Mosses and Incidental Lichens in Siliceous Areas of the Sunshine Meadows-Egypt Lake Area of Banff National Park

Image: Ryan James

Prepared by

Ryan James, B.Sc.

For

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1.0 Introduction

1.1 Background

Mosses are adapted to the substrates they live on. Many groups of mosses are differentiated based on whether they grow on siliceous, basic, or calcareous substrates (Bates, 1982, 2008; Flora of North America Editorial Committee [FNAEC], 2007, 2014). Alberta's Rocky Mountains are dominated by areas of calcareous rock and areas of siliceous rock are rare (Pana & Elgr, 2013). The latter occur mainly along the Continental Divide from Waterton Lakes National Park in the south to Wilmore Wilderness Provincial Park in the north (Pana & Elgr, 2013). Numerous mosses that are common in siliceous regions of British Columbia have found rare suitable habitat in siliceous areas of the moist Continental Divide in some parts of Alberta, making regions of siliceous rock important for rare mosses in the province (Belland, 2011). Siliceous areas in Jasper National Park and Willmore Wilderness Park, especially, have proven to have a rich siliceous moss flora that includes many rare mosses (Belland, 2011).

In Banff National Park siliceous rock occurs in a narrow one to two mountain range wide band along the Continental Divide from Citadel Peak to Lake Louise with scattered outcrops along the Icefields Parkway (Pana & Elgr, 2013; R.A. Price, Cook, Aitken, & Mountjoy, 1980; R.A. Price & Mountjoy, 1972a, 1972b). While surveys for bryophytes have occurred frequently in the Banff National Park, most surveys have occurred in largely calcareous areas along the main transportation corridors, in particular the Icefields Parkway, Johnston Canyon, the vicinity of the Banff Townsite, and the Lake Louise-Moraine Lake area (Appendix 1; Table 1).

Few surveys have taken place in the purely siliceous areas of the Sunshine Meadows-Egypt Lake area and most were conducted prior to the 1970s. For instance, in the early 1900s A.H. Brinkman searched the Egypt Lake area. During the same time frame, surveys were conducted by both N.B. Sanson and A.H. Brinkman along Healy Creek and at Simpson Pass. Since the early 1900s little collecting has taken place. Some small collections by C.E. Beil and C.D. Bird occurred in the Egypt Lake area in 1965. The Sunshine Meadows and Sunshine Ski Hill were surveyed by F.A. MacFadden (1920s), W.A. Webber (1959), and G.W. Scotter (1969-1971). It is likely the Banff Ecological (Biophysical) Classification (Holland & Coen, 1982) survey collected in the study area in the late 1970s, but survey locations and specimens could not be confirmed.

Currently, 43 moss species are recorded for the Sunshine Meadows-Egypt Lake area, and 326 mosses for Banff National Park (Appendix 1; Tables 2, 3). For context, the Alberta Conservation Information Management System (ACIMS) lists the presence of 553 moss species in Alberta (Alberta Environment and Parks [AEP], 2017). This makes Banff National Park an important conservation area for Alberta mosses because Banff protects approximately 60% of Alberta's moss flora (AEP, 2017). Within the Sunshine Meadows-Egypt Lake area, ACIMS records indicate that five rare mosses and two potentially rare (SU) mosses (*Hypnum procerrimum* [S2S3], *Mnium blyttii* [S2S3], *Tayloria froelichiana* [S2], *Tayloria lingulata* [S2S3], *Tortella inclinata* [S2S3], *Scorpidium cossonii* [SU], *Grimmia alpestris* [SU]) have been previously recorded in the area (AEP, 2017). ACIMS records also indicate that 14 rare lichen species have previously been recorded for the Sunshine Meadows-Egypt Lake area (Appendix 1; Table 4) (AEP, 2017).

1.2 Purpose

The *Canada National Parks Act* (S.C. 2000, c.32) requires that the "[m]aintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks" (s. 8(2)). Further, the definition of ecological integrity in the *Canada National Parks Act* includes "the composition and abundance of native species and biological communities, rates of change and supporting processes" (s. 2(1)). Mosses and lichens play ecological roles in alpine environments that support natural processes and other species. Thus, the conservation and protection of mosses and lichens would aid in fulfilling Parks Canada's responsibilities under the *Canada National Parks Act*.

1.2.1 Ecological Significance of Mosses and Lichens

Mosses and lichens support other species in several ways. Mosses are used as a nesting material for birds and other animals (Hallingbäck & Hodgetts, 2000), as an important food source for aquatic invertebrates in low nutrient and alpine streams (McWilliam-Hughes, Jardine, & Cunjak, 2009; Suren & Winterbourn, 1991), as habitat for terrestrial and aquatic microfauna (Jonsson et al., 2015; Lee & Hershey, 2000; McWilliam-Hughes et al., 2009), and as an important conserver of fungal diversity (Kauserud, Mathiesen, & Ohlson, 2008; Yu et al., 2014). Similarly, lichens are also an important source for nesting material for birds and other mammals, and as an important habitat for microfauna and bacteria (Brodo, Sharnoff, & Sharnoff, 2001; Zedda & Rambold, 2015).

Mosses and lichens also play an important role in several ecosystem processes. Both mosses and lichens have an essential role in carbon and nitrogen cycling, fixation, transformation, and loss processes (Turetsky, 2003; Zedda & Rambold, 2015). The effect of mosses on these cycles has had a global effect since land plants first originated (Knack et al., 2015). This ancient global effect on carbon and nitrogen cycles is due to a complex and poorly understood relationship between mosses, fungi, nitrogen fixing bacteria and other microbes (Knack et al., 2015). Mosses are important for retaining water in ecosystems, especially in environments where they dominate, such as peatlands and alpine areas (Hallingbäck & Hodgetts, 2000). In alpine areas, mosses and lichens also contribute to retaining soil and preventing erosion, often playing this role as a component of a biological soil crust (Hallingbäck & Hodgetts, 2000; Zedda & Rambold, 2015).

While potentially supporting a suite of rare mosses, the siliceous areas of Banff National Park also have some of the highest human use in the Park. In the Sunshine Meadows-Egypt Lake area, overuse by visitors has been a management concern since at least the 1970s (Lesko & Robson, 1975) and continues to be a management concern (Parks Canada Agency, 2018a). In December 2018, a winter visitor increase from 6000 to 8500 visitors per day was approved for the Sunshine Village Ski Resort (Parks Canada Agency, 2018a). In 2016 the reintroduction of summer gondola, chairlift, and hotel operations increased access to the Sunshine Meadows area with visitation increasing from 14,000 to 33,000 visitors per season, with peak days of 1,300 visitors, and averages of about 400 (Parks Canada Agency, 2018a).

1.2.2 Threats

Approximately 50,000 people visited the Sunshine Meadows area in the summer of 2018 (Parks Canada Agency, 2018a). Parks Canada seeks to both allow visitors to responsibly experience the meadows and to protect the unique alpine vegetation (Parks Canada Agency, 2018a). Concerns about summer overuse have led to the banning of off-trail hiking in the Sunshine Meadows area.

Globally, the main threats to alpine mosses are off-road vehicle use, trampling, dislodging by climbers, and air pollution (Hallingbäck & Hodgetts, 2000). Winter impacts of ski hills on vegetation are not well known, other than the occurrence of scalping of vegetation early and late in the ski season during ski run grooming, and some changes in vegetation communities due to compacted snow melting more slowly (M.F. Price, 1985). Skiing and associated grooming activities are considered a lesser threat to mosses, but are still an important threat if late snow patches are affected (Hallingbäck & Hodgetts, 2000).

Climate change is also a threat to alpine mosses and lichens. A field study simulating climate change in alpine tundra resulted in the impoverishment of mosses and lichens compared to unaltered sites (Jägerbrand, Lindblad, Björk, Alatalo, & Molau, 2006). Mosses that are associated with late snowmelt areas are particularly sensitive to climate change due to warming temperatures that reduce snowbed duration leading to a decrease or loss of suitable habitat (Björk & Molau, 2007; Woolgrove & Woodin, 1994).

Alpine vegetation is fragile and susceptible to human use (M.F. Price, 1985; Willard & Marr, 1970). Mosses and lichens, can only grow when they are wet, such as after precipitation events, heavy dew, or during snow melt. This means that the growing season is shorter for alpine mosses and lichens than for alpine vascular plants (days versus weeks respectively). Although mosses reproduce by spores, the majority of spores fall close to the plant (Vanderpoorten & Goffinet, 2009) indicating that many mosses usually only disperse short distances. Similarly, lichen spores and propagules are also mostly dispersed short distances (Goward, 2011). If a rare bryophyte or lichen species were to be disturbed by humans it could potentially be extirpated from an area. Because of these differences between vascular plants and mosses and lichens, it often takes mosses and lichens longer to recover from disturbances, making alpine mosses and lichens especially sensitive to human overuse.

Due to the fragility of alpine vegetation trampling impacts can occur quickly and have long lasting effects. This is because a short growing season leads to slow vegetation recovery (Achuff, 1992; M.F. Price, 1985; Willard & Marr, 1970). Also, trail braiding and deepening cause further vegetation impairment (Leung & Marion, 1996) and trampling induced soil compaction prevents recovery (Crisfield, Macdonald, & Gould, 2012). When the above factors interact with environmental factors further degradation often occurs (Crisfield et al., 2012; Leung & Marion, 1996). An overall decrease in bryophyte and lichen cover due to trampling has been documented in alpine areas of Alberta (Achuff, 1992; Crisfield et al., 2012) with lichens being more sensitive than mosses (Achuff, 1992). However, some early successional moss species, and moss species released from vascular plant competition can show an increase in cover with trampling (Gremmen, Smith, & Tongeren, 2003). Trampling has also been associated with changing the dominance pattern of bryophyte and lichen community groups (Jägerbrand & Alatalo, 2015). In the Northern Rockies of Alberta, trampling caused alpine plant communities to switch to trampling resistant communities with lower cover and species diversity (Crisfield et al., 2012).

The high human use in combination with the rarity of siliceous areas in Banff National Park necessitates the need for a better understanding of the moss and lichen flora in the Sunshine

Meadows-Egypt Lake area, and especially the rare component, to support resource management and to ensure that the ecological integrity of siliceous areas in Banff National Park can be maintained. The purpose of this paper is to present a survey of the siliceous moss and incidental lichen collections of the Sunshine Meadows-Egypt Lake area of Banff National Park, with an analysis of their distributions, habitat and microhabitat preferences. In addition, management recommendations will be provided to better conserve the moss and lichen flora of this unique region.

1.3 Objectives

The objectives of this study are to:

1. Determine the siliceous species diversity and presence of rare moss species in an undersurveyed siliceous area of high human use in Banff National Park.
2. Contribute to the understanding of the distributions, habitats, and microhabitats of rare and common siliceous moss species in Banff National Park and Alberta.
3. Collection of incidental lichen species to contribute to the understanding of the lichen species diversity of the study area.
4. Provide management recommendations based on the findings of the survey to conserve moss and lichen species diversity in the siliceous portions of the Sunshine meadows-Egypt Lake area and Banff National Park.

2.0 Methods

2.1 Survey Areas

The main survey area covers the Vista Lake-Twin Lakes-Gibbons Pass Trail starting from Highway 93 South, extending west to the Continental Divide, east to the first range east of the Continental divide, and south to Citadel Pass (Appendix 2; Figures 1, 2). A secondary opportunistic survey area occurred on a calcareous ridge between Tyrrell and Wapiti Peaks (Appendix 2; Figure 1). All sites were accessed by foot from Sunshine Village except for Pharaoh Ridge and the Tyrrell-Wapiti sites which were accessed by helicopter. Collection activity occurred near Gibbons Pass, near Ball Pass, the Red Earth Warden Cabin, Egypt Lake Area, and the Sunshine Meadows Area (Appendix 2; Figure 2, Appendix 1; Table 5).

2.2 Field Work

Field work occurred over 11 days between July 31 and August 21, 2018. A total of 342 bryophyte samples were collected, 309 mosses and 33 liverworts. Lichens were collected incidentally as time allowed with a total of 47 samples collected. A total of 103 sites were sampled (Appendix 1; Table 5). Each site represented a single habitat type. Moisture, habitat, substrate, and microhabitat information was recorded for each site. In total 24 habitat and nine microhabitat types were surveyed (Appendix 1; Table 6). An effort was made to sample as many different habitats types as possible.

Site selection prioritised siliceous substrates (using geological maps and personal experience) in alpine areas. There was also a focus on surveying the edges of late snowbeds which are ideal habitats for many rare mosses. To access as many microhabitats as possible, a large area was covered less thoroughly than a systematic survey would cover in a smaller area. Each day focused on surveying new microhabitats that had not been previously searched.

Samples were collected within a radius of approximately 15 m from the site coordinates. Only good quality specimens with laboratory identifiable characteristics were collected. The sites were not systematically surveyed because species were ignored when samples were of poor quality or the microhabitat was not surveyed. Some microhabitats were not surveyed because they were inaccessible (e.g. cliff faces and shelves), and due to time constraints not all snowbeds were reached. Humified dung, and soft conifer logs were undersurveyed since these microhabitats were not actively selected.

The main species in each sample was identified. When possible, secondary species in samples were also identified. Liverwort, *Bryum species s.l.*, along with most of the *Schistidium* and *Pohlia* samples, and a few *Racomitrium s.l.* samples were not identified. Most of the lichens in the *Peltigera* genus were only identified to a sub-generic group level.

Identified rare moss samples in *Grimmia, Racomitrium,* Leskeaceae, *Pohlia* and *Ditrichum* were verified by Steve Joya. The few identified rare *Schistidium* samples were verified by Terry McIntosh. All other identified samples were verified by Dr. Rene Belland. All moss and unidentified bryophyte samples are deposited in the University of Alberta Botanic Gardens (formerly the Devonian Botanic Gardens) Herbarium (UADBG). Lichen samples were verified by Dr. Diane Haughland and are deposited at the Royal Alberta Museum Herbarium(PMAE).

2.3 Floristic Analysis

Microhabitats and habitats were standardized for analysis of the frequency of species by moisture regime, habitat, and microhabitat. The habitat and microhabitat classification used was created by the author (Appendix 1; Table 6). Alpine refers to habitats above treeline, upper subalpine habitats are below treeline in the closed forest canopy zone, and krummholz habitats are in the transition zone between alpine and upper subalpine that consists of a mix of forest clumps and meadows. The Mesic Upper Subalpine Meadow habitat includes a ski run that is a meadow habitat, but whose history is unknown (i.e. may have once been forest or may have always been meadow). Permanent Upper Subalpine Stream and Permanent Alpine Pool habitats include both hygric and mesic moisture regimes (e.g. flowing/open water and mesic banks).

Lists of previously recorded moss species for Banff National Park, the Sunshine Meadows-Egypt Lake area, and the Lake Louise-Moraine Lake area were compiled from:

- Digitized herbaria records (Belland, 2019; Consortium of North American Bryophyte Herbaria [CNABH], 2019),
- ACIMS occurrence records (AEP, 2017),
- Publications (Bird, 1968; Brinkman, 1915; Emig, 1922; Holland & Coen, 1982; Scotter & Zoltai, 1982), and
- Unpublished reports (Krieger, 2003; Scotter, 1973; Western Canada Bryophyte and Lichen Interest Group, 2015).

No samples from herbariums were verified and the records were assumed to be correctly identified. Records for species that were clearly out of their range were excluded from the lists (e.g. maritime, high arctic, and eastern species).

Species identified in this study were compared with the compiled lists of previously recorded species to determine the presence and rarity of new species to Banff National Park and the study area. ACIMS (AEP, 2017) records were consulted to determine the provincial conservation status of the identified species and whether any identified species were new to Alberta.

Habitat information from the Flora of North America (FNA) (FNAEC, 2007, 2014) and digitized herbarium records (Belland, 2019; CNABH, 2019) were used to determine which of the identified species, and which of the species previously recorded in the study area and Banff National Park preferred siliceous substrates. To determine how the study area compared with other siliceous areas in Alberta and Banff National Park, the identified species were compared to published literature (Belland, 2011; Vitt & Belland, 1997), digitized herbarium records (Belland, 2019; CNABH, 2019), and the Lake Louise-Moraine Lake area species list. A combined annotated list of the rare species to Alberta and new species to Banff National Park was created from the above information to update the distributions of these species in Alberta and Banff National Park.

The identified lichen species were compared with the Banff-Jasper Ecological Land Classification (Holland & Coen, 1982) to determine the presence of any new lichen species to Banff National Park, and rarity was determined by cross referencing with ACIMS tracking lists (AEP, 2017). Since lichens were collected incidentally no extensive analysis was conducted.

Species taxonomy for mosses generally follows that of the FNA (FNAEC, 2007, 2014), except for Encalyptaceae (Horton, 1983), Mniaceae (Koponen, 1974), and *Racomitrium* (Frisvoll, 1983, 1988). For lichens, taxonomy generally follows Esslinger (2018), except for *Stereocaulon* (Brodo, 2016) and *Thamnolia* (Goward, 1999).

3.0 Results

A total of 78 moss species were found and identified (Appendix 1; Table 7), of which nine are new species to Banff National Park. In the study area, 52 of the moss species are new to the study area (Appendix 1; Table 7). These additional species increase the total known moss flora for the study area to 97 species. This comprises 29% of the total Banff National Park moss flora and 18% of the Alberta flora. The number of ACIMS conservation ranked rare species (S1 and S2) found is 15 or 19% of the species encountered.

For lichens, a total of 29 species were found (Appendix 1; Table 8), of which six species are new to Banff National Park. No rare lichen species were found.

3.1 Distributions and Rarity of Mosses in the Study Area

3.1.1 Frequency

Of all the moss species encountered, 49% (38) were only found at a single site and only 10% (8) were found at 10 or greater sites (Appendix 1; Table 7). Many of the single collections of mosses are species known to be fairly common to common (S3-S5) (e.g. *Pohlia nutans, Ptychostomum pseudotriquetrum*) (Appendix 1; Table 7). Eight mosses were commonly encountered, *Dicranoweisia crispula* (23 sites), *Campylium stellatum* (14 sites), *Polytrichastrum alpinum* and *Sanionia uncinata* (12 sites), *Polytrichum piliferum* and *Philonotis fontana* (11 sites), and *Aulacomnium palustre* and *Palustriella falcata* (10 sites) (Table 7).

Eleven rare moss species (73% of all rare species) were only found at one site (Appendix 1; Table 7). The most frequent rare mosses were *Tayloria lingulata* (4 sites), and *Racomitrium sudeticum* (3 sites). Two rare moss species were found at two sites (*Dicranella palustris, Hygrohypnum smithii*). Several rare and potentially rare mosses (SU) previously found from the study area but which were not found in this study are: *Grimmia alpestris* (SU), *Hygrohypnum duriusculum* (SU), *Hypnum procerrimum* (S2S3), *Scorpidium cossonii* (SU), *Tayloria froelichiana* (S2), and *Tortella inclinata* (S2S3).

3.1.2 Distribution and Rarity of Mosses on Siliceous Substrates in Banff National Park
Siliceous species that are previously known to Banff National Park that were not found in this study are *Amphidium lapponicum*, *Andreaea nivalis, Blindia acuta, Conostomum tetragonum, Cynodontium strumiferum, C. tenellum, Grimmia alpestris, G. donniana, G. pilifera, G. torquata, Hygrohypnum alpestre, H. duriusculum, Kiaeria blyttii, K. starkei, and Ulota curvifolia*.

Species associated with siliceous geology that were not found in this study but which were found previously to the study area are: *Grimmia alpestris* and *Hygrohypnum duriusculum*. The siliceous species reconfirmed to be in the study area are: *Dicranoweisia crispula*, *Hygrohypnum bestii*, *Paraleucobryum enerve*, *Polytrichum piliferum,* and *Racomitrium canescens*.

3.2 Moisture Analysis
Moisture played an important role in the presence of moss species. Mesic sites had the greatest moss diversity, and wetter sites (hygric and mesic combined) have more diversity than xeric sites. (Appendix 2; Figure 3). Of all the species encountered, 29 were found at hygric sites, 55 at mesic sites, and 28 at xeric sites. Examples of commonly found species at hygric sites include: *Aulacomnium palustre, Campylium stellatum, Cratoneuron filicinum, Palustriella falcata, Sanionia uncinata, Sphagnum capillifolium*, and *Tomentypnum nitens*. Examples of species that were common at mesic sites include: *C. stellatum, Dicranoweisia crispula, Dicranum scoparium, Polytrichastrum alpinum, Polytrichastrum sexangulare, Polytrichum piliferum, Pseudoleskea radicosa, Racomitrium canescens, Sanionia uncinata, Syntrichia ruralis.* Examples of species commonly found at xeric sites include: *D. crispula, P. alpinum, P. piliferum, and R. canescens*.

Hygric sites had the greatest rare moss diversity and there was no overlap in moisture regime between the rare species (Appendix 2; Figure 3). There were eight rare species (53%) found at hygric sites (*Dicranella palustris, Hygroamblystegium varium, Hygrohypnum smithii, H. styriacum, Racomitrium fasciculare, Sphagnum platyphyllum, Tayloria lingulata*), six (40%) at mesic sites (*Dicranella subulata, Lescuraea saxicola, Mnium arizonicum, M. blyttii, Oligotrichum hercynicum, Racomitrium sudeticum*), and two (13%) at xeric sites (*Grimmia longirostris, Kiaeria falcata*).

3.3 Habitat Analysis
Mosses were found in a wide diversity of habitats (Appendix 1; Table 9). Overall, *Dicranoweisia crispula* was a generalist species, being found in many different habitats, while the other commonly encountered species grouped themselves into more specific habitats. The most diverse habitats (10 or more species) along with the commonly encountered mosses in each habitat were Mesic Upper Subalpine Forest (*D. crispula, Pseudoleskea radicosa*), Permanent Upper Subalpine Stream (*Campylium stellatum*, *Palustriella falcata, Philonotis fontana)*, Mesic Krummholz Zone (*D. crispula, Racomitrium canescens, Syntrichia ruralis*), Alpine Seep (*Aulacomnium palustre, C. stellatum, Sphagnum capillifolium, Tomentypnum nitens*), Xeric Alpine Rock Outcrop (*Distichium capillaceum*), Hygric Permanent Alpine Stream (*C. stellatum,*

P. fontana, Sanionia uncinata), Alpine Late Snowbed (*D. crispula, Polytrichastrum alpinum, P. sexangulare, S. uncinata*), and Xeric Alpine Talus Slope (*D. crispula, Grimmia sessitana*) (Appendix 1; Table 9, see Appendix 3; Photos 1-5 for examples of some of the habitats).

Rare moss species (S1 and S2) were also found in a wide diversity of habitats (Appendix 1; Table 10, see Appendix 3; Photos 1-5 for some habitat examples). Overall, there was little overlap between habitats for most rare species with rare moss species being found in 58% of habitats surveyed. The habitats with the highest rare species diversity had two rare species each (7 habitats). These habitats are: Permanent Upper Subalpine Stream (*Dicranella palustris, Hygrohypnum smithii*) (Appendix 3; Photo 1), Mesic Upper Subalpine Forest (*Lescuraea saxicola*, *Mnium arizonicum*), Alpine Seep (*Dicranella palustris, Tayloria lingulata*) (Appendix 3; Photo 3), Hygric Upper Subalpine Cliff Seep (*Hygroamblystegium varium, T. lingulata*), Hygric Permanent Alpine Stream (*Hygrohypnum styriacum, T. lingulata*), Mesic Upper Subalpine Meadow (*Dicranella subulata, Oligotrichum hercynicum*), and Xeric Alpine Gravel Bed (*Grimmia longirostris, Kiaeria falcata*). All of the Mesic Upper Subalpine Forest rare species were found at one site on the Sunshine Village Ski Resort lease, with both of the species (*L. saxicola*, *Mnium arizonicum*) being found only at this site. Seven habitats contained only one rare species: Permanent Alpine Pool (*Racomitrium fasciculare*) (Appendix 3; Photo 4), Hygric Permanent Stream in Krummholz Zone (*Hygrohypnum smithii*), Hygric Upper Subalpine Meadow (*Sphagnum platyphyllum*) (Appendix 3; Photo 5), Mesic Krummholz Zone (*Mnium blyttii*), Mesic Alpine Heath-Meadow (*Racomitrium sudeticum*), Mesic Alpine Talus Slope (*R. sudeticum*), and Xeric Upper Subalpine Talus Slope (*L. saxicola*). Ten habitats had no rare moss collections.

Habitats that were important for both rare mosses and all mosses identified were Mesic Upper Subalpine Forest, Permanent Upper Subalpine Stream, Alpine Seep and Hygric permanent Alpine Stream (Appendix 1; Tables 9 & 10).

3.4 Microhabitat Analysis

Similar to habitat, moss species were found in a variety of microhabitats (Appendix 2; Figure 4). Overall, there was little overlap in species between each microhabitat. The most diverse microhabitats and the commonly encountered species in each were Mineral Soil (*Aulacomnium palustre, Campylium stellatum, Dicranoweisia crispula, Palustriella falcata, Polytrichastrum alpinum, P. sexangulare, Polytrichum piliferum, Racomitrium canescens, Sanionia uncinata*), Rock (*C. stellatum, D. crispula, Hygrohypnum spp., P. falcata*), Humus (*A. palustre, Polytrichum commune, Sphagnum capillifolium*), Boulder (*D. crispula, Pseudoleskea radicosa, Grimmia sessitana*), and Rock Crevice (*D. crispula, P. alpinum*) (Appendix 2; Figure 4).

Rare moss species were also found in a wide variety of microhabitats, however rare mosses were only found in 56% of the microhabitats versus in 58% of habitats indicating that some rare mosses had a slightly stronger affinity for microhabitat than habitat (Appendix 2; Figure 4 & Appendix 1; Table 10). Overall, there was very little overlap between microhabitats for most rare moss species. The microhabitats containing the highest species diversity were Rock with eight species *(D. palustris, Grimmia longirostris, Hygroamblystegium varium, Hygrohypnum smithii, H. styriacum, Kiaeria falcata, Racomitrium sudeticum, T. lingulata*), and Mineral Soil with five species (*Dicranella palustris*, *D. subulata, Mnium blyttii, Oligotrichum hercynicum, Tayloria lingulata)*. Three rare species were found in the Humus microhabitat (*M. arizonicum, Racomitrium fasciculare, Sphagnum platyphyllum*), two in the Boulder microhabitat (*L. saxicola, Mnium arizonicum*) and one in the Rock Crevice microhabitat (*R. sudeticum*). No rare mosses were found on cliff shelves, cliff faces, humified dung, or soft conifer logs.

4.0 Discussion

4.1 Moss Ecology

The Sunshine Meadows-Egypt Lake area has proven to have a diversity of rare siliceous moss species and contains species not previously known to be in Banff National Park (Appendix 1; Table 7). The rare component showed the highest diversity in hygric sites followed by mesic sites, however habitat and microhabitat were also factors in rare species diversity (Appendix 1; Table 10 & Appendix 2; Figures 3, 4). The lack of overlap in rare species diversity between moisture regimes, and minimal overlap between differing habitats and microhabitats (see Results, Sections 3.2-3.4), indicates that moisture requirements in combination with appropriate habitat and microhabitat drive rare moss diversity in the study area. Although xeric sites were not the most diverse habitats they did have rare species (Appendix 2; Figure 3). This underscores that even though mesic and hygric sites have the greatest diversity of rare species, xeric sites should not be overlooked when surveying for and conserving rare mosses.

The majority of rare species diversity was found on mineral soil and rocky microhabitats (Appendix 2; Figure 3), which were prevalent in the study area. Boulders, rock, and rock crevices each had a fairly unique set of rare species indicating that weathering of mountains creates multiple habitats and microhabitats for rare mosses (see section 3.4 in Results for species). Ericaceous low shrub species and graminoid species often covered the majority of the ground surface in alpine meadows, the krummholz zone, and subalpine forest meadows, which likely restricts mosses to rocks, dry blowout areas, wet sites, and mineral soil in the high alpine above the limit of vascular plant tolerance.

Late snowbeds are known to be excellent bryophyte habitats (Belland, 1983; Kudo & Ito, 1992). Late snowbed areas may not have yielded a high rare species diversity because not all late snowbed sites were searched and not all of the late snowbed species could be identified. Further, snow in the study area often lingers into mid-July and sometimes into early August, which makes the whole study area a late snowmelt region. *Polytrichastrum sexangulare*, which is known to be an indicator of extremely late snowbed habitat (Belland, 2011; Heegaard, 2002; Kudo & Ito, 1992), was found around the edges of snowbeds (see Appendix 3; Photo2), and within the alpine and krummholz habitats surveyed in this study. Because the study area is a late snowmelt area, some sites that were classified as xeric in the field but yielded species associated with mesic or wet habitats (e.g. *Aulacomnium palustre*) were dry at the time of sampling, but may have actually been wet a few weeks prior due to snowmelt. This late snowmelt would leave a relatively short seasonal desiccation window, that would allow these normally wet area associated species to survive. Speculatively, these species could also be benefiting from boulders shading mineral soil in talus slopes and keeping the soil moist for most of the growing season. The lower number of snowbed species could also be due to climate change. Anecdotally, the author has noticed that snowbed longevity has decreased in the Sunshine Meadows-Egypt Lake area in the last 10 years, and areas that once were hygric are becoming mesic. Studies have shown a decrease in snowbed associated species and communities with decreased snowbed duration (Woolgrove & Woodin, 1994). This could be due to the loss of moisture and nutrients that snowbeds provide (Björk & Molau, 2007). Thus, with the shorter late snowbed duration in the study area it is likely that climate change is impacting the species diversity of the study area, but the full effects of climate change are unknown.

Since the sampling in this study was not systematic the frequency of the number of sites a species was found at may not be the true frequency of the species in the study area. For example, *Ceratodon purpureus* was only collected at four sites. This moss is well known to grow in a variety of places from rooftops to early successional habitats. A focus on finding new and rare species led to *C. purpureus* being under collected. However, the high frequency of sites with *Dicranoweisia crispula* is likely accurate, due to this species being a siliceous area generalist that grows on many substrates from soil to rock. This species also looks very different wet and dry. Since collection effort focused on finding new species that looked different, inevitably *D. crispula* was favoured in collecting.

An interesting finding was that the rare species *Tayloria lingulata* was found growing in hygric situations in seepage. Previous collectors have reported this species from mesic sites (Belland, 2019; CNABH, 2019; Marino, 2014).

4.2 Moss Distributions on Siliceous Substrates

The search of siliceous substrates (quartzite, quartzite conglomerate, shale, quartz sandstone, and mineral soil derived from these rocks) confirmed the presence of rare mosses associated with siliceous substrates in the study area. Many siliceous moss species that are fairly common in siliceous areas elsewhere in Alberta were found in the study area (e.g. *Dicranoweisia crispula*, *Hygrohypnum bestii, Paraleucobryum enerve, Polytrichastrum alpinum, Polytrichum piliferum*) (Appendix 1; Table 7). Further, the majority of the rare species found and most of the species new to Banff National Park are only found on siliceous substrates (Appendix 1; Table 7). The siliceous areas between the latitude of Banff Townsite and Jasper National Park are patchy, and siliceous areas in Banff National Park are disjunct from Waterton Lakes National Park (Pana & Elgr, 2013). Thus, the Sunshine Meadows-Egypt Lake area provides a protected "refuge" for siliceous associated species between Jasper and Waterton Lakes National Parks.

This study also filled gaps in distributions (e.g. *Hygrohypnum styriacum*) and found range extensions for rare siliceous species (e.g. *Kiaeria falcata, Oligotrichum hercynicum, Polytrichum sexangulare, Racomitrium fasciculare*) (see section 6.0 - Annotated List). Many of these species were only previously known from Waterton Lakes or Jasper National Parks (Belland, 2011). These findings give a better understanding of which mosses are widely distributed in siliceous areas of Alberta and which are more restricted. For instance, *Polytrichastrum sexangulare* is a new species to Banff National Park that is only found on siliceous substrates in alpine areas (Belland, 2011). *P. sexangulare* is relatively widespread in siliceous areas in Jasper (Belland, 2011) and is now known to be relatively common in the study area in Banff National Park.

Siliceous species have also been previously documented in the Lake Louise-Moraine Lake area of Banff National Park. When the Lake Louise-Moraine Lake flora is compared to the floras in the study area, both floras appear to be relatively distinct (Appendix 1; Table 11). Since both areas have the same rock types this is likely an artifact of survey effort. In addition, no systematic survey has been completed for the Lake Louise-Moraine Lake area with most of the collections occurring from easily accessible areas near lakeshores (Appendix 1; Table 1). It is likely that if future systematic surveys were conducted in the Sunshine Meadows-Egypt Lake and Lake-Louise-Moraine Lake areas the floras will prove to be more similar to each other and also to the siliceous areas of Jasper National Park.

Several of the species new to Banff National Park have an unranked conservation status (Appendix 1; Table 6). Most of these species are in the *Grimmia*, and *Racomitrium s.l.* genera. These three genera are difficult to identify which leads to misidentification and taxonomic uncertainty. An example of this from the study area is the case of *Grimmia sessitana* and *G. alpestris*. Previously, *G. alpestris* has been documented in the Sunshine Meadows-Egypt Lake area, and now *G. sessitana* is also documented from this area. Both species have been synonymized in North America with each other by different authors at different times (Hastings & Greven, 2007), making the identity of the historical collections in Alberta uncertain without further examination. This study only found *G. sessitana*, but this does not mean that the previous records of *G. alpestris* for the study area are invalid. Examination of historic *G. alpestris* samples in the study area or further targeted surveys could help determine if both species are present. Despite the taxonomic uncertainty and difficulty of identification of *Grimmia* and *Racomitrium s.l.* it is well known that *Racomitrium s.l.* and most *Grimmia* species are associated with siliceous substrates. Given the rarity of siliceous areas in Alberta, the unranked species in these two genera will likely prove to be rare species in Alberta, if further taxonomic work on these genera is completed.

4.3 Lichen Incidental Collections

Since lichens were collected incidentally, the chance of finding rare species was low. However, several new species were documented for Banff National Park (Appendix 1; Table 8). These new Banff lichen species are segregates from taxonomically challenging groups (*Bryoria s.l., Cetraria s.l., Melanelia s.l., and Peltigera*) and are not considered rare in Alberta (Appendix 1; Table 8). Currently, genetic taxonomic studies of Alberta specimens in the *Peltigera rufescens*, *P. leucophlebia*, and *P. neopolydactyla* groups are taking place as a collaboration between the Alberta Biodiversity Monitoring Institute, the Royal Alberta Museum, and Duke University. These genetic studies are seeking to settle the taxonomy of these *Peltigera* groups in Alberta with results to be published in the coming years (personal communication, Diane Haughland, 2019). Species collected in the *Peltigera rufescens*, *P. leucophlebia*, and *P. neopolydactyla* groups should be identified to species level once the studies are published. Observationally, there appears to be a rich lichen flora in the study area, and further surveys by lichenologists should be considered to gain a better understanding of the lichens in the Sunshine Meadows-Egypt Lake area.

4.4 Management Concerns

4.4.1 Ecological Integrity

Mosses and lichens are important components in the study area that provide ecosystem processes that aid in maintaining the ecological integrity of the study area and Banff National Park. For example, aquatic mosses such as *Hygrohypnum* species would provide stream habitat for invertebrates and protect water quality services and processes (Lee & Hershey, 2000). Many of the *Hygrohypnum* species are rare to Banff (*Hygrohypnum smithii, H. styriacum*) so their protection is needed to maintain the ecological integrity of stream habitats for invertebrates. The mosses found on soil are likely preventing soil erosion and contributing to carbon and nitrogen cycles (Turetsky, 2003). *Sphagnum* and seep mosses retain and slowly release water, which is important for water availability for animals, plants, fish, and other downstream users (Hallingbäck & Hodgetts, 2000). *Sphagnum platyphyllum*, a rare peat moss, was found forming mats around an alpine lake. *S. platyphyllum* would be aiding in the filtration and retention of water at this lake. The presence of mosses in streams and on the soil protects these processes, and aids in their continuance which in turn maintains ecological integrity. Many of the mosses encountered and a significant component of the rare species were found in wetland habitats or on the ground in the study area indicating that these mosses play a role in the ecological integrity of wetland areas (Appendix 1; Tables 9, 10, & Appendix 2; Figures 3, 4).

4.4.2 Human Overuse

Ten (67%) of the rare mosses were found adjacent to trails. Thus, rare mosses are at high risk of being trampled if human overuse occurs. Trampling is considered one of the main worldwide threats to alpine mosses(Hallingbäck & Hodgetts, 2000). Alpine wet areas are particularly sensitive to trampling effects (M.F. Price, 1985). Some rare species that were found growing adjacent to trails that could be at risk of trampling are: *Dicranella palustris, D. subulata, Hygrohypnum smithii, Mnium arizonicum, Oligotrichum hercynicum, Racomitrium fasciculare, R. sudeticum, Sphagnum platyphyllum, and Tayloria lingulata.*

Species found on rocks are of lower concern since many of the species are tightly bound to rock surfaces, and the difficult walking terrain of talus slopes discourages most people from accessing these sites. Sites with large boulders or rock outcrops that provide good views or are tempting to climb may be of higher risk of trampling or dislodging of moss while climbing. Rock climbing or mountain climbing could possibly dislodge rare mosses during climbing and summiting attempts. Dislodging of mosses by climbers is one of the top three threats to mosses in mountainous and alpine areas (Hallingbäck & Hodgetts, 2000). Rare species that can grow on rocks on talus slopes or cliffs that could be sensitive to the impacts of mountain climbers and rock climbers are: *Grimmia longirostris, Lescuraea saxicola, Racomitrium sudeticum*.

It has been previously noted that lichens are sensitive to trampling in the study area (Achuff, 1992). Lichen samples from Pharaoh Ridge showed evidence of trampling (personal communication, Diane Haughland, 2019) even through there are no trails along this ridge. This indicates that even minor off-trail hiking can impact lichen growth in alpine environments. The trampling evidence indicates that occasional hiking along this ridge occurs by backcountry visitors staying in the Egypt Lake and Shadow Lake areas.

Another observed threat for both mosses and lichens is garbage accumulation. Garbage was found smothering vegetation in popular out-of-bounds ski/snowboarding areas on Twin Cairns Mountain and Wawa Ridge. Items included food serving trays, beverage containers, broken ski equipment, and snack bags/wrappers. These items if not regularly removed could become a major impact on the survival of ground dwelling mosses and lichens in addition to vascular plants due to smothering effects and slow vegetation recovery after removal

4.5 Recommendations for Conservation Action

4.5.1 Recommendations for Human Use

Human use if wisely managed should prevent adverse effects on mosses and lichens. The recent increase in visitation and the high human use of the Sunshine Meadows-Egypt Lake area requires careful management. Currently, during the summer hiking season, off-trail hiking restrictions are in place in the Sunshine Meadows area to protect a variety of organisms. Much of the rare and common moss flora in the study area occurred on mineral soil and humus, and in permanent or ephemeral wet areas which are sensitive to trampling (see Results sections 3.3 & 3.4, Appendix 1; Tables 9, 10, & Appendix 2; Figures 3, 4). Moss and lichen cover in the study area has been noted to decrease along trails (Achuff, 1992). While conducting field work it was also observed that very few of the hikers had the proper footwear to hike through puddles or wet areas, so preventing wet spots on trails is critical to prevent trail braiding, trampling, and the erosion of habitat by channelization. Rock scaling and cleaning of rock walls by rock climbers or mountaineers in siliceous areas of Banff National Park could also unknowingly dislodge or extirpate rare mosses from siliceous rock sites.

Recommendations for summer human use focus on preventing excessive trampling, dislodging, and human caused erosion, because these are acute and preventable impacts. These acute impacts can be prevented by:

1. Maintaining the seasonal off-trail hiking restrictions in the Sunshine Meadows to prevent trampling of rare species;
2. Properly designing and maintaining trials to prevent excessive erosion and trail braiding in wet areas (i.e. seeps, ephemeral and permanent streams and pools), since mesic and hygric habitats contained the greatest rare species diversity; and
3. Discouraging or preventing rock scaling by climbers or mountaineers in siliceous areas of Banff National Park to prevent the dislodging of rare species from rock faces.
4. Periodic removal of garbage in popular out-of-bounds ski/snowboarding areas in the Sunshine Village area (e.g. Twin Cairns Mountain and Wawa Ridge) every five years. Five years would reduce trampling impacts on fragile vegetation in off-trail areas and minimize the amount of vegetation smothered by garbage.

Current, winter ski hill operations are likely having a low impact. The ski season finishes before the majority of the snow melts and there is usually a good snow base before the ski hill opens. Thus, scalping of vegetation by grooming equipment is of low concern. Further, some of the older ski runs in the Meadow Park area may be preventing tree encroachment and maintaining forest meadow habitat. No changes in winter management for mosses and lichens are recommended at this time.

4.5.2 Recommendations for Conservation of Rare Species

Rare mosses and lichens can be conserved if their habitats and microhabitats are protected. This requires that moss and lichen species are valued because if a species is not valued its habitat will rarely be protected. Thus, in addition to the support of moss and lichen conservation by Parks

Canada both a public appreciation and understanding of the importance of mosses and lichens to the functioning of ecosystems and other species is needed. Rare species conservation also involves collaboration between multiple stakeholders with differing interests and values. The most recent strategic environmental assessment for the Sunshine Village Site Guidelines did not include mosses or lichens (Parks Canada Agency, 2018b). This was an oversight that should not continue if Parks Canada desires to conserve rare moss and lichen species and the ecosystem process that these species provide as required by the *Canada National Parks Act* (S.C. 2000, c.32). Rare moss species were found on the Sunshine Village lease in a forested habitat. It is likely that further surveys on the Sunshine Village lease would find more rare moss species populations. In order to conserve rare mosses and lichens in the study area the following is recommended:

1. Environmental Impact Assessments for ski hill and other development proposals should include mosses and lichens.
2. Surveys for rare mosses and lichens should be conducted by trained bryologists and lichenologists and not by consulting firms who rarely have the expertise to properly assess mosses and lichens.
3. Banff National Park should partner with museums and academic institutions that have the expertise and staff to conduct environmental impact assessments, and rare bryophyte and lichen surveys.
4. Parks Canada should retain bryologists and lichenologists on staff for the entire Parks System, much in the same manner that Parks Canada has archeologists on staff that can be called in to survey for archeological resources as needed.
5. Monitoring of rare moss and lichen species should occur at regular intervals (see section 4.4.3).
6. A variety of habitats in each moisture regime should be conserved and protected from development to maintain microhabitats suitable for a variety of rare mosses.
7. Studies on the impacts of climate change on mosses and lichens in the study area should be completed to better understand the effects of climate change on these taxa in siliceous alpine late snowmelt areas.

To create an appreciation of the ecological importance of mosses and lichens by the public an interpretive program should be created. Visitors were curious about this study and asked many questions about mosses and lichens when field work was being conducted. This demonstrates an interest by the public for an interpretive program focusing on the importance and intrinsic beauty of these often overlooked and fascinating organisms. The interpretive program could include:

1. Interpretive displays with close-up photographs of mosses and lichens from the area to showcase the diversity and beauty of the organisms present;
2. Displays and presentations showcasing the importance of mosses and lichens to other organisms and ecosystems; and
3. Interpretive hikes with a moss and lichen theme.

In addition, the public could also be engaged and gain a conservation appreciation through volunteering in moss and lichen conservation efforts with Parks Canada staff.

4.5.3 Recommendations for Monitoring

Rare mosses should be monitored to ensure that human use and climate change is not adversely affecting the presence of rare mosses in the Sunshine Meadows-Egypt Lake area. Monitoring recommendations are as follows:

1. Presence checks should be completed every five years for rare species. A time frame of longer than five years is too long to adequately respond to changes from human use or climate change.
2. Some sites for every rare species should be picked for each round of monitoring.
3. Sites that are close to trails (1-2 m or within the allowable trail buffer) should be prioritized (see Appendix 1; Table 12 for priority sites and the species present).
4. At each site a representative sample should be collected and species presence confirmed in a lab with microscopes by an expert.

4.5.4 Recommendations for Future Surveys

This study found nine new species to Banff National Park and 15 rare species with an *ad hoc* floristic survey in a siliceous area of Banff National Park. The Sunshine Meadows-Egypt Lake area is also now known to contain 29% of the Banff moss flora and 18% of the Alberta flora. Additional targeted and systematic floristic surveys in siliceous areas of the study area and elsewhere in Banff National Park would likely find new locations of rare species and would further the understanding of the siliceous flora in Banff National Park. Areas of siliceous geology that are likely to be promising are the Ball Bass-Shadow Lake area, Gibbons Pass Area, and Arnica-Twin Lakes area since these areas have siliceous rocks (Pana & Elgr, 2013; R.A. Price & Mountjoy, 1972a, 1972b), have not been previously surveyed (other than the three sites visited in this study), and are also forested (siliceous forested areas were not studied in this report). In addition, the siliceous areas of the Lake Louise-Moraine Lake area are also under surveyed. Future surveys for known rare species would aid in the understanding of their distributions in Banff National Park and Alberta, as well as providing information on areas of high conservation priority in the Park. This would also provide appropriate information for adequately assessing the environmental impacts of proposed developments and managing human use to conserve rare moss species in the heavily visited siliceous areas of Banff National Park.

Recommendations for future surveys in the Sunshine Meadows-Egypt Lake area are:

1. Surveys of mosses in the upper subalpine forest on the Sunshine Village lease, especially in the Meadow Park area and the forests on Wawa Ridge which have siliceous rocks. Rare species were found in the upper subalpine forest on the Sunshine Village lease (*Lescuraea saxicola, Mnium arizonicum*). This is the only known location for both these species in the study area. It is likely that more locations of these rare mosses would be found in forested areas of the Sunshine Village lease, and more surveys should be conducted to better understand where these species occur on the lease.
2. Further surveys of late snowbed areas. There are a few rare moss species that occur in the seepage of late snowbeds on siliceous substrates that were not found in this study but are likely to occur. These species include *Pohlia obtusifolia* (Villars ex Brid.) L.F. Koch and *Grimmia mollis* Bruch & Schimp., which are

found in similar habitats in Jasper National Park and Willmore Wilderness Park on the same geological formations (Belland, 2011; Pana & Elgr, 2013).
3. Further surveys of lichens since these organisms are understudied in the Sunshine Meadows-Egypt Lake area and are particularly sensitive to trampling. There have been many taxonomic changes since the Banff-Jasper Ecological Land Classification was completed (Holland & Coen, 1982), and a more complete understanding of which species are present in the area is needed given the high human use and proposed ski hill developments. Observationally, there also appeared to be a rich lichen flora in the area.

Recommendations for future moss surveys elsewhere in Banff National Park:

1. Targeted surveys of siliceous areas of Banff National Park and the microhabitats of known rare moss species in order to better understand rare and siliceous substrate moss occurrences and distributions in the Park.
2. Surveys of Lake Louise-Moraine Lake area including the Lake Louise Ski Hill, because of high human use and ski hill development proposals on siliceous areas, and the previously recorded presence of rare siliceous moss species.
3. Surveys of the Ball Bass-Shadow Lake area, Gibbons Pass Area, and Arnica-Twin Lakes area since these areas have forested siliceous habitats that have not been surveyed in Banff.

5.0 Conclusion

This study has contributed to the understanding of the siliceous flora of the study area and Banff National Park. It is clear that the Sunshine Meadows-Egypt Lake area contains a rich siliceous moss flora with many widespread species and some more restricted rare species. A total of nine new species and 15 rare moss species to Banff National Park were found in one short *ad hoc* survey. It is remarkable that such a small geographic area contains 29% of the Banff National Park moss flora and 18% of the Alberta moss flora, making the study area an important area of moss biodiversity and conservation in Banff National Park and Alberta. Several range extensions of rare moss species were found which contributes to the understanding of distributions of the rare moss species of the siliceous areas in Alberta. Further systematic surveys of siliceous areas in the Sunshine Meadows-Egypt Lake area and elsewhere in Banff National Park will likely yield more new moss species to Banff and new occurrences of rare species. A high percentage (67%) of rare moss species were present adjacent to trails, putting some populations at risk of trampling. In addition, some of the incidental lichen collections in off-trail areas showed evidence of trampling. The high human use of siliceous areas in Banff National Park necessitates the wise and careful conservation and management of the siliceous moss and lichen flora. This is required to maintain ecological integrity of moss and lichen communities and the other organisms supported by these mosses and lichens in siliceous areas of the Sunshine Meadows-Egypt Lake area and elsewhere in Banff National Park. This wise and careful conservation and management if done in partnership with museums, academic institutions, and the public has great potential to succeed.

6.0 Annotated List of Rare Moss Species Identified in the Study Area and New Species to Banff National Park

NOTE: Conservation ranks are from the ACIMS (AEP, 2017). Information on previous species records and habitat in Alberta is from MerlnSQL (Belland, 2019), the Consortium of North American Bryophyte Herbaria (2019), and the Canadian Forest Service-Northern Forestry Centre Herbarium (CAFB) unless otherwise cited. Appendix 1; Table 7 provides a quick reference for which species are new to Banff National Park.

The species information is presented in the following order: *Scientific name, Taxonomic Author, Site #: Sample #, Locality in study area. Conservation Rank***.**

Dicranella palustris (Dicks.) Warb. HE6: 1, Meadows Below Healy Pass; TC 11: 5, Sunshine-Twin Cairns Trail. S2S3.

D. palustris is known from infrequent locations from Banff National Park to Willmore Wilderness Park. It has only been previously recorded in Banff National Park from the summit of Castle Mountain by John Macoun in the late 1800s. In the study area it was found in seeps on irrigated siliceous gravel and mineral soil. It has also been known to occur on stream edges (Belland, 2011).

Dicranella subulata (Hedw.) Schimp. HE5: 1, Meadows Below Healy Pass. S2S3.

D. subulata was found growing on siliceous mineral soil on the edge of a trail in a mesic meadow. Previously found at Lake Agnes near Lake Louise this is the second record of this species in Banff National Park. Elsewhere in Alberta it is found mainly in Jasper National Park with a few occurrences in Kananaskis, Swan Hills, and the Boreal Forest on mineral soil in seasonally wet areas.

Grimmia longirostris Hook. PH4: 2, Pharaoh Ridge. S2S3.

G. longirostris is known in Alberta from Waterton to Jasper in the Rockies and from the Caribou Mountains. This is the sixth record of this species in Banff National Park. It was first found in 1891 at an unknown location and at Lake Louise in 1904 by John Macoun. In 1925 F.A. MacFadden collected it east of Banff along the highway. In the 1950s H.A. Crum and W.B. Schofield collected it in the Moraine Lake and Vermilion Pass areas. It was also found at Moraine Lake by Dale Vitt in the 1960s. Both Crum and Vitt recorded the species to be growing on quartzitic rocks. In the study area is was found growing on siliceous gravel.

Hygroamblystegium varium (Hedw.) Mönk. - BP2: 1, 3, 4. Ball Pass Area. S2S3.

H. varium is found scattered throughout the Rocky Mountain, Foothills, and Boreal Forest regions in Alberta in continuous seepage or edges of wetlands on a variety of substrates. It was found growing in seepage on a quartz cliff below Ball Pass near the Hawk Creek Trail, and constitutes the sixth record of this species in Banff National Park. It is known elsewhere in Banff National Park from the Banff Mineral Springs, the Cave and Basin Outflow, Vermilion Lakes, and Johnston Canyon.

Hygrohypnum smithii (Sw.) Broth. CTD1: 3, Citadel Peak Area; SIM10: 2, Simpson Pass Trail. S1.

H. smithii is previously known from three sites in Alberta, Maligne Canyon in Jasper National Park, the Caribou Mountains, and the Helen Lake Trail in Banff National Park. This species is now known from 5 locations in Alberta. It grows on siliceous rocks or sometimes wood in slow moving water or ponds (Jamieson, 2014). The rock type at the sites in the study area was uncertain.

Hygrohypnum styriacum (Limpr.) Broth. WS2: 4, Whistling Pass Area. S1S2.

New to Banff National Park. In Alberta *H. styriacum* is found growing on siliceous and calcareous rocks in streams in the Alberta Rockies. It has a scattered distribution from the Oldman River Watershed north to Jasper National Park. In Banff, it was found forming large hummocks on irrigated rock adjacent to a stream on the north side of Whistling Pass.

Kiaeria falcata (Hedw.) I. Hagen. TC24: 5, Twin Cairns Area. S1.

New to Banff National Park, *K. falcata* constitutes a southern range extension. It was previously known from 3 locations in Jasper, 1 in Wilmore, and 1 in the Kakwa Wildlands growing on siliceous substrates. *K. falcata* was found growing on siliceous gravel on Twin Cairns Mountain.

Lescuraea saxicola (Schimp.) Molendo. MP7: 9, Sunshine-Meadow Park Trail. S1.

Previously known in Banff National Park from Lower Consolation Lake this is the second occurrence of this species in Banff National Park. *L. saxicola* has a scattered distribution from Waterton to Wilmore on siliceous substrates. In the study area it was only found on siliceous boulders in the forest on the Meadow Park Trail on the Sunshine Ski Hill.

Mnium arizonicum Amann. MP7: 1, 9, 12, Sunshine-Meadow Park Trail. S2S3.

M. arizonicum is known from the Rocky Mountains from Waterton to Grande Cache in exposed to shaded mesic habitats on rock, soil, or humus. This species is recorded as present in Banff National Park in the Ecological Land Classification (Holland & Coen, 1982), but previous locations in Banff National Park could not be confirmed. The only location where this species was found in the study area was in a forested section of the Meadow Park Trail on the Sunshine Ski Hill where it was found growing on boulders and humus.

Mnium blyttii B.S.G. CTD2: 2, Citadel Peak Area. S2S3.

M. blyttii is found from Waterton to Grande Cache in exposed to shaded conditions on rock, soil, and humus. In Banff National Park, it was previously known from the outflow of Moraine Lake. There are now two known locations for this species in Banff National Park.

Oligotrichum hercynicum (Hedw.) Lam. & de Candolle. HE5: 1, Meadows Below and East of Healy Pass. S1S3.

New to Banff National Park, *O. hercynicum* is a major range extension for this species south from Jasper National Park, where the previous southern extent was Jonas Pass (Belland, 2011). Until now this species was only known from siliceous regions of Jasper National Park, Wilmore Wilderness Park, and the Swan Hills. It grows on moist siliceous soils along trails, moraines, and late snow beds. It was found growing below Healy Pass on a trail edge along the Simpson-Healy Pass Trail.

Polytrichastrum sexangulare (Brid.) G.L. Smith. CTD5: 2, Citadel Peak Area; HE1: 7, Healy Pass; HE2: 8, Between Simpson and Healy Pass; PH6: 2, Pharaoh Ridge; QTZ4: 1,2,3,6, Quartz Ridge. S3.

New to Banff National Park, these new occurrences for *P. sexangulare* are a major southern range extension in Alberta. *P. sexangulare* is widely distributed in the study area. It is also widely distributed in siliceous areas of Jasper and Wilmore. Based on collection records, *P. sexangulare* prefers late snowmelt areas growing on wet mineral soil on the ground and on cliffs.

Racomitrium fasciculare (Hedw.) Brid. SIM1: 4,5. S1S3.

New to Banff National Park, previously this species was only known from Jasper National Park and Willmore Wilderness Park, this collection constitutes a major range extension in Alberta. It was found growing on the edge of an alpine pool.

Racomitrium macounii Kindb. ex Kindb. HE4: 5, Meadows Below and East of Healy Pass. SU.

New to Banff National Park. *R. macounii* is, part of the taxonomically challenging *R. heterostichum* group (Frisvoll, 1988). ACIMS (AEP, 2017) lists this species as present in the province. It was found growing on irrigated sandstone in a seep.

Racomitrium sudeticum (Funck) Bruch & Schimp. CTD8:1, Citadel Peak Area; HE1:5, Healy Pass; HE:4, Meadows Below and East of Healy Pass. S2S3.

R. sudeticum has a scattered distribution in siliceous areas of the Rocky Mountains from Waterton to Jasper. In Banff National Park it has previously been collected from three locations: The Consolation Lakes Trail, the outlet to Moraine Lake, and near the BC border on Highway 1. It is also part of the taxonomically challenging *R. heterostichum* group (Frisvoll, 1988). In the study area is was found growing in rock crevices and on rock surfaces in mesic to hygric situations.

Sarmentypnum sarmentosum (Wahlenb.) Tuomikoski & T. Kop. TC11: 3, Sunshine-Twin Cairns Trail. SU.

New to Banff National Park, *S. sarmentosum* was found growing on humus in an alpine seep. It is known from Jasper National Park in fens, springs, and areas with late snowbeds. This collection is the southernmost known location of this species in Alberta. It has often been confused with *Calliergon* species and *Straminergon stramineum* (Hedenas, 2014).

Schistidium frigidum H.H. Blom. EG6: 3, Egypt Lake Area- Mummy Lake. SU.

New to Banff National Park, *S. frigidum* was found growing on limestone above Mummy Lake. It is often confused with other *Schistidium* species (McIntosh, 2007) which makes its distribution in Alberta uncertain.

Sphagnum platyphyllum (Lindb.) Warnst. HE3: 2, Trail Between Simpson and Healy Passes. S2.

New to Banff National Park, S. *platyphyllum* is a rare peat moss. It is known from the Tonquin Valley in Jasper, an entrance to a coal mine south of Hinton, sand dune areas near Edmonton, and the Athabasca Sand Dunes. It prefers seasonally flooded open areas near edges of fens, lakes, ponds, and streams (FNAEC, 2007). A good population was found growing on a gently sloping plain around the edge of an alpine lake between Simpson and Healy Passes.

Tayloria lingulata (Dickson) Lindb. BP2: 4,5, Ball Pass Area; TC11: 7, Sunshine-Twin Cairns Trail; TC21: 2,3,4, Twin Cairns; WS2: 5, Whistling Pass. S2S3.

The presence of this rare species is reconfirmed for the Sunshine Meadows area. *T. lingulata* was previously found on Wawa Ridge and east of Twin Cairns Mountain by G.W. Scotter in the 1960s. It is now known to also occur near Ball and Whistling Passes. Elsewhere in Banff National Park it has previously been collected from three locations: Lake Louise, Moraine Lake, and Mt. Borgeau. This species is found in the Rocky Mountains where it ranges from Banff National Park to Willmore Wilderness Park. Most collectors have reported this species from mesic sites (Marino, 2014), but in the study area it was found growing in hygric situations in seepage on cliff shelves, siliceous gravel and mineral soil.

7.0 Acknowledgements

I want to thank Parks Canada and the Resource Conservation Staff in Banff National Park for encouraging me and giving me the opportunity to contribute to the understanding of mosses and lichens in Banff National Park. I also want to thank Dr. Rene Belland of the University of Alberta for tutelage and assistance with bryophyte identification and species confirmation, for providing bryophyte species records to create a species list for Banff National Park, and for providing feedback on the writing of this report. Steve Joya's and Terry McIntosh's assistance in confirming rare species is greatly appreciated. Dr. Richard Caners of the Royal Alberta Museum also provided invaluable feedback on the drafts of this report. Brittney Millar of the Alberta Biodiversity Monitoring Institute helped me figure out the differing taxonomic treatments of the *Racomitrium s.l.* group of mosses. Dr. Diane Haughland of the Royal Alberta Museum was instrumental in assisting with and confirming Lichen identification and for providing feedback on this report. For the use of lab space and microscopes I want to thank Dr. Ellen Macdonald of the University of Alberta. I am grateful for Allyn Esau and Chris (An Bang) Cheng for their assistance with data entry when I had a period of illness. Two anonymous reviewers also aided in the proof reading of the text. All the of the above organizations and people contributed to the success of this study and report.

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9.0 List of Tables

10.0 List of Figures

Appendix 1 – Tables

Table 1. Previous bryophyte surveys in Banff National Park including collector(s), year(s) and location compiled from digitized herbarium records (Belland, 2019; CNABH, 2019), ACIMS occurrence records (AEP, 2017), publications (Bird, 1968; Brinkman, 1915; Emig, 1922; Holland & Coen, 1982; Scotter & Zoltai, 1982), and unpublished reports (Krieger, 2003; Scotter, 1973; Western Canada Bryophyte and Lichen Interest Group, 2015). Surveys that included siliceous locations are in **bold text**.

Collector(s)	**Year(s)**	**Location**
J. Macoun	1885, 1890, 1891, 1903, 1904	**Throughout Park along railway**
F.J. Suelly	1888	Banff Townsite Area
L.R. Waldron	1898, 1901, 1902, 1902	Banff Townsite Area
H.L. Bolley	1901	Banff Townsite Area
L.R. Wilson	1901	Banff Townsite Area
S.A. Skinner	1902	**Lake Louise Area**
N.B. Sanson	1903, 1904, 1910, 1913	Banff Townsite Area; **Simpson Pass Area**
D.L.H. Franklin	1910	Banff Townsite Area
A.H. Brinkman	1910, 1912, 1913, 1928	Banff Townsite Area; **Simpson Pass**; Mt. Borgeau; **Egypt Lake Area**
E.R. Fox	1915	**Lake Louise Area**
C.A. Vanderhoof	1918	**Lake Louise Area**
D. Ghirardelli	1922	**Lake Louise Area**
W.A. Setchell	1923	**Lake Louise Area**
J. Noble	1924	**Lake Louise Area**
F.A. MacFadden	1924-1928	Banff Townsite Area; Johnston Canyon; **Vermilion Pass Area**, **Moraine Lake Area**
M.S. Brown	1928	Banff Townsite Area; **Lake Louise Area**
F. Bjorkman	1937	**Vermilion Pass Area; Consolation Lakes**
L. Rakestraw	1937	**Vermilion Pass Area**
E. Lawton	1937, 1951	**Moraine Lake Area**, Banff Townsite Area, **Bow Summit Area**
F.J. Scully	1938	**Lake Louise Area**
E.M. Wells	1939	**Lake Louise Area**
T.C. Frye & E.M. Frye	1940	**Vermilion Pass Area**
A.E. Porsild	1946	**Lake Louise Area**
E.H. Moss	1947	Bow Summit Area
E. Whitehouse	1951	Banff Townsite Area; Johnston Canyon; **Moraine Lake Area**
W.H. Welch	1951	Banff Townsite Area; **Moraine Lake Area**; Johnston Canyon
L. Jenkins	1952	Banff Townsite Area
W.J. Noble	1953	Banff Townsite Area
H.A. Crum & W.B. Schofield	1955	**Throughout Park along Highway 1 and Icefields Parkway**
C.D. Bird et al. (not including C.E. Beil)	1955, 1960-1965, 1967, 1970	**Throughout Park**
G. Toth	1958, 1963	Cascade River Valley; North Saskatchewan River Valley
W.A. Weber	1959	Snow Creek Pass Area; Johnston Canyon; **Sunshine Region**
C.H. Hand	1960	Castle Mountain
G.H. Turner M.D.	1961	**Lake Louise Area**; **Bow Summit Area**
C.E. Beil & C.D. Bird	1965	Banff Townsite Area; **Boom Creek**; **Healy Creek**; **Pharaoh Creek**
P.W. Stringer	1965	Banff Townsite Area
R.R. Ireland	1965	**Lake Louise Area**
K. Beder, et al.	1965-1966	Snow Creek Pass Area
G.W. Scotter	1969-1971	**Sunshine Region**; Panther River; Red Deer Lakes
P.D. Lulman	1970	Icefields Parkway
W.B. Schofield	1970, 1971	**Moraine Lake Area**; Icefields Parkway
A.H. Marsh	1971	Howse River Warden Cabin
D.H. Vitt	1971, 1974, 1978, 1980	**Throughout Park Along Highways**
A.J. Sharp	1972	Banff Townsite Area

T. Koponen	1972	**Boom Lake**
R.S. Williams	1974	Banff Townsite Area
E. Haber	1975	**Peyto Lake Area**
S. Kojima & I. Corns	1975-1976	Throughout Park
B.C. Tan	1976	Protection Mountain Campsite
D.G. Horton	1977-1978	Banff Townsite Area; **Lake Louise Area**; Red Earth Creek
B.M. Murray	1978	Banff National Park: Panther Falls. 9.1 km S of Jasper-Banff Park Boundary.
E. Nyholm	1978	Red Earth Creek; **Moraine Lake**
J. Marsh	1978	Peters Creek
P. Achuff	1978	Banff Townsite Area
J. Shaw	1979	Mt. Athabasca (Banff side)
W.R. Buck	1982	Nigel Creek Area; Castle Mountain Area
J.M. Glime	1984	**Peyto Lake Area**
I. Bisang & R. Schumacker	1986	**Peyto Lake Area**
O. Lee	1988	Banff Townsite Area; Johnston Canyon
T.C. Wells	1988	**Lake Louise Area**
J.-P. Frahm	1989	Mistaya Canyon
R.I. Hastings	1990	Icefields Parkway
B. Goffinet	1994	**Lake Louise Area; Peyto Lake Area**
C. Hamel	1994, 1996	Carrot Creek
J.D. Johnson	1995	Boundary Lake
P. Nagy	1996	**Moraine Lake Area**
M. Krieger	2002	Banff Mineral Springs
R.T. Caners	2010	North Saskatchewan River Crossing
J. Doubt & A.W. Lepitzki	2012	Cave and Basin Springs
S.J. Davis	2013	Banff Townsite Area; **Helen Lake Area**

Table 2. Moss species previously recorded in the Sunshine Meadows-Egypt Lake area compiled from digitized herbaria records (Belland, 2019; CNABH, 2019), ACIMS occurrence records (AEP, 2017), publications (Bird, 1968; Brinkman, 1915; Emig, 1922; Holland & Coen, 1982; Scotter & Zoltai, 1982), and an unpublished report (Scotter, 1973). Species taxonomy generally follows that of the Flora of North America (FNAEC, 2007, 2014), except for Encalyptaceae (Horton, 1983), Mniaceae (Koponen, 1974), and *Racomitrium* (Frisvoll, 1983, 1988). Provincial conservation ranks (S-Rank) are from ACIMS (AEP, 2017).

Moss Species Name	S-Rank
Aulacomnium palustre (Hedw.) Schwaegr.	S5
Brachythecium salebrosum (Hoffm. ex Web. & Mohr) Schimp.	S4
Brachythecium turgidum (C.J. Hartm.) Kindb.	S3S4
Ceratodon purpureus (Hedw.) Brid.	S5
Cratoneuron filicinum (Hedw.) Spruce	S3S4
Dicranoweisia crispula (Hedw.) Lindb. ex Milde	S4
Dicranum fuscescens Turn.	S4
Grimmia alpestris (Web. & Mohr) Schleich.	SU
Grimmia sessitana De Not.	SU
Hygrohypnum bestii (Renauld & Bryhn) Holzinger	S3
Hygrohypnum duriusculum (De Not.) D.W. Jamieson	SU
Hypnum procerrimum Mol.	S2S3
Leptobryum pyriforme (Hedw.) Wils.	S4
Meiotrichum lyallii (Mitt.) G.L. Smith	S3
Mnium blyttii Bruch & Schimp.	S2S3
Mnium lycopodioides Schwaegr.	S3
Mnium thomsonii Schimp.	S3
Paludella squarrosa (Hedw.) Brid.	S3S4
Palustriella falcata (Brid.) Hedenas	S3
Paraleucobryum enerve (Thed. ex C.J. Hartm.) Loeske	S3
Philonotis fontana (Hedw.) Brid.	S3S4
Polytrichum commune Hedw.	S4
Polytrichum juniperinum Hedw.	S4
Polytrichum piliferum Hedw.	S4
Polytrichum strictum Brid.	S5
Ptilium crista-castrensis (Hedw.) De Not.	S5
Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen	S4
Racomitrium canescens (Hedw.) Brid.	S3
Sanionia uncinata (Hedw.) Loeske	S5
Sciuro-hypnum latifolium (Kindb.) Ignatov & Huttunen	S3S4
Scorpidium cossonii (Schimp.) Hedenas	SU
Sphagnum capillifolium (Ehrhart) Hedw.	S4
Sphagnum fuscum (Schimp.) Klinggr.	S4
Sphagnum girgensohnii Russ.	S4
Sphagnum warnstorfii Russ.	S4
Stegonia latifolia (Dickson) Broth.	S3
Syntrichia norvegica Web.	S3
Syntrichia ruralis (Hedw.) Web. & Mohr	S4
Tayloria froelichiana (Hedw.) Mitt. ex Broth.	S2
Tayloria lingulata (Dickson) Lindb.	S2S3
Tortella inclinata (R. Hedw.) Limpr.	S2S3
Tortella tortuosa (Hedw.) Limpr.	S4
Tortula hoppeana (Shultz) Ochyra	S3

Table 3. Moss species previously recorded in Banff National Park compiled from digitized herbaria records (Belland, 2019; CNABH, 2019), ACIMS occurrence records (AEP, 2017), publications (Bird, 1968; Brinkman, 1915; Emig, 1922; Holland & Coen, 1982; Scotter & Zoltai, 1982), and unpublished reports (Krieger, 2003; Scotter, 1973; Western Canada Bryophyte and Lichen Interest Group, 2015). Species taxonomy generally follows that of the Flora of North America (FNAEC, 2007, 2014), except for Encalyptaceae (Horton, 1983), Mniaceae (Koponen, 1974), and *Racomitrium* (Frisvoll, 1983, 1988).

Moss Species
Abietinella abietina (Hedw.) M. Fleisch.
Aloina brevirostris (Hook. & Grev.) Kindb.
Aloina rigida (Hedw.) Limpr.
Amblyodon dealbatus (Hedw.) P. Beauv.
Amblystegium serpens (Hedw.) Schimp.
Amphidium lapponicum (Hedw.) Schimp.
Andreaea nivalis Hook.
Andreaea rupestris Hedw.
Anomobryum julaceum (Schrad. ex Gaertn., B. Mey. & Scherb.) Schimp.
Atrichum selwynii Austin
Aulacomnium palustre (Hedw.) Schwaegr.
Aulacomnium turgidum (Wahlenb.) Schwaegr.
Barbula convoluta Hedw.
Bartramia ithyphylla Brid.
Blindia acuta (Hedw.) Bruch & Schimp.
Brachytheciastrum collinum (Schleich. ex Müll. Hal.) Ignatov & Huttunen
Brachytheciastrum leibergii (Grout) Ignatov & Huttunen
Brachytheciastrum velutinum (Hedw.) Ignatov & Huttunen
Brachythecium albicans (Hedw.) Schimp.
Brachythecium campestre (Müll. Hal.) Schimp.
Brachythecium coruscum I. Hagen
Brachythecium rivulare Schimp.
Brachythecium rutabulum (Hedw.) Schimp.
Brachythecium salebrosum (Hoffm. ex Web. & Mohr) Schimp.
Brachythecium turgidum (C.J. Hartm.) Kindb.
Bryoerythrophyllum recurvirostrum (Hedw.) Chen
Bryum argenteum Hedw.
Buxbaumia aphylla Hedw.
Calliergon giganteum (Schimp.) Kindb.
Calliergon richardsonii (Mitt.) Kindb. ex Warnst.
Calliergonella cuspidata (Hedw.) Loeske
Campyliadelphus chrysophyllus (Brid.) Kanda
Campylium stellatum (Hedw.) C. Jens.
Campylophyllum halleri (Hedw.) M. Fleische
Campylophyllum hispidulum (Brid.) Hedenas
Campylophyllum sommerfeltii (Myrin) Hedenas
Catoscopium nigritum (Hedw.) Brid.
Ceratodon purpureus (Hedw.) Brid.
Cinclidium stygium Sw.
Climacium dendroides Web. & Mohr
Conardia compacta (Hook.) H. Rob.
Conostomum tetragonum (Hedw.) Lindb.
Cratoneuron filicinum (Hedw.) Spruce
Cynodontium alpestre (Whalenb.) Milde
Cynodontium schisti (Web. & Mohr) Lindb.
Cynodontium strumiferum (Hedw.) Lindb.
Cynodontium tenellum (Schimp.) Limpr.
Cyrtomnium hymenophylloides (Huebener) T. Kop.
Cyrtomnium hymenophyllum (Bruch & Schimp.) Holmen
Dichelyma falcatum (Hedw.) Myrin
Dichodontium pellucidum (Hedw.) Schimp.
Dicranella heteromalla (Hedw.) Schimp.
Dicranella palustris (Dicks.) Warb.
Dicranella schreberiana (Hedw.) Hilferty ex H.A. Crum & L.E. Anderson
Dicranella subulata (Hedw.) Schimp.
Dicranella varia (Hedw.) Schimp.
Dicranoweisia crispula (Hedw.) Milde
Dicranum acutifolium (Lindb. & Arnell) C. Jens. ex Weinm.
Dicranum bonjeanii De Not.
Dicranum brevifolium (Lindb.) Lindb.
Dicranum elongatum Schleich. & Schwaegr.
Dicranum flagellare Hedw.
Dicranum fragilifolium Lindb.
Dicranum fuscescens Turn.
Dicranum majus Turn.
Dicranum muehlenbeckii Bruch & Schimp.
Dicranum polysetum Sw.
Dicranum scoparium Hedw.

Dicranum spadiceum Zett.

Dicranum undulatum Brid.

Didymodon fallax (Hedw.) R.H. Zander

Didymodon ferrugineus (Schimp. ex Besch.) M.O. Hill

Didymodon johansenii (Williams) H.A. Crum

Didymodon nigrescens (Mitt.) K. Saito

Didymodon rigidulus Hedw.

Didymodon subandreaeoides (Kindb.) R.H. Zander

Didymodon tophaceus (Brid.) Lisa

Didymodon vinealis (Brid.) R.H. Zander

Distichium capillaceum (Hedw.) Bruch & Schimp.

Distichium inclinatum (Hedw.) Bruch & Schimp.

Ditrichum flexicaule (Schwaegr.) Hampe

Ditrichum gracile (Mitt.) Kuntze

Ditrichum heteromallum (Hedw.) E. Britton

Ditrichum montanum Leiberg

Drepanocladus aduncus (Hedw.) Warnst.

Drepanocladus longifolius (Wilson ex Mitt.) Broth. ex Paris

Drepanocladus polygamus (Schimp.) Hedenas

Encalypta affinis Hedw.

Encalypta alpina Sm.

Encalypta brevicollis (Bruch & Schimp.) Angstr.

Encalypta brevipes Schljak.

Encalypta ciliata Hedw.

Encalypta mutica Hagen

Encalypta procera Bruch

Encalypta rhaptocarpa Schwaegr.

Encalypta spathulata C. Muell.

Encalypta vulgaris Hedw.

Eucladium verticillatum (Hedw.) Bruch & Schimp.

Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen

Fissidens adianthoides Hedw.

Fissidens bryoides Hedw.

Fissidens crispus Mont.

Fissidens grandifrons Bride.

Fissidens osmundioides Hedw.

Funaria hygrometrica Hedw.

Gemmabryum caespiticium (Hedw.) J.R. Spence

Gemmabryum tenuisetum (Limpr.) J.R. Spence & H.P. Ramsay

Grimmia alpestris (Web. & Mohr) Schleich.

Grimmia anodon Bruch & Schimp.

Grimmia donniana Smith

Grimmia elatior Bruch ex Bals.-Criv. & De Not.

Grimmia longirostris Hook.

Grimmia ovalis (Hedw.) Lindb.

Grimmia pilifera P. Beauv.

Grimmia sessitana De Not.

Grimmia teretinervis Limpr.

Grimmia torquata Hornsch. ex Grev.

Gymnostomum aeruginosum Sm.

Hamatocaulis vernicosus (Mitt.) Hedenas

Hedwigia ciliata (Hedw.) P. Beauv.

Hennediella heimii (Hedw.) R.H. Zander

Herzogiella turfacea (Lindb.) Z. Iwats.

Heterocladium dimorphum (Brid.) Schimp.

Homalothecium nevadense (Lesq.) Renauld & Cardot

Homalothecium aeneum (Mitt.) E. Lawton

Homalothecium aureum (Spruce) H. Rob.

Homalothecium fulgescens (Mitt ex Mull. Hal.) A. Jaeger

Hygroamblystegium varium (Hedw.) Mönk.

Hygrohypnum alpestre (Hedw.) Loeske

Hygrohypnum bestii (Ren. & Bryhn) Holz.

Hygrohypnum duriusculum (De Not.) D.W. Jamieson

Hygrohypnum luridum (Hedw.) Jennings

Hygrohypnum smithii (Sw.) Broth.

Hylocomium splendens (Hedw.) Schimp.

Hymenostylium recurvirostre (Hedw.) Dix.

Hypnum bambergeri Schimp.

Hypnum callichroum Brid.

Hypnum cupressiforme Hedw.

Hypnum hamulosum Schimp.

Hypnum lindbergii Mitt.

Hypnum procerrimum Mol.

Hypnum recurvatum (Lindb. & Arn.) Kindb.

Hypnum revolutum (Mitt.) Lindb.

Hypnum vaucheri Lesq.

Isopterygiopsis pulchella (Hedw.) Z. Iwats.

Kiaeria blyttii (Bruch & Schimp.) Broth.

Kiaeria starkei (Web. & Mohr) Hag.

Leptobryum pyriforme (Hedw.) Wils.
Leptodictyum riparium (Hedw.) Warnst.
Lescuraea saxicola (Schimp.) Molendo
Leskea polycarpa Ehrh. ex Hedw.
Leskeella nervosa (Brid.) Loeske
Meesia longiseta Hedw.
Meesia triquetra (L. ex Jolyclerc) Angstr.
Meesia uliginosa Hedw.
Meiotrichum lyallii (Mitt.) G.L. Smith
Mnium arizonicum Amann
Mnium blyttii Bruch & Schimp.
Mnium lycopodioides Schwaegr.
Mnium marginatum (Dicks. ex With.) P. Beauv.
Mnium spinulosum Bruch & Schimp.
Mnium thomsonii Schimp.
Myurella julacea (Schwaerg.) Schimp.
Myurella tenerrima (Brid.) Lindb.
Neckera menziesii Drumm.
Oncophorus virens (Hedw.) Brid.
Oncophorus wahlenbergii Brid.
Orthothecium chryseum (Schwaegr. ex Schultes) Schimp.
Orthothecium intricatum (C.J. Hartm.) Schimp.
Orthothecium strictum Lor.
Orthotrichum affine Brid.
Orthotrichum alpestre Hornsch. ex Bruch & Schimp.
Orthotrichum anomalum Hedw.
Orthotrichum cupulatum Hoffm.ex Brid.
Orthotrichum elegans Schwaegr. ex Hook. & Grev.
Orthotrichum laevigatum Zett.
Orthotrichum obtusifolium Brid.
Orthotrichum pallens Bruch ex Brid.
Orthotrichum pellucidum Lindb.
Orthotrichum pulchellum Brunton
Orthotrichum pumilum Sw.
Orthotrichum pylaisii Brid.
Orthotrichum rupestre Schleich. ex Schwaegr.
Orthotrichum speciosum Nees
Paludella squarrosa (Hedw.) Brid.
Palustriella falcata (Brid.) Hedena
Paraleucobryum enerve (Thed. ex C.J. Hartm.) Loeske
Paraleucobryum longifolium (Hedw.) Loeske
Philonotis fontana (Hedw.) Brid.
Philonotis marchica (Hedw.) Brid.
Plagiobryum demissum (Hook.) Lindb.
Plagiobryum zieri (Hedw.) Lindb.
Plagiomnium cuspidatum (Hedw.) T. Kop.
Plagiomnium drummondii (Bruch & Schimp.) T. Kop.
Plagiomnium ellipticum (Brid.) T. Kop.
Plagiomnium medium (Bruch & Schimp.) T. Kop.
Plagiomnium rostratum (Schrad.) T. Kop.
Plagiopus oederianus (Sw.) Limpr.
Plagiothecium denticulatum (Hedw.) Schimp.
Plagiothecium laetum Schimp.
Platydictya jungermannioides (Brid.) H.A. Crum
Pleurozium schreberi (Brid.) Mitt.
Pogonatum urnigerum (Hedw.) P. Beauv.
Pohlia cruda (Hedw.) Lindb.
Pohlia drummondii (C. Muell.) Andr.
Pohlia elongata Hedw.
Pohlia filum (Schimp.) Mårtensson
Pohlia nutans (Hedw.) Lindb.
Pohlia proligera (Kindb. ex Limpr.) Lindb. ex Arnell
Pohlia wahlenbergii (Web. & Mohr) Andr.
Polytrichastrum alpinum (Hedw.) G.L. Smith
Polytrichum commune Hedw.
Polytrichum juniperinum Hedw.
Polytrichum piliferum Hedw.
Polytrichum strictum Brid.
*Pseudobryum cinclidioides (*Hüb.) T. Kop.
Pseudocalliergon brevifolium (Lindb.) Hedenas
Pseudocalliergon trifarium (Web. & Mohr) Loeske
Pseudocalliergon turgescens (T. Jens.) Loeske
Pseudocampylium radicale (P. Beauv) Vanderpoorten & Hedenas
Pseudoleskea incurvata (Hedw.) Loeske
Pseudoleskea patens (Lindb.) Kindb.
Pseudoleskea radicosa (Mitt.) Mac. & Kindb.
Pseudoleskea stenophylla Renauld & Cardot
Pseudoleskeella rupestris (Berggr.) Hedenas & L. Soderström
Pseudoleskeella tectorum (Funck ex Brid.) Kindb. in Broth.

Pterigynandrum filiforme Hedw.

Ptilium crista-castrensis (Hedw.) De Not.

Ptychostomum calophyllum (R. Br.) J.R. Spence

Ptychostomum cernuum (Hedw.) Hornsch.

Ptychostomum creberrimum (Taylor) J.R. Spence & H.P. Ramsay

Ptychostomum cryophilum (Mårtensson) J.R. Spence

Ptychostomum cyclophyllum (Schwaegr.) J.R. Spence

Ptychostomum inclinatum (Sw. ex Brid.) J.R. Spence

Ptychostomum intermedium (Brid.) J.R. Spence

Ptychostomum lonchocaulon (Müll. Hal.) J.R. Spence

Ptychostomum pallens (Sw.) J.R. Spence

Ptychostomum pallescens (Schleich. ex Schwaegr.) J.R. Spence

Ptychostomum pendulum Hornsch.

Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen

Ptychostomum turbinatum (Hedw.) J.R. Spence

Ptychostomum weigelii (Spreng.) J.R. Spence

Pylaisia intricata (Hedw.) Schimp. in Bruch & Schimp.

Pylaisia polyantha (Hedw.) Schimp. in Bruch & Schimp.

Racomitrium canescens (Hedw.) Brid.

Racomitrium ericoides (Brid.) Brid.

Racomitrium heterostichum (Hedw.) Brid.

Racomitrium lanuginosum (Hedw.) Brid.

Racomitrium sudeticum (Funck) Bruch & Schimp.

Rhizomnium andrewsianum (Steere) T. Kop.

Rhizomnium gracile T. Kop.

Rhizomnium magnifolium (Horik.) T. Kop.

Rhizomnium pseudopunctatum (Bruch & Schimp.) T. Kop.

Rhizomnium punctatum (Hedw.) T. Kop.

Rhynchostegium serrulatum (Hedw.) A. Jaeger

Rhytidiadelphus triquetrus (Hedw.) Warnst.

Rhytidiopsis robusta (Hedw.) Broth.

Rhytidium rugosum (Hedw.) Kindb.

Roellobryon roellii (Broth.) Ochyra

Rosulabryum capillare (Hedw.) J.R. Spence

Rosulabryum elegans (Nees) Ochyra

Rosulabryum flaccidum (Brid.) J.R. Spence

Saelania glaucescens (Hedw.) Bomanss. & Broth.

Sanionia uncinata (Hedw.) Loeske

Sarmentypnum exannulatum (Schimp.) Hedenas

Sarmentypnum tundrae (Arnell) Hedenas

Schistidium agassizii Sull. & Lesq. in Sull.

Schistidium apocarpum (Hedw.) Bruch & Schimp.

Schistidium confertum (Funck) Bruch & Schimp.

Schistidium dupretii (Thériot) W.A. Weber

Schistidium heterophyllum (Kindb. in Mac. & Kindb.) McIntosh

Schistidium pulchrum H.H. Blom

Schistidium rivulare (Brid.) Podp.

Schistidium robustum (Nees & Hornsch.) H.H. Blom

Sciuro-hypnum curtum (Lindb.) Ignatov

Sciuro-hypnum hylotapetum (N.L. Higinbotham & B.L. Higinbotham) Ignatov & Huttunen

Sciuro-hypnum latifolium (Kindb.) Ignatov & Huttunen

Sciuro-hypnum oedipodium (Mitt.) Ignatov & Huttunen

Sciuro-hypnum plumosum (Hedw.) Ignatov & Huttunen

Sciuro-hypnum reflexum (Starke) Ignatov & Huttunen

Scorpidium cossonii (Schimp.) Hedenas

Scorpidium revolvens (Sw.) Rubers

Scorpidium scorpioides (Hedw.) Limpr.

Scouleria aquatica Hook. in Drumm.

Seligeria calcarea (Hedw.) Bruch & Schimp.

Seligeria campylopoda Kindb. in Mac. & Kindb.

Sphagnum angustifolium (C. Jens.) C. Jens.

Sphagnum capillifolium (Ehrh.) Hedw.

Sphagnum centrale C. Jens.

Sphagnum fuscum (Schimp.) Klinggr.

Sphagnum girgensohnii Russ.

Sphagnum magellanicum Brid.

Sphagnum russowii Warnst.

Sphagnum warnstorfii Russ.

Splachnum sphaericum Hedw.

Splachnum vasculosum Hedw.

Stegonia latifolia (Schwaegr.) Venturi ex Broth.

Syntrichia norvegica Web.

Syntrichia ruralis (Hedw.) Web. & Mohr

Tayloria froelichiana (Hedw.) Mitt. ex Broth.

Tayloria hornschuchii (Grev. & Arnott) Broth.

Tayloria lingulata (Dickson) Lindb.

Tayloria splachnoides (Schleich. ex Schwaegr.) Hook.

Tetraphis pellucida Hedw.
Tetraplodon angustatus (Hedw.) Bruch & Schimp.
Tetraplodon mnioides (Hedw.) Bruch & Schimp.
Thuidium recognitum (Hedw.) Lindb.
Timmia austriaca Hedw.
Timmia megapolitana Hedw.
Timmia norvegica J.E. Zetterst.
Timmia sibirica Lindb. & Arnell
Tomentypnum nitens (Hedw.) Loeske
Tortella fragilis (Drumm.) Limpr.
Tortella inclinata (R. Hedw.) Limpr.
Tortella tortuosa (Hedw.) Limpr.
Tortula hoppeana (Shultz) Ochyra
Tortula leucostoma (R. Brown) Hook. & Grev.
Tortula mucronifolia Schwaegr.
Tortula obtusifolia (Schwaegr.) Mathieu
Tortula systylia (Schimp.) Lindb.
Trichodon cylindricus (Hedw.) Schimp.
Trichostomum tenuirostre (Hook. & Taylor) Lindb.
Ulota curvifolia (Whalenb.) Lilj.
Voitia nivalis Hornsch.
Warnstorfia fluitans (Hedw.) Loeske
Weissia controversa Hedw.

Table 4. Rare lichen species previously recorded in the Sunshine Meadows-Egypt Lake area based on ACIMS (AEP, 2017) occurrence records and conservation ranks (S-Rank). Taxonomy follows Esslinger (2018).

Lichen Species Name	S-Rank
Aspicilia arctica (Lynge) Oxsner	S1
Buellia concinna Th. Fr.	S1
Cladonia symphycarpia (Flörke) Fr.	S2S4
Farnoldia jurana (Schaer.) Hertel	S1
Lathagrium undulatum (Flotow) Otálora	S2S3
Lecanora pringlei (Tuck.) I.M. Lamb	S1S2
Lecidea leucothallina Arnold	S2
Lecidea syncarpa Zahlbr.	S1S2
Ochrolechia inaequatula (Nyl.) Zahlbr.	S1S2
Peltigera degenii Gyelnik	SU
Phaeophyscia sciastra (Ach.) Moberg	S3
Polysporina arenacea (H. Magn.) K. Knudsen & Kocourk	S2
Porpidia thomsonii Gowan	S1
Rhizocarpon polycarpum (Hepp) Th. Fr.	SU
Solorina octospora (Arnold) Arnold	S3
Stereocaulon rivulorum H. Magn.	S3
Thrombium epigaeum (Pers.) Wallr.	S2
Umbilicaria lambii Imshaug	S2S3
Verrucaria nigrescens Pers.	S2

Table 5. Collection sites with geographic coordinates in Universal Transverse Mercator (UTM), WGS 1984 datum.

Site	UTM Zone	Easting	Northing	Elevation (m)	Locality
BP1	11U	570651	5664613	2108	Ball Pass Trail
BP2	11U	570860	5664712	2063	Ball Pass Trail
CTD1	11U	589243	5652977	2274	Citadel Peak Area
CTD2	11U	589294	5652902	2283	Citadel Peak Area
CTD3	11U	589287	5652730	2307	Citadel Peak Area
CTD4	11U	589350	5652663	2326	Citadel Peak Area
CTD5	11U	589483	5652673	2316	Citadel Peak Area
CTD6	11U	589643	5652802	2295	Citadel Peak Area
CTD7	11U	589964	5652902	2326	Citadel Peak Area
CTD8	11U	590405	5652862	2360	Citadel Pass
CTD9	11U	590508	5652820	2371	Citadel Pass
CTD10	11U	590454	5652866	2366	Citadel Pass
CTD11	11U	589475	5653174	2286	Citadel Pass Trail
CTD12	11U	589128	5653343	2263	Citadel Pass Trail
EG1	11U	575634	5664840	2250	Egypt Lake Area-Sphynx Lake
EG2	11U	576123	5663746	2202	Egypt Lake Area-Black Rock Lake
EG3	11U	576557	5663082	2131	Egypt Lake Area-Pharaoh Lake
EG4	11U	576564	5663070	2131	Egypt Lake Area-Pharaoh Lake
EG5	11U	576496	5662757	2174	Egypt Lake Area
EG6	11U	576310	5660465	2265	Egypt Lake Area-Mummy Lake
EG7	11U	576329	5661393	2128	Egypt Lake Area-Scarab Lake
GB1	11U	571616	5671999	2101	Gibbons Pass Area
GB2	11U	572039	5671633	2137	Gibbons Pass Area
HE1	11U	579448	5661295	2363	Healy Pass
HE2	11U	581237	5659285	2215	Meadows East of Healy Pass
HE3	11U	580995	5659376	2211	Meadows East of Healy Pass
HE4	11U	580539	5659704	2207	Meadows East of Healy Pass
HE5	11U	580430	5659977	2198	Meadows East of Healy Pass
HE6	11U	580410	5660020	2190	Meadows East of Healy Pass
HE7	11U	580364	5660154	2192	Meadows East of Healy Pass
HE8	11U	580368	5660181	2192	Meadows East of Healy Pass
MP1	11U	585289	5659545	2147	Sunshine-Meadow Park Trail/Ski Run
MP2	11U	585279	5659560	2158	Sunshine-Meadow Park Trail/Ski Run
MP3	11U	585250	5659665	2174	Sunshine-Meadow Park Trail/Ski Run
MP4	11U	585263	5659783	2199	Sunshine-Meadow Park Trail/Ski Run
MP5	11U	585182	5660124	2263	Sunshine-Meadow Park Trail/Ski Run
MP6	11U	585239	5659763	2197	Sunshine-Meadow Park Trail/Ski Run

MP7	11U	585254	5659769	2187	Sunshine-Meadow Park Trail/Ski Run
MP8	11U	585173	5660119	2269	Sunshine-Meadow Park Trail/Ski Run
PH1	11U	574266	5666359	2364	Pharaoh Ridge
PH2	11U	574196	5666337	2402	Pharaoh Ridge
PH3	11U	574144	5666349	2424	Pharaoh Ridge
PH4	11U	574148	5666239	2443	Pharaoh Ridge
PH5	11U	574219	5665996	2410	Pharaoh Ridge
PH6	11U	574464	5665773	2406	Pharaoh Ridge
PH7	11U	574694	5665146	2338	Pharaoh Ridge
PH8	11U	574762	5665121	2346	Pharaoh Ridge
PH9	11U	574798	5665108	2356	Pharaoh Ridge
QTZ1	11U	586233	5655344	2412	Quartz Ridge Area
QTZ2	11U	586249	5655338	2409	Quartz Ridge Area
QTZ3	11U	586270	5655356	2399	Quartz Ridge Area
QTZ4	11U	586245	5655323	2411	Quartz Ridge Area
QTZ5	11U	586285	5655232	2433	Quartz Ridge Area
QTZ6	11U	586300	5655194	2442	Quartz Ridge Area
QTZ7	11U	586369	5655070	2457	Quartz Ridge Area
QTZ8	11U	586417	5654865	2493	Quartz Ridge Trail
QTZ9	11U	587555	5654907	2324	Quartz Ridge Trail
QTZ10	11U	587307	5655214	2356	Quartz Ridge Trail
QTZ11	11U	587133	5655632	2283	Quartz Ridge Trail
RE1	11U	575484	5670012	1745	Red Earth Warden Cabin
RE2	11U	575495	5670008	1735	Red Earth Warden Cabin
RE3	11U	575523	5670033	1733	Red Earth Warden Cabin
RE4	11U	575500	5670031	1732	Red Earth Warden Cabin
SIM1	11U	584177	5660127	2335	Simpson Pass Trail
SIM2	11U	583987	5660117	2331	Simpson Pass Trail
SIM3	11U	583939	5660172	2324	Simpson Pass Trail
SIM4	11U	583758	5660208	2269	Simpson Pass Trail
SIM5	11U	583716	5660244	2261	Simpson Pass Trail
SIM6	11U	583346	5660537	2251	Simpson Pass Trail
SIM7	11U	583135	5660460	2231	Simpson Pass Trail
SIM8	11U	582916	5660489	2182	Simpson Pass Trail
SIM9	11U	582153	5659631	2166	Simpson Pass Trail
SIM10	11U	581805	5659308	2144	Simpson Pass Trail
SIM11	11U	581377	5659275	2198	Simpson Pass Trail
TC1	11U	584454	5659882	2341	Sunshine-Twin Cairns Trail
TC2	11U	584472	5659196	2325	Sunshine-Twin Cairns Trail
TC3	11U	584528	5658853	2319	Sunshine-Twin Cairns Trail

TC4	11U	584537	5658821	2318	Sunshine-Twin Cairns Trail
TC5	11U	584550	5659010	2322	Sunshine-Twin Cairns Trail
TC6	11U	584406	5659420	2337	Sunshine-Twin Cairns Trail
TC7	11U	584411	5659437	2338	Sunshine-Twin Cairns Trail
TC8	11U	584470	5659747	2335	Sunshine-Twin Cairns Trail
TC9	11U	584352	5659748	2339	Sunshine-Twin Cairns Trail
TC10	11U	584442	5659887	2343	Sunshine-Twin Cairns Trail
TC11	11U	584385	5659764	2340	Sunshine-Twin Cairns Trail
TC12	11U	584388	5659797	2340	Sunshine-Twin Cairns Trail
TC13	11U	584411	5659817	2341	Sunshine-Twin Cairns Trail
TC14	11U	584133	5659774	2364	Twin Cairns Area
TC15	11U	584122	5659677	2379	Twin Cairns Area
TC16	11U	584098	5659621	2388	Twin Cairns Area
TC17	11U	584064	5659569	2380	Twin Cairns Area
TC18	11U	583977	5659424	2352	Twin Cairns Area
TC19	11U	583813	5659242	2352	Twin Cairns Area
TC20	11U	583731	5659206	2357	Twin Cairns Area
TC21	11U	583689	5659174	2365	Twin Cairns Area
TC22	11U	583665	5659150	2371	Twin Cairns Area
TC23	11U	583668	5659052	2406	Twin Cairns Area
TC24	11U	583701	5659044	2404	Twin Cairns Area
TC25	11U	583713	5659002	2416	Twin Cairns Area
TC26	11U	583766	5658939	2440	Twin Cairns Area
TY1	11U	582413	5730932	2380	Ridge between Tyrrell and Wapiti Mountains
WS1	11U	573712	5664388	2023	Whistling Pass Area
WS2	11U	575107	5662611	2224	Whistling Pass Area

Table 6. Habitats and microhabitats sampled in the study area.

Habitat	Microhabitat
Alpine Late Snowbed	Boulder
Alpine Seep	Cliff Face
Hygric Permanent Alpine Stream	Cliff Shelf
Hygric Permanent Stream in Krummholz Zone	Humified Dung
Hygric Upper Subalpine Cliff Seep	Humus
Hygric Upper Subalpine Meadow	Mineral Soil
Hygric Upper Subalpine Meadow Seep	Rock
Mesic Alpine Heath-Meadow	Rock Crevice
Mesic Alpine Talus Slope	Soft Conifer Log
Mesic Ephemeral Alpine Pool	
Mesic Ephemeral Alpine Stream	
Mesic Krummholz Zone	
Mesic Rock Outcrop in Krummholz Zone	
Mesic Talus Slope in Krummholz Zone	
Mesic Upper Subalpine Forest	
Mesic Upper Subalpine Forest Clearing	
Mesic Upper Subalpine Meadow	
Permanent Alpine Pool	
Permanent Upper Subalpine Stream	
Xeric Alpine Cliff	
Xeric Alpine Gravel Bed	
Xeric Alpine Rock Outcrop	
Xeric Alpine Talus Slope	
Xeric Upper Subalpine Talus Slope	

Table 7. Moss species identified in the study area with conservation ranks (S-Rank) from ACIMS (AEP, 2017) , new species to Banff National Park (BNP), New Species to Study Area, Number of Sites a species was found, Subtrate ffinity (from FNAEC, 2007, 2014), and Site Number - Sample Number (Collection Number). Substrate affinity is classified as Siliceous (S), Calcareous (C), Indifferent (I), Siliceous to Neutral (S-N), Siliceous to Calcareous (S-C), and Calcareous to Siliceous (C-S). A question mark (?) denotes uncertainty in the substrate affinity. See Table 5 for site locations.

Species	S-Rank AB	New to BNP	New to Study Area	Number of Sites Found	Substrate Affinity	Site#-Sample#
Andreaea rupestris Hedw.	S3S4	N	Y	1	S-N	TC15-1
Aulacomnium palustre (Hedw.) Schwaegr.	S5	N	N	10	I	CTD10-1, CTD10-2, HE2-3, HE4-4, PH4-3, RE1-2, RE1-6, RE1-7, RE1-8, RE1-9, RE1-12, SIM1-7, SIM1-8, SIM1-9, SIM1-10, TC11-4, TC4-7, TC4-8, TC9-2, TC12-2
Barbula convoluta Hedw.	S3	N	Y	1	C	TC3-1
Brachythecium turgidum (C.J. Hartm.) Kindb.	S3S4	N	N	1	I	QTZ2-4
Calliergon giganteum (Schimp.) Kindb.	S4	N	Y	1	I	SIM8-1
Campylium stellatum (Hedw.) C. Jens.	S4	N	Y	14	I	BP2-6, BP2-9, CTD11-1, QTZ2-4, QTZ9-2, RE2-4, RE3-1, SIM2-1, SIM2-5, SIM5-2, TC4-6, TC11-3, TC18-1, TC18-2, TC20-1, TC21-2, TC21-3, TC21-4, WS2-5, WS2-6
Ceratodon purpureus (Hedw.) Brid.	S5	N	N	4	I	MP1-4, MP2-1, MP5-3, PH4-5
Cratoneuron filicinum (Hedw.) Spruce	S3S4	N	N	1	C	SIM2-2
Dichodontium pellucidum (Hedw.) Schimp.	S3S4	N	Y	6	I	BP2-3, RE3-2, SIM2-1, TC11-7, TC21-4, TC4-6
Dicranella palustris (Dicks.) Warb.	S2S3	N	Y	2	S	HE6-1, TC11-5
Dicranella subulata (Hedw.) Schimp.	S2S3	N	Y	1	S	HE5-1
Dicranoweisia crispula (Hedw.) Milde	S4	N	N	23	S	BP1-6, CTD3-7, CTD4-3, CTD4-4, CTD4-5, CTD5-2, CTD5-3, CTD7-2, HE1-6, MP7-8, PH7-1, QTZ6-4, QTZ6-5, QTZ7-4, SIM7-3, SIM11-2, TC1-1, TC7-1, TC8-2, TC11-6, TC14-1, TC15-2, TC22-1, TC22-3, TC22-4, TC23-3, TC24-1, TC25-3, TC25-4, TC26-1
Dicranum brevifolium (Lindb.) Lindb.	S3S4	N	Y	2	I	CTD6-2, TC10-1
Dicranum fuscescens Turn.	S4	N	N	1	I	MP7-7

Dicranum scoparium Hedw.	S4	N	Y	5	I	CTD3-5, MP7-4, RE1-5, RE1-9, RE3-5, SIM1-7
Distichium capillaceum (Hedw.) Bruch & Schimp.	S4	N	Y	7	C	CTD5-1, QTZ9-3, SIM10-3, SIM3-1, SIM3-7, SIM7-5, TC3-2, WS2-6
Distichium inclinatum (Hedw.) Bruch & Schimp.	S3S4	N	Y	3	C (wet S)	BP2-6, EG6-1, QTZ2-5
Ditrichum flexicaule (Schwaegr.) Hampe	S4	N	Y	2	C	RE2-2, RE3-5
Encalypta affinis Hedw.	S3	N	Y	3	C	CTD2-1, CTD12-3, QTZ11-1
Encalypta ciliata Hedw.	S3S4	N	Y	1	S-N	TC2-2
Encalypta rhaptocarpa Schwaegr.	S3	N	Y	1	S-N	PH4-4
Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen	S4	N	Y	1	I	SIM7-7
Grimmia longirostris Hook.	S2S3	N	Y	1	S	PH4-2
Grimmia sessitana De Not.	SU	N	N	6	S	CTD4-1, CTD7-1, HE1-2, PH2-01, QTZ6-3, TC1-3
Hygroamblystegium varium (Hedw.) Mönk.	S2S3	N	Y	1	N	BP2-1, BP2-3, BP2-4
Hygrohypnum bestii (Ren. & Bryhn) Holz.	S3	N	N	2	S	EG2-2, EG2-3, MP6-6
Hygrohypnum luridum (Hedw.) Jennings	S3	N	N	1	C	EG4-1
Hygrohypnum smithii (Sw.) Broth.	S1	N	Y	2	S	CTD1-3, SIM10-2
Hygrohypnum styriacum (Limpr.) Broth.	S1S2	Y	Y	1	S-C	WS2-4
Hylocomium splendens (Hedw.) Schimp.	S5	N	Y	2	I	CTD6-5, RE1-2, RE1-3, RE1-4
Hypnum cupressiforme Hedw.	S3	N	Y	4	I	CTD5-1, EG6-4, QTZ8-4, TC11-9
Hypnum lindbergii Mitt.	S4	N	Y	1	I	HE7-2
Hypnum revolutum (Mitt.) Lindb.	S4	N	Y	1	I	CTD3-5
Kiaeria falcata (Hedw.) I. Hagen	S1	Y	Y	1	S	TC24-5
Lescuraea saxicola (Schimp.) Molendo	S1	N	Y	1	S	MP7-9
Meesia uliginosa Hedw.	S4	N	Y	1	C	BP2-7
Meiotrichum lyallii (Mitt.) G.L. Smith	S3	N	N	3	I	CTD3-1, SIM1-1, TC6-1
Mnium arizonicum Amann	S2S3	N	Y	1	I	MP7-1, MP7-9, MP7-12
Mnium blyttii Bruch & Schimp.	S2S3	N	N	1	I	CTD2-2
Mnium thomsonii Schimp.	S3	N	N	2	C	EG6-1, RE2-2, RE2-4

Oligotrichum hercynicum (Hedw.) Lam. & de Candolle	S1S3	Y	Y	1	S	HE5-1
Oncophorus virens (Hedw.) Brid.	S3	N	Y	4	I	CTD11-1, RE3-4, TC20-1, WS2-5
Orthothecium chryseum (Schwaegr. ex Schultes) Schimp.	S3	N	Y	3	C	QTZ2-1, RE2-2, SIM2-2, SIM2-3
Orthotrichum speciosum Nees	S4	N	Y	1	I	QTZ8-1
Palustriella falcata (Brid.) Hedena	S3	N	N	10	C	BP2-10, CTD1-1, CTD10-3, MP6-4, SIM5-2, SIM5-3, SIM10-4, TC4-4, TC4-5, TC18-1, TC18-2, TC19-1, TC20-1
Paraleucobryum enerve (Thed. ex C.J. Hartm.) Loeske	S3	N	N	1	S	TC17-1
Philonotis fontana Brid.	S3S4	N	N	11	I	CTD10-4, GB1-1, HE4-4, HE7-1, HE7-2, QTZ2-2, QTZ2-4, QTZ3-1, RE2-2, SIM2-2, SIM2-3, SIM2-5, SIM5-4, TC4-1, TC4-6, WS2-1, WS2-2, WS2-5
Pleurozium schreberi (Brid.) Mitt.	S5	N	Y	1	I	RE1-2, RE1-3, RE1-5, RE1-12
Pohlia drummondii (C. Muell.) Andr.	S3	N	Y	2	S	QTZ5-2, SIM7-6
Pohlia nutans (Hedw.) Lindb.	S5	N	Y	1	I	MP7-10, MP7-14, MP7-15
Polytrichastrum alpinum (Hedw.) G.L. Smith	S3	N	Y	12	S	CTD3-2, CTD5-4, CTD9-1, EG6-5, MP7-3, PH6-3, PH6-4, QTZ1-2, QTZ4-4, QTZ4-5, QTZ5-1, TC15-3, TC23-4, TC23-5, TC24-2
Polytrichastrum sexangulare (Brid.) G.L. Smith	S3	Y	Y	5	S	CTD5-2, HE1-7, HE2-8, PH6-2, QTZ4-1, QTZ4-2, QTZ4-3, QTZ4-6
Polytrichum commune Hedw.	S4	N	N	3	I	HE2-1, HE2-2, HE2-3, SIM1-8, SIM1-9, SIM1-10, TC11-4
Polytrichum juniperinum Hedw.	S4	N	N	4	I	CTD12-4, MP1-1, RE2-2, RE4-5
Polytrichum piliferum Hedw.	S4	N	N	11	S	CTD3-4, HE1-4, MP5-3, MP8-1, PH3-1, PH7-1, QTZ7-1, QTZ8-4, RE4-6, TC10-1, TC24-3
Pseudoleskea radicosa (Mitt.) Mac. & Kindb.	S4	N	Y	7	S-C	BP1-7, CTD2-2, CTD9-2, CTD9-3, MP7-8, SIM3-2, SIM11-3, TC24-1
Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen	S4	N	Y	1	I	EG6-5
Racomitrium canescens (Hedw.) Brid.	S3	N	N	8	S-C	CTD2-2, CTD2-3, MP3-2, PH8-1, QTZ8-2, QTZ9-1, SIM1-2, SIM4-1, TC8-1
Racomitrium fasciculare (Hedw.) Brid.	S1S3	Y	Y	1	S	SIM1-4, SIM1-5

Racomitrium lanuginosum (Hedw.) Brid.	S3	N	Y	3	S	CTD5-5, PH5-1, PH9-1
Racomitrium macounii Kindb. ex Kindb.	SU	Y	Y	1	S	HE4-5
Racomitrium sudeticum (Funck) Bruch & Schimp.	S2S3	N	Y	3	S	CTD8-1, HE1-5, HE4-6
Rhytidium rugosum (Hedw.) Kindb.	S4	N	Y	1	S-C	CTD6-4
Roellobryon roellii (Broth.) Ochyra	S3	N	Y	1	I	GB2-2
Sanionia uncinata (Hedw.) Loeske	S5	N	N	12	I	CTD11-1, CTD4-6, MP7-15, QTZ2-4, QTZ3-1, RE1-7, RE1-12, RE2-1, RE2-4, RE3-5, SIM2-1, SIM2-6, TC9-2, TC11-7, WS2-5
Sarmentypnum exannulatum (Schimp.) Hedenas	S3S4	N	Y	1	I	HE3-1
Sarmentypnum sarmentosum (Wahlenb.) Tuomikoski & T. Kop.	SU	Y	Y	1	S?	TC11-3
Schistidium frigidum H.H. Blom	SU	Y	Y	1	C	EG6-3
Sphagnum capillifolium (Ehrh.) Hedw.	S4	N	N	5	I	HE2-1, HE4-4, RE1-7, RE1-8, TC11-4, TC12-1, TC12-2, TC12-4
Sphagnum platyphyllum (Lindb.) Warnst.	S2	Y	Y	1	N	HE3-2
Syntrichia norvegica Web.	S3	N	N	3	I	MP4-1, SIM7-4, TC2-3
Syntrichia ruralis (Hedw.) Web. & Mohr	S4	N	N	7	I	BP1-2, CTD2-2, QTZ7-2, SIM3-6, SIM5-6, TC1-2, TC2-3
Tayloria lingulata (Dickson) Lindb.	S2S3	N	N	4	S-N?	BP2-4, BP2-5, BP2-8, TC11-7, TC21-2, TC21-3, TC21-4, WS2-5
Tetraplodon mnioides (Hedw.) Bruch & Schimp.	S3S4	N	Y	1	I	RE1-2
Timmia austriaca Hedw.	S4	N	Y	2	I	CTD6-2, RE2-1, RE2-2, RE2-3
Tomentypnum nitens (Hedw.) Loeske	S4	N	Y	4	I	CTD10-1, CTD10-2, RE1-6, RE1-8, TC11-2, TC4-8
Tortella tortuosa (Hedw.) Limpr.	S4	N	N	1	C	QTZ9-2
Tortula hoppeana (Shultz) Ochyra	S3	N	N	2	C	CTD3-5, MP8-1

Table 8. Lichen species found in the study area with New Species to Banff National Park, conservation ranks (S-Rank) from ACIMS (AEP, 2017), and Site Number - Sample Number (Collection Number). See Table 5 for site locations.

Lichen Species Name	New to Banff	S-Rank AB	Site#-Sample#
Bryoria pikei Brodo & D. Hawksw.	Y	SU	MP7-2
Cetraria ericetorum Opiz *subsp. ericetorum*	N	S3S5	RE4-1, TC17-3
Cetraria ericetorum subsp. reticulata (Räsänen) Kärnefelt	N	SU	PH1-4, PH1-8, QTZ6-1, QTZ6-2
Cetraria islandica (L.) Ach. *subsp. islandica*	N	S3S5	CTD6-6, MP5-1, PH1-7
Cladonia arbuscula subsp. mitis (Sandst.) Ruoss	N	S3S5	PH1-2, PH1-3, TC10-2
Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel	N	S3S5	MP7-18
Cladonia ecmocyna Leighton	N	S3S5	MP7-17, PH1-8, TC2-4
Cladonia ecmocyna subsp. intermedia (Robbins) Ahti	N	SU	MP7-16
Cladonia fimbriata (L.) Fr.	N	S3S5	MP3-3, RE4-2
Cladonia pyxidata (L.) Hoffm.	N	S3S5	MP3-3
Cladonia sulphurina (Michaux) Fr.	Y	S3S5	MP7-18
Dactylina arctica (Hooker f.) Nyl.	N	S3S5	CTD6-1
Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell	N	S3S5	CTD6-3
Flavocetraria nivalis (L.) Kärnefelt & A. Thell	N	S3S5	PH1-6
Letharia columbiana (Nutt.) J.W. Thomson	Y	S4	EG1-1
Letharia lupina Altermann, Leavitt & Goward (Altermann et al. 2016)	N	S3S5	MP7-5
Melanohalea elegantula (Zahlbr.) O. Blanco et al.	Y	S3S5	MP7-2
Parmeliopsis hyperopta (Ach.) Arnold	N	S3S5	MP7-18
Peltigera canina (L.) Willd.	N	S3S5	RE4-4
Peltigera leucophlebia group (Nyl.) Gyelnik	N	S3S5	CTD3-3, MP3-4
Peltigera neopolydactyla group (Gyelnik) Gyelnik	N	S3S4	TC12-3
Peltigera ponojensis Gyelnik	Y	S3S5	MP1-5, MP2-2
Peltigera rufescens group (Weiss) Humb.	N	S3S5	MP8-2, RE4-2, RE4-3
Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.	N	S3S4	CTD8-3
Psoroma hypnorum (Vahl) Gray	N	S3S5	MP5-2
Solorina crocea (L.) Ach.	N	S4	CTD4-2, HE1-9, PH7-2, QTZ7-3, TC6-2, TC17-2
Solorina saccata (L.) Ach.	N	S3S4	SIM7-2
Stereocaulon alpinum Laurer ex Funck	N	S3S5	MP3-1, PH1-1
Thamnolia subuliformis (Ehrh.) W.L. Culb.	N	S3S4	PH1-5
Umbilicaria deusta (L.) Baumg.	N	S3S5	TC16-1
Umbilicaria hyperborea (Ach.) Hoffm.	N	S3S5	CTD8-2
Umbilicaria hyperborea (Ach.) Hoffm. *var. hyperborea*	N	SU	PH1-9
Vulpicida juniperina (L.) J.-E. Mattsson & M.J. Lai (Saag et al. 2014)	Y	S3S5	EG6-2

Table 9. Number and percent of all moss species (identified collections) in each habitat in the study area.

Habitat	Number of Species	Percent of Species
Mesic Upper Subalpine Forest	19	24
Permanent Upper Subalpine Stream	18	23
Mesic Krummholz Zone	17	22
Alpine Seep	15	19
Alpine Late Snowbed	11	14
Hygric Permanent Alpine Stream	11	14
Xeric Alpine Rock Outcrop	11	14
Xeric Alpine Talus Slope	10	13
Xeric Alpine Gravel Bed	9	12
Mesic Alpine Heath-Meadow	8	10
Hygric Upper Subalpine Cliff Seep	7	9
Mesic Talus Slope in Krummholz Zone	7	9
Mesic Upper Subalpine Meadow	7	9
Xeric Alpine Cliff	7	9
Hygric Upper Subalpine Meadow Seep	6	8
Mesic Ephemeral Alpine Stream	6	8
Permanent Alpine Pool	6	8
Hygric Upper Subalpine Meadow	5	6
Mesic Alpine Talus Slope	5	6
Xeric Upper Subalpine Talus Slope	5	6
Hygric Permanent Stream in Krummholz Zone	2	3
Mesic Ephemeral Alpine Pool	2	3
Mesic Upper Subalpine Forest Clearing	2	3
Mesic Rock Outcrop in Krummholz Zone	1	1

Table 10. Number and percent of rare moss species (identified collections) in each habitat in the study area.

Habitat	Number of Rare Species	Percent of Rare Species
Mesic Upper Subalpine Forest	2	13
Permanent Upper Subalpine Stream	2	13
Alpine Seep	2	13
Hygric Permanent Alpine Stream	2	13
Xeric Alpine Gravel Bed	2	13
Hygric Upper Subalpine Cliff Seep	2	13
Mesic Upper Subalpine Meadow	2	13
Mesic Krummholz Zone	1	7
Mesic Alpine Heath-Meadow	1	7
Hygric Upper Subalpine Meadow Seep	1	7
Permanent Alpine Pool	1	7
Hygric Upper Subalpine Meadow	1	7
Mesic Alpine Talus Slope	1	7
Hygric Permanent Stream in Krummholz Zone	1	7
Alpine Late Snowbed	0	0
Xeric Alpine Rock Outcrop	0	0
Xeric Alpine Talus Slope	0	0
Mesic Talus Slope in Krummholz Zone	0	0
Xeric Alpine Cliff	0	0
Mesic Ephemeral Alpine Stream	0	0
Xeric Upper Subalpine Talus Slope	0	0
Mesic Ephemeral Alpine Pool	0	0
Mesic Upper Subalpine Forest Clearing	0	0
Mesic Rock Outcrop in Krummholz Zone	0	0

Table 11. Moss species previously documented from the Lake Louise-Moraine Lake Area and presence of those species in the Sunshine Meadows-Egypt Lake study area (both previous and new occurrences). Lake Louise-Moraine Lake area species were compiled from digitized herbaria records (Belland, 2019; CNABH, 2019), ACIMS occurrence records (AEP, 2017), and publications (Bird, 1968; Brinkman, 1915; Emig, 1922). Species taxonomy generally follows that of the Flora of North America (FNAEC, 2007, 2014), except for Encalyptaceae (Horton, 1983), Mniaceae (Koponen, 1974), and *Racomitrium* (Frisvoll, 1983, 1988). Conservation ranks (S-Rank) from ACIMS (AEP, 2017).

Moss Species Name (Lake Louise-Moraine Lake Area)	Present in Sunshine Meadows-Egypt Lake Area	S-Rank
Amphidium lapponicum (Hedw.) Schimp.	N	S3S4
Andreaea rupestris Hedw.	Y	S3S4
Aulacomnium palustre (Hedw.) Schwaegr.	Y	S5
Barbula convoluta Hedw.	Y	S3
Bartramia ithyphylla Brid.	N	S3S4
Blindia acuta (Hedw.) Bruch & Schimp.	N	S2S3
Brachytheciastrum collinum (Schleich. ex Müll. Hal.) Ignatov & Huttunen	N	S3
Brachythecium rivulare Schimp.	N	S3
Brachythecium salebrosum (Web. & Mohr) B.S.G.	Y	S4
Brachythecium turgidum (C.J. Hartm.) Kindb.	Y	S3S4
Bryoerythrophyllum recurvirostrum (Hedw.) Chen	N	S4
Calliergon giganteum (Schimp.) Kindb.	Y	S4
Calliergon richardsonii (Mitt.) Kindb. ex Warnst.	N	S3S4
Campyliadelphus chrysophyllus (Brid.) Kanda	N	S4
Campylium stellatum (Hedw.) C. Jens.	Y	S4
Catoscopium nigritum (Hedw.) Brid.	N	S3S4
Ceratodon purpureus (Hedw.) Brid.	Y	S5
Cinclidium stygium Sw.	N	S3S4
Cratoneuron filicinum (Hedw.) Spruce	Y	S3S4
Cynodontium schisti (Web. & Mohr) Lindb.	N	S2S3
Cynodontium tenellum (Schimp.) Limpr.	N	S2S3
Dichelyma falcatum (Hedw.) Myrin	N	S2S3
Dicranella schreberiana (Hedw.) Hilferty ex H.A. Crum & L.E. Anderson	N	S3S4
Dicranella subulata (Hedw.) Schimp.	Y	S2S3
Dicranoweisia crispula (Hedw.) Lindb. ex Milde	Y	S4
Dicranum brevifolium (Lindb.) Lindb.	Y	S3S4
Dicranum elongatum Schleich. & Schwaegr.	N	S3S4
Dicranum fuscescens Turn.	Y	S4
Dicranum majus Turn.	N	S1
Dicranum muehlenbeckii Bruch & Schimp.	N	S2S3
Dicranum scoparium Hedw.	Y	S4
Dicranum spadiceum Zett.	N	S2S3
Didymodon rigidulus Hedw.	N	S3S4
Distichium capillaceum (Hedw.) Bruch & Schimp.	Y	S4
Distichium inclinatum (Hedw.) Bruch & Schimp.	Y	S3S4
Ditrichum flexicaule (Schwaegr.) Hampe	Y	S4
Drepanocladus longifolius (Wilson ex Mitt.) Broth. ex Paris	N	SU
Drepanocladus polygamus (Schimp.) Hedenas	N	S4

Encalypta affinis R. Hedw.	Y	S3
Encalypta brevicollis (Bruch & Schimp.) Angstr.	N	S2S3
Encalypta procera Bruch	N	S3S4
Encalypta rhaptocarpa Schwaegr.	Y	S3
Encalypta vulgaris Hedw.	N	S3
Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen	N	S4
Fissidens adianthoides Hedw.	N	S3S4
Fissidens bryoides Hedw.	N	S3
Fissidens osmundioides Hedw.	N	S3S4
Funaria hygrometrica Hedw.	N	S4
Gemmabryum caespiticium (Hedw.) J.R. Spence	N	S3S4
Grimmia anodon Bruch & Schimp.	N	S3S4
Grimmia donniana Smith	N	S1S2
Grimmia elatior Bruch ex Bals.-Criv. & De Not.	Y	S1
Grimmia longirostris Hook.	Y	S2S3
Grimmia torquata Hornsch. ex Grev.	N	S3
Hamatocaulis vernicosus (Mitt.) Hedenas	N	S4
Heterocladium dimorphum (Brid.) Schimp.	N	S2
Hygrohypnum bestii (Renauld & Bryhn) Holzinger	Y	S3
Hygrohypnum luridum (Hedwig) Jennings	Y	S3
Hylocomium splendens (Hedw.) Schimp.	Y	S5
Hymenostylium recurvirostrum (Hedw.) Dix.	N	S3S4
Hypnum revolutum (Mitt.) Lindb.	Y	S4
Isopterygiopsis pulchella (Hedw.) Z. Iwats.	N	S3
Leptobryum pyriforme (Hedw.) Wils.	Y	S4
Lescuraea saxicola (Schimp.) Molendo	Y	S1
Meesia longiseta Hedw.	N	S2S3
Meesia triquetra (L. ex Jolyclerc) Angstr.	N	S4
Meesia uliginosa Hedw.	Y	S4
Mnium blyttii Bruch & Schimp.	Y	S2S3
Mnium lycopodioides Schwaegr.	Y	S3
Mnium marginatum (Dickson ex Withering) P. Beauv.	N	S3S4
Mnium thomsonii Schimp.	Y	S3
Myurella julacea (Schwaerg.) Schimp.	N	S3S4
Myurella tenerrima (Brid.) Lindb.	N	S2S3
Neckera menziesii Drumm.	N	S3
Oncophorus virens (Hedw.) Brid.	Y	S3
Orthothecium chryseum (Schwaegr. ex Schultes) Schimp.	Y	S3
Orthothecium intricatum (C.J. Hartm.) Schimp.	N	S2
Orthotrichum alpestre Hornsch. ex Bruch & Schimp.	N	S3
Orthotrichum laevigatum Zett.	N	S3S4
Orthotrichum pylaisii Brid.	N	S2
Orthotrichum rupestre Schleich. ex Schwaegr.	N	S3
Paludella squarrosa (Hedw.) Brid.	Y	S3S4
Palustriella falcata (Brid.) Hedenas	Y	S3
Paraleucobryum enerve (Thed. ex C.J. Hartm.) Loeske	Y	S3
Paraleucobryum longifolium (Hedw.) Loeske	N	S1
Philonotis fontana (Hedw.) Brid.	Y	S3S4
Plagiobryum zieri (Hedw.) Lindb.	N	S2S3
Plagiopus oederianus (Sw.) Limpr.	N	S3

Plagiothecium laetum Schimp.	N	S4
Platydictya jungermannioides (Brid.) H.A. Crum	N	S4
Pleurozium schreberi (Brid.) Mitt.	Y	S5
Pogonatum urnigerum (Hedw.) P. Beauv.	N	S3
Pohlia cruda (Hedw.) Lindb.	N	S4
Pohlia drummondii (C. Muell.) Andr.	Y	S3
Pohlia filum (Schimp.) Mårtensson	N	S1
Pohlia nutans (Hedw.) Lindb.	Y	S5
Polytrichastrum alpinum (Hedw.) G.L. Smith	Y	S3
Polytrichum juniperinum Hedw.	Y	S4
Polytrichum piliferum Hedw.	Y	S4
Pseudobryum cinclidioides (Hüb.) T. Kop.	N	S2S3
Pseudocalliergon trifarium (Web. & Mohr) Loeske	N	S4
Pseudocalliergon turgescens (T. Jens.) Loeske	N	S2S3
Pseudoleskea patens (Lindb.) Kindb.	N	S1S2
Pseudoleskea radicosa (Mitt.) Mac. & Kindb.	N	S4
Pseudoleskea stenophylla Renauld & Cardot	N	S2S3
Pterigynandrum filiforme Hedw.	N	S3
Ptychostomum cyclophyllum (Schwaegr.) J.R. Spence	N	S2S3
Ptychostomum inclinatum (Sw. ex Brid.) J.R. Spence	N	SU
Ptychostomum pallescens (Schleich. ex Schwaegr.) J.R. Spence	N	S3
Ptychostomum weigelii (Spreng.) J.R. Spence	N	S3
Racomitrium canescens (Hedw.) Brid.	Y	S3
Racomitrium ericoides (Brid.) Brid.	N	S1
Racomitrium heterostichum (Hedw.) Brid.	N	S3
Racomitrium lanuginosum (Hedw.) Brid.	Y	S3
Racomitrium sudeticum (Funck) Bruch & Schimp.	Y	S2S3
Rhizomnium andrewsianum (Steere) T. Kop.	N	S2
Rhizomnium gracile T. Kop.	N	S4
Rhizomnium magnifolium (Horik.) T. Kop.	N	S2S3
Rhytidiopsis robusta (Hedw.) Broth.	N	S3
Rhytidium rugosum (Hedw.) Kindb.	Y	S4
Saelania glaucescens (Hedw.) Bomanss. & Broth.	N	S2S3
Sanionia uncinata (Hedw.) Loeske	Y	S5
Sarmentypnum tundrae (Arnell) Hedenas	N	S3S4
Schistidium agassizii Sull. & Lesq. in Sull.	N	S2
Schistidium apocarpum (Hedw.) Bruch & Schimp.	N	S4
Schistidium confertum (Funck) Bruch & Schimp.	Y	SU
Scorpidium cossonii (Schimp.) Hedenas	Y	SU
Scorpidium revolvens (Swartz) Rubers	N	S4
Scorpidium scorpioides (Hedw.) Limpr.	N	S3S4
Seligeria campylopoda Kindb. in Mac. & Kindb.	N	S2S3
Sphagnum angustifolium (C. Jens.) C. Jens.	N	S4
Sphagnum capillifolium (Ehrh.) Hedw.	Y	S4
Sphagnum centrale C. Jens.	N	S3S4
Sphagnum girgensohnii Russ.	Y	S4
Sphagnum magellanicum Brid.	N	S4
Sphagnum warnstorfii Russ.	Y	S4

Splachnum sphaericum Hedw.	N	S3S4
Splachnum vasculosum Hedw.	N	S1S2
Syntrichia norvegica Web.	Y	S3
Syntrichia ruralis (Hedw.) Web. & Mohr	Y	S4
Tayloria froelichiana (Hedw.) Mitt. ex Broth.	Y	S2
Tayloria lingulata (Dickson) Lindb.	Y	S2S3
Tayloria splachnoides (Schleich. ex Schwaegr.) Hook.	N	S1
Thuidium recognitum (Hedw.) Lindb.	N	S4
Timmia austriaca Hedw.	Y	S4
Timmia megapolitana Hedw.	N	S4
Tomentypnum nitens (Hedw.) Loeske	Y	S4
Tortella fragilis (Drumm.) Limpr.	N	S4
Tortella tortuosa (Hedw.) Limpr.	Y	S4
Tortula hoppeana (Shultz) Ochyra	Y	S3
Tortula mucronifolia Schwaegr.	N	S4
Ulota curvifolia (Wahlenb.) Lilj.	N	S2S3
Weissia controversa Hedw.	N	S3S4

Table 12. Priority monitoring sites that are adjacent to trails for rare mosses and the species present at each site.

Site	Rare Species Present
HE3	*Sphagnum platyphyllum*
HE5	*Dicranella subulata, Oligotrichum hercynicum*
HE6	*Dicranella palustris*
MP7	*Lescuraea saxicola, Mnium arizonicum*
SIM1	*Racomitrium fasciculare*
SIM10	*Hygrohypnum smithii*
WS2	*Hygrohypnum styriacum, Tayloria lingulata*

Appendix 2 – Figures

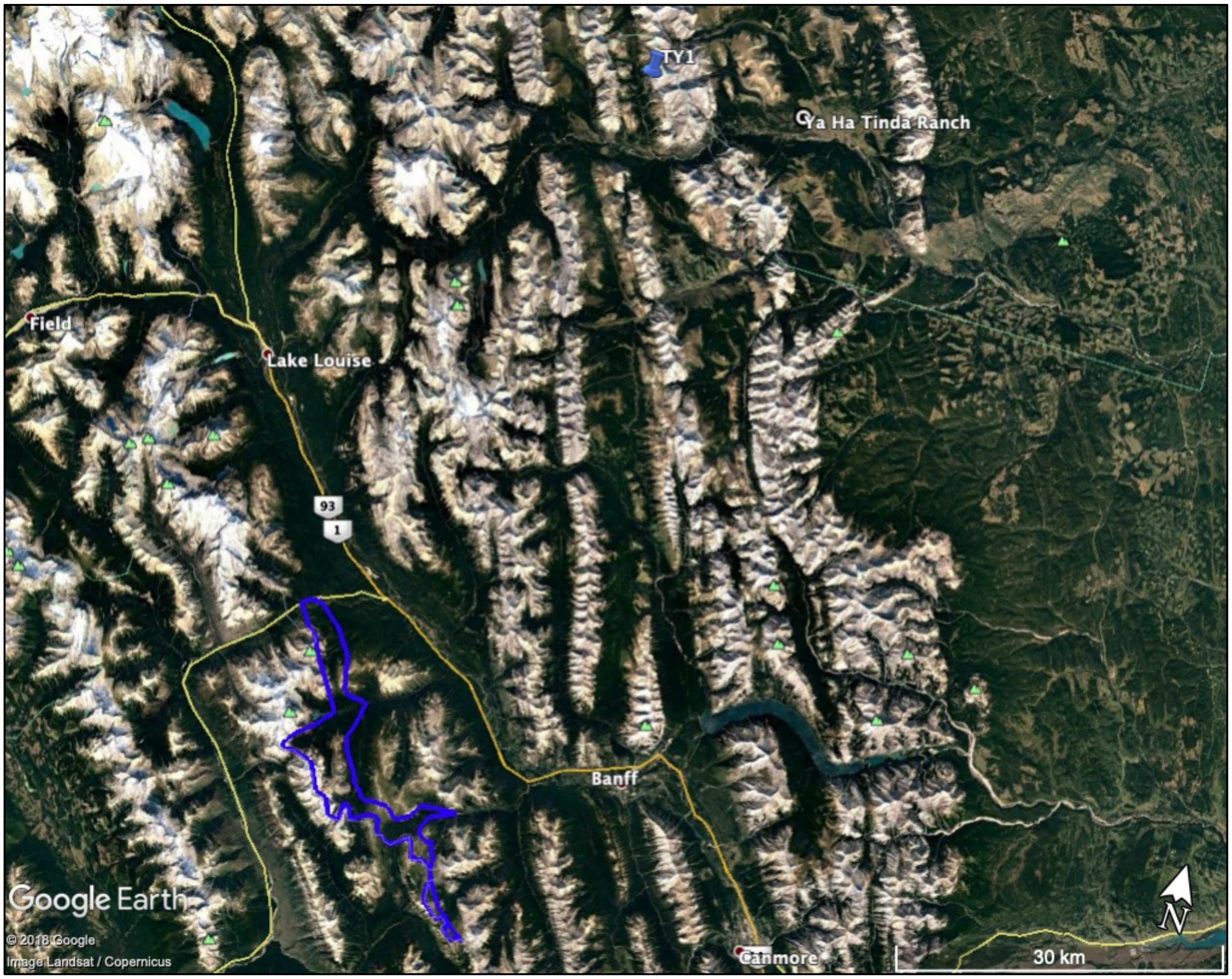

Figure 1. Survey areas for the study. The Main Study area is outlined in blue and the Tyrrell-Wapiti Site is marked with the blue pin (TY1). Map created with Google Earth Pro (Google LLC, 2019).

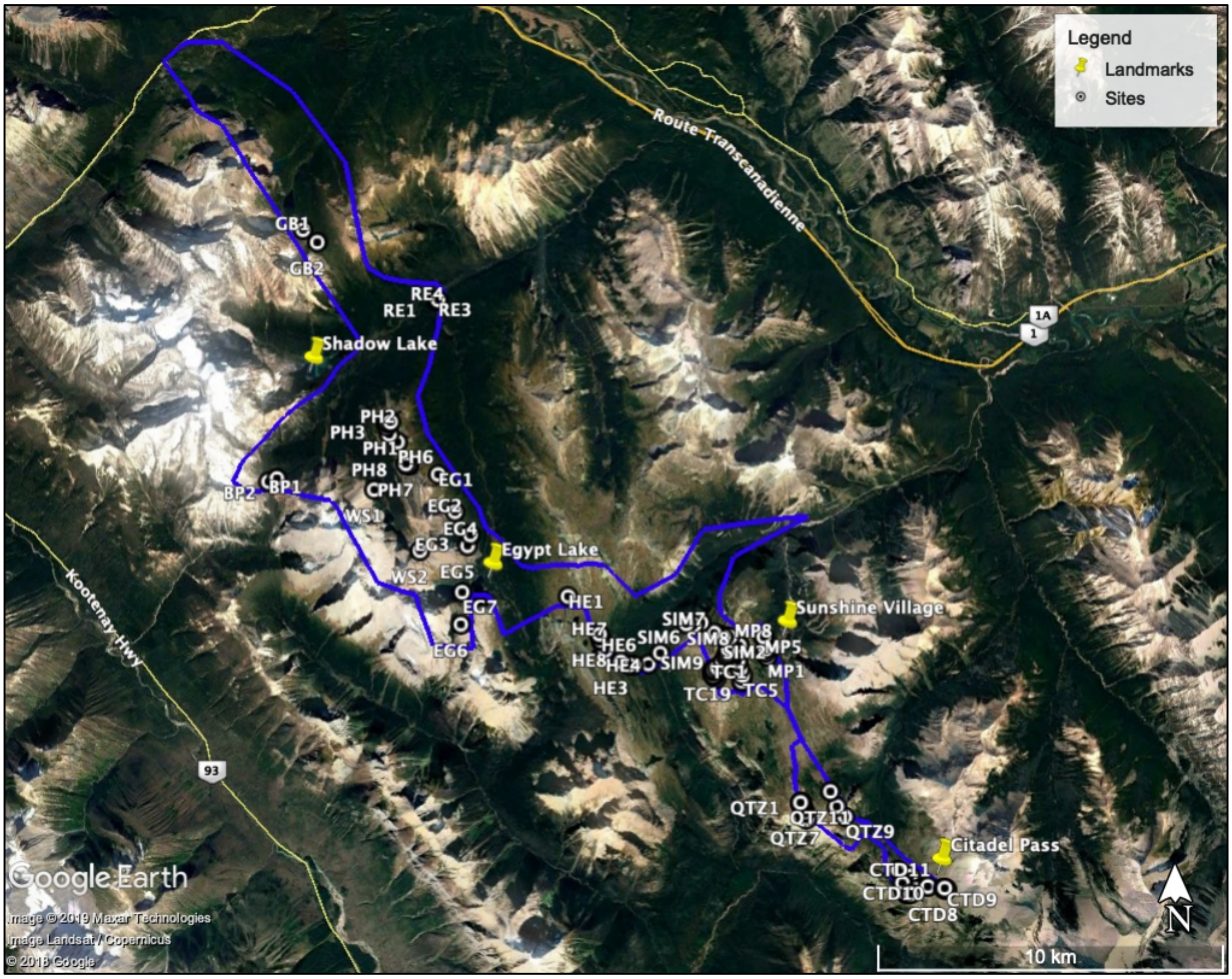

Figure 2. Collection sites in the main study area. Map created with Google Earth Pro (Google LLC, 2019)

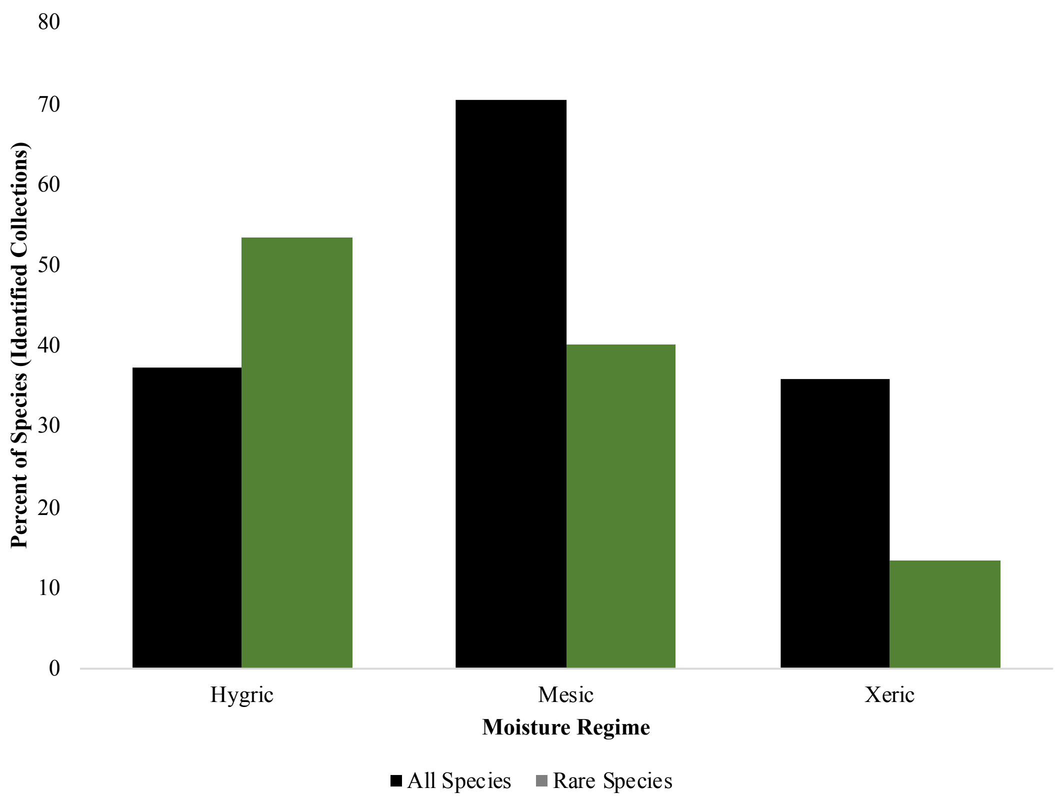

Figure 3. Percent of species (identified collections) for all species and rare species in each moisture regime in the study area.

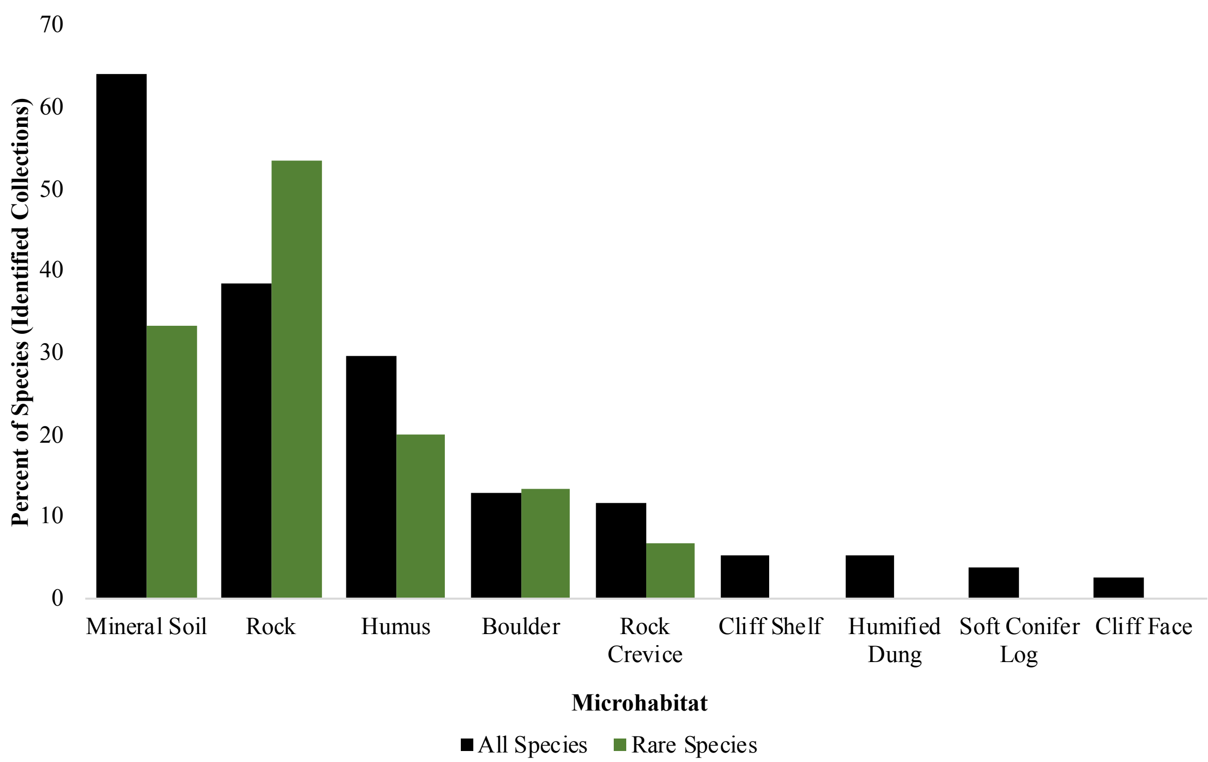

Figure 4. Percent of species (identified collections) for all species and rare species in each microhabitat in the study area.

Appendix 3 – Photos

Photo 1. Example of the diverse Permanent Upper Subalpine Stream habitat with thick growth of *Hygrohypnum spp.* growing between vascular plants (left) and Xeric Alpine Talus Slope habitat with some Alpine Late Snowbed habitat (right). Images: Ryan James/Parks Canada

Photo 2. *Polytrichastrum alpinum* (left) growing in late snowbed meltwater (right). Images: Ryan James/Parks Canada

Photo 3. Alpine Seep habitat where rare species such as *Dicranella palustris* and *Tayloria lingulata* were found.
Image: Ryan James/Parks Canada

Photo 4. Permanent Alpine Pool habitat where rare species such as *Racomitrium fasciculare* can be found.
Image: Ryan James/Parks Canada

Photo 5. Hygric Upper Subalpine Meadow habitat where the rare species *Sphagnum platyphyllum* was found.
Image: Ryan James/Parks Canada