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Nonvascular Plants and Invertebrates

Moving beyond the minimum: The addition of nonvascular plant inventories to vegetation research in Alaska's national parks

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Abstract

Alaska's national parks encompass a wide range of habitat types and climate gradients known to support a rich and diverse flora. At such northern latitudes, nonvascular plants, particularly bryophytes and lichens, contribute a significant portion to overall biomass and biodiversity, provide a wide range of ecosystem functions, and can serve as important indicators of air quality and climate change. A number of Alaskan parks have recently completed or are conducting comprehensive inventories that are documenting extraordinary nonvascular plant diversity. Alaska's Inventory and Monitoring networks have also developed vegetation and air quality vital-sign monitoring programs that include nonvascular plant communities in their baseline sampling. University partnerships have played an important role in contributing to our understanding of nonvascular vegetation communities in Alaska's national parks. Such collaboration has provided a strong foundation for future studies and has enhanced NPS efforts toward resource management goals.

Key words

air quality, Alaska, bryophytes, inventory, lichens, monitoring, vegetation

Lichen-covered rock outcrops in Bering Land Bridge National Preserve

Figure 1. Comprising 16 units of the National Park System, the four inventory and monitoring networks of Alaska recently have been conducting nonvascular plant inventories and have incorporated nonvascular plant communities into vegetation and air quality vital-signs monitoring.

ALASKA'S NATIONAL PARKS include nearly two-thirds of the land area in the entire National Park System and some of the most spectacular and intact arctic and subarctic ecosystems in the world. The Alaska Inventory and Monitoring (I&M) Program, organized into four I&M networks and covering 16 national park units (fig. 1), oversees natural resource inventories and monitoring programs across these lands. Nationally, the I&M Program provides funding for parks to complete a set of 12 basic natural resource inventories (NPS 2009), 2 of which are intended to produce species lists and species occurrence data for vascular plants and vertebrates.

Nonvascular plants, particularly bryophytes (mosses, liverworts, hornworts) and lichens, dominate much of Alaska's landscape and serve a number of important ecological functions (fig. 2). Although the original 12 baseline inventories did not include nonvascular plants, a number of Alaska parks have recently completed or are conducting comprehensive inventories. In addition, several of the I&M networks have developed vegetation monitoring programs that include nonvascular plants in their baseline sampling (table 1, page 66).

Bryophytes and lichens are a significant component of the vegetation in many of Alaska's ecosystems (fig. 3). In Gates of the Arctic National Park and Preserve, for example, nonvascular plants account for more than 50% of all plant species present (Nietlich and Hasselbach 1998) and may represent a dominant or codominant portion of the biomass in certain community types. In the Southwest Alaska Network, bryophytes and lichens have been found to comprise 60 to 70% of all plant species recorded in vegetation monitoring plots. At Denali National Park and Preserve in the Central Alaska Network, the proportion of nonvascular plants is 30% of total vegetative richness over more than 1,000 monitoring plots.

Nonvascular plant species are also often key components of primary succession, nutrient cycling, and carbon sequestration (Turetsky 2003). Lichens may provide a sizable portion of fixed nitrogen in the nutrient-poor ecosystems of the Arctic (Longton 1992), and they serve as an important winter food source for caribou (Joly et al. 2010). Bryophytes, when abundant, can alter soil moisture and temperature, regulating the presence of other plant species (Turetsky et al. 2010).


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Figure 2. The yellow moose dung moss (*Splachnum luteum*) spreads its spores via flying insects that visit the herbivore's dung on which the plant grows and helps to decompose.

Air quality monitoring

Perhaps one of the earliest discoveries about bryophytes and lichens from a land management context was their potential utility as a monitoring device: serving as an indicator species for monitoring air quality. Because bryophytes and lichens do not possess roots, they must get their mineral nutrition from the atmosphere. They are uniquely adapted to absorbing these required elements through deposition by air, dust, and precipitation and thus can be used as passive samplers by collecting tissue

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Figure 3. Lichen-covered boulders in Bering Land Bridge National Preserve. Lichens are a major component of the flora in many of Alaska's national parks.

for elemental analyses. When exposed to even low levels of certain pollutants, particularly sensitive species will decline or die, making nonvascular community composition or richness also a good indicator of ecosystem health. Local, regional, and global pollution sources are of considerable concern in some of Alaska's national parks.

The Arctic Network has used the widespread moss *Hylocomium splendens* (fig. 4) as a passive sampler for 15 years to explore the concentration of mine-related and fugitive dustborne heavy metals along the Red Dog Mine haul road in Cape Krusenstern National Monument (fig. 5). Zinc, lead, and cadmium levels found in moss tissue decrease with distance from the road, and the rich-

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Figure 4. The stair-step moss (*Hylocomium splendens*) is used in several Alaska parks to monitor deposition of airborne contaminants.

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Figure 5. Along the Red Dog Mine haul road in Cape Krusenstern National Monument, a switch to solid-sided ore trucks since 2001 and the application of dust palliatives (primarily calcium chloride) to the road surface have helped control dust, which has led to a decrease in heavy metal contamination in moss tissues in the park.

Table 1. Status of nonvascular plant projects across the Alaska Inventory and Monitoring Region

Network and Network Parks	Bryophtye Inventory Status	Lichen Inventory Status	Bryophytes and Lichens Used in Vital Sign Monitoring	Select Publications and Reports
Central Alaska Network				
Denali National Park and Preserve	x	p	x	Stehn et al. 2013b
Wrangell–St. Elias National Park and Preserve			x	
Yukon-Charley Rivers National Preserve			x	
Arctic Network				
Bering Land Bridge National Preserve		x	x	Holt et al. 2007; Holt et al. 2008; Holt and Neitlich 2010a
Cape Krusenstern National Monument		x	x	Ford and Hasselbach 2001; Hasselbach et al. 2005; Neitlich et al. 2014a, b; Holt and Neitlich 2010a
Gates of the Arctic National Park and Preserve		x	x	Neitlich and Hasselbach 1998; Holt and Neitlich 2010a; Nelson et al. 2014
Kobuk Valley National Park		x	x	Holt and Neitlich 2010a
Noatak National Preserve		x	x	McCune et al. 2009; Holt and Neitlich 2010a
Southwest Alaska Network				
Alagnak Wild River				
Aniakchak National Monument and Preserve	x	x		Hasselbach 1995
Katmai National Park and Preserve		ip	x	McCune et al. in progress
Kenai Fjords National Park	p	ip	x	Walton et al. 2014
Lake Clark National Park and Preserve		ip	x	McCune et al. in progress
Southeast Alaska Network				
Glacier Bay National Park and Preserve		ip	x	Schirokauer et al. 2008
Klondike Gold Rush National Historical Preserve		x	x	Spribille et al. 2010
Sitka National Historical Park	x	x	x	LaBounty 2005

x = Comprehensive inventory complete.
p = Comprehensive inventory partially complete.
ip = Comprehensive inventory in progress.

ness of nearby lichen communities is closely linked to moss tissue elemental concentrations (Hasselbach et al. 2005; Neitlich et al. 2014a). Dust control efforts implemented in part because of this monitoring have led to a decrease in contamination of moss tissues (Neitlich et al. 2014b). Moss and lichen community monitoring continues to track recovery.

The Southeast Alaska Network uses epiphytic lichen tissue samples as part of their airborne contaminants monitoring. Tissue concentrations from lichens collected over 10 years in Klondike Gold Rush National Historical Park (NHP) contained evidence of increased nitrogen and decreased lead and nickel, which were both attributed to changes in local source contaminants (increased cruise ship port time and cessation of uncontained mining ore transfers, respectively). Because of its success, lichen tissue monitoring as part of the airborne contaminants program was expanded to include all Southeast Alaska Network parks in 2008 (Schirokauer et al. 2008).

Vegetation community monitoring

Bryophyte and lichen species are important components of the many plant communities currently monitored in Alaska. Because particular species are both abundant and sensitive to changes in the environment, they can serve as useful indicators for detecting long-term trends in the larger ecological community. The Central Alaska, Arctic, and Southwest Alaska Networks track nonvascular species occurrence in their vegetation monitoring programs.

Since 2001, the Central Alaska Network has collected data on vascular and nonvascular species occurrence and now has one of the largest species-level data sets of ground-layer bryophyte and macrolichen communities in North America, with more than 1,000 vegetation plots installed in Denali National Park and Preserve, and intensive work also occurring in Yukon-Charley Rivers National Preserve and Wrangell–St. Elias National Park and Preserve with several hundred additional plots installed. The Arctic Network has more than 500 lichen monitoring plots for ungulate grazing habitat, contaminant effects, and trends in diversity, and approximately 200 vegetation structure monitoring plots that include lichens and bryophytes in their ground strata. The Southwest Alaska Network has more than 130 vegetation monitoring plots that include ground-layer bryophyte and macrolichen occurrence, with an additional 29 epiphytic macrolichen community plots.

Inclusion of nonvascular plants in these plots has been a challenge because of the difficulty of species detection and identification, and time-intensive sampling because of high species diversity. However, because the nonvascular species data have been collected with a broad set of other ecological variables such as tree and shrub cover, soil temperature, and vascular plant richness, researchers are able to develop a more complete understanding of these organisms and their environment. For example, repeat photography and preliminary data from vegetation monitoring plots suggest that climate change is leading to increasing shrub cover across subarctic and arctic landscapes (Hinzman et al. 2005). One of the expected impacts of this is the encroachment of shrubs into abundant forage, lichen-dominated plant communities. This encroachment has the potential to increase shade and leaf debris at the ground layer and, as a result, cause shifts in species composition through time, including the loss of lichen and moss cover, which may in part affect the distribution and population dynamics of caribou populations. For the Western Arctic Caribou Herd, which can contain up to 500,000 animals and is one of the largest free-roaming herds in North America, the consequences of lichen habitat decline could be substantial for the ecosystem and the subsistence economies of local communities (Joly et al. 2010).

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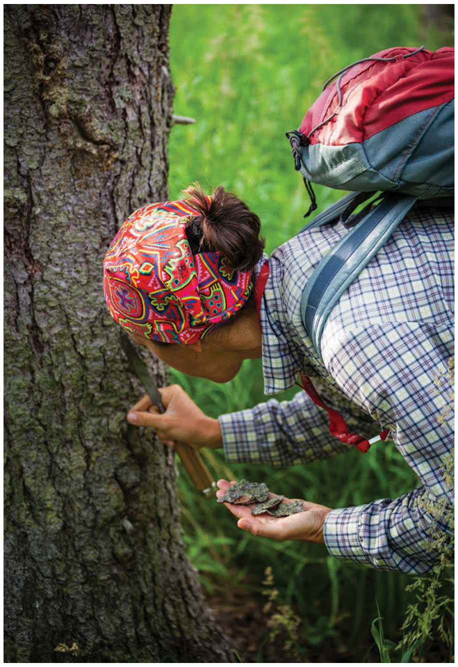

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Figure 6. A researcher from the University of Gräz in Austria collects lichens during an inventory for Katmai National Park and Preserve.

Assessing the diversity of nonvascular species in the parks

Recent inventories conducted within national parks of Alaska have revealed that lichen and bryophyte diversity is high. An inventory completed in Klondike Gold Rush National Historial Park (Spribille et al. 2010) reported the largest number of lichens per unit acre on record and the largest number of lichen species recorded from any national park. More than 766 taxa of lichenized and lichenicolous fungi were detected in this park, with at least 196 taxa new to Alaska, 34 new or confirmed taxa for North America, and 4 described as new to science. An inventory of the western arctic parklands (Holt and Neitlich 2010b) described 491 lichen species, 16 of which are new to Alaska or North America and 3 of which are new to science. Lichen inventories currently under way in Katmai National Park and Preserve and Lake Clark National Park and Preserve are documenting several hundred previously unreported taxa for southwestern Alaska, including at least one species new to science. A bryophyte inventory in previously unexplored regions of Denali National Park and Preserve, including its remote southern regions, has increased the number of known taxa by nearly 30%, with 499 species now documented (Stehn et al. 2013b). In Kenai Fjords National Park, an inventory of bryophytes and lichens along the park's remote coastal forests identified hundreds of

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previously undocumented species for the park, including several new state records and many regionally rare to uncommon taxa (Walton et al. 2014).

These recent inventories have benefited greatly from university cooperation, primarily from institutions in North America and Europe. The number of participants for each project varies, but has included world and regional taxonomic experts (fig. 6, previous page). The inventories have resulted in a number of peer-reviewed publications and have provided a foundation for further studies in and around Alaska's national parks. For example, discovery of the globally critically endangered epiphytic lichen *Erioderma pedicellatum* in Denali during inventory work instigated a park-funded occupancy and abundance study that revealed the south-central Alaska population to be the largest known in the world (Stehn et al. 2013a).

All data collected on nonvascular plant communities of Alaska's national parks are making an important contribution to NPS resource management goals by documenting species diversity and changes in the structure and composition of ecological communities. As environmental and anthropogenic stresses increase, Alaska's I&M networks are establishing important baseline data sets that can be used to set benchmarks for measuring levels of ecological integrity. Continued and future investment in scientific capacity through partnerships with universities and other research institutions will further contribute to our understanding of nonvascular vegetation communities in Alaska's national parks.

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