# Inventory and Survey Methods for Rare Plants and Lichens

## Standards for Components of British Columbia's Biodiversity No. 43

Prepared by
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# Preface

This document was developed in response to a critical need to standardize methods of detecting the presence of rare vascular plants, bryophytes, and lichens in British Columbia (BC) to inform projects related to environmental assessment, species at risk surveys, and other inventories where it is important to know the distribution of rare plants and lichens. The compilation was guided in part by published standards employed in other North American jurisdictions as well as by the experience and knowledge of BC's community of professional botanists.

The primary survey types are floristic inventories and targeted surveys. Floristic inventories record all species encountered in a defined area, including specific data on the rare ones, whereas targeted surveys only focus on the rare species. Floristic inventories which employ the intuitive meander technique are effective for maximum detection of rare vascular and non-vascular plants and lichens in large project areas in the heterogeneous landscapes typical in BC. The technique allows the surveyor to concentrate survey effort on habitats most likely to support rare plants.

Proper reporting and documentation through species inventory database submission templates, and vouchering are important for obtaining defensible results and contributing to valuable knowledge of BC's rare plants and lichens threats and distribution in the province.

# Acknowledgments

The government of British Columbia Resources Information Standards Committee (RISC), funded the preparation of this document. RISC supports the effective, timely, and integrated use of land and resource information for planning and decision making by developing and delivering focused, cost-effective, common provincial standards and procedures for information collection, management, and analysis.

Representatives to the Committee and its Task Forces are drawn from the ministries and agencies of the Canadian and the British Columbia governments, academia, industry, and First Nations. RISC evolved from the Resources Inventory Committee (RIC), which received funding from the Canada-British Columbia Partnership Agreement of Forest Resource Development Agreement (FRDA II), the Corporate Resource Inventory Initiative (CRII), and Forest Renewal BC (FRBC), and addressed concerns of the 1991 Forest Resources Commission. For further information about RISC, please access its website at http://www.gov.bc.ca/risc-standards .

All decisions regarding protocols and standards are the responsibility of RISC. The first draft of this manual was written by Curtis Björk (Enlichened Consulting Ltd.). Early in the editing phase, Diana Demarchi (BC Ministry of Environment and Climate Change Strategy (BC MOE)) provided guidance. Jenifer Penny and Nyssa Temmel (BC MOE) revised the document. Dave McEwan (BC MOE) provided RISC guidance. Review comments were provided by Ksenia Barton (Ecologist, consultant), Ryan Batten (Beacon Botanical Research), Brenda Costanzo (BC MOE), Marta Donovan (BC MOE), Matt Fairbarns (Aruncus Consulting Ltd.), Jamie Fenneman (University of British Columbia), Karen Golinski (Smithsonian Institute), Linda Jennings (Beaty Biodiversity Museum), Damien Joly (BC MOE), Eric Lofroth (Boreas Ecological), Mike Miller (LGL Ltd.), Josie Symonds (Ministry of Forest, Lands and Natural Resource Operations and Rural Development), Erica Wheeler (Royal BC Museum), and Patrick Williston (Ministry of Environment).

# Abbreviations

| | |
|---|---|
| BC CDC | British Columbia Conservation Data Centre |
| BC MOE | British Columbia Ministry of Environment and Climate Change Strategy |
| BEC | Biogeoclimatic Ecosystem Classification |
| COSEWIC | Committee on the Status of Endangered Wildlife in Canada |
| RISC | Resources Information Standards Committee |
| SARA | Species At Risk Act |
| SPI | Species Inventory database |
| TEM | Terrestrial Ecosystem Mapping |

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# 1. Introduction

## 1.1 Rationale

British Columbia is the most ecologically diverse province in Canada and has the highest diversity of native flora in the country (British Columbia (BC) Ministry of Environment 2010, Natureserve Explorer 2017). The province is home to more than 2500 native vascular plant species, subspecies and varieties (BC Conservation Data Centre, BC CDC, 2016a; MacKenzie et al. 2016). In addition, there are more than 1000 non-vascular native plants (BC CDC 2016a; MacKenzie et al. 2016), and over 2000 lichens currently verified with many others to yet to be assessed (Goward & Björk 2018). Native species are subject to various stressors and the cumulative effects of activities such as urbanization, agricultural development and natural resource development take their toll on the environment (Government of British Columbia 2008). Currently, one fifth of the plants and lichens in the province are considered of conservation concern by the BC CDC, and a subset of these species (currently 81 taxa) have also been designated under Schedule I of Canada's *Species at Risk Act* (Committee on the Status of Endangered Wildlife 2016; BC CDC 2016a).

Comprehensive ecological and distribution information is required to support sound policy decisions for protecting species that are at-risk. Data are lacking for many plants and lichens in the province, particularly in remote areas that are less intensively surveyed, making it critical for environmental impact assessments or any other type of conservation assessment to incorporate plant surveys within the scope of their inventory methodology. Surveys that identify the distribution and abundance of plants, as well as threats to their populations are important to build knowledge and ensure that conservation efforts are allocated where they are needed most (Government of British Columbia 2014). Access to science-based information about plants in the province facilitates accurate status assessments undertaken by the BC CDC and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2016). This baseline biodiversity knowledge is also important to a variety of stakeholders as they carry out conservation and stewardship projects.

## 1.2 Terminology and Inventory Group

The term "plants" in this document refers to vascular plants and non-vascular plants. Vascular plants have specialized conducting tissues and support structures that have earned them status as "higher plants" and include groups like clubmosses, horsetails, ferns, conifers and flowering plants. In contrast, the non-vascular plants or bryophytes which include mosses, liverworts and hornworts do not have such specialized features and individuals are limited to relatively small sizes. The protocol is also relevant to surveys for lichens. For brevity "rare plant and lichen surveys" is shortened to "rare plant surveys" and henceforth "rare plants" is used in this text to refer to both plants and lichens.

Inventory methods for macrofungi are described in another provincial protocol: Standardized Inventory Methodologies For Components Of British Columbia's Biodiversity: Macrofungi (including the phyla Ascomycota and Basidiomycota) (Ministry of Environment, Lands, and Parks, 1997). This protocol does not treat marine algae.

Rarity is only one aspect of the conservation status but the term "rare plants" is commonly used to describe plants of conservation concern. The BC CDC considers the rarity of each

plant, along with the population trend and conservation threats, and assigns a status rank using the Natureserve methodology (Natureserve 2017b). Based on those ranks, native species are placed on colour lists that correspond to their risk of extirpation from the province (Red - most at risk, Blue - vulnerable, and Yellow – secure, Table 1).

**Table 1. Explanation of BC CDC Ranks and Lists.**

| **BC CDC Subnational Rank** | **MOE List Status** | **Description** |
|---|---|---|
| S1, S2, S1S3, SH, or SX | RED | critically imperilled or imperilled |
| S2S3, S3 | BLUE | vulnerable |
| S3S4, S4, S4S5, S5 | YELLOW | secure or apparently secure |

These plants may also have a COSEWIC status (Endangered, Threatened, Special Concern, or Extirpated), and may be listed under Schedules I, II or III of the federal *Species at Risk Act* (S.C. 2002, c.29). There are currently two plant species listed under the BC Forest and Range Practices Act (2002) as Identified Wildlife (*Actaea elata* var. *elata* (tall bugbane) and *Corydalis scouleri* (Scouler's corydalis)) (Government of British Columbia, 2017) with other candidates under review for addition. Plants tracked by the BC CDC on the Red and Blue lists are rare or at risk for a variety of reasons including having a restricted range (e.g., endemic, or peripheral to BC in their global range), specific habitat requirements, a small population size, intrinsic vulnerabilities (e.g., reproductive limitations), and/or threats (e.g., urbanization, invasive species, climate change, among others).

# 2. Surveyor Qualifications

Surveyors should be experienced botanists with the knowledge and experience listed below, or they should have worked for several seasons under the supervision of a more senior botanist with those qualifications. All surveyors should also meet the requirements of technicians and/or crew leaders noted by Ministry of Environment, Lands and Parks Resources Inventory Branch (1998), including appropriate first-aid training, and the ability to use the relevant field equipment. In addition, all field workers should be physically fit and able to safely navigate wilderness environments. Indicators of the experience, skills, and knowledge required for a senior rare plant botanist are listed below:

- Five to ten years of experience in conducting floristic inventories or rare plant surveys, including planning and implementing field projects, advanced field identification of plants, and specimen vouchering.
- Familiarity with the regional flora, being able to recognize most or all rare plants likely to be encountered through the use of taxonomic keys, and an awareness of difficult-to-identify genera/species and subtaxa.
- Familiarity with plants of federal or provincial concern within a region, including their status, identification, and ecology.
- Knowledge of the relevant legislation and/or regulations (including applicable permitting), the individuals or organizations that should be contacted, and the data submission requirements.

Qualifications of a botanical technician or junior botanist are listed below:

- Three months or greater (or in general at least one field season) experience in conducting rare plant surveys, including field identification of plants, data collection, and specimen vouchering.
- Ability to use taxonomic keys to identify plants.
- Familiarity with plants of federal or provincial concern within a region, including their status, identification, and ecology.
- Knowledge of the relevant legislation and/or regulations (including applicable permitting), the individuals or organizations that should be contacted, and the data submission requirements.

# 3. Survey Design

Important considerations related to designing surveys include defining the objectives, scope and survey areas, identifying the plant targets, and considering the search effort and intensity that will be required. The scope of the survey involves consideration to both the species groups included and the survey areas selected within the study area. It is also important to select the appropriate survey methods and techniques, prepare well for fieldwork, and time visits for maximum detectability of target plants (e.g., which may include more than one visit to a single location). For large study areas, a reconnaissance survey is recommended to focus the search effort in areas that are most likely to yield rare plants.

## 3.1 Survey Scope

### 3.1.1 Survey Areas

Defining the survey area is important to determining the geographical scope of the rare plant survey. Survey areas may be defined by ecological features, species habitat requirements, property or project boundaries, buffer zones, and even reference sites outside project areas. Surveyors should identify target areas in which to focus effort and ensure that those areas are accessible.

For environmental assessment projects, the surveyor should be familiar with the locations of the proposed footprint and the potential direct and indirect impacts of alteration on the landscape prior to conducting a rare plant survey. Some projects may have impacts beyond the project footprint in the local, or larger regional area, or even beyond the project boundaries (i.e., projects with substantial air emissions). For projects with significant harmful gas emissions such as ground-level ozone, nitrogen oxides and/or sulphur dioxide, it is important to document rare plants occurring outside footprint areas that may be threatened by harmful atmospheric concentrations or deposition, either by direct effects of exposure or by indirect effects from eutrophication or soil acidification. Direct effects on vegetation include reduced photosynthesis, and plant growth, and increased sensitivity to disease (Government of BC 2018; United States Environmental Protection Agency 2018a,b,c). Likewise, projects with effluent discharges may impact aquatic species downstream. Erosion, inundation and introduction of invasive species are also important considerations.

Another factor to consider is land ownership and jurisdiction, as these may limit access to the survey areas, or may require that the surveyor apply for permits well in advance of commencing a survey. Surveys within British Columbia Provincial Parks, Ecological Reserves, and National Parks require a permit (BC Parks 2016; Parks Canada 2016). Surveys conducted on private or First Nations land also require permission. Furthermore, permission is required from First Nations and landowners in order to submit any data gathered on their lands to the Species Inventory database. Permits should be carried by botanists while working in the field.

### 3.1.2 Search Effort

Regarding search effort, the surveyor needs to consider how to maximize field time and effectively distribute the sampling effort within the study area.

Factors influencing search effort include, but are not limited to:

- Survey objectives,
- Size of the study area,
- Rare plants potentially occurring in the study area (see Section 3.4.3),
- The diversity of ecosystems and habitats occurring within the study area (see Section 2.6.9),
- Survey intensity (see also Section 3.2.5),
- Access to survey sites, including considerations to remote areas, types of access and the safety measures that need to be in place,
- The number of field days required,
- The time of year and phenology of the target rare plant species (see Section 2.6.10).

When distributing the sampling effort across the survey areas, surveyors should ensure that the sample sites represent:

- Areas that are going to be affected by development, and those more sensitive to ecological disturbance,
- Each habitat type identified within the survey areas selected, if possible (some of these are captured during traverses between high quality habitats),
- All previously identified uncommon habitats,
- Microhabitats and unique geographic landscape features,
- Include visits to all previously recorded locations of rare plants, where practical (some historical reports have vague locations, and others have recently been visited).

The surveyor should be familiar with the preferred habitats of rare plants. In any given landscape, rare plants tend to be clustered around features such as seepages, large rock outcrops, shores, among others. Unusual rock types such as serpentine, limestone, tufa, and areas of concentrated heavy metals that provide the unusual chemistry required/tolerated by some rare plant species. Grasslands and shrub steppe, and estuaries are also habitats that often support a higher diversity of rare plants. It is also important to design a survey that allows for common or disturbed habitats to be surveyed en route between microhabitats to increase the potential of recording rare plants that occur outside of microhabitats and maximize the area surveyed.

It may also be justified to conduct some searches outside the footprint areas. The project design may change after rare plant survey work has been conducted, and the survey results from these areas can help reposition development away from detected rare plant populations. Knowledge of the occurrence of rare plants in these areas may also contribute to any necessary mitigation plans.

### 3.1.3 Biological Scope

Surveyors may not be qualified to survey the full scope of the species groups covered (vascular plants, bryophytes, and lichens). Even when qualified, they may find it difficult to survey for all of these simultaneously. Botanists who are not qualified to address a species group should not be attempting to make collections and report out on them without the knowledge of the best practices. It may be necessary to include specialized expertise where appropriate, and budgets should include any associated extra costs. Some rare plants and lichens are impossible to identify in the field, and require further examination, or review by taxonomic experts. These unknown plants or lichens could be rare or even new to science,

and should not be missed in a study area. A successful inventory would record these species, but one should guard against inadvertently collecting specimens from populations that are very rare, particularly where ethical collecting should be employed. Budgeting should include consideration to scope to allow for any extra compensation that may be needed for specialist support.

## 3.2 Survey Methods

### 3.2.1 Rare Plant Surveys vs. Ecological Community mapping

Rare plant surveys and ecological community mapping both focus on vegetation and are commonly conducted simultaneously during environmental assessments. Ecological mapping can be an important tool in preparing for rare plant surveys (see Section 3.2.4.1) and when appropriate, a well-designed sampling plan may allow for some overlap in the two types of surveys. Combining them in a single survey, however, can compromise the surveyors' ability to detect rare plants (Government of Saskatchewan 2017). The survey methodologies differ with respect to survey intensity level and spatial distribution of survey sites. Specifically, ecological mapping surveys generally involve collecting data at sites that represent the common habitats in a region so that the data collected can be used to document species assemblages at the ecosystem level, and extrapolate the survey data to support ecosystem classification of plant communities across the landscape. Rare plants generally occupy habitats that are spatially defined at finer scales than those used for vegetation mapping, or that are defined by attributes that are not considered in vegetation mapping schemes.

### 3.2.2 Survey Types

#### 3.2.2.1 Floristic Inventories

Floristic inventories are surveys where every plant encountered is identified to the taxonomic level necessary to determine whether it is rare (California Natural Resources Agency 2009). They are employed in many jurisdictions. For example standardized guidelines have been developed for Alberta (Alberta Native Plant Council 2012), California (California Natural Resources Agency 2009), and Washington (Washington Department of Natural Resources 2015) among others. Floristic inventories are recommended to effectively report on the distribution of rare plants and lichens in environmental assessments. The floristic inventory facilitates detection of rare plants by the process of carefully assessing and documenting the diversity of the flora in the study area. During these inventories, the surveyor investigates habitats outside those expected for the potential rare plants, as well as in those considered of high value for rare plants. The goal is not a comprehensive list of plants for the study area, but rather a list of those plants that are encountered on the routes in between those habitats. Surveyors should carefully document what they observe, or rare plants will be missed. For example the surveyor may observe a species that is not typical of the common species in the area or share features in common with rare ones (i.e., a lookalike), and thus flag a potential rare plant. Otherwise, difficult to identify species would be missed.

The floristic inventory is done by recording a track log with a Global Positioning Satellite (GPS) device (as per Section 4.2.3) and lists of plants found in defined areas or habitats and making collections (see Section 4.1). If a plant is determined to be rare following fieldwork,

then knowledge of the day, area and/or habitat in which it was found allows the surveyor to document the rare plant observation, and/or more easily relocate the population(s) and gather the relevant data.

#### 3.2.2.2 Targeted Surveys

Targeted, directed or species at-risk (SAR) surveys (referred to as detailed rare plant surveys in Alberta, Alberta Native Plant Council 2012), focus on a single species or a few speciesthat often occur together in similar habitats. Targeted surveys, in contrast to floristic inventories, are focused only on rare plants as opposed to inventories which document all plants observed in survey areas. Targeted surveys can also be required as part of environmental assessments, however, they are more commonly commissioned to support habitat protection or status assessment at provincial or federal levels. There are instances where during environmental assessments, rare plants that were first found during the floristic inventory, are revisited with the goal of obtaining more thorough data than is possible to gather during inventories (i.e. the full extent of the occurrence).

#### 3.2.2.3 Monitoring Surveys

In British Columbia, monitoring surveys are mainly associated with revisits to known locations of specific rare plants that have been assessed by COSEWIC and listed by the Government of Canada Species at Risk Act (2002) to support reporting and management actions. Re-visits to provincially listed species are done to update BC CDC element occurrences, but guidance on a standardized provincial approach to monitoring populations of rare plants is not yet available. Monitoring results are valuable to understanding the population dynamics and habitat requirements of rare plants. These surveys may be conducted over multiple years, with observations made at different times in the growing season to document the abundance and extent of a given population, and to collect information on plant reproduction and phenology. In the context of the present guideline, monitoring is recommended to meet the requirements of any management plans that have been created associated with projects. Monitoring data may be useful to establish how effective any mitigation has been. Further information on the design and implementation of monitoring surveys can be found in Antos and Miller (2002), Klinkenberg and Klinkenberg (2002), and Elzinga et al. (1998).

### 3.2.3 Potential Rare Plant List

A potential rare plant list should be compiled to inform allocation of field effort in advance of field work, as this list is a starting point for determining which species could be expected to occur in the study area. However, search effort should not be limited to the rare plants on the potential list compiled since none of the resources mentioned below on their own can be comprehensive in characterizing the rare flora of an area. Each of the tools has caveats associated with their use for this purpose (e.g., BC Species and Ecosystem Explorer CDC areas-based searches may not reflect recently mapped occurrences), and inventory data is incomplete for many areas in the province. In addition, cataloguing specimens is an ongoing task for most herbaria. Surveyors should be aware that specimens of rare plants may exist that are not captured in online searches. Therefore, it is possible to discover rare plants in the project area that are not identified on the pre-fieldwork potential list. The following will help identify potential rare plants:

- Use the BC CDC Species and Ecosystems Explorer (BC CDC 2016a) to determine potential plants occurring in the survey area by searching by habitat type,

Biogeoclimatic Ecosystem Classification (BEC) zone, District etc. Red and Blue-listed plants, and legally-designated species have been categorized by BEC zones and subzones (BC CDC 2016a), allowing users to do area-based searches.

- Use the BC CDC iMap tool (BC CDC 2016b) to determine if there are any rare plant occurrences mapped in or near the study area. The absence of occurrences in the study area of interest does not indicate that there are no rare plants present; it may indicate only that there are no occurrences currently recorded in the BC CDC database.
- Consult regional herbaria via online databases or a visit in person (e.g., Beaty Biodiversity Museum (Beaty Biodiversity Museum 2016)) to check for collections of rare plants in the study area. The Consortium of Pacific Northwest Herbaria (University of Washington Herbarium 2016) 'search by location' tool allows the user to spatially capture records by drawing a polygon around a search area.

#### 3.2.3.1 Gathering Information on Potential Rare Plants

Surveyors should become familiar with the key features and ecology of the potential rare plants within the survey area by examining species descriptions, illustrations, herbarium specimens and photographs. It is helpful to compile a rare plant guide for the survey area for use in the field which includes information on rare plant habitats, phenology, and key identification features.

Descriptions and illustrations are found in the Illustrated Flora of BC for most rare plants (Douglas et al. 1998-2002) and online at E-flora BC (E-flora 2016). For those plants not treated in Illustrated Flora of BC, consult the Flora of North America website (Flora of North America Association 2008). E-flora BC has a large coverage of photographs of BC plants. Flickr is another excellent resource (https://www.flickr.com/). The photos always need to be vetted for accuracy of identification.

Note the average phenology of each potential rare taxon to ensure that timing of surveys is appropriate (i.e., look up dates of photos online, and herbarium specimens) and check appropriate floras for key characteristics used in differentiating rare species from similar common species.

### 3.2.4 Survey Preparations

Thorough preparations prior to starting field-work are necessary to ensure that the appropriate level of survey effort is invested to yield defensible results. Pre-survey tasks include:

- Determining if a reconnaissance survey is necessary or feasible, depending on timing and budgets
- Determining the survey methods and areas that need to be searched to address the survey goal(s)
- Identifying what rare plants have the potential to occur in the survey area
- Becoming familiar with the rare plants potentially occurring in the survey area
- Planning timing of sampling periods based on optimal timing for identifying individual target species, taking into consideration elevation, wetland draw-down, etc.
- Determining the field data collection requirements (see Sections 3.1 and 3. 2)

#### 3.2.4.1 Gathering Information on the Survey Area

- Identify any unusual physical landscape features or ecosystems/habitats of interest using aerial/digital imagery (e.g., Google Earth) and available ecosystem mapping (e.g., BC Ministry of Environment Terrestrial Ecosystem Mapping (TEM) and Biogeoclimatic Ecosystem Classification (BEC) mapping).
- Where available, surface geology or soil survey maps should be reviewed to detect any habitats that may support rare species that require specific soil or substrate conditions
- Collate information on known rare plant occurrences in the study area
- Review relevant reports on rare plant in the vicinity of the study area
- If possible, confer with regional ecologists or field botanists with expertise in the survey area to gather up to date and local information that may not be documented in other sources

#### 3.2.4.2 Reconnaissance Surveys

Reconnaissance surveys are preliminary surveys to get an overview of the physical setting of a study area and to help plan the more detailed fieldwork to follow. They may be conducted, when feasible, to gather information on the extent and type of potential rare plant habitats and to estimate the survey effort that will be required. Generally, this type of survey can be done during other kinds of ecological surveys. Reconnaissance surveys are ideally done the season before rare plant surveys are planned, and they should be conducted during the growing season. These surveys can be conducted by helicopter, truck, ATV, or on foot as appropriate for the study area in question.

#### 3.2.4.3 Timing of Rare Plant Surveys

Rare plant inventories must be conducted when the diagnostic features of the potential plants are most visible. This usually involves both early- and late-season field surveys to detect different species. According to Lancaster (2000), one of the minimum requirements for a defensible rare vascular plant survey is conducting fieldwork at least twice during a growing season. Exact timing of fieldwork will vary depending on elevation, latitude, and other geographical considerations. Wetland plants and plants at higher latitudes and elevations have later phenologies. Weather fluctuations may also influence the decision on when to commence fieldwork. Depending on the timing and duration of precipitation and temperature patterns, some rare plants appear earlier or later than under average conditions (e.g., annuals in seepages, alpine plants dependant on snow melt, or plants at lower elevations dependent on temperature gradients, slope aspect or meltwater). An understanding of the species habitat requirements is also important to timing visits effectively. For example, plants on receding lake or river shores might need to be surveyed particularly late in the season (e.g., *Ammannia robusta*, *Lipocarpha micrantha*, and *Rotala ramosior*) if water levels may remain high until autumn. Alternately, some particularly exposed, dry sites may require spring-season surveys as the plants may have completed their life cycles and are beyond recognition by the onset of summer.

Depending on the nature of the proposed project and of the local flora, it mayin some cases be necessary to allocate survey effort across multiple years to account for annual variation. This may be necessary in landscapes having numerous rare annual plants, some of which may remain dormant in the soil seed bank in non-optimal years. In addition, some perennials with subterranean organs may not have above-ground growth for one or more years (e.g., bulbous

geophytes such as *Calochortus lyallii* (Lyall's mariposa lily), *Cephalanthera austinae* (phantom orchid), *Orobanche* species, and rhizomatous geophytes including *Actaea elata* (tall bugbane), *Corydalis scouleri* (Scouler's corydalis), *Erythranthe dentata* (tooth-leaved monkey-flower), and *Botrychium* species (Miller and Antos, 2002; Klinkenberg and Klinkenberg, 2002; Johnson-Groh 2004). Therefore, an understanding of the life histories of the rare plants expected in the survey area is important.

### 3.2.5 Intuitive Meander Survey Technique

Successful rare plant presence/no detection surveys balance covering a maximum portion of the project area and concentrating survey effort in habitats known to be associated with rare plants. Some protocols are non-prescriptive while others are detailed in their guidance on systematic methods (California Natural Resources Agency 2009; Alberta Native Plant Council, 2012; Government of Saskatchewan 2017; Henderson 2009). Meander surveys are recommended in many inventory protocols (Alberta Native Plant Council 2012; Goff et al. 1982; Johnson-Groh 2004; Pensylvania Department of Conservation and Natural Resources 1992; Whiteaker et. al. 1998; Wisconsin Department of Natural Resources. 2015, among others). In this protocol, it is recommended that intuitive meander surveys (meander searches) be employed, especially over large heterogeneous study areas.

The intuitive meander survey is a route taken by a botanist to increase the likelihood of encountering rare plants in a study area which takes into consideration all pre-survey planning, but especially the most efficient means of traversing a path to the highest value habitat. During meander searches, the surveyor covers a larger area than they would if they were using other techniques such as transects or grids. This geographic coverage is important because rare species are often associated with features that are not evenly distributed over the landscape. In this protocol, meander searches are modified by the term, intuitive, because the botanist employs expertise and knowledge to determine the route. Paired with the floristic inventory approach, the botanist is also examining other lesser value habitats on their route between high quality habitats. By recording the intuitive meander route as a GPS track, it is can be re-located and also be used to demonstrate search effort. Furthermore the pre-survey planning recommended throughout the survey methodology stratification of habitats in the sampling plan.

Some protocols recommend transects or grids (e.g., Government of Saskatchewan, 2017). These may be useful under some circumstances (e.g., small study areas, or in sampling lakes for aquatic plants (Hauxwell et al. 2010)). However, Figures 1-4 illustrate how effective the intuitive meander survey method is in detecting rare plants in terrestrial habitats. Figure 1 shows example rare plant habitats as they might occur surrounded by common habitat (in this case conifer forest) in a hypothetical landscape in British Columbia. In Figure 2, stars representing the rare plant populations are located disproportionately in the landscape in vicinity of these habitats. Using the meander search method, a GPS track will often look like the white line in Figure 2 by the end of a single field day on a rare plant survey. There is a strong overlap with the meander route where rare plant populations might be detected in the hypothetical landscape, in contrast with the lack of overlap to the plots featured in Figure 3 and the contour transects featured in Figure 4.

Different techniques are discussed in literature as described above. The onus is on the surveyor to choose the appropriate technique within their survey design. Given the variety of

survey areas (e.g. different sizes, and topography), and the varied objectives of projects, a combination of approaches may be desired (Alberta Native Plant Council 2012).

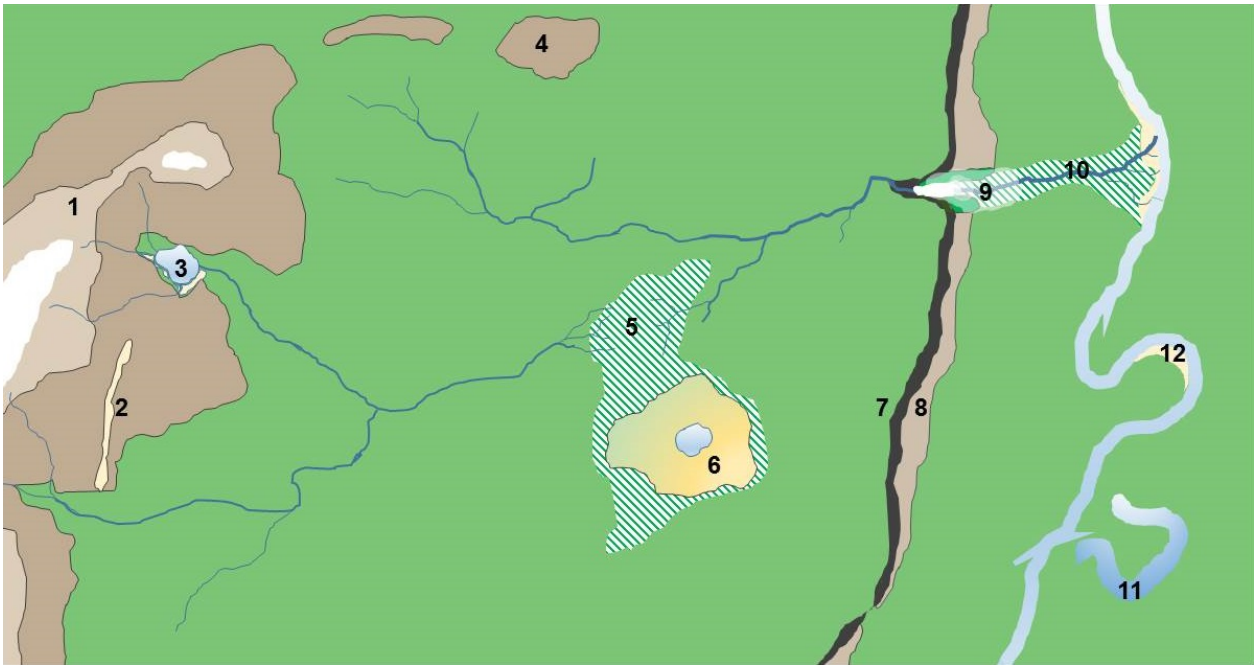


**Figure 1: Habitats are numbered: 1. Alpine ridge. 2. Limestone seam. 3. Subalpine lake. 4. Rock outcrop. 5. Old-growth swamp forest. 6. Fen. 7. Cliff. 8. Talus. 9. Waterfall spray-zone. 10. Old-growth riparian forest. 11. Oxbow. 12. River gravel bar.**

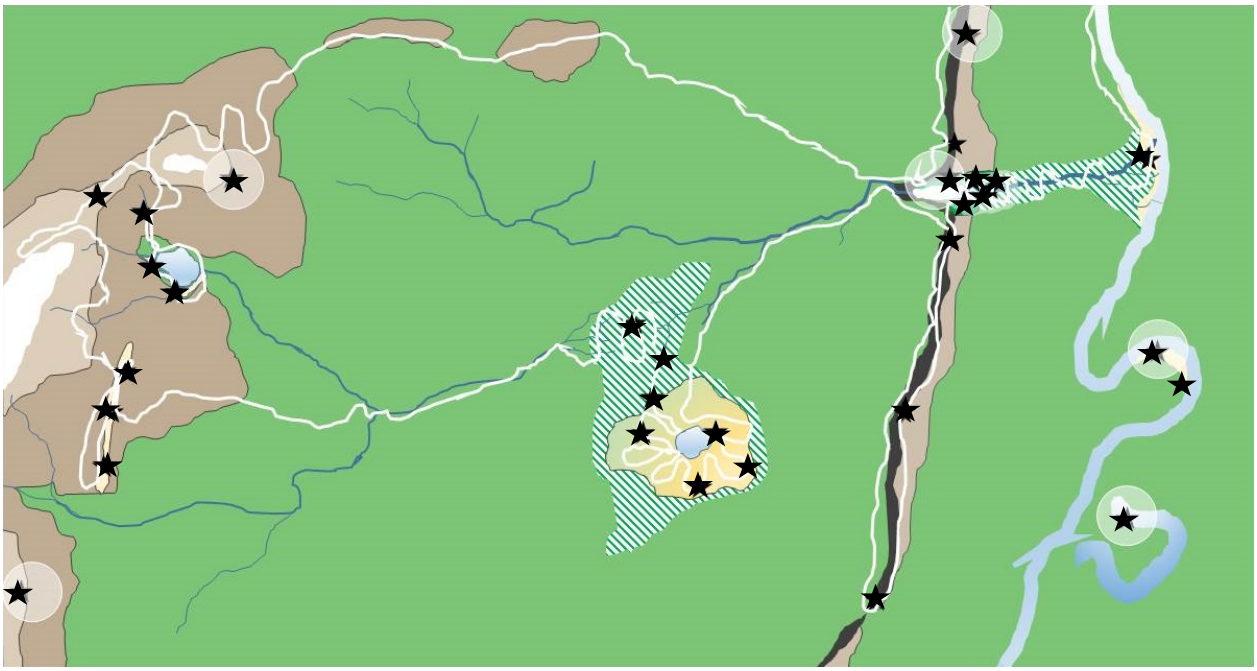

**Figure 2: Rare plant populations (stars) hypothetically captured by an intuitive meander search (white line). The six circles show the few populations that would be missed by an intuitive meander but demonstrates that most are captured.**

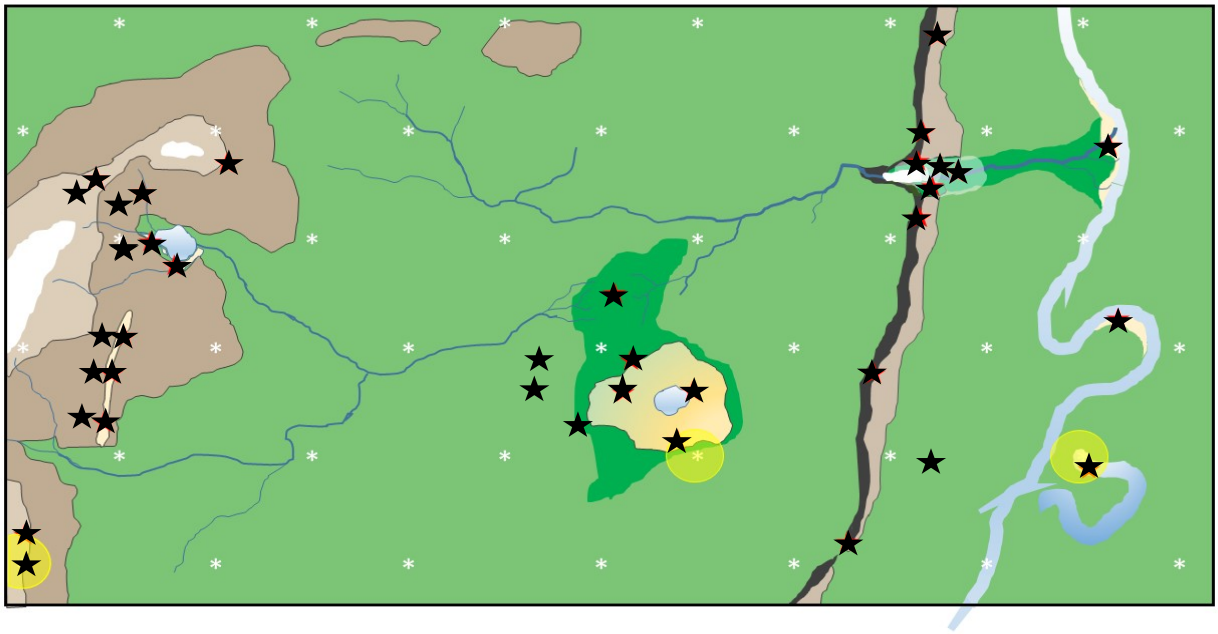

**Figure 3. Graphic showing a grid of evenly spaced plots. The yellow highlighting shows which populations are captured by the plot method.**

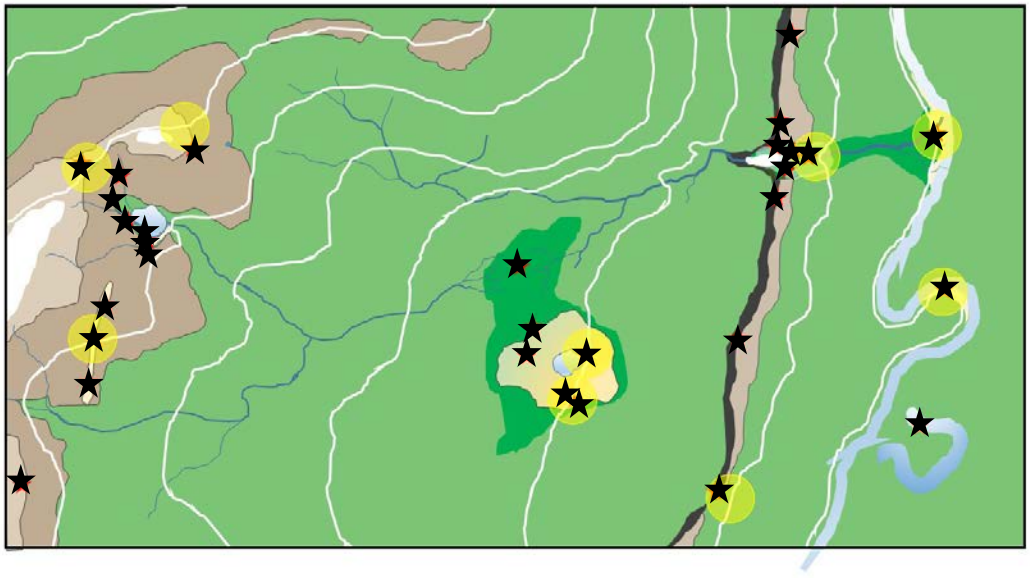

**Figure 4. Graphic showing contour transects. The yellow highlighting shows which populations are captured by the transect method.**

# 4. Reporting Requirements

After completing fieldwork, expect to spend additional time collating results, preparing specimens, managing photos, preparing project reporting, and submitting data to the BC Government Species Inventory (SPI) database (see Section 3.2 below). Recording of accurate spatial information ensures that any rare plant population discovered can be identified for protection if necessary or revisited at a future date for management purposes by another surveyor. Comprehensive documentation is necessary to assess the quality of the survey and the results. By submitting to the SPI database and preparing vouchers according to defined standards, data and specimens are collected in a uniform format allowing informed natural resource decisions and the curation of quality specimens. The information collected can then be used by government agencies and others to build on current knowledge of rare plants within the province.

## 4.1 Project Reporting

The methods of any rare plant survey should be described in enough detail to allow the survey to be repeated. Any new information regarding the ecological requirements, population trends or geographical distribution of a rare plant should be presented in the results, as should any notes on actual and potential threats to the populations. Spatial data should be included with reports because it is important for documenting survey effort, occurrences of rare plants found, and identifying areas of appropriate habitat that are not currently occupied (negative data).

Project reports must include an introduction, and sections describing the methods used, results, and a discussion of the results as described below. Depending on project scope, appendices may include a checklist of all the plants encountered (or reference to the SPI submission templates), and species accounts for the rare plants. Species accounts should include photos of the rare plants, as well as a short description of the diagnostic characteristics of the taxon. Inclusion of full species lists depend on the project scope, however, best practises in performing inventories are floristic in nature and demonstrate the rigour applied to the rare plant searches. In general, the project reporting for a rare plant survey should include the following information:

**Introduction:**

- Project or survey description, including the rationale and objectives for the rare plant survey
- A description of the ecological context of the survey area, including reference to the BEC zone, hydrology, geology, ecology, history of human use of the landscape, and any other elements that influence the occurrence of rare plants in the study area

**Study Area:**

- A map of the study area and sampling plan
- A description of the study area (location, ecological context etc.)
- Spatial information indicating surveyed areas (shapefiles, or waypoint files of GPS coordinates, GPS track, whether perimeters were marked or only central points, etc.)

**Methods:**

- The scope of the fieldwork (e.g., vascular plants only, or with addition of bryophytes and/or lichens, taxa ranked as S1-S3 by the BC CDC, *SARA*-listed species, etc.)
- The survey design used, including the sampling methods
- Dates of fieldwork
- Reference to existing reports or additional expertise consulted, and previously documented rare plant occurrences in the survey area
- Reference to the pre-survey potential rare plant list that was compiled for the study area
- Methods used to document search effort (e.g., GPS tracks)
- Methods used to document rare plant occurrences (including recording the location, plant counts, habitat that they occupy, etc. as per data submission templates)
- Specimen collection and curation methods, and which herbarium they are deposited in
- Details of photography used for documentation (e.g., taking close-ups photographs of any features that are diagnostic for identifications)

**Results:**

- A table showing total numbers of rare plants, the number of observations of each, phenology observed, and which plants were collected (including rare plants found that are not currently listed by the BC CDC and any identifications made by experts, where required)
- A summary of the search effort including the types of habitats surveyed that could sustain rare plant populations, and the spatial products (GPS track log and centroid UTMs for search polygons (blocks on SPI template).

**Discussion:**

- Notable rare plants found, particularly important habitats or observations
- A comparison of the rare plants recorded during the survey to the currently known distributions at the local, regional, and global scales
- Information about habitat specificity, sensitivity to disturbance, and/or limitations to reproduction and dispersal, of rare plants found
- A review of the relevant scientific literature pertaining to the rare plants (if deemed necessary)
- Negative results such as previously reported rare plant locations that were not relocated, with a justification regarding due diligence in detection efforts
- If applicable, the potential direct, indirect and cumulative impacts of the proposed project within the context of footprint areas
- If applicable, how the results presented should be used in developing mitigation plans to address potential impacts on rare plants
- Limitations of the application of the results of the study
- Discussion of any future work needed to complete the survey or assessment

**Appendices:**

- The pre-survey potential rare plant list that was compiled for the study area

- Lists of plants/lichens by species group encountered during surveys with the correct authority names (i.e., for floristic inventories)

## 4.2 Provincial Reporting for Rare Plant Observations

### 4.2.1 Naming Standard

Plants reported during inventories must follow the provincial naming standard established by Resource Inventory Standards Committee (RISC) (BC CDC 2016a; MacKenzie et al. 2016). The following references were utilized in building the checklist by MacKenzie et al. (2016):

**Vascular plants**:
Flora of North America Volumes. 1-9, 12, 19-23, 26 (Flora of North America Editorial Committee, 1993+) and other relevant floras.

International Plant Names Index (IPNI, 2015)

Integrated Taxonomic Information System (ITIS, 2017)

Tropicos (Missouri Botanical Garden Taxonomic web tool; Tropicos, 2015)

VASCAN (Database of Canadian Vascular plants; Desmet & Brouillet, 2013)

**Mosses:**
Flora of North America Vols. 27 and 28 (Flora of North America Ed. Comm. 2007; Flora of North America Ed. Comm., 2015)

**Liverworts and Hornworts:**
World checklist of hornworts and liverworts (Söderström et al. 2016)

**Lichens:**
A Cumulative Checklist for the Lichen-forming, Lichenicolous and Allied Fungi of the Continental United States and Canada checklist (Esslinger, 2016).

The vascular plant checklist is built by reviewing references and specimens with a team of botanists, herbarium managers, and government staff annually. Keeping current with emerging taxonomic treatments is challenging and some are not yet incorporated, therefore, botanists may choose to provide alternate names. These names should be submitted with the proper author citation, the synonym that matches MacKenzie et al. (2016), and referenced using a checklist or a flora. This is particularly true of fungi and other plant groups where lists are updated less frequently. The references above may be helpful in determining proper nomenclature in conjunction with the developing provincial standard.

During inventories, a surveyor may observe plants that are rare or at-risk but have not yet been incorporated in the BC CDC lists, including plants new to science or those previously unknown in the province. These plants should be reported so that the BC CDC may assess them for inclusion in the provincial flora.

Full species lists compiled during the duration of an inventory may be submitted in two ways: 1) in the submission template on the ‘Site Descriptions & Assoc spp’ worksheet (see web link below) using one row per species (or subtaxon); a minimum of data fields should be updated

to ensure that the species list is tied to the survey, or 2) in a separate Excel spreadsheet attached to the deliverables.

### 4.2.2 Rare Plant Observation Data

All rare plant observations collected during provincial resource inventories or targeted surveys are to be submitted to the Species Inventory (SPI) database using the plant and lichen template at the following web page:

www.gov.bc.ca/wildlife-data-templates

In the Species Inventory (SPI) Fundamentals guidelines (Ministry of Environment, Lands and Parks Resources Inventory Branch 1998), a variety of design components are used in planning surveys including sampling stations, transects, and blocks (which delineate areas that are surveyed completely. The block is the design component that is used in the template found at the link above. The blocks or search areas sites relate to specific habitats such as ridges, wetlands etc. within which one might expect to find rare plants. These search areas should be spatially recorded (as polygons or centroid UTMs). These coordinates, in conjunction with the GPS track route, will serve to document search effort effectively for rare plant surveys.

Upon making a rare plant observation, the surveyor should establish central coordinates for the population or delineate a polygon around the occupied area. Identified populations should be marked using flagging tape or coloured survey stakes. These should be removed when no longer needed.

Several types of data are required to document the occurrence and definitions are available for all fields in the template. The mandatory fields in the SPI data submission template for Survey Observations and Site Descriptions are listed below:

- Study Area
- Block Label
- Species Name
- Location
- Date
- Surveyor
- UTM coordinates (Or Latitude/Longitude)
- number of individuals found
- Area covered by individuals
- Full Extent Surveyed
- Habitat Description
- Site Condition
- Landscape Context

### 4.2.3 Spatial Data

Spatial data is to be submitted using the SPI plant submission template or as separate spatial files to accompany the template, as directed at the submission web site noted above. Coordinates should be submitted as Universal Trans Mercator (UTM) datum and quality-controlled by the surveyor on digital imagery or other GIS layers to ensure that the observations are correctly shown. The precision for GPS coordinates may be supplied (using

the Comments field in the submission template) but it is not required. Averaging is useful in recording small areas to increase precision.

Shapefiles of rare plant locations should be provided in BC Albers projection (BC government standard) or, if projection files are included, other projections are acceptable. A description of how the data was captured should be included (using the Comments field in the submission template). For multiple observations recorded in waypoint files, these should be cross-referenced with the waypoint numbers (plot labels in the submission template). Spatial features should only represent areas actually occupied by rare plants. If the features include buffers (e.g., to incorporate additional habitat for mitigation measures), this should be clearly explained.

### 4.2.4 Voucher Specimens

Specimens are required to document rare plant observations (For details see Appendix B). Specimens and digital photos are the proof of the occurrence, and demonstrate that the plant has been correctly identified. In some cases, populations of rare plants include too few individuals to allow ethical collecting. In these cases, digital photographs should be used to document the observation. Ethical collection will not damage the population or its ability to persist. **In general, no specimen should be taken from a population with fewer than 20 individuals** (Wagner 1997).

This "Rule of 20" is very widely applied during rare plant surveys throughout North America, however, the following are exceptions:

- Woody species, in which collection of a small portion of the plant (e.g., leafy twig, inflorescence) is considered sufficient for documentation or identification, and whose collection would not negatively impact the individual;
- Annual species that have completed seed dispersal;
- Species with well-developed underground components (e.g., Botrychium, geophytes, strongly cespitose or rhizomatous graminoids), in which collection of some above-ground material is not expected to result in any long-term harm to the plant. Note that collection of rare perennial species should never include underground material unless there are more than 20 individuals in the population, and collections from individual plants should never be made repeatedly over subsequent years.

### 4.2.5 Digital Photographs

Photos should be provided in the project reporting to verify that the surveyor has correctly identified the rare plants observed, and should be submitted along with the SPI plant submission template. The template includes a field for loading photos by their file name. Photographs are essential where it is not possible to take specimens such as when the number of individuals in a population surveyed are too few for ethical collection. In the case of plant observations of particular interest (e.g., new to a jurisdiction, or an important range extension), photos should be submitted digitally and printed on archival quality paper and submitted as specimens to a herbarium. Close-up photos showing the rare plant should be in focus, in the best possible lighting to illustrate any key features to confirm identification and include a scale object. For bryophytes and lichens, depending on the lighting when the occurrence is found, it may be necessary to illustrate them post fieldwork with photos taken under a dissecting microscope. Digital photos should also be taken of the rare plant habitat.

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# Appendix A. Collecting Equipment

The following is a list of suggested equipment for use in collecting vascular and non-vascular plants in the field (BCMF 1996).

## General equipment

Topographic maps of survey area
GPS unit
Permanent felt markers
Compass
Clinometer
Small altimeter
Leather gardening gloves
Waterproof field notebook
Plot cards
Soft lead pencils/sharpener
Field Manual for Describing Terrestrial Ecosystems – 2nd edition (BC MFR/MOE 2010)
BEC guides appropriate for the region the study area is in.
Plant Field Guides and Survey Rare Plant Guide (collated by survey team)

## Vascular plant specimens

Waterproof tags
Plastic and paper bags of various sizes
Knife
Hand lens
Trowel or shovel
Pruning shears or secateurs
Soil charts
Plant press with adjustable straps
Newsprint
Cardboard separator sheets (45 × 30 cm)
Seed packets of acid-free paper

## Aquatic specimens

Telescoping pole with prongs or a leaf rake
Plastic food containers with lids
Plastic zipper bags
White plastic slate, wax marking pencil
Snorkelling or scuba equipment

## Bryophytes and lichens

Rock hammer (or stone chisel and hammer)
Spray bottle
Safety glasses
Hand lens
Plastic zipper bags
Fixed-blade knife
Paper bags

# Appendix B. Vouchering Guidelines for Plants and Lichens[1]

## Introduction

Museum collections are the fundamental reference material that documents the province's biological diversity. The specimens that are vouchered in these institutions are used in research related to classification, taxonomy, evolutionary relationships and the data repositories that they feed into are foundational to many government initiatives. Many species recorded in environmental impact or other biological surveys can only be reliably identified if they are preserved as specimens and at the same time, may also contribute to the value of the museum's research collection (Ministry of Environment, Lands, and Parks, 1999).

Specimens collected should be deposited at an indexed herbarium, or a herbarium that has been recognized as being fully equipped to properly preserve plant material and manage the data associated with the material. In British Columbia, the primary herbaria are at the Beaty Biodiversity Museum at the University of British Columbia (index herbariorum code[2], UBC) in Vancouver, and the Royal British Columbia Museum (V) in Victoria. Specimens must be of a quality that meets the expectations of the herbarium, therefore the surveyor should obtain guidance from the herbarium staff on specimen requirements prior to conducting a rare plant survey.

Specimens may need to be sent to taxonomic experts for identification confirmation. If so, full label data needs to be enclosed when the specimen is sent and the return of the specimens to the collector needs to be discussed. Specimens should be of a quality that meets the standards of taxonomic experts, if not, they may be unable to provide an identification. The specimens should be in good condition (i.e., well preserved, with ample material for observation and mounting) and all the label data should be included with the specimens.

The following sections outline guidelines for the collection of three types of herbarium specimens (vascular plant, bryophyte and lichen). Guidance for fungi is found in Ministry of Environment, Lands and Parks (1997).

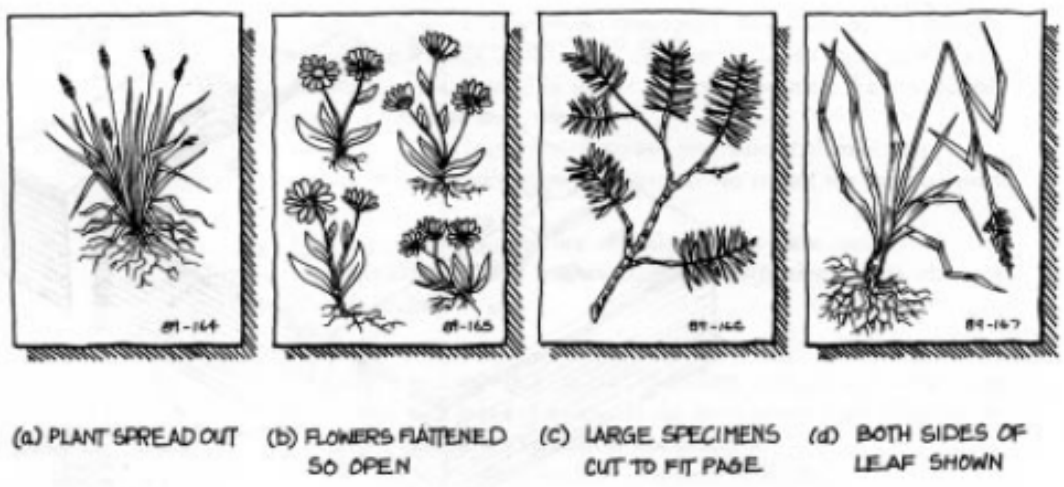
## Collection Guidelines for Terrestrial Vascular Plant Specimens

- Specimens should be collected that are in optimal condition, i.e., free of fungal growths or galls, clean of soil, not mixed with other plants;

[1] This guidance replaces the Voucher Specimen Collection, Preparation, Identification and Storage Protocol for Plants & Fungi (Version 2.0) (Resources Inventory Committee 1999).

[2] Index herbariorum codes are assigned by New York Botanical Garden (Thiers 2018).

- If a press cannot be carried in the field surveys, then specimens should be gathered in sturdy plastic bags and kept moist, ideally with moistened paper towels or moist, robust mosses that are clean of soil and pressed as soon as possible after collection;
- The surveyor should be familiar with the parts of the plant that are needed in a specimen for accurate identification, i.e., with flowers (both sexes, if dioecious), fruits, and other distinguishing feathers used for identification;
- Plants collected in a wet condition should be blotted first before being inserted into the press;
- Specimens may be pressed with more than one individual per population on a sheet, but should not include more than one taxon (or at least an effort should be made to separate material that looks different before more careful observation of key characters) or they may be pressed with individuals of the same species from different populations;
- The collector number, date and identification should be written on the sheet where easily seen in stacks of sheets (i.e., along the edge of the sheet);
- Plants should be pressed using a good quality plant press (consisting of two pieces of solid plywood or wood grid 46 x 31 cm, a number of cardboard sheets, blotter paper, and raw newsprint of the same dimensions, and straps) to rapidly dry material; it may be necessary periodically to replace damp blotter paper with dry sheets to facilitate rapid drying; ventilation is more important than heat for drying plants in a press;
- Plants should be pressed so that anatomical parts show their characteristics clearly (see figure below);




*Arrangement of specimens on herbarium sheets (Fig. 5 from BCMF 1996)*

- Thin sheets of foam may be used help with bulky plants;
- Collections should be indexed in the collector's notebooks and/or digital database; each collection must have a unique number; collection data must be submitted to the herbarium in the form of printed labels (on acid-free bond paper), or in the form of deposit lists with full collection data; the following should be included on the label:
    - Species name
    - Location
    - Detailed description of the habitat it was found in, and associated species
    - Collector name(s)
    - Collection number

    - Collection date
    - Determiner
    - Determination date
- Specimens should be handled carefully during transport to avoid being damaged and submitted to the herbarium in their newsprint sheets; they should not be mounted unless a special arrangement has been made with the herbarium.

## Collection Guidelines for Aquatic Vascular Plant Specimens

- Specimens should be gathered in sturdy plastic bags and pressed as soon as possible after collection;
- The surveyor should be familiar with the parts of the plant that are needed in a specimen for accurate identification, i.e., with flowers (both sexes, if dioecious), fruits, and other distinguishing feathers used for identification;
- Stiff, erect and emergent plants (i.e., plants that don't clump together when taken from the water) should be laid on top of appropriately-sized card stock with a high-rag content (95%) that won't wrinkle too much during drying process which will be used later by the herbarium as the mounting paper as well;
- Flaccid aquatic plants (i.e., ones that would clump together) need to be arranged on the high-rag content card stock (of appropriate size as above) by floating them in a tray of water, placing the card stock underneath them and raising the card stock out of the water carefully with plants marooned on the surface which will be used as the mounting medium later by the herbarium staff; let excess water drain off and put a piece of blotting paper on top to further absorb water away from plants, and place in press (for more details see Ministry of Environment, Lands and Parks (1994);
- Specimens may be pressed with more than one individual per population on a sheet (extra material is often desirable and many small plants can fit on a sheet), but should not include more than one taxon (or at least an effort should be made to separate material that looks different before more careful observation of key characters); or they may be pressed with individuals of the same species from different populations;
- The collector number, date and identification should be written on the sheet where easily seen in stacks of sheets (i.e., along the edge of the sheet);
- Plants should be pressed using a good quality plant press (consisting of two pieces of solid plywood or wood grid 46 x 31 cm, a number of cardboard sheets, blotter paper, and raw newsprint of the same dimensions, and straps) to rapidly dry material; ventilation is more important than heat for drying plants in a press;
- Plants should be pressed so that anatomical parts show their characteristics clearly (see figures above as per guidelines for terrestrial plant collection);Collections should be indexed in the collector's notebooks and/or digital database; each collection must have a unique number; collection data must be submitted to the herbarium in the form of printed labels (on acid-free bond paper), or in the form of deposit lists with full collection data;
    - Species name
    - Location specimen was collected from
    - Detailed description of the habitat it was found in
    - Collector name(s)

    - Collection number
    - Collection date
    - Determination date
- Specimens should be handled carefully during transport to avoid being damaged and submitted to the herbarium in their newsprint sheets; they should not be mounted unless a special arrangement has been made with the herbarium.

## Collection Guidelines for Bryophyte Specimens

- Specimens should be collected that are in optimal condition, which may require searches for sporophytes in the case of dioecious taxa (i.e., have male and female plants);
- Specimens should be collected in paper bags; more than one specimen may be inserted into a bag if they are from exactly the same locality, but too many specimens in a bag may result in soil-covered specimens; all specimens in a bag should be from the same location, habitat and substrate; avoid excess soil;
- Coin packets or envelopes should not be used to collect bryophytes; plastic bags may be used temporarily for particularly wet specimens, but upon returning from the field these should be removed from the plastic bags, dried, and transferred to paper bags;
- Specimens should be dried rapidly and not pressed;
- Collecting bags should have location coordinates (lat/long or UTMs) written on the bag, along with the date;
- Specimens should remain in their bags while drying, though particularly wet specimens may be removed from the bag and splayed out on top of the bag in a well-ventilated place, with care taken to ensure that the specimens are returned to the right bags;
- After returning from the field or upon sorting and identification, specimens are transferred from their collecting bags to folded herbarium-standard packets; packets should be folded with side flaps folded toward the front and tucked under the top flap;
- The specimen packet top-flap should have the identification written at the top left, the location and habitat data and date in the centre, and the collection number and collector name in the top right;
- Specimens on soil may be particularly delicate, these should be placed in folded tissues;
- A 3 x 5 card should be placed in the packet under the specimen; any microscopy observations should be written/drawn on the card;
- Specimens should not be glued onto the card except for some delicate specimens on fragile soils; if glue is used, it should not soak up into the moss;
- Collections should be indexed in the collector's notebooks and/or digital database; each collection must have a unique number; collection data must be submitted to the herbarium in the form of printed labels (on acid-free bond paper), or in the form of deposit lists with full collection data;
- Specimens should be submitted to the herbarium in packets, not bags.

## Collection Guidelines for Lichen Specimens

- Specimens should be collected that are in optimal condition, i.e. robust, adult thalli free from parasites or rot, and, when possible, bearing apothecia;

- Specimens should be collected in paper bags; more than one specimen may be inserted into a bag if they are from exactly the same locality, but too many specimens in a bag may result in soil-covered specimens; multiple specimens in a bag should be all from the same substrate;
- Coin packets, envelopes and plastic bags should never be used for lichen collections;
- Collecting bags should have location coordinates (lat/long or UTMs) written on the bag, along with the date;
- Specimens should remain in their bags while drying, though particularly wet specimens may be removed from the bag and splayed out on top of the bag in a well-ventilated place, with care taken to ensure that the specimens are returned to the right bags;
- Specimens should be dried rapidly; ventilation is more important than heat, and drying should occur within 24 hours to prevent denaturing of the characteristic chemistry or DNA; mould can grow on lichen specimens in as little as 24 hours on persistently damp specimens;
- Lichen specimens should not be pressed;
- After returning from the field, specimens are transferred from their collecting bags to folded herbarium-standard packets; packets should be folded with side flaps folded toward the front and tucked under the top flap;
- The specimen packet top-flap should have the identification written at the top left, the location and habitat data and date in the centre, and the collection number and collector name in the top right;
- Specimens on soil may be particularly delicate, these should be placed in folded tissues; cotton batting should not be used unless it is very fine, as coarse batting tangles with the lichens and can rip them apart when peeled away from the specimen;
- A 3 x 5 card should be placed in the packet under the specimen; any microscopy observations should be written/drawn on the card;
- Specimens should not be glued onto the card except for some delicate specimens on fragile soils; if glue is used, it should not soak up into the lichen;
- Collections should be indexed in the collector's notebooks and/or digital database; each collection must have a unique number; collection data must be submitted to the herbarium, in the form of printed labels (on acid-free bond paper), or in the form of deposit lists with full collection data;
- Specimens should be submitted to the herbarium in packets, not bags.

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