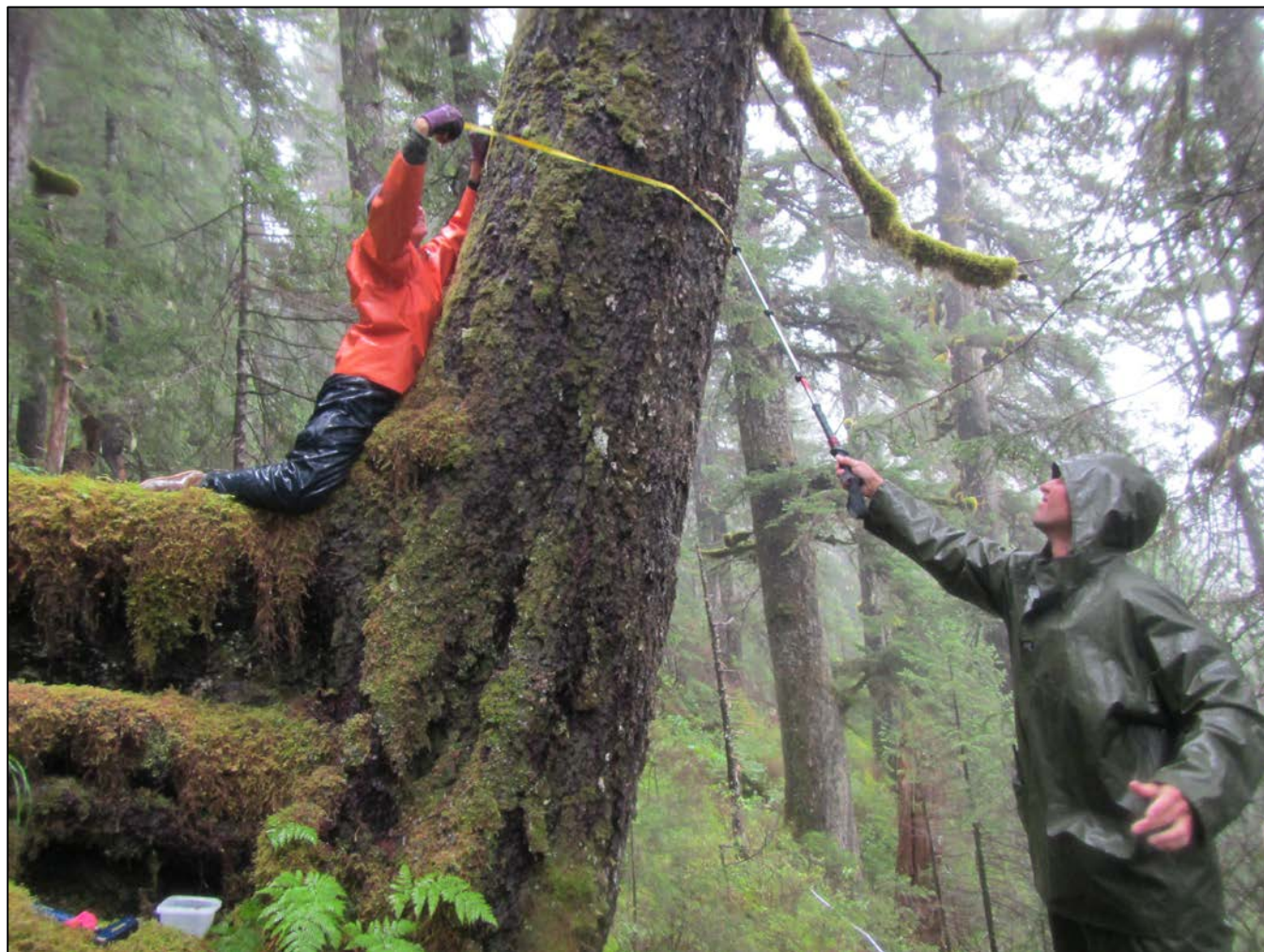




Vegetation monitoring – Southwest Alaska Network

2013 Annual Report – Baseline Sampling in Coastal Forests of Kenai Fjords

Natural Resource Data Series NPS/SWAN/NRDS—2014/675



ON THE COVER

Measurement of a coastal Sitka spruce (*Picea sitchensis*) in Kenai Fjords is a team event. Photograph by Amy Miller.

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Executive summary

This report summarizes the results of vegetation sampling in Kenai Fjords National Park (KEFJ) in 2013. Nine coastal forest monitoring plots (0.25 ha) were established in Sitka spruce-mountain hemlock stands along the outer fjords in KEFJ. Plot measurements included stem diameters and height for estimates of basal area and aboveground biomass, tree and seedling density, canopy cover, and coarse woody debris (CWD) loads. Epiphytic lichen inventories were completed in 2012 using the U.S. Forest Service's (USFS) Forest Inventory and Analysis (FIA) off-frame sampling protocol. Summary data from three USFS-FIA plots in KEFJ are included in this report for comparison with the NPS Inventory and Monitoring (I&M) forest monitoring data.

Tree data from the I&M monitoring plots show that coastal forests in KEFJ are characterized by 200-500 year old trees, a range of age- and size classes that contribute to structural complexity, a low density of standing snags, and CWD loads that comprise less than 1% of aboveground biomass. Seedling establishment appears to be highly dependent on nurse logs provided by decaying CWD. Epiphytic lichen inventory plots yielded 32 taxa, most of which are characteristic of old-growth coastal forest, and many of which are sensitive indicators of air quality. Lichen species of interest included *Hypogymnia duplicata*, a species of management concern in the Pacific Northwest and Gulf of Alaska (FEMAT 1993).

Acknowledgments

We thank NPS employees E. Heck and C. Kriedeman for help in the field. KEFJ resource, law enforcement, and administrative staff provided logistical support. NPS data managers T. Shepherd and R. Frith assisted with data compilation and analysis, and biological technician L. Schomaker formatted and edited the document.

Introduction

Monitoring objectives for vegetation composition and structure are to document trends in the structure (e.g., height, density), composition (e.g., species richness and diversity), mortality and species turnover of selected mid- to late-successional vegetation types in the three largest parks in the SWAN. In Kenai Fjords NP (KEFJ), baseline sampling has focused on the tree component of mature coastal forests, including tree species composition, condition, and epiphytic lichen community composition. These ecological types dominate the narrow forested band along the Gulf of Alaska, from the outer coast of Glacier Bay to the southern tip of the Kenai Peninsula (Boggs et al 2008). For example, the Sitka Spruce Ecological System comprises 13% of the vegetated land within KEFJ. The stands sampled and described here are some of the most common forested landcover classes for KEFJ. This report summarizes the results of field work in KEFJ for the 2012-2013 field seasons.

Methods

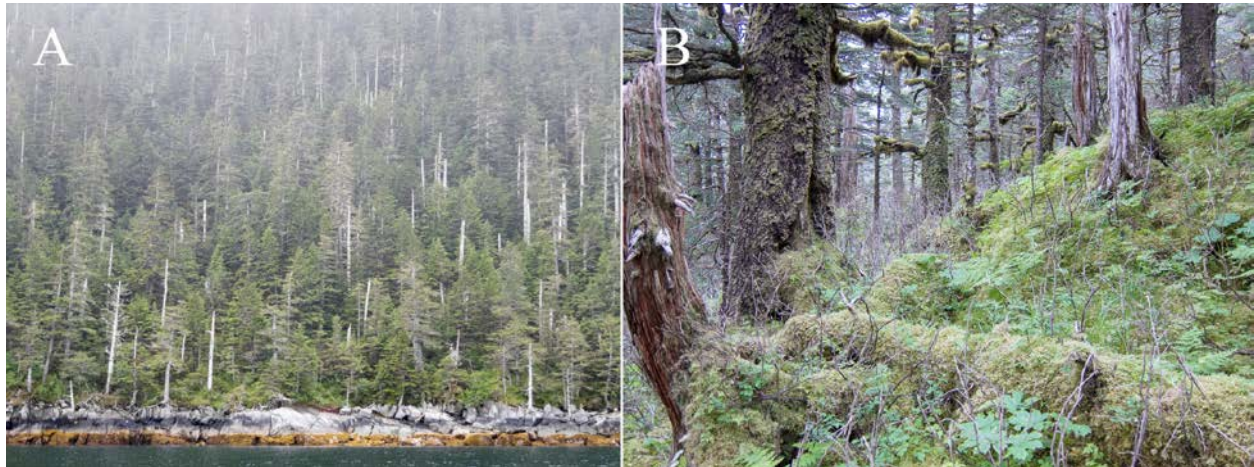
Sampling sites

We used a geographic information system (GIS) prior to going into the field to evaluate site accessibility in mature Sitka spruce-mountain hemlock (*Picea sitchensis*-*Tsuga mertensiana*) stands on the outer fjords of KEFJ. GIS layers including known landing locations, slope (≤ 30 degrees), elevation (≤ 450 m), estimated USFS-FIA plot locations, and landcover class (coniferous forest classes) were used to delineate potential study areas. Points were randomly assigned within the resultant polygons, and field reconnaissance and site selection were completed in August, 2012.

In August 2012, we established eleven 34.7 m-radius circular lichen inventory plots using an 'off-frame' survey method developed by the Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service (Table 1; <http://www.fia.fs.fed.us/library/field-guides-methods-proc/>). At each plot, we made a series of voucher collections and assigned an abundance code for each macrolichen species found on woody material > 0.5 m in height. Freshly fallen macrolichens in the litter were also collected. Surveys lasted a minimum of 30 minutes and a maximum of two hours. Surveys were terminated when no additional new species were encountered within ten minutes time.

In August 2013, we established nine inventory and monitoring (I&M) forest monitoring plots, seven of which were co-located with the 2012 off-frame FIA lichen inventory plots. Our I&M monitoring plots supplemented three existing U.S. Forest Service Forest Inventory and Analysis (FIA) plots established in 1999 (Figure 1; Table 1). All sites occurred within the Coastal Western Hemlock-Sitka Spruce Forest ecoregion and included open mountain hemlock, closed Sitka spruce, and open and closed Sitka spruce-mountain hemlock landcover classes (Boggs et al. 2008; Table 1). The open mountain hemlock landcover class is characterized by tree canopy cover ranging from 25-60%, with mountain hemlock comprising 75% or more of total tree cover. It is found on slopes and moraines between sea level and treeline. The shrub layer includes tall shrubs such as blue huckleberry (*Vaccinium ovalifolium*) and devil's club (*Oplopanax horridus*). The closed Sitka spruce landcover class is characterized by 60% or greater tree cover, with Sitka spruce as the dominant tree species. It is common on slopes, alluvial fans, floodplains and

moraines. Understory species are similar to those for open mountain hemlock, and may also include Sitka alder (*Alnus viridis* ssp. *sinuata*). Sitka spruce-mountain hemlock landcover classes consist of at least 25% contributions by Sitka spruce and mountain hemlock to total tree cover, which ranges from 25-60% (open) to greater than 60% (closed) tree cover (Boggs et al. 2008).



Shoreline view of mature Sitka spruce-mountain hemlock forest at (A) Square Bay (S998), and view of understory vegetation at (B) Chance Cove (S999). Defoliator damage on huckleberry at Chance Cove has resulted in extensive dieback of the existing branches, as shown in the foreground in (B). Many of these shrubs are starting to resprout at the base. Both sites are near MacArthur Pass, on the East Arm of Nuka Bay.

Field methods and plot layout for the I&M monitoring plots are described in detail in Miller et al. (2010) and summarized briefly here. We did not sample the USFS-FIA plots, but we include data from the national FIA database (<http://www.fia.fs.fed.us/tools-data/default.asp>) for comparison with the I&M plots. At each I&M site, we established a 50 m $\times$ 50 m (0.25 ha) monitoring plot and intensively sampled trees, tree seedlings, and coarse woody debris (CWD) within the inner 30 m $\times$ 30 m (0.09 ha). The plot area is comparable to that of FIA plots (0.10 ha), but the layout of the two plot types, including the configuration of subplots, differs between the I&M and FIA plots. We did not sample understory vegetation due to sampling and time constraints, and to the likely damage that would occur due to trampling along transect lines. We recorded dominant understory species, however, as well as signs of herbivory and defoliation.

We measured average canopy cover in the I&M plots using a spherical densitometer at the plot center and four corners. We measured the height and diameter of all trees at breast height (1.37 m; DBH) and recorded a decay class for dead trees. We tagged a minimum of 50 trees per plot, and at most plots we tagged all trees present. The tagged trees will be used in two ways: 1) to estimate radial growth rates through remeasurement of DBH at a fixed location on the tree bole; and 2) to monitor tree demography by tracking recruitment and mortality in each stand.

We established three 30-m transects and tallied live spruce and hemlock seedlings across fifteen 4 m² quadrats arrayed along the transects. We also recorded CWD intercepts along the transects, following the methods of Brown (1974).

We calculated basal area for trees within the 0.09 hectare inner plot as follows:

$$\text{Basal area (cm)} = \pi \times (\text{DBH}/2)^2 \quad [1]$$

We estimated aboveground standing biomass (live and dead) using allometric equations derived for *Picea sitchensis* (Eqn. 2; Bormann 1990) and *Tsuga heterophylla* (Eqn. 3; Shaw 1979):

$$\text{Dry mass } P. \text{ sitchensis (Mg)} = ((17.6 + (172.1 \times (\text{DBH (cm)}/100)^2 \times (\text{height (m)})) \times 0.001)) \quad [2]$$

$$\text{Dry mass } T. \text{ mertensiana (Mg)} = ((0.049 + (0.0211 \times (\text{DBH (cm)})^2 \times (\text{height (m)})) \times 0.001)) \quad [3]$$

We estimated coarse woody debris (CWD) loads using the line-intersect method

(Van Wagner 1968, Brown 1974), and assuming a specific gravity of 0.33 g/cm³ for Sitka spruce (Harmon et al. 2011):

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

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

Seedling densities were estimated for each monitoring plot by dividing seedling counts in the 4-m² quadrats by the total area sampled. We defined a seedling as any individual between 15 cm and 137 cm in height. The seedling density estimates were scaled up to a per hectare basis for comparison with the USFS-FIA forest plot data. The FIA program defines seedlings as any individual ≥ 15 cm tall and less than 2.54 cm DBH, and so includes a broader range of size classes in its estimate of ‘seedlings’ than does NPS.

We collected tree cores from 2-5 trees per size class (<20 cm; 20-50 cm; >50 cm) per plot. Minimum tree age estimates were based on the longest ring count for each plot and do not include a pith correction or coring height correction. Most trees were cored within 30 cm of the root crown and for the smaller-diameter cores that were on-pith, we assumed that the ring count approximated tree age. For the largest diameter trees that were cored at breast height, we added an age correction of 8 years, as used by the USFS-FIA program (R. Pattison, U.S. Forest Service, Pacific Northwest Research Station, Anchorage, AK; *pers. comm.*).

Data analysis

Field data were entered directly into an SQL database with MS Access front end. Selected plot variables (basal area by species and condition class; species occurrence; cover by growth form and height class) were summarized within plots using PROC UNIVARIATE and PROC SURVEYMEANS in SAS (SAS Institute, Cary, NC; Miller et al. 2010), or by using automated QA/QC queries within the SQL database. Frequency distributions for stem diameter classes were calculated using PROC FREQ for all species and condition classes.

We used two-way hierarchical agglomerative cluster analysis in PC-ORD 6 (McCune & Mefford 2009) to subjectively evaluate groupings of FIA lichen plots based on the FIA lichen community composition. This clustering method independently groups sample units and species and then combines them into a single diagram. The data were relativized by species maximum to diminish

the influence of species totals on species clustering. We used the flexible beta method with $\beta=0.25$ and a Sørensen distance measure.

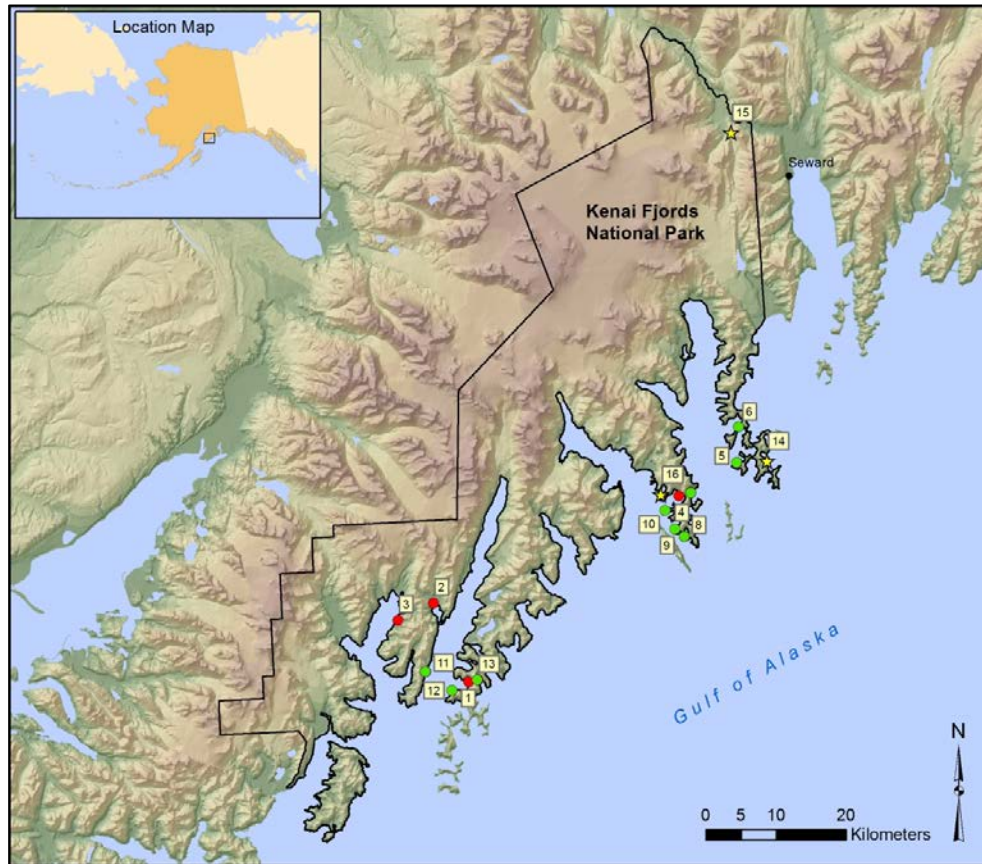


Figure 1. Forest monitoring plots in Kenai Fjords NP. Plots include forest monitoring plots (green) and epiphytic lichen plots (red) established by the SWAN in 2012-2013, and U.S. Forest Service Forest Inventory and Analysis (FIA) plots (yellow stars) established in 1999. Numbers correspond to the plots listed in Table 1. The SWAN completed FIA off-frame lichen plots at eleven sites, nine of which are collocated with forest monitoring plots (Table 1). The plots shown in red were sampled only for epiphytic lichens and were not permanently marked for monitoring. Map scale 1:690,000.

Table 1. Forest and lichen inventory plots sampled in KEFJ in 2012-2013. Year of plot establishment is indicated in the plot id number. Off-frame FIA epiphytic lichen plots were sampled in 2012 at sites indicated by a (§). Tree, seedling, and CWD sampling was completed only at plots established in 2013. USFS Forest Inventory and Analysis (FIA) plots were established in 1999 and resampled in 2004. All USFS-FIA plot locations are fuzzed, and so FIA latitude/longitude values are approximate. Plant community types are as follows: PISI/VAOV/DRDI2 = *Picea sitchensis/Vaccinium ovalifolium/Dryopteris expansa*; PISI/VAOV-OPHO = *Picea sitchensis/Vaccinium ovalifolium-Oplopanax horridus*; TSME-PISI/VAOV-OPHO = *Tsuga mertensiana-Picea sitchensis/Vaccinium ovalifolium-Oplopanax horridus*. Understory species data were not available for the USFS-FIA forest plots. Datum = NAD83. ND=no data.

	Plot id	Geographic location	Landcover class (Boggs et al. 2008)	Plant community type (DeVelice et al. 1999)	Elev (m)	Longitude (° W)	Latitude (°N)	Slope (°)	Aspect (°)
5	1 KEFJ_2012_01_S987§	Square Bay	Closed mountain hemlock	1A1. TSME-PISI/VAOV-OPHO	20	-150.34161	59.4874	25	240
	2 KEFJ_2012_01_S988§	James Lagoon	Closed Sitka spruce	1A1a. PISI/VAOV-OPHO	5	-150.42032	59.5874	1	180
	3 KEFJ_2012_01_S989§	North Arm, Nuka	Closed Sitka spruce	1A1. TSME-PISI/VAOV-OPHO	23	-149.78075	59.7052	28	265
	4 KEFJ_2012_01_S990§	Crater Bay	Closed Sitka spruce	1A1. TSME-PISI/VAOV-RUSP	45	-149.61649	59.7884	35	330
	5 KEFJ_2013_01_S991§	Three Hole Bay	Open Sitka spruce-mountain hemlock	1A1a. PISI/VAOV/DRDI2	47	-149.6276	59.7435	35	76
	6 KEFJ_2013_01_S992§	Bear Cove	Closed Sitka spruce	1A1a. PISI/VAOV/DRDI2	45	-149.6166	59.7886	35	330
	7 KEFJ_2013_01_S993§	Verdant Cove	Closed Sitka spruce-mountain hemlock	1A1. TSME-PISI/VAOV-OPHO	64	-149.7497	59.7088	20	62
	8 KEFJ_2013_01_S994§	Fire Cove	Closed Sitka spruce	1A1a. PISI/VAOV-OPHO	61	-149.7733	59.6534	27	328
	9 KEFJ_2013_01_S995	Ripple Cove	Closed Sitka spruce	1A1a. PISI/VAOV/DRDI2	37	-149.7963	59.6634	40	0
	10 KEFJ_2013_01_S996	Crater Bay	Closed Sitka spruce	1A1a. PISI/VAOV-OPHO/DRDI2	50	-149.8179	59.6883	40	270
	11 KEFJ_2013_01_S997§	East Arm, Nuka	Closed Sitka spruce	1A1a. PISI/VAOV-OPHO/DRDI2	67	-150.4497	59.5005	30	140
	12 KEFJ_2013_01_S998§	Square Bay	Open mountain hemlock	1A1a. PISI/VAOV/DRDI2	62	-150.3855	59.4746	30	15
	13 KEFJ_2013_01_S999§	Chance Cove	Open mountain hemlock	1A1a. PISI/VAOV/DRDI2	60	-150.3195	59.4866	35	30
	14 USFS_FIA_17383	Pony Cove	Open Sitka spruce-mountain hemlock	ND	213	-149.5497	59.7430	20	120
	15 USFS_FIA_38135	Resurrection River	Open Sitka spruce	ND	457	-149.5856	60.1646	ND	ND
	16 USFS_FIA_58457	Ripple Cove	Closed Sitka spruce	ND	152	-149.7864	59.6803	85	265

Results and Discussion

Basal area estimates and percent mortality

Basal area is a measure of the area of land occupied by trees and can be used as an index of forest productivity (e.g., Alaback 1982, Marshall and Waring 1986, Fralish 1994). Basal area estimates ranged from approximately 45 m²/ha to 82 m²/ha in the I&M plots, and were comparable or lower in the USFS-FIA plots (Table 2). Sitka spruce comprised 58% to 100% of basal area, with mountain hemlock comprising the remainder. USFS-FIA plots occurred at higher elevations and had consistently higher mountain hemlock cover (52%-100%) than the I&M plots.

Most sites had between 10% and 25% mortality, as estimated in terms of basal area. Only one site (Ripple cove, S995) had greater than 30% mortality (Table 2). The majority of the dead trees were in the smallest size classes (Figure 2). We assume that the high mortality, up to one-third of trees, in the smallest size classes is due in large part to competition for light. Overstory canopy cover ranged from 87% to 94% at our sites, and many of the understory trees have died before they reach 10 cm DBH. We also found a number of older, larger-diameter, moderately- to highly decayed snags across the sites, with the highest snag densities at Ripple Cove (S995).

Defoliator damage in understory shrubs

Blue huckleberry (*Vaccinium ovalifolium*) was an understory dominant at all I&M plots. At two-thirds of the plots we recorded dieback in at least 50% of the aboveground stems, presumably due to damage by geometrid moth defoliators between 2010 and 2012 (U.S. Forest Service 2013). Damage was greatest at Chance Cove (S999), Square Bay (S998), and Ripple Cove (S995), with nearly 100% of the shrub crowns damaged. Many of these shrubs were beginning to sprout from the base (root crown). We found no damage on huckleberries at the East Arm (S999) and Crater Bay (S996) sites. With the exception of salmonberry (*Rubus spectabilis*), no other shrub species appeared to have been affected.

Age and size class distributions

Most sites showed the highest frequency of stems in the smallest diameter classes, indicating a mature population with continuous mortality. Tree ring counts showed minimum estimated ages of roughly 280-570 years, with the oldest trees at Verdant Cove, Square Bay and the East Arm of Nuka Bay (Table 2; Figure 3). The oldest trees sampled were Sitka spruce. Minimum age estimates for mountain hemlock did not exceed 350 years (Figure 3). USFS-FIA plots had younger trees, with minimum age estimates ranging from 177-223 years (Table 2). The trees ages in the USFS-FIA plots roughly correspond with the end of the Little Ice Age (ca. 1850) and may represent a wave of tree establishment at higher elevations and/or on areas that were more recently deglaciated.

Seedling and sapling densities

Seedling densities ranged from 0 to 2500 stems/ha across the I&M plots. This was within the range recorded for USFS-FIA plots (600-3200 stems/ha), although seedling densities in the I&M plots tended to be lower (median = 333 stems/ha). Seedling densities in the I&M plots were strongly correlated with CWD loads ($r=0.89$; $P<0.001$; Table 4), indicating that nurse logs are critical to establishment in this environment. On-transect measurements of CWD ranged from 0.01% to 0.25% of total aboveground tree biomass (Table 3). Although we found no relationship

between canopy cover and seedling density, or canopy cover and CWD, we expect that CWD loads could be positively associated with canopy gaps. Canopy gap formation is known to facilitate the establishment and growth of conifer seedlings in closed-canopy stands, particularly in shade-tolerant genera such as *Tsuga* (Gray and Spies 1996). No other variable tested (site age, percent standing dead, basal area) was a good predictor of seedling or sapling density.

Epiphytic lichen communities

Off-frame FIA epiphytic macrolichen surveys documented 32 species across 11 sites (Figure 5; Table A1 (Appendix)). Epiphytic lichen species richness ranged from seven species at Chance Cove (S999), to sixteen species at James Lagoon (S988) and Fire Cove (S994). Two macrolichens, the yellow witch's hair lichen *Alectoria sarmentosa* var. *sarmentosa* and the coral lichen *Sphaerophorus tuckermanii*, were encountered at all eleven survey sites.



The very common (A) coral lichen (*Sphaerophorus tuckermanii*) and (B) yellow witch's hair lichen (*Alectoria sarmentosa* var. *sarmentosa*) were found at all eleven FIA lichen survey sites. Two rare to uncommon Kenai Peninsula coastal forest lichens, the (C) lettuce lichen (*Lobaria oregana*), and the (D) Pacific Northwest endemic tube lichen (*Hypogymnia duplicata*), were observed at only one survey site each.

Five species were observed only once, with four of those seen at James Lagoon (S988), a mid-successional floodplain forest that differed from the other survey sites in mature closed forest. The most notable species was the tube lichen *Hypogymnia duplicata*, a Pacific Northwest endemic considered rare to uncommon throughout its range (NW Oregon to Prince William Sound). A species of management concern under the Northwest Forest Plan (FEMAT 1993), *H. duplicata* displays a narrow ecological amplitude (it occurs in high precipitation zones in old-growth forests) and a limited distribution that may be susceptible to decline from anthropogenic or natural disturbance of its habitat. It was found at Fire Cove (S994).

Lichen communities are sensitive to a number of atmospheric pollutants, including sulfur dioxide, and nitrogen and sulfur-containing compounds (Farmer et al. 1992, Nash and Gries 2002). The epiphytic lichen community in KEFJ includes species sensitive to airborne pollutants, such that their presence indicates unimpaired air quality (e.g., Geiser & Nietlich 2007). Prominence of these pollution-sensitive species, and a low abundance of nitrophilous species, are due in part to low nitrogen (N) deposition throughout most of the region (NADP 2012).

Summary of forest conditions and plans for future monitoring

Coastal forests in KEFJ are characterized by 200-500 year old trees, a range of age- and size classes that contribute to structural complexity, standing snags, and CWD loads that comprise less than 1% of aboveground biomass. Seedling establishment appears to be highly dependent on nurse logs provided by decaying CWD. The epiphytic lichen community includes a number of sensitive air quality indicators, and the presence of uncommon species such as *Hypogymnia duplicata* underscores the importance of these forests for providing suitable habitat for regionally specialized taxa.

The I&M forest monitoring and FIA off-frame lichen plots will be resampled every 10 years to evaluate tree condition, growth, and recruitment. We will continue to harvest USFS-FIA data for KEFJ, although the USFS-FIA plots occur in higher elevation sites and contain a higher proportion of young trees, predominantly mountain hemlock. The USFS-FIA plot near Pony Cove (17383) appears to be most similar to the I&M forest monitoring plots and could be used to supplement the I&M data set. USFS-FIA plots are resampled every 10 years.

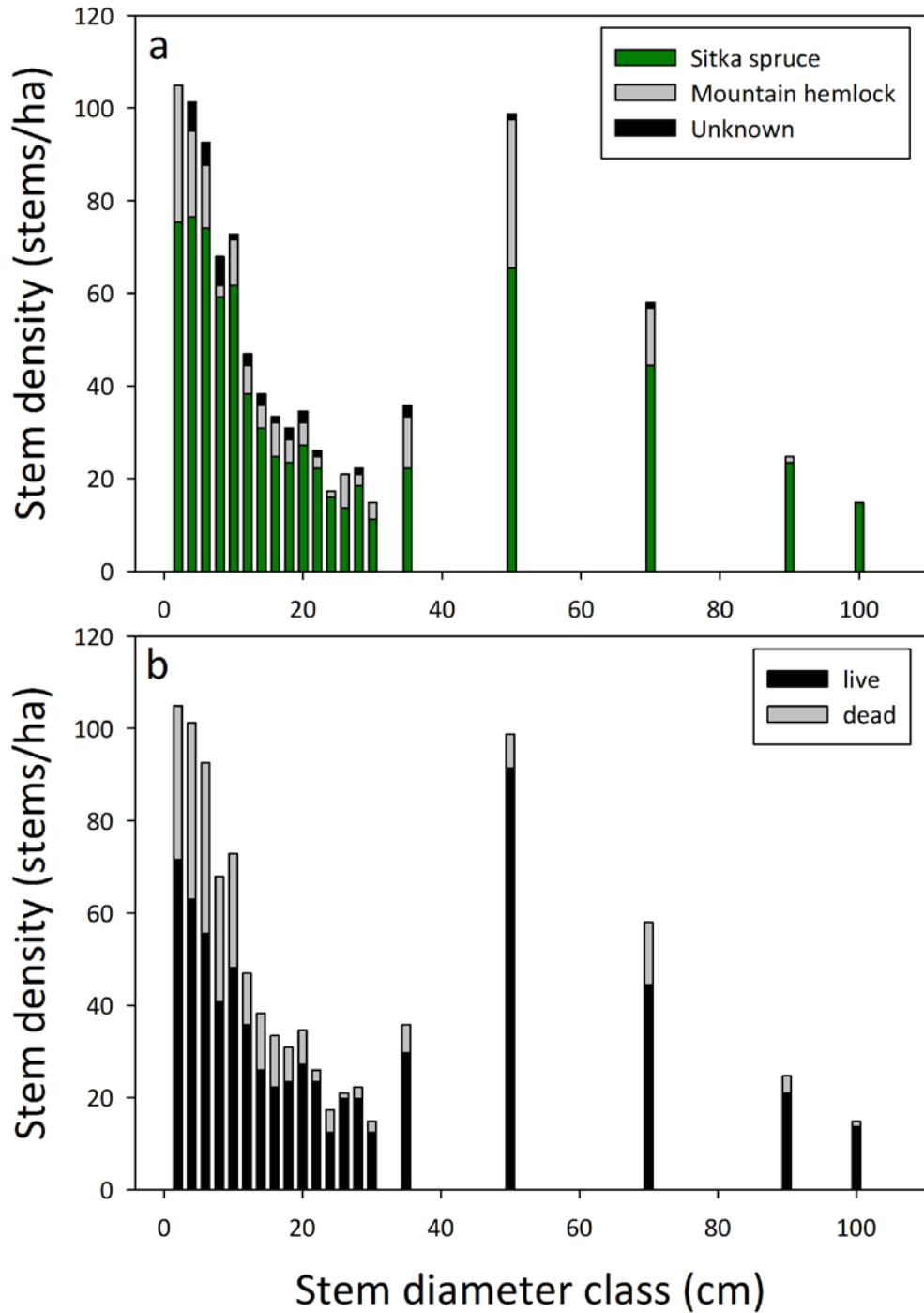


Figure 2. Composite frequency distributions for stem diameter (DBH) classes in forest monitoring plots in KEFJ (n=775). (a) Stem diameters plotted by species (Sitka spruce = *Picea sitchensis*; mountain hemlock = *Tsuga mertensiana*). High stem counts in the 0-10 cm and 35-50cm DBH classes indicated continuous recruitment and at least two cohorts of trees in these stands. (b) Stem diameters plotted by condition showed the greatest proportion of dead trees in the smallest size classes.

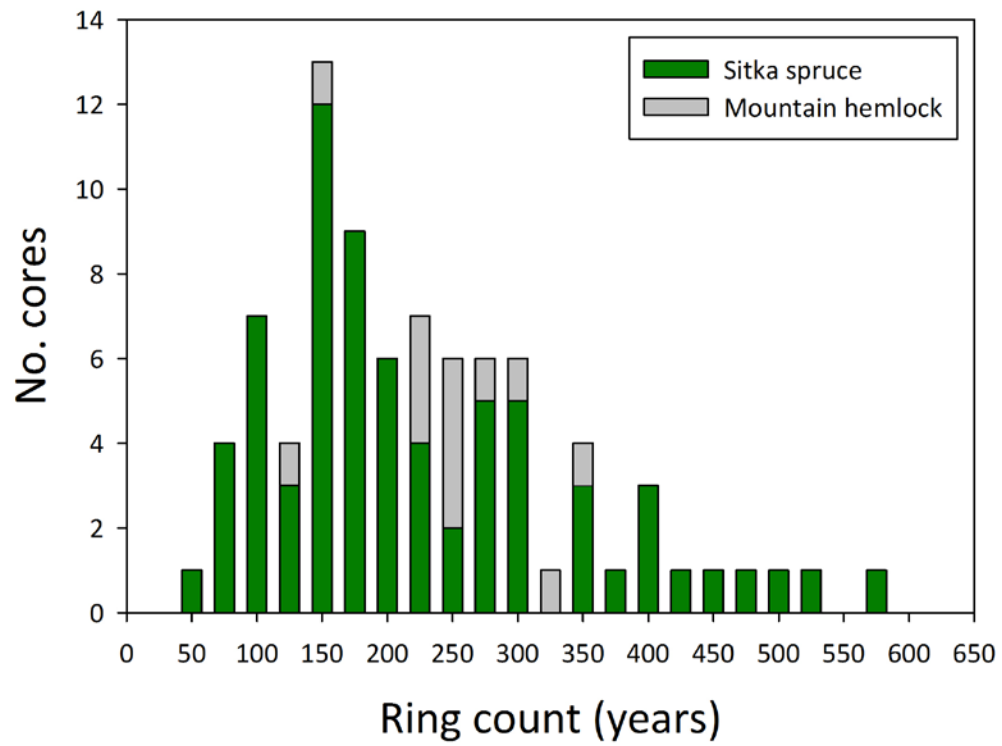


Figure 3. Composite frequency distribution for minimum ring counts on sampled live trees in KEFJ (n=84). Ring counts on incomplete cores are included.

Table 2. Basal area estimates (m²/ha) for forest plots in KEFJ. Proportion of standing dead, Sitka spruce, and mountain hemlock at each site is expressed as a percentage of total basal area, where 1.00 indicates 100%. Minimum estimated age for each plot is based on the longest ring count recorded in a live tree. Actual tree ages will be substantially older, in some cases. ND=no data.

Plot id	Total basal area (m ² /ha)	Standing dead (%)	Sitka spruce (%)	Mountain hemlock (%)	Minimum est. age (y)	Canopy cover (%)
KEFJ_2013_01_S991	66.8	0.15	0.76	0.24	289	94
KEFJ_2013_01_S992	45.8	0.04	0.79	0.21	338	91
KEFJ_2013_01_S993	62.8	0.26	0.58	0.42	572	91
KEFJ_2013_01_S994	79.0	0.28	0.73	0.27	396	87
KEFJ_2013_01_S995	61.6	0.32	0.88	0.12	466	88
KEFJ_2013_01_S996	61.4	0.12	0.95	0.05	424	87
KEFJ_2013_01_S997	82.4	0.02	1.00	0.00	530	92
KEFJ_2013_01_S998	75.5	0.27	0.95	0.05	491	93
KEFJ_2013_01_S999	69.2	0.18	0.85	0.15	280	91
USFS_FIA_17383	66.4	0.24	0.48	0.52	177	ND
USFS_FIA_38135	37.5	0.09	0.00	1.00	223	ND
USFS_FIA_58457	2.6	0.06	0.01	0.99	188	ND

Table 3. Total aboveground biomass estimates for trees and coarse woody debris (CWD), and estimated stem densities for tree seedlings, saplings, and trees in forest plots in KEFJ. CWD data were not available for USFS-FIA plots. Seedlings included in the estimates below were live tree seedlings between 15 cm and 137 cm tall (KEFJ monitoring plots), or live tree seedlings >15 cm tall and <2.5 cm DBH (USFS-FIA plots). Tree seedling densities were strongly correlated with CWD biomass across sites (Table 4).

Plot id	Standing biomass (kg/ha)		Seedlings (0 cm DBH)	Stem density (stems/ha)		
	Tree aboveground biomass	Coarse woody debris		Saplings (<5 cm DBH)	Small trees (5-10 cm DBH)	Trees (>10 cm DBH)
KEFJ_2013_01_S991	416.2	0.232	333	356	256	622
KEFJ_2013_01_S992	267.5	0.201	1000	311	156	378
KEFJ_2013_01_S993	379.2	0.680	833	100	89	656
KEFJ_2013_01_S994	539.3	0.285	333	122	78	378
KEFJ_2013_01_S995	393.1	0.329	333	267	211	444
KEFJ_2013_01_S996	413.0	1.022	2500	278	144	333
KEFJ_2013_01_S997	667.2	0.093	0	289	89	322
KEFJ_2013_01_S998	502.6	0.643	1667	411	333	556
KEFJ_2013_01_S999	352.6	0.000	0	100	367	989
USFS_FIA_17383	155.9	N/A	1100	200	N/A	550
USFS_FIA_38135	103.0	N/A	3200	300	N/A	890
USFS_FIA_58457	9.2	N/A	600	100	0	100

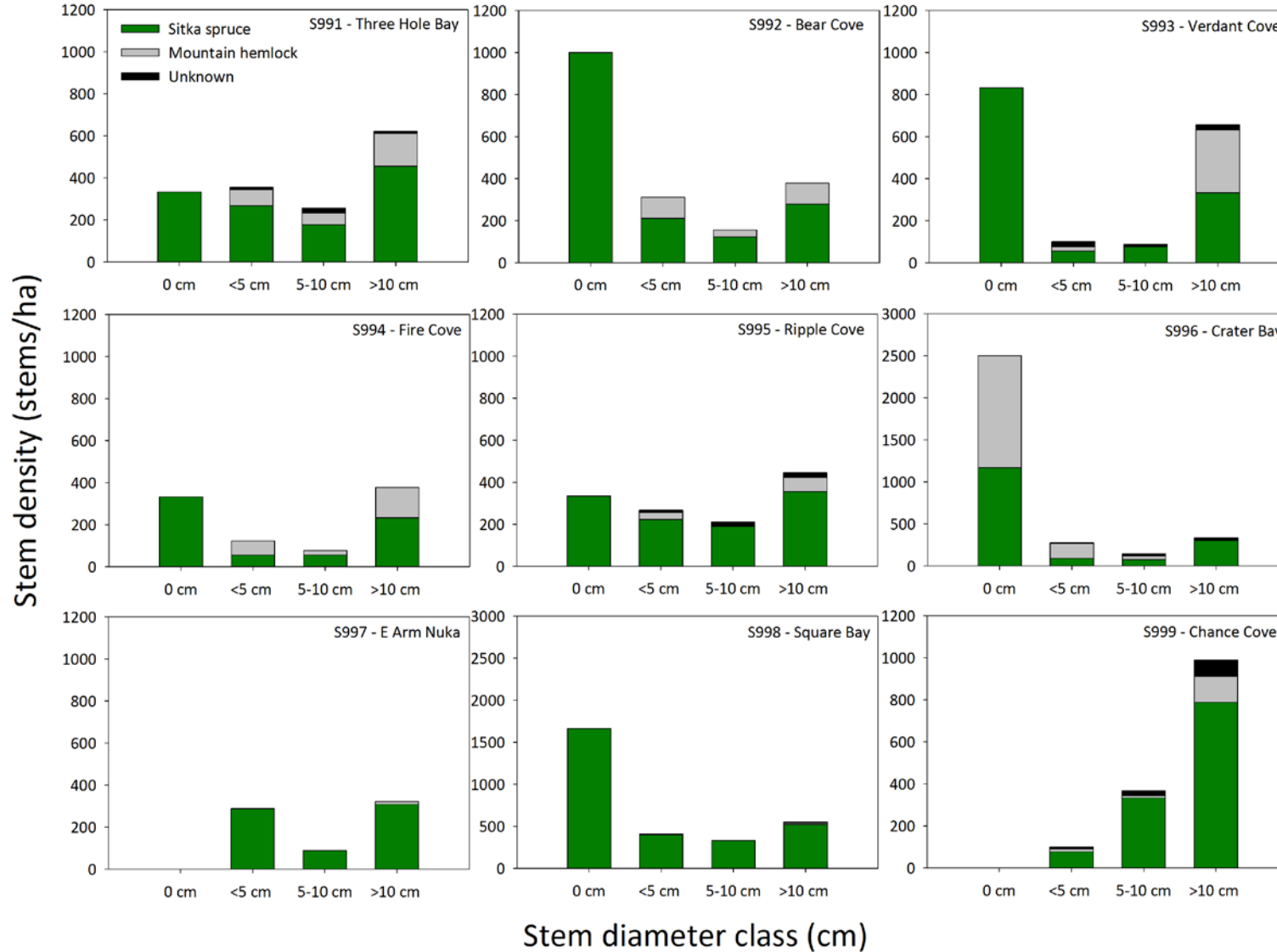


Figure 4. Seedling, sapling and tree densities for Sitka spruce and mountain hemlock in forest plots in KEFJ. Crater Bay (S996) and Square Bay (S998) had the highest seedling densities, and Crater Bay was the only site with hemlock seedlings. Note the difference in Y-axis at those sites.

Table 4. Pearson correlation coefficients (n = 9) for plot and environmental variables in coastal forest monitoring plots (2013). Correlation coefficients (r) are shown as the upper value for each pair. Probabilities > |r| are shown below. Significant correlations are shown in bold face.

	Latitude	Aspect	%Canopy	Basal Area	%Hemlock	%Dead	Seedling	Sapling	Tree	CWD
Latitude	1.0000	0.4665	-0.2461	-0.7253	0.5791	-0.0968	0.1757	0.0051	-0.3170	0.2022
		0.206	0.523	0.027	0.102	0.804	0.651	0.990	0.406	0.602
Aspect		1.0000	-0.4955	-0.2249	0.0888	-0.4427	0.2690	-0.0797	-0.6052	0.0952
			0.175	0.561	0.820	0.233	0.484	0.839	0.084	0.807
Canopy%			1.0000	0.1049	-0.0157	-0.2645	-0.2253	0.4303	0.3803	-0.3058
				0.788	0.968	0.491	0.560	0.248	0.313	0.424
Basal Area				1.0000	-0.2994	-0.2994	-0.3171	-0.0840	0.0246	-0.1683
					0.434	0.434	0.406	0.830	0.950	0.665
%Hemlock					1.0000	0.3198	-0.2188	-0.5632	0.2923	-0.0051
						0.402	0.572	0.114	0.445	0.990
%Dead						1.0000	-0.0188	-0.2595	0.2537	0.2417
							0.962	0.500	0.510	0.531
Seedling density							1.0000	0.3721	-0.3286	0.8932
								0.324	0.388	0.001
Sapling density								1.0000	-0.4004	0.1527
									0.286	0.695
Tree density									1.0000	-0.2893
										0.450
CWD										1.0000

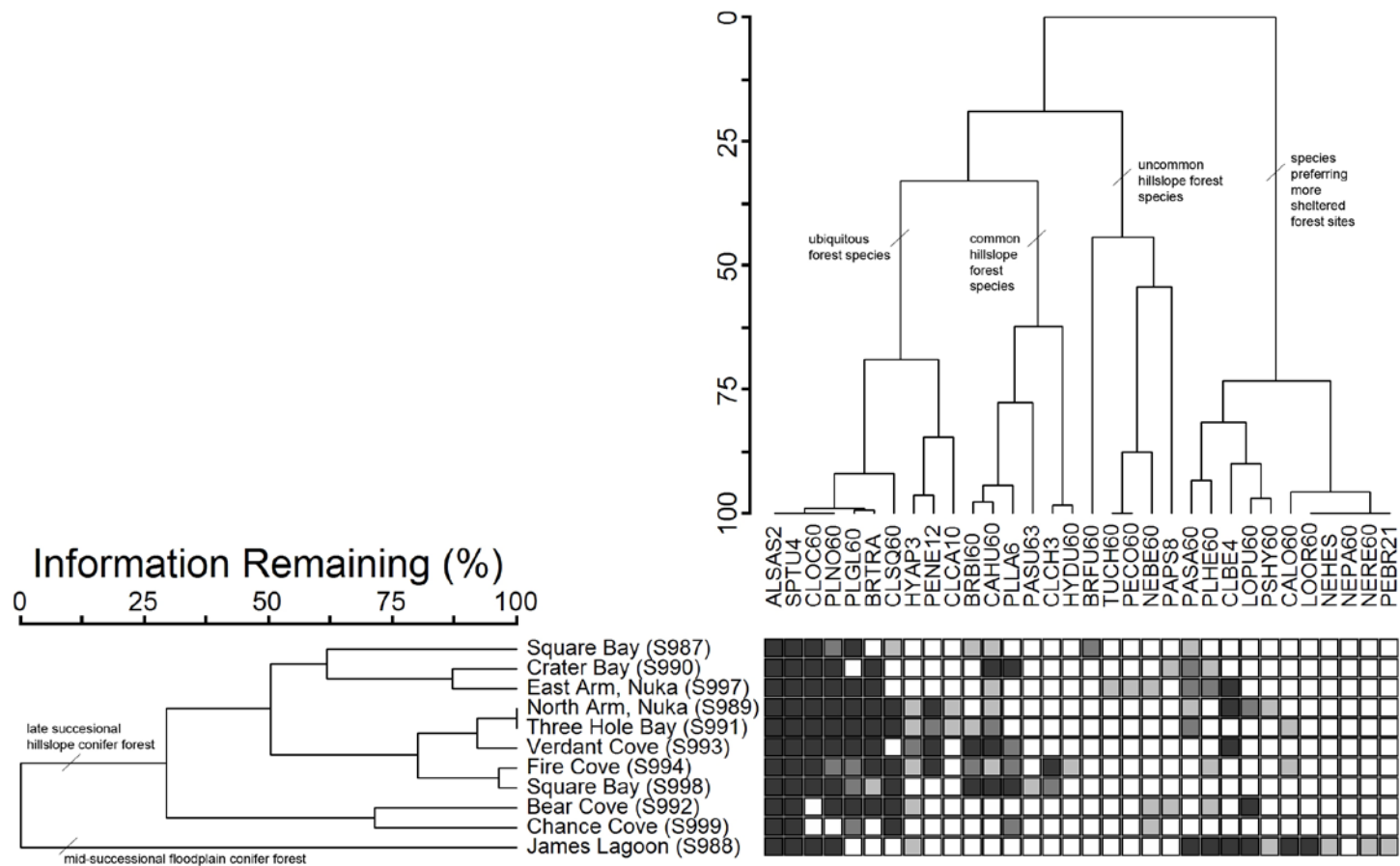


Figure 5. Two-way cluster analysis dendrogram of 11 plots and 32 epiphytic macrolichen species. Each square represents the relative abundance by column (darker is more abundant). Two plot clusters and six species clusters are indicated at the branch tips with vertical black lines at the node. In general, all survey sites shared a similar suite of lichen species, with the exception of the James Lagoon site (S988), which included several additional species typically found in more sheltered, riparian forest habitats. Site group and species group interpretations are relatively subjective given the small nature of the dataset. Species codes can be found in Table A1.

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Appendix A

Table A1. Epiphytic macrolichen species occurrence and abundance codes (**1 = Rare** (1-3 individuals in lichen plot), **2 = Uncommon** (4-10 individuals in lichen plot), **3 = Common** (> 10 individuals in lichen plot but less than half of the boles and branches have that species present), **4 = Abundant** (more than half of all legal substrate in lichen plot has the subject species present). Incidental collections, i.e., macrolichens not noticed during a survey but incidentally vouchered along with a target species, are assigned a default abundance code of 0.01.

Taxon	Code	Site ID										
		S98 7	S98 8	S98 9	S99 0	S99 1	S99 2	S99 3	S99 4	S99 7	S99 8	S99 9
Alectoria sarmentosa subsp. sarmentosa	ALAS A2	3	3	3	3	3	3	3	3	3	3	3
Bryoria bicolor	BRBI60	1				1		3	2		3	
Bryoria fuscescens	BRFU60	2										
Bryoria trichodes subsp. americana	BRTR A			3	3	3	3	3	3	3	1	
Cavernularia hultenii	CAHU60	1		1	3	2	0.01	3	1	1	3	
Cavernularia lophyrea	CALO60		3			1			1			
Cladonia bellidiflora	CLBE4		3	3				3		3		
Cladonia carneola	CLCA10			1		1						
Cladonia chlorophaea group	CLCH3								3		2	
Cladonia ochrochlora group	CLOC60	3	3	3	3	3	0.01	3	3	3	3	0.01
Cladonia squamosa	CLSQ60	1		3		3	3		3		3	3
Hypogymnia apinnata	HYAP3		1	1		1	1	2	1			
Hypogymnia duplicata	HYDU60								1			
Lobaria oregana	LOOR60		3									
Lobaria pulmonaria	LOPU60		3	2			3					
Nephroma bellum	NEBE60						1			1		1
Nephroma helveticum subsp. sipeanum	NEHE S		1									
Nephroma parile	NEPA60		0.01									
Nephroma resupinatum	NERE60		1									
Parmelia pseudosulcata	PAPS8				1		1					
Parmelia saxatilis	PASA60	1	3	1	2	2				2		
Parmelia sulcata	PASU										1	

		Site ID										
Taxon	Code	S98 7	S98 8	S98 9	S99 0	S99 1	S99 2	S99 3	S99 4	S99 7	S99 8	S99 9
	60											
<i>Peltigera britannica</i>	PEBR 21		1									
<i>Peltigera collina</i>	PECO 60									1		
<i>Peltigera neopolydactyla</i>	PENE 12			3		2		3	3			
<i>Platismatia glauca</i>	PLGL 60	3		3	0.0 1	3	3	3	2	3	2	2
<i>Platismatia herrei</i>	PLHE 60		3		1		1		1	2		
<i>Platismatia lacunosa</i>	PLLA6				3			2	2		3	2
<i>Platismatia norvegica</i>	PLNO 60	2	3	3	3	3	3	3	2	3	3	
<i>Psoroma hypnorum</i>	PSHY 60		1	1								
<i>Sphaerophorus tuckermanii</i>	SPTU 4	3	3	3	3	3	3	3	3	3	3	3
<i>Tuckermannopsis chlorophylla</i>	TUCH 60	0.0 1								1		

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