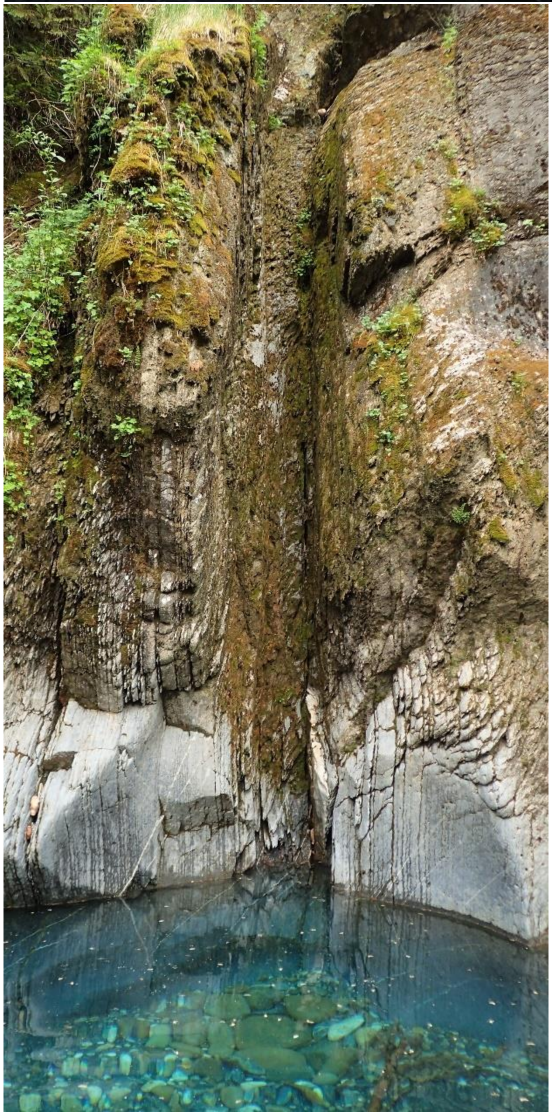

Plant and Lichen Inventory of the Walker Drainage, British Columbia

Report prepared for the Conservation North

by

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ABSTRACT

The Walker study area, Upper Fraser region in east-central British Columbia, corresponds to the entire Walker Creek drainage and adjacent valleys reaching to the shores of the Fraser, McGregor, Morkill, and Torpy Rivers. It is a widlerness area roughly 25 x 40 km in size, almost entirely without roads or prior major industrial development, the largest area in the Upper Fraser drainage that remains free from major economic use. This area was almost entirely unexplored for plant and lichen biodiversity prior to the current study. Our goal was to document all lichen and plant (both bryophyte and vascular plant) species present in the habitats surveyed, using a controlled intuitive wander method. Over 15 days of field effort, a wide array of habitat types were searched, from the lowest to the highest elevations, including various forest and wetland types, cliffs, alpine ridges, and anthropogenic habitats. In total, 1297 species, subspecies, and varieties of lichens and plants were documented in the 2023 surveys, including 433 lichens, 334 bryophytes, and 532 vascular plants. The results from the Walker study area contribute well over 200 species to the flora of the greater Robson Valley area, which has now risen to over 2700 taxa. A great number of noteworthy species are included in this newly documented flora, including some that appear to be new discoveries for science. Numerous special habitats are highlighted for their disproportionate contributions to the overall Walker lichen and plant diversity, and for some of the threats to these habitats resulting from potential and proposed human-caused impacts. Recommendations are made for further research in the Walker landscape and the some of the needs for conservation are discussed.

INTRODUCTION

The Walker Creek drainage and immediate surroundings form the largest remaining undeveloped areas in the Upper Fraser region of east-central British Columbia. It is a wilderness landscape, almost entirely unroaded, which has thus far made it impossible for major resource extraction to occur. While most of the rest of the southern half of British Columbia is either industrialized or settled, the Walker remains free from major economic use. Current and past human use of the landscape has had only light, sustainable impacts (hunting, fishing, and mostly low-intensity recreational use).

Botanical and lichenological documentation was previously almost entirely devoid from the Walker study area. Only eight plant and lichens specimens were previously documented from the study area, all from the fringes (Consortium Pacific Northwest Herbaria 2023, Consortium Lichen Herbaria 2023). A series of lichen and plant species inventories was conducted in a number of provincial parks nearby in the Robson Valley in the years 2016-2021 (Björk & Goward 2017, 2018, 2019, 2022). The Walker study area lies within the greater Robson Valley, which corresponds to the western half of the northernmost reach of the Fraser River, where it flows out of the Rocky Mountain Trench. The northern end of the Columbia Mountains and adjacent western ranges of the Rocky Mountains form the western and eastern flanks of the Robson Valley, respectively.

The Walker helps to complete the greater Robson Valley floristic inventories, which leading up to 2023 had revealed an outstandingly rich flora, having a high concentration of lichen and bryophyte species that places it among globally highest priority biodiversity areas (Björk & Goward 2017, Björk & Goward 2018, Björk, Goward & Coxson pending), and a vascular plant flora that is particularly rich in the Canadian context. Many species new to science were first discovered during previous floristic inventories in the Robson Valley. Some of these novelties are already published, including *Chaenothecopsis edbergii* (Selva & Tibell 1999), *Collema coniophilum* (Spribille et al. 2009), and *Sticta fasciculata* (Di Meglio & Goward 2023), while many others are in manuscript (Björk pending, Björk, Goward & Coxson pending). The Robson Valley has also served as a natural laboratory for ecological studies (Campbell & Fredeen 2004, Radies & Coxson 2004, Radies et al. 2009, MacDonald & Coxson 2013, MacDonald, Coxson & Björk 2013, Björk & Coxson, pending). The noteworthy results of those previous Robson Valley studies made it urgent to explore the Walker study area, which by its proximity and similar climate could be assumed to be a priority for further biodiversity exploration.

The only previous characterization of the Walker study area was provided within the framework of the Biogeoclimatic classification (Meidinger et al. 1988), which is the official ecosystem classification used by the government of British Columbia. The only habitats described therein are forests, characterized in ways considered relevant to timber extraction and post-cut restoration to desired managed forest types. The distributions of the great majority of lichen and plant species are determined by ecological attributes that operate at a smaller spatial scale than those relevant to forestry, making the Biogeoclimatic classification nearly irrelevant to plant and lichen biodiversity and autecological studies.

Satellite imagery available on Google Earth is of poor quality (pixillated or winter images) where it shows the study area except in the easternmost portions. The satellite imagery provides only vague impressions of the ecosystems present. No other resource was available on the ecosystems within the study area, making the Walker an unknown regarding the types of habitats present or how the landscape and ecosystems might compare with other areas of the Robson Valley. The absence of any means of a priori landscape-scale habitat assessments and the near lack of biodiversity documentation presented the opportunity for baseline exploration without prior assumptions.

Study Area

The Walker study area (Figure 1) is a contiguous area measuring approximately 25 km from north to south, and 40 km wide. The boundaries of the study area were defined to include the wilder landscapes bound on all sides by extensive road networks and clearcuts, as well as to include as much habitat diversity as possible from the shores of the larger rivers up to the highest peaks surrounding Walker Creek.

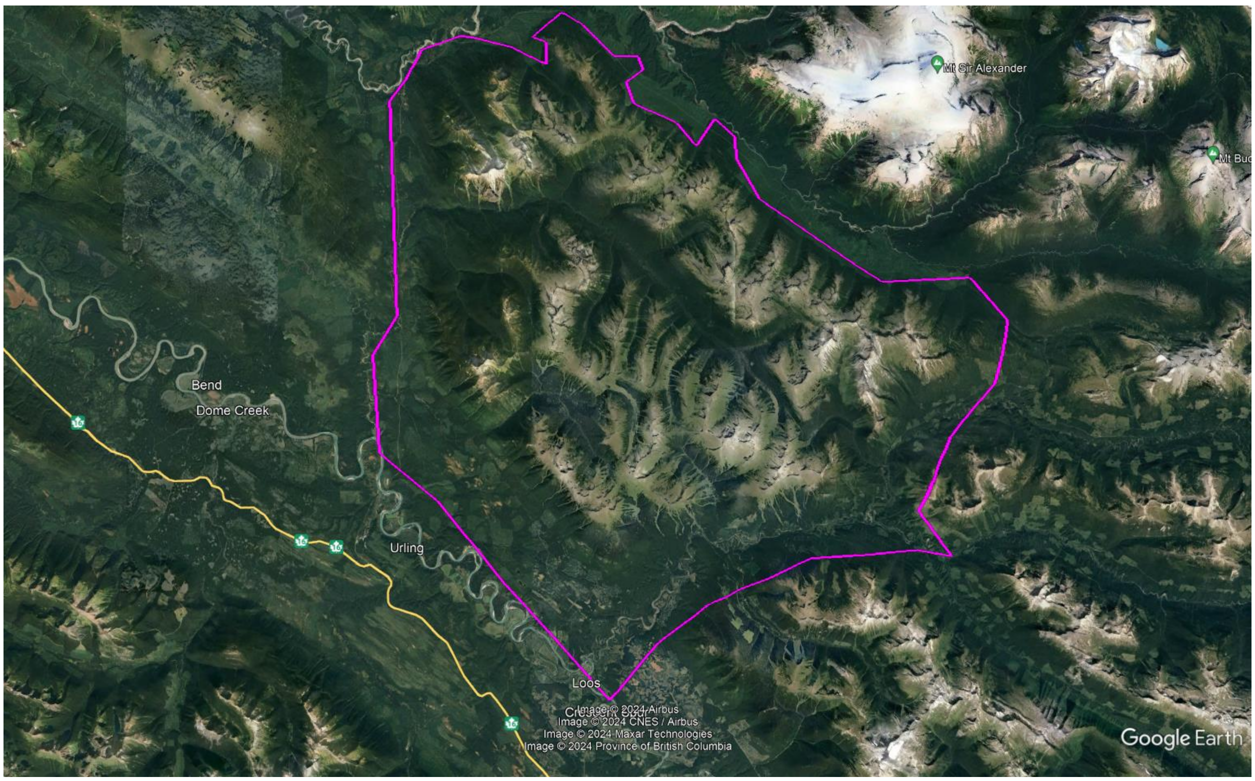

Figure 1. The Walker study area. Imagery from Google Earth, view from 67 km altitude.

Walker Creek emerges from the eastern portions of the study area and flows in a semi-circular arc into the Torpy River in the western edge of the study area. The McGregor River bounds the study area on the north, the Fraser River forms the southern boundary, and the study area extends eastward following the Morkill River east to Morkill Falls, then north along Forgetmenot Creek toward the McGregor River. The mountains forming the Walker Creek tributary headwaters and the flanks of the adjacent drainages are part of the greater McGregor Ranges of the Rocky Mountains.

The Robson Valley is well known regionally for its cool, wet weather that in some key ways approximates a northeast Pacific coastal climate (i.e. similarities to the Alaska Panhandle or northern British Columbia coast). The region lies at the northern end of the Interior Wetbelt (Björk 2010, DellaSala et al. 2011) a north-south trending band having higher precipitation and milder temperatures than the surrounding regions. Within the Interior Wetbelt, the wettest regions support interior rainforest (Arsenault & Goward 2000a, DellaSala et al. 2011), as do large portions of the Robson Valley (Goward &

Spribille 2005, Radies et al. 2009, Coxson et al. 2012). Many species of lichens and plants present in the Interior Wetbelt are geographically disjunct there from primarily coastal distributions (Björk 2010).

The southern portions of the Robson Valley, where the rainshadow effect of the Columbia Mountains blocks much of the precipitation) abruptly grades into a drier, continental climate more characteristic of the Canadian Rocky Mountains, as from McBride to Valemount. Because the Walker study area is contiguous with both the Robson Valley maritime climate to the west and the more continental climate to the south, it was not possible to predict the climatic attributes of the study area and its effects on the habitat types and species present there. Following observations during the 2023 inventories, and based on the vegetation types and species observed, the climate in the study area might be described as follows: overall, humid continental with an apparent gradient in oceanic influence depending on aspect and distance from the Rocky Mountain Trench. Though exact climate data are lacking, the winter temperatures may be expected to be cold, usually below freezing, and occasionally falling below -30°C. Summer temperatures may be expected to be milder than those on the Fraser Plateau west and south of the Robson Valley, with daytime highs usually below 25°C. Annual precipitation appears to be high for an interior region, and peak precipitation likely occurs during the growing season.

Plant and lichen distributions are strongly affected by substrate and soil chemistry (Körner 2003, Kruckeberg 2002). Accordingly, knowledge of the rock types (especially the pH of those rocks) present in a species inventory study area can help to predict where higher species richness and certain rare species might be found (Seaward 1977, Gilbert 2000). Carbonate rocks provide particularly rich settings for plants that demand high pH and an abundance of mineral nutrients (Hayek 1926, Good 1964, Daubenmire 1974).

The surface geology of the study area is mapped in detail (Campbell et al. 1973). The valley floors are dominated by Quaternary alluvium from which some small bedrock outcroppings emerge. At middle and upper elevations, the eastern two thirds of the study area is underlain primarily by the Miette Group rocks of Hadrynian age, most of which are sedimentary: argillite, mudstone, phyllite, sandstone, conglomerate, siltstone). The western third is more complex, formed by bands of mostly the Cambrian age Mcnaughton, Lynx, Mahto, and Mural formations, all of which are dominated by carbonate sedimentary rocks such as limestone and dolomite. Thus. it could be predicted that the western portions of the study area might be particularly important for floristic exploration.

Old-growth forest is particularly important for rare lichens (Gauslaa 1985, Gauslaa 1995, Ellis & Coppins 2010). In the past 20 years, British Columbia has lost old forests at a rate possibly exceeding that of any other part of the world during recent decades. The rate of cutting remains extremely fast today. Healthy, species-rich floras require wild landscapes. Frequent logging cut cycles, homogenization of forest structure and microhabitats, and loss of species with which lichens ecologically interact are factors that bring about local extirpation of arboreal lichen populations (Goward & Arsenault 2000). In the Robson Valley, large swathes of old forest have been lost due to logging and subsequent industrial forest management. These impacts have compromised the rainforest landscape there, as well as riparian forest, and drier forest types. The continuous forest of the Walker drainage upstream from the Walker Forest Service Road, almost entirely free from industrial impacts, presents the potential for an intact epiphytic lichen flora that is not compromised by forest loss, overmanaged tree plantings, or edge effects near the margins of clearcuts and roads.

The near lack of roads and clearcuts in this portion of the study area may also present the opportunity to document a set of vegetation formations that are not compromised by the invasive plant species that disperse outward from road corridors into surrounding vegetation. The invasion of exotic plant species (mostly from Europe) into wild vegetation in the Robson Valley has proceeded from roads and clearcuts, with potentially devastating effects which are already seen as with the aggressive spread of *Cirsium palustre* and *Galeopsis bifida* into otherwise pristine wetlands and forest understory (Björk & Goward 2017, 2018).

Most of the study area is densely forested with *Picea glauca*, *Picea glauca* x *engelmannii*, *Betula papyrifera*, *Populus* x *hastata*, and *Populus tremuloides*. *Thuja plicata*, *Tsuga heterophylla*, and *Pseudotsuga menziesii* are less abundant, but locally dominant in wetter or warmer portions of the study area within the Rocky Mountain Trench and upstream along the tributary drainages at lower elevations. The understory is also mostly dense, with heavy cover of the shrubs *Alnus alnobetula*, *Alnus incana*, *Cornus stolonifera*, *Lonicera involucrata*, *Oplopanax horridus*, *Salix* spp., *Sambucus callicarpa*, *Vaccinium membranaceum*, and *Vaccinium ovalifolium*. Mature forests dominate the study area from lower elevations to the subalpine, and attributes of older forest are common and widespread, such as nurse logs, aged snags, large-diameter trees, and aging bracket fungi. Little of the landscape shows signs of recent wildfire. Extensive areas at low to middle elevations are vegetated with muskeg, bog, fens, marshes, beaver pond, and riparian forest vegetation, or sparse vegetation of rock outcrops and cliffs.

Methods

Floristic species inventories are biodiversity studies of a defined geographical area with the goal of capturing the entire species richness. The methods of species inventories can reveal concentrations of species richness, elucidate ecological attributes of species, document populations of rare species, and allow the discovery of any species previously unknown to science.

British Columbia's terrestrial and freshwater flora consists of five main groupings: bryophytes, vascular plants, lichens, cyanobacteria, and algae. Cyanobacteria and algae are not usually treated in floristic species inventories and are not further discussed here. Bryophytes are mosses, liverworts, and hornworts. No hornworts were found in the study area and are not further discussed. Vascular plants are green plants that bear water-conducting vessels; these are seed plants, ferns and lycopods (horsetails, fir mosses, quillworts, club mosses). Lichens are a symbiosis of a fungus and a photosynthetic partner. These symbioses have evolved over hundreds of millions of years, involving a number of fungal lineages (Lutzoni et al. 2004), as well as various photosynthetic organisms (lineages of green algae, cyanobacteria and brown algae) (Friedl & Büdel 2008). Lichens are grouped into those that develop a three-dimensional thallus free from the substrate (the macrolichens), and those that grow two-dimensionally attached to the substrate (microlichens). Further lichen groupings are based on the type of photosynthetic partner: those having cyanobacteria being are termed cyanolichens, and those with green algae are termed chlorolichens.

During the 2023 Walker species inventories we sought to record all plant and lichen species present. To this end, we used a controlled intuitive wander survey method (Ministry of Environment and Climate Change Strategy 2018), which concentrates search effort in habitat types and habitat occurrences most likely to yield additions to the overall study area species list. Accordingly, search effort in the study area covered all the spatially major habitat types present, including old and young rain forest, riparian forest, montane forest, alpine peaks, bogs, and muskeg, as well as spatially minor habitats with overall high biodiversity such as cliffs, talus, shrub carrs, wetlands, *Populus* drip zones, waterfall spray zones, river shores, seeps, clay erosional slopes, and calcareous wetlands. The surveys were floristic in nature, such that all species encountered were recorded. Floristic inventories are well served by the intuitive wander method, in contrast to plot or straight-line transect methods, which can capture only a small portion of the lichen species richness on site. Detection of rare species occurrences is also favoured by intuitive wander methods.

Field surveys were conducted by Curtis Björk with assistance from Shane Johnson, during the dates June 6-11, July 1, August 3-8, and September 18-19, 2023. The June, July, and September fieldwork was conducted by road access around the margins of the study area. Access into the core of the study area required helicopter travel. Field work in August was conducted from three base camps, the first two at high elevations, the third along the middle portion of Walker Creek. Movement between base camps was accomplished by helicopter travel.

Due to the steep and often cliffy terrain of the Walker study ara, survey traverses were often short, covering less than one kilometer. But because species richness was often high in the habitats surveyed on these traverses, and because the study area was almost entirely floristically unknown previously, distance was deemed less important than thoroughness; detection of all the species present in each habitat surveyed took priority over access to additional habitat types and habitat occurrences. This approach leaves the vast majority of the Walker study area unexplored, but it also presented the opportunity for the discovery of a great number of the small and inconspicuous species that constitute a large portion of any regional flora.

Latitude-longitude coordinates were recorded with the use of a Garmin GPSmap 65s hand-held unit. Accuracy (variance) as displayed by the GPS units varied between 0 and 4 m. The datum used for mapping is NAD83. Documentation of results in the field was made by voice recorder, the files of which were later transcribed. All species encountered on each day’s route were recorded when field identifications were possible.

Photographs were taken of as many species as possible, including most of the rare species. A wide diversity of habitat types was also documented by photographs. In total 2,833 photos were taken during the field surveys. Photographs that document species occurrences have the generic, specific, and any infraspecific epithets included in the file name to facilitate searches. The photographs are archived on four devices and can be accessed upon request.

When identifications required laboratory methods, specimens were gathered with a GPS waypoint, date, and habitat written on the collection bag. A total of 718 specimens were curated and retained for deposit. No specimens were taken from exceedingly small populations. Specimens were promptly dried in their collecting bags (bryophytes and lichens) or plant press (vascular plants), then curated, and prepared for deposit to the herbarium UBC (Beaty Biodiversity Museum, University of British Columbia). Laboratory identifications were accomplished by standard microscopy and (for lichens) spot-test methods. In some cases, further chemical methods will be necessary (thin-layer chromatography, TLC) to confirm identifications or to further characterize potentially novel taxa. Sampling for TLC is planned for February 2024, with the assistance of Troy McMullin (Canadian National Museum, Ottawa).

To document the lichen flora, all symbiotically lichenized species were sought, as well as allied non-lichenized or weakly lichenized fungi that are usually treated with the lichens (i.e., all non-parasite genera treated in the checklist of North American lichens (Esslinger 2024). Lichenicolous (i.e. lichen-parasite) fungi were collected only as incidentals on specimens of lichenized species and are not reported. All bryophyte and vascular plant species were also sought, including both native and nonnative species.

The taxonomy of lichens reported follows the draft checklists and floras of the authors (Goward & Björk unpublished), and nomenclature follows Mycobank (Mycobank 2024) with corrections when necessary. Identification employed the standards of lichen taxonomic literature in the form of floras and original literature (journal articles and monographs) for North America and Eurasia, as well as our draft keys to epiphytic crust lichens of British Columbia (Spribille et al. pending). Bryophyte taxonomy and nomenclature follows Bryophyte Nomenclator (Brinda & Atwood 2024), with orthographic corrections where necessary, and identifications were made based on a wide array of floras and original literature. The taxonomy of vascular plants follows the draft Manual of the Vascular Plants of British Columbia (Björk & Cronk, pending).

RESULTS & DISCUSSION

General floristics and comparisons

In total, 1,297 species and infraspecies (taxa) of bryophytes, lichens and vascular plants were found during the 2023 Walker inventory (Table 1, Appendix B). Of these, 41 are introduced species, all of them vascular plants, and the remaining 1,256 taxa constitute the native flora of the study area. The greatest proportion (41%) of species in the flora are vascular plants, followed by lichens (33%), mosses (20%), and liverworts (6%). Nearly all of the exotic species were observed along roads at the margins of the study area. The only exceptions were the find of a small colony of *Cirsium palustre* in a wetland near Walker Creek in the heart of the study area, and a few invasive species at high elevations close to heliskiers' stakes. The results of the 2023 Walker inventory bring 216 additions to the greater Robson Valley flora, which now includes 2729 species and infraspecies.

The most species-rich genera found in the Walker in 2023 are (followed by number of taxa): *Carex* (38), *Cladonia* (30), *Lecanora* (21, including recent segregate genera), *Salix* (20), *Sphagnum* (18), *Peltigera* (15), *Poa* (15), *Verrucaria* (15), *Epilobium* (13), *Juncus* (13), *Lecidea* (13), *Botrychium* (12), *Ranunculus* (12), *Viola* (11), and *Biatora*, *Hypogymnia*, and *Ptychostomum* (10).

Group	Genera	Species
Chloro-macrolichens	30	112
Cyano-macrolichens	21	75
Macrolichen total	**51**	**187**
Crusts, chlorococcoid	77[1]	221
Crusts, trentepohlioid	7	9
Crustose lichen total	**83**	**230**
Calicioids	**5**	**14**
Microlichens total	**88**	**246**
Total lichens	**139**	**433**
Liverworts	46	80
Mosses	137	254
Bryophytes total	**183**	**334**
Native vascular plants	215	491
Exotic vascular plants	24[2]	41

Vascular plants total		**255**		**532**
Total native flora	523		1256	
Total exotic flora	24[2]		41	
Total flora		**537**		**1297**

Table 1. Floristic richness of the 2023 Walker species inventory, by species group. No exotic lichens or bryophytes were found. [1]*Arthonia* includes both chlorococcoid and trentepohlioid species or forms. [2]Twenty-eight genera are represented only by exotic species; nineteen genera include both native and exotic species.

Only 37% of the total lichen species richness in the study area is accounted for by macrolichens. The majority of species and genera recorded are microlichens, a ratio close to that expected in lichen species inventories (Spribille et al. 2010). With only 14 calicioid species, the Walker is less diverse than the wetter, western portions of the Robson Valley, where 53 species have been recorded (Björk et al. pending). However, 75 cyanolichens is a high number considering the amount of area covered in the 2023 Walker surveys. This is likely due to the abundance of high-pH substrates in the study area, as most cyanolichens are calciphilic (Laundon 1970, Türk & Wirth 1975, Goward & Arsenault 2000, Nimis et al. 2020). Only 9 trentepohlioid lichens is low compared to the rest of the Robson Valley, especially considering that only 3 of those are epiphytic. Epiphytic trentepohliate crusts are most common and diverse in British Columbia in areas having a humid, mild climate without long periods of low humidity in summer (Björk pers. obs.). The study area may be too cold and/or dry in winter to support a larger epiphytic trentepohliate crust flora. The Walker study area presents some outstanding additions to the Robson Valley flora that might be unexpected in such a wet cool climate, such as *Aloina rigida*, *Artemisia frigida*, *Collema coccophorum*, *Dermatocarpon atrogranulosum*, *Husnotiella asperifolia*, *Pellaea* spp., and *Tortula atrovirens*, all observed on south-facing limestone slopes, and *Catapyrenium psoromoides* and *Tingiopsidium sonomense*, on a south-facing subalpine cliff.

NOTEWORTHY SPECIES

The 2023 Walker species inventory revealed previously undocumented populations of one federally listed species, *Pinus albicaulis* (listed under the Species at Risk Act, or SARA, ranked by the Committee on the Status of Endangered Wildlife in Canada, or COSEWIC), and one Species of Concern, *Nephroma occultum*. Another SARA listed species, *Bartramia halleriana*, was observed, but the occurrence was already well documented (COSEWIC 2011). Additionally, 44 provincially listed species were found (Tables 2-5), 10 of them with the higher conservation priority Red status, and 34 with the lower conservation priority Blue status. A large portion of the Blue and Red listed liverworts and mosses need re-assessment to refine their conservation ranks, as they appear to be far more common, widespread, and less threatened than previously thought. Many other rare species were documented in the Walker study that lack provincial conservation ranks. Brief notes are given for each noteworthy species in Appendix A. Data on the populations of these species is given in CDC rare element occurrence sighting forms in Appendix C.

Many of the species having official government conservation listing (provincial or federal) are not actually the highest conservation priorities in the Walker flora. Lengthy and bureaucratic processes are undertaken to test whether a species merits provincial tracking or COSEWIC listing, or federal legal protection. Governmental tracking or protection is unlikely to be conferred on newly discovered species, or a rare species newly found in an occurrence well outside its core range, or a species that is in rapid decline but for which published demographic data are lacking. Even for species having well documented rarity and declines, the slow pace of listing, protection, and recovery are hinderances to conservation. Species that have occupied the tracked species lists for a long period of time are in many cases simply overlooked and not actually rare. The down-listing process for erroneously conservation-flagged species is often hindered by requirements of full specimen documention for all known occurrences, a process slowed by the obstacles to specimen accessioning at herbaria.

The best choices of which species are given conservation listing depend on defensible taxonomy, but those making taxonomic decisions for the provincial and federal governments are in many cases not taxonomists and are at best minimally trained in current and/or best methods of plant and lichen systematics. Provincial and federal bureaucracies tend to favour familiar taxonomic lists, and conflate "taxonomic conservatism" with an unwillingness to learn an improved and more accurate taxonomic model. Hence, many species that are recognized by taxonomists are synonymized as part of common widespread species without any published justifications that are based on repeatable taxonomic methods. Canada's flora is far less well known than are the floras of the US and Eurasia. Accordingly, using the same or a similar model for lichen and plant conservation as the US or a European country may not be the best strategy for listing and conservation in Canada.

Status reports commissioned by COSEWIC for lichen and plant species are expected to report on results of visits to previously documented populations, not absence data from complete search effort; COSEWIC does not fund full searches in potential habitat for lichen and plant species. This has resulted in the situation of ongoing capture of numerous newly discovered occurrences that had not been documented at the time of federal listing. Had those additional populations been documented when a species was first commissioned for a status report, it would likely have failed to gain federal listing. Incomplete baseline data resulted in SARA Schedule-1 registration for relatively common species such as *Collema coniophilum* while many rarer and more endangered species are given no protection.

Other structural problems are built into COSEWIC and SARA, and in British Columbia's provincial conservation ranking, such as the application of SARA only to federal lands (which are geographically highly limited). Overly lengthy processes plague federal de-listing in ways similar to the provincial de-listing processes described above. Recovery strategies for lichens and plants are usually based on obviously deficient (i.e. non-existent) baseline population data, standardized use of population biology that is more appropriate for tetrapods than for lichens and plants, and use of the IUCN Rank Calculator (NatureServe 2024).

In assessing rarity, the IUCN rank calculator emphasizes range extent for plants and lichens (sessile organisms having on average relatively strict ecological requirements) to the same degree as for tetrapods (motile and able to occupy more habitats within a landscape). That results in de-emphasized conservation for lichen and plant species species that rely on rare, widely separated habitat occurrences such as calcareous fens, waterfall sprayzones, or dolomite outcrops. Also, global rarity is not taken into consideration by government conservation offices that employ IUCN methods (Kim et al. 2012), including the British Columbia Conservation Data Centre. Also, conservation needs of infrataxa (subspecies, varieties, forma) are downplayed in IUCN-based lists (Palacio et al. 2023), which may lead to a deficit of conservation for organisms that are in active species-level evolutionary processes, which may be important contributors to the survival of entire major lineages as environmental conditions continue to change. A species that is documented from hundreds of locations in Alberta, the Yukon, Montana, and Idaho but is documented from only few locations in BC can therefore bear the same Blue or Red status as one that is known from as few as ten locations worldwide.

Partly because the IUCN rank calculator does not include global rarity in its algorithm parameters, SARA status has often been conferred on species that are common or even weedy in adjacent parts of the US, only because the Canadian portion of the population is rare (Bunnell et al. 2004). Similarly, stewardship responsibility, that is the portion of global population present in Canada (Bunnell et al. 2006), is also not taken into consideration.

Further, federal status and recovery strategies now are subject to "stakeholder review", which can give industrial and social interests the opportunity to further dilute the efficacy of species conservation. That stakeholder review strategy is based on a model of no-cost conservation; that any amount of industrial development can be accomplished while a satisfying level of conservation is also accomplished.

Given these structural and practical faults of Canada's and British Columbia's conservation framework, it is important to be critical of conservation that is based only on official, governmental methods of species listing and protection. Effective conservation of lichens and plants in Canada might best be affected by other means. Official provincial and national conservation rankings are sometimes best bypassed when highlighting the importance of a landscape in its contributions to regional, national, and global biodiversity. Single-species conservation efforts should be allocated for rare species whether or not those species are recognized as taxonomic entities by government agencies, and whether or not those species have official conservation status. British Columbia lacks any law that protects its Blue and Red list species, so conservation of those species is voluntary, and therefore, conservation can be freely allocated to any rare species without prioritization for Blue and Red listed species.

On a multi-species conservation model, there is no official conservation prioritization in British Columbia or Canada for landscapes based on their overall (accurately) quantified biodiversity. One study on the biodiversity value of southern Canadian ecoregions (Kraus & Hebb 2020) used only trees to represent all photosynthetic organisms. Trees are a poor proxy for overall plant diversity given the exceedingly low ratio of trees to all plants (Björk & Cronk, unpublished data from the pending manual of vascular plants of British Columbia), and especially the low ratio of trees to all photosynthetic terrestrial organisms in British Columbia and elsewhere in western North America. Kraus & Hebb (2020) also over-emphasize tetrapods, and use as their geographical matrix broad "ecoregions" that may actually have little internal geographical coherence (e.g., the Robson Valley within the same ecoregion as the Flathead Valley and Shuswap Highlands, both of which have, within the context of British Columbia, strikingly different sets of species and habitats.

Likewise, special habitats having rare or uncommon sets of attributes and ecologically endemic species are not necessarily prioritized for conservation when only occurrences of provincialy and federally listed species are the basis of conservation strategies. Conservation priority areas of Canada have been highlighted based on concentrations of federally listed species (Canada Key Biodiversity Areas 2024). But occurrences of federally listed species cannot serve as proxies for overall biodiversity, especially considering the problems inherent in Canada's methods of federal listing.

Also, some areas of Canada are highlighted for having high levels of species richness, but those areas all occur near dense population centres such as Vancouver and Toronto, which suggests that they are just relatively well explored and not necessarily richer in species than poorly explored regions. For example Link-Pérez & Laffan (2018) mapped fern and lycophyte diversity throughout northwestern North America, based only on catalogued herbarium specimens without ground-truthing, which results in heavily biased results, favouring grid cells that are well represented in herbarium collections. Assessing relative levels of biodiversity in Canada relies on fuller documentation of all the landscapes of the country, data that are lacking for the vast majority of Canada's landscapes. The Robson Valley, from Purden Lake east to the Walker, from Evanoff Park south to McBride, has been overlooked as a major centre of biodiversity in previous assessments of Canadian landscapes. But the data on floristic diversity are available now, and conservation of the Robson Valley landscape should be emphasized accordingly.

Species	BC Status	COSEWIC	Notes
Blepharostoma arachnoideum	S2, Red		
Bucegia romanica	S2S3, Blue		
**Cephaloziella rubella*	S3, Blue		Not rare, underreported
**Fuscocephaloziopsis pleniceps*	S3, Blue		Not rare, underreported
**Marchantia polymorpha* subsp. *montivagans*	S3, Blue		Not rare, underreported
**Mesoptychia badensis*	S2S3, Blue		Not rare, underreported
**Mesoptychia bantriensis*	S2S3, Blue		Not rare, underreported
**Nardia geoscyphus*	S3, Blue		Not rare, underreported
**Pellia epiphylla*	S2, Red		Not rare, underreported
**Saccobasis polita*	S2S3, Blue		Not rare, underreported
**Scapania irrigua*	S2, Red		Not rare, underreported
**Scapania mucronata*	S3, Blue		Not rare, underreported
**Scapania paludicola*	S2, Red		Not rare, underreported
**Schljakovianthus quadrilobus*	S3, Blue		Not rare, underreported
**Tritomaria exsecta*	S3, Blue		Not rare, underreported
**Tritomaria scitula*	S3, Blue		Not rare, underreported

Table 2. Provincially tracked liverwort species found in the study area in the 2023 Walker species inventory. *Denotes species that should be de-listed to yellow status.

Species	BC Status	COSEWIC	Notes
Amblyodon dealbatus	S3, Blue		
Bartramia halleriana	S2, Red	Threatened	
Bryobrittonia longipes	S3, Blue		
Bryum blindii	S2S3, Blue		
**Didymodon icmadophilus*	S2S3, Blue		Not rare, underreported
**Grimmia donniana*	S2S3, Blue		Not rare, underreported
Husnotiella asperifolia	S2S3, Blue		
Hygroamblystegium varium	S3, Blue		
**Meesia longiseta*	S3, Blue		Not rare, underreported
**Molendoa sendtneriana*	S2S3, Blue		Not rare, underreported
Orthothecium strictum	S3, Blue		
Philonotis marchica	S2S3, Blue		
Philonotis yezoana	S2S3, Blue		
**Pohlia crudoides*	S2S3, Blue		Not rare, underreported
Ptychostomum inclinatum	S3, Blue		
**Ptychostomum schleicheri*	S2S3, Blue		Not rare, underreported
**Schistidium confertum*	S1, Red		Not rare, underreported
**Schistidium pulchrum*	S3, Blue		Not rare, underreported
Schistidium robustum	S3, Blue		
Schistidium tenerum	S3, Blue		
**Sphagnum balticum*	S2S3, Blue		Not rare, underreported
**Sphagnum contortum*	S3, Blue		Not rare, underreported
Timmia norvegica	S3, Blue		
Tortula atrovirens	S2, Red		

Table 3. Provincially tracked moss species found in the study area in the 2023 Walker species inventory. *Denotes species that should be de-listed to yellow status.

Species	BC Status	COSEWIC	Notes
Carex pedunculata	S3, Blue		
Epilobium saximontanum	S2, Red		
Pinus albicaulis	S2S3, Blue	Endangered	
Selaginella rupestris	S2, Red		

Table 4. Provincially tracked vascular plant species found in the study area in the 2023 Walker species inventory. SoC = Species of Concern.

Species	BC Status	COSEWIC	Notes
Dermatocarpon atrogranulosum	S2, Red		
Fuscopannaria ramulina	S2S3, Blue		
Melanelia agnata	S3, Blue		
Nephroma isidiosum	S3, Blue		
Nephroma occultum	S3, Blue	SoC	
Pilophorus robustus	S2S3, Blue		
Tingiopsidium sonomense	S3, Blue		
Zahlbrucknerella calcarea	S1, Red		

Table 5. Provincially tracked lichen species found in the study area in the 2023 Walker species inventory. SoC = Species of Concern.

HABITATS OF SPECIAL NOTE

Though best known for old-growth rain forest, the Robson Valley encompasses a great number of habitats, including a remarkable diversity of wetlands. The high species richness recorded is attributable in part to this assortment of habitat types. Important attributes of these habitats include undisturbed status, often high-pH, calcareous soils and carbonate rock types, unusual hydrology, and time since last natural disturbance. Undisturbed habitats can be expected to harbour dispersal-limited species and species that are slow to establish. Such species often require stable conditions or microhabitat features that develop only with long-term habitat continuity. Human management of landscapes for economic use disturbs habitats, often periodically, as with 60-80 year timber removal cycles. Old forests (120 years or older) produce microhabitats such as snags, decorticated branches, cottonwood drip zones (Arsenault & Goward 2000b), *Sphagnum*-dominated ground layer and many other attributes that are slow to form, slower than 60-80 year cut cycles will allow. The vegetation of human-managed landscapes also tend to convert in part or sometimes entirely to exotic species. Natural attributes of the wild habitats in the study area are collectively diverse. These attributes and the plant and lichen diversity that accompanies that diversity in a selection of habitats are described below.

Old-age, low-elevation *Thuja-Tsuga* (cedar-hemlock) forest

Figure 2. Conifer-dominated low-elevation rain forest on deep soil.

These are forests of old age (Figure 2), including trees hundreds of years old or perhaps as much as 1,000 years in age, occurring at low elevations. The soils underlying these forests are often deep, more persistently moist, and richer in nitrogen than those on the steeper, rockier slopes above. During dry periods, these forests remain naturally irrigated by ground water associated with the high water table along the Fraser and Torpy Rivers. Cedar-hemlock forests are not as widespread in the Walker study area as they are further west in the Robson Valley, limited mostly to the proximity of the Fraser River.

Thuja plicata and *Tsgua heterophylla* are dominant species in the canopy, along with a minor component of *Abies bifolia, Betula papyrifera*, *Picea glauca*, *Populus* x *hastata*, and *Pseudotsuga menziesii*. The understory is variable, with shifting dominance of *Alnus incana, Cornus stolonifera, Oplopanax horridus, Ribes lacustre, Sambucus callicarpa, Vaccinium membranaceum* and *Vaccinium ovalifolium* in the shrub layer, and *Aruncus dioicus, Athyrium filix-femina, Circaea alpina, Cornus unalaschkensis, Dryopteris expansa, Gymnocarpium disjunctum, Lysichiton americanus, Rubus pedatus, Tiarella trifoliata* in the herb layer. The ground layer is poor in lichens, presumably due to a combination of factors: low light availability, perpetually damp conditions, poor ventilation, and high competition from fast-growing pleurocarpous mosses. The bryophytes dominant in the understory are usually *Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis,* and *Sphagnum girgensohnii*. In many areas, such as under dense *Oplopanax* stands, bryophyte cover may be minimal.

On sites with a shallow water table, these old rain forests become dominated more by *Tsuga* and *Picea* than by *Thuja*, and where the ground layer is wet enough and the microclimate cool enough, *Sphagnum* forms a dominant layer. These wettest/coolest expressions of the lowland rainforests are often called "puddle forest" owing to the abundant standing water that occupies old tip-up depressions (the divots left by the root masses of large naturally downed trees). Very little of this formation was observed in the

Walker, but may be common along the Fraser and Torpy (and perhaps lower portions of Walker Creek, Morkill, and McGregor River Valleys) outside the area surveyed in 2023. Puddle forests have an open canopy, partly owing to the short stature of many of the old trees. By contrast, on faster growing trees, any lichen that establishes on an older, defoliating branch is at risk of becoming excluded rapidly as the higher, younger branches grow outward, cutting off light and ventilation. The short-stature, old-age trees are important epiphytic lichen habitat; the slow growth of these trees provides stable microhabitats for epiphytes that are slow to reproduce and/or establish. The SARA-listed species *Lobaria retigera* occurs most frequently in puddle forest; it was sought in 2023 without success but may be found in future if more puddle forest is surveyed in future. In the Robson Valley, puddle forests may have the highest habitat variation among forest types, with correspondingly high biodiversity. Despite their importance to biodiversity (and despite their scenic value), they are not described in the province's BEC classification of vegetation types, and are seldom mentioned as a priority for conservation.

Microhabitat diversity is high in old forest, and increases past initial old-growth phases into the age at which the forest is older than its oldest individual trees (the antique forest stage). Certain microhabitats of old forest are lacking or poorly developed in disturbed or managed forests, such as snags, shaded tipup mounds, large-diameter trees, slowly decaying polypore fungi, or aged birch bark peels. All of these habitats develop communities of uncommon or rare cryptogams (especially lichens). So long as the environmental conditions surrounding them remain stable, these habitats can continue to accumulate microhabitat specialists. Environmental stability of microhabitats becomes disrupted with selective or clear-cut logging, fires, and large blow-downs. Most of the calicioid species (especially of the genera *Chaenotheca* and *Chaenothecoposis*) found in the study area occur on snags in these old forests, and were not found in clear-cut forests. Some mosses, such as *Schistostega pennata* occured in the study area only on large tipup mounds in oldgrowth forest. More detailed studies of these microhabitats in old forest, and more thorough searches for their apparently dependent species would be an interesting topic of further study.

Subalpine forest

Figure 3. A creek clearing in subalpine forest near the Walker Creek headwaters.

Snow accumulations are particularly high in these high elevation forests, and the snow persists late into the year. Ventilation and insolation vary widely with canopy density. The soils also vary greatly, from thin and rocky to deep and loamy. There is no sharp distinction between this forest type and middle-elevation forests, and in some areas, the subalpine forests grade into subalpine meadows with patchy groves.

The dominant tree is *Abies lasiocarpa*, with a minor amount of *Picea engelmannii*. The understory is dominated by, in the shrub layer, *Rhododendron albiflorum* and *Vaccinium membranaceum*, and in the herb layer *Arnica latifolia*, *Epilobium angustifolium*, *Rubus pedatus*, *Streptopus lanceolatus*, *Valeriana sitchensis*, and *Veratrum viride*. The ground layer is often sparse, or sometimes includes extensive patches of *Barbilophozia* spp., *Cladonia* spp., *Dicranum spp.,* and *Peltigera* spp. Because subalpine forests are so widespread and rather uniform in attributes, they are unlikely to present rare species. Little time was spent in subalpine forests in 2023 during the Walker surveys in order to prioritize the open high-elevation habitats that have a more variable and richer flora. That probably resulted in omissions from the project species list, such as the expected moss species *Rhizomnium nudum* (R.S.Williams) T.J.Kop., *Roellobryum roellii* (Broth.) Ochyra, and *Sciurohypnum hylotapetum* (B.L. Higinb. & N.L.Higinb.) Ignatov & Huttunen. Although subalpine spruce-fir forests are generally not of prime interest for plant and lichen biodiversity exploration, they play an important role in providing forage for caribou (see discussion under Low-Elevation Spruce-Fir Forest, below)

Undisturbed Low-Elevation Spruce-Fir Forest

Most of the forest in the middle to lower elevations of the Walker Creek Valley (Figure 3), and undisturbed portions of the adjacent river valleys, are dominated by spruce-fir forest that is distinct from subalpine spruce-fir forest (ESSF in the BEC system) in several ways. These forests occur on richer soils and are subject to warmer temperatures and a longer growing season. Presumably due to these factors, at least in part, the epiphytic flora on the trees in these valley-elevataion forests have a rich epiphytic lichen flora of *Bryoria*, *Ramalina*, and cyanolichen species, and a diverse array of crustose species. These Walker-Valley habitats give the impression of subalpine forest transported to low elevations and enriched with both boreal and rain-forest lichen floras.

Figure 3. Low-elevation, mature spruce-fir forest in the Walker Creek Valley.

While subalpine spruce-fir forest is widespread and comparatively well studied (Goward & Ahti 1992, Goward & Arsentault 1997, Lewis 1998, Coxson & Coyle 2003), low elevation spruce-fir forests like those of the Walker Valley are poorly documented for their biodiversity and ecological attributes. Because the provincial government's regional forest classification (DeLong 2003) is based only on visually dominant and easily identified species (a problem endemic to British Columbia's ecosystem classification), it does little to present a characterization of these forests in terms of biodiversity or ecosystem processes. Under this classification scheme, the regional low-elevation spruce- and/or fir-dominated forests are particularly vague in how they are classified, and important aspects of their ecology and biodiversity are not mentioned in this classification. In short, these spruce-fir forests are generally poorly known.

Arboreal hair lichens are essential in the diet of the rare, regionally endemic, and federally listed Deep-Snow Mountain subspecies of Caribou (Edwards & Ritcey 1960, Edwards et al. 1960, Goward & Campbell 2005). During periods when the mountain snowpack is insufficiently deep to elevate the caribou up to the elevation over the ground where arboreal hair lichens grow above the snow trimline (Goward 2003, Kinley et al. 2006), but sufficiently deep to prevent access to terrestrial lichens (Kinley et al. 2003), Deep-Snow Caribou must migrate downslope to lower-elevation forest. The open-canopy, mature spruce-fir forests of the Walker and surroundings are therefore potentially of prime importance as a forage area during times when otherwise the caribou would face starvation conditions. Young and managed forest cannot reliably provide sufficient hair lichen loadings to maintain this foraging system (Goward et al. submitted), partly owing to the dense canopy of young, managed forest (Goward et al. 2022). Hence, the survival of Deep-Snow Caribou will fail without the preservation of undisturbed forest that is capable of supporting abundant arboreal hair lichens. The wild spruce-fir forests of the Walker and surrounding valleys provide possibly the largest remaining expanses of such habitat, while such forests in adjacent regions have been greatly reduced in area, lost to industrialization.

Riparian forest

These forests occur on the flood plains of the Fraser, McGregor, Morkill (Figure 4), and Torpy Rivers, and lower Walker Creek. The soils are consistently moist and rich in mineral nutrients and nitrogen. Humidity is high during the growing season, and the canopy is often open, allowing for good insolation. Due to the greater light penetration from the adjacent canopy gap, the air temperatures may be warmer in these forests during the growing season than in adjacent *Thuja-Tsuga* or *Picea-Abies* forest.

Figure 4. Riparian forest on the Morkill River floodplain.

Dominant trees include *Betula papyrifera*, *Picea glauca* and *Populus trichocarpa* and/or *P. x hastata*. Occurrences of this forest type vary widely between those dominated by *Picea* and those with a prevalence of deciduous trees. The shrub layer is variably dominated by mixes of *Alnus incana*, *Cornus stolonifera*, *Lonicera involucrata*, *Oplopanax horridus*, *Ribes lacustre*, *Rosa acicularis*, *Rosa* x *engelmannii* nothosubsp. *britannicae-columbiae*, *Rubus idaeus*, *Salix spp.*, *Sambucus callicarpa*, and *Viburnum* spp. The herb layer is a variable mix of dominant species, including *Aralia nudicaulis*, *Athyrium filix-femina*, *Canadanthus modestus, Cornus unalaschcensis, Gymnocarpium* spp., *Maianthemum racemosum, Matteuccia pensylvanica*, and *Tiarella trifoliata*. The ground layer is poor in lichens, and is generally dominated by the mosses *Hylocomium splendens, Pleurozium schreberi, Plagiomnium spp., Rhizomnium* spp., and *Rhytidiadelphus* (sensu lato) spp.

The epiphytic lichen and bryophyte flora is particularly rich in riparian forest, partly due to nutrients pumped through the tree canopy from the rich soils and depositing as natural throughfall, especially where *Populus* (Gauslaa & Goward 2012) and large arboreal willows occur. Old cottonwoods (*Populus trichocarpa*) attain especially large sizes on rich soils, and such massive trees are particularly efficient at providing a nutrient rain on conifers below (Goward & Arsenault 2003, Goward et al. 2021), supporting species of the Lobarion lichen community (Gauslaa 1995). Alder-dominated riparian forests also support a rich lichen flora (Doering & Coxson 2010). Large areas of riparian forest in the Robson Valley have been clear-cut or are compromised by logging roads (Björk pers. obs., Darwyn Coxson pers. comm.). Due to the cutting the old cottonwoods and large arboreal willows and their associated conifer under-canopy, or by damaging riparian alder stands, or by other deleterious impacts of industrialization such as the loss of large spruces, those managed riparian forests will have a reduced capacity for species richness.

Glacial Lakebed Sediment Erosion Slopes

Thick deposits of glacial lakebed sediments occur in extensive areas in a band of about 700-850 m elevation along the Morkill River and perhaps along the lower Walker/Torpy Valley. In the Morkill Valley, these silts are densely forested and deeply incised, forming a mounded topography interspersed with streams and natural erosional slopes (Figure 5). Two of these erosional features were surveyed (Figure 6), and were found to be lightly vegetated mostly with mosses, liverworts, and horsetails (*Equisetum arvense*) in faster-eroding areas, and with shrubs in relatively stable areas. No rare species were located on this habitat, but other occurrences of these erosional features merit further exploration. Also, it should be noted that the erosional features reveal the speed with which these sediments erode. Logging and roads may cause slumping and excessive silting of the Morkill River.

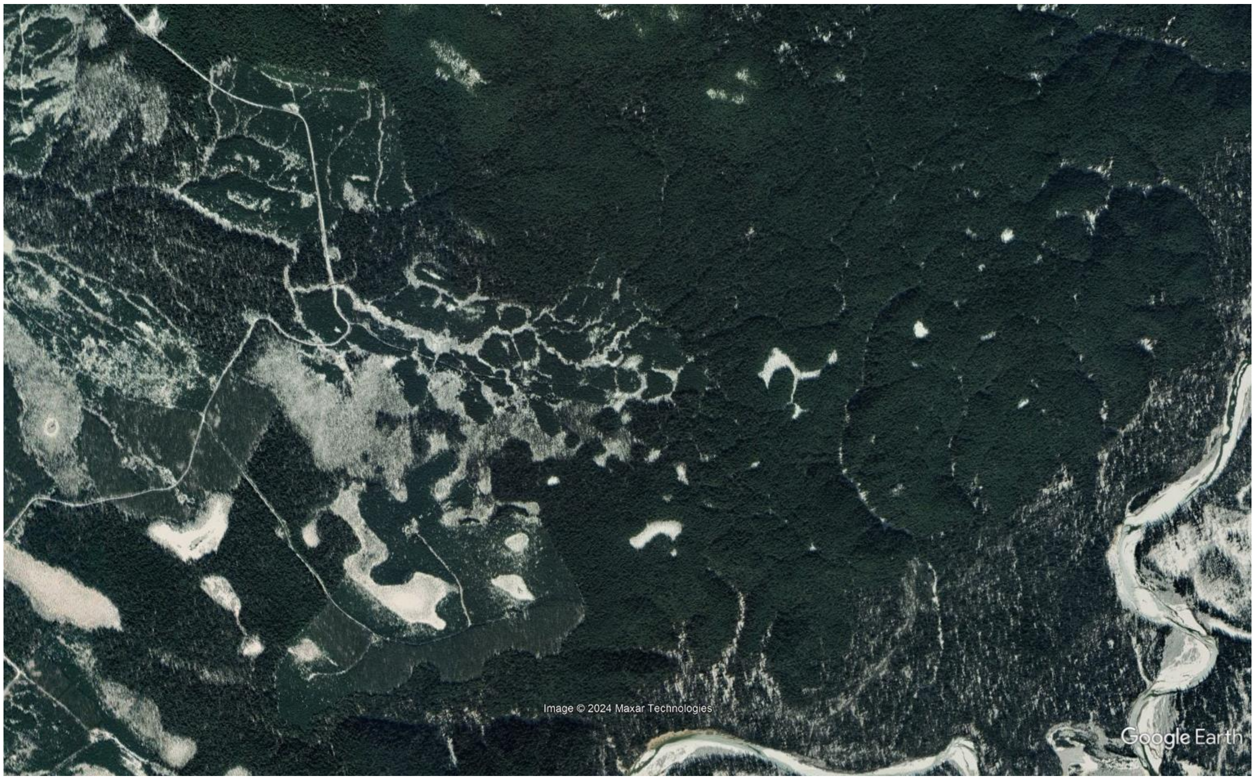

Figure 5. An area of mounded topography with erosional features on thick (ca. 100 m) glacial lakebed sediments in the Morkill Valley. The Morkill River appears in the lower right. A large area on the left has been subject to logging. The area on the right remains wild; the features that appear white in that area appear to be natural erosional features like those surveyed on June 16. Google Earth view from 15.4 km altitude.

Figure 6. A naturally fast-eroding slope on silt-clay glacial lakebed sediments in the Morkill Valley.

Swamps

Figure 7. Alder swamp on the Walker Creek floodplain.

Small areas of alder swamp habitat occur in the study area along the Walker Creek (Figure 7) and Torpy River floodplains, and more can be expected along the Fraser River. These are shrub and tree dominated wetlands with a dense herb and shrub understory. Humidity is constantly high, and the soil is kept moist by the high water table that is elevated by proximity to rivers. Ventilation is poor during the growing season due to the dense foliar canopy. Humidity is very high, and temperatures can be warm compared to other shaded habitats, perhaps owing to the greenhouse-like alder overstory. The nutrient-rich soils and constant moisture availability create the conditions for very dense vegetation.

Dominant species in the swamps surveyed are *Alnus incana, Athyrium filix-femina, Carex sitchensis, Lonicera involucrata, Lysichiton americanus, Matteuccia pensylvanica, Spiraea douglasii, Thalictrum sparsiflorum*, and *Viburnum edule*. The moss layer is patchy, occurring mostly on hummocks at the bases of shrubs, and lichens in this habitat are almost all epiphytic. In some areas, *Picea glauca, Picea mariana* and their hybrid *P. x albertana* grow on hummocks in swamps, mostly in habitat transitional into muskeg.

Bogs

The term 'bog' has been used in North America to refer to a wide variety of wetland types. The definition used here aligns with usage in Europe: Wetlands in which *Sphagnum* peat decays so slowly that it builds up a platform layer higher than the water table. The effect of this elevated peat is that the living *Sphagnum* and other dominant plants cannot access mineral rich ground water. Thus only rain water is available to plants in bogs and the rooting substrate is strongly acidic. Bogs can form only in cool or cold climates or microclimates; with a warmer climate, the peat decays too rapidly, sinking down into ground water and forming a fen instead.

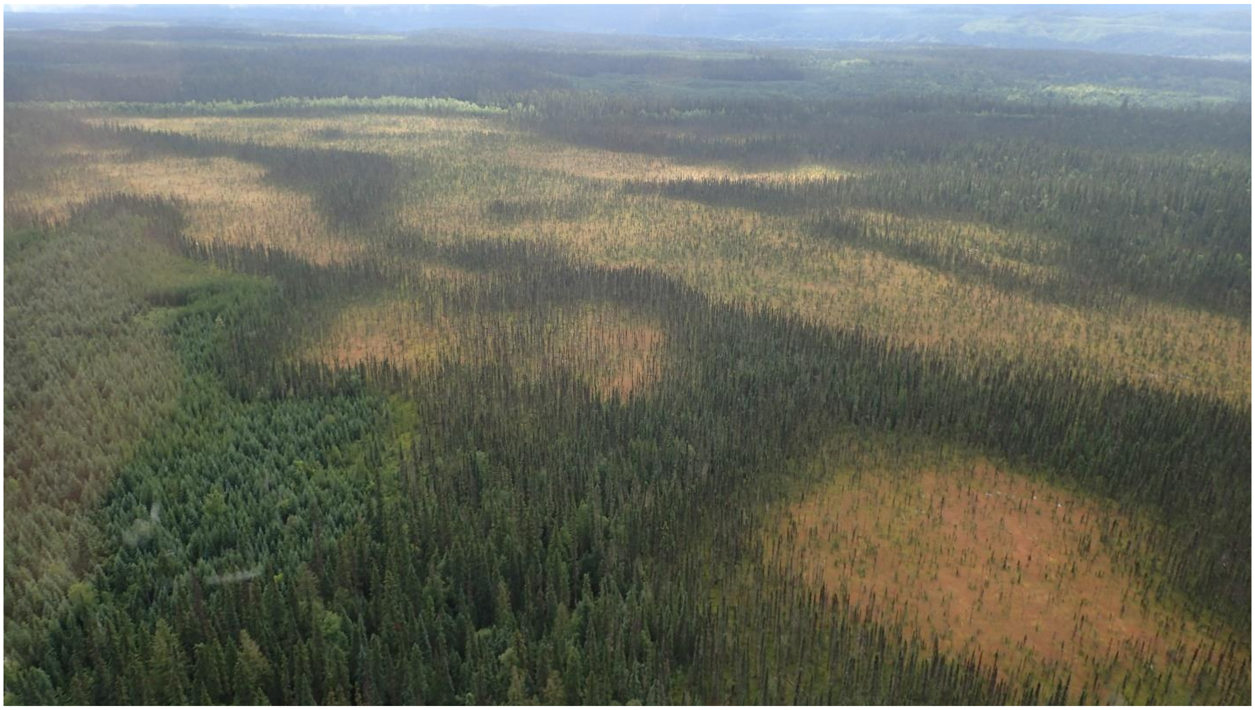

Figure 8. A large bog/muskeg complex on the Fraser River floodplain.

No bogs were surveyed in the Walker study area in 2023. The bog/muskeg complex illustrated in Figure 8 lies shortly outside the Walker as defined by the study area outline prior to the 2023 field season. Any future inventory work for the Walker should include this wetland. Any effects by the extensive local clear-cut logging on the hydrology of the Robson Valley are as yet unknown. The expansive bogs further west in the Robson Valley were studied by Björk et al. (pending), resulting in surprising floristic finds such as *Sphagnum cuspidatum* s. str., otherwise uknown as a native species in British Columbia, and *Sphagnum viride*, which has previously been recorded in the province. The Robson Valley bogs present vegetation types that defy identification in the British Columbia government's wetland classification (MacKenzie & Moran 2004).

Subalpine fens and meadows

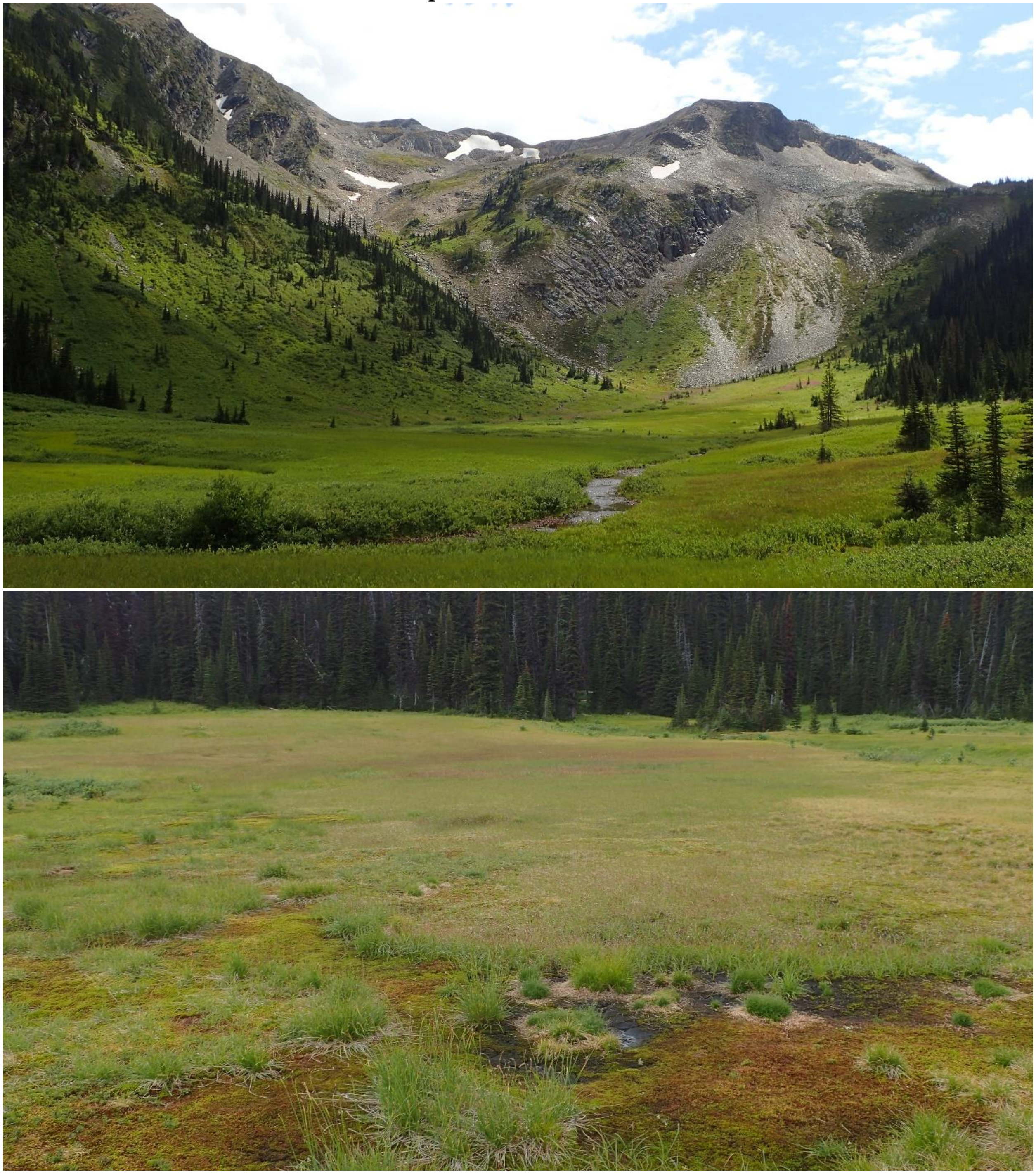

Figure 9. Subalpine meadow and fen ecosystems near the Walker Creek headwaters.

Extensive areas of subalpine fens and wet meadows (Figure 9) occur in the study area in the Walker Creek headwaters and probably in other valleys nearby. The soil in these fens is too wet to support tree and shrub growth, or even subalpine meadow vegetation. The fens are mostly somewhat sloped, suggesting they are formed by seepage rather than by a level water table. The fen illustrated in figure 9 (lower) lies at the base of a limestone peak, and it is probably for this reason that numerous calciphilic species occur there, such as *Juncus castaneus, Juncus triglumis, Paludella squarrosa,* and *Tomentypnum nitens*. Abundant species in the subalpine fens include *Aulacomnium palustre, Carex sitchensis, Eriophorum angustifolium, Leptarrhena pyrolifolia, Salix* spp., *Sphagnum* spp., and *Vahlodea atropurpurea*. Due to the spatially highly variable vegetation in these fens and meadows, none of these species or any other could be termed a regular dominant. The overall diversity of species in these fens is rich and heterogenous, such that a great deal of time can be spent there recording additional, often surprising, species. How species in these fens and meadows sort into subordinate microhabitats would be an interesting subject for ecological study.

Figure 10. A natural ochre-stained stream near the Walker Creek headwaters.

One portion of these subalpine fens is strikingly distinct in chemistry, with ochre springs and ochre-stained streams (figure 10). Gossan, a metaliferous rock type rich in sulfide minerals, often irridescent, and with a rust-coloured oxidized veneer was observed as surface cobbles and boulders within this portion of the meadow and scattered along the creek downslope. However, no bedrock exposures of gossan were found. Sulphur-rich rocks such as gossan sometimes support populations of rare acidophilic bryophytes such as *Mielicchoferia* species, so if a surface exposure of gossan is located in the study area, it would merit future survey effort for these and other rare acid-loving extremophile species.

Middle-elevation sloped fens

Figure 11. A sloped fen near Walker Creek.

Sloped fens are a common feature in coastal British Columbia in the Boundary and Cassiar Mountains, but are less common in the southern two thirds of the province. Almost no examples of middle-elvation sloped fens are known to occur elsewhere in the Robson Valley, but we found that they are common in the Walker Creek Valley (Figure 11). Presumably, uncommon combinations of soil, climatic, and hydrological conditions are necessary for sloped fens to form and to persist without becoming covered in forest. The set of conditions present in the Walker Creek Valley that foster sloped fen formation is unknown to us. Level fens are a common wetland type in British Columbia. Poor drainage contributes to the presence of fens and to the exclusion of tree and shrub cover, and it is easy to surmise why level sites could be poorly drained. Sloped sites with drainage sufficiently poor to exclude tree cover and foster fen vegetation must require a persistently high water table, perhaps due to the surfacing of groundwater due in turn to unknown subterranean structure, such as (perhaps) a semi-impervious clay layer.

Calcareous fens

Figure 12. Calcareous springs and surrounding calcareous fen vegetation below Clout Mountain.

Calcareous fens occur where ground water draining from the carbonate rocks seeps out onto flood plains into sites where cold air pools and where the ground is saturated. This set of environmental conditions encourages moss growth over woody vegetation. These sites support fen vegetation, including many calciphilic mosses and *Sphagnum* species that require a high pH enviornment. Two calcareous fens were explored in the 2023 Walker species inventory. The larger of the two is shown in Figure 12.

Dominant species vary among the calcareous fens, including a great variety of herb and shrub species: *Betula glandulosa, Betula pumila, Carex cordorhiza, Carex diandra, Carex echinata, Comarum palustre, Eriophorum angustifolium, Eriophorum chamissonis, Eriophorum viridicarinatum, Erythranthe* sp. nov., *Menyanthes trifolia, Salix pedicellaris, Triantha glutinosa, Trichophorum alpinum, Trichophorum caespitosum,* and *Triglochin maritima*. The dominant bryophytes are: *Aulacomnium palustre, Campylium stellatum, Hamatocaulis vernicosus, Helodium blandowii, Meesia triquetra, Paludella squarrosa, Scorpidium spp., Sphagnum centrale, Sphagnum russowii, Sphagnum teres, Sphagnum warnstorfii,* and *Tomentypnum nitens*. Trees and large shrubs are generally absent, though small groves of *Picea* x *albertiana* and *Pinus contorta* occur on small areas of elevated ground within the fens.

Among all the wetland types in the study area, calcareous fens may perhaps be the richest in vascular plant (and perhaps moss) species. Additionally, a great number of species were found in this habitat only within the study area, such as: *Andromeda polifolia, Carex cordorrhiza, Cicuta bulbifera, Cinclidium latifolium, Drosera anglica, Epilobium leptophyllum, Eriophorum viridicarinatum, Erythranthe* sp. nov., *Galium labradoricum, Geum rivale, Hamatocaulis vernicosus, Helodium blandowii, Meesia longiseta, Meesia triquetra, Mesoptychia gillmanii, Muhlenbergia glomerata, Paludella squarrosa, Pedicularis parviflora, Salix candida, Sphagnum contortum, Sphagnum warnstorfii, Stellaria longifolia, Tomentypnum falcifolium, Trichophorum alpinum, Triglochin maritimum,* and *Viola nephrophylla*.

Beaver ponds

Figure 13. An old beaver pond on the Walker Creek floodplain.

Beavers migrate, abandoning old dam sites where they have exhausted the available food in favour of new or "renovated" dams located where forage is abundant. Consequently, the ponds backed up by beaver dams are impermanent. After beavers abandon a pond, the draw-down period may be gradual or abrupt. Long after a period of vegetation succession, the recovery of forage shrubs may invite the beavers to return, restoring the pond and returning the vegetation back to an aquatic type.

The disturbance-recovery cyclical nature results in highly variable floras among beaver ponds, and that variability across landscapes elevates the overall species richness, making beavers an important driver in wetland plant species richness. However, the repeated disturbance associated with beavers' foraging and the fluctuation of water levels also makes beaver ponds susceptible to invasion by exotic species. Björk et al. (pending) observed high frequency and cover of invasive species such as *Cirsium palustre* and *Galeopsis bifida* in and near beaver ponds. While the vectoring of invasive plants by beavers has not been studied in detail in North America, such effects have been observed in regions where they have been introduced or reintroduced (Anderson et al. 2005, Juhász et al. 2020). Thus, it is important to prevent the spread of human-caused disturbance in wild beaver-occupied landscapes, as human economic activity (roads, logging, mining, ranching) facilitates aggressive expansions of invasive plants (Nathan 2006, Bullock et al. 2018) into wild vegetation where invasive species are so far lacking or scarce.

The numerous beaver ponds surveyed in the study area (example in Figure 13) are diverse in characteristics, depending on soil conditions, canopy shade, topographic position, age of the pond, and whether the dam(s) are actively maintained. This variability in environmental attributes makes for variable vegetation. There are no regularly dominant species among all the beaver ponds surveyed. Beaver ponds with deeper standing water have abundant submerged or emergent aquatics like *Hippuris* *vulgaris*, *Potamogeton* spp., and *Ranunculus aquatilis* s. lat. Those with shallower standing water have various other abundant species including *Comarum palustre, Glyceria* spp., *Juncus* spp., *Scirpus* spp., *Sparganium* spp., *Sphagnum* spp., or *Torreyochloa pauciflora*. Many species were observed in the study area only in beaver ponds, including: *Alopecurus aequalis, Bidens cernua, Callitriche palustris, Cardamine flexuosa, Cardamine occidentalis* aff., *Carex crawfordii, Carex stipata, Hippuris vulgaris, Juncus solutus, Ranunculus gmelinii, Ranunculus hyperboreus, Rumex pseudonatronatus,* and *Sparganium angustifolium*.

Stony River and Creek shores

Portions of the Morkill River and Walker Creek surveyed in 2023 flow through cobble- and boulder-sized Quaternary alluvium or over bedrock (Figure 14). The lichen and bryophyte communities on the stony shores are rich in species and highly variable according to the lithology of the stones. The tentatively identified rare species *Codriophorus norrisii* (in need of verification by a specialist in racomitrioid mosses) occurs on boulders along Walker Creek in this habitat type. Ecologically compromised examples of this habitat are a common sight in British Columbia; increased sediment input resulting from extensive upstream logging has greatly reduced the value of this ecosystem to lichens and bryophytes and possibly also to vascular plants. Sediment-coated stony shores are seen, for example, in the heavily logged Kispiox Basin in northwestern British Columbia (Björk pers. obs.), where remaining shoreline lichens below the high-water mark have been observed to be smothered in silt, or the stones are entirely devoid of lichens. Similarly, along those shores in the Kispiox Basin, mosses are commonly observed with only a few stem-tip leaves exposed and the rest thickly coated.

An additional threat to the lichen and bryophyte floras of stony stream shores may come from blooms of so-called rock-snot algae (*Didymosphaeria*), which have been noted to be more common and/or widespread in recent decades. Heavily impacted streams can have a thick, almost continuous coating of the algae on all rock surfaces that are subject to prolonged submersion. Dried mats of the algae on exposed shorelines can persist through the dry summer and early autumn months. The effects on lichens and bryophytes can be similar to that of heavy siltation, with smothering effcts that evidently can kill lichen thalli and that may reduce photosynthesis of mosses and liverworts. Causes of the increased frequency and extent (Bothwell et al. 2011) of *Didymosphaeria* outbreaks have been hypothesized to include changes in water temperature and hydrology, vectoring by recreationists, and altered nitrogen-phosphorus ratios resulting from reductions in anadromous fish populations (Coyle & Wilhelm 2014).

Given the threats to stony shoreline habitats outlined above and the observable reduction in the number of undamaged examples across British Columbia, it is important both to highlight the value of these habitats to lichen and plant diversity, and to preserve water quality of streams that currently retain pristine conditions. The species-rich rocky shores observed along Walker Creek and the Morkill River may be prone to major species losses in the event of upstream landscape industrialization. Currently, the water quality of Walker Creek, prior to its entry into the Quaternary sediments of the Torpy Valley, is in a natural, pristine state, and the lichen and bryophyte floras of the rocks along this stretch of the creek are evidently healthy and diverse.

Figure 14. Stony shores of (above) the Morkill River and (below) Walker Creek. Species-rich lichen and bryophyte communities occur on the larger stones along these shores.

Waterfall sprayzones

The plunge of sizable waterfalls produces a misting effect, where humidity remains perpetually elevated. Sizeable waterfalls also create, by the force of their plunge, a constant wind that ventilates the shoreline habitats downstream. These humid, breezy sites are termed waterfall sprayzones, and are sometimes noted to provide habitat for many rare or even locally endemic species (Hill 2003, King et al. 2012, Vandvik et al. 2014, Sabaj et al. 2020, Björk et al. pending). Waterfall sprayzones are often noted to have higher species richness of lichens and bryophytes than surrounding habitats, even higher than adjacent riparian habitats (Bressard 1972). The great variation in vegetation within and among waterfall sprayzones is so high that no species could be identified as characteristic dominants.

Morkill Falls (Figure 15), near the east end of the study area, is a large cataract with an associated secondary smaller waterfall wich, together, produce a forceful wind and a misting effect over a large area downstream along the Morkill River. Nutrient deposition from solutes in the Morkill River apparently enrich the aerial surfaces in the sprayzone, adding to the elevated humidity and ventilation effects of the sprayzone to support a large flora of lichens and bryophytes in permanently non-forested and hence well-insolated habitat. Some of the rare species of note here are *Bartramia halleriana, Buellia dialyta, Lempholemma radiatum,* and *Odontoschisma francisci.* Other, smaller waterfall sprayzones such as Hellroaring Falls also occur in the study area, each having its own special array of species. Indeed, every sizeable sprayzone habitat can be expected to have a high degree of floristic dissimilarity from other sprayzones (Björk et al. pending).

Many waterfalls are the sites of proposed or actualized hydroelectric development (Kallio 1969, Odland et al. 1991, Quinn et al. 2005). Morkill Falls has in the past been proposed for independent power production hydroelectric development by Robson Valley Power. The proposal was met with opposition from local (Crescent Spur-Loos Community Association 2009) and environmental (Valhalla Wilderness Society 2009) organizations. While it appears that the proposal was shelved, legal protection for the site is still lacking. Diversion hydroelectric systems can reduce the flow of streams by 20-50% on average from impoundment to powerhouse, or even over 90% at some times (Hatfield et al. 2003, Gower et al 2012). As it is always the high-grade portion of a stream that is directly affected by these run-of-the-river projects, and because waterfalls plunge over the sort of steep terrain required for diversion hydroelectric power generation, many of the province's waterfalls have been severely impacted or are threatened. Greatly diminished water flow over a cataract would reduce the distance and intensity of sprayzone effects.

Figure 15. Morkill Falls, a prime example of a species-rich waterfall sprazyone habitat.

Cliffs

Cliff habitats have long been noted to host a rich flora of lichens, bryophytes, and vascular plants, including many endemic species (Panitsa et al. 2021, Salas et al. 2023). The fine-scale variation in environmental traits on cliff surfaces produce an equally fine-scale segregation of species into many micro-communities (Mathes et al. 2000, Kuntz & Larson 2006), the sum of which can produce very high overall species richness. Cliff ecosystems are too diverse in characteristics for there to be regular, characteristic dominant species. Experienced botanical and lichenological explorers know to include cliff habitats in species inventories, and to allocate ample time to record the full array of species present.

Figure 16. Limestone cliffs near the Morkill FSR bridge over the Fraser River.

The various cliff ecosystems studied in the 2023 Walker inventory yielded a disproportionate amount of the total species diversity recorded in the project. Cliffs at low elevations and close to the forest service roads have, in some cases, been damaged by quarrying for road material. The cliff shown in the upper half of Figure 16, near the Fraser River bridge at Crescent Spur has been gouged by quarrying, producing a large area of disturbed and weedy talus below. Further road construction and maintenance would likely use this quarry, risking the remaining integrity of the ecosystem and its rare species. Other cliffs along the Morkill and Walker Forest Service Roads have been dynamited for road engineering, and the further construction of roads would likely damage additional cliff ecosystems. All cliffs in natural condition are important contributors to overall landscape-level biodiversity, regardless of rock type chemistry. But calcareous cliffs and those formed of unusual rock types often support rare edaphic specialists and endemics (Gilbert 2000, Kruckeberg 2002) and so may be especially high priorities for conservation.

Figure 17. Slate cliffs along the Morkill Forest Service Road.

CONCLUSIONS AND RECOMMENDATIONS

The Walker is a case study in the need for biodiversity inventories. If species ranges were modeled based on the currently available autecological data, only common and widespread species, such as dominant trees and shrubs, could be accurately predicted to occur there. The great number of rare and otherwise noteworthy species, including those that are evidently taxonomic novelties, could only be discovered by exploration of the wide array of special habitats in the landscape. The need for intensive biodiversity inventories is also highlighted by the Walker's addition of well over 200 species to the overall Robson Valley flora despite the great amount of time that has been spent exploring the greater region in past years. Efforts to identify high biodiversity areas in British Columbia have failed to fully capture the importance of the Robson Valley to the province's overall plant and lichen diversity. And essentially nothing was known about the array of species and habitats present in the Walker study area prior to the 2023 inventory.

With its recent 30 by 30 pledge (Environment and Climate Change Canada 2024), Canada has announced its commitment to protect 30% of its landscape by 2030. The need for biodiversity protection is front-and-centre in the declared motivation of this pledge. If effective biodiversity protection is indeed a prime motivator, then fuller and more accurate data on species distributions are needed, as well as improvements to the taxonomic lists currently recognized by government agencies, and a clearer understanding of past and ongoing erosion of wilderness and regional biodiversity levels due to resource extraction and other development.

Remote and wild locations on such steep terrain as the Walker are poorly explored compared to the more easily explored regions close to Canada's urban centres. It is the latter, the easily explored regions, that have most often been celebrated as major centres of diversity in Canada, such as southern British Columbia's Garry Oak Ecosystem (Garry Oak Ecosystem Revoery Team 2024) and southern Okanagan

Valley (Okanagan Collaborative Conservation Program 2024). The comparative ease with which species in those near-at-hand regions are assessed for rarity and threat status has been partly responsible for a concentration of federally listed species in the regions of Canada with a large human population, mostly along the country's southern border. As the Key Biodiversity Areas program relies heavily on distribution data of federally listed species for its assessments of biodiversity concentrations, and that program in turn may inform the 30 by 30 program, wild and remote but species-rich landscapes such as the Walker and its Robson Valley surroundings may well be neglected for protection.

These problems should be remedied with a sense of urgency, especially as industrial development of wild, remote lands in British Columbia reduces the habitat diversity of enormous swathes of the province, converting it to ecologically damaged, homogonized, and weedy clearcuts and other industrial sites. These effects of industry have gone largely unnoticed by the general Canadian public. It is of vital importance to document Canada's biodiversity much more thoroughly, especially in areas having such complex habitat diversity as the Walker. But it is of equal importance to help the Canadian public and international conservation community to understand the shortcomings of Canada's efforts to document and preserve species-rich landscapes.

Our newly gained understanding of the plant and lichen flora of the Walker and the landscape's diversity of special habitats is far from complete. It is a large landscape, traversed only with great difficulty, so the vast majority of the landscape remains unexplored. New additions to the Walker flora were accumulated with ease right up to the end of the last day of the 2023 inventories. That continued steep ascent of the effort-species accumulation curve means that further work is very much merited. Many distinctive looking habitats were observed from a distance along the 2023 survey traverses; habitats that very likely have their own peculiar set of ecological traits that in turn support unique species assemblages. Industrial development of the Walker Creek drainage and adjacent drainages would have any number of unknown, undocumented effects on habitats and rare lichen and plant species. British Columbia's and Canada's conservation interests (and indeed international conservation organizations) should not be left blind to these potential losses.

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