	0.07			0.13	0.13	0.27
Lophozia ventricosa (Dicks.) Dumort. var. *ventricosa*				0.13		
Niphotrichum ericoides (Bridel) Bednarek-Ochyra & Ochyra in R. Ochyra et al.	0.07					
Pleurozium schreberi (Brid.) Mitt.	0.07				0.60	0.13
Pohlia nutans (Hedw.) Lindb. †	0.13			0.40	0.20	0.27
Polytrichum commune Hedw. var. *commune* †	0.93			0.87	0.80	1.00
Polytrichum juniperinum Hedw.	0.07					
Polytrichum piliferum Hedw.	0.07					
Polytrichum strictum Brid. †	0.20				0.60	0.20

3d. Mid-elevation (450-900 m) dwarf shrub tundra

	Site ID					
	07-02-002	**07-02-015**	**07-02-016**	**08-02-042-2**	**10-02-016**	**10-02-099**
Ptilidium ciliare (L.) Hampe	0.07					
Ptilium crista-castrensis (Hedw.) De Not.	0.07			0.07	0.13	0.20
Racomitrium lanuginosum (Hedw.) Brid.				0.20		
Rhytidium rugosum (Hedw.) Kindb.	0.13					0.40
Sanionia uncinata (Hedw.) Loeske					0.07	
Sphagnum girgensohnii Russow				0.07	0.33	
Sphagnum warnstorfii Russow				0.07		
Tetraplodon mnioides (Hedw.) Bruch & Schimp.					0.07	

3e. Mid-elevation (450-900 m) low shrub tundra

	Site ID				
	07-02-006	07-02-007	08-02-006	08-02-042-1	08-02-049
Vascular					
Arctostaphylos alpina (L.) Spreng.	0.07	0.20	0.23		
Artemisia arctica Less. subsp. *arctica*	0.02	0.07			
Betula nana L. †	0.87	1.00	0.77	1.00	1.00
Betula nana L. x *Betula neoalaskana* Sarg.			0.03		
Calamagrostis canadensis (Michx.) P. Beauv. †	0.13	0.13		0.73	0.97
Calamagrostis lapponica (Wahlenb.) Hartm.		0.47		0.47	
Campanula lasiocarpa Cham.					0.53
Carex lugens T. Holm †	0.71	0.07	0.50		
Carex microchaeta T. Holm †		0.67		0.87	1.00
Carex microchaeta T. Holm subsp. *nesophila* (T. Holm) E. Murray †					0.50
Chamerion angustifolium (L.) Holub			0.10		
Delphinium L. sp. 1		0.07			
Empetrum nigrum L. †	0.93	1.00	0.40	1.00	
Festuca altaica Trin. †		0.07	0.37	0.07	1.00
Hierochlöe alpina = *Anthoxanthum monticola* ssp. *alpinum* (Sw. ex Willd.) Soreng†	0.42	0.80	0.27	0.40	0.90
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén †	0.96	0.87	0.93	1.00	
Loiseleuria procumbens (L.) Desv.	0.18	0.27		0.07	
Lycopodium alpinum L.	0.03			0.07	
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen	0.07	0.07	0.33	0.20	
Pedicularis capitata M.F. Adams			0.03		
Pedicularis labradorica Wirsing	0.09	0.07	0.03		
Petasites frigidus (L.) Fr.	0.04				
Petasites frigidus (L.) Fr. var. *frigidus*	0.02				
Picea glauca (Moench) Voss †	0.31		0.33	0.20	0.20
Poa arctica R. Br.					0.03
Populus balsamifera L.			0.03		
Rubus chamaemorus L.	0.40		0.13		

3e. Mid-elevation (450-900 m) low shrub tundra

	Site ID				
	07-02-006	07-02-007	08-02-006	08-02-042-1	08-02-049
Salix fuscescens Andersson		0.07			
Salix glauca L.			0.13	0.07	0.20
Salix phlebophylla Andersson		0.07			
Salix pulchra Cham.	0.31	0.20		0.27	
Spiraea stevenii (C.K. Schneid.) Rydb.	0.02	0.20	0.13	0.13	
Trientalis europaea L. subsp. *arctica* (Fisch. ex Hook.) Hultén †		0.07			0.77
Vaccinium uliginosum L. †	1.00	0.53	0.87	0.93	
Vaccinium vitis-idaea L. †	0.87	1.00	0.83	0.93	0.77
Lichens					
Bryocaulon divergens (Ach.) Karnefelt			0.07		
Cetraria islandica (L.) Ach. subsp. *crispiformis* (Rasanen) Karnefelt	0.13		0.27		0.13
Cetraria laevigata Rass. †	0.73		0.27		1.00
Cladonia amaurocraea (Flörke) Schaerer †			0.27		0.60
Cladonia arbuscula subsp. *beringiana* Ahti †	0.73		0.87		1.00
Cladonia bellidiflora (Ach.) Schaerer	0.13		0.07		
Cladonia borealis S. Stenroos	0.07				0.20
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. †	0.47		0.40		0.20
Cladonia cornuta (L.) Hoffm. subsp. *cornuta* †	0.27		0.47		0.13
Cladonia crispata (Ach.) Flotow var. *crispata* †	0.60		0.60		0.67
Cladonia deformis (L.) Hoffm.			0.20		0.13
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti	0.07		0.07		
Cladonia gracilis (L.) Willd. subsp. *vulnerata* Ahti †	0.80		0.80		0.87
Cladonia macrophylla (Schaerer) Stenh.			0.13		
Cladonia phyllophora Hoffm.			0.47		0.07
Cladonia pleurota (Flörke) Schaerer			0.27		
Cladonia rangiferina (L.) F. H. Wigg. †	0.27				0.33
Cladonia scabriuscula (Delise) Nyl.			0.20		0.07
Cladonia squamosa (Scop.) Hoffm.	0.13				0.20
Cladonia stellaris (Opiz) Pouzar & Vězda	0.27		0.20		

3e. Mid-elevation (450-900 m) low shrub tundra

	Site ID				
	07-02-006	**07-02-007**	**08-02-006**	**08-02-042-1**	**08-02-049**
Cladonia stygia (Fr.) Ruoss †	0.73		0.87		0.73
Cladonia subfurcata (Nyl.) Arnold	0.07				
Cladonia subulata (L.) F.H. Wigg.	0.13				
Cladonia sulphurina (Michx.) Fr.			0.13		
Cladonia uncialis (L.) F.H. Wigg. †	0.40		0.60		0.33
Dactylina arctica (Richardson) Nyl.					0.33
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell †	0.87		0.53		1.00
Flavocetraria nivalis (L.) Karnefelt & A. Thell	0.07		0.13		
Lobaria linita (Ach.) Rabenh.	0.07				
Melanelia septentrionalis (Lynge) Essl. †			0.27		0.87
Nephroma arcticum (L.) Torss.	0.13		0.07		
Parmelia omphalodes (L.) Ach. subsp. *omphalodes*	0.07				
Parmeliopsis ambigua (Wulfen) Nyl. †	0.47		0.67		0.20
Parmeliopsis hyperopta (Ach.) Arnold †	0.53		0.73		0.47
Peltigera aphthosa (L.) Willd. †	0.47		0.40		0.27
Peltigera malacea (Ach.) Funck †	0.07		0.33		0.47
Peltigera polydactylon (Neck.) Hoffm. †	0.07		0.20		0.40
Peltigera scabrosa Th. Fr.	0.13		0.20		0.07
Sphaerophorus globosus (Huds.) Vain.			0.13		
Stereocaulon paschale (L.) Hoffm. †	0.47		0.40		1.00
Thamnolia subuliformis (Ehrh.) W.L. Culb.	0.27				
Thamnolia vermicularis (Sw.) Ach. ex Schaerer †			0.27		0.73
Tuckermannopsis sepincola (Ehrh.) Hale †	0.73		0.80		0.07
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai †	0.73		0.87		0.27
Bryophytes					
Aulacomnium palustre (Hedw.) Schwägr.	0.27		0.20		
Aulacomnium turgidum (Wahlenb.) Schwägr. †	0.27		0.40		0.80
Conostomum tetragonum (Hedw.) Lindb.					0.07
Dicranum fuscescens Turner var. *fuscescens*	0.20				

3e. Mid-elevation (450-900 m) low shrub tundra

	Site ID				
	07-02-006	**07-02-007**	**08-02-006**	**08-02-042-1**	**08-02-049**
Dicranum groenlandicum Brid. †	0.27		0.33		0.80
Dicranum scoparium Hedw. †	0.40		0.33		
Dicranum undulatum Brid. †	0.13		0.27		0.20
Hylocomium splendens (Hedw.) Schimp. †	0.60		0.33		
Jungermannia L. emend. Dumort.	0.07				
Lophozia ventricosa (Dicks.) Dumort. var. *ventricosa*	0.13		0.13		
Pleurozium schreberi (Brid.) Mitt. †	0.67		0.60		0.53
Pohlia cruda (Hedw.) Lindb.	0.07				
Pohlia nutans (Hedw.) Lindb.	0.27		0.07		
Polytrichum commune Hedw. var. *commune* †	0.67		0.87		0.87
Polytrichum hyperboreum R. Br.					0.07
Polytrichum strictum Brid. †	0.33		0.40		0.67
Ptilidium ciliare (L.) Hampe †	0.07		0.33		0.20
Ptilium crista-castrensis (Hedw.) De Not.	0.07		0.27		
Racomitrium lanuginosum (Hedw.) Brid.					0.13
Rhytidium rugosum (Hedw.) Kindb. †			0.20		1.00
Sanionia uncinata (Hedw.) Loeske	0.07				
Sphagnum girgensohnii Russow	0.13		0.13		

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Vascular species							
Andromeda polifolia L.	0.13			0.27			
Androsace chamaejasme Wulfen			0.53		0.07		
Androsace chamaejasme Wulfen subsp. *lehmanniana* (Spreng.) Hultén			0.53		0.07		
Anemone narcissiflora L. †	0.93	1.00	1.00	0.40	0.80	1.00	0.87
Antennaria friesiana (Trautv.) Ekman †			0.73		0.73		
Antennaria monocephala DC. †	0.80	0.93	1.00	0.07	0.07	0.27	0.48

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Arctostaphylos alpina (L.) Spreng.						0.40	0.87
Arnica frigida C.A. Mey. ex Iljin †	0.33	1.00	1.00		0.53	0.53	0.93
Artemisia arctica Less. subsp. *arctica* †	0.47	0.13	0.67			0.13	
Astragalus umbellatus Bunge ‡			0.07				
Betula nana L.	0.60					0.13	
Campanula lasiocarpa Cham. †	1.00	0.93	1.00	0.27	0.13	0.93	0.67
Carex microchaeta T. Holm †	1.00	1.00	1.00	0.40	1.00	1.00	0.93
Carex microchaeta T. Holm subsp. *nesophila* (T. Holm) E. Murray						0.07	0.13
Cassiope tetragona (L.) D. Don	0.13			0.27			
Diapensia lapponica L. †	0.87	1.00	1.00	0.40	0.73	1.00	1.00
Douglasia alaskana (Coville & Standl. ex Hultén) S. Kelso					0.13		
Dryas octopetala L. †	1.00	1.00	1.00	0.40	1.00	1.00	1.00
Empetrum nigrum L. †	0.53		0.07	0.20		0.80	0.27
Festuca altaica Trin.	0.73		0.13				
Festuca brachyphylla Schult. ex Schult. & Schult. f.			0.47		0.40		
Festuca brevissima Jurtzev							0.20
Gentiana algida Pall.			0.33				
Gentiana glauca Pall.	0.53	0.07	0.07	0.07		0.07	
Geum rossii (R. Br.) Ser.				0.07			0.40
Anthoxanthum monticola ssp. alpinum (Sw. ex Willd.) Roem. & Schult. †	1.00	1.00	1.00	0.40	1.00	1.00	1.00
Huperzia selago (L.) Bernh. ex Schrank & Mart.	0.53		0.20	0.20		0.33	
Lagotis glauca Gaertn.			0.47				
Ledum palustre L. subsp. *decumbens* (Aiton) Hultén †	0.67		0.13	0.33		0.93	0.93
Lloydia serotina (L.) Salisb. ex Rchb. †	0.13		0.60		0.93	0.93	
Loiseleuria procumbens (L.) Desv. †	1.00	0.40	0.67	0.40		0.60	1.00
Luzula arcuata (Wahlenb.) Sw.					0.80		
Luzula spicata (L.) DC.			0.13				
Lycopodium alpinum L.	0.13						
Lycopodium lagopus (Laest. ex Hartm.) Zinserl. ex Kuzen ‡	0.07						

3f. High elevation (> 900 m) dwarf shrub tundra					Site ID		
	03N-006	03S-001	03S-008	03S-097	03S-098	03S-099	03S-121
Minuartia macrocarpa (Pursh) Ostenf. †		0.53	0.27		0.67	0.07	0.20
Oxytropis nigrescens (Pall.) Fisch. ex DC. var. *nigrescens* †	0.33	1.00	1.00		1.00	0.93	1.00
Packera cymbalaria (Pursh) W.A. Weber & A. Löve	0.33		0.53		0.07	0.13	
Pedicularis capitata M.F. Adams			0.47	0.07	0.13	0.67	
Pedicularis lanata Cham. & Schltdl.				0.20	0.40		
Pedicularis langsdorffii Fisch. ex Stev.		0.67					
Pedicularis sudetica Willd. subsp. *interioides* Hultén	0.20		0.40				
Pedicularis verticillata L.					0.20	0.27	
Poa macrocalyx Trautv. & C.A. Mey.					0.67		
Poa pseudoabbreviata Rosh.					0.53		
Polygonum viviparum L. †	0.47	0.07	0.80	0.07	0.13	0.27	0.20
Potentilla nana Willd. ex Schltdl. ‡			0.07				
Potentilla villosa Pall. ex Pursh							0.27
Primula cuneifolia Ledeb.		0.27	0.67				
Rhodiola integrifolia Raf.		0.13	0.40		0.53	0.13	
Salix arctica Pall. †			0.87		0.93	0.73	0.07
Salix reticulata L.			0.27				
Saxifraga bronchialis L. subsp. *funstonii* (Small) Hultén					0.27	0.20	
Salix phlebophylla Andersson †	0.87	0.93	1.00	0.40	0.93	0.93	0.93
Stellaria crispa Cham. & Schltdl. ‡					0.07		
Tofieldia coccinea Richardson	0.27		0.87				0.07
Tofieldia pusilla (Michx.) Pers.				0.13			
Trisetum spicatum (L.) K. Richt. †	0.20	0.47	0.87		0.40		
Vaccinium uliginosum L. †	0.67		0.47	0.40		0.87	1.00
Vaccinium vitis-idaea L. †	0.93	0.07	0.33	0.20		0.87	0.33
Lichens							
Alectoria ochroleuca (Hoffm.) A. Massal. †	0.27	0.80	0.80	0.33	1.00	0.73	1.00
Allantoparmelia alpicola (Th. Fr.) Essl.			0.07				

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Arctoparmelia separata (Th. Fr.) Hale †		0.87	0.60			0.07	0.13
Asahinea chrysantha (Tuck.) W.L. Culb. & C.F. Culb. †	0.13	0.80	0.40	0.13		0.53	1.00
Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	0.07	0.53	0.13			0.13	
Baeomyces placophyllus Ach.			0.13				0.13
Brodoa oroarctica (Krog) Goward	0.13	0.13				0.20	
Bryocaulon divergens (Ach.) Karnefelt †	0.20	0.60	0.67	0.20	1.00	0.93	1.00
Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.						0.07	0.53
Cetraria aculeata (Schreb.) Fr.		0.07					
Cetraria ericetorum Opiz subsp. *ericetorum*						0.33	
Cetraria ericetorum Opiz subsp. *reticulata* (Rasanen) Karnefelt †		0.40	0.07	0.40		0.27	0.33
Cetraria islandica (L.) Ach. subsp. *crispiformis* (Rasanen) Karnefelt †	1.00	0.33	0.73		1.00	0.40	0.67
Cetraria kamczatica Savicz †	0.93	0.33	0.60	0.33	0.40	0.27	0.93
Cetraria laevigata Rass.						0.27	0.07
Cetraria nigricans Nyl. †	0.73	0.93	0.80	0.40		0.47	0.87
Cetrariella fastigiata (Delise ex Nyl.) Kärnefelt & A. Thell		0.27					
Cladonia amaurocraea (Flörke) Schaerer †	0.87		0.33	0.13	0.60	0.33	0.47
Cladonia arbuscula subsp. *beringiana* Ahti †	1.00	0.60	0.93	0.40	1.00	1.00	0.93
Cladonia borealis S. Stenroos †	0.87	0.67	0.73	0.27	0.80	0.33	0.60
Cladonia cervicornis (Ach.) Flotow subsp. *verticillata* (Hoffm.) Ahti	0.07		0.13				
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.	0.33	0.07			0.20	0.20	0.07
Cladonia cornuta (L.) Hoffm. subsp. *cornuta*						0.07	
Cladonia crispata (Ach.) Flotow var. *crispata*	0.27		0.07	0.13			0.07
Cladonia cyanipes (Sommerf.) Nyl.	0.07						
Cladonia deformis (L.) Hoffm.					0.20		
Cladonia gracilis (L.) Willd. subsp. *elongata* (Jacq.) Vain.	0.20						
Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti	0.13						
Cladonia gracilis (L.) Willd. subsp. *vulnerata* Ahti				0.33	0.20		0.53
Cladonia macroceras (Delise) Hav. †	0.67	0.13	0.67	0.33		0.47	0.80
Cladonia nipponica Asah. †	0.27			0.13			0.87

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Cladonia phyllophora Hoffm.	0.47	0.07	0.07	0.07			0.40
Cladonia pleurota (Flörke) Schaerer	0.27						
Cladonia pyxidata (L.) Hoffm. †	0.40	0.27	0.33	0.07	0.20		0.27
Cladonia rangiferina (L.) F. H. Wigg.							0.67
Cladonia squamosa (Scop.) Hoffm.					0.60		
Cladonia stellaris (Opiz) Pouzar & Vězda †	0.87					0.60	0.40
Cladonia stygia (Fr.) Ruoss †	0.67	0.07	0.27	0.20	0.60	0.87	0.33
Cladonia subfurcata (Nyl.) Arnold	0.13			0.27		0.07	0.13
Cladonia sulphurina (Michx.) Fr.	0.07						
Cladonia uncialis (L.) F.H. Wigg. †	0.53	0.40	0.87	0.27	1.00	0.67	0.93
Dactylina arctica (Richardson) Nyl.			0.33		0.20	0.13	0.27
Dactylina ramulosa (Hook.) Tuck. †	0.07	0.60	0.53	0.20	0.80		0.27
Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell †	0.20	0.13	1.00	0.20	1.00	0.87	1.00
Flavocetraria nivalis (L.) Karnefelt & A. Thell †	1.00	0.93	1.00	0.40	1.00	1.00	1.00
Gowardia nigricans (Ach.) P. Halonen, L. Myllys, S. Velmala, & H. Hyvärinen †	0.80	0.07	0.53	0.33	1.00	0.87	0.53
Hypogymnia subobscura (Vain.) Poelt †		0.27	0.40		1.00	0.13	0.27
Lobaria kurokawae Yoshim.			0.07				
Lobaria linita (Ach.) Rabenh.			0.53		1.00		0.07
Melanelia hepatizon (Ach.) A. Thell †	0.27	1.00	0.40		0.20	0.27	0.13
Melanelia panniformis (Nyl.) Essl.		0.07					
Melanelia stygia (L.) Essl.		0.13			0.20	0.20	0.13
Nephroma arcticum (L.) Torss.						0.20	
Nephroma expallidum (Nyl.) Nyl.			0.07		0.20		
Parmelia omphalodes (L.) Ach. subsp. *omphalodes* †	0.07	0.93	0.80		1.00	0.40	0.07
Peltigera aphthosa (L.) Willd.		0.07	0.07		0.40	0.07	
Peltigera didactyla (With.) J.R. Laundon		0.07				0.07	0.07
Peltigera extenuata (Vainio) Lojka						0.07	
Peltigera leucophlebia (Nyl.) Gyel.			0.13		0.40		
Peltigera malacea (Ach.) Funck	0.07		0.07				

3f. High elevation (> 900 m) dwarf shrub tundra	Site ID						
	03N-006	03S-001	03S-008	03S-097	03S-098	03S-099	03S-121
Peltigera polydactylon (Neck.) Hoffm.			0.07				
Peltigera rufescens (Weiss) Humb.			0.07				
Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.					0.20		
Pseudephebe pubescens (L.) M. Choisy †	0.13	1.00	0.53		0.20	0.33	0.13
Psoroma hypnorum (Vahl) A. Gray			0.13				0.07
Solorina crocea (L.) Ach.		0.07	0.07	0.07			
Sphaerophorus fragilis (L.) Pers.	0.13						
Sphaerophorus globosus (Huds.) Vain. †	0.47	1.00	1.00	0.20	1.00	0.93	1.00
Stereocaulon botryosum Ach.	0.27						
Stereocaulon glareosum (Savicz) H. Magn.	0.07						
Stereocaulon paschale (L.) Hoffm. †	0.13		0.33			0.40	0.93
Stereocaulon sterile (Savicz) Lamb ex Krog	0.07						
Stereocaulon tomentosum Fr.			0.20	0.20	0.20		
Stereocaulon vesuvianum Pers.	0.07	0.07	0.07	0.07			
Sticta arctica Degel.			0.13		0.80		
Thamnolia subuliformis (Ehrh.) W.L. Culb. †	1.00	1.00	0.60				
Thamnolia vermicularis (Sw.) Ach. ex Schaerer †			0.60	0.40	0.80	0.93	1.00
Umbilicaria hyperborea (Ach.) Hoffm. var. *hyperborea* †	0.27	0.60				0.47	
Umbilicaria krascheninnikovii (Savicz) Zahlbr. †	0.33	0.47	0.27		0.20	0.99	0.07
Umbilicaria proboscidea (L.) Schrad.	0.07	0.87				0.13	
Umbilicaria torrefacta (Lightf.) Schrad.		0.27					0.07
Vulpicida tilesii (Ach.) J.-E. Mattsson & M.J. Lai			0.07				
Bryophytes							
Abietinella abietina (Hedw.) Fleisch.					0.20		
Anastrophyllum minutum (Schreb.) R.M. Schust. var. *minutum*			0.40		0.80	0.20	
Andreaea rupestris Hedw. †	0.80	0.53	0.33	0.27		0.20	0.07
Anthelia juratzkana (Limpr.) Trevis.	0.07	0.07	0.13	0.27			0.07
Aulacomnium turgidum (Wahlenb.) Schwägr.			0.47		0.40	0.13	0.07

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Barbula convoluta Hedw. var. *convoluta*			0.07		0.20		
Bartramia ithyphylla Brid.					0.20		0.07
Bucklandiella heterosticha (Hedwig) Bednarek-Ochyra & Ochyra in R. Ochyra et al.			0.07				
Ceratodon purpureus (Hedw.) Brid. var. *purpureus*		0.07	0.07				0.07
Codriophorus fascicularis (Hedwig) Bednarek-Ochyra & Ochyra in R. Ochyra et al.			0.07				
Conostomum tetragonum (Hedw.) Lindb.	0.13	0.07	0.13				0.07
Cynodontium glaucescens (Lindb. & Arnell) Par.						0.13	
Dicranum fuscescens Turner var. *fuscescens*			0.27		0.20		0.13
Dicranum groenlandicum Brid. †	0.53	0.33	0.47	0.13	0.60	0.80	0.40
Dicranum muehlenbeckii Bruch & Schimp.			0.07				
Dicranum scoparium Hedw.	0.13		0.13		0.20		0.13
Dicranum undulatum Brid.			0.07		0.20		
Diplophyllum taxifolium (Wahlenb.) Dumort. var. *macrosticta* H. Buch	0.07	0.20	0.33		0.40	0.07	0.07
Ditrichum flexicaule (Schwägr.) Hampe			0.07				
Ditrichum heteromallum (Hedw.) E. Britton			0.13				
Gymnomitrion corallioides Nees		0.40	0.13				
Hylocomium splendens (Hedw.) Schimp.	0.13		0.40		0.20	0.07	0.07
Hypnum plicatulum (Lindb.) A. Jaeger	0.07		0.13		0.40		
Imbribryum alpinum (Huds. ex With.) Pedersen			0.07				
Lophozia sudetica (Nees ex Huebener) Grolle var. *sudetica*		0.07					
Marsupella emarginata (Ehrh.) Dumort. subsp. *emarginata*			0.07				
Nardia scalaris A. Gray				0.13			0.07
Niphotrichum ericoides (Bridel) Bednarek-Ochyra & Ochyra in R. Ochyra et al.	0.20		0.13		0.20		
Paraleucobryum enerve (Thed.) Loeske			0.40				
Pogonatum urnigerum (Hedw.) P. Beauv. †	0.20	0.60	0.07		0.20	0.20	0.27
Pohlia andrewsii Shaw						0.20	
Pohlia crudoides (Sull. & Lesq.) Broth.							0.07
Pohlia nutans (Hedw.) Lindb.	0.27	0.33	0.13				
Polytrichastrum alpinum (Hedw.) G.L. Sm. var. *alpinum*	0.07		0.27		0.60	0.07	

3f. High elevation (> 900 m) dwarf shrub tundra

	Site ID						
	03N-006	**03S-001**	**03S-008**	**03S-097**	**03S-098**	**03S-099**	**03S-121**
Polytrichum hyperboreum R. Br. †	0.40	0.93			0.20	0.80	0.13
Polytrichum juniperinum Hedw.	0.13		0.40	0.33	0.20	0.07	0.13
Polytrichum piliferum Hedw. †	0.60	0.87	0.47	0.07	0.40	0.27	0.47
Polytrichum strictum Brid.							0.13
Ptychostomum creberrimum (Taylor) J. R. Spence & H. P. Ramsay			0.13				0.33
Racomitrium lanuginosum (Hedw.) Brid. †	0.53	0.60	0.93	0.40		0.20	0.87
Radula prolifera S.W. Arnell			0.13				
Rhytidium rugosum (Hedw.) Kindb.	0.07		0.47		0.60		0.13
Sanionia uncinata (Hedw.) Loeske		0.07	0.07		0.40		
Scapania hyperborea Jörg.	0.07						
Schistidium apocarpum (Hedw.) Bruch & Schimp.			0.07				
Sphagnum compactum DC.				0.07			
Sphagnum girgensohnii Russow				0.07			
Tetralophozia setiformis (Ehrh.) Schljakov	0.07						
Tetraplodon mnioides (Hedw.) Bruch & Schimp.							0.07

Appendix 4. Mean frequencies (± 1 SE) for a selected subset of vascular and nonvascular species in each vegetation type. Dashes (-) indicate that the species was not present. Frequencies are calculated for 4-m^2 quadrats. Species that occurred with high constancy (CV ≤35%) across sites are in boldface.

4a. Vascular species	**Low elevation (0-450 m)**				**Mid-elevation (450-900 m)**				**High (>900 m)**	
	Spruce woodland		**Closed spruce**		**Spruce woodland**		**Dwarf shrub**		**Dwarf shrub**	
Growth form & species	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**
Tree										
Picea glauca	**15.8 (3.3)**	**0.21**	**48.9 (7.4)**	**0.15**	**27.8 (4.5)**	**0.16**	8.3 (3.7)	0.45	-	-
Betula neoalaskana	2.4 (1.4)	0.59	6.7 (3.9)	0.58	-	-	-	-	-	-
Shrub										
Arctostalphylos alpina	**15.2 (4.3)**	**0.28**	-	-	3.3 (2.4)	0.71	**31.7 (7.7)**	**0.24**	18.1 (7.0)	0.39
Betula nana	**80.0 (5.5)**	**0.07**	2.2 (2.1)	0.98	**95.6 (2.5)**	**0.03**	**0.95 (2.5)**	**0.03**	10.5 (4.8)	0.46
Ledum palustre ssp. *decumbens*	**96.4 (1.3)**	**0.01**	15.6 (7.8)	0.50	**87.8 (4.8)**	**0.05**	**98.3 (1.6)**	**0.02**	**42.9 (8.7)**	**0.20**
Salix arctica	-	-	-	-	-	-	-	-	**37.1 (9.3)**	**0.25**
Salix glauca	**10.3 (3.3)**	**0.32**	1.1 (1.1)	0.98	**16.7 (5.3)**	**0.32**	13.3 (4.9)	0.37	-	-
Salix phlebophylla	-	-	-	-	-	-	6.7 (4.9)	0.74	**85.7 (4.5)**	**0.05**
Salix pulchra	**10.3 (3.4)**	**0.33**	15.6 (5.8)	0.37	10.0 (3.9)	0.39	**21.7 (5.5)**	**0.26**	-	-
Spiraea beauverdiana	**19.4 (5.2)**	**0.27**	1.1 (1.1)	0.98	18.9 (7.6)	0.40	3.3 (2.2)	0.65	-	-
Vaccinium uliginosum	**83.6 (4.0)**	**0.05**	13.3 (6.9)	0.51	**78.9 (6.2)**	**0.08**	**93.3 (4.9)**	**0.05**	**48.5 (8.4)**	**0.17**
Viburnum edule	-	-	**23.3 (7.4)**	**0.32**	-	-	-	-	-	-
Dwarf shrub										
Empetrum nigrum	**55.8 (7.6)**	**0.14**	**34.4 (6.8)**	**0.20**	**93.3 (3.5)**	**0.04**	**63.3 (10.8)**	**0.17**	**26.7 (6.7)**	**0.25**
Diappenisa lapponica	-	-	-	-	-	-	-	-	**85.7 (4.7)**	**0.06**
Dryas octopetala	-	-	-	-	-	-	-	-	**91.4 (4.6)**	**0.05**
Loiseleuria procumbens	-	-	-	-	-	-	**11.7 (3.7)**	**0.32**	**58.1 (7.5)**	**0.13**
Vaccinium vitis-idaea	**97.0 (3.0)**	**0.03**	**58.9 (9.8)**	**0.17**	**100.0 (0.0)**	**0.00**	**96.7 (3.2)**	**0.03**	**39.0 (8.1)**	**0.21**
Graminoid										
Carex lugens	**17.6 (5.4)**	**0.31**	-	-	**47.8 (6.9)**	**0.14**	**93.3 (4.3)**	**0.05**	-	-
Carex microchaeta	-	-	-	-	-	-	-	-	**90.5 (4.6)**	**0.05**
Calamagrostis canadensis	**50.3 (6.5)**	**0.13**	**88.9 (4.2)**	**0.05**	**11.1 (3.9)**	**0.35**	-	-	-	-
Festuca altaica	3.6 (1.6)	0.44	5.6 (4.4)	0.79	**21.1 (7.5)**	**0.35**	5.0 (4.8)	0.96	12.4 (5.8)	0.47
Anthoxanthum monticola ssp. alpinum	5.4 (2.6)	0.48	1.1 (1.1)	0.98	**44.4 (8.9)**	**0.20**	**76.7 (10.0)**	**0.13**	**91.4 (4.6)**	**0.05**
Trisetum spicatum	-	-	-	-	-	-	-	-	-	-
Forb										
Achillea millefolium ssp. borealis	-	-	-	-	-	-	-	-	-	-
Anemnone narcissiflora	-	-	-	-	7.8 (5.5)	0.71	8.3 (4.4)	0.53	**85.7 (4.7)**	**0.06**
Arnica frigida	-	-	-	-	-	-	-	-	21.0 (7.6)	0.36
Artemisia arctica ssp. arctica	-	-	-	-	14.4 (7.2)	0.50	5.0 (3.5)	0.69	**20.0 (6.2)**	**0.31**
Campanula lasiocarpa	2.4 (2.4)	0.99	-	-	2.2 (1.5)	0.67	10.0 (6.4)	0.65	**70.5 (8.2)**	**0.12**
Chamerion angustifolium	3.0 (1.3)	0.41	**41.1 (9.1)**	**0.22**	16.7 (7.8)	0.47	-	-	-	-
Oxytropis nigricans ssp. bryophila	-	-	-	-	-	-	1.7 (1.6)	0.96	**75.2 (8.5)**	**0.11**
Polygonum viviparum	-	-	-	-	-	-	1.7 (1.6)	0.96	**28.6 (6.4)**	**0.22**
Rhodiola integrifolia	-	-	1.1 (1.1)	0.98	-	-	-	-	**17.1 (4.7)**	**0.28**
Trientalis europaea	-	-	**35.6 (9.1)**	**0.26**	8.9 (3.6)	0.41	-	-	-	-

4b. Nonvascular species - Lichens	Low elevation (0-450 m)				Mid-elevation (450-900 m)						High (>900 m)	
	Spruce woodland		Closed spruce		Spuce woodland		Low shrub		Dwarf shrub		Dwarf shrub	
Growth form & species	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**
Cetraria islandica ssp. *crispiformis*	**34.5 (4.5)**	**0.13**	1.1 (1.1)	0.98	**55.6 (7.8)**	**0.14**	**17.8 (3.8)**	**0.21**	**76.7 (8.1)**	**0.11**	**54.7 (10.5)**	**0.19**
Cetraria kamczatica	-	-	-	-	-	-	-	-	16.7 (7.8)	0.47	**55.8 (6.8)**	**0.12**
Cetraria laevigata	**29.7 (5.0)**	**0.17**	-	-	**34.4 (7.4)**	**0.21**	**66.7 (11.8)**	**0.18**	26.7 (10.4)	0.39	5.3 (4.2)	0.80
Cetrariella fastigiata	-	-	-	-	-	-	-	-	-	-	4.2 (2.4)	0.57
Cladonia amaurocraea	**20.6 (5.3)**	**0.26**	-	-	14.4 (5.2)	0.36	28.9 (10.5)	0.36	25.0 (9.5)	0.38	**36.8 (8.4)**	**0.27**
Cladonia arbuscula ssp. *beringiana*	**77.6 (4.2)**	**0.05**	1.1 (1.1)	0.98	**74.4 (6.1)**	**0.08**	**86.7 (5.5)**	**0.06**	**93.3 (4.3)**	**0.05**	**82.1 (5.6)**	**0.07**
Cladonia bellidiflora	-	-	-	-	7.8 (2.8)	0.40	6.7 (3.2)	0.47	**26.7 (5.5)**	**0.21**	-	-
Cladonia borealis	1.2 (0.8)	0.69	-	-	3.3 (2.4)	0.71	8.9 (4.6)	0.52	1.7 (1.6)	0.96	**58.9 (5.5)**	**0.09**
Cladonia chlorophaea	**16.4 (3.2)**	**0.19**	10.0 (3.9)	0.39	**33.3 (5.5)**	**0.16**	**35.6 (6.1)**	**0.17**	**65.0 (8.6)**	**0.13**	**11.6 (3.1)**	**0.27**
Cladonia cornuta ssp. *cornuta*	**26.1 (4.0)**	**0.15**	5.6 (3.1)	0.55	**47.8 (4.2)**	**0.09**	**28.9 (7.1)**	**0.25**	**35.0 (7.2)**	**0.20**	1.1 (1.0)	0.98
Cladonia crispata ssp. *crispata*	**20.6 (4.2)**	**0.20**	2.2 (1.5)	0.67	**38.9 (3.7)**	**0.09**	**62.2 (4.9)**	**0.08**	**75.0 (6.7)**	**0.09**	**8.4 (2.7)**	**0.32**
Cladonia cyanipes	4.8 (2.1)	0.44	1.1 (1.1)	0.98	7.8 (2.8)	0.36	-	-	8.3 (4.4)	0.53	1.1 (1.0)	0.98
Cladonia gracilis ssp. *elongata*	-	-	1.1 (1.1)	0.98	-	-	-	-	15.0 (8.6)	0.57	3.2 (2.2)	0.71
Cladonia gracilis ssp. *vulnerata*	**77.6 (4.9)**	**0.06**	1.1 (1.1)	0.98	**77.8 (4.1)**	**0.05**	**82.2 (7.4)**	**0.09**	**81.7 (6.5)**	**0.08**	**14.7 (4.9)**	**0.33**
Cladonia macroceras	-	-	-	-	-	-	-	-	1.7 (1.6)	0.96	**48.4 (6.7)**	**0.14**
Cladonia phyllophora	3.0 (1.5)	0.50	-	-	8.9 (3.2)	0.36	17.8 (7.4)	0.41	16.7 (6.2)	0.37	**16.8 (5.0)**	**0.30**
Cladonia rangiferina	7.3 (3.1)	0.42	2.2 (1.5)	0.67	3.3 (1.8)	0.53	20.0 (10.0)	0.50	15.0 (5.9)	0.39	10.5 (5.7)	0.54
Cladonia scabriuscula	**6.1 (2.0)**	**0.33**	2.2 (1.5)	0.67	**14.4 (4.9)**	**0.34**	8.9 (6.4)	0.72	**20.0 (5.8)**	**0.29**	-	-
Cladonia squamosa	1.8 (1.0)	0.55	-	-	3.3 (1.8)	0.53	11.1 (5.6)	0.50	15.0 (6.7)	0.45	3.2 (3.1)	0.98
Cladonia stygia	**76.4 (4.1)**	**0.05**	1.1 (1.1)	0.98	**92.2 (3.6)**	**0.04**	**77.8 (6.7)**	**0.09**	**83.3 (5.2)**	**0.06**	**41.1 (7.7)**	**0.19**
Cladonia stellaris	**24.2 (5.0)**	**0.21**	-	-	**26.7 (6.9)**	**0.26**	15.6 (6.1)	0.39	**41.7 (9.6)**	**0.23**	-	-
Cladonia subfurcata	2.4 (1.4)	0.59	-	-	2.2 (2.2)	0.98	2.2 (2.1)	0.95	10.0 (5.0)	0.50	**9.5 (2.7)**	**0.29**
Cladonia sulphurina	6.7 (2.4)	0.36	2.2 (1.5)	0.67	**14.4 (3.5)**	**0.24**	4.4 (2.8)	0.63	**16.7 (5.2)**	**0.31**	1.1 (1.0)	0.98
Cladonia uncialis	**15.2 (4.6)**	**0.31**	-	-	**36.7 (7.4)**	**0.20**	**44.4 (8.2)**	**0.18**	**73.3 (6.0)**	**0.08**	**63.2 (6.2)**	**0.10**
Flavocetraria cucullata	**18.8 (5.4)**	**0.29**	2.2 (2.2)	0.98	**37.8 (9.8)**	**0.26**	**80.0 (8.4)**	**0.10**	**88.3 (5.5)**	**0.06**	**58.9 (9.6)**	**0.16**
Lobaria linita	0.6 (0.6)	0.99	2.2 (2.2)	0.98	3.3 (2.4)	0.71	2.2 (2.1)	0.95	6.7 (2.7)	0.41	14.7 (6.8)	0.46
Peltigera aphthosa	**52.1 (4.4)**	**0.08**	3.3 (1.8)	0.53	**66.7 (5.2)**	**0.08**	**37.8 (8.0)**	**0.21**	**36.7 (6.6)**	**0.18**	5.3 (2.5)	0.48
Peltigera britannica	-	-	-	-	-	-	-	-	-	-	-	-
Peltigera leucophlebia	**9.7 (2.9)**	**0.30**	12.2 (5.3)	0.43	**17.8 (5.4)**	**0.31**	-	-	**20.0 (6.7)**	**0.33**	4.2 (2.4)	0.57
Peltigera malacea	**28.5 (5.0)**	**0.18**	1.1 (1.1)	0.98	**34.4 (5.4)**	**0.16**	**28.9 (7.1)**	**0.25**	15.0 (6.3)	0.42	2.1 (1.4)	0.67
Peltigera polydactyla	**13.3 (3.2)**	**0.24**	2.2 (1.5)	0.67	**24.4 (4.9)**	**0.20**	**22.2 (7.4)**	**0.33**	**25.0 (6.7)**	**0.27**	1.1 (1.0)	0.98
Peltigera praetextata	-	-	5.6 (3.1)	0.55	-	-	-	-	-	-	-	-
Peltigera scabrosa	**37.0 (5.5)**	**0.15**	-	-	**44.4 (6.2)**	**0.14**	13.3 (5.5)	0.41	**26.7 (4.9)**	**0.18**	-	-
Psoroma hypnorum	1.8 (1.3)	0.73	-	-	6.7 (3.2)	0.47	-	-	6.7 (2.7)	0.41	3.2 (1.7)	0.53
Sphaerophorus globosus	1.2 (1.2)	0.99	-	-	-	-	4.4 (2.8)	0.63	16.7 (7.8)	0.47	**77.9 (7.5)**	**0.10**
Stereocaulon paschale	**8.5 (2.9)**	**0.34**	-	-	**46.7 (6.5)**	**0.14**	**62.2 (9.7)**	**0.16**	**85.0 (7.2)**	**0.08**	**28.4 (8.6)**	**0.30**
Thamnolia subuliformis	1.2 (0.8)	0.69	-	-	-	-	8.9 (4.6)	0.52	-	-	**41.1 (10.8)**	**0.26**
Thamnolia vermicularis	0.6 (0.6)	0.99	-	-	6.7 (4.7)	0.71	**33.3 (11.8)**	**0.35**	**76.7 (7.4)**	**0.10**	**50.5 (9.3)**	**0.18**
Tuckermannopsis sepincola	**64.8 (5.4)**	**0.08**	1.1 (1.1)	0.98	**52.2 (5.0)**	**0.10**	**53.3 (11.8)**	**0.22**	**26.7 (6.4)**	**0.24**	-	-

4c. Nonvascular species - Bryophytes	**Low elevation (0-450 m)**				**Mid-elevation (450-900 m)**						**High (>900 m)**	
	Spruce woodland		**Closed spruce**		**Spruce woodland**		**Low shrub**		**Dwarf shrub**		**Dwarf shrub**	
Growth form & species	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**	**mean**	**CV**
Anastrophyllum minutum var. *minutum*	-	-	-	-	2.2 (1.5)	0.67	-	-	1.7 (1.6)	0.96	13.7 (5.4)	0.39
Aulacomnium palustre	**45.5 (5.5)**	**0.12**	**14.4(4.1)**	**0.29**	**27.8 (6.9)**	**0.25**	15.6 (6.9)	0.44	10.0 (4.4)	0.44	-	-
Aulacomnium turgidum	**26.1 (6.8)**	**0.26**	1.1 (1.1)	0.98	24.4 (9.0)	0.37	**48.9 (11.0)**	**0.22**	**50.0 (7.7)**	**0.15**	12.6 (4.5)	0.36
Barbilophozia kunzeana	-	-	-	-	-	-	-	-	-	-	-	-
Dicranum fuscescens var. *fuscescens*	2.4 (1.1)	0.47	-	-	3.3 (2.4)	0.71	6.7 (6.3)	0.95	8.3 (8.0)	0.96	7.4 (3.1)	0.42
Dicranum groenlandicum	-	-	-	-	**24.4 (6.4)**	**0.26**	**46.7 (9.5)**	**0.20**	**65.0 (6.3)**	**0.10**	**45.3 (5.6)**	**0.12**
Dicranum scoparium	**18.8 (4.5)**	**0.24**	**11.1 (3.9)**	**0.35**	**56.7 (5.1)**	**0.09**	24.4 (8.8)	0.36	**76.7 (8.8)**	**0.11**	7.4 (3.1)	0.42
Dicranum undulatum	**10.9 (2.6)**	**0.24**	5.6 (3.1)	0.55	**24.4 (7.8)**	**0.32**	**20.0 (7.1)**	**0.35**	13.3 (8.0)	0.60	13.3 (8.0)	0.60
Hypnum plicatulum	2.4 (1.4)	0.59	2.2 (1.5)	0.67	**11.1 (3.9)**	**0.35**	-	-	**15.0 (4.8)**	**0.32**	5.3 (2.5)	0.48
Hylocomium splendens	**47.3 (6.3)**	**0.13**	**98.9 (1.1)**	**0.01**	**63.3 (5.1)**	**0.08**	**31.1 (9.0)**	**0.29**	**35.0 (10.4)**	**0.30**	**11.6 (3.8)**	**0.32**
Pleurozium schreberi	**70.3 (5.5)**	**0.08**	**21.1 (7.5)**	**0.35**	**57.8 (8.9)**	**0.15**	**60.0 (7.1)**	**0.12**	20.0 (7.5)	0.37	-	-
Polytrichum commune ssp. *commune*	**40.0 (6.2)**	**0.16**	**14.4 (4.9)**	**0.34**	**83.3 (4.5)**	**0.05**	**80.0 (5.5)**	**0.07**	**90.0 (4.4)**	**0.05**	-	-
Polytrichum juniperinum	4.8 (2.4)	0.50	7.8 (3.6)	0.46	-	-	-	-	1.7 (1.6)	0.96	**17.9 (4.5)**	**0.25**
Polytrichum strictum	**46.1 (6.2)**	**0.13**	1.1 (1.1)	0.98	**43.3 (6.9)**	**0.16**	**46.7 (7.7)**	**0.17**	**25.0 (8.2)**	**0.33**	2.1 (2.1)	0.98
Ptilidium ciliare	**25.5 (5.1)**	**0.20**	**18.9 (5.6)**	**0.30**	8.9 (3.2)	0.36	**20.0 (7.1)**	**0.35**	1.7 (1.6)	0.96	-	-
Ptilium crista-castrensis	**19.4 (3.9)**	**0.20**	**55.6 (8.4)**	**0.15**	**8.9 (2.8)**	**0.32**	11.1 (4.6)	0.41	**11.7 (2.9)**	**0.25**	-	-
Racomitrium lanuginosum	1.2 (0.8)	0.69	-	-	6.7 (4.7)	0.71	4.4 (4.2)	0.95	5.0 (4.8)	0.96	**55.8 (6.8)**	**0.12**
Rhytidiadelphus loreus	-	-	-	-	-	-	-	-	-	-	-	-
Rhytidiadelphus triquetrus	-	-	15.6 (6.0)	0.39	-	-	-	-	-	-	-	-
Sanionia uncinata	4.2 (2.2)	0.53	**14.4 (2.6)**	**0.18**	-	-	2.2 (2.1)	0.95	1.7 (1.6)	0.96	4.2 (2.4)	0.57
Sphagnum girgensohnii	**23.0 (4.2)**	**0.18**	2.2 (1.5)	0.67	**10.0 (3.3)**	**0.33**	8.9 (3.3)	0.37	10.0 (5.6)	0.56	1.1 (1.0)	0.98

Appendix 5. Indicator species for major vegetation types sampled in KATM (2009) and LACL (2010). Indicator values (IV) range between 0 (no indication) to 100 (perfect indication), and were tested for significance using a Monte Carlo randomization test. Only those species with an IV of *P*≤0.05 are reported. Species with an IV >60 (arbitrary threshold) are shown inboldface.

5a. Low elevation (0-450 m) closed spruce forest (including beetle kill)

Species	Observed Indicator Value (IV)	*P*<
Vascular		
Aconitum delphiniifolium	20.0	0.0334
Artemisia tilesii	20.0	0.0338
Betula neoalaskana	52.6	0.0004
Calamagrostis canadensis	51.4	0.0002
Cornus suecica	39.7	0.0016
Equisetum arvense	48.7	0.0002
Goodyera repens	40.0	0.0016
Gymnocarpium dryopteris	30.0	0.0024
Linnaea borealis	**60.0**	**0.0002**
Lycopodium annotinum	20.0	0.0294
Moneses uniflora	36.8	0.0038
Orthilia secunda	**62.8**	**0.0002**
Picea glauca	46.0	0.0002
Populus balsamifera	46.6	0.0006
Pyrola grandiflora	40.0	0.002
Ribes triste	40.0	0.002
Rosa acicularis	49.5	0.0004
Rubus arcticus	38.4	0.0014
Rubus arcticus ssp. *arcticus*	30.0	0.005
Trientalis europaea subsp. *arctica*	40.2	0.0034
Viburnum edule	40.0	0.0014
Lichens		
Cladonia umbricola	33.4	0.003
Hypogymnia bitteri	20.0	0.0296
Nephroma bellum	30.0	0.0024
Parmelia sulcata	22.5	0.017
Peltigera collina	20.0	0.0292
Peltigera praetextata	**60.0**	**0.0002**
Bryophytes		
Brachythecium erythrorrhizon	27.8	0.0104
Brachythecium nelsonii	30.0	0.0038
Dicranum fragilifolium	20.0	0.0294
Dicranum tauricum	50.0	0.0002

5a. Low elevation (0-450 m) closed spruce forest (including beetle kill)

Species	Observed Indicator Value (IV)	*P<*
Eurhynchiastrum pulchellum var. *pulchellum*	34.9	0.003
Hylocomium splendens	40.7	0.0002
Plagiomnium medium	40.0	0.0014
Ptilium crista-castrensis	57.7	0.0002
Rhytidiadelphus loreus	30.0	0.0036
Rhytidiadelphus triquetrus	**70.0**	**0.0002**
Sanionia uncinata	40.9	0.0028
Timmia austriaca	30.0	0.0034

5b. Low elevation (0-450 m) white spruce woodland

Species	Observed Indicator Value (IV)	*P<*
Vascular		
Betula nana	36.9	0.0002
Ledum palustre subsp. *decumbens*	30.6	0.0002
Salix glauca	35.4	0.015
Vaccinium vitis-idaea	27.7	0.0002
Lichens		
Cetraria laevigata	35.8	0.0094
Cladonia cenotea	27.5	0.0208
Cladonia gracilis subsp. *vulnerata*	40.8	0.0002
Cladonia stygia	30.2	0.0024
Parmeliopsis ambigua	30.1	0.0304
Peltigera aphthosa	45.8	0.0002
Tuckermannopsis sepincola	49.8	0.0002
Bryophytes		
Aulacomnium palustre	39.4	0.0012
Dicranum undulatum	31.1	0.0438
Pleurozium schreberi	35.9	0.0002
Polytrichum strictum	35.0	0.0116
Sphagnum girgensohnii	38.2	0.005

5c. Mid elevation (450-900 m) white spruce woodland/treeline

Species	Observed Indicator Value (IV)	*P<*
Vascular		
Achillea millefolium var. *borealis*	33.3	0.0036
Carex lugens	30.9	0.023
Chamerion angustifolium	34.8	0.0206
Empetrum nigrum	29.7	0.0002

5c. Mid elevation (450-900 m) white spruce woodland/treeline

Species	Observed Indicator Value (IV)	*P<*
Lycopodium lagopus	37.5	0.0042
Poa arctica subsp. *arctica*	22.0	0.0254
Sanguisorba canadensis	33.3	0.0038
Lichens		
Cladonia carneola	28.5	0.017
Cladonia cornuta subsp. *cornuta*	39.3	0.0004
Cladonia cyanipes	38.0	0.0072
Cladonia sulphurina	39.0	0.0032
Nephroma arcticum	30.0	0.0462
Peltigera malacea	38.4	0.0022
Peltigera polydactylon	34.5	0.0124
Peltigera scabrosa	36.4	0.0038
Bryophytes		
Dicranum scoparium	33.3	0.0044
Lophozia ventricosa var. *ventricosa*	34.4	0.0054
Polytrichum commune var. *commune*	33.5	0.0002
Ptilidium ciliare	30.2	0.041

5d. Mid elevation (450-900 m) dwarf shrub tundra

Species	Observed Indicator Value (IV)	*P<*
Vascular		
Arctostaphylos alpina	36.4	0.0086
Carex microchaeta subsp. *nesophila*	22.4	0.0308
Dryas sp.	31.2	0.0068
Pedicularis labradorica	34.5	0.0066
Lichens		
Arctocetraria andrejevii	25	0.0114
Cetraria islandica subsp. *crispiformis*	33.2	0.0124
Cetrariella fastigiata	29.1	0.0148
Cladonia arbuscula subsp. *beringiana*	27.8	0.0006
Cladonia bellidiflora	48.4	0.001
Cladonia crispata var. *crispata*	38.5	0.0006
Cladonia gracilis subsp. *elongata*	40.8	0.0042
Flavocetraria cucullata	35.3	0.0052
Lobaria linita	36.7	0.0146
Stereocaulon paschale	42.3	0.0008

5e. High elevation (>900 m) dwarf shrub tundra (*LACL data only)

Species	Observed Indicator Value (IV)	*P<*
Vascular		
Androsace chamaejasme ssp. *lehmanniana*	28.6	0.0104
Anthoxanthum monticola subsp. *alpinum*	43.3	0.0002
Arnica frigida	**64.0**	**0.0002**
Anemone narcissiflora	**71.9**	**0.0002**
Antennaria friesiana	20.7	0.0444
Antennaria monocephala	**98.4**	**0.0002**
Campanula lasiocarpa	**61.5**	**0.0002**
Carex microchaeta	53.9	0.0002
Cassiope tetragona	22.1	0.0312
Diapensia lapponica	**84.4**	**0.0002**
Dryas octopetala	**86.9**	**0.0002**
Festuca brachyphylla	28.6	0.0104
Gentiana glauca	48.7	0.0004
Geum rossii	28.6	0.012
Huperzia selago	45.1	0.0008
Lloydia serotina	47.6	0.0006
Loiseleuria procumbens	34.7	0.0088
Minuartia macrocarpa	**71.4**	**0.0002**
Oxytropis nigrescens* var. *nigrescens	**62.6**	**0.0002**
Packera cymbalaria	57.1	0.0004
Pedicularis capitata	38.7	0.005
Pedicularis lanata	28.6	0.0108
Pedicularis sudetica subsp. *interioides*	28.6	0.0088
Polygonum viviparum	**63.5**	**0.0002**
Primula cuneifolia	24.1	0.0262
Rhodiola integrifolia	29.0	0.0234
Saxifraga bronchialis subsp. *funstonii*	28.6	0.012
Salix phlebophylla	**71.3**	**0.0002**
Tofieldia coccinea	34.5	0.0018
Trisetum spicatum	47.1	0.0004
Lichens		
Alectoria ochroleuca	**90.9**	**0.0002**
Arctoparmelia separata	56.1	0.0002
Asahinea chrysantha	**75.4**	**0.0002**
Asahinea scholanderi	57.1	0.0002
Baeomyces placophyllus	26.1	0.0072
Brodoa oroarctica	42.9	0.0008
Bryocaulon divergens	**90.2**	**0.0002**
Bryoria nitidula	28.6	0.0104

5e. High elevation (>900 m) dwarf shrub tundra (*LACL data only)

Species	Observed Indicator Value (IV)	*P<*
Cetraria ericetorum* subsp. *reticulata	**70.0**	**0.0002**
Cetraria kamczatica	**68.6**	**0.0002**
Cetraria nigricans	**82.3**	**0.0002**
Cladonia amaurocraea	39.0	0.005
Cladonia borealis	**64.9**	**0.0002**
Cladonia macroceras	53.9	0.0002
Cladonia nipponica	35.1	0.003
Cladonia pyxidata	**62.3**	**0.0002**
Cladonia uncialis	39.0	0.0008
Dactylina arctica	44.6	0.0012
Dactylina ramulosa	**85.7**	**0.0002**
Flavocetraria nivalis	**77.1**	**0.0002**
Gowardia nigricans	**95.4**	**0.0002**
Hypogymnia subobscura	**71.4**	**0.0002**
Melanelia hepatizon	**83.5**	**0.0002**
Melanelia stygia	52.3	0.0002
Parmelia omphalodes* subsp. *omphalodes	**81.1**	**0.0002**
Pseudephebe pubescens	**80.1**	**0.0002**
Solorina crocea	42.9	0.0012
Sphaerophorus globosus	**73.8**	**0.0002**
Sticta arctica	28.6	0.0104
Stereocaulon vesuvianum	40.8	0.0004
Thamnolia subuliformis	26.1	0.0182
Thamnolia vermicularis	39.9	0.002
Umbilicaria hyperborea var. *hyperborea*	40.2	0.0006
Umbilicaria krascheninnikovii	**76.6**	**0.0002**
Umbilicaria proboscidea	42.9	0.0008
Umbilicaria torrefacta	28.6	0.0108
Bryophytes		
Andreaea rupestris	**72.8**	**0.0002**
Anthelia juratzkana	46.2	0.0006
Barbula convoluta var. *convoluta*	28.6	0.0104
Bartramia ithyphylla	28.6	0.0094
Conostomum tetragonum	26.3	0.028
Dicranum groenlandicum	41.2	0.0028
Diplophyllum taxifolium* var. *macrosticta	**60.9**	**0.0004**
Nardia scalaris	28.6	0.012
Niphotrichum ericoides	35.0	0.003
Polytrichastrum alpinum var. *alpinum*	57.1	0.0004
Polytrichum hyperboreum	58.5	0.0002

5e. High elevation (>900 m) dwarf shrub tundra (*LACL data only)

Species	Observed Indicator Value (IV)	*P<*
Polytrichum juniperinum	42.1	0.002
Polytrichum piliferum	**82.0**	**0.0002**
Pogonatum urnigerum	**84.0**	**0.0002**
Ptychostomum creberrimum	28.6	0.0086
Racomitrium lanuginosum	43.5	0.002
Rhytidium rugosum	30.0	0.0182

Appendix 6.

2010 Field Season Logistics

Personnel
Chris Lauver – NPS Research Coordinator, PNW CESU
Chuck Lindsay – Physical Science Technician, SWAN
Zachary Meyers – graduate student assistant, University of Alaska Fairbanks
Amy Miller – Ecologist, SWAN
Michael Shephard – Program Manager, SWAN
Rosemary Sheriff – Ecologist, Humboldt State University
Andrew Shulstad – Biological Science Technician, SWAN
James Walton – Biological Science Technician, SWAN

Flight services and aircraft used
Lake Clark National Park and Preserve, Port Alsworth – Cessna 206 on floats
Lake Clark Air, Port Alsworth – Cessna 206 on floats

Snipe Lake
Personnel: ZM, AM, AS, JW
Access to survey area: Snipe Lake – mid-lake landings due to intermittent shallow areas around shoreline.
Camp location: Snipe Lake Ranger Cabin, (NAD 83) 60.622, -154.316.
Hiking: The terrain is primarily rolling spruce woodland with low to moderate density shrub cover (*Betula*, *Salix*).
Weather and environmental conditions: Rain and cool temperatures most days.
Safety considerations: Bear and moose scat around Snipe Lake. Some slick, rocky areas also around shoreline. Recommended footwear includes rubber boots and hiking shoes.
Phenology observations: Extensive *Betula nana* damage – defoliator unknown.
General notes: Each plot was easily surveyed within a 10-h day (including travel time).

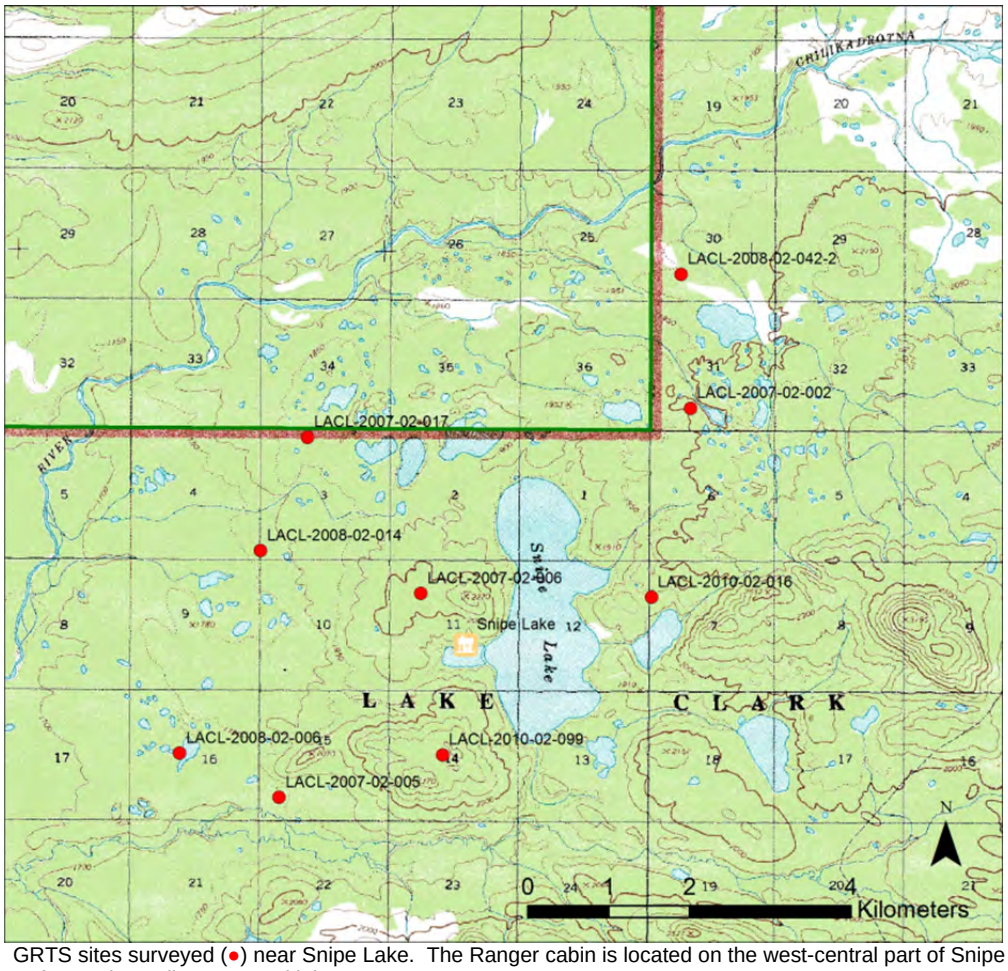

Figure A6-a. GRTS sites surveyed (●) near Snipe Lake. The Ranger cabin is located on the west-central part of Snipe Lake, along the north shore of a much smaller unnamed lake.

Turquoise Lake
Personnel: ZM, AM, AS, JW
Access to survey area: Turquoise Lake – mid-lake landings due to intermittent shallow areas around shoreline.
Camp location: Camp was on small rise on southwest peninsula, (NAD83) 60.781, -153.995.
Hiking: The terrain is primarily low shrub around the lakeshore, and low shrub alpine tundra at higher elevations.
Weather and environmental conditions: Cool temperatures and moderate to strong winds most days.
Safety considerations: To access survey sites north of Turquoise Lake, a lake crossing is required near the inlet of the Mulchatna River. Strong afternoon westerly's were common in the area, producing whitecap conditions on the lake. Recommended footwear includes rubber boots and hiking shoes.
General notes: Because of longer travel times to some plots, and high species richness (nonvascular), survey times were ≥10 h (including travel time).

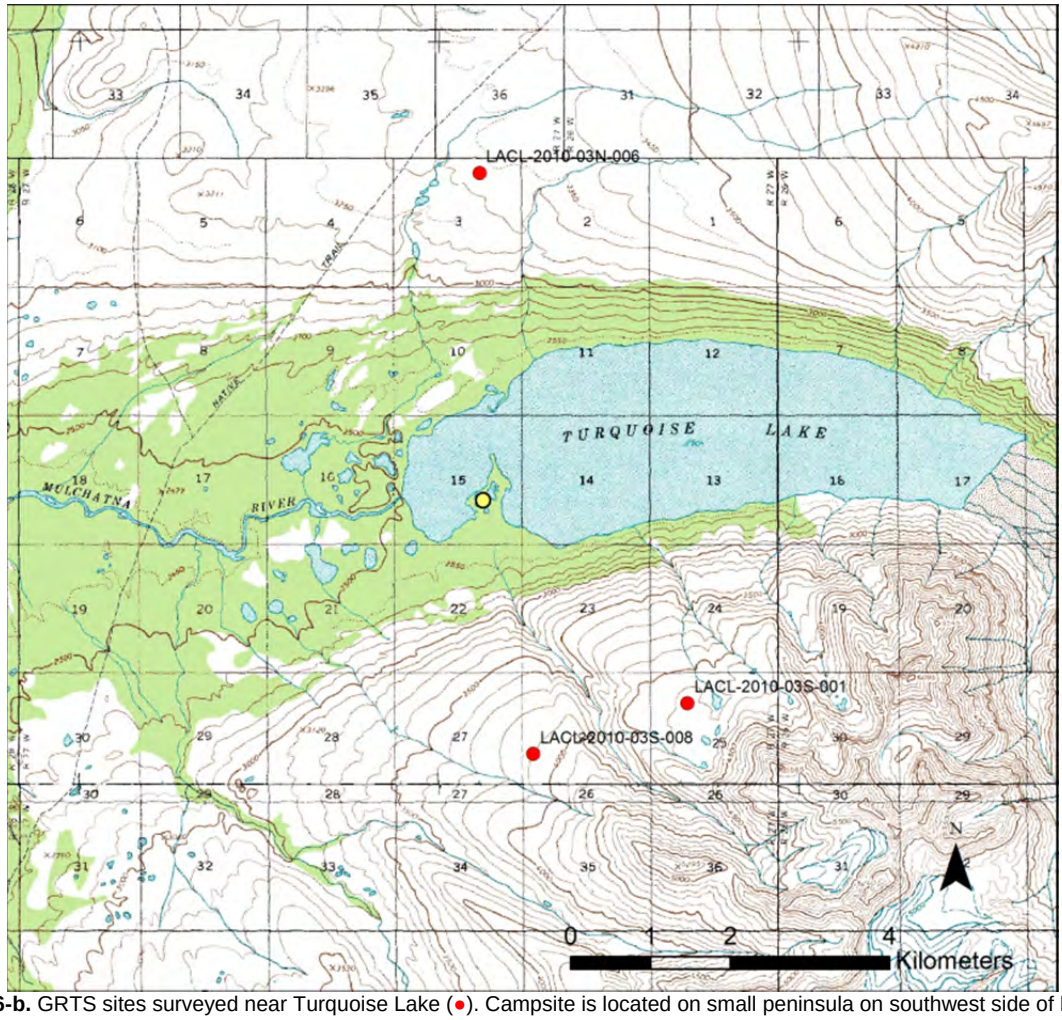

Figure A6-b. GRTS sites surveyed near Turquoise Lake (●). Campsite is located on small peninsula on southwest side of lake (●)

Lower Twin Lake
Personnel: ZM, AS, JW
Access to survey area: Lower Twin Lake – traditional landing area near Lower Twin Ranger Cabin.
Camp location: On beach, approx. 200 m west of Lower Twin Ranger Cabin, (NAD83) 60.622339, -154.316928.
Hiking: Mid-elevation terrain is primarily rolling spruce woodland with low to moderately dense shrub cover. High elevation survey sites required a 2-3 hour hike through "Death Valley" canyon, a rocky outwash which includes walking in creek and navigating around waterfall sections.
Weather and environmental conditions: Cool temperatures, moderate to strong winds, and light to moderate rain most days.
Safety considerations: A boat shuttle (from volunteers at the Ranger Cabin) is required to access sites north of the Mulchatna River. The "Death Valley" hike is over unstable rocky outwash, and includes crossing a creek numerous times, shimmying around deep pools in the creek, and scrambling a steep area to get around a large waterfall. Recommended footwear includes rubber boots, sturdy hiking shoes, and sandals for walking in creek.
General notes: Each plot was easily surveyed within one day (including travel time).

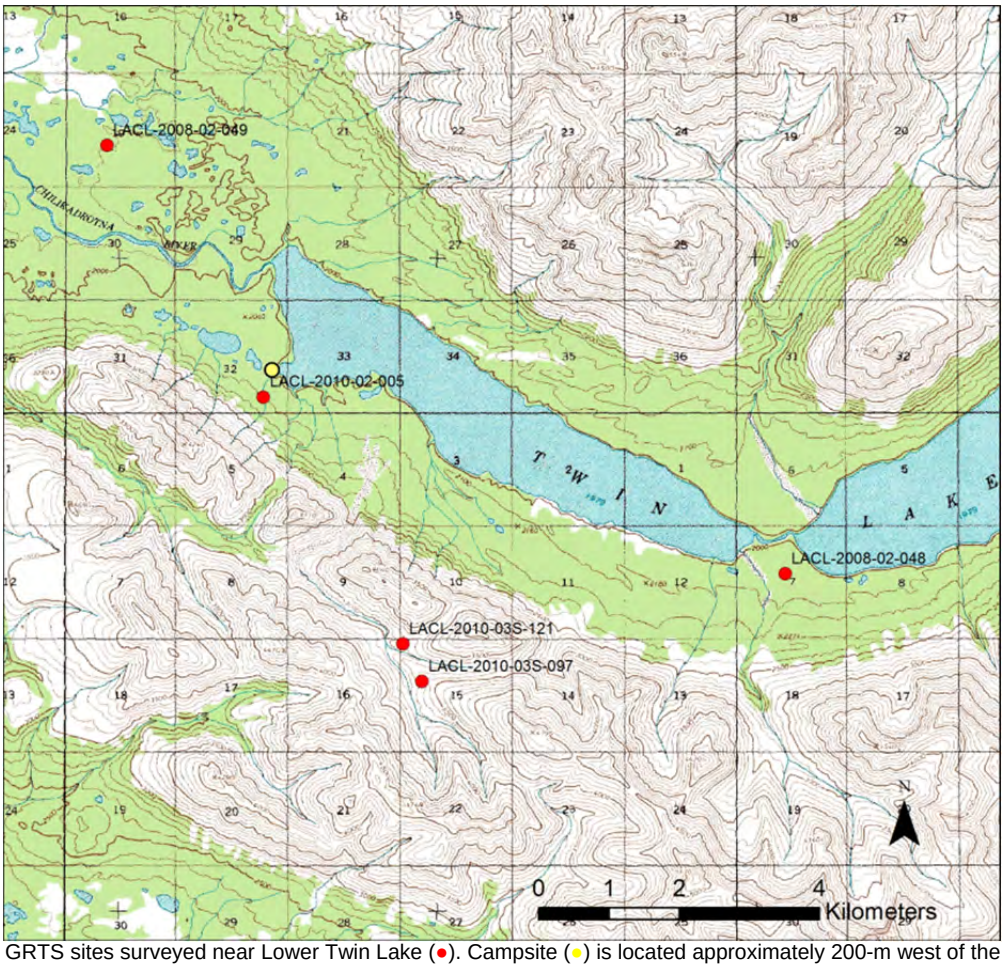

Figure A6-c. GRTS sites surveyed near Lower Twin Lake (●). Campsite (●) is located approximately 200-m west of the Lower Twin Ranger Patrol Cabin.

Two Lakes
Personnel: ZM, AS, JW
Access to survey area: Two Lakes – the two landing areas were adjacent to the two campsites.
Camp location: west campsite: tucked into small clearing in forest next to beach, (NAD 83) 61.121, -153.833; north campsite: on sandy beach area between two small drainages, (NAD 83) 61.136766, -153.740.
Hiking: Terrain is primarily rolling spruce woodland to spruce forest with low to moderately dense shrub cover. Some wetland crossings in area – hip-boots and/or rubber boots are advised.
Weather and environmental conditions: Cool temperatures and light to moderate rain most survey days.
Safety considerations: moose sign observed throughout area. Hip-boots and/or rubber boots and hiking shoes advised.
General notes: Each plot was easily surveyed within a 10-h day (including travel time).

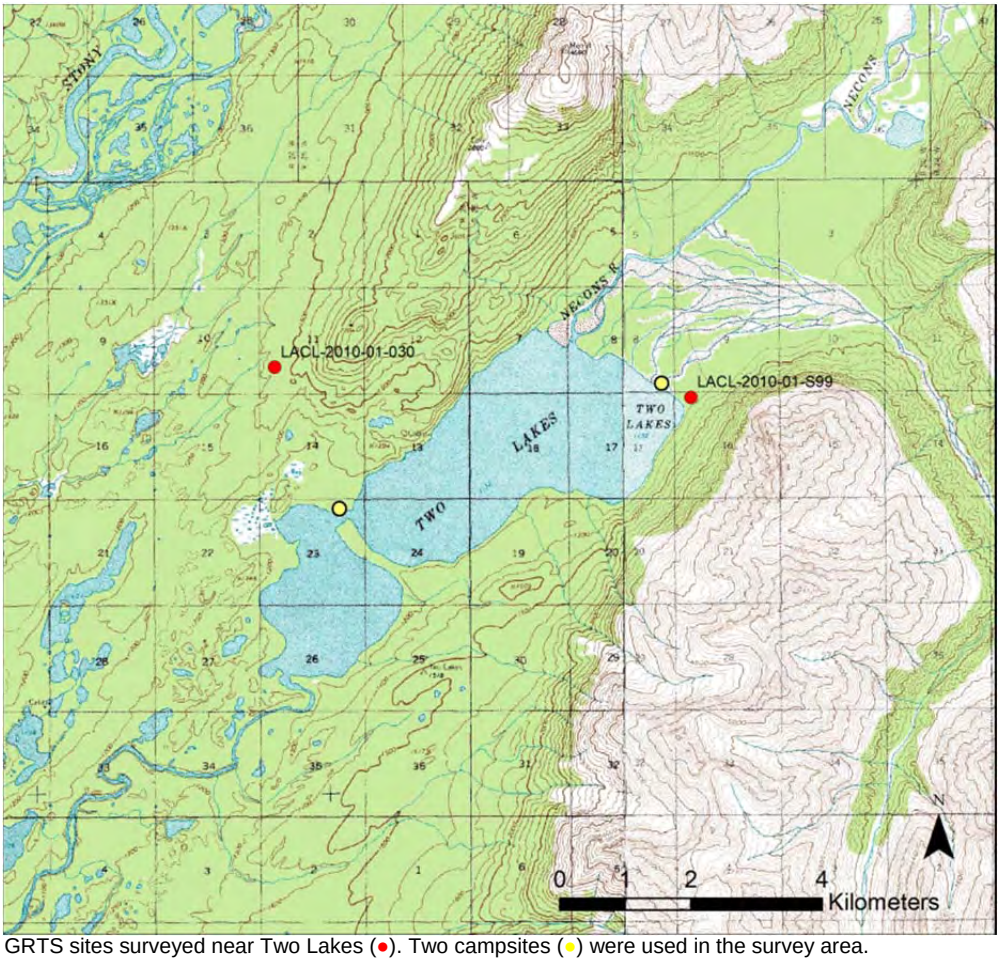

Figure A6-d. GRTS sites surveyed near Two Lakes (●). Two campsites (●) were used in the survey area.

Lachbuna Lake
Personnel: AM, RS, ZM, MS, AS, JW
Access to survey area: Lachbuna Lake - a mid-lake landing is required due to intermittent shallow areas around lake shoreline.
Camp location, At hunter's camp next to seasonal creek, (NAD 83) 60.495, -154.007. A second hunter's camp in the cove just north of the mouth of College Creek (not shown) was used to access the ridgeline sites.
Hiking: Terrain is primarily rolling spruce woodland to spruce forest with low to moderately dense shrub cover. Small creek crossing required to access higher elevation sites to the west (if camped at site shown in yellow).
Weather and environmental conditions: Cool temperatures and light to moderate rain most days.
Safety considerations: Moose sign observed throughout area; creek crossing can be done in rubber boots upstream of outlet if water-level is low enough. Recommended footwear includes rubber boots and hiking shoes.
General notes: Each plot was easily surveyed within a 10-h day (including travel time). Plan on a full 10-h day for upper ridgeline site (LACL-2010-01-098).

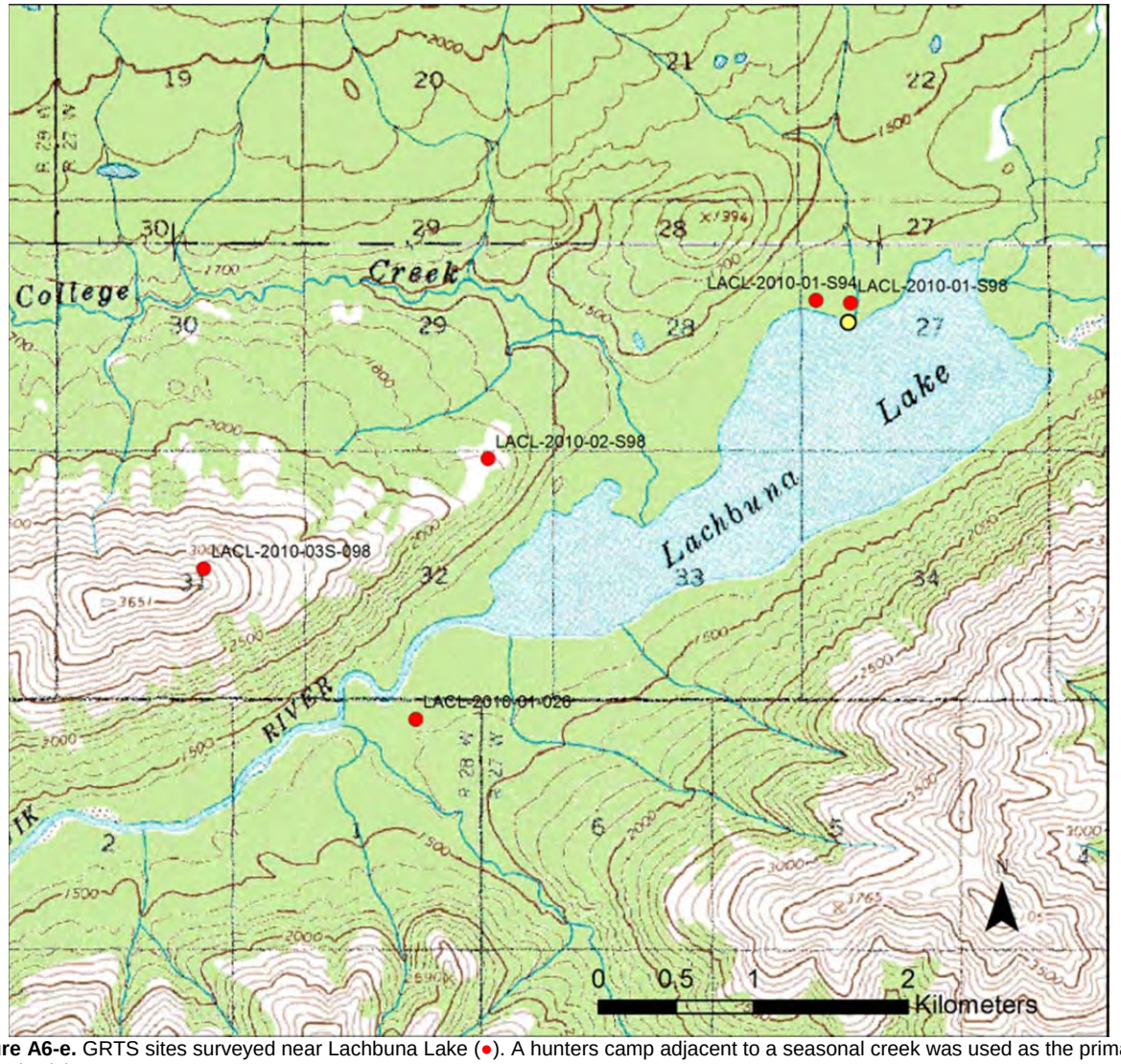

Figure A6-e. GRTS sites surveyed near Lachbuna Lake (●). A hunters camp adjacent to a seasonal creek was used as the primary campsite (●).

Upper Tazimina Lake
Personnel: AM, RS, ZM, CL, AS, JW
Access to survey area: Upper Tazimina Lake – the lake is deep throughout, so no obvious landing hazards.
Camp location: western campsite: directly on beach, (NAD 83) 60.036, -154.237; eastern campsite: established campsite area just east of creek outlet, (NAD 83) 60.040, -154.012.
Hiking: Terrain is primarily rolling spruce woodland to spruce forest with low to moderately dense shrub cover.
Weather and environmental conditions: Cool temperatures and light to moderate rain most days.
Safety considerations: Moose sign observed throughout area. GRTS survey site LACL-2010-01-S97 had abundant blowdown. Recommended footwear includes rubber boots and hiking shoes.
General notes: Each plot was easily surveyed within a 10-h day (including travel time).

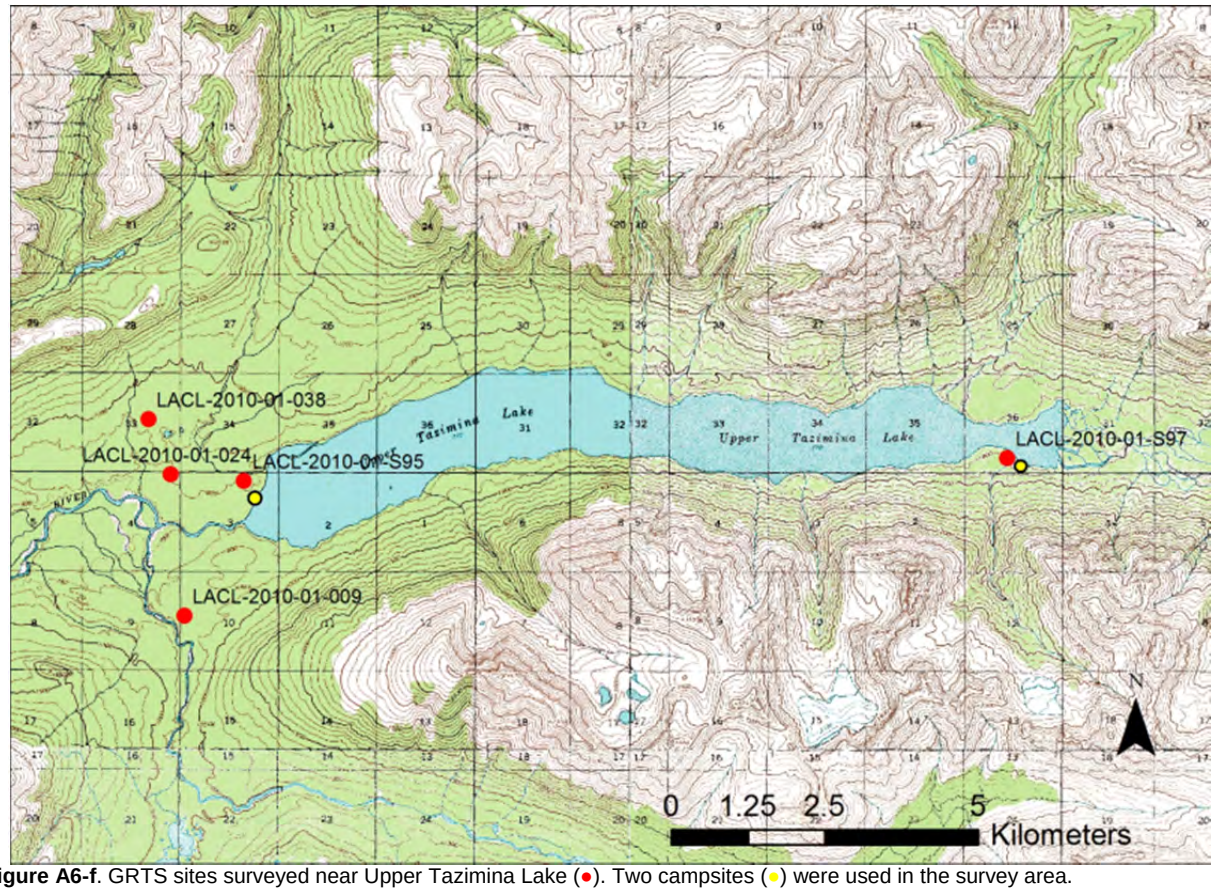

Figure A6-f. GRTS sites surveyed near Upper Tazimina Lake (●). Two campsites (●) were used in the survey area.

Tlikakila River
Personnel: AM, RS, ZM, AS, JW
Access to survey area: Daytrip from Port Alsworth using large NPS freight boat.
Hiking: Terrain is primarily spruce forest with moderately dense shrub cover and a mosaic of wetland area.
Weather and environmental conditions: Cool temperatures and light to moderate rain during the survey day. The boat ride can be cold due to wind chill and bow-water spray.
Safety considerations: Moose sign observed throughout area. Hip boots or rubber boots recommended for navigating through wetland areas.
General notes: The plot was easily surveyed within a 10-h day (including travel time).

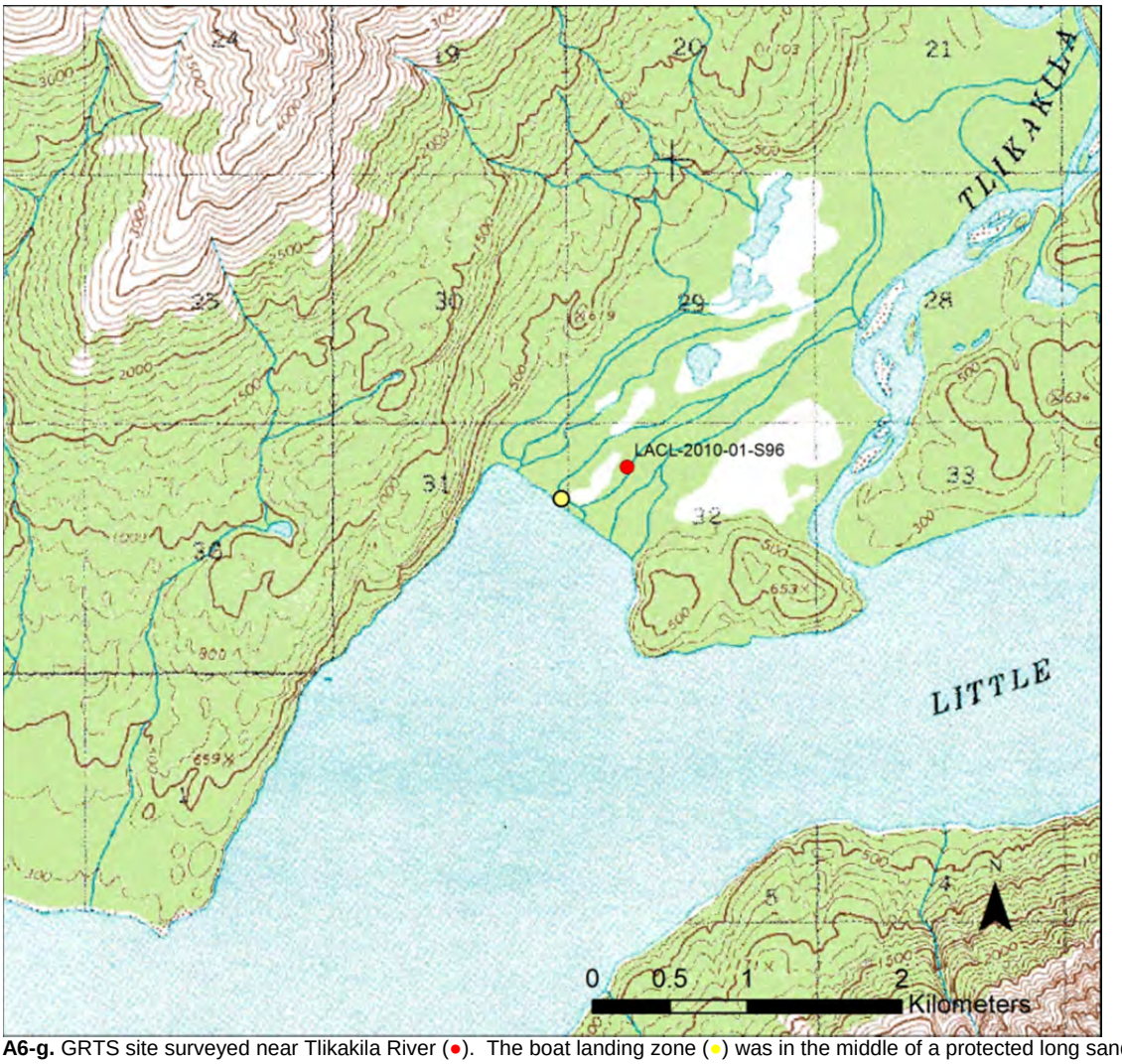

Figure A6-g. GRTS site surveyed near Tlikakila River (●). The boat landing zone (●) was in the middle of a protected long sandy beach.

Telaquana Lake
Personnel: CL, AS, JW
Access to survey area: Telaquana Lake – The lake is shallow within 100-m of campsite area, so a mid-lake landing is required.
Camp location: Campsite area shows signs of past use due to it being the only usable beach space along the southwestern shoreline, (NAD 83) 60.962, -150.001.
Hiking: Terrain is primarily rolling spruce woodland with low to moderately dense shrub cover. Hip boots or rubber boots are recommended for accessing most survey sites due to wetland crossings.
Weather and environmental conditions: Cool temperatures and moderate to heavy rain most days.
Safety considerations: Moose sign observed throughout area. Wetland crossings are common, notably to GRTS survey site LACL-2010-01-051, where hip-boots are strongly recommended.
General notes: Each plot was easily surveyed within a 10-h day (including travel time).

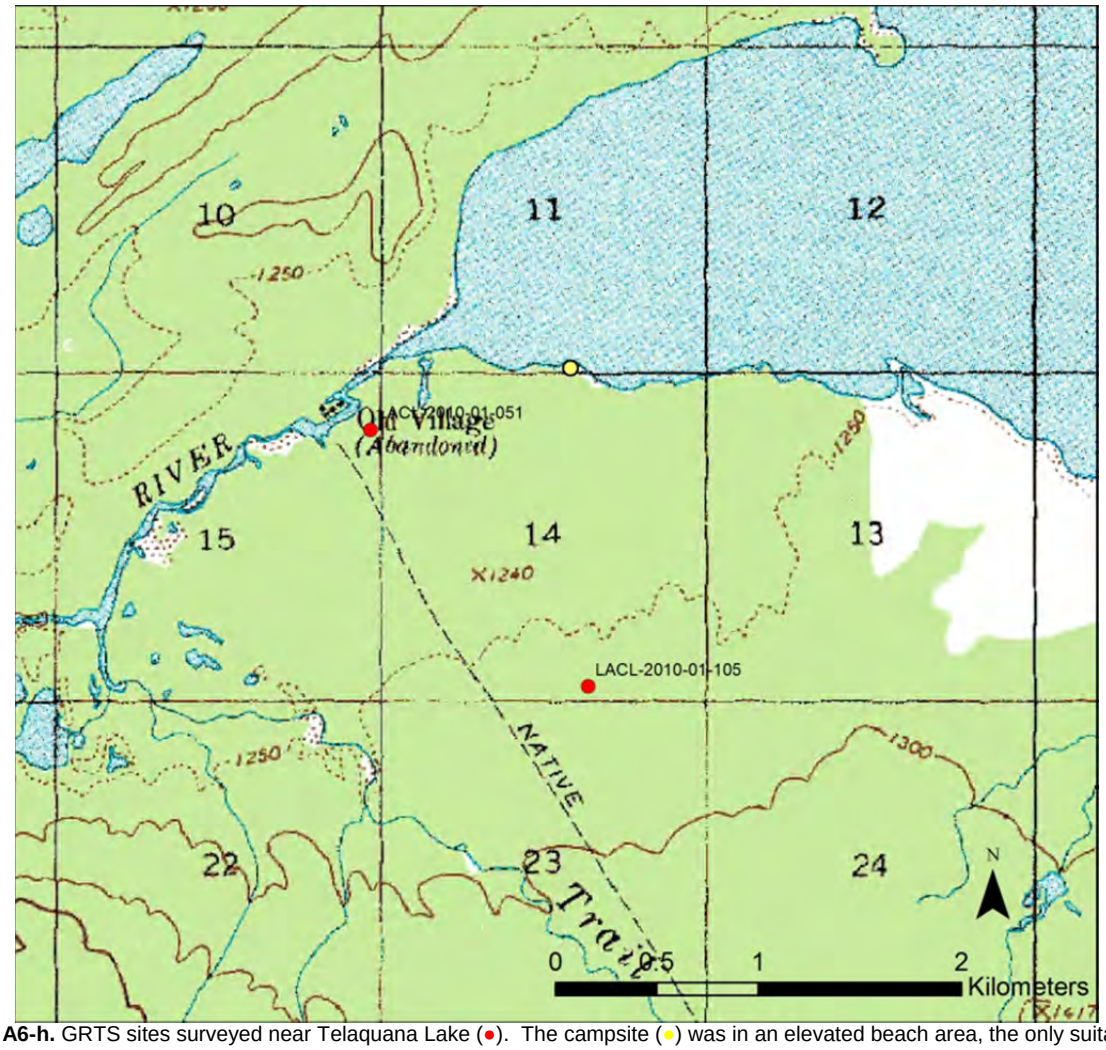

Figure A6-h. GRTS sites surveyed near Telaquana Lake (●). The campsite (●) was in an elevated beach area, the only suitable spot for camping along the southwest shoreline.

Fishtrap
Personnel: CL, AS, JW
Access to survey area: Fishtrap Lake – mid lake landing recommended due to size of lake.
Camp location: Camp was on a nearby ridgeline to allow for greater sight distance in watching for bears, (NAD 83) 60.489, -154.324.
Hiking: Terrain is primarily rolling spruce woodland with low to moderately dense shrub cover.
Weather and environmental conditions: Cool temperatures and light to moderate rain during the survey day.
Safety considerations: Moose sign observed throughout area. Rubber boots and hiking shoes are recommended.
General notes: The plot was easily surveyed within a 10-h day (including travel time).

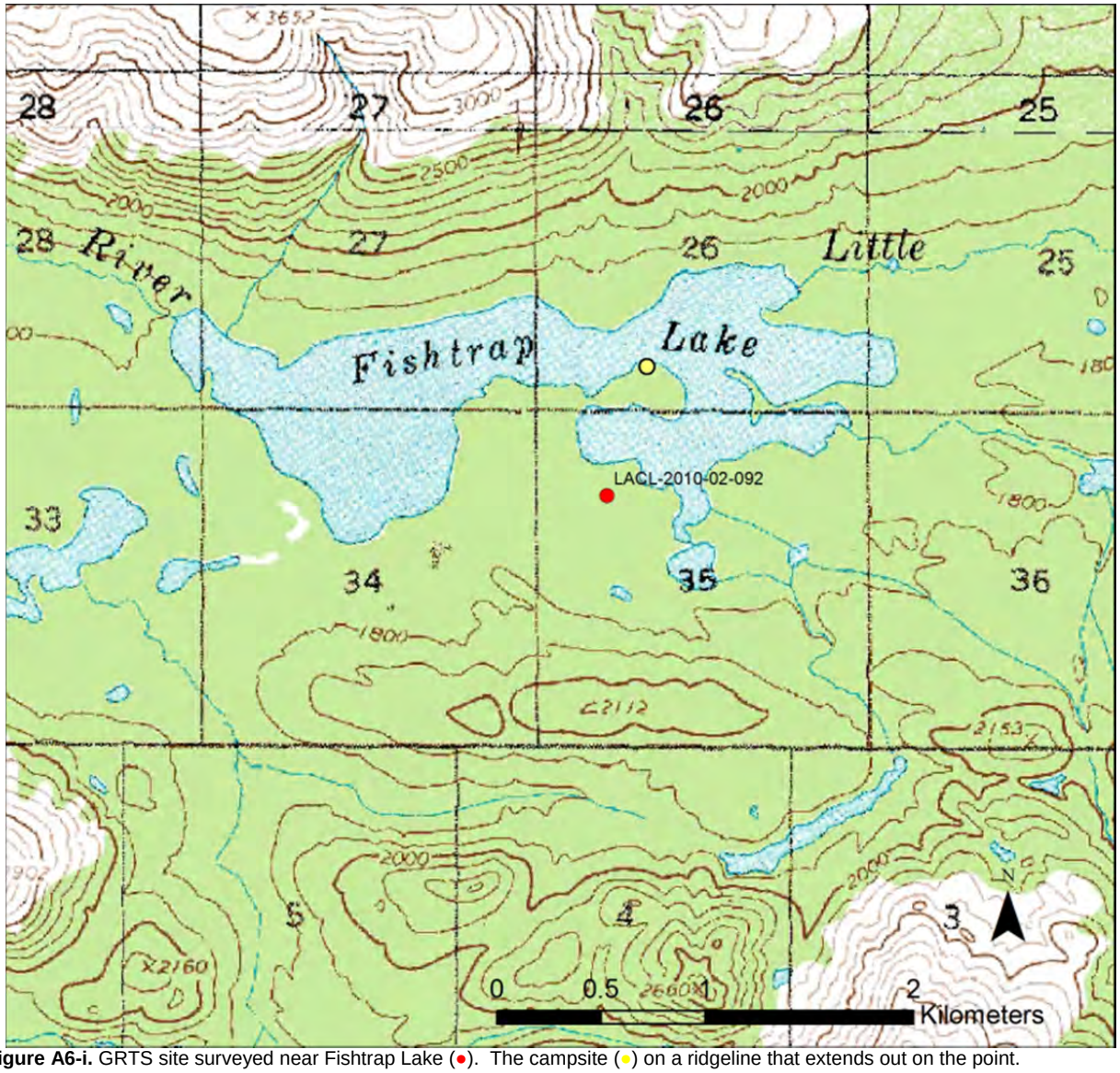

Figure A6-i. GRTS site surveyed near Fishtrap Lake (●). The campsite (●) on a ridgeline that extends out on the point.

Pickerel Lakes
Personnel: CL, ZM, AS, JW
Access to survey area: Pickeral Lake – The lake is shallow around the shoreline so a mid-lake landing is required. The safest place to beach the plane ((NAD 83) 59.948, -154.758) is shown in Figure a6-j.
Hiking: Terrain is primarily rolling spruce woodland with low to moderately dense shrub cover.
Weather and environmental conditions: Cool temperatures and mild to moderate rain most days.
Safety considerations: Moose and bear sign observed throughout area. Rubber boots and hiking shoes are recommended.
General notes: Each plot was easily surveyed within a 10-h day (including travel time).

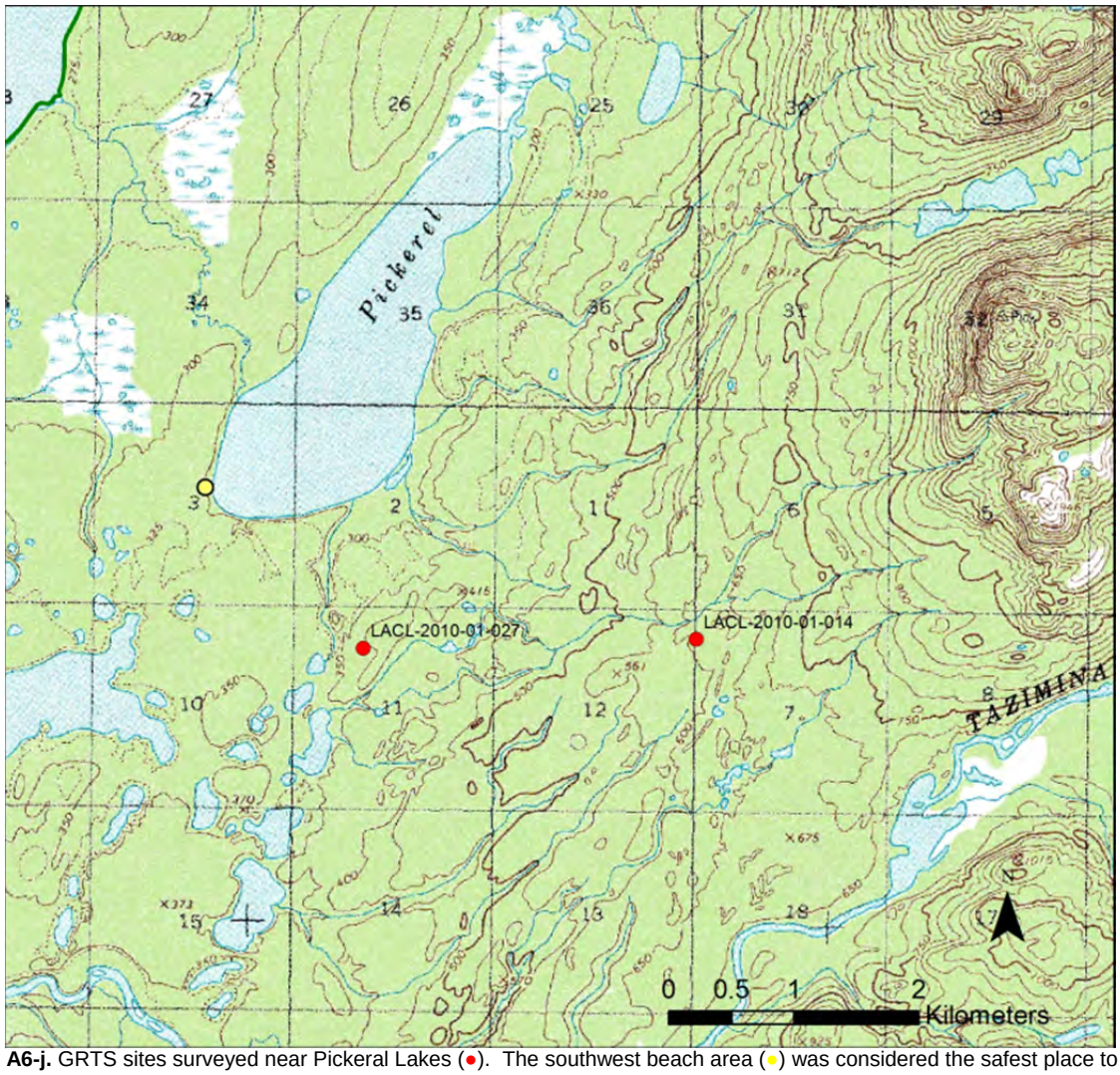

Figure A6-j. GRTS sites surveyed near Pickeral Lakes (●). The southwest beach area (●) was considered the safest place to taxi the aircraft.

Currant Creek
Personnel: CL, AM, ZM, AS, RS, JW
Access to survey area: Daytrip from Port Alsworth using large NPS freight boat. Shallow areas exist around beach area and an acceptable beach landing zone ((NAD 83) 60.305, -154.007) is shown in Figure a6-k.
Hiking: Terrain is spruce forest and is easily navigable.
Weather and environmental conditions: Cool temperatures were encountered during the survey day.
Safety considerations: If Lake Clark has relatively high seas, then a beach landing will not be possible at this site. Rubber boots and hiking shoes are recommended.
General notes: The plot was easily surveyed within a 10-h day (including travel time).

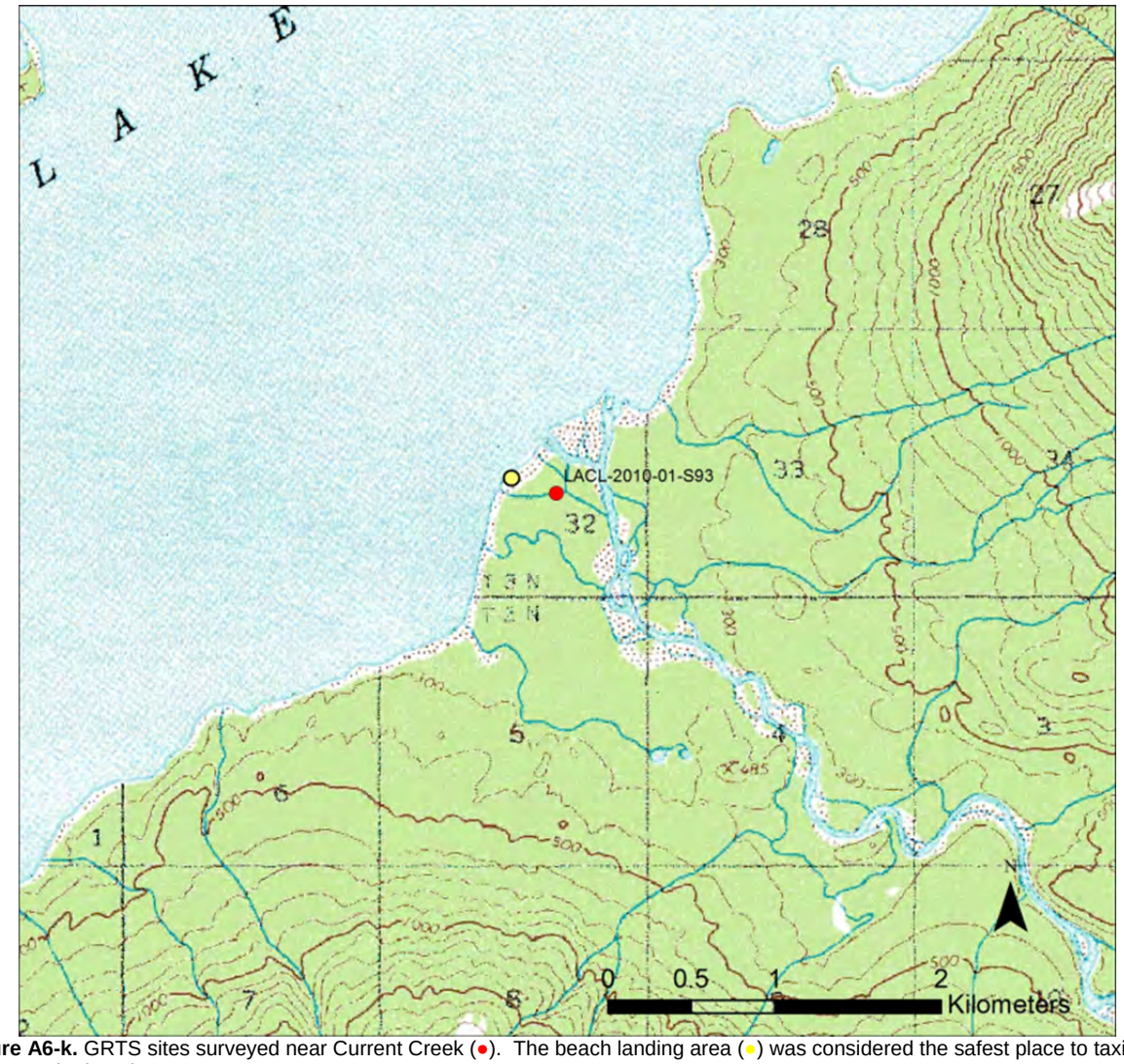

Figure A6-k. GRTS sites surveyed near Current Creek (●). The beach landing area (●) was considered the safest place to taxi the boat onto the beach.

Port Alsworth
Personnel: AM, ZM, AS, MS, RS, JW
Access to survey area: Daytrips from Port Alsworth. A canoe crossing is required to reach sites south of the Tanalian River.
Hiking: Terrain is rolling spruce – birch woodland with low to moderate shrub cover. Steep bedrock and mesic meadow on the mid-slopes of Tanalian Mountain will also be encountered.
Weather and environmental conditions: Cool temperatures and mild to moderate rain and wind.
Safety considerations: Tanalian Mountain can get very windy and cold any time of year. Trail is steep and slick in places, when wet. Take care on the descent. Recommended footwear includes sturdy hiking boots or shoes.
General notes: Due to longer travel times, plan on a 10-h work day (including travel time).

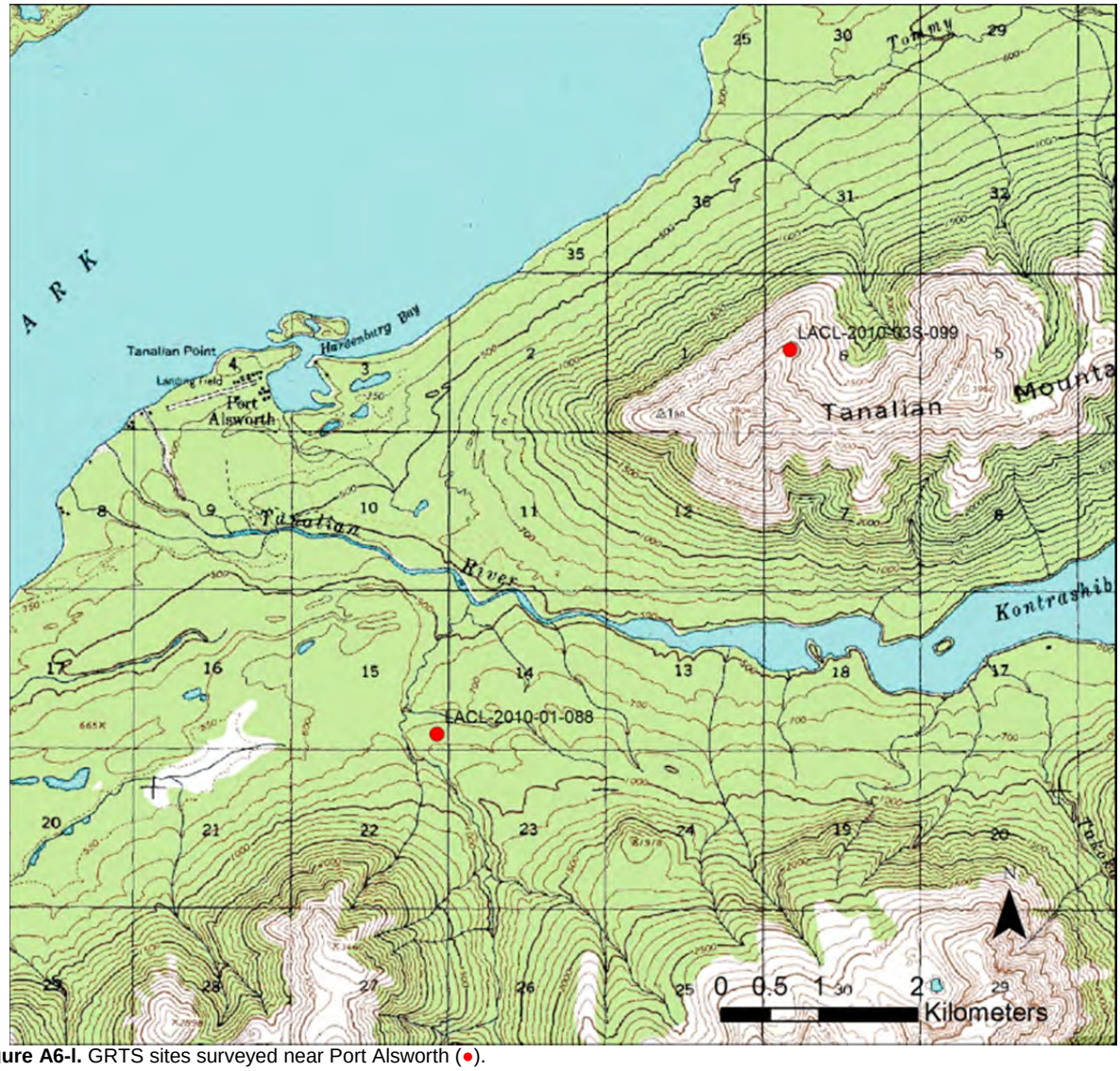

Figure A6-I. GRTS sites surveyed near Port Alsworth (●).

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National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov