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Mish, Bogs, and Berries: The Significance of Boreal Heathlands as Indigenous Cultural Landscapes

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Abstract

Heathlands are a significant land cover type across the circumpolar boreal biome. A growing body of knowledge has developed around the ecology of heathland ecosystems, but little work has been done to document their cultural significance to Indigenous Peoples. In this study, we integrate plot-based vegetation surveys, a desktop review of Indigenous Mi'kmaq ethnobotany, and interviews with Miawpukek First Nation community members to understand Indigenous values, uses and perspectives of heathlands across the Ktaqmkuk boreal region (Newfoundland, Canada). Although historically perceived as unproductive land of limited value for development or conservation, we found that heathlands provide a diversity of culturally significant habitats and plants used by Indigenous Peoples for berry picking, hunting, traveling, and food preservation. Specifically, Miawpukek First Nation community members hold detailed environmental knowledge of biodiversity, ecology, environmental change, and ethics of respect, reciprocity, and responsibilities to heathland landscapes. Heathlands also facilitate personal and shared community experiences of being on the land that are crucial for sustaining Indigenous customary foods, fostering social and intergenerational bonding, supporting the maintenance and transmission of Indigenous knowledge, and instilling a sense of cultural identity. By highlighting the tangible and intangible cultural values associated with boreal heathlands, our analysis draws attention to the biocultural significance of open and sparsely treed ecosystems of the boreal biome and their importance to conservation and sustainable use.

Keywords

heathland, ethnobotany, cultural landscape, berries, Indigenous-led conservation

Introduction

Canada's boreal forest region is one of the five "Great Forests" left on the planet due to its vast size and relative intactness (Bryant, Nielsen, and Tangley 1997; Watson et al. 2018; Wells et al. 2020). Along with the planet's other remaining large natural forests, such as the tropical rainforests of the Amazon and Congo Basin, the Canadian boreal provides globally significant ecosystem services, including climate regulation, freshwater provision and important habitat for wildlife, including large animals (e.g., caribou, grizzly bears, and bison) that have been extirpated from much of their southern range and billions of songbirds that migrate thousands of kilometers annually between the southern and northern hemispheres (Carlson, Wells, and Jacobson 2015; Wells et al. 2020). Although typically described as a "forest" in the scholarly and popular literature, the term "boreal forest" is in fact a misnomer because much of the vegetation zones within the Canadian boreal region, and the global boreal biome more broadly, are sparsely treed (e.g., open-crown lichen woodlands) or lack tree cover altogether, even at lower latitudes. These open boreal ecosystems include peatlands, wetlands, and heathlands; the latter covering nearly 50,000 km^2 of eastern North America (Hamel 2020).

Heathlands are open, shrub-dominated habitats characterized by nutrient-poor conditions and the prevalence of dwarf shrubs, such as blueberry (*Vaccinium* spp.), common heather (*Calluna vulgaris*), and gorse (*Ulex* spp.), as well as a diversity of

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graminoid species (Mallik 1995; Specht 1979). They occur in a diversity of habitat types, including mountain ridges (Savard and Payette 2013; Abis and Brovkin 2017), rock outcrops and coastal headlands (Burley, Harper, and Lundholm 2010; Cameron and Bondrup-Nielsen 2013), where low soil fertility or exposure to wind or salt spray prevents the development of taller vegetation or trees. They are also often the predominant successional plant community after fire or anthropogenic forest clearance in which overstory tree species have been replaced by dwarf shrubs, particularly in the family *Ericaceae* (Meades 1983; Mallik 1995; Oberndorfer and Lundholm 2009). The geographic spread and diversity of *Ericaceae*-dominated ecosystems is as significant as is the complexity of terms used to describe them (e.g., "heathland," "heath," "barren," "blanket bog," "muir," "moor," "mire," and the Indigenous Mi'kmaq term "mish").

In addition to providing valuable habitat for biodiversity (i.e., Morán-Ordóñez et al. 2013; Benetková et al. 2022; Kerdoncuff, Måren, and Eycott 2023), heathlands are also important cultural landscapes that embody elements of tangible heritage, including culturally significant flora and fauna (Lacey 1993; Morán-Ordóñez et al. 2013) and intangible heritage such as traditional knowledge, expressions of meaning and identity-making, and place-based belonging (Baránková and Špulerová 2023). For example, in Scandinavia and the British Isles, heathlands dominated by *Calluna vulgaris* (ling) have been an integral component of semi-natural and agricultural landscapes for centuries, arising from human agency and intensive land management (Ombashi and Løvschal 2023). Before the Neolithic, *C. vulgaris* and other heather species were restricted to coniferous forest understories (Webb 1998). Starting from the Bronze Age (~4000 years ago), anthropogenic deforestation mediated the rapid expansion of *C. vulgaris* heathlands (Gimingham 1972; Karg 2007) that have been used for grazing animals (Webb 1998), harvesting peat, and hunting (Allen et al. 2016) for centuries.

In comparison, boreal heathlands are dominated by another ericaceous shrub, *Kalmia angustifolia* (sheep laurel, hereafter *Kalmia*) instead of *C. vulgaris* (Mallik 1995). The widespread establishment of *Kalmia* heathland is thought to have begun much later in eastern North America compared to Europe, following the clearance of boreal black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*) forests on the Atlantic coast (Meades 1983) with European colonization and settlement.

In further contrast to European heathlands, the cultural values of boreal heathlands are poorly understood. Unlike *C. vulgaris* heathlands, boreal heathlands in eastern North America are not known to be intentionally created or maintained by human societies through customary practices, such as grazing or prescribed burning. Furthermore, due to the unique life history traits of *Kalmia*, boreal heathlands can remain stable and persist on the landscape for centuries without human intervention, such as prescribed burning or grazing (Girard, Payette, and Gagnon 2008). Rather than being thought of as cultural landscapes created, sustained, and used by people, boreal heathlands are often framed as "unproductive," "undesirable," and a management problem, as the dominance of *Kalmia* and other boreal ericaceous species interferes with market activities, such as forestry and agriculture (Thiffault and Jobidon 2006; Bradley et al. 2008). Nevertheless, they are an important component of the traditional territories of many Indigenous Peoples in eastern North America, including the Mi'kmaq, Maliseet, Passamaquoddy, Innu, Cree, and Anishinaabe Nations (Native Land Digital 2024), and Indigenous plant knowledge holders and ethnobotanists have documented the use of boreal heathland vegetation in Indigenous food and medicine systems (Lacey 1993; Moerman 2009; Hall and Evans 2022).

In this paper, we present the first investigation of the cultural significance of heathlands of the Canadian boreal forest region, employing both ecological and ethnographic methods to identify culturally significant plants and the relationships that Indigenous Mi'kmaq Peoples have with them. Our specific research objectives are (1) to describe how Indigenous ethnobotanical resources are distributed across heathland and forest ecosystems in the Ktaqmkuk boreal region of eastern North America (Newfoundland, Canada); (2) to identify characteristic ethnobotanical plants that could serve as useful indicator species of heathland and forest vegetation for biocultural monitoring; and (3) to describe the biocultural dynamics of boreal heathlands through documentation of human–plant associations and relationships that Mi'kmaq Indigenous Peoples have with them.

Methods

Study Area

Samiajij Miawpukek First Nation is a Mi'kmaq First Nation community located on the Bay D'Espoir on the south coast of the island of Newfoundland; known in the Mi'kmaq language as Ktaqamkuk, meaning "land across the water." (Chief Mi'sel Joe, personal communication, 2023). "Miawpukek" translates to "the Middle River" in the English language and refers to the Conne River, where most MFN community members reside today. The community of Conne River is centered on an ancestral Mi'kmaq village that has been continuously occupied for centuries and which is part of a vast network of semi-permanent camping sites which were used by nomadic Mi'kmaq travelling across the vast region of Mi'kmawey (including modern day Labrador, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Maine). Miawpukek people call their traditional territories "Mimaju'nnulkwe'kati," meaning "life-giving land." Miawpukek First Nation's title, rights and responsibilities over their traditional lands and waters in Ktaqamkuk were never extinguished by treaty, and they remain the rightful stewards, although this is still not fully recognized by colonial governments (Prins 1997). Detailed ethnographic information, traditional land use mapping and other cultural resources on Miawpukek First Nation are available at the cultural center in Conne River and on a website curated by Hall and Evans (2022).

Most of Miawpukek First Nation's traditional territory of 16,673 km^2 lies within the Maritime Barrens boreal ecoregion. The climate and ecology of the Maritime Barrens are strongly impacted by their proximity to the Atlantic Ocean, with cool, foggy summers and mild winters (Bell 2002). The Maritime Barrens is subdivided within Miawpukek First Nation's territory into two subregions: the Central Barrens and the South Coast Barrens. The Central Barrens, occurring north of Conne River, experiences less fog than the coast, has a rolling topography with low relief, and vegetation consisting of *Kalmia* heathlands, blanket bogs, and boreal forest stands dominated by balsam fir and black spruce (Damman 1983). In comparison, the South Coast Barrens are composed of wind-exposed, rugged, rocky headlands that experience frequent fog (Damman 1983).

This paper derives from a collaborative case study, initiated in 2020 and maintained to the present day, between researchers at the University of Guelph and Indigenous natural resource management practitioners from Miawpukek First Nation (MFN). In early 2019, researchers at the University of Guelph were invited by one of the co-authors of this study, Gregory Jeddore, the then manager of MFN's Natural Resources Department, to collaborate on Indigenous-led environmental research in support of MFN's vision to establish a network of Indigenous Protected and Conserved Areas (IPCAs) in their traditional territories in Ktaqamkuk. The second author of this paper, FM, travelled to MFN later in 2019, where he met Gregory and former MFN Chief Mi'sel Joe and initiated a research partnership that has to date involved several biocultural projects.

Vegetation Survey

Vegetation surveys were conducted in 2021 and 2023 at twelve sites along the Bay d'Espoir highway (NL-360) to identify and describe the ethnobotanical species found in Miawpukek First Nation territories. Candidate sites were identified in 2021 with the assistance of the Miawpukek First Nation Guardians, who introduced us to the different forests and heathlands in their territory through guided tours by foot, off-road motorized vehicles, boats, and helicopters. They also participated in vegetation surveys when they had time, and shared cultural information about plants and other species during guided walks and field visits throughout the study. Six of the chosen sites are representative of heathland ecosystems; three are located within the Central Barrens (Central Heath) and three within the South Coast Barrens (South Coast Heath) subregions. The other six sites represent eastern boreal forest ecosystems; three are located within the Central Barrens and three within the South Coast Barrens subregions. Within each subregion, heathland and forest sites were selected adjacent to each other to ensure that the sites shared as similar environmental conditions as possible. At each site, we randomly established three 20×20 m^2 vegetation sampling plots. Two sample plots in one of the Central Barrens sites were destroyed in a wildfire in the summer of 2022. The plots were reestablished and sampled in an adjacent unburned heathland the following summer. In addition, one Central Barrens Forest site was dropped to avoid conflict with denning coyotes that were present in the area at the time of sampling. In total, we sampled plant and ethnobotanical species in 400 quadrats distributed across 40 plots within the entire study area (Figure 1).

In each 20×20 vegetation sampling plot, we conducted plant community surveys at two vegetation strata: the ground vegetation layer (vascular and non-vascular plants < 0.5 m in height) and the shrub layer (woody vegetation ≥ 0.5 m in height) (Puric-Mladenovic 2016). We visually estimated the % cover of all ground vegetation species in 10 1×1 m quadrats randomly established within each 20×20 m plot and the % cover of all shrub species in a 10×10 m sub-plot nested in the southwest corner of each 20×20 m^2 plot. Species were identified using regional field guides and floras (Conard and Redfearn 1979; Ireland 1982; Boland 2013, 2017; Meades and Meades 2024) and in consultation with the Miawpukek First Nation Guardians. Scientific names are reported following the convention of the Tropicos database v 3.4.1 (Missouri Botanical Garden 2023). Voucher specimens of species observed at each site were collected to verify species identification. Specimens are stored at the Biodiversity Institute of Ontario herbarium, located on the University of Guelph campus.

Ethnobotanical Identification of Plants

Lists of ethnobotanical flora have previously been compiled by Mi'kmaq community members (Unama'ki Institute of Natural Resources 2012; Miawpukek First Nation 2019). We cross-referenced the species that we encountered in the vegetation surveys with these and other published literature sources that report Mi'kmaq plant uses (Lacey 1993; Uprety et al. 2012; AMEC Environment & Infrastructure 2013; Hall and Evans 2022). We also consulted with members of the Miawpukek First Nation Indigenous Guardians and other community members on guided plant walks on the land. Where data were available, we reported ethnobotanical use categories following the system of Cook (1995). This plant-use category system provides a method to summarize the cultural significance of plants and has served as the standard method of classifying plant use in ethnobotanical studies (Gruca et al. 2014). The standard includes the following use categories: food, food additives, animal food, bee plants, invertebrate food, materials, fuels, social and spiritual use, vertebrate poisons, non-vertebrate poisons, medicines, environmental uses, and gene sources (Cook 1995).

Data Analysis

Data analyses were completed using R version 4.2.2 (R Core Team 2022) and visualizations were produced using the "ggplot2" package (Wickham 2016).

Species Diversity. To quantify the vegetation and ethnobotanical diversity for each plot, we calculated species richness for all

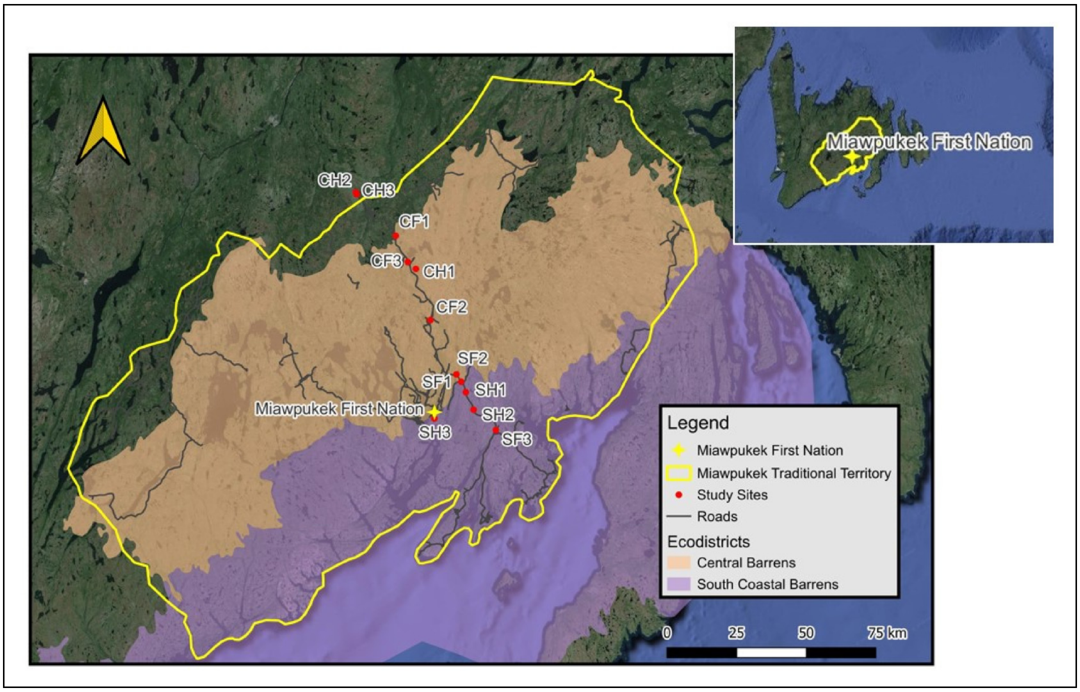

Figure 1. Regional map of Miawpukek First Nation's traditional territory, showing the locations of vegetation survey sites within the Central Barrens and South Coastal Barrens subregions.
Data sources: Jeddore, n.d. unpublished data, Statistics Canada 2010.

species and the subset of ethnobotanical species, and Shannon's Index of the ground and shrub layer, within each plot using the "vegan" package (Oksanen et al. 2020). While the Shannon Index is a widely used metric to quantify species diversity in ecosystems, it is sensitive to sample size and is unable to accurately weigh either rare or overly abundant species. Consequently, the Shannon Index is an abstract measure that does not relate to ecosystem processes or functions (Gotelli and Colwell 2001). To determine differences in species richness, Shannon Index, and ethnobotanical species richness across ecosystem types, we conducted Kruskal–Wallis tests using the "rstatix" package (Kassambara 2023) followed by Dunn's test for pairwise comparison, with p-values adjusted with the Holm method (Ogle et al. 2022).

Plant Community Ordinations. To assess differences in the composition of plant species across ecosystem types, we ran an Analysis of Similarities (ANOSIM) using vegan's "anosim" function (Oksanen et al. 2022), followed by pairwise ANOSIM with p-values adjusted with the Bonferroni method using the "anosim. pairwise" function (Gai 2021) on the Bray-Curtis distance matrix of Hellinger-transformed %cover data. Following ANOSIM, we ran an NMDS ordination using vegan's "metaMDS" function (Oksanen et al. 2022) to characterize changes in species composition across ecosystem types. Similarly, to assess and describe differences in the ethnobotanical composition of the different ecosystem types, we ran a second ANOSIM and NMDS ordination on the subset of plant species that are ethnobotanicals.

Characteristic Species of Forests and Heathlands. We considered abundant or indicator species to be characteristic plant species of each ecosystem type. The most abundant species of a given ecosystem type are defined as species having an average % cover of $\geq$ 1.0% and occurring in at least half of the sites within the ecosystem type. In contrast to abundant species, which may be abundant across multiple ecosystem types, indicator species occur in one or a subset of ecosystem types and are therefore predictive of the given ecosystem type (Chytrý et al. 2002). To identify indicator species, we calculated the Indicator Value index (INDVAL) of species for each ecosystem type, using the "multipatt" function from the "indicspecies" package (De Cáceres and Legendre 2009). The significance of INDVAL values was tested by 999 permutations (De Cáceres and Legendre 2009), and species were identified as indicators if $A > 0.6$, $B > 0.25$, and INDVAL > 0.25 (De Cáceres and Legendre 2009).

Scoping Interviews

In July 2023, H. J. conducted semi-structured scoping interviews with 11 community members to elucidate Indigenous Mi'kmaq cultural values attached to forests and heathlands. Interview participants, who were identified through snowball sampling, were between 17 and 80 years old and resided in Conne River at the time of the interviews. People were suggested based on their specialized knowledge and experience with plants. All participants were compensated with an honorarium. Interview length ranged from 45 to 60 min, during which participants were asked questions on how they interact with forest and heathland landscapes, plants, and wildlife in their traditional territory. Interviews were conducted in English and in person at the participant's home or occasionally on the land and concomitantly recorded and transcribed. Interview transcripts were imported into NVivo qualitative software release 14.23.3 (Lumivero 2020) for analysis. Y. Z. N. analyzed the interview data using an inductive thematic approach involving preliminary coding of interview transcripts, identification of key patterns and themes, and refinement and organization of codes under the identified themes (Braun and Clarke 2006). In inductive analysis, codes and themes are not established a priori but are derived from data (Braun and Clarke 2006). This method enables the participants' accounts to play a greater role in the development of themes and research narratives and can center Indigenous perspectives without the bounds of a pre-established theoretical framework (Richmond and Nightingale 2021).

The interviews were approved by the Research Ethics Boards at the University of Guelph (approval: 20-06-015) on July 27, 2021.

Results

Floristic and Ethnobotanical Diversity

The vegetation surveys recorded 117 plant species from 75 genera and 46 families (Figure 2). The families (Figure 2) with the highest number of recorded species were *Ericaceae* (18 species and 10 genera), *Dicranaceae* (14 species and four genera), *Sphagnaceae* (11 species and one genus), and *Rosaceae* (eight species and six genera). Plant species varied in growth forms (Figure 3) and include mosses (39 species), liverworts (eight species), ferns and fern allies (five species), graminoids (seven species), forbs (22 species), dwarf shrubs (16 species), shrubs (13 species) and trees (seven species).

Twenty-five species were culturally significant as food, medicine, materials, fuel, or poison (Table 1). One species, partridgeberry (*Vaccinium vitis-idaea*), was only consumed as food, two species, black ash (*Fraxinus nigra*) and witherod viburnum (*Viburnum cassinoides*), were solely used as materials, and nine species were solely used as medicine. The other 13 ethnobotanical species were culturally significant in multiple use categories. Ethnobotanical plants represented 13 families and 20 genera (Figure 2) and exhibited the following growth forms (Figure 3): forbs (eight species), dwarf shrubs (five species), shrubs (five species), and trees (seven species).

Distribution of Floristic and Ethnobotanical Diversity Across Forests and Heathlands

The species richness and Shannon Index of the ground vegetation layer ranged from 6 to 41 species per plot, and 0.59 to 2.82 per plot. The Kruskal–Wallis tests identified significant differences in mean ground vegetation species richness ($\chi^2 = 18.96$, df = 3, $p < 0.001$) and Shannon Index ($\chi^2 = 17.5$, df = 3, $p < 0.001$) between ecosystem types. The mean ground vegetation species richness (Figure 4a) was significantly higher in South Coastal heathlands compared to Central heathlands ($z = 4.2$, $p < 0.001$), while the mean species richness in South Coastal forests was only marginally significantly higher than Central forests ($z = 2.47$, $p = 0.054$) and Central heathlands ($z = 2.5$, $p = 0.061$). Similarly, the mean ground vegetation Shannon Index (Figure 4b) was significantly higher in South Coastal forests compared to Central heathlands ($z = 2.7$, $p = 0.035$), and in South Coastal heathlands compared to Central forests ($z = 2.55$, $p = 0.043$) and Central heathlands ($z = 3.82$, $p < 0.001$).

Within the shrub layer, species richness ranged from one to eight species per plot, while the Shannon Index ranged from 0 to 1.69 per plot. Kruskal–Wallis tests (Figure 4c, d) identified significant differences in mean shrub species richness ($\chi^2 = 16.24$, df = 3, $p = 0.001$) and shrub Shannon diversity ($\chi^2 = 20.32$, df = 3, $p < 0.001$). South Coastal forests had significantly higher mean shrub species richness ($z = 2.63$, $p = 0.034$), and marginally significantly higher shrub Shannon Index ($z = 2.44$, $p = 0.059$) compared to central forests. Additionally, South Coastal heathlands had significantly higher mean shrub species richness compared to Central heathlands ($z = 2.64$, $p = 0.041$) and South Coastal forests ($z = 3.47$, $p = 0.0031$). Similarly, the mean shrub Shannon Index was significantly higher in South Coastal heathlands compared to Central heathlands ($z = 3.4$, $p = 0.003$) and South Coastal forests ($z = -4.19$, $p < 0.001$).

Ethnobotanical plants were observed at all sites, and the number of ethnobotanical plants encountered ranged from two to 16 species per plot. Similar overall numbers of ethnobotanical species were observed in all ecosystem types: 17 ethnobotanical plant species were recorded in South Coastal heathlands, 16 in both Central heathlands and South Coastal forests, and 13 in Central forests. Nevertheless, there were significant differences in mean ethnobotanical richness per plot between ecosystem types ($\chi^2 = 14.16$, df = 3, $p = 0.0027$). South Coastal heathlands had the highest mean number of ethnobotanical plant species per plot (11.11 ± 0.99), followed by South Coastal forests (6.78 ± 1.12 species) and Central forests (6.43 ± 0.53 species). Central heathlands had the lowest number of ethnobotanical species per plot (5.53 ± 0.89). Differences in mean ethnobotanical richness (Figure 5) were significant between South Coastal heathlands and Central heathlands ($z = 3.73$, $p = 0.0011$) and marginally significant between South Coastal heathlands and South Coastal forests ($z = 2.42$, $p = 0.078$)

Floristic and Ethnobotanical Composition of Forests and Heathlands

The NMDS ordinations of vegetation survey plots performed on the full plant community (Figure 6) and the subset of ethnobotanical plants (Figure 7) converged, respectively, with stress

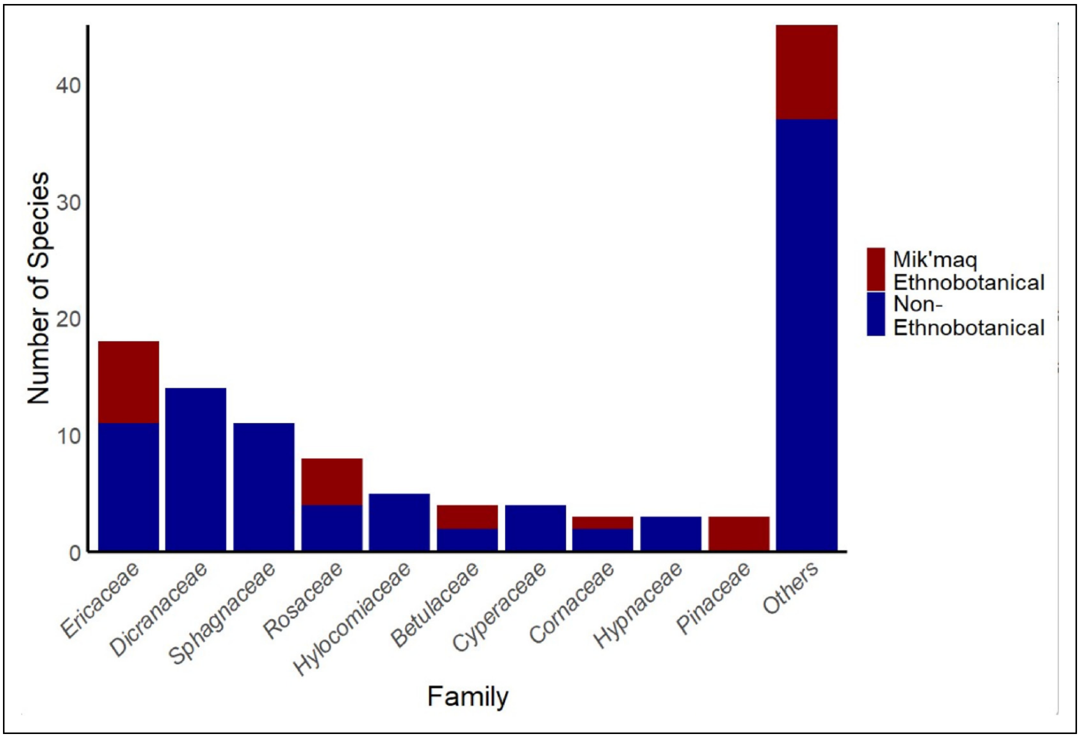

Figure 2. Number of plant species and ethnobotanical species by family encountered during vegetation surveys in Miawpukek First Nation's traditional territory.

values of 0.072 and 0.089 in two dimensions, indicating good representations of the multivariate distance between plots. ANOSIM results confirmed that the four ecosystem types significantly differed in plant species composition (ANOSIM $R = .8838$, $p < .001$) and ethnobotanical composition (ANOSIM $R = .89$, $p < .001$), except for Central forests and South Coastal forests, which had similar assemblages of plant species (Pairwise ANOSIM $R = .2$, $p = .1$) and ethnobotanical species (Pairwise ANOSIM $R = .16$, $p = .38$).

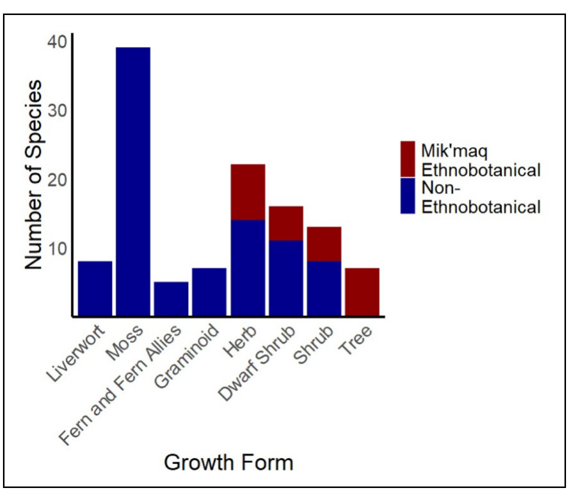

Figure 3. Growth forms of plant species and ethnobotanical species encountered during vegetation surveys in Miawpukek First Nation's traditional territory.

Indicator species and abundant species are presented in Table 2 and Supplementary Table 1. Heathland ecosystems showed a clear separation in both plant and ethnobotanical composition from forest ecosystems along NMDS1. Indicator species analysis identified 12 species associated with Central and South Coastal forests. Six forest indicator species: *A. balsamea*, *Dicranum majus* (greater fork moss), *Gaultheria hispidula* (creeping snowberry), *Hylocomnium splendens* (stairstep moss), *Ptilium crista-castrensis* (ostrich-plume feathermoss) and *Sphagnum nemoreum* (northern peatmoss) are abundant in both forest types. An additional three forest indicators; *Bazzania trilobata* (three-lobed whipwort), *Dryopteris carthusiana* (spinulose wood fern), and *Linnaea borealis* (twinflower), are only abundant in South Coastal forests. Two forest indicator species; *A. balsamea* and *G. hispidula*, are ethnobotanical.

Eight species were identified as indicators of both Central and South Coastal heath ecosystems. Four heath indicators, namely *Kalmia* in the ground layer, *R. canadense* (rhodora), *R. groenlandicum* (Labrador tea), and *V. angustifolium* (lowbush blueberry), are abundant in both Central and South Coastal heaths. Additionally, the heath indicator *D. polysetum* (wavy-leaved broom moss) was abundant in Central heathlands, and another heath indicator, *Sphagnum rubellum* (red peat moss), was abundant in South Coastal heathlands. Additionally, NMDS ordinations show that plots located in

Table 1. Cultural Uses of Mi'kmaq Ethnobotanical Species Recorded in Vegetation Surveys in Miawpukek First Nation's Traditional Territory.

				Mi'kmaq Ethnobotanical Uses				
Genus	Species	Common Name	Mi'kmaq Name	*Food*	*Medicine*	*Material*	*Fuel*	*Poison*
Abies	*balsamea*	Balsam Fir	*Stoqon*	*+	*+#	*+?	*	
Acer	*spicatum*	Mountain Maple			*			
Betula	*alleghaniensis*	Yellow Birch	*Nimnoqn*	*	*#?	*		
Betula	*papyrifera*	Paper Birch	*Maskwi*	+		*+		
Clintonia	*borealis*	Bluebead lily			*			
Coptis	*trifolia*	Canker-root	*Wisowtakjijkl*		*+#?			
Cornus	*canadensis*	Bunchberry	*Ka'qaju'manaqsi'l*		*#?			
Empetrum	*nigrum*	Crowberry			#			
Fraxinus	*nigra*	Black Ash				*+		
Gaultheria	*hispidula*	Creeping Snowberry	*A'ldaia'al*	+	*#			
Juniperus	*communis*	Common Juniper	*Apatamkiejit*	*	*+#?		*	
Kalmia	*angustifolia*	Sheep Laurel			*#?			*
Larix	*laricina*	Tamarack	*Apu'tam'kie'jit*		*#?		*	
Picea	*mariana*	Black Spruce	*Kawatkw*	*	*#?	*+	*	
Prunus	*pensylvanica*	Pin cherry	*Wijokemusi*		*+#			
Prunus	*virginiana*	Chokecherry	*Luimanaqsi*		*+#?			
Rhododendron	*groenlandicum*	Labrador Tea	*Apuistekie'ji'jit*	*	*+#?			
Rubus	*chamaemorus*	Bake Apple	*Pko'kmin*	*	*			
Rubus	*pubescens*	Dewberry			*			
Sarracenia	*purpurea*	Purple Pitcher Plant	*Mko'qewik*		*#?			
Taxus	*canadensis*	Yew		*	*?	*		
Vaccinium	*angustifolium*	Lowbush blueberry	*Pkwimann*	*	*			
Vaccinium	*oxycoccos*	Bog Cranberry		+#	#			
Vaccinium	*vitis-idaea*	Partridgeberry	*Poqomannaqsiis*	*+				
Viburnum	*cassinoides*	Witherod Viburnum				+		

Note: Information on Ethnobotanical Uses comes from the Following Sources: * = AMEC Environment & Infrastructure (2013), + = Hall and Evans (2022), # = Lacey (1993), and ? = Uprety et al. (2012). Mi'kmaq Names of Ethnobotanical Species are Given if Known.

the South Coast subregion differed in composition from plots located in the Central subregion along NMDS2. However, indicator species analysis did not identify species that distinguished Central subregion plots from South Coastal subregion plots.

Forty plant species were identified as indicators of a single ecosystem type. Twenty-six species were associated with South Coastal heathlands, including six ethnobotanical species: *Empetrum nigrum* (black crowberry), *Juniperus communis* (common juniper), *Larix laricina* (tamarack), *P. mariana*, *Rubus chamaemorus* (bake apple), and *V. vitis idaea*. Furthermore, ten indicator species were also abundant in South Coastal heathlands, including *Kalmia* and *E. nigrum*, which were the first and second most abundant South Coastal heath species. Five species were indicators of Central Forest ecosystems, including the ethnobotanicals *F. nigra* and *Rubus pubescens* (dewberry). However, none of the Central Forest indicator species were abundant in that ecosystem type. Only two species, *Epilobium palustre* (marsh willowherb) and *Polytrichum strictum* (bog hair cap moss), were identified as indicators of Central heathlands, and neither of these species were abundant in their associated ecosystem type. Finally, seven species were identified as indicators of South Coastal forests, including the ethnobotanicals *Betula alleghaniensis* (yellow birch) and *Clintonia borealis* (blue-bead lily). Only one South Coastal Forest indicator; *Sphagnum andersonianum* (Anderson's peat moss), was also abundant in South Coastal Forest plots.

Miawpukek First Nation Community Perspectives of Forests and Heathlands

The conversations with Miawpukek First Nation community members reveal a multifaceted narrative of the landscape that intertwines plants and ecosystems, human practices, and traditional knowledge. We identified four themes that reflect the community's relationship with heathland and forest ecosystems: environmental knowledge, the cultural importance of heath and forest ecosystems, stewardship values, and change and continuity.

Miawpukek Environmental Knowledge.. Interview participants communicated an intimate knowledge of the ecological structures, processes, and species composition of the lands within their traditional territories, and a detailed internal system of understanding and classifying diverse landscape units. Forests are characterized by the presence of trees, and vocabulary associated with forests occurred 32 times across the interviews with

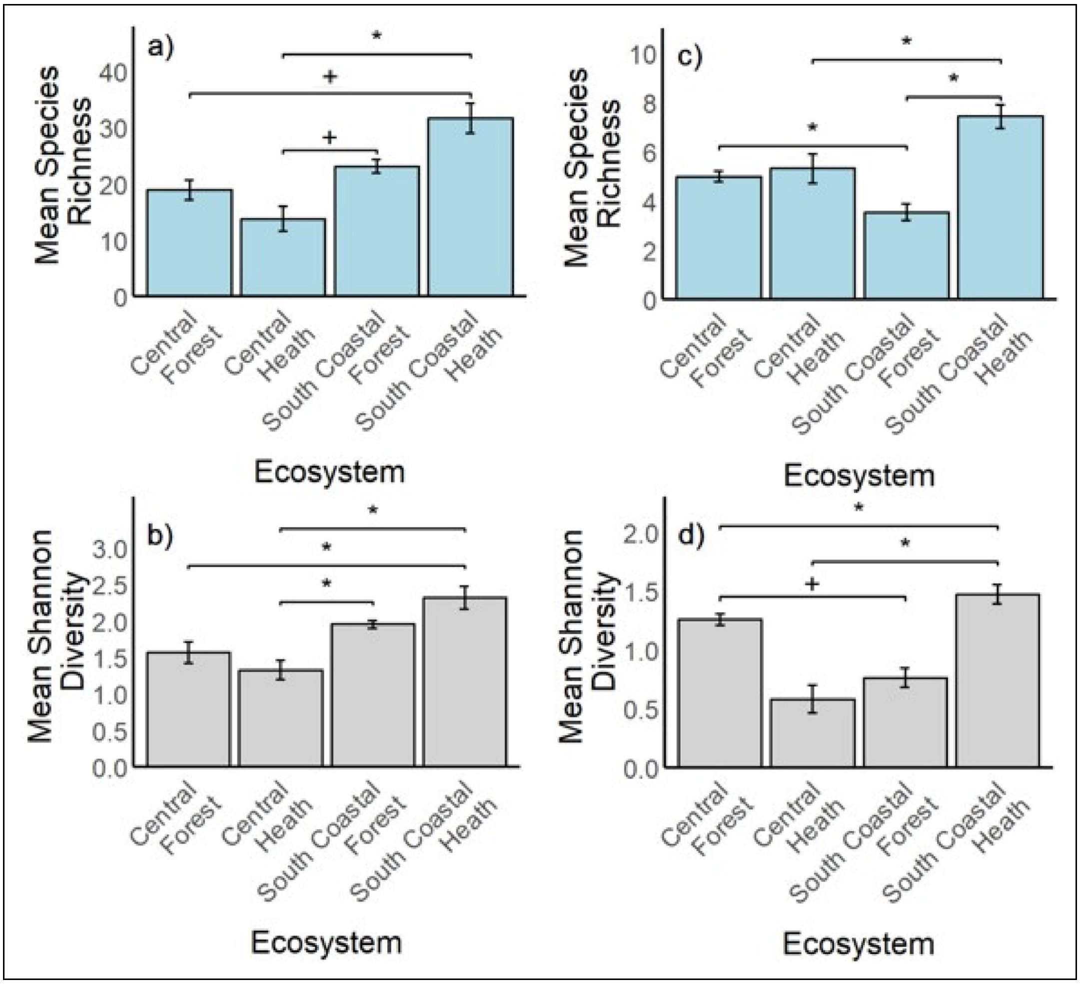

Figure 4. Differences in mean (a) ground vegetation species richness, (b) ground vegetation Shannon diversity, (c) shrub species richness, and (d) shrub Shannon diversity in plots located in Central Forest, Central Heath, South Coastal Forest, and South Coastal Heath ecosystem types. The error bars show one standard error around the mean. Asterisks (*) denote significant differences between means ($p < .05$) while crosses (+) denote marginally significant differences between means ($0.5 < p < .1$).

Miawpukek First Nation community members. Participants particularly pointed out patches of old-growth forests that occur in the territory.

In contrast, terminology associated with heathlands occurred 385 times in the interviews with community members. Interviewees identified heathlands, often called barrens in conversation, by low vegetation and a proliferation of wildflowers. Heathlands were subdivided into mish (dry heath with "pink flowers" - *Kalmia* - and grass cover) and bog (wet and mucky heath). Bogs are additionally divided into yellow/floating bogs and black bogs. Yellow bogs have soils that are light in color, compact enough to walk across and freeze in the winter. In contrast, black bogs are described as having black, quicksand-like soils that do not freeze in the winter. Black bogs are often identified as a hazard because "the suction is that bad usually. And you could get stuck and lost…And in the winter it doesn't freeze. So, once you go over ice, it could break, and you lose your skidoo."

Participants also demonstrated extensive knowledge of the flora and fauna that thrive in different ecosystem types. Plants that can be found in forests include mosses, ferns, black spruce, pine, juniper, cherry trees, alders, birches, witch hazel, raspberries, teaberries (*G. hispidula*), blackberries, black currants, and gooseberries. Heathlands are particularly associated with berry species, including blueberries, raspberries, strawberries, gooseberries, teaberries, bake apples, partridgeberries, and cranberries. Small birch and spruce trees also occur in the mish, but one community member emphasized that mish trees do not support lichen growth. Bogs are also associated with unique plant species, such as pitcher plants and beaver root (likely *Nymphaea odorata*).

Cultural Significance of Forests and Heathlands.. During the interviews, community members recounted many stories of participating in land-based activities. These stories provide insight into the importance of heathland and forest ecosystems for

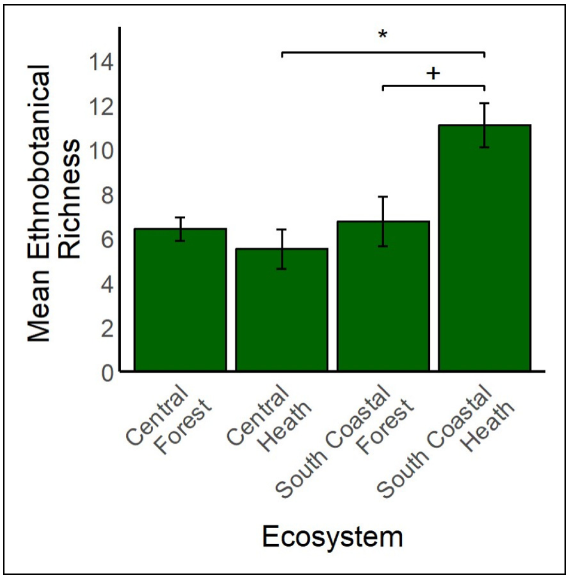

Figure 5. Differences in the average number of ethnobotanical species present in plots located in Central Forest, Central Heath, South Coastal Forest, and South Coastal Heath ecosystem types. The error bars show one standard error around the mean. Asterisks (*) denote significant differences between means ($p < .05$) while crosses (+) denote marginally significant differences between means ($0.5 < p < .1$).

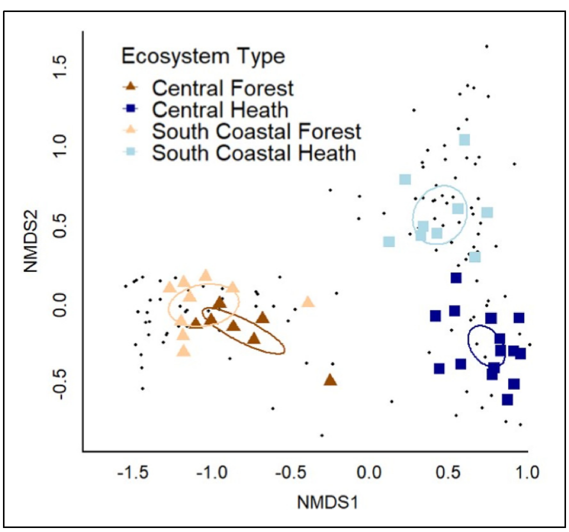

Figure 6. NMDS ordination of vegetation survey plots in Central forests and heathlands and South Coastal forests and heathlands, performed on the Bray–Curtis distance matrix of Hellinger transformed % cover data of all plant species encountered. Squares and triangles depict plots, and black dots depict species in ordination space. Ellipses show the 95% confidence intervals around the compositional centroids of each ecosystem type, illustrating significant differences in the vegetation composition of all ecosystem types (ANOSIM $R = .88$, $p < .001$, stress value = 0.072) except between Central and South Coastal forests (pairwise ANOSIM $R = .2$, $p = .1$).

sustaining local food systems, cultural land-based practices, and identity-making. As articulated by one community member, "All the land is used one way or the other."

Forests are visited to cut wood for fire, harvest medicines, and hunt and trap animals. Often, community members place camps and cabins in forests. In contrast, heathlands are most often associated with berry picking, with all participants recalling memories of gathering berries in heathlands. Heathlands are also advantageous for hunting because animals congregate in heathlands to feed on berries, waterfowl congregate around bog ponds, and the open terrain provides good sightlines. As one hunter explained, heathlands are "…very useful because a lot of times you catch a moose going from one island of woods to the other…So it's good in that perspective… Because you can see. Oh yes. Far, far away." Furthermore, because heathland soils remain cold year-round, the food that was gathered on the land can be preserved in holes dug into heathlands. For example, one participant recalled, "Nan would bury her vegetables and like, put it in a bag and just bury it up. And then when she's ready for it, she'd go dig it out again… there's something, it stays cold."

Additionally, in winter, participants traveled across frozen-over heathlands in skidoos and snowmobiles. One interview explained that this:

> was an old way of travel. Like you, there's a big marshland. I forgot the name of it, but it is like 12 km long, and it will take you from Gall Lake Pond to all the way up to Miguel's Brook. Just by that, just like that is. That is huge. I was on the skidoo. It looks like you're on a different planet. You can see the curvature of the Earth.

Before snowmobile technology, overland travel across heathlands was conducted with sleds pulled by dog teams. People who traveled over heathlands developed extensive knowledge of natural landmarks or created landmarks on high places on the landscape to aid in navigation.

Heathlands are also imbued with immaterial values fostered through the memory of time spent on the land. Heathlands often hold special significance as the location where fond and fun memories are made. For example, one community member recalls:

> And I personally, me and my buddies go out there all the time. Have fun. We go out there, have campfires, we find nice lookouts, and there's a lot of markings there where you can find specific rocks…and that's really it. I love the bog, loves it all.

Narratives set within heathlands, and about plants and animals that inhabit them, often pivot around shared experiences with families, friends, and the broader community. These stories illustrate how being on the heath facilitates the development of social bonds and communal life. For example, one woman recounts:

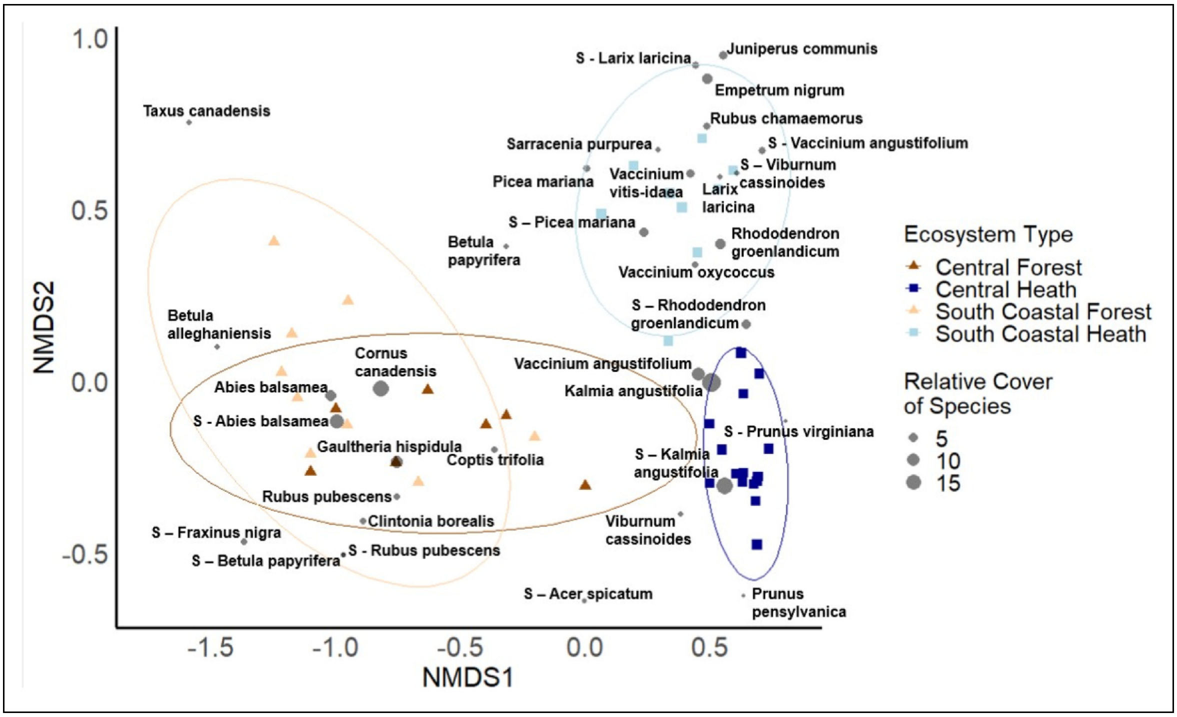

Figure 7. NMDS ordination of vegetation survey plots in Central forests and heathlands and South Coastal forests and heathlands performed on the Bray–Curtis distance matrix of Hellinger transformed % cover data of Mi'kmaq ethnobotanical species. Squares and triangles depict plots in relation to ethnobotanical species in ordination space. Ellipses show the 95% confidence intervals around the ethnobotanical assemblage centroids of each ecosystem type, illustrating significant differences in ethnobotanical composition between all ecosystem types (ANOSIM $R = .89$, $p < .001$, and stress value = .089) except between Central and South Coastal forests (pairwise ANOSIM $R = .16$, and $p = .38$).

> Oh, it was fun because it was a bunch of women. It was ten of us. Yeah. And we stayed in for the weekend. Yeah. We went fishing and berry picking and so that was fun. Very good. So, there was a women's group and there was one man with us, and he was the cook.

One participant further spoke of a sense of pride from being able to source her food from the land, "And just being a mega mom, you look forward to living off the land. You take pride. More in food that comes from the land than what you do from when you go to the store."

Due to the vital role of heathlands in cultural activities and social memory, they form an important part of the cultural identity of the community. As expressed by an interviewee, "Actually, I can't imagine people without bog. I have seen people from like ten years old there up to 75 years old up there. Everyone uses it. I can't imagine, can't remember without mish because everyone uses it."

Stewardship Values.. The values of respect for and reciprocity towards the environment run through the narratives shared by participants and manifest in how people carry out land-based activities (Scott 1989). Harvesting, be it for berries or game animals, is guided by the principles of only taking what one needs, using all parts of what is taken so that nothing is wasted, and sharing the harvest with the wider community. As an example, one berry picker explained that she only gathered berries by hand and would never use mechanical berry pickers because "then you're getting all the leaves and the ones that's not ripe and all that goes in, right? …you're destroying the new ones that's coming up because you're picking everything off." Several hunters also emphasize that the harvest of animals is followed by, "always giv[ing] back Mother Nature or something in return…Tobacco, berries, anything that you would give back to Mother Nature."

Furthermore, several interviewees recounted stories of their ancestors conducting cultural burnings as a way of taking care of the land. Although cultural burning has not been practiced for generations, community members can still identify heathland patches created by cultural burning conducted by grandparents and more distant ancestors. For example, one participant explained that "burning was the way community was protecting the berries, right? So that next, two years later, more berries will grow. And yeah, the older people used to do that, you know, back in my grandmother's days or my dad's. Yeah, but I can't. We never done it, though." These stories illustrate that, despite decades of government fire suppression policies, understandings of the role of fire and Indigenous methods of fire stewardship continue to persist in community knowledge.

Change and Continuity.. Numerous stories shared by community members centered on reflections of change, including changes

Table 2. Results of Indicator Species Analysis Performed on % Cover Data from Vegetation Survey Plots Located in Central Forests, Central Heathlands, South Coastal Forests, and South Coastal Heathlands.

Ecosystem Type	Species	INDVAL	*p*-Value	Ethnobotanical
Central Forest	*Claytonia caroliniana*	0.535	0.035	No
	Dicranum montanum	0.535	0.027	No
	Fraxinus nigra	0.535	0.027	Yes
	Rubus pubescens	0.620	0.01	Yes
	Scapania nemorea	0.535	0.027	No
Central Heathland	*Epilobium palustre*	0.577	0.017	No
	Polytrichum strictum	0.681	0.009	No
South Coastal Forest	*Betula alleghaniensis*	0.667	0.005	Yes
	Clintonia borealis	0.731	0.005	Yes
	Cystopteris fragilis	0.710	0.002	No
	Ilex verticillata	0.577	0.029	No
	Neottia cordata	0.577	0.02	No
	Rhytidiadelphus triquetrus	0.577	0.021	No
	Sphagnum andersonianum	0.745	0.002	No
South Coastal Heathland	*Andromeda polifolia*	0.667	0.006	No
	Aronia prunifolia	0.538	0.047	No
	Betula glandulosa	0.577	0.017	No
	Betula pumila	0.577	0.022	No
	Chamaedaphne calyculata	**0.854**	**0.001**	**No**
	Deschampsia flexuosa	0.667	0.004	No
	Dicranum scoparium	0.577	0.018	No
	Empetrum eamesii	**0.816**	**0.001**	**No**
	Empetrum nigrum	**0.986**	**0.001**	**Yes**
	Ilex mucronata	0.698	0.04	No
	Juniperus communis	**1.000**	**0.001**	**Yes**
	Kalmia polifolia	**0.885**	**0.001**	**No**
	Kalmia procumbens	0.577	0.026	No
	Larix laricina (ground)	0.644	0.011	Yes
	Larix laricina (shrub)	0.656	0.003	Yes
	Leucobryum glaucum	0.577	0.019	No
	***Myrica gale* (ground)**	**0.812**	**0.001**	**No**
	Myrica gale (shrub)	0.577	0.023	No
	Picea mariana (shrub)	0.770	0.011	Yes
	Ptilidium ciliare	**0.876**	**0.001**	**No**
	Racomitrium lanuginosum	**1.000**	**0.001**	**No**
	Rubus chamaemorus	0.746	0.003	Yes
	Sibbaldiopsis tridentata	0.667	0.003	No
	Trichophorum cespitosum	0.730	0.003	No
	Vaccinium uliginosum	**0.940**	**0.001**	**No**
	Vaccinium vitis-idaea	0.795	0.002	Yes
Central Forest + South Coastal Forest	***Abies balsamea* (ground)**	**0.908**	**0.001**	**Yes**
	***Abies balsamea* (shrub)**	**0.909**	**0.001**	**Yes**
	Bazzania trilobata	**0.925**	**0.001**	**No**
	Dicranum condensatum	0.656	0.027	No
	Dicranum majus	**1.000**	**0.001**	**No**
	Dryopteris carthusiana	0.791	0.002	No
	Gaultheria hispidula	**0.881**	**0.004**	**Yes**
	Hylocomium splendens	**0.970**	**0.001**	**No**
	Linnaea borealis	**0.865**	**0.001**	**No**
	Monotropa uniflora	0.612	0.012	No
	Ptilium crista-castrensis	**0.995**	**0.001**	**No**
	Sphagnum nemoreum	**0.846**	**0.004**	**No**
Central Heathland + South Coastal Heathland	*Amelanchier bartramiana*	0.757	0.005	No
	Dicranum polysetum	**0.913**	**0.001**	**No**
	Kalmia angustifolia	**0.975**	**0.001**	**Yes**
	***Rhododendron canadense* (ground)**	**0.997**	**0.001**	**No**

(continued)

Table 2. Continued.

Ecosystem Type	Species	INDVAL	*p*-Value	Ethnobotanical
	***Rhododendron canadense* (shrub)**	**0.842**	**0.002**	**No**
	***Rhododendron groenlandicum* (ground)**	**0.904**	**0.001**	**Yes**
	Rhododendron groenlandicum (shrub)	0.758	0.017	Yes
	Sphagnum rubellum	0.645	0.031	No
	Vaccinium angustifolium	**0.985**	**0.001**	**Yes**
Central Forest + South Coastal Heathland	*Maianthemum canadense*	0.707	0.005	No
	Picea mariana (ground)	0.748	0.014	Yes
Central Forest + Central Heathland + South Coastal Heathland	***Kalmia angustifolia* (shrub)**	**0.956**	**0.001**	**Yes**
Central Forest + South Coastal Forest + South Coastal Heathland	***Cornus canadensis***	**0.978**	**0.001**	**Yes**
	Pleurozium schreberi	**0.928**	**0.004**	**No**
	Trientalis borealis	0.786	0.042	No

Note: Species in bold have a particularly strong association (INDVAL > 0.80) with the given ecosystem type(s).

in the biophysical environment and people's knowledge of and relationships to the land. Accounts were primarily focused on heathlands and ranged from a general sense of change to specific observations. In general terms, three participants described perceiving heathlands as less green, vibrant, or alive compared to the past. More specifically, there was consensus among all interviewees that vegetation cover, particularly berry abundance, has decreased compared to the past. The observed changes in vegetation abundance were attributed to several factors in the interviews, including the introduction of moose, off-road vehicles, infrastructure development, and climate change. Community members also described how winters have become warmer than in the past, and warm winter conditions have been accompanied by a decrease in snow and ice cover that has made travel by skidoo across heathlands more dangerous. Summers have also become warmer and drier and have been associated with the disappearance of wetlands and ponds and the decreased production of berries. For example, one interviewee explained, "Especially with all this heat we're getting. Well, I remember growing up, though, the bogs were always wet because we didn't get a whole lot of sunshine like we get now…but now it's dries out."

Interviewees named several impacts of environmental change on traditional lifestyles and subsistence practices. The decreased abundance of berries in heathlands has resulted in berry harvesting becoming more difficult because berry pickers must spend more time, and travel longer distances to find good berry patches. The difficulty is particularly felt by the elderly, who may not be able to traverse long distances due to health concerns or decreased stamina.

Interview participants also grappled with the impact of modernization on younger generations' engagement with traditional practices. Interviewees have observed that "a lot of our youths don't bother with the country or go berry picking… they don't bother. I didn't see no kids berry picking." Due to this trend, current land users expressed concerns about the loss of knowledge with the passing of older generations, and a desire to document traditional practices for posterity. For example, one Elder reflected:

> Believe it or not, some of the stories my father used to tell, and my grandfather used to tell if I paid good attention. I mean, right now it would be priceless. But see, we never paid much attention then. We never looked to the future…we only dealt with the present.

Despite the decreasing trend in community engagement with the land, participants pointed to several community strengths that facilitate the continuation of cultural land-based practices and the transfer of land-based knowledge. Bonds between members of different generations are the most important factor contributing to cultural continuity. For example, one woman emphasized her grandfather's role in her daughters' lives:

> Yep, yep. Sydney's went with her grandfather and got bake apples on the quad and Orchard Trail and got some bake apples. And they've been blueberry picking and all that…they do it occasionally and sometimes like if dad will say, hey, I'm going berry picking tomorrow and then the girls, I have three girls. So, the two oldest are like, well, we'll go with you. So, they eat more berries than they pick, but they do go.

Practices of harvest sharing, and the proliferation of local country food vendors have also enabled community members, who are no longer able to go on the land themselves, to continue to access wild berries and game. As one Elder explains, "You know what I do now? I buy my bake apples, and I miss not getting them myself…So, I ordered them down the coast a couple of days ago."

Discussion

In this study, we used an interdisciplinary approach to investigate the cultural significance of boreal heathlands, which Miawpukek First Nation community members refer to as mish and bogs. We demonstrate that, far from being an unproductive landscape, heathlands hold substantial cultural value to Indigenous Mi'kmaq Peoples that manifests in a multitude of ways, including as habitat for at least 25 culturally significant plant and berry species, and as key spaces for the sustenance of customary food systems, lifeways, knowledge systems, and cultural identity.

Distribution of Vegetation and Ethnobotanical Diversity

The ecological surveys of forest and heathland ecosystems found that South Coastal heathlands had the highest values for species richness and Shannon diversity for both ground vegetation and shrubs, while Central heathlands consistently exhibited low values in diversity metrics. In comparison, the two forest types had intermediate floristic diversity, with South Coastal forests being slightly higher in ground vegetation diversity than Central Forests and Central forests being slightly higher in shrub diversity than South Coastal forests. The richness of ethnobotanical plants followed similar patterns as overall floristic diversity; however, South-Coastal heathlands supported twice the number of ethnobotanical species as any other ecosystem type.

Characteristic Ethnobotanical Indicator Species

Both the vegetation surveys and community interviews show that boreal heathlands provide a suite of ethnobotanical plants that differ from those found in forests. It should be first noted that the ecological framework that informed the design of the vegetation surveys differed from the ecological framework by which community members described their traditional territory. How Indigenous peoples understand and classify their landscape is a critical component of Indigenous knowledge systems and informs how Indigenous Peoples interact with and manage their environment (Johnson 2010). Furthermore, the environmental characteristics that define partitions in Indigenous landscape classification systems are often those that are most important to local values and lifeways (Hernandez-Stafanoni, Pineda, and Valdes-Valadez 2006; Abraao et al. 2008).

Our vegetation sampling was stratified into ecosystem types that were differentiated by vertical vegetation structure (forest vs. heathland) and biogeoclimatic (Central vs. South Coast subregion) classes. Miawpukek First Nation community members also identified forests and heathlands as distinct ecological units, but rather than using biogeoclimatic criteria, interviewees defined different heathland types using finer-scale environmental characteristics. For example, mish (dry heathlands) is differentiated from bogs (wet heathlands) by soil moisture and water table depth. Bogs are further subdivided into yellow and black bogs by their qualitative soil characteristics.

The NMDS ordinations showed that South Coastal heathlands and Central heathlands had distinct compositions of plant and ethnobotanical species. Forest plant communities also differed in species composition from heathland plant communities, but the species composition of Central forests and South Coastal forests was similar. South Coastal heathlands are characterized by high abundances of several culturally important berry species, including *V. angustifolium*, *R. chamaemorus*, *E. nigrum*, *V. vitis-idaea*, and *J. communis*. In comparison, *V. angustifolium* is the only abundant berry species in Central heathlands, which are otherwise characterized by the dominance of *Kalmia* and *R. groenlandicum.* Correspondingly, heathlands have a strong cultural association with berries and berry picking. Miawpukek First Nation community members picked berries from mish and bogs found in both the Central and South Coastal subregions, and the characteristic indicator species of Central and South Coastal heath are also the species that were most often harvested (e.g., *V. angustifolium*). There were also several heathland-associated ethnobotanical plants, such as strawberries (*Fragaria* spp.), gooseberries (*Ribes* spp.), raspberries (*Rubus idaeus*), and beaver root (likely *Nymphaea odorata*), that were mentioned in the interviews but not recorded in our vegetation surveys. To more closely align with how community members use heathland communities, future ecological investigations should examine differences in the vegetation composition of heathlands at spatial scales that more closely align with community members' methods of traditional ecosystem classification.

Compared to heathlands, which were overwhelmingly associated with berry picking, interviewees most often spoke of forests as a place to gather medicines and harvest wood. The vegetation surveys corroborated the importance of forests for medicines and woody materials by identifying important medicinal and technology plants, such as *A. balsamea*, *B. alleghaniensis* (food, medicine, and technology), *C. borealis*, *C. canadensis*, and *R. pubescens* (medicine) as characteristic forest species. The interviews also mentioned food species, such as butter and cream fern and teaberries (*G. hispidula*) that were harvested in forests, but of those, only *G. hispidul*a were detected in forest vegetation plots.

Several ethnobotanical species were also abundant across multiple ecosystem types. For example, *K. angustifolia* was prominent in all four ecosystem types investigated in the vegetation surveys. Similarly, *C. canadensis* was abundant in all ecosystem types except for Central heathlands, while *V. angustifolium* and *R. groenlandicum* were abundant in both Central and South Coastal heathlands. These species can be considered habitat generalists, as they can persist at multiple different points along the environmental gradients that separate the four ecosystem types.

Boreal Heathlands as Indigenous Cultural Landscapes. The insights that emerged from interviews with community members illustrate that the heathland landscape is inextricably interwoven into Miawpukek First Nation subsistence economies, traditional knowledge systems, and cultural and community identity. The relationships that have been cultivated between community members and heathlands over generations imbue boreal heathlands with material, epistemological, and emotional/spiritual values, that we believe render heathlands as an important Mi'kmaq cultural landscape in boreal regions. This would render them analogous to European heathlands which receive protection under national and international designation, including UNESCO world heritage status, in part due to their cultural significance.

The material cultural heritage of landscapes is embodied in the direct human-nature interactions that occur throughout daily activities on the land (Davidson-Hunt 2003) and can be quantified by the number of culturally significant plants or biota (Turner 2020) on the landscape, the degree and diversity of ways in which boreal heathlands are used (Cuerrier et al. 2015) and the physical signs of inhabitation, land use, and stewardship (Carroll 2015). We identified 20 culturally significant species that occurred in Central or South Coastal heathlands, which is not exhaustive of all the culturally significant species that exist in these environments. Interviewees perceived that a significant proportion of the community accessed heathlands for a variety of purposes, including gathering berries and other food and medicines, hunting, fishing, trapping, winter travel, food storage, and leisure activities. The diversity of ethnobotanical species, especially berries, and the large number of people who harvest in heathlands point to the importance of heathlands for sustaining customary food systems. Furthermore, though customary Mi'kmaq land management practices, such as cultural burning, have been suppressed by colonial governments for decades (Christianson et al. 2022), community members continue to be able to identify heathland patches shaped by ancestral stewardship activities. Current generations also continue to influence heathland ecosystems on a localized scale, such as by adhering to cultural harvesting ethics and Miawpukek First Nation Indigenous Guardians' monitoring of plant and animal populations (Lukawiecki 2022).

Because vegetation is a critical component of ecosystem structure and function, and plants play a ubiquitous role in all cultures as food and medicine, plant life is salient in how almost all Indigenous Peoples understand their homelands (Abraao et al. 2008; Babai and Molnar 2013; Cuerrier et al. 2022). Thus, folk ecotypes are often recognized for the presence, abundance, or structure of vegetation or specific plant species. For example, Baniwa peoples in the Upper Rio Negro, Brazil, distinguish vegetation types by the presence of important edible fruits (Abraao et al. 2008), Q'eqchi' Maya peoples recognize different forest types as places to go to search for specific medicinal plants (Pesek et al. 2009), and the Gitksan name forest types after the most abundant species (Johnson 2010). The Urarani, an Indigenous People of the Peruvian Amazon, distinguish distinct types of peatland communities based on vegetation height and density (Schulz et al. 2019), and pastoralists in the Hungarian (Molnar 2012) and Mongolian (Gantuya et al. 2019) steppes describe grassland communities by their pasture quality. The results of this study suggest that *mish* is similarly a folk ecotype of boreal heathland landscapes, which is recognized by Miawpukek First Nation by the presence of characteristic indicator plant species (e.g., Labrador tea, blueberry), as well as the relationships that community members have with mish, such as the harvesting of wild berries that grow on mish, or the tending of mish with fire to promote preferred plant species.

The intangible cultural heritage of boreal heathlands manifests in Indigenous knowledge systems (Davidson-Hunt and Berkes 2010) and emotional place attachment (Briggs, Stedman, and Krasny 2019). Indigenous knowledge has widely been described as holistic and encompassing of empirical knowledge of natural phenomena (Naidoo and Hill 2006; Schulz et al. 2019) as well as ethics, worldviews, and methods of knowledge transmission (Castellano 2000; Kimmerer 2012). The cultural and subsistence activities conducted by community members in the heathlands inform a body of empirical and philosophical knowledge that is unique to the Miawpukek Mi'kmaq. Miawpukek First Nation's empirical knowledge of heathlands varies from the scale of species (i.e., which plants grow in heathlands, locations of specific plant patches, edible, medicinal, and other utilitarian properties of heathland plants, etc.) to ecosystems (i.e., descriptions of different heathland types and their characteristics, understanding of fire and successional processes in heathlands). Furthermore, appreciation for boreal heathlands and the invaluable resources that they provide are encoded in cultural teachings of respect, ethical ways of harvesting, and protocols for practicing reciprocity, such as the leaving of tobacco or other offerings. This body of knowledge and values is learned and passed on through social interactions between community members, especially those of different generations, and through personal and shared experiences of being on the land. As the fabric upon which personal and shared community experiences and history are created, heathlands further become imbued with a myriad of emotions that anchor people to place (Briggs, Stedman, and Krasny 2019). Though anchoring emotions may be both positive and negative (Briggs, Stedman, and Krasny 2019), many emotions that interviewees invoked in association with heathlands, such as love, joy, appreciation, sense of beauty, and pride, were positive.

Implications for Conservation

Although originating from heritage studies of the European countryside (Sauer 1925), research on cultural landscapes has increasingly emphasized the unique ways in which Indigenous Peoples relate to their environments and the role of Indigenous customary stewardship in maintaining their composition and character (International Society of Ethnobiology 2018). The identification of cultural landscapes, and constituent tangible and intangible heritage elements (e.g., culturally significant flora and fauna) is increasingly being advanced in decolonized approaches to conservation that uphold Indigenous knowledge systems, governance, and rights and responsibilities, including community-led and biocultural approaches to conservation (Gavin et al. 2018; Lukawiecki et al. 2022; Mattalia et al. 2024). Global conservation campaigns and governance models (e.g., state-regulated parks and protected areas) continue to emphasize the protection of biodiversity, biophysical (e.g., carbon storage), and economic dimensions of conserving intact forests as if they are "pristine wilderness" or "unpeopled places" shaped exclusively by natural processes and elements, such as wildfire, soils and climate, when in fact Indigenous Peoples actively manage and tend their territories under sustainable practices of care and customary stewardship (Smith 2015; Christianson et al. 2022). Historically perceived as unproductive land with relatively low numbers of wildlife species, boreal heathlands have received less conservation attention than old growth forests and other landscapes with charismatic megafauna (e.g., large carnivores) and flora (ancient cedar trees) in Canada (Moola and Roth 2019). By ignoring boreal heathlands in conservation policy and practice (e.g., prescribed burning, monitoring programs), we risk being unaware of potential threats or declines to important culturally significant species and further the erasure of Indigenous Peoples' knowledge, use and traditional management of these important open and sparsely treed habitat types of the boreal biome.

Conclusion

This study utilizes an interdisciplinary approach, integrating ecological science and social science methods, to understand Indigenous values, uses and perspectives of heathlands across the Ktaqmkuk boreal region (Newfoundland, Canada). However, the study has some limitations. We relied largely on secondary sources to identify ethnobotanical species important to Mi'kmaq and despite collaboration among Indigenous and settler researchers in its design and execution, the study doesn't explicitly weave together western science and Indigenous knowledge systems, using Two-Eyed Seeing or other Indigenous-led frameworks of knowledge integration (Reid et al. 2021). The literature on Indigenous research methodologies is growing and can inform future studies on the ethnobiology of mish and bogs (e.g., Popp et al. 2020; Schneider 2023; Gisloti et al. 2025).

By demonstrating the value of boreal heathlands (mish and bogs) as an Indigenous cultural landscape, we highlight both the need and opportunity for Indigenous-settler partnerships and Indigenous biocultural relations to inform heathland management. As landscapes that sustain Indigenous food and medicine systems, subsistence activities, and cultural identity, heathland management objectives should include the preservation of culturally significant biota, harvesting locations, travel routes, and other culturally significant locations. Furthermore, the Miawpukek Mi'kmaq possess a detailed, on-the-ground understanding of the biodiversity and ecology of heathland ecosystems, including timely observations of environmental change and emerging threats. Thus, engaging Indigenous perspectives and expertise of heathlands can inform conservation objectives, interventions, and monitoring programs that are more adaptive, effective, and locally relevant.

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Ethical Considerations

This study was approved by the Research Ethics Boards at the University of Guelph, including our interviews (approval: 20-06-015) on July 27, 2021.

Consent to Participate

Respondents gave written consent for review before starting interviews.

Author Contributions

YZN contributed to data collection, formal analysis, and writing–original draft, review and editing; FM contributed to conceptualization, funding acquisition, methodology, project administration, supervision, data collection, and writing–original draft, review and editing. HJ contributed to data collection; GJ contributed to data collection; RY contributed to data collection; KM contributed to data collection; AJ contributed to data collection; JW contributed to writing–review and editing; and AUM contributed to writing–review and editing.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

All of the data generated in this study are stored in the University of Guelph Research Data Repository and available at: https://borealisdata.ca/dataverse/guelph.

Supplemental Material

Supplemental material for this article is available online.

References

Abis, B., and V. Brovkin. 2017. "Environmental Conditions for Alternative Tree-Cover States in High Latitudes." *Biogeosciences* 14: 511–527. https://doi.org/10.5194/bg-14-511-2017.

Abraao, M. B., B. W. Nelson, J. C. Baniwa, D. W. Yu, and G. H. Sherpard Jr. 2008. "Ethnobotanical Ground-Truthing: Indigenous Knowledge, Floristic Inventories and Satellite Imagery in the Upper Rio Negro, Brazil." *Journal of Biogeography* 35: 2237–2248. https://doi.org/10.1111/j.1365-2699.2008.01975.x.

Allen, K. A., P. Denelle, F. M. S. Ruiz, V. M. Santana, and R. H. Marrs. 2016. "Prescribed Moorland Burning Meets Good Practice Guidelines: A Monitoring Case Study Using Aerial Photography in the Peak District, UK." *Ecological Indicators* 62: 76–85. https://doi.org/10.1016/j.ecolind.2015.11.030.

AMEC Environment & Infrastructure. 2013. *A Mi'kmaq Historical and Ecological Knowledge Review of the Gaetz Brook Property*. Dartmouth, Nova Scotia: Nova Scotia Department of Resources.

Babai, D., and Z. Molnar. 2013. "Multidimensionality and Scale in a Landscape Ethnoecological Partitioning of a Mountainous Landscape (Gyimes, Eastern Carpathians, Romania)." *Journal of Ethnobiology and Ethnomedicine* 9 (1): 11. https://doi.org/10.1186/1746-4269-9-11.

Bars ánková, Z., and J. Špulerová. 2023. "Human–Nature Relationships in Defining Biocultural Landscapes: A Systematic Review." *Ekológia (Bratislava)* 42: 64–74. https://doi.org/10.2478/eko-2023-0008.

Bell, T. 2002. Maritime Barrens. Accessed March 26, 2024. https://www.heritage.nf.ca/articles/environment/maritime-barrens.php.

Benetková, P., R. van Diggelen, L. Háněl, F. Vicentini, R. Moradi, M. Weijters, R. Bobbink, J. A. Harris, and J. Frouz. 2022. "Soil Fauna Development During Heathland Restoration from Arable Land: Role of Soil Modification and Material Transplant." *Ecological Engineering* 176: 106531. https://doi.org/10.1016/j.ecoleng.2021.106531.

Boland, T. 2013. *Trees and Shrubs of Newfoundland and Labrador*. Portugal Cove-St. Philip's, Newfoundland, Canada: Boulder Books.

Boland, T. 2017. *Wildflowers and Ferns of Newfoundland*. Portugal Cove-St. Philip's, Newfoundland, Canada: Boulder Books.

Bradley, R., G. Joanisse, P. Lebel, N. Thiffault, and C. Preston. 2008. "Degradation of Boreal Forest Soil Fertility Caused by the Invasion of Kalmia Angustifolia: A Forest Management Problem." *15th International Congress of the International Soil Conservation Organization: Soil and Water Conservation, Climate Change and Environmental Sensitivity*. International Soil Conservation Organization, Budapest.

Braun, V., and V. Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3: 77–101. https://doi.org/10.1191/1478088706qp063oa.

Briggs, L., R. Stedman, and M. Krasny. 2019. "Place Attachment and Social–Ecological System Sustainability Examined Through the Voices of Indigenous Guatemalan Women." *Sustainability Science* 14: 655–667. https://doi.org/10.1007/s11625-018-0634-6.

Bryant, D., D. Nielsen, and L. Tangley. 1997. *The Last Frontier Forests. Ecosystems and Economies on the Edge*. Washington, DC: World Resources Inst.

Burley, S. T., K. A. Harper, and J. T. Lundholm. 2010. "Vegetation Composition, Structure and Soil Properties Across Coastal Forest–Barren Ecotones." *Plant Ecology* 211: 279–296. https://doi.org/10.1007/s11258-010-9789-7.

Cameron, R. P., and S. Bondrup-Nielsen. 2013. "Plant Communities Within Atlantic Coastal Heathlands in Nova Scotia." *Northeastern Naturalist* 20: 694–709. https://doi.org/10.1656/045.020.0420.

Carroll, C.. 2015. *Roots of Our Renewal: Ethnobotany and Cherokee Environmental Governance*. 1st ed. Minneapolis, MN: University of Minnesota Press.

Carlson, M., J. Wells, and M. Jacobson. 2015. "Balancing the Relationship Between Protection and Sustainable Management in Canada's Boreal Forest." *Conservation and Society* 13 (1): 13–22. https://doi.org/10.4103/0972-4923.161209.

Castellano, M. B. 2000. "Updating Aboriginal Traditions of Knowledge." In *Indigenous Knowledges in Global Contexts: Multiple Readings of Our World*, edited by G. J. S. Dei, B. L. Hall, and D. G. Rosenberg, 21–36. Toronto, Canada: University of Toronto Press.

Christianson, A. C., C. R. Sutherland, F. Moola, N. Gonzalez Bautista, D. Young, and H. MacDonald. 2022. "Centering Indigenous Voices: The Role of Fire in the Boreal Forest of North America." *Current Forestry Reports* 8: 257–276. https://doi.org/10.1007/s40725-022-00168-9.

Chytrý, M., L. Tichý, J. Holt, and Z. Botta-Dukát. 2002. "Determination of Diagnostic Species with Statistical Fidelity Measures." *Journal of Vegetation Science* 13: 79–90. https://doi.org/10.1111/j.1654-1103.2002.tb02025.x

Conard, H. S., and P. L. Redfearn Jr. 1979. *How to Know the Mosses and Liverworts*. J.F. Bamrick and E.T. Cawley, eds. 2nd ed. Dubuque, Iowa: Wm. C. Brown Company Publishers.

Cook, F. E. M. 1995. *Economic Botany Data Collection Standard*. Kew, Richmond, UK: Royal Botanic Gardens.

Cuerrier, A., C. Clark, F. Dwyer-Samuel, and M. Rapinski. 2022. "Nunatsiavut, 'Our Beautiful Land': Inuit Landscape Ethnoecology in Labrador, Canada." *Botany* 100 (2): 159–174. https://doi.org/10.1139/cjb-2021-0112.

Cuerrier, A., N. J. Turner, T. C. Gomes, A. Garibaldi, and A. Downing. 2015. "Cultural Keystone Places: Conservation and Restoration in

Cultural Landscapes." *Journal of Ethnobiology* 35: 427–448. https://doi.org/10.2993/0278-0771-35.3.427.

Damman, A. W. H. 1983. "An Ecological Subdivision of the Island of Newfoundland." In *Biogeography and Ecology of the Island of Newfoundland*, edited by R. G. South, 163–206. The Hague: Dr. W. Junk Publishers.

Davidson-Hunt, I., and F. Berkes. 2010. "Journeying and Remembering: Anishinaabe Landscape Ethnoecology from Northwestern Ontario." In *Landscape Ethnoecology: Concepts of Biotic and Physical Space*, edited by L. M. Johnson, and E. S. Hunn. 1st ed, 222–240. New York: Berghahn Books.

Davidson-Hunt, I. J. 2003. "Indigenous Lands Management, Cultural Landscapes and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada." *Environments* 31: 21+.

De Cáceres, M. De, and P. Legendre. 2009. "Associations Between Species and Groups of Sites: Indices and Statistical Inference." *Ecology (Durham)* 90: 3566–3574. https://doi.org/10.1890/08-1823.1

Gai, Z. 2021. R/Anosim.Pairwise.R, https://rdrr.io/github/ZhonghuiGai/veganEx/src/R/anosim.pairwise.R (Accessed March 26, 2024)

Gantuya, B., A. Avar, D. Badai, A. Molnar, and Z. S. Molnar. 2019. ""A Herder's Duty is to Think": Landscape Partitioning and Folk Habitats of Mongolian Herders in a Mountain Forest Steppe (Khuvsugul-Murun Region)." *Journal of Ethnobiology and Ethnomedicine* 15 (1): 15–54. https://doi.org/10.1186/s13002-019-0328-x.

Gavin, M. C., J. McCarter, F. Berkes, A. T. P. Mead, E. J. Sterling, R. Tang, and N. J. Turner. 2018. "Effective Biodiversity Conservation Requires Dynamic, Pluralistic, Partnership-Based Approaches." *Sustainability* 10: Article 1846. https://doi.org/10.3390/su10061846.

Gimingham, C. H. 1972. *Ecology of Heathlands*. London: Chapman and Hall.

Girard, F., S. Payette, and R. Gagnon. 2008. "Rapid Expansion of Lichen Woodlands Within the Closed-Crown Boreal Forest Zone Over the Last 50 Years Caused by Stand Disturbances in Eastern Canada." *Journal of Biogeography* 35: 529–537. https://doi.org/10.1111/j.1365-2699.2007.01816.x.

Gisloti, L., S. Pavão, M. Pedro, and G. Monfort. 2025. "Guardians of Biodiversity: Unraveling Guarani-Kaiowá Biocultural Memories and Ecological Wisdom in Atlantic Rainforests." *Ecology and Society* 30 (1): Article art15. https://doi.org/10.5751/ES-15823-300115.

Gotelli, N. J., and R. K. Colwell. 2001. "Quantifying Biodiversity: Procedures and Pitfalls in the Measurement and Comparison of species Richness." *Ecology Letters* 4 (4): 379–391. https://doi.org/10.1046/j.1461-0248.2001.00230.x.

Gruca, M., R. Cámara-Leret, M. J. Macía, and H. Balslev. 2014. "New Categories for Traditional Medicine in the Economic Botany Data Collection Standard." *Journal of Ethnopharmacology* 155: 1388–1392. https://doi.org/10.1016/j.jep.2014.06.047.

Hall, P., and J. Evans. 2022. "Miawpukek – The Middle River." In *Towards an Encyclopedia of Local Knowledge*. Breakwater Books, St. John's, Newfoundland. https://encyclopediaoflocalknowledge.com/chapter3/.

Hamel, B. 2020. *Vegetation Zones of Canada: A Biogeoclimatic Perspective [dataset]*. Canadian Forest Service. Great Lake Forestry Center, Sault Ste. Marie, Canada: Open Data Canada.

Hernandez-stafanoni, J. L., J. B. Pineda, and G. Valdes-valadez. 2006. "Comparing the Use of Indigenous Knowledge with Classification and Ordination Techniques for Assessing the Species Composition and Structure of Vegetation in a Tropical Forest." *Environmental Management* 37: 686–702. https://doi.org/10.1007/s00267-004-0371-8.

International Society of Ethnobiology. 2018. Declaration of Belém +30. Belém do Pará, Brazil.

Ireland, R. R. 1982. *Moss Flora of the Maritime Provinces*. Ottawa, Ontario: National Museum of Natural Sciences.

Jeddore, G. n.d. Miawpukek Traditional Territory.

Johnson, L. M. 2010. *Trail of Story, Traveller's Path: Reflections on Ethnoecology and Landscape*. 1st ed. Edmonton: Athabasca University Press.

Karg, S. 2007. "Direct Evidence of Heathland Management in the Early Bronze Age (14th Century B.C.) from the Grave-Mound Skelhøj in Western Denmark." *Vegetation History and Archaeobotany* 17: 41–49. https://doi.org/10.1007/s00334-007-0109-7.

Kassambara, A. 2023. _rstatix: Pipe-Friendly Framework for Basic Statistical Tests_ R Package Version 0.7.2.

Kerdoncuff, M., I. E. Måren, and A. E. Eycott. 2023. "Traditional Prescribed Burning of Coastal Heathland Provides Niches for Xerophilous and Sun-Loving Beetles." *Biodiversity and Conservation* 32: 4083–4109. https://doi.org/10.1007/s10531-023-02684-x.

Kimmerer, R. W. 2012. "Searching for Synergy: Integrating Traditional and Scientific Ecological Knowledge in Environmental Science Education." *Journal of Environmental Studies and Sciences* 2: 317–323. https://doi.org/10.1007/s13412-012-0091-y.

Lacey, L. 1993. *Micmac Medicines: Remedies and Recollections*. A. Webb, ed. 1st ed. Halifax, Nova Scotia: Nimbus Publishing Limited.

Lukawiecki, J. 2022. Notes from the Field: Miawpukek First Nation Land Guardians, May 26. Accessed May 18, 2024. https://conservation-reconciliation.ca/blog/notes-from-the-field-miawpukek-first-nation-land-guardians.

Lukawiecki, J., J. Wall, R. Young, J. Gonet, G. Azhdari, and F. Moola. 2022. "Operationalizing the Biocultural Perspective in Conservation Practice: A Systematic Review of the Literature." *Environmental Science & Policy* 136: 369–376. https://doi.org/10.1016/j.envsci.2022.06.016.

Lumivero. 2020. NVivo (Version 14.23.3).

Mallik, A. U. 1995. "Conversion of Temperate Forests into Heaths: Role of Ecosystem Disturbance and Ericaceous Plants." *Environmental Management* 19: 675–684. https://doi.org/10.1007/BF02471950.

Mattalia, G., A. Mcalvay, I. Teixidor-Toneu, J. Lukawiecki, F. Moola, Z. Asfaw, R. Cámara-Leret, et al. 2024. "Cultural Keystone Species as a Tool for Biocultural Stewardship. A Global Review." *People and Nature (Hoboken, N.J.)* 7: 947–959. https://doi.org/10.1002/pan3.10653

Meades, S. J., and W. J. Meades. 2024. Flora of Newfoundland and Labrador. Accessed March 26, 2024. https://newfoundland-labradorflora.ca/index.cfm.

Meades, W. J. 1983. "The Origin and Successional Status of Anthropogenic Dwarf Shrub Heath in Newfoundland." *Advances in Space Research* 2: 97–101. https://doi.org/10.1016/0273-1177(82)90226-5.

Miawpukek First Nation. 2019. Medicinal Plants of Miawpukek First Nation, Presentation, Conne River, Newfoundland.

Missouri Botanical Garden. 2023. Tropicos v3.4.1.

Moerman, D. E. 2009. *Native American Medicinal Plants: An Ethnobotanical Dictionary, Abridged*. Portland, Oregon: Timber Press.

Molnar, Z. 2012. "Classification of Pasture Habitats by Hungarian Herders in a Steppe Landscape (Hungary)." *Journal of Ethnobiology and Ethnomedicine* 8 (1): 28. https://doi.org/10.1186/1746-4269-8-28.

Moola, F., and R. Roth. 2019. "Moving Beyond Colonial Conservation Models: Indigenous Protected and Conserved Areas Offer Hope for Biodiversity and Advancing Reconciliation in the Canadian Boreal Forest." *Environmental Reviews* 27 (2): 200–201. https://doi.org/10.1139/er-2018-0091.

Morán-Ordóñez, A., R. Bugter, S. Suárez-Seoane, E. de Luis, and L. Calvo. 2013. "Temporal Changes in Socio-Ecological Systems and Their Impact on Ecosystem Services at Different Governance Scales: A Case Study of Heathlands." *Ecosystems* 16: 765–782. https://doi.org/10.1007/s10021-013-9649-0.

Naidoo, R., and K. Hill. 2006. "Emergence of Indigenous Vegetation Classifications Through Integration of Traditional Ecological Knowledge and Remote Sensing Analyses." *Environmental Management* 38: 377–387. https://doi.org/10.1007/s00267-004-0338-9.

Native Land Digital. 2024. Native-Land.ca: Our Home on Native Land. https://native-land.ca/.

Oberndorfer, E. C., and J. T. Lundholm. 2009. "Species Richness, Abundance, Rarity and Environmental Gradients in Coastal Barren Vegetation." *Biodiversity and Conservation* 18: 1523–1553. https://doi.org/10.1007/s10531-008-9539-5.

Ogle, D. H., J. C. Doll, P. Wheeler, and A. Dinno. 2022. FSA: Fisheries Stock Analysis. Accessed March 26, 2024. https://github.com/fishR-Core-Team/FSA.

Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, , et al. 2020. *Community Ecology Package 'Vegan' v 2.5-7*. https://cran.r-project.org/web/packages/vegan/vegan.pdf.

Oksanen, J., G. Simpson, F. Blanchet, R. Kindt, P. Legendre, P. Minchin, R. O'Hara, , et al. 2022. Vegan: Community Ecology Package. R Package Version 2.6-4.

Ombashi, H., and M. Løvschal. 2023. "Anthropogenic Heathlands in Prehistoric Atlantic Europe: Review and Future Prospects." *European Journal of Archaeology* 26: 341–358. https://doi.org/10.1017/eaa.2022.42.

Pesek, T., M. Abramiuk, D. Garagic, N. Fini, J. Meerman, and V. Cal. 2009. "Sustaining Plants and People: Traditional Q'eqchi' Maya Botanical Knowledge and Interactive Spatial Modeling in Prioritizing Conservation of Medicinal Plants for Culturally Relative Holistic Health Promotion." *EcoHealth* 6 (1): 79–90. https://doi.org/10.1007/s10393-009-0224-2.

Popp, J. N., P. Priadka, M. Young, K. Koch, and J. Morgan. 2020. "Indigenous Guardianship and Moose Monitoring: Weaving Indigenous and Western Ways of Knowing." *Human-Wildlife Interactions* 14 (2): 296–308. https://doi.org/10.26077/67f5-d36b

Prins, H. 1997. "We Fight With Dignity: The Miawpukek Mi'kmaq Quest for Aboriginal Rights in Newfoundland." *Papers of the Algonquian Conference* 28: 283–305.

Puric-Mladenovic, D. 2016. The VSP Field Sampling Methodology. http://forests-settled-urban-landscapes.org/VSP/methodology.html.

R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing.

Reid, A. J., L. E. Eckert, J. Lane, N. Young, S. G. Hinch, C. T. Darimont, S. J. Cooke, N. C. Ban, and A. Marshall. 2021. ""Two-Eyed Seeing": An Indigenous Framework to Transform Fisheries Research and Management." *Fish and Fisheries (Oxford, England)* 22 (2): 243–261. https://doi.org/10.1111/faf.12516.

Richmond, C., and E. Nightingale. 2021. "Introduction to Special Section: Geographies of Indigenous Health and Wellness." *The Canadian Geographer* 65: 4–7. https://doi.org/10.1111/cag.12678.

Sauer, C. 1925. "The Morphology of Landscape." In *University of California Publications in Geography*, 19–53.

Savard, J., and S. Payette. 2013. "Origin and Plant Species Diversity of High-Altitude Tundra Summits Across the Boreal Forest Zone in Eastern Canada." *Écoscience* 20: 283–295. https://doi.org/10.2980/20-3-3581.

Schneider, L. 2023. "Decolonizing Conservation? Indigenous Resurgence and Buffalo Restoration in the American West." *Environment and Planning. E, Nature and Space (Print)* 6 (2): 801–821. https://doi.org/10.1177/25148486221119158.

Schulz, C., M. M. Branas, C. N. Perez, M. D. A. Villacorta, N. Laurie, I. T. Lawson, and K. H. Roucoux. 2019. "Peatland and Wetland Ecosystems in Peruvian Amazonia: Indigenous Classifications and Perspectives." *Ecology and Society* 24: 12. https://doi.org/10.5751/ES-10886-240212.

Scott, C. 1989. "Knowledge Construction among the Cree Hunters: Metaphors and Literal Understanding." *Journal de La Société Des Américanistes* 75 (1): 193–208. https://doi.org/10.3406/jsa.1989.1349.

Smith, M. A. (Peggy). 2015. "A Reflection on First Nations in Their Boreal Homelands in Ontario: Between a Rock and a Caribou." *Conservation and Society* 13 (1): 23–38. https://doi.org/10.4103/0972-4923.161214.

Specht, R. L. 1979. "Heathlands and Related Shrublands of the World." In *Heathlands and Related Shrublands: Ecosystems of the World*, edited by R. L. Specht, 1–18. Amsterdam: Elsevier.

Statistics Canada. 2010. Road Network File - 2010 - Newfoundland and Labrador.

Thiffault, N., and R. Jobidon. 2006. "How to Shift Unproductive Kalmia Augustifolia – Rhododendron Groenlandicum Heath to

Productive Conifer Plantation." *Canadian Journal of Forest Research* 36: 2364–2376. https://doi.org/10.1139/x06-090.

Turner, N. J. 2020. *Plants, People, and Places: The Roles of Ethnobotany and Ethnoecology in Indigenous Peoples' Land Rights in Canada and Beyond*. N. J. Turner, ed. 1st ed. Montreal, Quebec: McGill-Queen's University Press. https://doi.org/10.2307/j.ctv153k6×6.

Unama'ki Institute of Natural Resources. 2012. Mi'kmaq Ecological Knowledge Distribution of Culturally Significant Plants. 56 p.

Uprety, Y., H. Asselin, A. Dhakal, and N. Julien. 2012. "Traditional Use of Medicinal Plants in the Boreal Forest of Canada: Review and Perspectives." *Journal of Ethnobiology and Ethnomedicine* 8: 7. https://doi.org/10.1186/1746-4269-8-7.

Watson, J. E. M., O. Venter, J. Lee, K. R. Jones, J. G. Robinson, H. P. Possingham, and J. R. Allan. 2018. "Protect the Last of the Wild." *Nature (London)* 563 (7729): 27–30. https://doi.org/10.1038/d41586-018-07183-6.

Webb, N. R. 1998. "The Traditional Management of European Heathlands." *Journal of Applied Ecology* 35: 987–990. https://doi.org/10.1111/j.1365-2664.1998.tb00020.x.

Wells, J. V., N. Dawson, N. Culver, F. A. Reid, and S. Morgan Siegers. 2020. "The State of Conservation in North America's Boreal Forest: Issues and Opportunities." *Frontiers in Forests and Global Change* 3: 1–18. https://doi.org/10.3389/ffgc.2020.00090

Wickham, H. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. New York: Springer Cham. https://doi.org/10.1007/978-3-319-24277-4.