

Predicting taxonomic, functional and phylogenetic diversity of
plant assemblages in the Okanagan Ecoregion

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Abstract

Taxonomic diversity, or species richness, has traditionally been the focus of biodiversity conservation efforts, but attention is increasingly being paid to measures of functional and phylogenetic diversity, which consider the range of ecological functions and unique evolutionary histories of assemblages. Despite the important benefits to using this multi-dimensional approach, especially in the context of rapid climate and land use change, regional-scale conservation initiatives continue to consider taxonomic diversity alone within their strategies. My general objective is to inform biodiversity conservation efforts in the Okanagan Ecoregion by quantifying and documenting, for the first time, current and future geographic patterns of taxonomic, functional, and phylogenetic diversity among the region's vascular plant assemblages. My specific objectives are to: 1) Use species distribution models to predict current and future distributions of plant species inhabiting the Okanagan Ecoregion; 2) Quantify, map and compare current taxonomic, functional, and phylogenetic diversity patterns and hotspots in the Okanagan Ecoregion and compare to the current protected area network; and 3) Use climate projections to assess how future patterns and hotspots of taxonomic, functional, and phylogenetic diversity may differ from current.

Using a reproducible protocol, I produced current and future species distribution models for 1,541 plant species. I then used three plant traits that represent the ecological variation of plant life history strategies as well as a recently published phylogeny to quantify and map patterns of functional and phylogenetic diversity for plant assemblages in the Okanagan Ecoregion.

Overall, I found that there was significant geographic variation between patterns of taxonomic, functional, and phylogenetic diversity. While current functional and phylogenetic diversity hotspots had the greatest amount of congruence, hotspots of species richness and functional diversity had essentially no congruence. With future climate projections, all hotspots showed significant decreases in congruence. Elevation became more positively correlated with all three diversity measures in the future, indicating that plant diversity may be shifting to higher elevation areas in response to climate change.

The novel findings I provide here concerning patterns of functional and phylogenetic diversity should complement the taxonomic diversity patterns that inform conservation efforts in the Okanagan Ecoregion.

Lay Summary

The method that is most commonly used to measure biodiversity assumes that all species in an ecosystem have equal conservation value. There are two other methods that can be used to quantify biodiversity that allow different conservation values to be considered. Functional diversity considers the physical traits of species and how they contribute to the health and function of the ecosystem. Phylogenetic diversity measures the unique evolutionary histories of the species in the community. I produced a series of maps that show where areas of high and low biodiversity of plant species are in the Okanagan Ecoregion based on these measures of biodiversity. I also produced a series of maps that show how these biodiversity patterns may change in the future with climate change. This is the first time that functional and phylogenetic diversity patterns have been mapped in the Okanagan Ecoregion.

Preface

This research was conducted at the University of British Columbia Okanagan under the supervision of Dr. Jason Pither. All of the research, including data collection, methodological development, and data display, analyses and interpretation, was conducted by myself with collaboration from Dr. Jason Pither. The initial research concept was created collaboratively with Dr. Jason Pither, Dr. Lael Parrott, and Dr. Karen Hodges. This thesis was written by myself, with guidance and review from Dr. Jason Pither, as well as my supervisory committee: Dr. Lael Parrott and Dr. Adam Ford.

A version of chapter 3 will be submitted to a peer-reviewed journal. I performed all of the background research, methodology, analyses, and writing for the manuscript with guidance and editing from Dr. Jason Pither.

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For Dallas

1 Background

1.1 Quantification of biodiversity

The Convention of Biological Diversity (1992) defines biodiversity as “the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystem” (Convention on Biological Diversity, 1992). While the concept of biodiversity is naturally perceivable by humans, biodiversity conservation and research only began to emerge in the 1980s. During this time, biologists were becoming increasingly aware of and concerned with species extinctions, and they began devising ways to conserve species. The most common method for quantifying biodiversity became the measure of species richness, or the number of species or taxa within an ecological assemblage. Species richness, which is a measure of taxonomic diversity, continues to be the most commonly used measure of biodiversity in conservation research (Marchese, 2015). This is likely partially attributed to the ease at which species richness can be quantified among most taxa. Generalizing biodiversity with this single measure takes away from the multi-dimensional nature of biodiversity. As shown in Figure 1.1, and expanded upon in Section 1.2, two assemblages could have identical species richness, but could differ dramatically with respect to *functional* and / or *phylogenetic* diversity – facets that, respectively, address the range of ecological functions and unique evolutionary histories of assemblages. This multi-faceted approach to quantifying biodiversity has become increasingly common in biodiversity conservation research due to the identification of links between functional traits and ecosystem functioning (Tilman *et al.*, 1997; Loreau, 2000; Diaz & Cabido, 2001; Hooper *et al.*, 2005; Cadotte, 2017), as well as increased efforts to conserve unique evolutionary histories (Mace *et al.*, 2003; Isaac *et al.*, 2007; Devictor *et al.*, 2010).

The following section describes these two facets of biodiversity, functional and phylogenetic diversity, and how and why they have been incorporated into biodiversity conservation research.

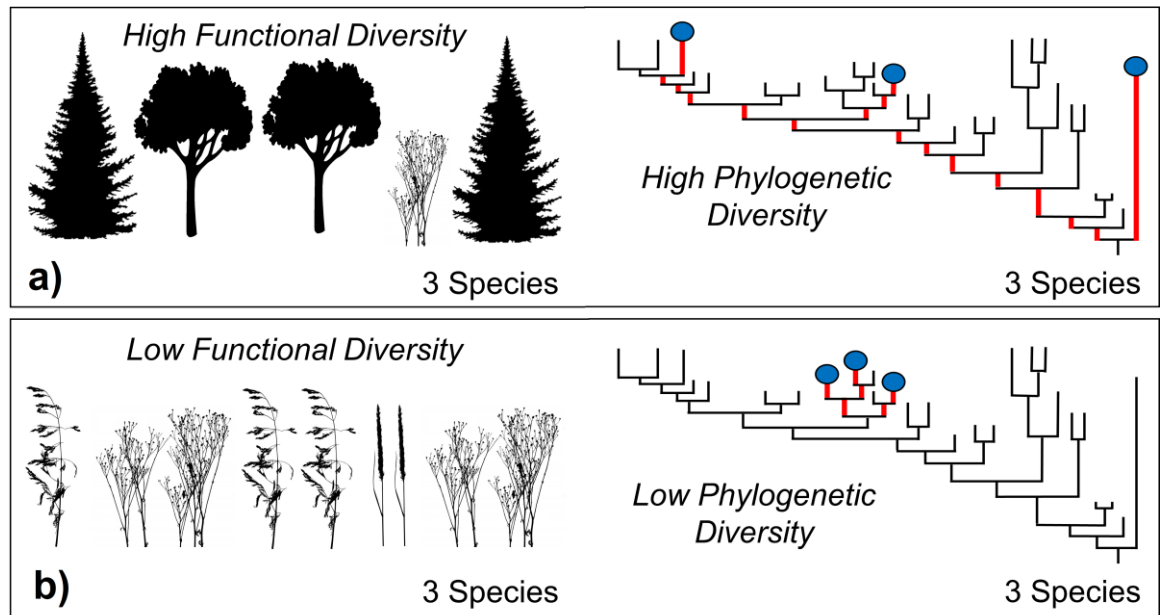


Figure 1.1 Illustration comparing taxonomic, functional, and phylogenetic diversity. Both assemblages have the same taxonomic diversity, with three species. The species in assemblage a) have a wider range of functions (greater functional diversity) than assemblage b). Similarly, the species in assemblage a) also have a wider phylogenetic distribution (greater phylogenetic diversity) compared to assemblage b). Figure modified from Brent Mishler (2014) Scientists enlist big data to guide conservation efforts. *Nature Communications*, University of California – Berkeley <https://phys.org/news/2014-07-scientists-big-efforts.html>.

1.2 A Multi-Faceted Approach to Biodiversity Conservation

1.2.1 Defining functional diversity and conservation applications

Swenson (2014) defines functional diversity as the “diversity or dissimilarity of the ecological strategies or performance of species upon the basis of their morphological physiological traits”. Functional diversity is an important facet of biodiversity that has gained a lot of attention in recent decades. This is largely attributed to an increased focus on mechanistic approaches that directly link traits to ecosystem functions, competitive interactions, and how traits relate to a species’ resilience to disturbances.

There are two main types of functional traits: functional effect and functional response traits (Diaz & Cabido, 2001). Functional effect traits are traits that contribute to ecosystem functions and ecosystem services. Functional effect traits are typically related to nutrient cycling, trophic transfer, and an individual’s ability to capture and conserve

resources (Grime, 2001; Leps *et al.*, 2006). The ability to fix nitrogen is an example of a functional effect trait, and one that can have desirable ecosystem effects. For example, Spehn *et al.* (2002) found that the presence of nitrogen-fixing legume species in an assemblage had a significant impact on the productivity of the assemblage, such that all species within an assemblage with legumes had significantly more above-ground biomass than assemblages without legumes. Notably, however, the presence of nitrogen-fixing plants can also negatively impact ecosystems: in one greenhouse experiment, it was shown that assemblages with soil enriched with fixed nitrogen from a native lupine species were more likely to have fewer native species and lower species richness than assemblages without lupine (Maron & Connors, 1996).

Functional response traits are traits that relate to a species' response to the abiotic and biotic disturbances, and typically measure the sensitivity and adaptive capacity of a plant. These can include traits that relate to dispersal, fecundity and resistance to disturbance, such as dispersal method, seed production, and bark thickness. Thus, as landscapes and climates change at a rapid pace, the resilience of the affected ecosystems will depend in part on the diversity of functional response traits within the constituent plant assemblages. When an assemblage possesses individuals with distinct environmental responses, the assemblage can be buffered to the stressor via compensatory dynamics (Gonzalez & Loreau, 2009). This means that if two competing species respond differently to environmental stressors, while one species is heavily impacted, the competing species is able to increase in abundance, and vice versa. If instead, all species in an assemblage responded in the same way to an environmental stressor, a whole assemblage can be devastated to one stressor or disturbance. Functional insurance, or the ability for an assemblage to maintain long-term ecosystem functioning due to variation in functional responses, is an important mechanism related to assemblage resilience.

Functional response traits can also be used to assess how an assemblage will respond to restoration efforts. Clark *et al.* (2012) found that plant trait models explained as much variability in plant responses to restoration efforts as species identity models, and thus could be used to make generalizations as to how plant assemblages would respond to restoration efforts. Most restoration efforts are species or site-specific; plant

traits may allow for more general characterizations of species responses to restoration treatments. Kane *et al.* (2017) also classified grassland species into functional types in order to evaluate how these groups would respond to different restoration efforts under different climate change scenarios. While the species within the functional groups did not have consistent responses to the climate changes scenarios (ie. within a given group, some species would have increased habitat suitability while some would have decreased habitat suitability), they did find that habitat suitability for shrub and tree species, as well as tall fescue (*Schedonorus arundinacea*), an invasive species in the region, would decrease. They emphasized that restoration efforts should consider how plant traits will impact a species' ability to persist in the future.

1.2.2 Defining phylogenetic diversity and conservation applications

Phylogenetic diversity measures the amount of evolutionary history that is represented by a given assemblage. The importance of conserving unique evolutionary histories, as well as advances in molecular sequencing and more readily available phylogenetic information, have resulted in the increased assessments of phylogenetic diversity (Davies & Buckley, 2011). The majority of phylogenetic diversity measures are based on the assumption that evolution occurs according to the Brownian motion model, assuming that traits evolve at the same rate across a phylogenetic tree, and that phylogenetic distances are representative of the amount of time since divergence from a common ancestor (Cadotte *et al.*, 2013). These assumptions are not always realistic, as exemplified by rapid diversification and niche filling among cichlid fish in African lakes, and convergence of traits amongst distantly related species under harsh environmental conditions (eg. Cactaceae and Euphorbiaceae) (Cadotte *et al.* (2013)).

Faith (1992) and Vane-Wright *et al.* (1991) were among the first to describe the importance of phylogenetic diversity in conserving biodiversity. Taxonomic diversity measures implicitly regard species as equal. Yet, species do not necessarily carry the same weight in terms of our conservation priorities. Vane-Wright *et al.* (1991) emphasizes this in asking the questions, "To a conservationist, regardless of relative abundance, is *Welwitschia* equal to a species of *Taraxacum*? Is the panda equivalent to one species of rat?" The answer may seem obvious, considering that the *Welwitschia* is

considered to be a living fossil, in a family with no other species, while the *Taraxacum*, or dandelion, genera is one of the most speciose. Phylogenetic diversity measures provide a method for quantifying this conservation value.

Although the importance of preserving evolutionary history is generally considered to be important in conservation prioritization, it is rarely implemented into conservation planning. The Evolutionarily Distinct and Globally Endangered (EDGE) of Existence program introduced by the Institute of Zoology in London, UK brings to light a prioritization scheme that combines both the evolutionary distinctiveness of a species as well as its global threat of extinction (Isaac *et al.*, 2007). This EDGE metric has been used to identify species of conservation priority around the world. Earlier work by Heard *et al.* (2000) and Mooers *et al.* (2008) suggests that extinction risk may be phylogenetically related. Later work by Davies & Buckley (2011) also found that plant species-at-risk in the South African Cape were phylogenetically clustered.

In terms of phylogenetic diversity conservation, it is also important to consider the affects that climate change will have. Thuiller *et al.* (2011) assessed how climate change would impact plant, bird, and mammal assemblages in Europe across the phylogenetic tree. Their results showed that phylogenetic diversity would be greatly reduced in high latitude and altitude areas, and that spatial turnover may be reduced by as much as 34% by 2080 in Europe, leading to continent-wide trend towards phylogenetic homogenization. These results emphasize the importance of considering phylogenetic diversity in biodiversity conservation efforts, as there has already been evidence of a trend towards phylogenetic homogenization.

1.2.3 Challenges related to the quantification of functional diversity that may be compensated for by coupling with phylogenetic diversity assessments

While focus on functional and phylogenetic biodiversity assessments is increasingly emphasized in biodiversity conservation research, there are still significant challenges to quantifying these facets. For one, functional diversity assessments depend on decisions about the set of functional traits that best signal the ecosystem function or response of interest. These decisions can be hard to make considering that biological systems are incredibly complex and traits that may be important to assess may be

overlooked, or trait data may be limited (Cadotte *et al.*, 2013; Davies *et al.*, 2016). Although phylogenies are continually being updated with new genetic information, phylogenetic diversity is considered to be easier to quantify and to more directly represent the actual degree of phylogenetic diversity represented by an ecological assemblage. Phylogenetic diversity measures are therefore often used to represent the evolutionary divergence of traits (Cadotte *et al.*, 2013; Chalmandrier *et al.*, 2015). If a suite of traits has a strong phylogenetic signal that means that closely related species are likely to retain the same ancestral functional traits. If this is the case, phylogenetic diversity may be a good predictor of functional diversity, as it may be representative of functional diversity based on unmeasured traits (Davies *et al.*, 2016). Cadotte *et al.* (2008) found that phylogenetic diversity was a better predictor of ecosystem productivity than species richness and functional diversity, where assemblages composed of more distantly related species had more stability than those more closely related.

Although phylogenetic diversity may be a good indicator of functional complementarity in the absence of complete trait data, it must be acknowledged that this is not always considered to be a good proxy. One reason for this is that phylogenetic diversity estimations are based on the neutral or Brownian motion model of evolution, which assumes that evolution occurs randomly across evolutionary history. However, it is likely that the traits that are relevant to specific ecosystem functions are likely under evolutionary selection (Davies *et al.*, 2016).

Two methods of community assembly that are commonly linked to phylogenetic relatedness are competitive exclusion and habitat filtering. Competitive exclusion assumes that closely related species are less likely to co-occur, and assemblages structured by competitive exclusion are typically considered to be “phylogenetically overdispersed” (Miller *et al.*, 2016). Habitat filtering on the other hand assumes that assemblages are structured based on their ability to withstand the environmental conditions or habitat that they are found in, resulting in assemblages that are “phylogenetically clustered”, with species that are more closely related than expected by chance, and possess similar traits (Miller *et al.*, 2016).

1.2.4 Rationale for consideration of both functional and phylogenetic diversity in conservation strategies

Biodiversity quantification and conservation is commonly based on species richness or other measures of taxonomic diversity alone (Devictor *et al.*, 2010; Marchese, 2015). Species-at-risk are another common priority in conservation decisions. While it is reasonable to prioritize areas that are known to support many species, or species that are at risk of extirpation or extinction, these conservation prioritization methods do not consider the distinct ecological functions and evolutionary histories that species may possess. For example, Hidasi-Neto *et al.* (2013), found that bird species that were put on the “Red List” in Brazil did not comprise greater FD or PD than expected by selecting an equal number of species at random, meaning that they were not ecologically or evolutionarily distinct species. Daugherty *et al.* (1990) also describes the taxonomic debate regarding the tuatara (*Sphenodon* spp.) in New Zealand in the early 20th century. Until 1990, the tuatara were considered to be a single taxonomic species, and was not considered to be taxonomically rare or threatened, being one of 6000 species in the suborder Rhynchocephalia (ie. lizards and snakes), and therefore did not receive significant conservation focus (VaneWright *et al.*, 1991; Redding & Mooers, 2006). Since 1990, genetic research has identified multiple subspecies or geographic variants of tuatara and identified the tuatara as being evolutionary distinct members of the Rhynchocephalia suborder. By 1990, however, one subspecies of tuatara that resided on the Cook Islands had become extinct. The tuatara are now considered to be “living fossils”, representing unique evolutionary histories and contributions to ecosystem functioning, and are now being considered as conservation priorities. These examples emphasize that all three facets of biodiversity, taxonomic, functional, and phylogenetic diversity, should be considered in order to fully encapsulate the variation in biological functions and evolutionary history, especially in the context of conservation.

When these three facets of biodiversity are used congruently to assess biodiversity patterns of assemblages, they can provide a more holistic approach that simultaneously considers multiple conservation objectives when considering areas for conservation priority, and also considers how a diversity of ecological functions and phylogeny in a community can provide resilience against disturbances such as climate change. For

example, when assessing global patterns of biodiversity hotspots based on species, functional and phylogenetic diversity of mammals, Mazel *et al.* (2014) found large spatial discrepancies in the three diversity measures, emphasizing the need for a multifaceted approach when assessing biodiversity for conservation strategies. Strecker *et al.* (2011) assessed taxonomic, functional, and phylogenetic diversity patterns of freshwater fish in the Lower Colorado River Basin, and although they found 75% congruence between the three diversity facets, they did highlight areas with disproportionately low diversity for each of the facets as areas of conservation focus. When assessing taxonomic, functional, and phylogenetic diversity patterns of bird species in protected areas in France, Devictor *et al.* (2010) found that functional diversity was not well represented, while taxonomic diversity was over-represented in protected areas. Thuiller *et al.* (2014) also found large discrepancies in patterns of current and future taxonomic, functional, and phylogenetic diversity for plant assemblages at different elevations in the French Alps. Albouy *et al.* (2017) identified hotspots for all three facets of biodiversity for marine mammals at a global scale and found that functional diversity hotspots were least correlated with species richness hotspots. While considering all three facets simultaneously can help overcome the limitations and assumptions associated with all three facets, these three facets also encapsulate the broad range of ecological functions and evolutionary histories that assemblages may possess. While there are many more studies that have adopted this multi-faceted biodiversity approach, species richness remains the main method of quantifying and conserving biodiversity at a regional scale. As most other studies have found a lack of spatial congruence for the three biodiversity facets, developing conservation strategies based on species richness alone may be resulting in the loss of functional and phylogenetic diversity.

1.3 The Okanagan Ecoregion and associated conservation efforts

The Okanagan Ecoregion (shown in Figure 1.2), defined by the Nature Conservancy, is an area of over 9.6 million hectares (96,000 km²) located within the rain shadow of the Cascade and Columbia mountain ranges, spanning the international boundary between south-central British Columbia and north-central Washington. Many species in the Okanagan Ecoregion are at their northern range limit but thrive in the mild

and dry climate that is found year-round in the Okanagan Ecoregion. Some of the most endangered ecosystems in British Columbia occur in this ecoregion, including low-elevation grasslands, shrub-steppe, and dry Ponderosa Pine forests. The physiography of the region is defined by repeated glaciation events during the Pleistocene Epoch 2.5 mya to 10 mya, which resulted in the wide valleys, large lakes, and rolling hills and plateaus, that are characteristic of the Okanagan (Nasmith, 1962). The elevation varies from 300 masl in the valleys to over 3,000 masl in the mountain ranges, resulting in a particularly high variance in climate across the region (Pryce *et al.*, 2006). The west is found within the rain shadow of the Cascade Mountains, resulting in a dry and hot climate giving the desert-like conditions characteristic of the Great Basin. To the east and in high elevation areas, temperatures decrease drastically and greater volumes of precipitation are typical.

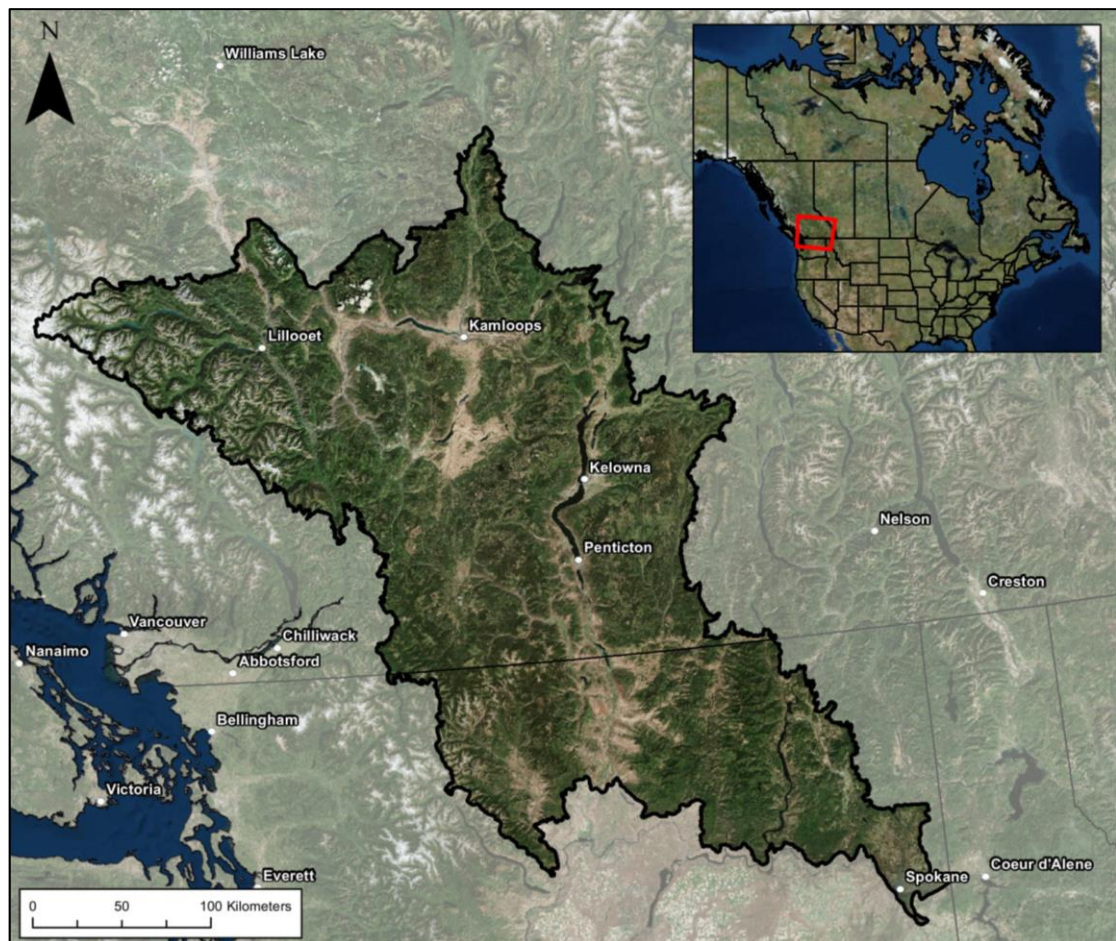


Figure 1.2 Okanagan Ecoregion (Nature Conservancy). Figure created by Carmen Chelick.

Biogeoclimatic (BEC) zones were developed by Dr. V.J. Krajina and his students from the University of British Columbia in the 1960s, characterizing ecosystems based on climate, soil, and vegetation (Meidinger & Pojar, 1991). Over 90% of the Okanagan Ecoregion is characterized by five BEC zones (Figure 1.3). BC Ministry of Forests (Meidinger & Pojar, 1991) generally describes these zones as follows. The Bunchgrass Zone (BG) is found at lower elevations in the region, and is dominated by bluebunch wheatgrass (*Agropyron spicatum*), with shrubs such as big sagebrush (*Artemisia tridentata*) found interspersed, and a defined cryptogam crust covering the ground. This zone has been impacted by overgrazing by livestock, which has dramatically altered the natural condition and structure of these plant assemblages. The Ponderosa Pine Zone (PP), with its dry, open canopied forest stands made up of Ponderosa pine (*Pinus ponderosa*) and understory of bluebunch wheatgrass, forbs, and the occasional shrubs, is found at middle elevations. Frequent fires are also a large part of the natural ecological cycles of this zone, with many serotinous species and species that depend on periodic fires to carry out life history stages. Fire suppression causing a build-up of fuel, as well as climate change, has increased the severity and frequency of fires in this zone in recent years. Along the elevational gradient, Interior Douglas-fir Zones (IDF) are typically found above the PP zone, although they are known to also occur at lower elevations. IDF zone forests are comprised of Interior Douglas-fir (*Pseudotsuga menziesii*), typically have more of a closed canopy, and can have a variable understory assemblage, depending on moisture and temperature conditions. IDF zones have experienced impacts from historical logging practices and cattle grazing. The Montane Spruce (MS) Zone typically occurs above the IDF zone and is comprised of open spruce (*Picea* spp.) and subalpine fir (*Abies lasiocarpa*) forests, with shrubs such as black huckleberry (*Vaccinium membranaceum*) and grouseberry (*Vaccinium scoparium*), and a variety of forbs and grasses. Logging and mountain pine beetle outbreaks have had significant impacts climax MS ecosystems. The Englemann Spruce – Subalpine Fir (ESSF) zone occurs at the highest alpine elevations. While closed canopy forests of Englemann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are typical of the climax condition of this zone, subalpine meadows containing a diverse herbaceous plant assemblages are also characteristic of this zone. Logging practices have also had significant impacts on the plant assemblages in this

zone. Most of these zones are in the “xh” subzone, which is indicative of the very hot, dry climates characteristic of the Okanagan Ecoregion. This ecoregion is considered to be a biodiversity hotspot in Canada, while also harbouring plant, bird and other animal species that do not occur anywhere else in Canada.

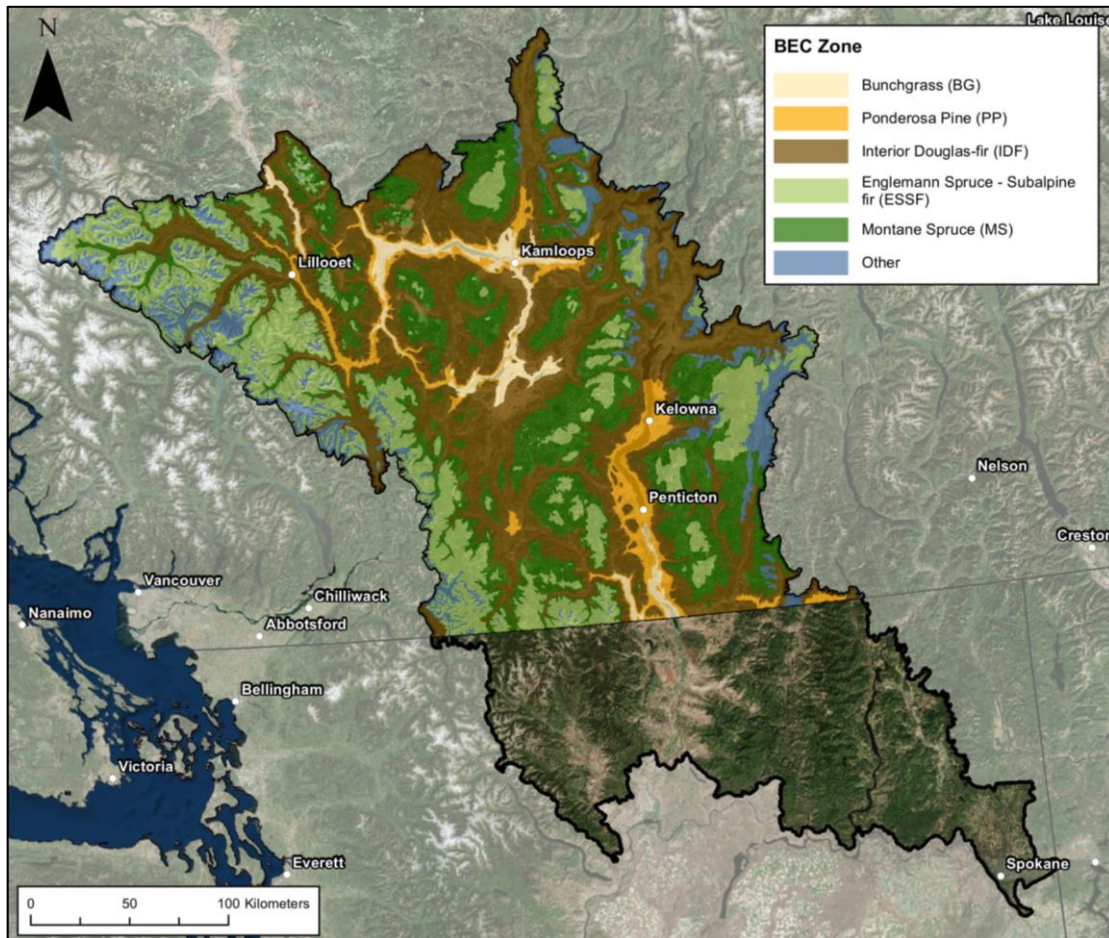


Figure 1.3 Biogeoclimatic zones found within the Okanagan Ecoregion. Figure created by Carmen Chelick.

The favourable climate and presence of mineral-rich soil created from sediments left behind from the last glacial cycle has also brought a great deal of development to the valley. Irrigation advancements in the 1930s resulted in the rapid growth of commercial orchards and vineyards. Currently, the Okanagan produces a large portion of the country's fruit, particularly apricots and sweet cherries. The Okanagan is also the second largest wine producing region in Canada. There are currently 172 licensed wineries in the central Okanagan valley alone, covering 8,619 acres of land, all benefitting from the

warm climate, variable terrain and mineral-rich soil. The Okanagan is also visited by millions of tourists each year. The rapid growth of the Okanagan's agricultural and tourism industries over the last century, along with other industries such as manufacturing and forestry, has endangered the diverse habitats and unique species of the Okanagan. Using aerial photographs dating back to the 1800s, Lea (2008) shows the rapid change that has occurred over the Okanagan landscape. Some of his results include a 53% decline in Ponderosa Pine-Bluebunch Wheatgrass ecosystems, a 92% decline in Water Birch-Red-osier Dogwood ecosystems, and an 84% decline in low-elevation wetlands. According to the BC Ministry of Environment, the BGxh grasslands and open PPxh forests are considered to be two of the most endangered ecosystems in Canada, and approximately 30% of the BC's Red-listed wildlife species and 46% of BC's Blue-listed wildlife species reside in the South Okanagan. Figure 1.4 shows examples of three plant species-at-risk that have global or continental ranges that are limited to the Okanagan Ecoregion. Species populations are likely to become even more impacted as development pressures continue to limit the availability of habitat, and climate change alters the conditions of the habitat.

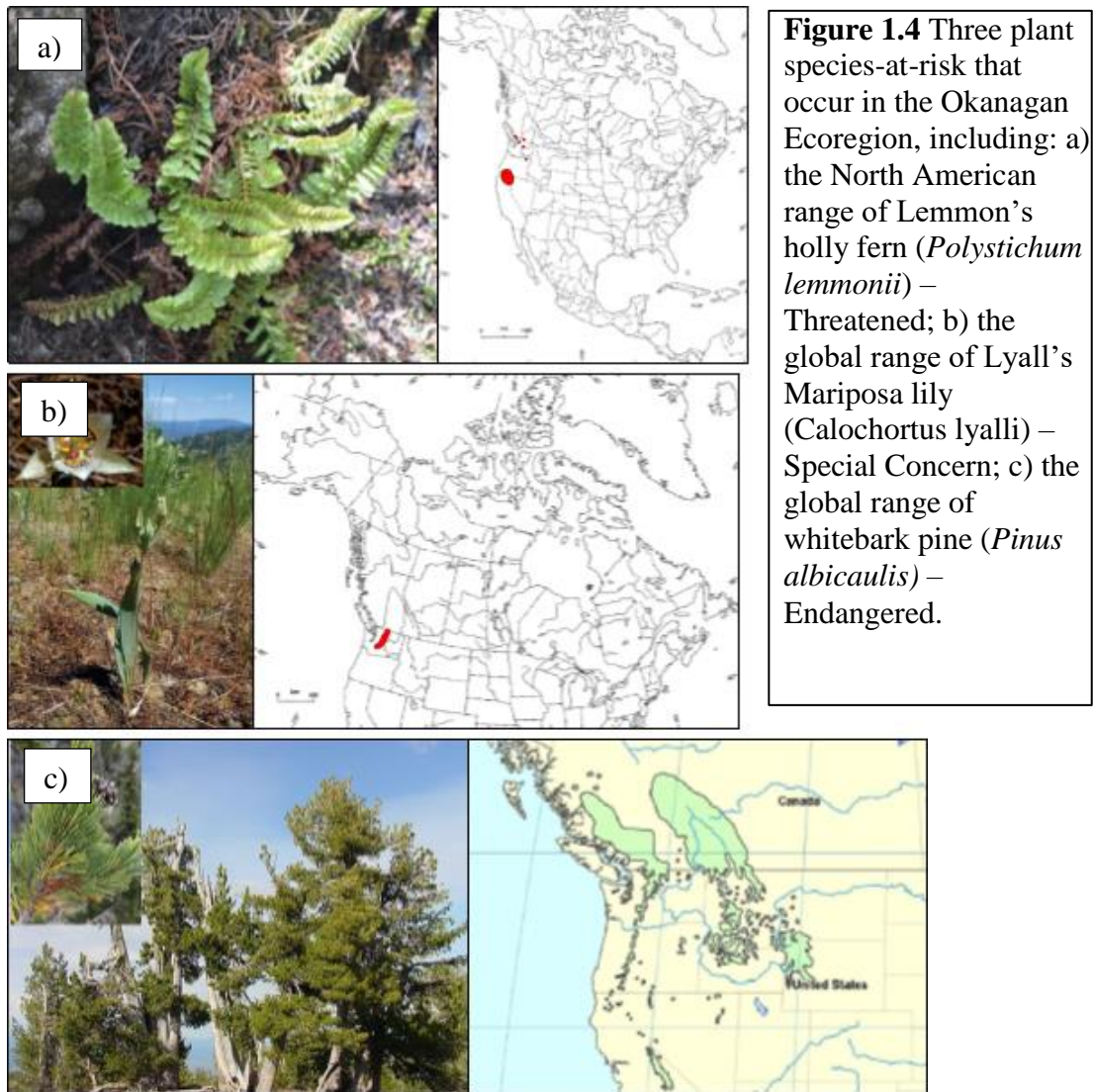


Photo and map credit: a) Southern Interior Rare Plants Recovery Implementation Group (2007) Recovery Strategy for the Lemmon's holly fern (*Polystichum lemmonii*) in British Columbia. Prepared for the British Columbia Ministry of Environment; b) Southern Interior Rare Plants Recovery Implementation Group (2008) Recovery Strategy for Lyall's Mariposa Lily (*Calochortus lyallii*) in British Columbia. Prepared for the British Columbia Ministry of Environment; c) COSEWIC (2010) COSEWIC Assessment and Status Report on the Whitebark Pine (*Pinus albicaulis*) in Canada. Committee on the Status of Endangered Wildlife in Canada.

The deterioration of the Okanagan's natural environment has not gone unnoticed by local government and non-government organizations that aspire to protect and restore biodiversity in the Okanagan. The South Okanagan Similkameen Conservation Program (SOSCP) began in 2000 as a partnership between various organizations that had the common interest of maintaining "A healthy environment that sustains the diversity of indigenous plants and animals while enriching people's lives" (SOSCP, 2016). Their

work has focussed on helping to assess the status of biodiversity in the South Okanagan and develop recommendations for maintaining biodiversity in the region (OCCP, 2014). Building on this, the Okanagan Collaborative Conservation Program (OCCP) worked to do the same assessments for Central and North Okanagan. These assessments involved the development of four decision support tools, maps representing conservation rankings, land management classes, habitat connectivity, and relative biodiversity.

Relative biodiversity was assessed based on biodiversity proxies such as distance from roads, size of natural areas, and the presence of important ecosystems, habitat features, or species at risk. Although this is a good starting point, these proxies do not necessarily represent the multi-faceted nature of biodiversity. For example, while prioritizing the conservation of species-at-risk is a prominent conservation tactic and there are often legislative requirements for their protection, they may not represent species that have diverse ecological traits and evolutionary histories. Species-at-risk assessments nationally, via the Canadian *Species at Risk Act*, are based on the IUCN's guidelines for identifying threatened species (Redding & Mooers, 2006). These guidelines are characterizing a species' conservation worth based on the degree of threat that they are faced with and assume equal worth for all species (Redding & Mooers, 2006). While prioritizing species based on decreasing population sizes and likelihood of extinction is a good tactic, increasing pressures will make it more difficult to continue to prioritize threatened species for conservation as there become more and more species with the risk of extinction. Therefore, when faced with prioritization of species for conservation outside of extinction risk, the distinct evolutionary histories and ecological traits, including traits that contribute to ecosystem services and their resilience to disturbances, should be considered.

The Nature Conservancy of Canada also used MARXAN software to produce conservation portfolio's identifying priority conservation areas in the Okanagan Ecoregion (Pryce *et al.*, 2006). This assessment used terrestrial and aquatic species and ecosystems as conservation targets, which were given scores of irreplaceability and vulnerability. Irreplaceability is measured as the number of sites that have the same ecological composition or representation as a given site and vulnerability is measured as the likelihood of an area losing biodiversity value (Margules & Pressey, 2000). To date,

functional and phylogenetic diversity have not been considered within evaluations of irreplaceability and vulnerability in the Okanagan Ecoregion.

One of the most common and effective methods for conserving species is the establishment of protected areas. While the establishment of protected areas is typically based on the ability to procure land, they are often chosen based on biodiversity hotspots or ecological representation. A network of protected areas, including provincial and regional parks, wildlife management areas, and private conservations lands with varying levels of protection is shown in Figure 1.5. These protected areas encompass around 800,000 hectares (8,000 km²) of land, approximately 8% of the Okanagan Ecoregion. In 2016, a national park was proposed to be established in the South Okanagan in order to have these arid, low elevation grassland ecosystems represented in the national park network. Another initiative within the Okanagan Ecoregion, the Transboundary Climate-Connectivity Project¹, explored the impacts that climate change will have on wildlife movement through the Washington-British Columbia transboundary area (Krosby *et al.*, 2016). By modelling future changes in the distributions of wildlife species of interest and vegetation assemblages, they identified corridors that would optimize wildlife movement throughout the region as climate changes. As protected areas and movement corridors are established in the Okanagan Ecoregion, maps representing hotspots of taxonomic, functional, and phylogenetic diversity would contribute to land acquisition decisions by ensuring that species richness is not the only facet of biodiversity being represented.

¹ <https://cig.uw.edu/resources/analysis-tools/the-washington-british-columbia-transboundary-climate-connectivity-project/>

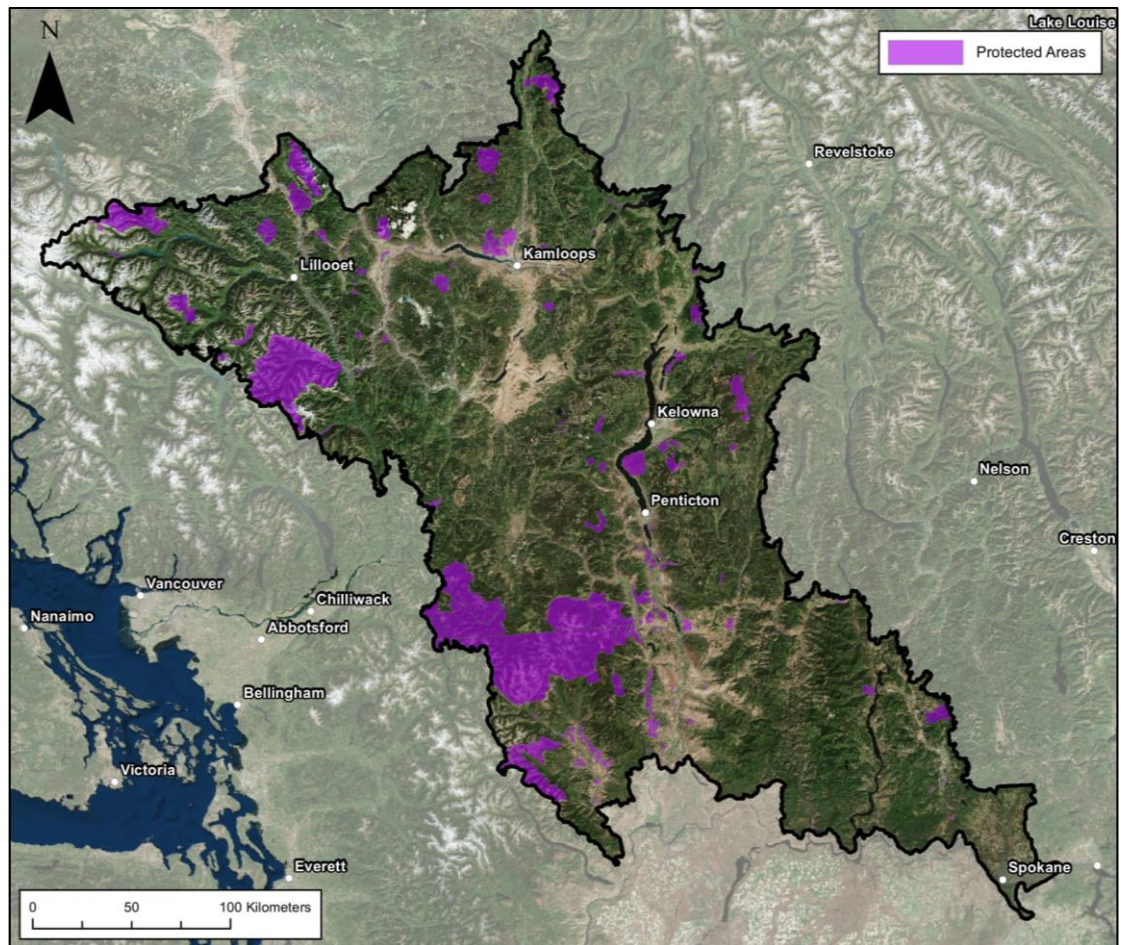


Figure 1.5. Protected areas in the Okanagan Ecoregion. Figure created by Carmen Chelick.

1.4 Thesis objectives

My general objective in this thesis is to inform biodiversity conservation efforts in the Okanagan Ecoregion by quantifying and documenting, for the first time, current and future geographic patterns of taxonomic, functional, and phylogenetic diversity among the region's vascular plants. My specific objectives are as follows:

- 1) To develop a reproducible protocol for predicting current and future patterns of taxonomic (TD), functional (FD), and phylogenetic diversity (PD) at regional extents;
- 2) To apply this protocol to plant assemblages in the Okanagan Ecoregion of southern British Columbia and northern Washington State, in order to:

- i) generate novel biodiversity maps that include estimates of current taxonomic, functional, and phylogenetic diversity, and that identify potential ‘hotspots’ of biodiversity;
- ii) generate maps of predicted future biodiversity patterns, based on predicted future climate data;
- iii) quantify geographic congruence among the three diversity facets;
- iv) determine the degree to which the three facets of diversity overlap with the current protected area network.

There are a number of aspects of this research that are novel, including the use of species distribution models (SDMs) to predict functional and phylogenetic diversity of such a wide range of taxa at a resolution high enough to produce maps that could be interpreted on a regional level. Chapter 2 of this thesis reviews the tools and data used to assess taxonomic, functional, and phylogenetic diversity patterns. Chapter 3 outlines the identification of hotspots of taxonomic, functional, and phylogenetic diversity of plant assemblages in the Okanagan Ecoregion. Chapter 4 concludes the thesis and summarizes future directions for this work.

2 Quantifying and mapping taxonomic, functional and phylogenetic diversity at a regional scale: a review of methods and a proposed reproducible protocol

2.1 Using species distribution models (SDMs) to quantify taxonomic, functional, and phylogenetic diversity

In order to quantify the three facets of biodiversity, distributions of all species within the region of interest are required. Range maps or presence point-to-grid maps are often used as the basis for predictions of taxonomic diversity (Devictor *et al.*, 2010; Mouillot *et al.*, 2011; Mazel *et al.*, 2014; Albouy *et al.*, 2017). However, these methods have been used more often for national or global estimates of diversity, and therefore do not have fine enough resolution to be useful at a regional level, where conservation planning typically takes place (Graham & Hijmans, 2006). The development of new, open source software, such as R Statistical Programming Software, as well as the increased availability of species occurrence data and environmental predictor data have resulted in the increased use of species distribution models (SDMs) to create predictions of multiple facets of biodiversity.

SDMs have been used for a variety of species and for a variety of purposes. Some SDMs, such as MaxEnt, have been demonstrated to produce accurate predictions of the ranges of rare and threatened species, even when limited occurrence data is available. Hernandez *et al.* (2006) demonstrated that MaxEnt was able to produce accurate predictions of ranges for threatened animal species in California, even for species with as few as 5 occurrences. Murray-Smith *et al.* (2009) used SDMs to predict areas of endemism for threatened species of *Myrtaceae* in coastal Brazilian forests. SDMs have also been used as cost-effective methods to predict invasion potential for introduced species. After creating SDMs for 15 invasive plant species in Southeast Asia, Truong *et al.* (2017) found that shrub species had the highest risk of invasion, and native species had an equal or even greater risk of becoming invasive, or expanding into areas that they were not currently known to inhabit, compared to non-native species. Ensing *et al.* (2013) used SDMs to predict the invasion of *Pilosella glomerata*, a hawkweed species, in

British Columbia, Canada, while also emphasizing that the reliability of these predictions is based on reliability in taxonomic identification.

SDMs have also become increasingly used to predict species richness. There are two approaches that have been commonly used to model the species richness of ecological assemblages: stacked species assemblage modelling and direct assemblage or environment-regression modelling approaches (Algar *et al.*, 2009; Ko *et al.*, 2016). Direct assemblage models estimate species richness using a “top-down” approach that relates the number of species in an assemblage to environmental predictors, and predicts outwards using regression/correlative approaches. One of the drawbacks to direct assemblage modelling techniques is that it does not consider assemblage composition, or the identity of the species within the assemblage, which is important for functional and phylogenetic diversity assessments. Generally, stacked species distribution models (S-SDMs) predict the individual distributions of multiple species, based on known occurrences and environmental predictors, and stacks them to obtain a measure of species richness. The main drawback of this approach is that it assumes that species distributions are based on their relationships with environmental variables only, and does not consider the effect that biotic interactions, adaptive or evolutionary processes, or dispersal limitations may have on their distributions (Drake, 2014; Zhang *et al.*, 2015). S-SDMs therefore often result in an overestimate of species richness. The range of environmental conditions that a species is able to live in is typically referred to as a species’ “fundamental niche”. Typically, stacked SDMs are not able to consider a species’ “realized niche”, or the range within which a species is actually found within, taking biotic interactions, adaptive or evolutionary processes, and dispersal limitations into account. With the assumption that S-SDMs are only able to consider species’ fundamental niche, assessments of taxonomic, functional, and phylogenetic diversity based on S-SDMs should be considered as predictions of “potential” diversity. Nevertheless, when compared to direct assemblage modelling approaches, S-SDMs typically yield accurate predictions of species richness (Ko *et al.*, 2016; Zurell *et al.*, 2016; Da Mata *et al.*, 2017).

Since S-SDMs are based on environmental predictors including climate, future climate scenarios are able to be used to predict future patterns of taxonomic, functional,

and phylogenetic diversity. Considering how assemblages will be impacted by climate change and other disturbances is an important aspect of conservation planning.

Conservation efforts are largely focussed on how species and ecosystem services are responding to current environmental conditions. However, climate projections show that environmental conditions are predicted to change drastically in the next century, which will have significant impacts on ecological assemblages (Hamann & Wang, 2006; Shafer *et al.*, 2015). Kane *et al.* (2017) used S-SDMs to predict how climate change will impact the habitat suitability of grassland species in the US Midwest, and therefore, how effective current restoration activities will be. Thuiller *et al.* (2014) also used S-SDMs to predict taxonomic, functional, and phylogenetic diversity for over 2,500 plant species in the French Alps, based on current and future climate conditions. They generally found that the current protected area network sufficiently protected current and future diversity patterns for all three facets of biodiversity.

2.2 Creating species distribution models using MaxEnt

Within the last two decades, many methods for creating SDMs have been developed. When compared to other models, MaxEnt often emerges with the highest predictive performance, and is especially robust to small sample sizes (Elith *et al.*, 2006; Fourcade *et al.*, 2014; Wan & Zhang, 2016; Kane *et al.*, 2017; Truong *et al.*, 2017). Its consistently high performance when predicting species distributions has been attributed to its ability to handle complex interactions between the species occurrences and the environmental covariates or predictor variables (Fourcade *et al.*, 2014; Truong *et al.*, 2017). While MaxEnt can be employed using a downloadable desktop application, it can also be accessed through functions available in multiple packages in R Statistical Programming software. Due to its ease of use coupled with robust results, it has been used in a wide range of applications (Elith *et al.*, 2011a), from complex assemblage ecology modelling, to species range and biodiversity mapping produced by government and non-government organizations, including the Point Reyes Bird Observatory online application and the Atlas of Living Australia.

2.2.1 How does MaxEnt work?

There are two main categories of SDMs: correlative and mechanistic (Shabani *et al.*, 2016). Although they have the potential to produce more accurate models, mechanistic approaches to SDMs require a vast amount of data and computational effort to properly model the complexities of the interactions involved in estimating species distributions. Correlative models on the other hand are easier to parameterize and can produce useful model outputs. MaxEnt, created by Phillips *et al.* (2006) is a correlative model that uses a machine learning approach and the Principle of Maximum Entropy to relate species occurrences with environmental data. According to this principle, the probability distribution that gives the best estimate for the system of interest is the distribution that maximizes entropy or uncertainty, while remaining within the constraints of the moments of the measured data. In the case of MaxEnt models, the constraints of the model are given by the statistical moments (the mean, variance, etc.) representing the environmental conditions at the locations of the species presences. The unknown distribution, or relative suitability of habitat for the given species, across the area of interest is therefore constrained by the environmental conditions experienced at the presence locations.

MaxEnt does not require absence data, but instead takes a presence-background modelling approach. Random samples from within the subject area are collected (default is typically 10,000 points), and represent the “background” conditions, or the range and variation in environmental conditions across the study area (Elith *et al.*, 2011b; Kane *et al.*, 2017). This background data represents the null condition where without occurrence data, a given species has no particular suitability for one environment over another and would instead be found in certain environmental conditions based on their availability (Elith *et al.*, 2011b). With the estimation from the background data as the base, the probability distribution becomes further constrained by the moments of the environmental conditions at the species occurrence locations. Because the MaxEnt model must be constrained to the moments of multiple covariates at once, the MaxEnt model performs transformations of the covariates, turning them into “features”, in order to allow complex relationships between covariates to be considered simultaneously (Elith *et al.*, 2011b). It is often the case that there are more features than covariates. According to Elith

et al. (2011a), MaxEnt has six classes of features: linear, product, quadratic, hinge, threshold and categorical, and by default, MaxEnt restricts the features based on the number of samples given. Linear features are always used, quadratic features are used with a minimum of 10 samples, hinge with 15 samples, and threshold and product features with more than 80 samples (Elith *et al.*, 2011b; Zhang *et al.*, 2016). However, the features used can also be set manually. With the potential to create many different features to fit the distribution to, MaxEnt models can quickly become overfit. In order to reduce overfitting, regularization can be applied to the distribution. Regularization penalizes complexity and creates a distribution that is more smooth, with higher values creating models that are overfit (Elith *et al.*, 2011b; Truong *et al.*, 2017)

The final output of the MaxEnt model comes as a raw representation of the exponential model or can be given in logistic output, with values between 0 and 1 that are generally representative of relative habitat suitability. Due to the nature of the conversion from raw output to logistic output, a number of assumptions about species prevalence across the landscape are made, so when possible, the raw output should be used to represent a specie's predicted distribution (Elith *et al.*, 2011b; Merow *et al.*, 2013). However, when trying to predict presence/absence for a species, the logistic output is often used (Merow *et al.*, 2013; Norris, 2014).

In order to convert a logistic output to a presence/absence output, a threshold value at above which to call a species "present" and below which to call a species "absent" must be chosen. It has been demonstrated that the choice of threshold can significantly alter the presence/absence output (Liu *et al.*, 2013; Norris, 2014). Thresholds are chosen either as an arbitrary value between 0 and 1, or are chosen statistically in relation to the model fitting. Martinson *et al.* (2016) for example used a threshold of 50% to delineate the range of 30 vascular plant species in North America. Less subjective thresholds however are produced as a result of the MaxEnt model. The minimum training presence threshold for example is a threshold that will result in a binary surface where all the training samples (discussed in further detail in Section 2.2.4) will be included as presences. Another set of commonly used thresholds produced by MaxEnt are the fixed cumulative value thresholds (5, 10, 15), which result in a binary surface that, in the case of the fixed cumulative value 5 threshold, will include all but 5%

of the training samples as presences. MaxEnt produces a number of different thresholds based on different aspects of the model inputs and model fitting, and it can be difficult to determine which threshold suits the data best.

Some things to consider when choosing a threshold are how broad you want your prediction to be, the types of error that you are most concerned about limiting, and your confidence in the input occurrence data (Norris, 2014). This largely depends on the goal of the model; whether it is being used to identify potential habitat for an endangered species for example, or is being used to identify where a species may currently be found. Norris (2014) found that the areas of unsuitable habitat predicted for lowland tapir in Brazilian forests ranged from 18-85% across seven different threshold values available in MaxEnt. This means that depending on the threshold used, the presence/absence output can be a significant overprediction of the actual distribution of the species. This may be a suitable result in the case of the endangered species, where an overprediction is identifying potential habitat for conservation efforts. However, in the case where the goal is to identify the actual distribution of a species, identifying too large of an unsuitable area may not be ideal. In these cases, more stringent thresholds such as the fixed cumulative value thresholds may be used. The type of error that is more important to minimize and the reliability of the occurrence records should also play a role in threshold choice. Type I error, false positives, or error of commission is an error where the MaxEnt model would predict a species is absent where we have presence records. Type II error, false negatives, or error of omission would produce an error where the model output would predict that a species is present in an area that it is not known to be. While both should be minimized whenever possible, in some cases, one is more detrimental than the other. In the example of the endangered species, which may have reliable but few occurrence records, commission error should be minimized as much as possible, in order to make sure that the known occurrences are included as presences in the model output (Pearson *et al.*, 2007). In this case, a minimum training presence threshold should be used. In the second case, where the goal is to try to predict the range of a species, an overprediction may not give the best representation of the actual range, so a more stringent threshold such as a fixed cumulative value threshold should be used. Although

there are many choices, one should choose a threshold as carefully as possible or consider multiple thresholds and the affect that has on the outcome of the model.

2.2.2 Occurrence data

One of the benefits of MaxEnt is that it is able to use presence-only data. Presence-only occurrence data for plant species is now easily accessible for download from online repositories such as the Botanical Information and Ecology Network (BIEN) and the Global Biodiversity Information Facility (GBIF). There are multiple packages in R Statistical Programming Software that allow occurrence data to be extracted from online sources with ease. Both data sources are able to integrate data from a variety of sources, including peer-reviewed publications, botanical inventories, and museum specimens collected since the 1800s, and create standardization schemes that scrub data for consistent taxonomic nomenclature. GBIF was established in 2001, and includes biodiversity data from all biological organisms around the globe, and has been used in conjunction with MaxEnt to create SDMs for plant species (Martinson *et al.*, 2011; Truong *et al.*, 2017). Work on the BIEN database began in 2008, and was made available in 2016. This database includes vegetation data for North and South America. Both of these databases provide dependable and easily accessible data on which SDMs can be built.

MaxEnt is able to produce a robust model from very few occurrence records due to its ability to consider complex relationships between multiple covariates and the occurrence data. According to Hernandez *et al.* (2006), a minimum of 10 distinct occurrence records is needed to produce an accurate model (Hernandez *et al.*, 2006). Algar *et al.* (2009) used 10 as the minimum number of occurrence records used for their analysis of the distributions of Canadian butterfly species using MaxEnt. Occurrence data used for MaxEnt modelling typically also excludes duplicate records, or points that occur within the same grid cell based on the resolution of the environmental data (Martinson *et al.*, 2011; Shabani *et al.*, 2016; Truong *et al.*, 2017), and records that have low geographic accuracy (i.e. longitudes and latitudes with less than two decimal places). One should also consider the temporal range of the occurrence data (i.e. contemporary or historical) that suites the research question, as species adapt to different conditions and

migrate over time, as well as the source of the occurrence records (ie. herbarium or survey data), as these decisions both introduce bias into the resulting SDM.

Sampling bias relating to the occurrence data used can also alter the outcome of the MaxEnt model. Errors of omission can occur in MaxEnt models if, for example, herbarium records are biased towards certain taxa, seasons, and time periods for which collectors were focussing on (Graham et al., 2016; Martinson et al., 2011). Herbarium records and survey data can also be geographically biased towards areas more easily accessed by surveyors (ie. roadsides). In order to produce the most accurate model possible, it is optimal to have occurrence records that span the full range of environmental conditions that a species can inhabit. Sampling bias is commonly reduced by first removing occurrence records that occur in the same environmental grid cell (Fourcade et al., 2014). In order to further reduce sampling bias, less weight can be applied to occurrence records from areas of dense sampling and more weight given to areas with few records (Shabani et al., 2016; Elith et al., 2010). Another approach to reducing sampling bias involves choosing background points based on a grid representing sampling bias, where each cell is scaled to represent the survey effort given to that cell (Elith *et al.*, 2011a). Regardless of the inevitable biases associated with occurrence data, MaxEnt models have proven to produce informative SDMs.

2.2.3 Predictor variables

The second input into a MaxEnt model is the predictor variables. Climate variables tend to be the main predictors for MaxEnt models. WorldClim makes global climate data freely accessible at resolutions as fine as 30 arcseconds ($\sim 1 \text{ km}^2$ at the equator), and packages are also available to download this data directly from the database into an R environment. BioClim variables, or variables that are considered to have more biological meaning, were derived from temperature, precipitation and seasonality measures and are commonly used in MaxEnt modelling (Hamann & Wang, 2006; Martinson *et al.*, 2011; Shabani *et al.*, 2016; Kane *et al.*, 2017; Truong *et al.*, 2017). WorldClim data is also available for historic, current and future climate. Current climate data from WorldClim data is derived from interpolations of observed data, representative of the years 1960-1990. WorldClim allows the user to select future climate data based on

representative concentration pathways (RCPs) and numerous global climate models (GCMs). GCMs create future climate projections using different mathematical models of the physical processes in the Earth's atmosphere, oceans and land. The "MPI-ESM-LR" GCM from the Max Planck Institute for Meteorology in Germany, for example, considered to be an improvement on the groups previous model, ECHAM5/MPIOM, accounts for surface albedo, aerosol, interactive vegetation dynamics, and the coupled carbon cycle. This GCM is considered to produce a median climate projection for North American climate (Batllori *et al.*, 2017). The four different RCPs were implemented by the Intergovernmental Panel on Climate Change's (IPCC's) Fifth Assessment Report (AR5), and are used to characterize four potential trajectories for atmospheric greenhouse gas concentrations. The range from RCP 2.6, which represents the situation where stringent climate policies that significantly reduce greenhouse gas emissions are implemented, to RCP8.5 which represents the "business as usual" scenario which assumes no change in climate policies than what is currently in place. RCP4.5 and RCP 6.0 fall in the middle of these two scenarios. The availability of such an extensive dataset makes it possible for many different scenarios to be considered for SDMs that look how species distributions may change in the future.

Climate is not the only abiotic variable that may play in to a species' distribution. Variables that relate to the topography of the land, such as elevation, slope, and aspect, also influence species distributions, and are also typically included in MaxEnt models (Martinson *et al.*, 2011; Truong *et al.*, 2017). Soil characteristics, such as soil moisture, nutrient content, and texture are also particularly important to consider when modelling species distributions, particularly plants (Martinson *et al.*, 2011; Zhang *et al.*, 2015; Truong *et al.*, 2017). Biogeoclimatic (BEC) zones characterize plant communities across British Columbia based mainly on climate, topography, and soil characteristics. While climate and topography data is easily accessible, obtaining good quality soil data with the appropriate resolution for a given area is more challenging. MaxEnt is also capable of handling categorical predictors, such as landcover, although they are often given too much weight (Truong *et al.*, 2017).

It is common practice to remove highly correlated predictor variables in order to decrease the noise and flexibility in the model and increase the performance of the model

(Fourcade *et al.*, 2014; Kane *et al.*, 2017; Truong *et al.*, 2017). This is considered to be best practice in most cases. On the other hand, Elith *et al.* (2011) suggests that high collinearity is less of a problem for machine learning methods such as MaxEnt that chooses the predictors that are most important in the model via regularization. This would suggest that if the predictive accuracy of the SDM output is the main goal, and the identification of the relative contributions of the predictor variables in the model is not an important aspect, then all predictor variables should be used as inputs (Merow *et al.*, 2013). Nevertheless, as with any ecological model, predictors selected by experts who are familiar with the species of interest should be given highest priority (Elith *et al.*, 2011a).

Once the desired predictor variables are chosen, one needs to consider the resolution of the data required to satisfy the scope of the study. Kane *et al.* (2017) used a resolution of 30 arcseconds ($\sim 1\text{km}^2$) for their regional assessment of a grassland conservation priority area in Missouri, USA, which encompasses an area of 28,000 hectares. Truong *et al.* (2017) used the same resolution in order to model the invasion potential for plants in Southeast Asia. Zhang *et al.* (2015) used an 8x8 km resolution, however, they were producing their model at a national scale, for all of China. The tradeoff between computational time versus resolution is a limiting factor in producing a MaxEnt model. Another thing to consider when preparing predictor variables is whether or not your predictor variables are in a geographic (unprojected) or projected coordinate system. If your predictor variables are covering a large area, the raster cell size will likely differ longitudinally, which is problematic as MaxEnt assumes that all predictor cells are equal in area when sampling for background data (Elith *et al.*, 2011a).

2.2.4 Model Performance & Validation

Using occurrence data that is independent of the data used to generate the MaxEnt model is the best way to test the accuracy of the MaxEnt model. However, in many cases, independent data is not available. MaxEnt allows the performance of the model outputs to be tested by partitioning the occurrence data into training data and test data. By default, MaxEnt uses 70% of the data for training the model, and sets aside 30% for testing purposes (Algar *et al.*, 2009; Truong *et al.*, 2017), while depending on the amount of data available, other studies have set aside less testing data (Martinson *et al.*, 2011;

Graham *et al.*, 2017). MaxEnt then calculates the sensitivity, or True Positive Rate (TPR), which is the number of the test points that were predicted within the suitable area predicted by MaxEnt. Similarly, the specificity, or True Negative Rate (TNR) calculates the number of test points that fall outside of the suitable area defined by the MaxEnt model. The Receiving Operator Characteristics (ROC) curve which plots the False Positive Rate (FPR), which is $1 - \text{specificity}$ and represents Type I error, is then used to determine whether or not the model produced a prediction that performs better or worse than a random guess (the background data). Figure 2.1 shows an example of an AUC plot, an output of the MaxEnt model that shows a red line that represents the ROC curve based on different thresholds in MaxEnt. An AUC value of 0.5 means that the model performed similarly to if the suitability was chosen by random chance, while a value greater than 0.5 means that the MaxEnt model had higher predictive power than expected by chance. AUC is commonly reported as a measure of the predictive performance of MaxEnt models and is often favoured over other measures because it is considered to be threshold-independent, as it gives a single value of performance based on many possible thresholds (Phillips *et al.*, 2006; Wan & Zhang, 2016; Graham *et al.*, 2017; Kane *et al.*, 2017).

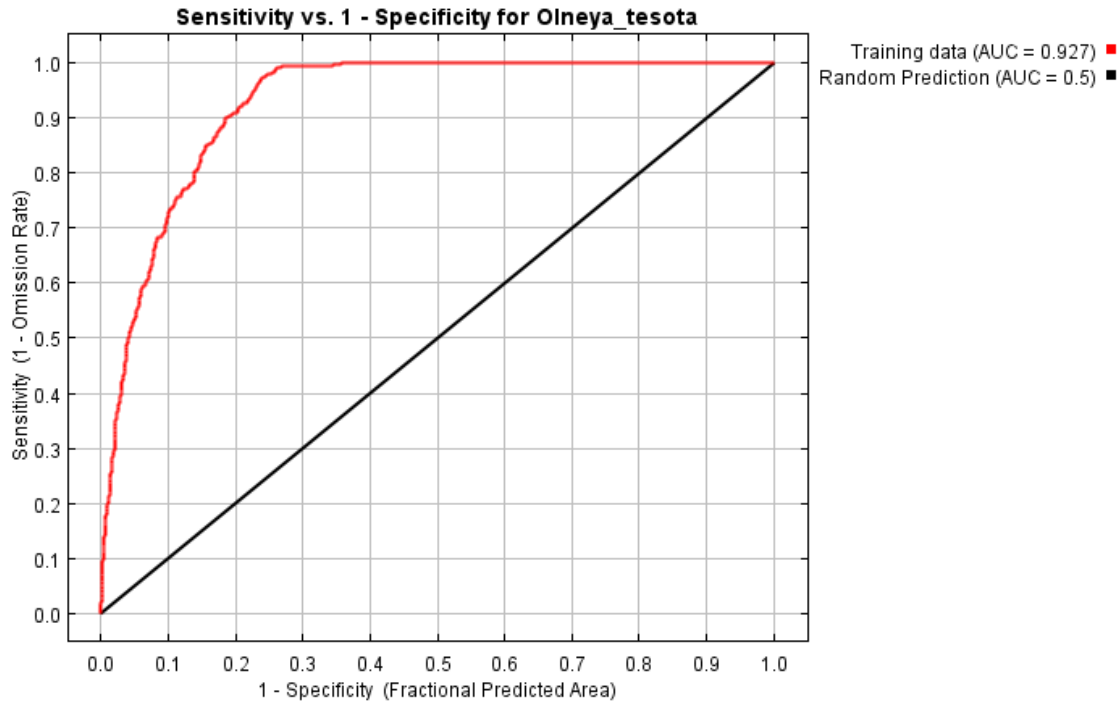


Figure 2.1. AUC plot showing an example of an AUC curve illustrating the predictive performance of the MaxEnt model based on a given threshold value. Illustration credit: Moghaddam-Gheshlagh *et al.* (2017) Climate change impact on *Olneya tesota* A. Gray (Ironwood) distribution in Sonoran desert using MaxEnt Modeling approach. *Journal of Wildlife and Biodiversity* 1(2): 110-117.

In some cases, independent occurrence data is available and can be used to validate the MaxEnt model. In a study on the distribution of invasive cheatgrass (*Bromus tectorum*) in Colorado, USA, MaxEnt models were created using presence data from 2007 and 2008 to 2013 (West *et al.*, 2016). A GLM was developed using presence/absence data from 2008 to 2013 and it was found that the MaxEnt model based on 2008 to 2013 presence data had an AUC of 0.96 while the GLM model had an AUC of 0.83. Even in the case of the MaxEnt model produced using only 2007 (ie. a smaller sample size), the AUC value was comparable to the GLM model (AUC=0.80). These results remained true even when using threshold dependent measures of model performance, indicating that MaxEnt could be appropriately used when absence data is not available and when occurrence data is limited.

2.3 Functional Diversity

2.3.1 Trait data collection

While functional diversity analyses have largely become more prevalent due to the mechanistic links identified between functional traits and ecosystem functioning (Tilman *et al.*, 1997; Loreau, 2000; Diaz & Cabido, 2001; Hooper *et al.*, 2005; Cadotte, 2017), increases in data availability have also facilitated more research in this field. Since the development of standardized plant trait data collection methods (Cornelissen *et al.*, 2003), trait data is constantly being contributed to large databases by researchers working around the world. Databases such as TRY Plant Trait Database have been used prominently as a data repository in the past. However, this database requires data to be requested from the originating authors who may then set up user agreements to their specifications. It can therefore take a long time to obtain the data required to do functional diversity analyses. Large data repositories that compile data from various research groups and provide an easy way to access it are becoming more common. Currently, the BIEN trait database comprises of 34 plant traits, 52,363 plant species with at least one trait observation, and 296,958 trait observations compiled from 550 different contributors including research groups, published literature, and data repositories. This data is now integrated into an R package that allows trait data to be pulled directly into R for analysis. Similarly, trait data from the Global Biodiversity Information Facility (GBIF) can also be accessed in R, however, it has also been integrated into the BIEN database.

Plant trait data for North American plants is also available through the United States Department of Agriculture (USDA) Plants Database. Although it has not yet been integrated into an R package, it can be easily downloaded from the database. Trait data is available for approximately 2,000 plant species and includes continuous and categorical traits related to morphology/physiology, growth requirements, reproduction, and as well as commercial uses. This data has been compiled from both peer-reviewed literature and grey literature.

Although compiling complete trait data for a full set of species for a given assemblage can take some time, trait data is more readily available than ever. The question then becomes which traits should functional diversity be calculated for?

2.3.2 Trait Selection

Ecological assemblages are complex systems and one of the biggest challenges when quantifying functional diversity is choosing traits that best signal the diversity of functions and responses of individuals in an assemblage (Cadotte *et al.*, 2013). Classically, functional traits are classified as either functional effect or functional response traits. Functional effect traits relate to the ecological role or ecosystem service that the species contributes to the assemblage, while functional response traits are related to a species' resilience to disturbances. Functional effect traits are typically associated with an individual's ability to capture and conserve resources such as nutrient cycling (Grime, 2001; Leps *et al.*, 2006). For example, Maron & Connors (1996) showed that the presence of bush lupine (*Lupinus arboreus*), a native nitrogen-fixing shrub with high productivity that grows along the Central Californian coast, can change the overall assemblage composition and potentially facilitate the establishment of invasive species. Spehn *et al.* (2002) also showed that in a cross-European study, the presence of nitrogen-fixing legumes significantly influenced the accumulation of nitrogen as well as the above-ground biomass of the assemblage. Functional effect traits such as timing of bloom, nectar resource traits, and morphological traits such as height of the plant and colour of flowers, have also been linked to pollinator richness and pollinator visitation frequency (Fornoff *et al.*, 2017).

Functional response traits measure the sensitivity and adaptive capacity of an individual's response to competition or environmental disturbances, and include traits such as dispersal, fecundity, seed production, dispersal method, fire and drought tolerance, and bark thickness. Spasojevic *et al.* (2015) used a set of continuous and categorical traits in order to assess the relationship between the diversity of traits relating to response to fire and the resilience of forest ecosystems in southwestern United States. The categorical traits they used included growth habit (eg. graminoid, shrub, tree), fire tolerance (yes or no), fire resistance (low, medium, high), and resprout ability (yes or no), which were all gathered from the USDA Plants Database. Although these seem to be broad categories, they are based on a suite of other traits, both categorical and numerical. For example, fire resistance is based on traits such as plant height, and whether or not

their height may be taller than flames, as well as bark thickness (Lavorel & Garnier, 2002; Spasojevic *et al.*, 2016). Spasojevic *et al.* (2016) found that diversity in fire tolerance, fire resistance and resprout ability had a strong effect on the recovery of a forest assemblage after a wildfire, while species richness and seed mass were not as strong.

Weiher *et al.* (1999) gives an outline of some of the challenges that plants face and the traits associated with these challenges (Table 1). They categorize these traits as either hard or easy traits, relating to their ease of measurement, stating that while some of the hard traits may be close to impossible to measure, the easy traits can act as analogs for the hard traits and are collected with much more ease. Some easy traits are able to act as a good signal for a given challenge. For example, seed mass and shape are considered to be good indicators of propagule longevity and therefore a good indicator of seed dispersal in time. Seed mass is also a reasonable indicator for seed dispersal distance for wind dispersed seeds, yet is not able to be related to other types of dispersal such as endozoochory or exozoochory. If easy traits are being used as analogs for a certain function or plant response, the degree to which the trait actually relates to the function or response needs to be considered.

Table 2.1 The common challenges faced by plants and some suggested traits (Weiher *et al.*, 1999).

Challenge	Hard Trait	Easy Trait
1. Dispersal		
Dispersal in space	Dispersal distance	Seed mass, Dispersal mode
Dispersal in time	Propagule longevity	Seed mass, Seed shape
2. Establishment		
Seedling growth	Seed mass Relative growth rate	Seed mass Specific Leaf Area (SLA) Leaf Water Content (LWC)
3. Persistence		
Seed production	Fecundity	Seed mass Above ground biomass
Competitive ability	Competitive effect and response	Height Above ground biomass
Plasticity	Reaction norm	SLA, LWC
Holding space/longevity	Life span	Life history, Stem density
Acquiring space	Vegetative spread	Clonality
Respond to disturbance: stress and disturbance avoidance	Resprouting ability Phenology Palatability	Resprouting ability Onset of flowering SLA, LWC

Another example of a hard trait that is difficult to represent using easy traits is a plants ability to obtain water and nutrients from the soil, which can also relate to a plant's ability to withstand disturbances such as drought or nutrient depletion in soil. While below ground aspects of plants, such as rooting structure, depth, and mycorrhizal associations are significant aspects of plant life that should be included into functional diversity assessments (Vojtko *et al.*, 2017), these trait data are generally lacking. However, it is often presumed that these hard traits are associated with soft traits from aboveground (Cornelissen *et al.*, 2001; Leps *et al.*, 2006).

There is a vast number of other traits that could be used in functional diversity analyses: life span (ie. annual, perennial), propagation type (ie. sexual, vegetative), mode of seed dispersal (ie. autochory, endochory, exochory), pollination system (ie. insect,

wind), sexual expression, inflorescence structure, leaf mass and structure, and even traits relating to socio-ecological groupings (ie. food plants) (Markowicz *et al.*, 2015; Pardo *et al.*, 2017). While focussing on traits that are known to be direct signals of the function of interest will give the best estimate of functional diversity, it is most likely that not all traits that are important for a given function are able to be measured or are even known.

2.3.3 LHS traits

Comparable to Grime's CSR life-history strategy model, comprising of competitors, stress-tolerators, and ruderals as the vertices of the triangle, Westoby's (1998) leaf-height-seed (LHS) plant strategy scheme characterizes plant species based on three plant traits: specific leaf area (SLA), plant height, and seed mass. SLA is measured as the area of one side of a complete, mature leaf divided by the dry mass (Cornelissen *et al.*, 2003), and is considered to represent the photosynthetic capacity of the leaf or the amount of light that a leaf is able to capture (Westoby, 1998). The trade-off associated with SLA is that although a high SLA means that there is a high rate of return for the plant, it is also associated with faster leaf degradation (Westoby, 1998). Plants with low SLA often have more robust leaves, where defensive and structural compounds are found in place of photosynthetic compounds. Plants with high SLA invest more energy into their leaf production at the expense of the lifespan of the leaf. Plant height relates to plant assemblage dynamics, where although the taller plants may receive benefits such as more light, they are also more susceptible to damage from disturbances like strong winds. Westoby (1998) describes this succession as different plants being "leaders in the race" at different points of successional time. The trade-offs associated with this trait are therefore related to their competitive ability and ability to respond to environmental stress (Chalmandrier *et al.*, 2015). Seed mass relates to the likelihood of establishment, where the trade-off is that a larger seed has a better chance of establishment, but takes more metabolic energy to create and is therefore also correlated with seed production, and smaller seeds, although they are created in more abundance, have a lower likelihood of establishment. The location of a plant species along these three trait axes captures the overall variation in plant ecological life history strategies in an assemblage, and also

characterizes both functional effects and functional responses of plant species (Chalmandrier *et al.*, 2015).

LHS traits have been used in various applications, from assemblage ecology looking at the relationship between functional diversity, environmental filtering and assemblage structure (Bello *et al.*, 2013; Herben *et al.*, 2013), to assessing the responses of functional diversity in plant assemblages to environmental management and restoration efforts (Lavorel *et al.*, 2011). LHS traits have continually been demonstrated to capture the ecological variation of plant life history strategies, and is therefore commonly used to assess the overall functional diversity of plant assemblages.

2.3.4 Intraspecific Trait Variability and Phenotypic Plasticity

Plant trait databases, such as TRY, TOPIC, and BIEN, have increased access to trait data for functional diversity analyses. When using trait data collected outside of the study region of interest, one must consider the implications that intraspecific trait variability has on functional diversity analyses. A trait for a given species can vary considerably depending on the climate and ecosystem it is found in, as well as biotic interactions with neighboring plant species (Abakumova *et al.*, 2016). The collection of plant trait data typically follows standardized sampling techniques (Cornelissen *et al.*, 2003). Plant height, for example, must be collected from healthy, adult plants that have foliage exposed to full sunlight, and since it can be extremely variable, it must be collected on at least 25 individuals in a given sampling effort (Cornelissen *et al.*, 2003). If these standard sampling techniques are followed for trait data collection, intraspecific trait variation is typically attributed to trait plasticity. Phenotypic, or trait, plasticity, is the ability of a species to alter traits in response to changes in both abiotic and biotic aspects of its environment (Weiher *et al.*, 1999). While trait plasticity has been included as a trait in itself in functional diversity analyses, quantified as the variation of the trait for the species, it is generally difficult to properly assess trait plasticity without controlled greenhouse experiments (Weiher *et al.*, 1999). Most typically, trait data for a given species is averaged in order to obtain a representative trait value. Although studies have found that species hierarchies for the different traits are still maintained (Craven *et al.*

,2016; Cordlandwehr et al., 2013; Kazakou et al., 2014), properly incorporating measures of trait plasticity into functional diversity analyses remains a challenge.

2.3.5 Data Scaling

Functional diversity can be calculated on a single trait or on a suite of traits that represent the function of interest. If multiple traits are used, it is important to consider that especially for plants, trait values may be measured on drastically different scales. When using the LHS traits for example, seed mass is typically measured in milligrams and plant height in meters. Since the range of values or scales of these traits can vary by orders of magnitude, traits with larger values may be given greater weight in the calculation of functional diversity. In order to correct for this, trait data can be transformed using an algebraic function, or be standardized according to the range of values in your dataset (Leps *et al.*, 2006). Trait data is commonly log-transformed, which can give an approximate normal distribution (Swenson, 2014). While this is a good approach for most continuous trait data, log transformation may not be appropriate in every case, especially when the trait data includes negative values, zeros that represent trait absence, or data on an interval scale (for example, phenological data like flowering onset) (Leps *et al.*, 2006).

Another approach to scaling data would be to scale according to the range of values in the dataset. For example, a Z-score could be calculated by subtracting each trait value from the mean of the trait then dividing by the standard deviation of the trait. This results in a set of traits expressed in units of standard deviation represented by their relation to the mean.

After trait data has been scaled based on the other values in the dataset, or using an algebraic function, multiple traits can be used to calculate functional diversity with each trait without the magnitude of the trait values affecting the weighting in the calculation. However, the correlation between traits still needs to be considered. For example, if multiple leaf measurements are used to calculate functional diversity, such as leaf dry mass and leaf area, it is likely that the two leaf traits are highly correlated and likely represent the same axis of function (Swenson, 2014). Principal Components Analysis (PCA) can be used to determine the distinct functional axes and eliminate trait

redundancy (Leps *et al.*, 2006; Swenson, 2014). Swenson (2014) suggests that only axes that explain over 90% of the variation in trait data should be selected. The PCA scores representing where all of the species fall on the given number of axes chosen can then be used to calculate the trait distance matrices and functional diversity metrics.

These scaling methods allow traits that are measured on different magnitudes (ie. seed mass versus plant height), and traits that may co-vary to be scaled and therefore be used to calculate functional diversity in a way that does not give too much weight to a certain trait and span the broad range of functions and responses of individuals in an assemblage.

2.3.6 Measures of Functional Diversity

In recent years, many indices have been created to calculate the functional diversity of an assemblage. Swenson (2014) describes some of the metrics that can be used to quantify or describe functional diversity patterns within an assemblage for a single trait. In order to get a first glimpse of an assemblage structure, four statistical moments regarding the trait distributions of an assemblage can be calculated – mean, standard deviation, skewness, and kurtosis (Swenson, 2014). The mean trait value gives the central tendency of the trait in the assemblage, and the standard deviation would give a measure of the spread of trait values in the assemblage, such that a higher standard deviation would indicate that species in the assemblage are functionally dissimilar. Skewness is a measure of the symmetry of traits in the assemblage, such that a high value of skew could indicate that while the majority of species are functionally similar, there are species with dissimilar trait values that would increase the functional diversity of the overall assemblage. Kurtosis measures the degree of flatness or “peakedness” of the traits in the assemblage, such that a low kurtosis value indicates that there is more trait disparity between species in the assemblage. All of these moments can also be weighted by abundance, or any other weighting such as percent cover (Swenson, 2014). The assemblage-weighted mean (CWM) is a commonly used metric to do just that. Grime's (1998) mass ratio theory, which states that the dominant plants and traits in an assemblage have the most impact on ecosystem functions, is accounted for by the CWM measurement (Dubuis *et al.*, 2013).

Together, these statistical moments can give a clear picture of the distribution of traits within the assemblage. However, on their own, statistical moments such as the mean trait value for an assemblage, do not necessarily give a measure of the overall diversity of functional traits in an assemblage, especially because they only describe the diversity of a single trait. One should therefore be wary of what these moments represent before using them in functional diversity analyses.

The overall objective of functional diversity analyses is to measure the range of functions in an assemblage based on species traits (Swenson, 2014). Functional diversity based on a single trait is therefore the range of values of the trait. When there are multiple traits, the range of functions being measured is calculated instead as the multi-dimensional volume of the convex hull that encapsulates all species and their traits in trait space (Swenson, 2014). The volume of the convex hull of a multi-dimensional trait space is known as Functional Richness (FRic) and gives a relative measure of how packed species are within a trait space.

Two other common classes of functional diversity metrics are based on trait distances: mean pair-wise trait distance (PW), and mean nearest-neighbor trait distance (NN) (Swenson *et al.*, 2012; Swenson, 2014). In order to calculate these metrics, trait distance matrices or dendrograms of traits must first be generated. Trait distance matrices are created using either Euclidean distances between species within a generated trait space or dendrogram branch lengths. The Euclidean distance approach is more favorable and straight-forward to calculate, however, trait dendrograms are sometimes preferred when the goal is to eventually relate functional traits to a phylogenetic tree, as these two formats are directly comparable. When creating distance matrices for multiple traits, where some of the traits are categorical as opposed to continuous, the distance matrix can be converted to Gower Distances or Gower Dissimilarity, which is measured from 0 (identical) to 1 (maximally dissimilar).

PW is calculated by summarizing the average distances between all pairs of species within an assemblage (Swenson, 2014). This metric gives the overall dissimilarity of the species in the assemblage, such that a high PW indicates that species in the assemblage are highly functionally dissimilar. NN on the other hand gives a more detailed measure of functional diversity by averaging the distance between each species

and it's nearest functional neighbour in the assemblage. The standard deviation of these nearest neighbour distances can also be taken and indicates the variation in nearest neighbour values. As with the other metrics, these can also be weighted by the abundances of each species in the assemblage if this data is available.

Other measures of functional diversity related to their distribution in multi-dimensional trait space include functional evenness (FEve), functional dispersion (FDis), and functional divergence (FDiv). FEve calculates the minimum spanning tree (MST) required to connect all species in the multi-dimensional trait space. FDis calculates the average distance from each species to the centroid in the trait space. FDiv gives an understanding of whether or not the species are dispersed more towards the maximum or minimum of the range of traits (Villeger *et al.*, 2008; Swenson, 2014).

2.3.7 Functional Diversity Null Models

If the goal of calculating functional diversity is to gain additional information about an assemblage above what is given with species richness, the functional diversity metric used should not be correlated with species richness. Swenson (2014) demonstrates that the NN and FRic metrics may be correlated with species richness. Although he also demonstrates that while the PW metric is not necessarily correlated with species richness, the variance in PW decreases with increasing species richness, suggesting that it is not completely independent of species richness. Swenson (2014) therefore suggests that although any given metric for functional diversity may not be correlated with species richness, a null model should still be used to compare any functional diversity metric to in order to minimize any underlying bias associated with species richness.

There are two main approaches to functional diversity null models; a null model where the functional trait data is constant and the assemblage data matrix is randomized, and a null model where the functional trait data is randomized and the assemblage data matrix is fixed (Swenson, 2014). The former was the first approach used, however, as null models based on the randomization of observed assemblage data often inadvertently end up randomizing other aspects of the data other than the pattern of interest, they end up inflating type I error (Swenson, 2014). The latter approach creates null models that, instead of basing the null model comparison on randomly constructed assemblages,

compares observed values to those based on randomized functional trait data (Swenson, 2014).

Swenson (2014) describes an unconstrained and constrained approach at randomizing functional trait data. An unconstrained model involves shuffling just the species names in the trait matrix, which allows the overall phenotypes or combinations of traits to be maintained and only randomizes the species that possesses this phenotype (Swenson, 2014). The constrained version of this null model involves pruning the species that can be randomly shuffled down to those that fall within the observed multi-dimensional trait volume, in order to account for the fact that these combinations of traits in the assemblage were filtered by abiotic factors and then by their similarity to other species in the assemblage. The combinations created by randomly shuffling all species could potentially create combinations of species that could not occur in real life. Although the constrained model makes more sense ecologically, it takes more computational effort and may not provide enough random combinations to provide statistical power (Swenson, 2014).

The output of the randomization is expressed as the standardized effect size (SES) or Z-score, calculated as:

$$SES = \frac{\text{Observed Diversity} - \text{Mean of Null Distribution}}{SD \text{ of Null Distribution}}$$

A positive value for the SES therefore reflects functional evenness, or a greater functional distance between the species in the assemblage than expected by chance (Swenson, 2014). On the other hand, a negative SES is indicative of functional clustering, or smaller functional distances among species in the assemblage than expected by chance (Swenson, 2014).

2.4 Phylogenetic Diversity

2.4.1 Phylogenies used

Calculating the phylogenetic diversity of an assemblage relies on an accurate phylogenetic tree structure and branch length estimation. According to Qian and Jin

(2015), over 10 versions of angiosperm megatrees already exist, and it is likely that these will continually be refined each year, with advances in molecular sequencing. The Angiosperm Phylogeny Group, an international collaboration between systematic biologists, created a number of megatrees that are continually being updated and are commonly used. These include the R20091110 (Brum *et al.*, 2012; Duarte *et al.*, 2012; Soliveres *et al.*, 2012; Qi *et al.*, 2014), R20100701 (Giehl & Jarenkow, 2012; Seger *et al.*, 2013; Brunbjerg *et al.*, 2014), and R20120829 (Cianciaruso *et al.*, 2013; Gonzalez-Caro *et al.*, 2014; Feng *et al.*, 2015; Matos *et al.*, 2016) supertrees which were all derived from APG III, the third update of the supertree from the group. The problem with using these supertrees for phylogenetic diversity analyses is two-fold. For one, these trees include only a small portion of all angiosperm families and species, and secondly, these trees do not include information on branch length, which is the basis for most phylogenetic diversity measures (Qian & Jin, 2015). Branch lengths for this tree are typically estimated using Phylomatic and BLADJ along with plant clade estimates from Wikstro *et al.* (2001), which itself only includes branch length estimates for less than 30% of the all angiosperm families that are incorporated by APG III (Qian & Jin, 2015).

A species-level phylogeny that includes branch length estimates has now been created by Zanne *et al.* (2014), based on seven gene regions, both slow evolving to quickly evolving regions (Qian & Jin, 2015). This phylogeny includes over 30,000 extant plant species and over 50% of the genera of all extant seed plants in the world (Zanne *et al.*, 2014; Qian & Jin, 2015). According to Web of Science, the Zanne *et al.* (2014) paper has been cited 228 times as of January 2018, with the phylogeny being used in many different applications. The one critique of this megatree according to Qian & Jin (2015) is that the taxonomy in this phylogeny is not necessarily consistent with international authority plant databases, such as The Plant List, in terms of naming conventions and the presence of species synonyms. Qian & Jin (2015) created an updated version of Zanne *et al.* (2014) megatree that eliminated any discrepancies in the taxonomy. Their tree, however, was not freely available at the time of this work.

BIEN has also developed a plant phylogeny that will include branch lengths, consistent taxonomy, and be easily accessible. The megatree developed by BIEN was estimated using a standardized list of New World plant species using a method similar to

that of Zanne *et al.* (2014), which involved querying GenBank for data regarding certain gene sequences. Although this tree is considered to be a work in progress, it has the benefit of being used in conjunction with occurrence data, trait data, and other data that are based on the same taxonomic naming scheme.

2.4.2 Measures of Phylogenetic Diversity

As more attention has been turned to phylogenetic diversity in recent decades, indices are continually being developed to represent this metric. Faith's (1992) PD index, one of the most widely used metrics, quantifies phylogenetic diversity as the total minimum length of the phylogenetic branches required to span all of the taxa within an assemblage on a phylogenetic tree. This metric is considered to be a form of “richness” metric, and can also be weighted by the abundance of each species in the assemblage, if the data is available (Swenson, 2014). Another option when using this metric is whether or not to include the root of the phylogeny in the summation of the total branch length. When this index was created, the root was not included in the calculation, yet recently, the root is typically included based on the rationale that the root includes information about the complete evolutionary history that lead up to the species being found in the assemblage of interest (Swenson, 2014). When the root is included, the metric is often termed “Evolutionary History” or “Evolutionary Heritage” (EH), and is considered as a historical diversity of an assemblage, which is typically preferred in conservation applications (Mooers & Heard, 2005; Swenson, 2014).

As with functional diversity, other methods that have been developed to represent phylogenetic diversity usually fall under the categories of pair-wise distance methods or nearest-neighbour distance methods (Swenson, 2014). Mean pair-wise distance, or MPD, developed by Webb *et al.* (2002) is the most commonly used pair-wise distance metric. It is calculated as:

$$mpd = \frac{\sum_i^n \sum_j^n \delta_{i,j}}{n}, \text{ where } i \neq j$$

where n is the number of species in the assemblage, δ are the pairwise phylogenetic distances between species i and j . MPD is therefore calculated as the average pairwise

distance between all species in the assemblage. Because this metric considers all pairwise distances between all species in an assemblage, it is considered to capture the overall phylogenetic dissimilarity of an assemblage, although unable to detect finer scale phylogenetic patterns (Swenson, 2014). As with Faith's PD index, MPD can be weighted by the abundances of the species in the assemblage, if this data is available. Although other pairwise distance methods have been developed, including Rao's D_{α} (Rao, 1982), which is similar to the abundance weighted MPD index, and Hardy *et al.*'s (2007) D_k , which has been likened to the phylogenetic version of the Shannon Index (Swenson, 2014), they are all significantly correlated to Webb *et al.*'s (2002) MPD index.

Another category of phylogenetic diversity indices that are not considered to be conceptually or mathematically related to pairwise distance measures (Swenson, 2014) are called nearest neighbor measures. While pairwise distance measures are considered to “basal”, representing the entire evolutionary history of the whole assemblage, nearest neighbour measures are considered to incorporate “terminal” evolutionary information, meaning that they give an idea of the phylogenetic distances between each species and its closest relative in the assemblage (Swenson, 2014). As in functional diversity analyses, nearest neighbour measures give an idea of the spread of species across the phylogeny. Webb *et al.* (2002) produced the mean nearest taxon distance (MNTD) metric, calculated as:

$$mntd = \frac{\sum_i^n \min \delta_{i,j}}{n}, \quad \text{where } i \neq j$$

where n is the number of species in the assemblage and $\min \delta_{i,j}$ is the minimum phylogenetic distance between species i and all other species in the assemblage. As with the other indices, this index can be weighted by abundances of each species in the assemblage if this data is available.

Although many phylogenetic diversity indices or metrics to measure evolutionary distinctiveness have been produced, many of them are correlated and it is crucial that the question of interest is matched with the appropriate metric. Davies *et al.* (2016) introduce a network theory approach that identifies important nodes in a phylogeny that may contribute to ecosystem functions using two measures of network centrality: betweenness and closeness. This approach allows one to consider branches in a phylogeny that may

have keystone effects on the ecosystem functioning of an assemblage, compared to tree-based measures such as Faith's PD that would assume that two branches of the same length would have equal contributions to phylogenetic diversity. Davies *et al.* (2016) were therefore able to identify a node representing the evolution of a trait that contributes greatly to the ecosystem function of the assemblage, nitrogen-fixation. Another metric that is considered to be a phylogenetic richness metric, similar to Faith's PD index, is called Evolutionary Distinctiveness (ED), which looks at the phylogenetic isolation of each taxa in an assemblage (Safi *et al.*, 2011).

2.4.3 Null model considerations

As with functional diversity metrics, null models are typically required in order to provide phylogenetic diversity measurements that are independent from species richness. For tree-based measures such as Faith's PD index, adding species simply increases the sum of the branch lengths, and is therefore directly related to species richness. Distance-based measures, such as MPD and MNTD, are less directly impacted by species richness. Matos *et al.* (2016) however, found that in their case, MPD was significantly correlated with species richness while MNTD was not. In order to remove this bias, the metric should be compared to a null distribution of phylogenetic diversity values based on randomized data.

Also analogous to a null model associated with functional diversity data, there are two main approaches to phylogenetic diversity null models: a null model where the phylogenetic tree is constant and the assemblage data matrix is randomized, and a null model where the phylogenetic tree is randomized and the assemblage data is fixed (Swenson, 2014). Although one can choose to randomize the observed assemblage data to create a null distribution of phylogenetic diversity metrics, this is not the preferred approach. Instead, Swenson (2014) suggests comparing observed values of the phylogenetic diversity metric for an assemblage to those based on randomized phylogenetic distances between species that are observed in the assemblage (Swenson, 2014). An example of one approach at doing this is to repeatedly shuffle the taxa labels across the phylogeny, essentially randomizing who is most closely related to whom (Swenson, 2014).

The standardized effect size can again be used to assess whether or not the phylogenetic diversity for an assemblage is higher or lower than expected given the number of species in the assemblage (Boesing, 2016). The choice of null model requires careful consideration, as the significance of the phylogenetic diversity metric depends on the null model used (Miller *et al.*, 2016). In order to address issues relating to null model selection, Miller *et al.* (2016) suggest creating a set of possible metrics and a set of possible null models, which undergo repeated matrix-wise randomizations, in order to give the most appropriate null model to compare the metric to. Regardless of the null model method used, standardization of phylogenetic diversity metrics allows a meaningful comparison between phylogenetic diversity, functional diversity, and taxonomic diversity or species richness to be made.

2.5 Development of a reproducible protocol

The data and computational tools needed to produce SDMs and to carry out functional and phylogenetic diversity analyses have become increasingly easy to access in recent years. One of the objectives of this project was to create reproducible methods that use SDMs to produce estimates of species richness, phylogenetic diversity and functional diversity at a regional scale. Figure 2.2 shows a summary of the analysis that carries out data compilation and manipulation, the output of MaxEnt SDM models, as well as estimations of functional and phylogenetic diversity based on multiple measures. The blue boxes represent analysis inputs, white dashed boxes represent data manipulations/pruning decisions, yellow circles represent computational analyses, green diamonds represent analysis decisions, and purple shapes represent final model outputs. BIEN, GBIF, and WorldClim data are able to be accessed directly within R while USDA and Kew data was downloaded from their respective websites before being loaded into R and pruned.

At various stages in this process, the modeller has the power to change the inputs in various ways in order to make it suit their needs. Throughout the process, there is very little need for manual data manipulation, which allows for this methodology to be reproducible. Figure 2.2 outlines the work flow process including the inputs needed at

various stages as well as some of the options that can be changed based on the needs of the modeller.

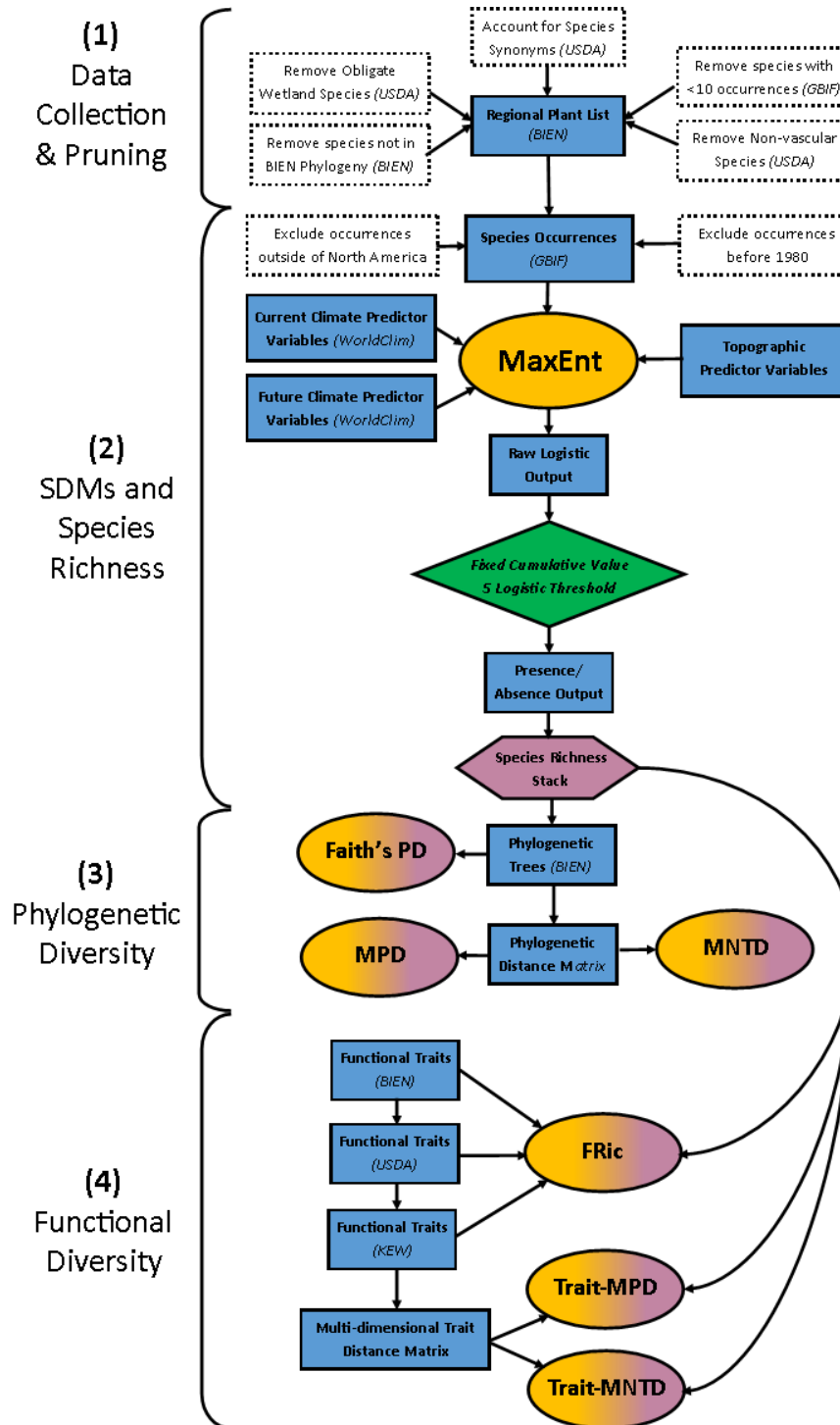


Figure 2.2. Schematic showing a summary of the analysis that carries out data compilation and manipulation, the output of MaxEnt SDM models, as well as estimations of functional and phylogenetic diversity based on multiple measures. The blue boxes represent analysis inputs, white dashed boxes represent data

manipulations/pruning decisions, yellow circles represent computational analyses, green diamonds represent analysis decisions, and purple shapes represent final model outputs.

3 Patterns of Taxonomic, Functional and Phylogenetic Diversity of Vascular plants in the Okanagan Ecoregion

3.1 Synopsis

An ongoing challenge in ecology and conservation biology is to improve upon methods used to quantify biodiversity, and to devise conservation management strategies that successfully conserve biodiversity and its associated benefits, now and into the future. Taxonomic diversity, commonly represented as species richness, has long been the focus of conservation research and practical efforts (Myers *et al.*, 2000; Davies & Cadotte, 2011; Marchese, 2015). However, quantifying biodiversity using taxonomic diversity in isolation implies that all taxa have equal conservation value. In recent years there has been increased emphasis on other facets of biodiversity that can offer important information about the structure and conservation value of an ecological assemblage. Phylogenetic diversity measures the evolutionary distinctiveness of an assemblage, while functional diversity, which is based on species traits, can give insight into the range of functions that species in an assemblage play, the ecosystem services they provide, as well as the potential resilience of an assemblage to disturbances such as climate change (Dubuis *et al.*, 2013; Spasojevic *et al.*, 2016). Considering all three facets of biodiversity simultaneously, as opposed to using measures of taxonomic diversity alone, can facilitate consideration of multiple conservation objectives (Devictor *et al.*, 2010).

The Okanagan Ecoregion, located in south central British Columbia, is considered to be a biodiversity hotspot in Canada, harbouring a large proportion of Canada's species and ecosystems at risk. The Okanagan Ecoregion is also considered to be a transition zone between various biomes and ecosystems (Pryce *et al.*, 2006), and may also be an important corridor for species moving across the landscape and species that may migrate north in response to climate change (Krosby *et al.*, 2016). Rapid urban and agricultural development in the region in the past century has had significant impacts on the species and ecosystems in the Okanagan Ecoregion. The Okanagan Collaborative Conservation Program (OCCP), a partnership between various government and non-government

organizations, initiated the Okanagan Biodiversity Strategy, which involved the identification of high priority conservation areas. Relative biodiversity was mapped for the region and was based on biodiversity proxies such as distance from roads, size of natural areas, and the presence of important ecosystems, habitat features, or species-at-risk, which are equivalent to taxonomic diversity measures. The Nature Conservancy of Canada also identified areas of significant conservation priority in the Okanagan Ecoregion using MARXAN software (Pryce *et al.*, 2006). This assessment identified conservation targets based on the relative scores of irreplaceability and vulnerability for terrestrial species, aquatic species, and rare plant communities; taxonomic diversity was the only facet of biodiversity that was considered. While this work provides good baseline information for planning biodiversity conservation efforts, all of this work has been largely based on taxonomic diversity, or species richness, alone and has not incorporated assessments of functional and phylogenetic diversity. Including these facets in biodiversity assessments and conservation prioritization decision making frameworks will help to identify areas in the Okanagan Ecoregion that have greater range of functions or encompass more evolutionary history than might be suggested based on the number of species present. For these reasons, maintaining functional aspects of the landscape as well as maintaining species that are evolutionarily distinct will add significant conservation value to the Ecoregion, especially as new protected areas are being considered (Parks Canada, 2018).

Traditionally, conservation efforts have largely focussed on how species and ecosystem services respond to contemporary stressors. However, projections have shown that climate is predicted to change drastically in the next century, which will have significant impacts on ecological assemblages (Hamann & Wang, 2006; Shafer *et al.*, 2015). Thus, considering how assemblages will be impacted by climate change and other disturbances is an important aspect of modern conservation planning. Using a climate envelope modelling approach for forest communities in British Columbia, Hamann & Wang (2006) found that suitable habitat for conifer species is estimated to significantly decrease in size under future climate scenarios while tree species that are currently at their northern limit in British Columbia will gain habitat. Hamann & Aitken (2013) also demonstrated using a similar approach that the current protected area network in British Columbia would be able to maintain between 35% and 85% of locally adapted forest

communities under climate change scenarios. They also emphasize that predictions of range change based on future climate are dependent on a species' migration ability (ie. ability to move to suitable habitat) and adaptive capacity (ie. ability to adapt to new climates and remain in place). In the Okanagan Ecoregion, annual temperatures are projected to increase by 1.8°C by 2050, with annual precipitation increasing by 6% (PCIC, 2013). Summer climate is projected to have a greater increase in temperature than other seasons and become drier, with an approximate increase of 2.2°C and precipitation decreasing by 9% by 2050 (PCIC, 2013). Despite these predictions, there is limited research addressing the impact that climate change will have on ecological assemblages and maintenance of biodiversity in the Okanagan Ecoregion.

Our objective here is to fill these important knowledge gaps, by addressing the following specific objectives: 1) Use species distribution models to predict current and future distributions of plant species inhabiting the Okanagan Ecoregion; 2) Quantify, map and compare taxonomic, functional, and phylogenetic diversity patterns and hotspots in the Okanagan Ecoregion and compare to the current protected area network; and 3) Use climate projections to assess how future patterns and hotspots of taxonomic, functional, and phylogenetic diversity may differ from current. We also use null models to quantify functional and phylogenetic diversity independent of species richness, and to identify areas that have greater functional or phylogenetic diversity than expected given species richness. Functional and phylogenetic diversity measures are often confounded by species richness, such that more species typically yields greater functional and phylogenetic diversity (Swenson, 2014). Null models are therefore used to complement the main findings by highlighting areas that are unusually rich or poor in the given diversity measure after accounting for the observed species richness.

This multi-faceted approach to quantifying biodiversity and identifying biodiversity hotspots allows different conservation values to be considered and will broaden our understanding of biodiversity patterns within the Okanagan.

3.2 Methods

3.2.1 Study Region and Species Occurrence Data

The Okanagan Ecoregion, defined by the Nature Conservancy, is a 96,000 km² area that spans the international boundary south-central British Columbia, Canada, and north-central Washington, USA (Figure 3.1). The large variance in climate and physiography found throughout the region has resulted in the presence of ecosystems that are not found anywhere else in Canada. Interior Douglas-fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) forests are characteristic of this region and transition to shrub-steppe and grasslands in the low-elevation valleys, with lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) forests dominating in the high elevation alpine (Pryce *et al.*, 2006). These ecosystems support the greatest diversity of breeding birds found in British Columbia as well as large assemblages of plant species that are nationally rare in Canada (Pryce *et al.*, 2006). These ecosystems have been highly impacted by agriculture, urban and industrial development, especially in the low elevation areas where grassland and wetland ecosystems have decreased by as much as 84% and 92% since the 1800s (Lea, 2008).

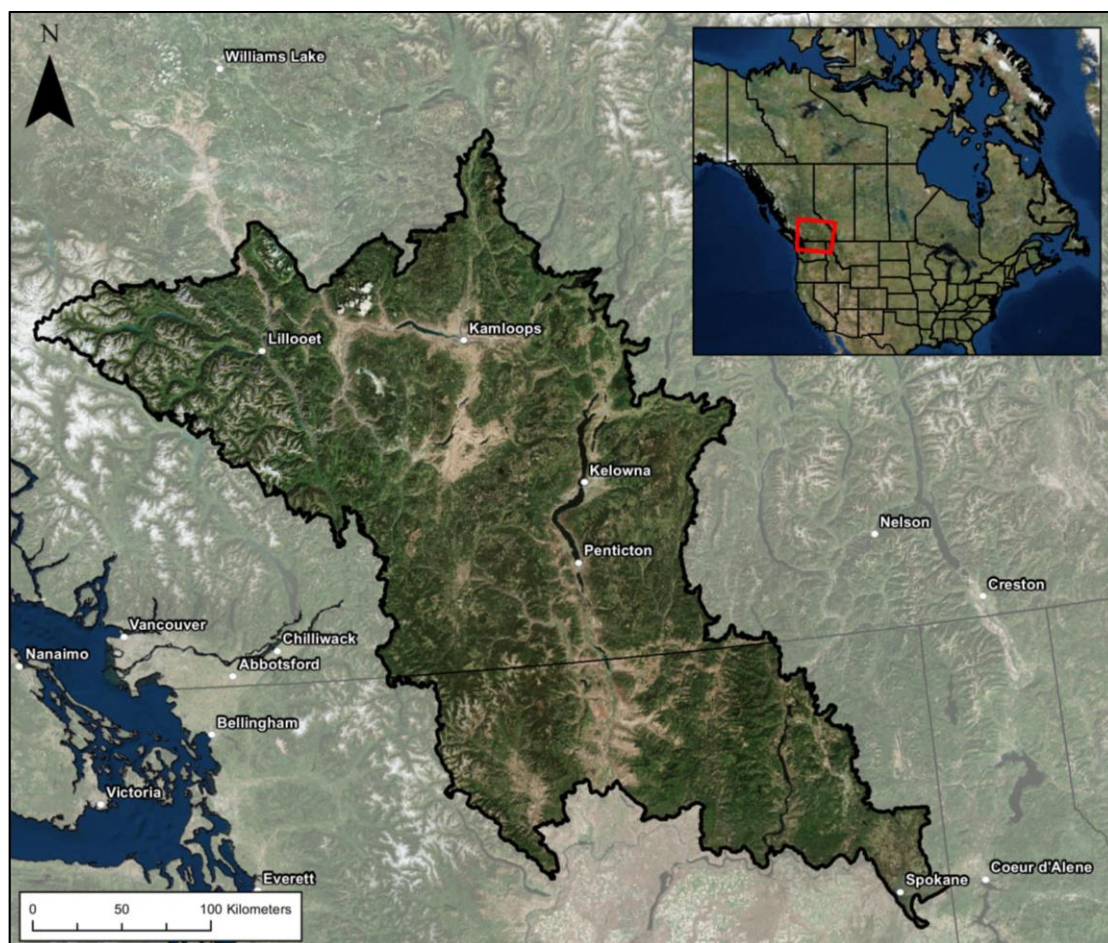


Figure 3.1 Okanagan Ecoregion (Nature Conservancy). Figure created by Carmen Chelick.

We used the BIEN package version 1.2.2 (Maitner *et al.*, 2018) in R version 3.4.2 (R Core Team, 2017) to obtain a list of plant species known to occur in the Okanagan Ecoregion. We excluded species if they belonged to the following categories: non-vascular species, obligate wetland species, hybrid, variant or subspecies. Non-vascular and obligate wetland species were excluded because their distributions would not be properly represented using the climate and topographic predictor variables used for the species distribution models. Hybrids, variants and subspecies were excluded to simplify the taxonomy. We also excluded species that were not present in the BIEN phylogeny. The final species list included 1,541 species (Appendix A1), comprising 1,221 native species and 320 exotic species, 982 forbs, 262 graminoids, 81 shrubs, 130 subshrubs (low growing shrubs under 1.0 m tall at maturity), and 86 trees.

Occurrence data for all species in the final plant list were extracted from the Global Biodiversity Information Facility (GBIF) using the *spocc* package version 0.7.0. Occurrences extracted from GBIF were limited to those found within North America, and records from 1980 to present. Kane *et al.* (2017) express that it is good practice to model distributions based on a larger area that encompasses the smaller geographic area, in order to increase the background data provided for the MaxEnt model and ensure that a broad range of environmental conditions are represented for each species. Also, by encompassing a much broader extent than the focal area, we ensure that when predicting future distributions in response to climate change (see below), we accommodate species whose ranges may shift into the focal region from elsewhere.

3.2.2 Species Distribution Models and Species Richness

We used the MaxEnt algorithm (Phillips *et al.*, 2006) to create current and future species distribution models for all species. MaxEnt is considered to be one of the most robust approaches to modeling species distributions, especially when using presence-only data and small sample sizes (Elith *et al.*, 2006; Fourcade *et al.*, 2014; Wan & Zhang, 2016; Kane *et al.*, 2017; Truong *et al.*, 2017). Distribution models were created using the default settings in Maxent. Predictor variables used in the MaxEnt models included 19 bioclimatic variables from Worldclim for both current (1960-1990) and future (2070) climate (Hijmans *et al.*, 2005) as well as elevation, aspect and slope derived from a Digital Elevation Model (DEM) for North America. All predictor variables had a resolution of 30 arc-seconds, which is approximately 1km² at the equator. For the future climate projection we used the “MPI-ESM-LR” general circulation model from the Max Planck Institute for Meteorology in Germany, which is considered to produce a median climate projection for North American climate (Batllori *et al.*, 2017), along with the representative concentration pathway (RCP) 8.5 which represents a “business as usual” scenario for potential trajectories of future atmospheric greenhouse gas concentrations.

Although it is generally recommended that collinear variables are eliminated from MaxEnt models (Fourcade *et al.*, 2014; Kane *et al.*, 2017; Truong *et al.*, 2017), Elith *et al.* (2011) suggests that since MaxEnt uses the process of regularization to choose predictors and features (transformations of predictors) that contribute most to the

distribution of a given species, all available predictors can be used to improve the predictive performance of the model. This would not be the case if the goal was to identify predictors that contribute most to the final SDM, however, this was outside of the scope of this work and since many species were being modelled concurrently, predictive performance was more important.

We input current environmental variables and occurrences for each species into the maximum entropy model Maxent version 3.3.3 k (Phillips *et al.*, 2006). To predict the future distribution for each species we input future environmental variables into the Maxent model.

After the raw Maxent output in logistic format was created for current and future species distributions, the “fixed cumulative value 5 logistic threshold” was applied to the output in order to produce presence/absence outputs for each species. This generally means that roughly 5% of the presences used as model inputs will be predicted as absences. This was used in order to account for some misidentification error or other errors in the input data, as opposed to using a less stringent threshold, such as minimum training presence, which generally gives minimal omission error, but produces outputs with a larger area of suitability (Norris, 2014). Presence/absence outputs for all species were stacked and a species richness map for the study region was created by summing all binary rasters representing each species’ presence and absences.

3.2.3 Functional and Phylogenetic Diversity measurement

All data mining and analyses described below were conducted using R statistical software (R Core Team, 2018) using the BIEN, caper, ape, picante, and geometry packages.

Different suites of traits are known to represent different functions and different responses to environmental disturbance. The leaf-height-seed (LHS) plant life strategy scheme, created by Westoby (1998), has been commonly used to represent different life history strategies in plants, similar to the Grime’s CSR scheme. Trait data for the Okanagan Ecoregion plant list was extracted from the BIEN database using the “BIEN_trait_mean” function in the BIEN package. This dataset incorporates data from larger botanical databases and independent studies that use standardized measurement

methods. Out of the 1,541 species in the overall plant list for the region, 1,220 had trait data for all three LHS traits: specific leaf area (SLA), plant height, and seed mass. These traits were then scaled and principal components analysis (PCA) was used to eliminate trait redundancy and to identify distinct functional axes (Leps *et al.*, 2006; Swenson, 2014).

Functional Richness (FRic) was calculated as the convex hull volume of each assemblage in three-dimensional trait space using the trait PCA scores.

The BIEN complete phylogeny (Maitner *et al.*, 2018) was used to create the phylogenetic tree representing all plant species in the Okanagan Ecoregion. Faith's Phylogenetic Diversity (PD) index, calculated as the sum of the branch lengths of all species in an assemblage, was quantified and used as a measure of phylogenetic richness.

The observed diversity metrics were then standardized using a null model. The taxa labels for both the phylogenetic and functional distance matrices were randomized 100 times. Each of the phylogenetic and functional diversity metrics were then recalculated based on the 100 randomized distance matrices, to create null distributions of each diversity metric. The standardized diversity metrics were then calculated as the standardized effect size, given as:

$$SES = \frac{\text{Observed Diversity} - \text{Mean of Null Distribution}}{SD \text{ of Null Distribution}}$$

This gives measures of functional and phylogenetic diversity that are independent of species richness.

3.3.4 Congruence between diversity facets, environmental variables, and protected areas

We used Spearman correlation test to assess the degree of congruence between the current and future biodiversity facets as well as the current and future environmental variables. P-values were not reported, as spatial autocorrelation between the metrics and the large sample size would greatly inflate Type-I error. Instead, only the strength of the correlation was given. Hotspots for all metrics were defined as the cells with the top 5%

of values (Mouillot *et al.*, 2011; Albouy *et al.*, 2017). Areas of congruence or overlap between hotspots were mapped for species richness (SR), standardized functional diversity (FRic_{ses}), and standardized phylogenetic diversity (PD_{ses}).

Protected areas found throughout the Okanagan Ecoregion (Figure 3.2) were also overlaid with the hotspots in order to identify the current and future protection of biodiversity under the current protected area network. The protected areas used included BC Parks, Ecological Areas, and Protected Areas, and Washington Protected Areas, all within IUCN Protected Area Categories I to V (Worboys, 2015). These protected areas encompass a total area of approximately 8,000 km², about 8% of the Okanagan Ecoregion.

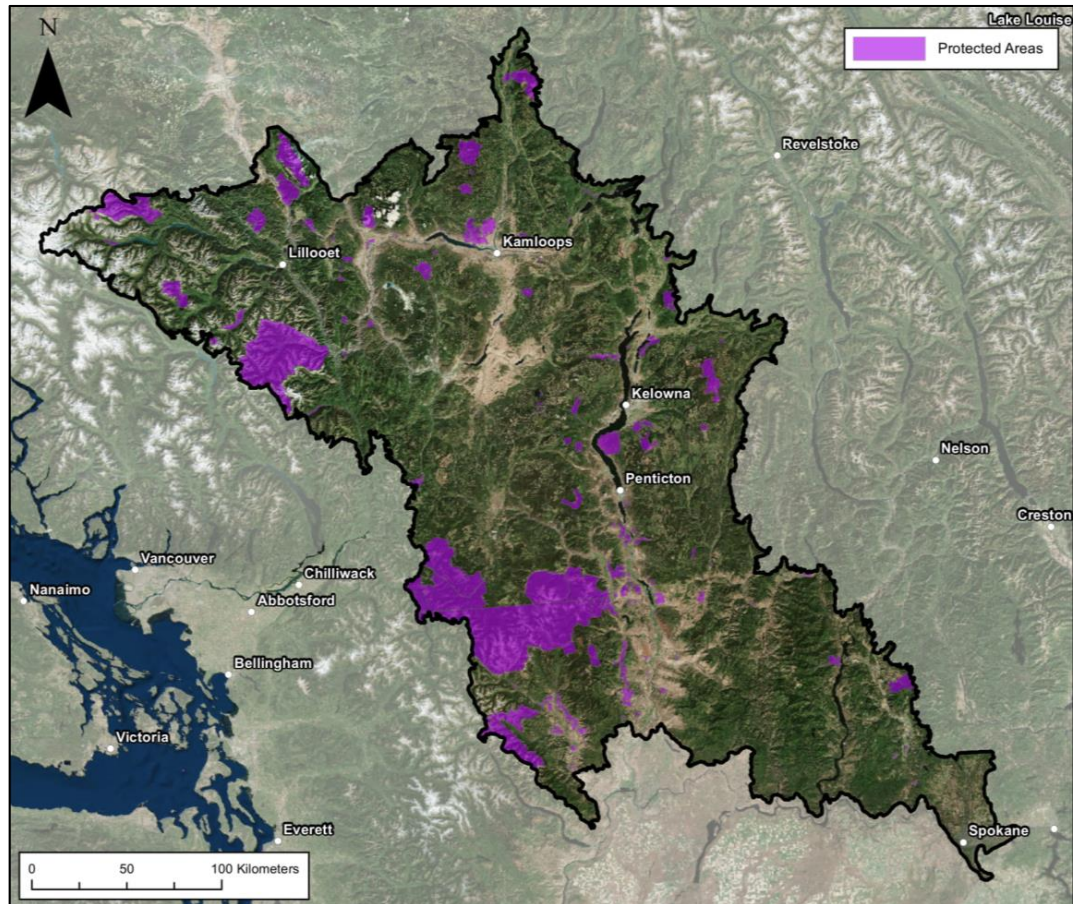


Figure 3.2 Protected areas found throughout the Okanagan Ecoregion.
Figure created by Carmen Chelick.

3.3 Results

All scripts required to achieve computational reproducibility of this research are available on the Open Science Framework (<https://osf.io/cxdj8/>). The SDMs used to predict taxonomic, functional, and phylogenetic diversity patterns for the 1,541 vascular plant species had a high predictive performance overall. Table 2 shows the mean number of occurrences extracted from GBIF for each species, the occurrences that actually went into the model, and the AUC of the model, which is a measure of the model's predictive performance.

A summary of the current and future diversity metrics and environmental variables across the Okanagan Ecoregion is found in Appendix A4 and A5.

Table 3.1. Number of occurrences used in the MaxEnt model as well as the AUC value, a measure of predictive performance.

Summary	Mean	SD	Min	Max
Total Occurrences (GBIF)	17,172	44,066	22	200,000
Occurrences Used (MaxEnt)	426	594	2	10,348
AUC (model performance)	0.96	0.031	0.81	0.9996

Appendix A2 and A3 show the correlations between the current and future diversity metrics and the current and future environmental predictor variables that were used to create the SDMs. While current SR was strongly ($\rho \geq |0.75|$) positively correlated with temperature of driest quarter (BIO 9), current PD, and FRic were not strongly correlated with any of the environmental predictor variables. None of the future diversity metrics were strongly correlated with any of the future environmental predictor variables. Current SR and PD went from being negatively correlated with elevation ($\rho = -0.44$ and $\rho = -0.67$, respectively) to being positively correlated with elevation ($\rho = 0.49$ and $\rho = 0.25$, respectively) in the future. Current FRic and elevation went from having $\rho = -0.65$ to $\rho = -0.05$ in the future.

All three diversity measures (SR, FRic, PD) showed highly concordant associations with the abiotic predictor variables; a Kendall's coefficient of concordance analysis using data from Appendix S2 was highly significant (Kendall's $W = 0.89$; $P < 0.001$). Thus, in general, if one of the measures exhibited a positive association with, for example, elevation, then the other two measures tended to also.

Current SR and PD were strongly positively correlated, while SR and FRic, and FRic and PD were weakly positively correlated (Table 3). After being standardized using the null model, $FRic_{ses}$ and PD_{ses} were only weakly correlated with SR. Current SR was highest in the southern parts of the region, with areas of high SR also occurring in some of the valleys in the northwest (Figure 3.3a). Current FRic was high in the northeast, southeast, and within the northwestern valleys (Figure 3.3b and 10c). PD was also high in the northwestern valleys, as well as in the southeast and southwest (Figure 3.3d and 3.3e). Hotspots of current FRic and PD, and SR and FRic had 2,179 km² and 2,280 km² area of congruence (Figure 3.4), respectively. Current SR and PD had the greatest area of congruence at 5,236 km². The hotspot congruence between current SR and FRic, SR and PD, and FRic and PD occurred mainly in the southeast and in some of the valleys in the northwest (Figures 3.4).

Table 3.2. Spearman correlation coefficients (ρ) between all diversity metrics according to current climate.

Diversity Metric	SR	FRic	$FRic_{ses}$	PD	PD_{ses}
SR		0.622	0.211	0.940	0.258
FRic	0.622		0.889	0.739	0.595
$FRic_{ses}$	0.211	0.889		0.395	0.614
PD	0.940	0.739	0.395		0.564
PD_{ses}	0.258	0.595	0.614	0.564	

None of the diversity metrics for future climate were strongly correlated (Table 4). Future SR was weakly negatively correlated with FRic, $FRic_{ses}$, and PD_{ses} , and

weakly positively correlated with PD. FRic and PD, and FRic_{ses} and PD_{ses} were also weakly positively correlated. Future SR and FRic had an area of congruence of 2,705 km², and future FRic and PD had an area of congruence of 2,514 km². Future SR and PD hotspots had the most congruence, with an area of 4,211 km². Hotspot congruence between SR, FRic and PD occurred mainly in the southwest (Figure 3.4).

Table 3.3 Spearman correlation coefficients (ρ) between all diversity metrics according to future climate.

Diversity Metric	SR	FRic	FRic _{ses}	PD	PD _{ses}
SR		-0.058	-0.380	0.215	-0.525
FRic	-0.058		0.003	0.269	0.033
FRic _{ses}	-0.380	0.003		0.167	0.216
PD	0.215	0.269	0.167		-0.254
PD _{ses}	-0.525	0.033	0.216	-0.254	

Overall, the current protected area network in the Okanagan Ecoregion will more effectively protect future diversity hotspots than current diversity hotspots. The current protected area network currently protects 292 km² of the current SR hotspots, and will protect 7,193 km² of future SR hotspots, an increase in protection of 2,363% (Figure 3.5). FRic and PD hotspots also both have an increase in the areas protected, with FRic increasing from 471 km² currently protected to 1,072 km² protected in the future (127% increase), and PD increasing from 422 km² currently protected to 1,683 km² protected in the future (299% increase) (Figure 3.5).

The standardized measures of FRic and PD were independent of SR, as shown by the weak correlations. Appendix A6 shows the heatmaps and hotspot congruence for SR, FRic_{ses}, and PD_{ses}. Current SR and FRic_{ses} hotspots had essentially no congruence (an area of 1 km²), FRic_{ses} and PD_{ses} had 2,016 km² area of congruence, and SR and PD_{ses} had 1,599 km² area of congruence. These areas of congruence occurred mainly in the northeast area of the region. Future SR hotspots had only 170 km² area of congruence

with PD_{ses} hotspots and essentially no congruence with $FRic_{ses}$ hotspots (an area of 1 km^2). Future $FRic_{ses}$ and PD_{ses} had 280 km^2 area of congruence.

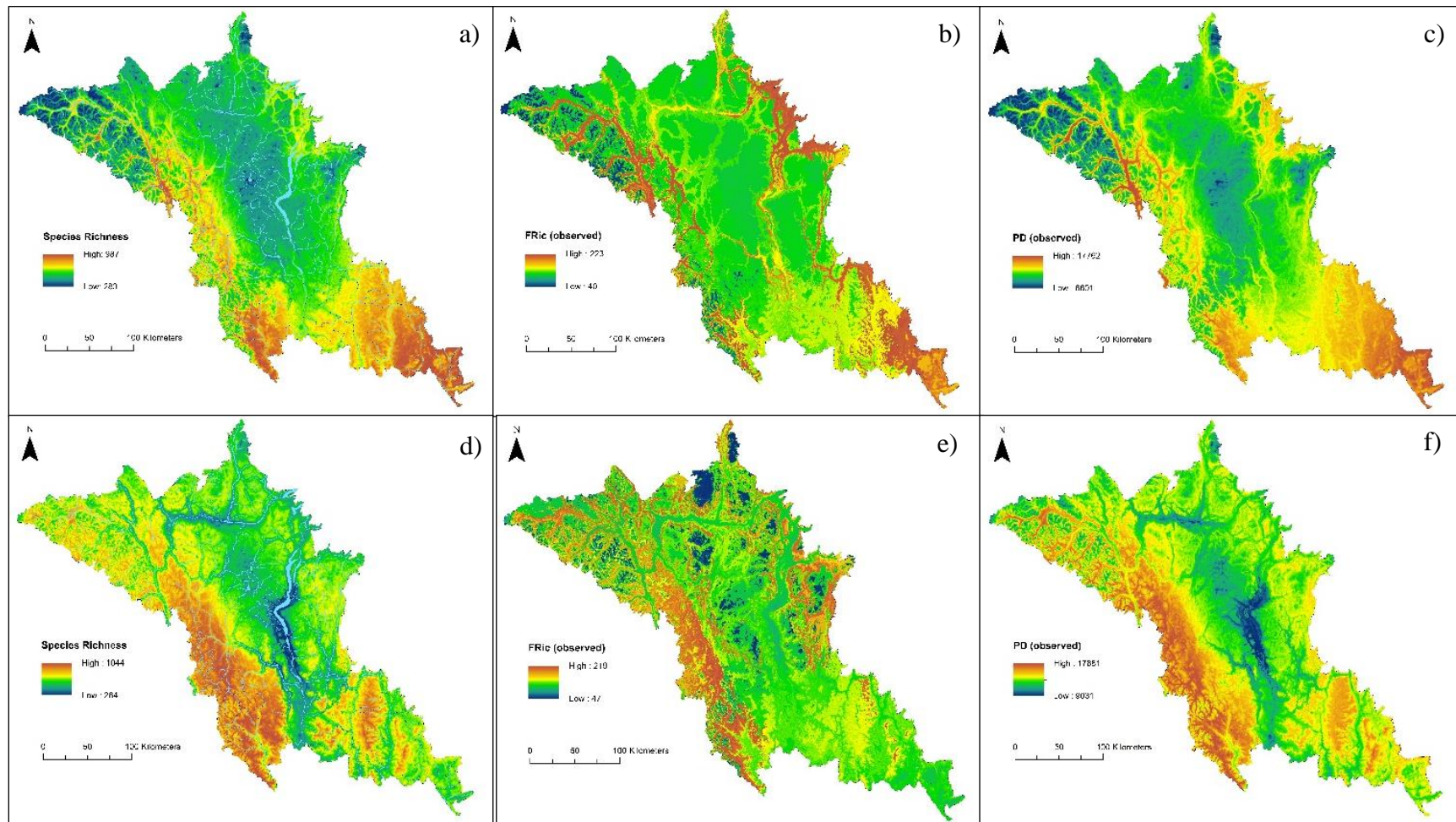


Figure 3.3 Maps depicting areas of high diversity (red hues), moderate diversity (yellow and green hues), and low diversity (blue hues), where a) represents current species richness; b) represents current observed FRic; c) represents current observed PD; d) represents future species richness; e) represents future observed FRic; f) represents future observed PD.

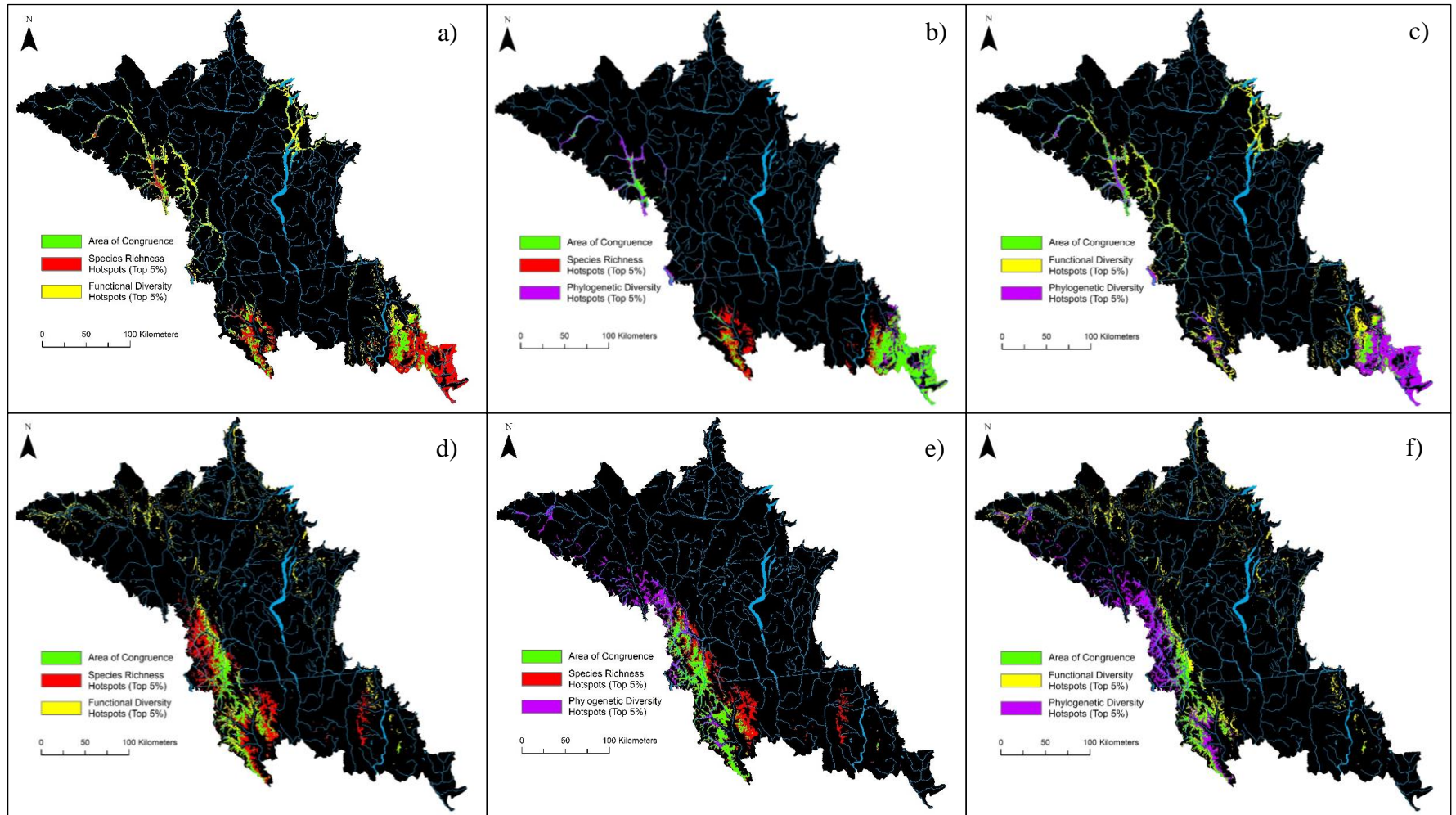


Figure 3.4 Maps showing the congruence between hotspots (top 5% of values) of a) current SR and observed FD; b) current SR and observed PD; c) current observed FD and observed PD; d) future SR and observed FD; e) future SR and observed PD; and f) future observed FD and observed PD.

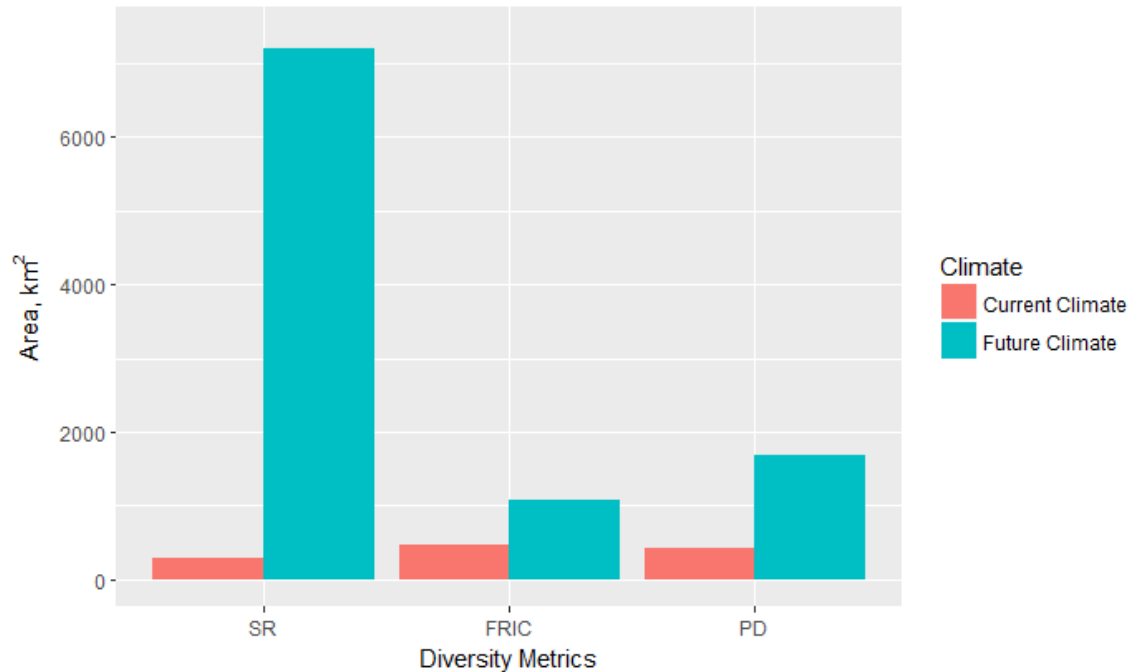


Figure 3.5 Grouped barplot depicting hotspot protection by the current protected area network for the three diversity metrics according to current and future climate.

3.4 Discussion

While taxonomic diversity is typically the only facet of biodiversity that is incorporated into regional conservation efforts, including functional and phylogenetic diversity in biodiversity assessments can allow other conservation priorities to be addressed, including the conservation of unique ecological and ecosystem functions (Tilman *et al.*, 1997; Loreau, 2000; Diaz & Cabido, 2001; Hooper *et al.*, 2005; Cadotte, 2017) and unique evolutionary histories (Mace *et al.*, 2003; Isaac *et al.*, 2007; Devictor *et al.*, 2010). Here we have provided novel quantitative analyses and maps of functional and phylogenetic plant diversity for the Okanagan Ecoregion, with the aim of broadening the information base available to inform regional conservation efforts, which thus far have exclusively considered taxonomic diversity.

Protected area establishment is considered to be one of the most common and effective methods for conserving biodiversity. According to these results, the Okanagan Ecoregion's current protected area network does not effectively protect hotspots of current taxonomic, functional, and phylogenetic diversity of plant communities.

However, we did find that hotspots of all three facets of biodiversity increased in protection in the future, with taxonomic diversity having a substantial increase in protection. Figure 3.3 illustrates shifts in taxonomic, functional and phylogenetic diversity from the east to the west in the future. The increase in the protection of all three facets of biodiversity in the future may be attributed to the presence of a large network of protected areas in the west, made up of Cathedral Provincial Park, Snowy Protected Area, and E.C. Manning Provincial Park in British Columbia, and the Wenatchee National Forest in Washington, which together make up almost 1.8 million hectares of protected land.

The overall increase in protection of all three biodiversity facets in the future may also be attributed to a shift in diversity towards higher elevation areas. While current observed biodiversity measures were negatively correlated with elevation, future observed biodiversity measures were found to be more positively correlated with elevation. Since the current protected area network encapsulates a number of mountain ranges and higher elevation areas within the Okanagan Ecoregion, a shift in biodiversity up in elevation may therefore result in increased protection in the future. Thuiller *et al.* (2014) also found a shift in plant diversity towards higher elevation areas in the French Alps, which resulted in increased protection within their current protected area network. It may therefore be important to focus protected area establishment on higher elevation areas in the Okanagan Ecoregion to compensate for the potential shift in plant diversity up in elevation.

Unlike the maps produced as a result of this research, the relative biodiversity maps created by the OCCP, based on biodiversity proxies such as distance from roads, size of natural areas, and the presence of important ecosystems, habitat features, or species-at-risk, show high biodiversity occurring mainly in the low elevation valleys in the Okanagan. This difference is likely attributed to the fact that many of the species- and ecosystems-at-risk in the Okanagan Ecoregion occur in low elevation grasslands and wetlands, and the goal of the OCCP maps is to highlight areas of conservation priority for the region. The maps of taxonomic, functional, and phylogenetic diversity, on the other hand, do not take extinction risk or regional significance into account.

It is also important to consider that spatial shifts observed between current and future biodiversity patterns are only possible if species have the ability to disperse to and track their preferred environmental conditions (Dullinger *et al.*, 2012; Thuiller *et al.*, 2014), are not outcompeted and displaced in new habitats by native and non-native competitors (Svenning *et al.*, 2014; Thuiller *et al.*, 2014), and are not able to adapt to climate variability and remain in their current habitats (Zimmermann *et al.*, 2009; Thuiller *et al.*, 2014). Taking these potential limitations into consideration, this work still emphasizes that protected area establishment and other conservation efforts need to not only consider protecting multiple facets of biodiversity, but also consider how these facets of biodiversity may change in the future.

Apart from the observed shift in biodiversity to higher elevation areas in the future, there were also lower or moderate elevation areas that were found to have high taxonomic, functional, and phylogenetic diversity according to current climate conditions. The Botanie Valley south of Lillooet, BC, also had high current taxonomic, functional, and phylogenetic diversity. In an ethnobotanical study by Turner *et al.* (2011), they found that the of the Nlaka'pmx Interior Salish people have been travelling to Pt-e'n'i (Botanie Valley) for hundreds of years to forage on the bounty of plant life available in this valley. Another area that had a significantly high current functional diversity is the area north of Vernon, BC. This area is considered to be a transition zone from the hot and dry ecosystems that are characteristic of the Okanagan Ecoregion, into moist and warm ecosystems of the Interior Cedar-Hemlock (ICH) biogeoclimatic zone.

Overall, our results illustrated significant geographic variation between patterns of taxonomic, functional, and phylogenetic diversity. There have been a number of other studies that have found discrepancies between diversity patterns of these three facets across a variety of taxonomic groups (Devictor *et al.*, 2010; Strecker *et al.*, 2011; Albouy *et al.*, 2017; Pardo *et al.*, 2017). Congruence between hotspots of functional and taxonomic diversity, and functional and phylogenetic diversity for both current and future climate was relatively low. Current and future hotspots of taxonomic and phylogenetic diversity had greater congruence. This means that while conservation efforts that focus on protecting hotspots of taxonomic diversity may result in the protection of phylogenetic diversity hotspots, but may not sufficiently protect functional diversity hotspots. We also

found, however, that all three current observed diversity measures were positively correlated. Positive relationships between the three facets of biodiversity have also been demonstrated in literature, with the relationship between functional and phylogenetic diversity being continually explored and debated. Although it is generally predicted that closely related species will be more functionally similar than distantly related species, this prediction does not hold true for all models of evolution, especially for traits that undergo strong selection pressure. While the debate within literature is ongoing, phylogenetic diversity is sometimes found to be a better signal of ecosystem function than species richness, and sometimes even functional diversity (Cadotte *et al.*, 2008). Using a long-term empirical data set on plant productivity, Davies *et al.* (2016) found no association between evolutionary distinctiveness and ecosystem functioning. They however do suggest that phylogenetic diversity may be a better predictor of functional diversity than species richness alone. They also suggest that one of the reasons why phylogenetic diversity may be a good proxy for ecosystem function is that it is often difficult to collect functional trait data that directly relates to a given ecosystem function and is therefore poorly represented in functional diversity assessments. Phylogenetic diversity based on up-to-date phylogenies has the potential to incorporate traits that are hard to measure into predictions of ecosystem functioning (Flynn *et al.*, 2011; Davies *et al.*, 2016). Forest *et al.* (2010) found that phylogenetic diversity and species richness patterns differed in plant assemblages in the Cape of South Africa, but phylogenetic diversity was more effectively related to species with greater feature diversity and economic and medicinal use than species richness. Phylogenetic signalling of traits of plant species in the Okanagan Ecoregion would need to be assessed in order to determine the potential for phylogenetic diversity to be used as a proxy for functional diversity. While we observed significant geographic variation in taxonomic, functional, and phylogenetic diversity among plant communities in the Okanagan Ecoregion that emphasizes the need for a multi-faceted approach to conservation efforts, the positive correlation observed between the facets and the evidence found in literature suggests that phylogenetic diversity may be used as a proxy for functional diversity when sufficient data to quantify functional diversity is lacking.

As part of this analysis, a null model was used in order to create measures of functional and phylogenetic diversity that are independent of taxonomic diversity. While these standardized measures are typically used to assess mechanisms of community assembly by identifying functional or phylogenetic overdispersion or clustering (Weiher *et al.*, 1995; Lessard *et al.*, 2012; Miller *et al.*, 2016), these assessments require fine-grain sampling in order to adequately measure these processes. Instead, we use these standardized measures of functional and phylogenetic diversity to identify areas that have greater functional or phylogenetic diversity than expected given taxonomic diversity. These standardized measures of functional and phylogenetic diversity show greater diversity in the northern areas of the Okanagan Ecoregion compared to the observed measures which are concentrated in the south. While the primary focus of this research was to determine how conservation measures focussed on taxonomic diversity relate to the conservation of observed measures of functional and phylogenetic diversity, the standardized measures of functional and phylogenetic diversity identify sites that harbour plant communities with greater functional and phylogenetic diversity than expected given taxonomic diversity, and could result in an overall increased protection of plant species that are functionally and evolutionarily unique.

Using individual species distribution models to develop patterns of taxonomic, phylogenetic, and functional diversity is uncommon in literature, but can be a useful method for identifying areas of conservation interest in regions that have not been extensively surveyed. The overall high AUC values that we obtained from the individual SDMs suggest that the taxonomic, functional, and phylogenetic patterns produced from these SDMs are good representations of the relative diversity patterns. One limitation of this approach however is that SDMs based on the abiotic requirements of species are only modelling a species' fundamental niche, and do not directly take into account biotic interactions, adaptive or evolutionary processes, or dispersal limitations (Drake, 2014; Zhang *et al.*, 2015). Therefore, the diversity patterns produced from these SDMs likely overestimate the actual diversity, and should instead be interpreted as predictions of "potential" diversity.

Overall, this research demonstrates the importance of considering multiple facets of biodiversity simultaneously as well as considering how these facets of biodiversity

may change with changing climate. While the current protected area established in the Okanagan Ecoregion does not sufficiently protect hotspots of any of the three biodiversity facets for plant communities, protection may increase in the future if species move west into larger protected area networks and move into protected areas in higher elevation areas. While the importance of all three facets of biodiversity has been increasingly demonstrated in scientific literature, there remains a need for more studies to bring the importance of these three facets of biodiversity into conservation efforts occurring at a regional scale. Using SDMs to predict diversity patterns, this research provides baseline estimates of the geographic variations in the three facets of biodiversity in plant communities across the Okanagan Ecoregion that may offer guidance for future conservation decisions.

4 Conclusion

The goal of this research was to predict current and future patterns of taxonomic, functional, and phylogenetic diversity for plant assemblages in the Okanagan Ecoregion. As complete survey data for the region was not available, stacked SDMs were used to first predict the ranges of all species known to occur in the Okanagan Ecoregion. These species ranges were then stacked to produce estimates of species richness, or taxonomic diversity, which was subsequently used to predict functional and phylogenetic diversity patterns. The species ranges were modelled for both current and future climate, which allowed for comparisons of current and future patterns of taxonomic, functional, and phylogenetic diversity. Hotspots of all three facets of biodiversity based on current and future climate were then compared to the current protected area network within the Okanagan Ecoregion. The approach used here highlighted the tools and data that is freely available to carry out multi-faceted biodiversity assessments, and this approach could therefore be used to do similar assessments within any region or for any group of species of interest. Null models were also used in order to create standardized measures of functional and phylogenetic diversity that are independent of species richness.

We found that hotspots of taxonomic, functional, and phylogenetic diversity had a limited amount of congruence and were also found to shift with changing climate. While current functional and phylogenetic diversity hotspots had the greatest amount of congruence, hotspots of species richness and functional diversity had essentially no congruence. With future climate projections, all hotspots showed significant decreases in congruence. Species richness surprisingly had the lowest level of protection from the current protected area network, however, with future climate projections, protection of species richness hotspots increased, functional diversity hotspot protection decreased, and phylogenetic diversity hotspots protection remained mostly constant.

This multi-faceted biodiversity approach, which also considers current and future climate conditions, will allow local conservation practitioners to consider multiple conservation priorities simultaneously. While taxonomic diversity is the only facet of biodiversity that is currently being considered by conservation efforts in the Okanagan Ecoregion, this project emphasizes the importance of considering functional and phylogenetic diversity facets in future efforts.

It is also important to consider the drastic impacts that climate change will have in the Okanagan Ecoregion. This research has shown that biodiversity patterns will shift in response to climate change, and while species richness may have increased protection in the current protected area network, functional diversity protection may decrease. Future conservation efforts in the Okanagan Ecoregion should therefore not only consider functional and phylogenetic diversity patterns alongside species richness, but should also consider how current biodiversity patterns will be impacted by climate change.

This research can be considered as a preliminary assessment of current and future patterns of taxonomic, functional, and phylogenetic diversity, and there are a number of steps that could be taken in the future to refine this work. Because stacked SDMs were used as the basis from which the diversity measures were quantified, the accuracy of the SDMs for each species impacts the subsequent diversity patterns. Although the predictive performance of the SDMs appeared to be high, field validations would have helped assess the accuracy of these models. If field validations are not possible, these results could also be validated against species lists that may exist for protected areas such as provincial parks. Validating these SDMs in the field would help to better understand the overall accuracy of using stacked SDMs to produce estimates of taxonomic, functional, and phylogenetic diversity patterns.

While LHS traits are commonly used to assess the overall range of life history strategies in plant assemblages, functional diversity of other plant traits could be assessed to determine the diversity of specific ecological functions and resilience to disturbances. Due to the increased frequency and intensity of forest fires in the region, for example, mapping the functional diversity of plant assemblages based on traits that relate to fire tolerance and resistance, such as seed dispersal method and bark thickness, would identify assemblages that may be more resilient to disturbance by fire, as well as assemblages that would be most vulnerable to fire. Mapping functional diversity based on traits that are related to pollinators, such as nectar resource traits and timing of flower bloom, could also identify potential restoration areas that could contribute to the connectivity of habitats for pollinator species. These assessments could also be produced for more specific species groups, such that they show where areas of high and low

taxonomic, functional and phylogenetic diversity of species-at-risk, for example, occur in the Okanagan Ecoregion.

This research provides the first baseline assessment of taxonomic, functional, and phylogenetic diversity for the region. Identifying hotspots of multiple facets of biodiversity for both current and future climate will allow conservation practitioners in the region to consider multiple conservation objectives and scenarios of landscape change as new protected areas are established. While these approaches are prominent in scientific literature, I have demonstrated a methodology that utilizes open source software and easily accessible data that could be used to create assessments at a scale that is meaningful for regional conservation decisions.

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Appendices

A1. Final Species List

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Abies amabilis</i>	Pacific silver fir	Pinaceae	Perennial	Tree	Native
<i>Abies grandis</i>	grand fir	Pinaceae	Perennial	Tree	Native
<i>Abies lasiocarpa</i>	subalpine fir	Pinaceae	Perennial	Tree	Native
<i>Abutilon theophrasti</i>	velvetleaf	Malvaceae	Annual	Forb	Exotic
<i>Acer campestre</i>	hedge maple	Aceraceae	Perennial	Tree	Native
<i>Acer circinatum</i>	vine maple	Aceraceae	Perennial	Tree	Native
<i>Acer glabrum</i>	Rocky Mountain maple	Aceraceae	Perennial	Shrub	Native
<i>Acer macrophyllum</i>	bigleaf maple	Aceraceae	Perennial	Tree	Native
<i>Acer negundo</i>	boxelder	Aceraceae	Perennial	Tree	Exotic
<i>Acer platanoides</i>	Norway maple	Aceraceae	Perennial	Tree	Exotic
<i>Acer saccharinum</i>	silver maple	Aceraceae	Perennial	Tree	Native
<i>Achillea millefolium</i>	common yarrow	Asteraceae	Perennial	Forb	Native
<i>Achlys triphylla</i>	sweet after death	Berberidaceae	Perennial	Forb	Native
<i>Achnatherum lemmonii</i>	Lemmon's needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Achnatherum lettermanii</i>	Letterman's needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Achnatherum nelsonii</i>	Columbia needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Achnatherum occidentale</i>	western needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Achnatherum richardsonii</i>	Richardson's needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Achnatherum thurberianum</i>	Thurber's needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Aconitum columbianum</i>	Columbian monkshood	Ranunculaceae	Perennial	Forb	Native
<i>Actaea rubra</i>	red baneberry	Ranunculaceae	Perennial	Forb	Native
<i>Adenocaulon bicolor</i>	American trailplant	Asteraceae	Perennial	Forb	Native
<i>Adiantum aleuticum</i>	Aleutian maidenhair	Pteridaceae	Perennial	Forb	Native
<i>Adiantum pedatum</i>	northern maidenhair	Pteridaceae	Perennial	Forb	Native
<i>Aegilops cylindrica</i>	jointed goatgrass	Poaceae	Annual	Graminoid	Exotic
<i>Aegopodium podagraria</i>	bishop's goutweed	Apiaceae	Perennial	Forb	Exotic
<i>Agastache urticifolia</i>	nettleleaf giant hyssop	Lamiaceae	Perennial	Forb	Native
<i>Agoseris aurantiaca</i>	orange agoseris	Asteraceae	Perennial	Subshrub	Native
<i>Agoseris glauca</i>	pale agoseris	Asteraceae	Perennial	Forb	Native
<i>Agoseris grandiflora</i>	bigflower agoseris	Asteraceae	Perennial	Forb	Native
<i>Agoseris heterophylla</i>	annual agoseris	Asteraceae	Annual	Forb	Native
<i>Agrimonia gryposepala</i>	tall hairy agrimony	Rosaceae	Perennial	Forb	Native
<i>Agropyron cristatum</i>	crested wheatgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Agropyron desertorum</i>	desert wheatgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Agrostemma githago</i>	common corncockle	Caryophyllaceae	Annual	Forb	Native
<i>Agrostis capillaris</i>	colonial bentgrass	Poaceae	Perennial	Graminoid	Exotic

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Agrostis exarata</i>	spike bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis gigantea</i>	redtop	Poaceae	Perennial	Graminoid	Exotic
<i>Agrostis hyemalis</i>	winter bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis idahoensis</i>	Idaho bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis mertensii</i>	northern bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis oregonensis</i>	Oregon bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis pallens</i>	seashore bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Agrostis scabra</i>	rough bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Ailanthus altissima</i>	tree of heaven	Simaroubaceae	Perennial	Tree	Exotic
<i>Alcea rosea</i>	hollyhock	Malvaceae	Biennial	Forb	Exotic
<i>Allium acuminatum</i>	tapertip onion	Liliaceae	Perennial	Forb	Native
<i>Allium ampeloprasum</i>	broadleaf wild leek	Liliaceae	Perennial	Forb	Native
<i>Allium cernuum</i>	nodding onion	Liliaceae	Perennial	Forb	Native
<i>Allium crenulatum</i>	Olympic onion	Liliaceae	Perennial	Forb	Native
<i>Allium douglasii</i>	Douglas' onion	Liliaceae	Perennial	Forb	Native
<i>Allium fibrillum</i>	Cuddy Mountain onion	Liliaceae	Perennial	Forb	Native
<i>Allium geyeri</i>	Geyer's onion	Liliaceae	Perennial	Forb	Native
<i>Allium nevii</i>	Nevius' garlic	Liliaceae	Perennial	Forb	Native
<i>Allium schoenoprasum</i>	wild chives	Liliaceae	Perennial	Forb	Native
<i>Allium textile</i>	textile onion	Liliaceae	Perennial	Forb	Native
<i>Alnus incana</i>	gray alder	Betulaceae	Perennial	Tree	Native
<i>Alnus rhombifolia</i>	white alder	Betulaceae	Perennial	Tree	Native
<i>Alnus rubra</i>	red alder	Betulaceae	Perennial	Tree	Native
<i>Alopecurus pratensis</i>	meadow foxtail	Poaceae	Perennial	Graminoid	Exotic
<i>Alyssum alyssoides</i>	pale madwort	Brassicaceae	Annual	Forb	Exotic
<i>Alyssum desertorum</i>	desert madwort	Brassicaceae	Annual	Forb	Exotic
<i>Amaranthus albus</i>	prostrate pigweed	Amaranthaceae	Annual	Forb	Exotic
<i>Amaranthus blitoides</i>	mat amaranth	Amaranthaceae	Annual	Forb	Exotic
<i>Amaranthus blitum</i>	purple amaranth	Amaranthaceae	Annual	Forb	Exotic
<i>Amaranthus californicus</i>	California amaranth	Amaranthaceae	Annual	Forb	Native
<i>Amaranthus cruentus</i>	red amaranth	Amaranthaceae	Annual	Forb	Native
<i>Amaranthus powellii</i>	Powell's amaranth	Amaranthaceae	Annual	Forb	Exotic
<i>Amaranthus retroflexus</i>	redroot amaranth	Amaranthaceae	Annual	Forb	Native
<i>Ambrosia acanthicarpa</i>	flatspine bur ragweed	Asteraceae	Annual	Forb	Native
<i>Ambrosia artemisiifolia</i>	annual ragweed	Asteraceae	Annual	Forb	Exotic
<i>Ambrosia psilostachya</i>	Cuman ragweed	Asteraceae	Annual	Forb	Exotic
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry	Rosaceae	Perennial	Tree	Native
<i>Amelanchier pumila</i>	dwarf serviceberry	Rosaceae	Perennial	Shrub	Native
<i>Amelanchier utahensis</i>	Utah serviceberry	Rosaceae	Perennial	Tree	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Amsinckia lycopsoides</i>	tarweed fiddleneck	Boraginaceae	Annual	Forb	Native
<i>Amsinckia menziesii</i>	Menzies' fiddleneck	Boraginaceae	Annual	Forb	Native
<i>Amsinckia tessellata</i>	bristly fiddleneck	Boraginaceae	Annual	Forb	Native
<i>Anagallis minima</i>	chaffweed	Primulaceae	Annual	Forb	Native
<i>Anaphalis margaritacea</i>	western pearly everlasting	Asteraceae	Perennial	Forb	Native
<i>Androsace occidentalis</i>	western rockjasmine	Primulaceae	Annual	Forb	Native
<i>Androsace septentrionalis</i>	pygmyflower rockjasmine	Primulaceae	Annual	Forb	Native
<i>Anemone drummondii</i>	Drummond's anemone	Ranunculaceae	Perennial	Forb	Native
<i>Anemone multifida</i>	Pacific anemone	Ranunculaceae	Perennial	Forb	Native
<i>Anemone occidentalis</i>	white pasqueflower	Ranunculaceae	Perennial	Forb	Native
<i>Anemone oregana</i>	blue windflower	Ranunculaceae	Perennial	Forb	Native
<i>Angelica arguta</i>	Lyll's angelica	Apiaceae	Perennial	Forb	Native
<i>Angelica genuflexa</i>	kneeling angelica	Apiaceae	Perennial	Forb	Native
<i>Antennaria alpina</i>	alpine pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria anaphaloides</i>	pearly pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria argentea</i>	silver pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria dimorpha</i>	low pussytoes	Asteraceae	Perennial	Subshrub	Native
<i>Antennaria flagellaris</i>	whip pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria friesiana</i>	Fries' pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria howellii</i>	Howell's pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria lanata</i>	woolly pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria luzuloides</i>	rush pussytoes	Asteraceae	Perennial	Subshrub	Native
<i>Antennaria media</i>	Rocky Mountain pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria microphylla</i>	littleleaf pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria neglecta</i>	field pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria parvifolia</i>	small-leaf pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria pulcherrima</i>	showy pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria racemosa</i>	raceme pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria rosea</i>	rosy pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria stenophylla</i>	narrowleaf pussytoes	Asteraceae	Perennial	Forb	Native
<i>Antennaria umbrinella</i>	umber pussytoes	Asteraceae	Perennial	Forb	Native
<i>Anthemis cotula</i>	stinking chamomile	Asteraceae	Annual	Forb	Exotic
<i>Anthoxanthum aristatum</i>	annual vernalgrass	Poaceae	Annual	Graminoid	Exotic
<i>Anthoxanthum monticola</i>	alpine sweetgrass	Poaceae	Perennial	Graminoid	Native
<i>Anthoxanthum odoratum</i>	sweet vernalgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Anthriscus sylvestris</i>	wild chervil	Apiaceae	Annual	Forb	Exotic
<i>Apera interrupta</i>	dense silkybent	Poaceae	Annual	Graminoid	Exotic
<i>Aphanes arvensis</i>	field parsley piert	Rosaceae	Annual	Forb	Exotic
<i>Apium graveolens</i>	wild celery	Apiaceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Apocynum androsaemifolium</i>	spreading dogbane	Apocynaceae	Perennial	Forb	Native
<i>Apocynum cannabinum</i>	Indianhemp	Apocynaceae	Perennial	Forb	Native
<i>Aquilegia flavescens</i>	yellow columbine	Ranunculaceae	Perennial	Forb	Native
<i>Aquilegia formosa</i>	western columbine	Ranunculaceae	Perennial	Forb	Native
<i>Arabidopsis lyrata</i>	lyrate rockcress	Brassicaceae	Biennial	Forb	Native
<i>Arabidopsis thaliana</i>	mouseear cress	Brassicaceae	Annual	Forb	Exotic
<i>Arabis eschscholtziana</i>	Eschscholtz's hairy rockcress	Brassicaceae	Annual	Forb	Native
<i>Arabis hirsuta</i>	hairy rockcress	Brassicaceae	Annual	Forb	Native
<i>Arabis nuttallii</i>	Nuttall's rockcress	Brassicaceae	Perennial	Forb	Native
<i>Arabis pycnocarpa</i>	creamflower rockcress	Brassicaceae	Annual	Forb	Native
<i>Arachis hypogaea</i>	peanut	Fabaceae	Annual	Forb	Native
<i>Aralia nudicaulis</i>	wild sarsaparilla	Araliaceae	Perennial	Subshrub	Native
<i>Arctium minus</i>	lesser burdock	Asteraceae	Biennial	Forb	Exotic
<i>Arctostaphylos nevadensis</i>	pinemat manzanita	Ericaceae	Perennial	Subshrub	Native
<i>Arctostaphylos uva-ursi</i>	kinnikinnick	Ericaceae	Perennial	Subshrub	Native
<i>Arenaria serpyllifolia</i>	thymeleaf sandwort	Caryophyllaceae	Annual	Forb	Exotic
<i>Aristida purpurea</i>	purple threeawn	Poaceae	Annual	Graminoid	Native
<i>Armoracia rusticana</i>	horseradish	Brassicaceae	Perennial	Forb	Exotic
<i>Arnica chamissonis</i>	Chamisso arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica cordifolia</i>	heartleaf arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica fulgens</i>	foothill arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica lanceolata</i>	lanceleaf arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica latifolia</i>	broadleaf arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica longifolia</i>	spearleaf arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica mollis</i>	hairy arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica ovata</i>	sticky leaf arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica parryi</i>	Parry's arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica rydbergii</i>	Rydberg's arnica	Asteraceae	Perennial	Forb	Native
<i>Arnica sororia</i>	twin arnica	Asteraceae	Perennial	Forb	Native
<i>Arrhenatherum elatius</i>	tall oatgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Artemisia absinthium</i>	absinthium	Asteraceae	Perennial	Subshrub	Exotic
<i>Artemisia annua</i>	sweet sagewort	Asteraceae	Annual	Forb	Native
<i>Artemisia arbuscula</i>	little sagebrush	Asteraceae	Perennial	Shrub	Native
<i>Artemisia arctica</i>	boreal sagebrush	Asteraceae	Perennial	Subshrub	Native
<i>Artemisia biennis</i>	biennial wormwood	Asteraceae	Annual	Forb	Native
<i>Artemisia campestris</i>	field sagewort	Asteraceae	Biennial	Forb	Native
<i>Artemisia douglasiana</i>	Douglas' sagewort	Asteraceae	Perennial	Forb	Native
<i>Artemisia dracunculus</i>	tarragon	Asteraceae	Perennial	Subshrub	Native
<i>Artemisia frigida</i>	prairie sagewort	Asteraceae	Perennial	Subshrub	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Artemisia longifolia</i>	longleaf wormwood	Asteraceae	Perennial	Subshrub	Native
<i>Artemisia michauxiana</i>	Michaux's wormwood	Asteraceae	Perennial	Subshrub	Native
<i>Artemisia tilesii</i>	Tilesius' wormwood	Asteraceae	Perennial	Subshrub	Native
<i>Artemisia tridentata</i>	big sagebrush	Asteraceae	Perennial	Tree	Native
<i>Artemisia tripartita</i>	threetip sagebrush	Asteraceae	Perennial	Shrub	Native
<i>Artemisia vulgaris</i>	common wormwood	Asteraceae	Perennial	Forb	Exotic
<i>Aruncus dioicus</i>	bride's feathers	Rosaceae	Perennial	Forb	Native
<i>Asarum caudatum</i>	British Columbia wildginger	Aristolochiaceae	Perennial	Forb	Native
<i>Asclepias fascicularis</i>	Mexican whorled milkweed	Asclepiadaceae	Perennial	Forb	Native
<i>Asclepias speciosa</i>	showy milkweed	Asclepiadaceae	Perennial	Forb	Native
<i>Asparagus officinalis</i>	garden asparagus	Liliaceae	Perennial	Forb	Exotic
<i>Aspidotis densa</i>	Indian's dream	Pteridaceae	Perennial	Forb	Native
<i>Asplenium trichomanes</i>	maidenhair spleenwort	Aspleniaceae	Perennial	Forb	Native
<i>Asplenium viride</i>	brightgreen spleenwort	Aspleniaceae	Perennial	Forb	Native
<i>Astragalus agrestis</i>	purple milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus alpinus</i>	alpine milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus beckwithii</i>	Beckwith's milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus canadensis</i>	Canadian milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus cicer</i>	chickpea milkvetch	Fabaceae	Perennial	Forb	Exotic
<i>Astragalus eucosmus</i>	elegant milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus filipes</i>	basalt milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus lentiginosus</i>	freckled milkvetch	Fabaceae	Annual	Shrub	Native
<i>Astragalus lotiflorus</i>	lotus milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus miser</i>	timber milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus purshii</i>	woollypod milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus robbinsii</i>	Robbins' milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus sclerocarpus</i>	woodypod milkvetch	Fabaceae	Perennial	Forb	Native
<i>Astragalus tenellus</i>	looseflower milkvetch	Fabaceae	Perennial	Forb	Native
<i>Athysanus pusillus</i>	common sandweed	Brassicaceae	Annual	Forb	Native
<i>Atriplex argentea</i>	silverscale saltbush	Chenopodiaceae	Annual	Forb	Native
<i>Atriplex hortensis</i>	garden orache	Chenopodiaceae	Annual	Forb	Exotic
<i>Atriplex micrantha</i>	twoscale saltbush	Chenopodiaceae	Annual	Forb	Exotic
<i>Atriplex patula</i>	spear saltbush	Chenopodiaceae	Annual	Forb	Exotic
<i>Atriplex rosea</i>	tumbling saltweed	Chenopodiaceae	Annual	Forb	Exotic
<i>Atriplex truncata</i>	wedgescale saltbush	Chenopodiaceae	Annual	Forb	Native
<i>Avena fatua</i>	wild oat	Poaceae	Annual	Graminoid	Exotic
<i>Avena sativa</i>	common oat	Poaceae	Annual	Graminoid	Exotic
<i>Axyris amaranthoides</i>	Russian pigweed	Chenopodiaceae	Annual	Forb	Exotic
<i>Balsamorhiza careyana</i>	Carey's balsamroot	Asteraceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Balsamorhiza sagittata</i>	arrowleaf balsamroot	Asteraceae	Perennial	Forb	Native
<i>Barbarea vulgaris</i>	garden yellowrocket	Brassicaceae	Biennial	Forb	Exotic
<i>Bassia hyssopifolia</i>	fivehorn smotherweed	Chenopodiaceae	Annual	Forb	Exotic
<i>Berberis aquifolium</i>	hollyleaved barberry	Berberidaceae	Perennial	Shrub	Native
<i>Berberis nervosa</i>	Cascade barberry	Berberidaceae	Perennial	Shrub	Native
<i>Berberis repens</i>	creeping barberry	Berberidaceae	Perennial	Shrub	Native
<i>Berberis thunbergii</i>	Japanese barberry	Berberidaceae	Perennial	Shrub	Exotic
<i>Berberis vulgaris</i>	common barberry	Berberidaceae	Perennial	Shrub	Exotic
<i>Berteroa incana</i>	hoary alyssum	Brassicaceae	Annual	Forb	Exotic
<i>Betula occidentalis</i>	water birch	Betulaceae	Perennial	Tree	Native
<i>Betula papyrifera</i>	paper birch	Betulaceae	Perennial	Tree	Native
<i>Betula pendula</i>	European white birch	Betulaceae	Perennial	Tree	Exotic
<i>Bidens frondosa</i>	devil's beggartick	Asteraceae	Annual	Forb	Exotic
<i>Bistorta vivipara</i>	alpine bistort	Polygonaceae	Perennial	Forb	Native
<i>Boechera collinsii</i>	Collins' rockcress	Brassicaceae	Biennial	Forb	Native
<i>Boechera divaricarpa</i>	spreadingpod rockcress	Brassicaceae	Biennial	Forb	Native
<i>Boechera holboellii</i>	Holboell's rockcress	Brassicaceae	Biennial	Forb	Native
<i>Boechera lemmonii</i>	Lemmon's rockcress	Brassicaceae	Perennial	Forb	Native
<i>Boechera lignifera</i>	desert rockcress	Brassicaceae	Perennial	Forb	Native
<i>Boechera lyallii</i>	Lyall's rockcress	Brassicaceae	Perennial	Forb	Native
<i>Boechera microphylla</i>	littleleaf rockcress	Brassicaceae	Perennial	Forb	Native
<i>Boechera retrofracta</i>	second rockcress	Brassicaceae	Biennial	Forb	Native
<i>Boechera sparsiflora</i>	sicklepod rockcress	Brassicaceae	Biennial	Forb	Native
<i>Boechera stricta</i>	Drummond's rockcress	Brassicaceae	Biennial	Forb	Native
<i>Borago officinalis</i>	common borage	Boraginaceae	Annual	Forb	Exotic
<i>Botrychium lanceolatum</i>	lanceleaf grapefern	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium lunaria</i>	common moonwort	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium minganense</i>	Mingan moonwort	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium montanum</i>	mountain moonwort	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium multifidum</i>	leathery grapefern	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium pinnatum</i>	northern moonwort	Ophioglossaceae	Perennial	Forb	Native
<i>Botrychium virginianum</i>	rattlesnake fern	Ophioglossaceae	Perennial	Forb	Native
<i>Brassica juncea</i>	brown mustard	Brassicaceae	Annual	Forb	Exotic
<i>Brassica nigra</i>	black mustard	Brassicaceae	Annual	Forb	Exotic
<i>Brassica rapa</i>	field mustard	Brassicaceae	Annual	Forb	Exotic
<i>Brickellia grandiflora</i>	tasselflower brickellbush	Asteraceae	Perennial	Subshrub	Native
<i>Brickellia oblongifolia</i>	Mojave brickellbush	Asteraceae	Perennial	Subshrub	Native
<i>Brodiaea coronaria</i>	crown brodiaea	Liliaceae	Perennial	Forb	Native
<i>Bromus arvensis</i>	field brome	Poaceae	Annual	Graminoid	Native

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<i>Bromus briziformis</i>	rattlesnake brome	Poaceae	Annual	Graminoid	Exotic
<i>Bromus carinatus</i>	California brome	Poaceae	Annual	Graminoid	Native
<i>Bromus ciliatus</i>	fringed brome	Poaceae	Perennial	Graminoid	Native
<i>Bromus diandrus</i>	ripgut brome	Poaceae	Annual	Graminoid	Native
<i>Bromus hordeaceus</i>	soft brome	Poaceae	Annual	Graminoid	Exotic
<i>Bromus inermis</i>	smooth brome	Poaceae	Perennial	Graminoid	Exotic
<i>Bromus marginatus</i>	mountain brome	Poaceae	Perennial	Graminoid	Native
<i>Bromus porteri</i>	Porter brome	Poaceae	Perennial	Graminoid	Native
<i>Bromus racemosus</i>	bald brome	Poaceae	Annual	Graminoid	Exotic
<i>Bromus secalinus</i>	rye brome	Poaceae	Annual	Graminoid	Exotic
<i>Bromus sitchensis</i>	Alaska brome	Poaceae	Perennial	Graminoid	Native
<i>Bromus squarrosus</i>	corn brome	Poaceae	Annual	Graminoid	Exotic
<i>Bromus suksdorfii</i>	Suksdorf's brome	Poaceae	Perennial	Graminoid	Native
<i>Bromus tectorum</i>	cheatgrass	Poaceae	Annual	Graminoid	Exotic
<i>Bromus vulgaris</i>	Columbia brome	Poaceae	Perennial	Graminoid	Native
<i>Buddleja davidii</i>	orange eye butterflybush	Buddlejaceae	Perennial	Shrub	Exotic
<i>Buglossoides arvensis</i>	corn gromwell	Boraginaceae	Annual	Forb	Exotic
<i>Cacaliopsis nardosmia</i>	silvercrown	Asteraceae	Perennial	Forb	Native
<i>Calamagrostis canadensis</i>	bluejoint	Poaceae	Perennial	Graminoid	Native
<i>Calamagrostis purpurascens</i>	purple reedgrass	Poaceae	Perennial	Graminoid	Native
<i>Calamagrostis rubescens</i>	pinegrass	Poaceae	Perennial	Graminoid	Native
<i>Calamagrostis stricta</i>	slimstem reedgrass	Poaceae	Perennial	Graminoid	Native
<i>Calamovilfa longifolia</i>	prairie sandreed	Poaceae	Perennial	Graminoid	Native
<i>Calochortus apiculatus</i>	pointedtip mariposa lily	Liliaceae	Perennial	Forb	Native
<i>Calochortus lyallii</i>	Lyall's mariposa lily	Liliaceae	Perennial	Forb	Native
<i>Calochortus macrocarpus</i>	sagebrush mariposa lily	Liliaceae	Perennial	Forb	Native
<i>Calystegia sepium</i>	hedge false bindweed	Convolvulaceae	Perennial	Forb	Exotic
<i>Camassia quamash</i>	small camas	Liliaceae	Perennial	Forb	Native
<i>Camelina microcarpa</i>	littlepod false flax	Brassicaceae	Biennial	Forb	Exotic
<i>Camissonia andina</i>	Blackfoot River evening primrose	Onagraceae	Annual	Forb	Native
<i>Camissonia subcaulis</i>	diffuseflower evening primrose	Onagraceae	Perennial	Forb	Native
<i>Camissonia tanacetifolia</i>	tansyleaf evening primrose	Onagraceae	Perennial	Forb	Native
<i>Campanula lasiocarpa</i>	mountain harebell	Campanulaceae	Perennial	Forb	Native
<i>Campanula parryi</i>	Parry's bellflower	Campanulaceae	Perennial	Forb	Native
<i>Campanula rapunculoides</i>	rampion bellflower	Campanulaceae	Perennial	Forb	Exotic
<i>Campanula rotundifolia</i>	bluebell bellflower	Campanulaceae	Perennial	Forb	Native
<i>Canadanthus modestus</i>	giant mountain aster	Asteraceae	Perennial	Forb	Native
<i>Cannabis sativa</i>	marijuana	Cannabaceae	Annual	Forb	Native

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<i>Capsella bursa-pastoris</i>	shepherd's purse	Brassicaceae	Annual	Forb	Exotic
<i>Capsicum annuum</i>	cayenne pepper	Solanaceae	Annual	Subshrub	Native
<i>Cardamine bellidifolia</i>	alpine bittercress	Brassicaceae	Perennial	Forb	Native
<i>Cardamine breweri</i>	Brewer's bittercress	Brassicaceae	Perennial	Forb	Native
<i>Cardamine cordifolia</i>	heartleaf bittercress	Brassicaceae	Perennial	Forb	Native
<i>Cardamine hirsuta</i>	hairy bittercress	Brassicaceae	Annual	Forb	Exotic
<i>Cardamine oligosperma</i>	little western bittercress	Brassicaceae	Annual	Forb	Native
<i>Cardamine parviflora</i>	sand bittercress	Brassicaceae	Annual	Forb	Native
<i>Cardamine pratensis</i>	cuckoo flower	Brassicaceae	Perennial	Forb	Exotic
<i>Carduus acanthoides</i>	spiny plumeless thistle	Asteraceae	Biennial	Forb	Exotic
<i>Carduus nutans</i>	nodding plumeless thistle	Asteraceae	Biennial	Forb	Exotic
<i>Carex aenea</i>	dryspike sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex albonigra</i>	blackandwhite sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex athrostachya</i>	slenderbeak sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex atrata</i>	sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex atosquama</i>	lesser blackscale sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex backii</i>	Back's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex bigelowii</i>	Bigelow's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex bolanderi</i>	Bolander's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex brevicaulis</i>	shortstem sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex brevior</i>	shortbeak sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex capillaris</i>	hair-like sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex capitata</i>	capitate sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex concinna</i>	low northern sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex concinnoides</i>	northwestern sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex cordillerana</i>	Cordilleran sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex deflexa</i>	northern sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex deweyana</i>	Dewey sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex douglasii</i>	Douglas' sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex duriuscula</i>	needleleaf sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex engelmannii</i>	Engelmann's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex filifolia</i>	threadleaf sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex fracta</i>	fragile sheath sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex garberi</i>	elk sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex geyeri</i>	Geyer's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex hassei</i>	salt sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex haydeniana</i>	cloud sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex heteroneura</i>	different-nerve sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex hoodii</i>	Hood's sedge	Cyperaceae	Perennial	Graminoid	Native

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<i>Carex illota</i>	sheep sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex infirmivervia</i>	weak-nerved sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex inops</i>	long-stolon sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex laeviculmis</i>	smoothstem sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex leptopoda</i>	taperfruit shortscale sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex macloviana</i>	thickhead sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex media</i>	closedhead sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex mertensii</i>	Mertens' sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex microptera</i>	smallwing sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex multicosata</i>	manyrib sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex nardina</i>	spike sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex nigricans</i>	black alpine sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex obtusata</i>	obtuse sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex parryana</i>	Parry's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex peckii</i>	Peck's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex petasata</i>	Liddon sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex phaeocephala</i>	dunhead sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex praegracilis</i>	clustered field sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex praticola</i>	meadow sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex preslii</i>	Presl's sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex pyrenaica</i>	Pyrenean sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex raynoldsii</i>	Raynolds' sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex rossii</i>	Ross' sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex saximontana</i>	Rocky Mountain sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex scirpoidea</i>	northern singlespike sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex spectabilis</i>	showy sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex sychnocephala</i>	manyhead sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex tahoensis</i>	Tahoe sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex tenera</i>	quill sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex vallicola</i>	valley sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carex vernacula</i>	native sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Carthamus tinctorius</i>	safflower	Asteraceae	Annual	Forb	Exotic
<i>Cassiope mertensiana</i>	western moss heather	Ericaceae	Perennial	Subshrub	Native
<i>Cassiope tetragona</i>	white arctic mountain heather	Ericaceae	Perennial	Subshrub	Native
<i>Castanea dentata</i>	American chestnut	Fagaceae	Perennial	Tree	Exotic
<i>Castilleja cervina</i>	deer Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Castilleja cusickii</i>	Cusick's Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Castilleja elmeri</i>	Wenatchee Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native

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<i>Castilleja hispida</i>	harsh Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native
<i>Castilleja lutescens</i>	stiff yellow Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Castilleja miniata</i>	giant red Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native
<i>Castilleja occidentalis</i>	western Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native
<i>Castilleja parviflora</i>	mountain Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native
<i>Castilleja raupii</i>	Raup's Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Castilleja suksdorfii</i>	Suksdorf's Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Castilleja sulphurea</i>	sulphur Indian paintbrush	Scrophulariaceae	Perennial	Subshrub	Native
<i>Castilleja tenuis</i>	hairy Indian paintbrush	Scrophulariaceae	Annual	Forb	Native
<i>Castilleja thompsonii</i>	Thompson's Indian paintbrush	Scrophulariaceae	Perennial	Forb	Native
<i>Catalpa bignonioides</i>	southern catalpa	Bignoniaceae	Perennial	Tree	Native
<i>Ceanothus sanguineus</i>	redstem ceanothus	Rhamnaceae	Perennial	Shrub	Native
<i>Ceanothus velutinus</i>	snowbrush ceanothus	Rhamnaceae	Perennial	Tree	Native
<i>Celastrus scandens</i>	American bittersweet	Celastraceae	Perennial	Forb	Native
<i>Celtis laevigata</i>	sugarberry	Ulmaceae	Perennial	Tree	Native
<i>Cenchrus longispinus</i>	mat sandbur	Poaceae	Annual	Graminoid	Exotic
<i>Centaurea diffusa</i>	diffuse knapweed	Asteraceae	Annual	Forb	Exotic
<i>Centaurea solstitialis</i>	yellow star-thistle	Asteraceae	Annual	Forb	Native
<i>Centaurea stoebe</i>	spotted knapweed	Asteraceae	Biennial	Forb	Exotic
<i>Cerastium arvense</i>	field chickweed	Caryophyllaceae	Perennial	Forb	Exotic
<i>Cerastium beeringianum</i>	Bering chickweed	Caryophyllaceae	Perennial	Forb	Native
<i>Cerastium fontanum</i>	common mouse-ear chickweed	Caryophyllaceae	Biennial	Forb	Exotic
<i>Cerastium glomeratum</i>	sticky chickweed	Caryophyllaceae	Annual	Forb	Exotic
<i>Cerastium nutans</i>	nodding chickweed	Caryophyllaceae	Annual	Forb	Native
<i>Cerastium pumilum</i>	European chickweed	Caryophyllaceae	Annual	Forb	Exotic
<i>Cerastium semidecandrum</i>	fivestamen chickweed	Caryophyllaceae	Annual	Forb	Exotic
<i>Ceratocephala testiculata</i>	curvseed butterwort	Ranunculaceae	Annual	Forb	Native
<i>Cercidiphyllum japonicum</i>	katsura tree	Cercidiphyllaceae	Perennial	Tree	Native
<i>Chaenactis douglasii</i>	Douglas' dustymaiden	Asteraceae	Biennial	Forb	Native
<i>Chaenorhinum minus</i>	dwarf snapdragon	Scrophulariaceae	Annual	Forb	Exotic
<i>Chamaerhodos erecta</i>	little rose	Rosaceae	Biennial	Forb	Native
<i>Cheilanthes feei</i>	slender lipfern	Pteridaceae	Perennial	Forb	Native
<i>Cheilanthes gracillima</i>	lace lipfern	Pteridaceae	Perennial	Forb	Native
<i>Chelidonium majus</i>	celandine	Papaveraceae	Biennial	Forb	Exotic
<i>Chenopodium atrovirens</i>	pinyon goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium berlandieri</i>	pitseed goosefoot	Chenopodiaceae	Annual	Forb	Native

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<i>Chenopodium capitatum</i>	blite goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium chenopodioides</i>	low goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium desiccatum</i>	aridland goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium fremontii</i>	Fremont's goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium glaucum</i>	oakleaf goosefoot	Chenopodiaceae	Annual	Forb	Exotic
<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium simplex</i>	mapleleaf goosefoot	Chenopodiaceae	Annual	Forb	Native
<i>Chenopodium strictum</i>	lateflowering goosefoot	Chenopodiaceae	Annual	Forb	Exotic
<i>Chimaphila menziesii</i>	little prince's pine	Pyrolaceae	Perennial	Subshrub	Native
<i>Chimaphila umbellata</i>	pipsissewa	Pyrolaceae	Perennial	Subshrub	Native
<i>Chorispura tenella</i>	crossflower	Brassicaceae	Annual	Forb	Exotic
<i>Cichorium intybus</i>	chicory	Asteraceae	Biennial	Forb	Exotic
<i>Circaea alpina</i>	small enchanter's nightshade	Onagraceae	Perennial	Forb	Native
<i>Cirsium arvense</i>	Canada thistle	Asteraceae	Perennial	Forb	Exotic
<i>Cirsium brevistylum</i>	clustered thistle	Asteraceae	Annual	Forb	Native
<i>Cirsium edule</i>	edible thistle	Asteraceae	Perennial	Forb	Native
<i>Cirsium flodmanii</i>	Flodman's thistle	Asteraceae	Perennial	Forb	Native
<i>Cirsium hookerianum</i>	white thistle	Asteraceae	Perennial	Forb	Native
<i>Cirsium undulatum</i>	wavyleaf thistle	Asteraceae	Perennial	Forb	Native
<i>Cirsium vulgare</i>	bull thistle	Asteraceae	Biennial	Forb	Exotic
<i>Cistanthe tweedyi</i>	Tweedy's pussypaws	Portulacaceae	Perennial	Forb	Native
<i>Cistanthe umbellata</i>	Mt. Hood pussypaws	Portulacaceae	Annual	Forb	Native
<i>Citrus aurantium</i>	sour orange	Rutaceae	Perennial	Shrub	Exotic
<i>Citrus reticulata</i>	tangerine	Rutaceae	Perennial	Tree	Native
<i>Clarkia pulchella</i>	pinkfairies	Onagraceae	Annual	Forb	Native
<i>Clarkia rhomboidea</i>	diamond clarkia	Onagraceae	Annual	Forb	Native
<i>Claytonia caroliniana</i>	Carolina springbeauty	Portulacaceae	Perennial	Forb	Native
<i>Claytonia cordifolia</i>	heartleaf springbeauty	Portulacaceae	Perennial	Forb	Native
<i>Claytonia lanceolata</i>	lanceleaf springbeauty	Portulacaceae	Perennial	Forb	Native
<i>Claytonia parviflora</i>	streambank springbeauty	Portulacaceae	Annual	Forb	Native
<i>Claytonia perfoliata</i>	miner's lettuce	Portulacaceae	Annual	Forb	Native
<i>Claytonia rubra</i>	redstem springbeauty	Portulacaceae	Annual	Forb	Native
<i>Claytonia sibirica</i>	Siberian springbeauty	Portulacaceae	Annual	Forb	Native
<i>Clematis columbiana</i>	rock clematis	Ranunculaceae	Perennial	Forb	Native
<i>Clematis hirsutissima</i>	hairy clematis	Ranunculaceae	Perennial	Subshrub	Native
<i>Clematis ligusticifolia</i>	western white clematis	Ranunculaceae	Perennial	Forb	Native
<i>Clematis occidentalis</i>	western blue virginsbower	Ranunculaceae	Perennial	Forb	Native
<i>Clintonia uniflora</i>	bride's bonnet	Liliaceae	Perennial	Forb	Native
<i>Collinsia parviflora</i>	maiden blue eyed Mary	Scrophulariaceae	Annual	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Collinsia sparsiflora</i>	spinster's blue eyed Mary	Scrophulariaceae	Annual	Forb	Native
<i>Collomia grandiflora</i>	grand collomia	Polemoniaceae	Annual	Forb	Native
<i>Collomia heterophylla</i>	variableleaf collomia	Polemoniaceae	Annual	Forb	Native
<i>Collomia linearis</i>	tiny trumpet	Polemoniaceae	Annual	Forb	Native
<i>Collomia tinctoria</i>	staining collomia	Polemoniaceae	Annual	Forb	Native
<i>Comandra umbellata</i>	bastard toadflax	Santalaceae	Perennial	Subshrub	Native
<i>Conium maculatum</i>	poison hemlock	Apiaceae	Biennial	Forb	Exotic
<i>Conringia orientalis</i>	hare's ear mustard	Brassicaceae	Annual	Forb	Exotic
<i>Consolida ajacis</i>	doubtful knight's-spur	Ranunculaceae	Annual	Forb	Exotic
<i>Convolvulus arvensis</i>	field bindweed	Convolvulaceae	Perennial	Forb	Exotic
<i>Conyza canadensis</i>	Canadian horseweed	Asteraceae	Annual	Forb	Native
<i>Coreopsis tinctoria</i>	golden tickseed	Asteraceae	Annual	Forb	Native
<i>Corispermum americanum</i>	American bugseed	Chenopodiaceae	Annual	Forb	Native
<i>Corispermum pallasii</i>	Siberian bugseed	Chenopodiaceae	Annual	Forb	Native
<i>Corispermum villosum</i>	hairy bugseed	Chenopodiaceae	Annual	Forb	Native
<i>Cornus florida</i>	flowering dogwood	Cornaceae	Perennial	Tree	Native
<i>Cornus nuttallii</i>	Pacific dogwood	Cornaceae	Perennial	Tree	Native
<i>Cornus sericea</i>	redosier dogwood	Cornaceae	Perennial	Tree	Native
<i>Cornus unalaschensis</i>	western cordilleran bunchberry	Cornaceae	Perennial	Subshrub	Native
<i>Corydalis aurea</i>	scrambled eggs	Fumariaceae	Annual	Forb	Native
<i>Corydalis sempervirens</i>	rock harlequin	Fumariaceae	Annual	Forb	Native
<i>Corylus cornuta</i>	beaked hazelnut	Betulaceae	Perennial	Tree	Native
<i>Cota tinctoria</i>	golden chamomile	Asteraceae	Perennial	Forb	Exotic
<i>Cotoneaster lucidus</i>	shiny cotoneaster	Rosaceae	Perennial	Shrub	Exotic
<i>Crataegus castlegarensis</i>	hawthorn	Rosaceae	Perennial	Tree	Native
<i>Crataegus chrysoarpa</i>	fireberry hawthorn	Rosaceae	Perennial	Tree	Native
<i>Crataegus douglasii</i>	black hawthorn	Rosaceae	Perennial	Shrub	Native
<i>Crataegus enderbyensis</i>	hawthorn	Rosaceae	Perennial	Tree	Native
<i>Crataegus monogyna</i>	oneseed hawthorn	Rosaceae	Perennial	Shrub	Exotic
<i>Crataegus okanaganensis</i>	Okanagan Valley hawthorn	Rosaceae	Perennial	Shrub	Native
<i>Crataegus okenonii</i>	O'kennon's hawthorn	Rosaceae	Perennial	Shrub	Native
<i>Crataegus phippsii</i>	Phipps' hawthorn	Rosaceae	Perennial	Tree	Native
<i>Crepis acuminata</i>	tapertip hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis atribarba</i>	slender hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis bakeri</i>	Baker's hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis capillaris</i>	smooth hawksbeard	Asteraceae	Annual	Forb	Exotic
<i>Crepis intermedia</i>	limestone hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis modocensis</i>	Modoc hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis nana</i>	dwarf alpine hawksbeard	Asteraceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Crepis occidentalis</i>	largeflower hawksbeard	Asteraceae	Annual	Forb	Native
<i>Crepis runcinata</i>	fiddleleaf hawksbeard	Asteraceae	Perennial	Forb	Native
<i>Crepis tectorum</i>	narrowleaf hawksbeard	Asteraceae	Annual	Forb	Exotic
<i>Crocidium multicaule</i>	common spring-gold	Asteraceae	Annual	Forb	Native
<i>Cryptantha affinis</i>	quill cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha ambigua</i>	basin cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha celosioides</i>	buttecandle	Boraginaceae	Biennial	Forb	Native
<i>Cryptantha circumscissa</i>	cushion cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha intermedia</i>	Clearwater cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha nubigena</i>	Sierra cryptantha	Boraginaceae	Perennial	Forb	Native
<i>Cryptantha pterocarya</i>	wingnut cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha torreyana</i>	Torrey's cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptantha watsonii</i>	Watson's cryptantha	Boraginaceae	Annual	Forb	Native
<i>Cryptogramma acrostichoides</i>	American rockbrake	Pteridaceae	Perennial	Forb	Native
<i>Cryptogramma cascadenis</i>	Cascade rockbrake	Pteridaceae	Perennial	Forb	Native
<i>Cryptogramma stelleri</i>	fragile rockbrake	Pteridaceae	Perennial	Forb	Native
<i>Cuscuta californica</i>	chaparral dodder	Cuscutaceae	Perennial	Forb	Native
<i>Cuscuta cephalanthi</i>	buttonbush dodder	Cuscutaceae	Perennial	Forb	Native
<i>Cuscuta pentagona</i>	fiveangled dodder	Cuscutaceae	Annual	Forb	Native
<i>Cynodon dactylon</i>	Bermudagrass	Poaceae	Perennial	Graminoid	Exotic
<i>Cynoglossum officinale</i>	gypsyflower	Boraginaceae	Biennial	Forb	Exotic
<i>Cynoglossum virginianum</i>	wild comfrey	Boraginaceae	Perennial	Forb	Native
<i>Cytisus scoparius</i>	Scotch broom	Fabaceae	Perennial	Shrub	Exotic
<i>Dactylis glomerata</i>	orchardgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Danthonia californica</i>	California oatgrass	Poaceae	Perennial	Graminoid	Native
<i>Danthonia intermedia</i>	timber oatgrass	Poaceae	Perennial	Graminoid	Native
<i>Danthonia spicata</i>	poverty oatgrass	Poaceae	Perennial	Graminoid	Native
<i>Danthonia unispicata</i>	onespike danthonia	Poaceae	Perennial	Graminoid	Native
<i>Dasiphora fruticosa</i>	shrubby cinquefoil	Rosaceae	Perennial	Shrub	Native
<i>Datura stramonium</i>	jimsonweed	Solanaceae	Annual	Forb	Exotic
<i>Datura wrightii</i>	sacred thorn-apple	Solanaceae	Annual	Forb	Native
<i>Delphinium bicolor</i>	little larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Delphinium depauperatum</i>	slim larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Delphinium glareosum</i>	Olympic larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Delphinium glaucum</i>	Sierra larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Delphinium menziesii</i>	Menzies' larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Delphinium nuttallianum</i>	twolobe larkspur	Ranunculaceae	Perennial	Forb	Native
<i>Deschampsia cespitosa</i>	tufted hairgrass	Poaceae	Perennial	Graminoid	Native
<i>Deschampsia danthonioides</i>	annual hairgrass	Poaceae	Annual	Graminoid	Native

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<i>Deschampsia elongata</i>	slender hairgrass	Poaceae	Perennial	Graminoid	Native
<i>Descurainia incana</i>	mountain tansymustard	Brassicaceae	Annual	Forb	Native
<i>Descurainia pinnata</i>	western tansymustard	Brassicaceae	Annual	Forb	Native
<i>Descurainia sophia</i>	herb sophia	Brassicaceae	Annual	Forb	Exotic
<i>Descurainia sophioides</i>	northern tansymustard	Brassicaceae	Biennial	Forb	Native
<i>Dianthus armeria</i>	Deptford pink	Caryophyllaceae	Annual	Forb	Exotic
<i>Dianthus deltoides</i>	maiden pink	Caryophyllaceae	Perennial	Forb	Exotic
<i>Dicentra cucullaria</i>	dutchman's breeches	Fumariaceae	Perennial	Forb	Native
<i>Dicentra formosa</i>	Pacific bleeding heart	Fumariaceae	Perennial	Forb	Native
<i>Dicentra uniflora</i>	longhorn steer's-head	Fumariaceae	Perennial	Forb	Native
<i>Dichanthelium acuminatum</i>	tapered rosette grass	Poaceae	Perennial	Graminoid	Native
<i>Dichanthelium oligosanthes</i>	Heller's rosette grass	Poaceae	Perennial	Graminoid	Native
<i>Digitaria ischaemum</i>	smooth crabgrass	Poaceae	Annual	Graminoid	Exotic
<i>Digitaria sanguinalis</i>	hairy crabgrass	Poaceae	Annual	Graminoid	Exotic
<i>Dipsacus fullonum</i>	Fuller's teasel	Dipsacaceae	Biennial	Forb	Native
<i>Draba albertina</i>	slender draba	Brassicaceae	Annual	Forb	Native
<i>Draba aurea</i>	golden draba	Brassicaceae	Perennial	Forb	Native
<i>Draba borealis</i>	boreal draba	Brassicaceae	Perennial	Forb	Native
<i>Draba breweri</i>	cushion draba	Brassicaceae	Perennial	Forb	Native
<i>Draba crassifolia</i>	snowbed draba	Brassicaceae	Annual	Forb	Native
<i>Draba densifolia</i>	denseleaf draba	Brassicaceae	Perennial	Forb	Native
<i>Draba incerta</i>	Yellowstone draba	Brassicaceae	Perennial	Forb	Native
<i>Draba lonchocarpa</i>	lancepod draba	Brassicaceae	Perennial	Forb	Native
<i>Draba macounii</i>	Macoun's draba	Brassicaceae	Perennial	Forb	Native
<i>Draba nemorosa</i>	woodland draba	Brassicaceae	Annual	Forb	Native
<i>Draba nivalis</i>	yellow arctic draba	Brassicaceae	Perennial	Forb	Native
<i>Draba oligosperma</i>	fewseed draba	Brassicaceae	Perennial	Forb	Native
<i>Draba paysonii</i>	Payson's draba	Brassicaceae	Perennial	Forb	Native
<i>Draba praealta</i>	tall draba	Brassicaceae	Biennial	Forb	Native
<i>Draba reptans</i>	Carolina draba	Brassicaceae	Annual	Forb	Native
<i>Draba ruaxes</i>	Rainier draba	Brassicaceae	Perennial	Forb	Native
<i>Draba stenoloba</i>	Alaska draba	Brassicaceae	Annual	Forb	Native
<i>Draba verna</i>	spring draba	Brassicaceae	Annual	Forb	Exotic
<i>Dracocephalum parviflorum</i>	American dragonhead	Lamiaceae	Annual	Forb	Native
<i>Dryas octopetala</i>	eightpetal mountain-avens	Rosaceae	Perennial	Subshrub	Native
<i>Dryopteris carthusiana</i>	spinulose woodfern	Dryopteridaceae	Perennial	Forb	Native
<i>Dryopteris expansa</i>	spreading woodfern	Dryopteridaceae	Perennial	Forb	Native
<i>Dryopteris filix-mas</i>	male fern	Dryopteridaceae	Perennial	Forb	Native
<i>Dysphania ambrosioides</i>	Mexican tea	Chenopodiaceae	Annual	Subshrub	Native

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<i>Dysphania botrys</i>	Jerusalem oak goosefoot	Chenopodiaceae	Annual	Forb	Exotic
<i>Dysphania pumilio</i>	clammy goosefoot	Chenopodiaceae	Annual	Forb	Exotic
<i>Echinocystis lobata</i>	wild cucumber	Cucurbitaceae	Annual	Forb	Exotic
<i>Elaeagnus angustifolia</i>	Russian olive	Elaeagnaceae	Perennial	Tree	Exotic
<i>Elaeagnus commutata</i>	silverberry	Elaeagnaceae	Perennial	Shrub	Native
<i>Eleocharis atropurpurea</i>	purple spikerush	Cyperaceae	Annual	Graminoid	Native
<i>Eleocharis bella</i>	beautiful spikerush	Cyperaceae	Annual	Graminoid	Native
<i>Eleocharis macrostachya</i>	pale spikerush	Cyperaceae	Perennial	Graminoid	Native
<i>Eleocharis ovata</i>	ovate spikerush	Cyperaceae	Annual	Graminoid	Native
<i>Elliottia pyroliflora</i>	copperbush	Ericaceae	Perennial	Shrub	Native
<i>Elmera racemosa</i>	yellow coralbells	Saxifragaceae	Perennial	Forb	Native
<i>Elymus canadensis</i>	Canada wildrye	Poaceae	Perennial	Graminoid	Native
<i>Elymus elymoides</i>	squirreltail	Poaceae	Perennial	Graminoid	Native
<i>Elymus glaucus</i>	blue wildrye	Poaceae	Perennial	Graminoid	Native
<i>Elymus lanceolatus</i>	thickspike wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Elymus macrourus</i>	tufted wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Elymus multisetus</i>	big squirreltail	Poaceae	Perennial	Graminoid	Native
<i>Elymus repens</i>	quackgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Elymus scribneri</i>	spreading wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Elymus trachycaulus</i>	slender wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Elymus villosus</i>	hairy wildrye	Poaceae	Perennial	Graminoid	Native
<i>Empetrum nigrum</i>	black crowberry	Empetraceae	Perennial	Subshrub	Native
<i>Epilobium anagallidifolium</i>	pimpernel willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium brachycarpum</i>	tall annual willowherb	Onagraceae	Annual	Forb	Native
<i>Epilobium clavatum</i>	talus willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium densiflorum</i>	denseflower willowherb	Onagraceae	Annual	Forb	Native
<i>Epilobium foliosum</i>	leafy willowherb	Onagraceae	Annual	Forb	Native
<i>Epilobium glaberrimum</i>	glaucus willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium halleianum</i>	glandular willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium hirsutum</i>	codlins and cream	Onagraceae	Perennial	Forb	Exotic
<i>Epilobium hornemannii</i>	Hornemann's willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium lactiflorum</i>	milkflower willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium latifolium</i>	dwarf fireweed	Onagraceae	Perennial	Forb	Native
<i>Epilobium luteum</i>	yellow willowherb	Onagraceae	Perennial	Forb	Native
<i>Epilobium minutum</i>	chaparral willowherb	Onagraceae	Annual	Forb	Native
<i>Epilobium torreyi</i>	Torrey's willowherb	Onagraceae	Annual	Forb	Native
<i>Equisetum arvense</i>	field horsetail	Equisetaceae	Perennial	Forb	Native
<i>Equisetum hyemale</i>	scouringrush horsetail	Equisetaceae	Perennial	Forb	Native
<i>Equisetum laevigatum</i>	smooth horsetail	Equisetaceae	Perennial	Forb	Native

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<i>Equisetum palustre</i>	marsh horsetail	Equisetaceae	Perennial	Forb	Native
<i>Equisetum scirpoides</i>	dwarf scouringrush	Equisetaceae	Perennial	Forb	Native
<i>Equisetum sylvaticum</i>	woodland horsetail	Equisetaceae	Perennial	Forb	Native
<i>Equisetum variegatum</i>	variegated scouringrush	Equisetaceae	Perennial	Forb	Native
<i>Eragrostis cilianensis</i>	stinkgrass	Poaceae	Annual	Graminoid	Exotic
<i>Eragrostis minor</i>	little lovegrass	Poaceae	Annual	Graminoid	Exotic
<i>Eragrostis pectinacea</i>	tufted lovegrass	Poaceae	Annual	Graminoid	Native
<i>Eragrostis pilosa</i>	Indian lovegrass	Poaceae	Annual	Graminoid	Exotic
<i>Eragrostis virescens</i>	Mexican lovegrass	Poaceae	Annual	Graminoid	Native
<i>Erechtites hieraciifolius</i>	American burnweed	Asteraceae	Annual	Forb	Native
<i>Eremogone capillaris</i>	slender mountain sandwort	Caryophyllaceae	Perennial	Forb	Native
<i>Eremogone congesta</i>	ballhead sandwort	Caryophyllaceae	Perennial	Forb	Native
<i>Eremogone kingii</i>	King's sandwort	Caryophyllaceae	Perennial	Forb	Native
<i>Eremopyrum triticeum</i>	annual wheatgrass	Poaceae	Annual	Graminoid	Exotic
<i>Ericameria bloomeri</i>	rabbitbush	Asteraceae	Perennial	Shrub	Native
<i>Ericameria greenei</i>	Greene's goldenbush	Asteraceae	Perennial	Subshrub	Native
<i>Ericameria nauseosa</i>	rubber rabbitbrush	Asteraceae	Perennial	Shrub	Native
<i>Erigeron acris</i>	bitter fleabane	Asteraceae	Annual	Forb	Native
<i>Erigeron aureus</i>	alpine yellow fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron compositus</i>	cutleaf daisy	Asteraceae	Perennial	Forb	Native
<i>Erigeron corymbosus</i>	longleaf fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron divergens</i>	spreading fleabane	Asteraceae	Biennial	Forb	Native
<i>Erigeron filifolius</i>	threadleaf fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron flagellaris</i>	trailing fleabane	Asteraceae	Biennial	Forb	Native
<i>Erigeron glabellus</i>	streamside fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron humilis</i>	arctic alpine fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron linearis</i>	desert yellow fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron lonchophyllus</i>	shortray fleabane	Asteraceae	Biennial	Forb	Native
<i>Erigeron peregrinus</i>	subalpine fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron philadelphicus</i>	Philadelphia fleabane	Asteraceae	Biennial	Forb	Native
<i>Erigeron pumilus</i>	shaggy fleabane	Asteraceae	Perennial	Forb	Native
<i>Erigeron speciosus</i>	aspen fleabane	Asteraceae	Perennial	Subshrub	Native
<i>Erigeron strigosus</i>	prairie fleabane	Asteraceae	Annual	Forb	Native
<i>Erigeron subtrinervis</i>	threenerve fleabane	Asteraceae	Perennial	Forb	Native
<i>Eriogonum baileyi</i>	Bailey's buckwheat	Polygonaceae	Annual	Forb	Native
<i>Eriogonum compositum</i>	arrowleaf buckwheat	Polygonaceae	Perennial	Forb	Native
<i>Eriogonum douglasii</i>	Douglas' buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum elatum</i>	tall woolly buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum flavum</i>	alpine golden buckwheat	Polygonaceae	Perennial	Subshrub	Native

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<i>Eriogonum heracleoides</i>	parsnipflower buckwheat	Polygonaceae	Perennial	Forb	Native
<i>Eriogonum ovalifolium</i>	cushion buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum pyrolifolium</i>	Shasta buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum strictum</i>	Blue Mountain buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum thymoides</i>	thymeleaf buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum umbellatum</i>	sulphur-flower buckwheat	Polygonaceae	Perennial	Subshrub	Native
<i>Eriogonum vimineum</i>	wickerstem buckwheat	Polygonaceae	Annual	Forb	Native
<i>Eriophyllum lanatum</i>	common woolly sunflower	Asteraceae	Annual	Subshrub	Native
<i>Eritrichium nanum</i>	arctic alpine forget-me-not	Boraginaceae	Perennial	Forb	Native
<i>Erodium cicutarium</i>	redstem stork's bill	Geraniaceae	Annual	Forb	Exotic
<i>Erucastrum gallicum</i>	common dogmustard	Brassicaceae	Biennial	Forb	Exotic
<i>Erysimum arenicola</i>	cascade wallflower	Brassicaceae	Perennial	Forb	Native
<i>Erysimum capitatum</i>	sanddune wallflower	Brassicaceae	Biennial	Forb	Native
<i>Erysimum cheiranthoides</i>	wormseed wallflower	Brassicaceae	Annual	Forb	Native
<i>Erysimum inconspicuum</i>	shy wallflower	Brassicaceae	Biennial	Forb	Native
<i>Erysimum repandum</i>	spreading wallflower	Brassicaceae	Annual	Forb	Native
<i>Erythronium grandiflorum</i>	yellow avalanche-lily	Liliaceae	Perennial	Forb	Native
<i>Eurybia conspicua</i>	western showy aster	Asteraceae	Perennial	Forb	Native
<i>Eurybia merita</i>	subalpine aster	Asteraceae	Perennial	Forb	Native
<i>Eurybia sibirica</i>	arctic aster	Asteraceae	Perennial	Forb	Native
<i>Euthamia graminifolia</i>	flat-top goldentop	Asteraceae	Perennial	Forb	Native
<i>Fallopia convolvulus</i>	black bindweed	Polygonaceae	Annual	Forb	Exotic
<i>Fallopia japonica</i>	Japanese knotweed	Polygonaceae	Perennial	Forb	Exotic
<i>Fallopia sachalinensis</i>	giant knotweed	Polygonaceae	Perennial	Forb	Exotic
<i>Fallopia scandens</i>	climbing false buckwheat	Polygonaceae	Perennial	Forb	Native
<i>Festuca altaica</i>	Altai fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca arundinacea</i>	tall fescue	Poaceae	Perennial	Graminoid	Exotic
<i>Festuca brachyphylla</i>	alpine fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca campestris</i>	rough fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca hallii</i>	plains rough fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca idahoensis</i>	Idaho fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca occidentalis</i>	western fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca ovina</i>	sheep fescue	Poaceae	Perennial	Graminoid	Exotic
<i>Festuca pratensis</i>	meadow fescue	Poaceae	Perennial	Graminoid	Exotic
<i>Festuca rubra</i>	red fescue	Poaceae	Perennial	Graminoid	Exotic
<i>Festuca saximontana</i>	Rocky Mountain fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca subulata</i>	bearded fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca viridula</i>	greenleaf fescue	Poaceae	Perennial	Graminoid	Native
<i>Festuca washingtonica</i>	Washington fescue	Poaceae	Perennial	Graminoid	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Floerkea proserpinacoides</i>	false mermaidweed	Limnanthaceae	Annual	Forb	Native
<i>Fragaria virginiana</i>	Virginia strawberry	Rosaceae	Perennial	Forb	Native
<i>Frangula purshiana</i>	Cascara buckthorn	Rhamnaceae	Perennial	Tree	Native
<i>Frasera albicaulis</i>	whitestem fraseria	Gentianaceae	Perennial	Forb	Native
<i>Fraxinus pennsylvanica</i>	green ash	Oleaceae	Perennial	Tree	Exotic
<i>Fritillaria affinis</i>	checker lily	Liliaceae	Perennial	Forb	Native
<i>Fritillaria camschatcensis</i>	Kamchatka fritillary	Liliaceae	Perennial	Forb	Native
<i>Fritillaria pudica</i>	yellow fritillary	Liliaceae	Perennial	Forb	Native
<i>Gaillardia aristata</i>	blanketflower	Asteraceae	Perennial	Forb	Native
<i>Galeopsis tetrahit</i>	brittlestem hempnettle	Lamiaceae	Annual	Forb	Exotic
<i>Galinsoga parviflora</i>	gallant soldier	Asteraceae	Annual	Forb	Exotic
<i>Galium aparine</i>	stickywilly	Rubiaceae	Annual	Forb	Native
<i>Galium bifolium</i>	twinleaf bedstraw	Rubiaceae	Annual	Forb	Native
<i>Galium boreale</i>	northern bedstraw	Rubiaceae	Perennial	Forb	Native
<i>Galium mexicanum</i>	Mexican bedstraw	Rubiaceae	Perennial	Forb	Native
<i>Galium serotinum</i>	Intermountain bedstraw	Rubiaceae	Perennial	Subshrub	Native
<i>Galium triflorum</i>	fragrant bedstraw	Rubiaceae	Perennial	Forb	Native
<i>Gaultheria humifusa</i>	alpine spicewintergreen	Ericaceae	Perennial	Shrub	Native
<i>Gaultheria ovatifolia</i>	western teaberry	Ericaceae	Perennial	Shrub	Native
<i>Gaultheria shallon</i>	salal	Ericaceae	Perennial	Shrub	Native
<i>Gaura coccinea</i>	scarlet beeblossom	Onagraceae	Perennial	Subshrub	Native
<i>Gaura mollis</i>	velvetweed	Onagraceae	Annual	Forb	Native
<i>Gayophytum diffusum</i>	spreading groundsmoke	Onagraceae	Annual	Forb	Native
<i>Gayophytum humile</i>	dwarf groundsmoke	Onagraceae	Annual	Forb	Native
<i>Gayophytum racemosum</i>	blackfoot groundsmoke	Onagraceae	Annual	Forb	Native
<i>Gayophytum ramosissimum</i>	pinyon groundsmoke	Onagraceae	Annual	Forb	Native
<i>Gentiana affinis</i>	pleated gentian	Gentianaceae	Perennial	Forb	Native
<i>Gentiana calycosa</i>	Rainier pleated gentian	Gentianaceae	Perennial	Forb	Native
<i>Gentiana glauca</i>	pale gentian	Gentianaceae	Perennial	Forb	Native
<i>Gentianella propinqua</i>	fourpart dwarf gentian	Gentianaceae	Annual	Forb	Native
<i>Gentianella tenella</i>	Dane's dwarf gentian	Gentianaceae	Annual	Forb	Native
<i>Geocaulon lividum</i>	false toadflax	Santalaceae	Perennial	Forb	Native
<i>Geranium bicknellii</i>	Bicknell's cranesbill	Geraniaceae	Annual	Forb	Native
<i>Geranium carolinianum</i>	Carolina geranium	Geraniaceae	Annual	Forb	Native
<i>Geranium pusillum</i>	small geranium	Geraniaceae	Annual	Forb	Exotic
<i>Geranium richardsonii</i>	Richardson's geranium	Geraniaceae	Perennial	Forb	Native
<i>Geranium robertianum</i>	Robert geranium	Geraniaceae	Annual	Forb	Exotic
<i>Geranium viscosissimum</i>	sticky purple geranium	Geraniaceae	Annual	Forb	Native
<i>Geum aleppicum</i>	yellow avens	Rosaceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Geum macrophyllum</i>	largeleaf avens	Rosaceae	Perennial	Forb	Native
<i>Geum triflorum</i>	old man's whiskers	Rosaceae	Perennial	Forb	Native
<i>Gilia aggregata</i>	scarlet gilia	Polemoniaceae	Biennial	Forb	Native
<i>Gilia sinuata</i>	rosy gilia	Polemoniaceae	Annual	Forb	Native
<i>Glandularia gooddingii</i>	southwestern mock vervain	Verbenaceae	Perennial	Forb	Native
<i>Glechoma hederacea</i>	ground ivy	Lamiaceae	Perennial	Forb	Exotic
<i>Gleditsia triacanthos</i>	honeylocust	Fabaceae	Perennial	Shrub	Native
<i>Glycine max</i>	soybean	Fabaceae	Annual	Forb	Exotic
<i>Glycyrrhiza lepidota</i>	American licorice	Fabaceae	Perennial	Forb	Native
<i>Gnaphalium stramineum</i>	cottonbatting plant	Asteraceae	Annual	Forb	Native
<i>Gnaphalium uliginosum</i>	marsh cudweed	Asteraceae	Annual	Forb	Exotic
<i>Graphephorum wolfii</i>	Wolf's trisetum	Poaceae	Perennial	Graminoid	Native
<i>Gutierrezia sarothrae</i>	broom snakeweed	Asteraceae	Perennial	Subshrub	Native
<i>Gypsophila elegans</i>	showy baby's-breath	Caryophyllaceae	Annual	Forb	Native
<i>Gypsophila paniculata</i>	baby's breath	Caryophyllaceae	Perennial	Forb	Exotic
<i>Hackelia deflexa</i>	nodding stickseed	Boraginaceae	Annual	Forb	Native
<i>Hackelia diffusa</i>	spreading stickseed	Boraginaceae	Perennial	Forb	Native
<i>Hackelia floribunda</i>	manyflower stickseed	Boraginaceae	Biennial	Forb	Native
<i>Hackelia micrantha</i>	Jessica sticktight	Boraginaceae	Perennial	Forb	Native
<i>Halenia deflexa</i>	American spurred gentian	Gentianaceae	Annual	Forb	Native
<i>Hedera helix</i>	English ivy	Araliaceae	Perennial	Forb	Exotic
<i>Hedysarum boreale</i>	Utah sweetvetch	Fabaceae	Perennial	Forb	Native
<i>Hedysarum sulphurescens</i>	white sweetvetch	Fabaceae	Perennial	Forb	Native
<i>Helenium autumnale</i>	common sneezeweed	Asteraceae	Perennial	Forb	Native
<i>Helianthus annuus</i>	common sunflower	Asteraceae	Annual	Forb	Exotic
<i>Helianthus cusickii</i>	Cusick's sunflower	Asteraceae	Perennial	Subshrub	Native
<i>Helianthus giganteus</i>	giant sunflower	Asteraceae	Perennial	Forb	Native
<i>Helianthus grosseserratus</i>	sawtooth sunflower	Asteraceae	Perennial	Forb	Native
<i>Helianthus maximiliani</i>	Maximilian sunflower	Asteraceae	Perennial	Forb	Exotic
<i>Helianthus nuttallii</i>	Nuttall's sunflower	Asteraceae	Perennial	Forb	Native
<i>Helianthus tuberosus</i>	Jerusalem artichoke	Asteraceae	Perennial	Forb	Exotic
<i>Heracleum maximum</i>	common cowparsnip	Apiaceae	Perennial	Forb	Native
<i>Herniaria hirsuta</i>	hairy rupturewort	Caryophyllaceae	Annual	Forb	Native
<i>Hesperis matronalis</i>	dames rocket	Brassicaceae	Biennial	Forb	Exotic
<i>Hesperochiron californicus</i>	California hesperochiron	Hydrophyllaceae	Perennial	Forb	Native
<i>Hesperochiron pumilus</i>	dwarf hesperochiron	Hydrophyllaceae	Perennial	Forb	Native
<i>Hesperostipa comata</i>	needle and thread	Poaceae	Perennial	Graminoid	Native
<i>Hesperostipa curtiseta</i>	shortbristle needle and thread	Poaceae	Perennial	Graminoid	Native
<i>Hesperostipa spartea</i>	porcupinegrass	Poaceae	Perennial	Graminoid	Native

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<i>Heterocodon rariflorum</i>	rareflower heterocodon	Campanulaceae	Annual	Forb	Native
<i>Heterotheca villosa</i>	hairy false goldenaster	Asteraceae	Perennial	Subshrub	Native
<i>Heuchera cylindrica</i>	roundleaf alumroot	Saxifragaceae	Perennial	Forb	Native
<i>Heuchera glabra</i>	alpine heuchera	Saxifragaceae	Perennial	Forb	Native
<i>Heuchera micrantha</i>	crevice alumroot	Saxifragaceae	Perennial	Forb	Native
<i>Hieracium albiflorum</i>	white hawkweed	Asteraceae	Perennial	Forb	Native
<i>Hieracium scouleri</i>	Scouler's woollyweed	Asteraceae	Perennial	Forb	Native
<i>Hieracium umbellatum</i>	narrowleaf hawkweed	Asteraceae	Perennial	Forb	Native
<i>Holodiscus discolor</i>	oceanspray	Rosaceae	Perennial	Shrub	Native
<i>Holosteum umbellatum</i>	jagged chickweed	Caryophyllaceae	Annual	Forb	Exotic
<i>Hordeum brachyantherum</i>	meadow barley	Poaceae	Perennial	Graminoid	Native
<i>Hordeum jubatum</i>	foxtail barley	Poaceae	Perennial	Graminoid	Native
<i>Hordeum murinum</i>	mouse barley	Poaceae	Annual	Graminoid	Exotic
<i>Hordeum vulgare</i>	common barley	Poaceae	Annual	Graminoid	Exotic
<i>Hornungia procumbens</i>	prostrate hutchinsia	Brassicaceae	Annual	Forb	Native
<i>Humulus lupulus</i>	common hop	Cannabaceae	Perennial	Forb	Exotic
<i>Huperzia occidentalis</i>	western clubmoss	Lycopodiaceae	Perennial	Forb	Native
<i>Hydrophyllum capitatum</i>	ballhead waterleaf	Hydrophyllaceae	Perennial	Forb	Native
<i>Hydrophyllum fendleri</i>	Fendler's waterleaf	Hydrophyllaceae	Perennial	Forb	Native
<i>Hyoscyamus niger</i>	black henbane	Solanaceae	Annual	Forb	Exotic
<i>Hypericum perforatum</i>	common St. Johnswort	Clusiaceae	Perennial	Forb	Exotic
<i>Hypericum scouleri</i>	Scouler's St. Johnswort	Clusiaceae	Perennial	Forb	Native
<i>Hypochaeris radicata</i>	hairy cat's ear	Asteraceae	Perennial	Forb	Exotic
<i>Idahoia scapigera</i>	oldstem idahoia	Brassicaceae	Annual	Forb	Native
<i>Impatiens aurella</i>	paleyellow touch-me-not	Balsaminaceae	Annual	Forb	Native
<i>Impatiens capensis</i>	jewelweed	Balsaminaceae	Annual	Forb	Native
<i>Impatiens noli-tangere</i>	western touch-me-not	Balsaminaceae	Annual	Forb	Native
<i>Inula helenium</i>	elecampane inula	Asteraceae	Perennial	Forb	Exotic
<i>Ipomoea purpurea</i>	tall morning-glory	Convolvulaceae	Annual	Forb	Native
<i>Ipomopsis aggregata</i>	scarlet gilia	Polemoniaceae	Biennial	Forb	Native
<i>Ipomopsis congesta</i>	ballhead ipomopsis	Polemoniaceae	Perennial	Subshrub	Native
<i>Iris missouriensis</i>	Rocky Mountain iris	Iridaceae	Perennial	Forb	Exotic
<i>Iva axillaris</i>	povertyweed	Asteraceae	Perennial	Subshrub	Native
<i>Juglans regia</i>	English walnut	Juglandaceae	Perennial	Tree	Exotic
<i>Juncus brachyphyllus</i>	tuftedstem rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus confusus</i>	Colorado rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus conglomeratus</i>	common rush	Juncaceae	Perennial	Graminoid	Exotic
<i>Juncus drummondii</i>	Drummond's rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus dudleyi</i>	Dudley's rush	Juncaceae	Perennial	Graminoid	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Juncus ensifolius</i>	swordleaf rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus longistylis</i>	longstyle rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus nevadensis</i>	Sierra rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus parryi</i>	Parry's rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus regelii</i>	Regel's rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus saximontanus</i>	Rocky Mountain rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus tenuis</i>	poverty rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus torreyi</i>	Torrey's rush	Juncaceae	Perennial	Graminoid	Native
<i>Juncus triglumis</i>	three-hulled rush	Juncaceae	Perennial	Graminoid	Native
<i>Juniperus communis</i>	common juniper	Cupressaceae	Perennial	Tree	Native
<i>Juniperus horizontalis</i>	creeping juniper	Cupressaceae	Perennial	Subshrub	Native
<i>Juniperus occidentalis</i>	western juniper	Cupressaceae	Perennial	Tree	Native
<i>Juniperus scopulorum</i>	Rocky Mountain juniper	Cupressaceae	Perennial	Tree	Native
<i>Juniperus virginiana</i>	eastern redcedar	Cupressaceae	Perennial	Tree	Native
<i>Kalmia latifolia</i>	mountain laurel	Ericaceae	Perennial	Tree	Native
<i>Kelloggia galioides</i>	milk kelloggia	Rubiaceae	Perennial	Forb	Native
<i>Knautia arvensis</i>	field scabiosa	Dipsacaceae	Annual	Forb	Exotic
<i>Kobresia myosuroides</i>	Bellardi bog sedge	Cyperaceae	Perennial	Graminoid	Native
<i>Kochia scoparia</i>	burningbush	Chenopodiaceae	Annual	Forb	Exotic
<i>Koeleria macrantha</i>	prairie Junegrass	Poaceae	Perennial	Graminoid	Native
<i>Lactuca biennis</i>	tall blue lettuce	Asteraceae	Annual	Forb	Native
<i>Lactuca canadensis</i>	Canada lettuce	Asteraceae	Annual	Forb	Exotic
<i>Lactuca ludoviciana</i>	biannual lettuce	Asteraceae	Biennial	Forb	Exotic
<i>Lactuca saligna</i>	willowleaf lettuce	Asteraceae	Annual	Forb	Native
<i>Lactuca sativa</i>	garden lettuce	Asteraceae	Annual	Forb	Native
<i>Lactuca tatarica</i>	blue lettuce	Asteraceae	Biennial	Forb	Native
<i>Lagophylla ramosissima</i>	branched lagophylla	Asteraceae	Annual	Forb	Native
<i>Lamium amplexicaule</i>	henbit deadnettle	Lamiaceae	Annual	Forb	Exotic
<i>Lamium maculatum</i>	spotted henbit	Lamiaceae	Perennial	Forb	Native
<i>Lamium purpureum</i>	purple deadnettle	Lamiaceae	Annual	Forb	Exotic
<i>Lappula occidentalis</i>	flatspine stickseed	Boraginaceae	Annual	Forb	Native
<i>Lappula squarrosa</i>	European stickseed	Boraginaceae	Annual	Forb	Exotic
<i>Lapsana communis</i>	common nipplewort	Asteraceae	Annual	Forb	Exotic
<i>Larix lyallii</i>	subalpine larch	Pinaceae	Perennial	Tree	Native
<i>Larix occidentalis</i>	western larch	Pinaceae	Perennial	Tree	Native
<i>Lathrocasis tenerrima</i>	delicate gilia	Polemoniaceae	Annual	Forb	Native
<i>Lathyrus lanszwertii</i>	Nevada pea	Fabaceae	Perennial	Forb	Native
<i>Lathyrus latifolius</i>	perennial pea	Fabaceae	Perennial	Forb	Exotic
<i>Lathyrus nevadensis</i>	Sierra pea	Fabaceae	Perennial	Forb	Native

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<i>Lathyrus ochroleucus</i>	cream pea	Fabaceae	Perennial	Forb	Native
<i>Lathyrus pauciflorus</i>	fewflower pea	Fabaceae	Perennial	Forb	Native
<i>Lens culinaris</i>	lentil	Fabaceae	Annual	Forb	Native
<i>Leonurus cardiaca</i>	common motherwort	Lamiaceae	Perennial	Forb	Exotic
<i>Lepidium appelianum</i>	hairy whitetop	Brassicaceae	Perennial	Forb	Exotic
<i>Lepidium campestre</i>	field pepperweed	Brassicaceae	Annual	Forb	Exotic
<i>Lepidium densiflorum</i>	common pepperweed	Brassicaceae	Annual	Forb	Native
<i>Lepidium draba</i>	whitetop	Brassicaceae	Perennial	Forb	Exotic
<i>Lepidium latifolium</i>	broadleaved pepperweed	Brassicaceae	Perennial	Forb	Exotic
<i>Lepidium perfoliatum</i>	clasping pepperweed	Brassicaceae	Annual	Forb	Exotic
<i>Lepidium ramosissimum</i>	manybranched pepperweed	Brassicaceae	Annual	Forb	Exotic
<i>Lepidium ruderae</i>	roadside pepperweed	Brassicaceae	Annual	Forb	Exotic
<i>Lepidium virginicum</i>	Virginia pepperweed	Brassicaceae	Annual	Forb	Native
<i>Leptarrhena pyrolifolia</i>	fireleaf leptarrhena	Saxifragaceae	Perennial	Forb	Native
<i>Leptosiphon liniflorus</i>	narrowflower flaxflower	Polemoniaceae	Annual	Forb	Native
<i>Leucanthemum vulgare</i>	oxeye daisy	Asteraceae	Perennial	Forb	Exotic
<i>Lewisia columbiana</i>	Columbian lewisia	Portulacaceae	Perennial	Forb	Native
<i>Lewisia pygmaea</i>	alpine lewisia	Portulacaceae	Perennial	Forb	Native
<i>Lewisia rediviva</i>	bitter root	Portulacaceae	Perennial	Forb	Native
<i>Lewisia triphylla</i>	threeleaf lewisia	Portulacaceae	Perennial	Forb	Native
<i>Leymus cinereus</i>	basin wildrye	Poaceae	Perennial	Graminoid	Native
<i>Leymus condensatus</i>	giant wildrye	Poaceae	Perennial	Graminoid	Native
<i>Leymus mollis</i>	American dunegrass	Poaceae	Perennial	Graminoid	Native
<i>Leymus triticoides</i>	beardless wildrye	Poaceae	Perennial	Graminoid	Native
<i>Ligusticum canbyi</i>	Canby's licorice-root	Apiaceae	Perennial	Forb	Native
<i>Ligusticum grayi</i>	Gray's licorice-root	Apiaceae	Perennial	Forb	Native
<i>Ligustrum vulgare</i>	European privet	Oleaceae	Perennial	Shrub	Exotic
<i>Lilium columbianum</i>	Columbia lily	Liliaceae	Perennial	Forb	Native
<i>Linanthus harknessii</i>	Harkness' flaxflower	Polemoniaceae	Annual	Forb	Native
<i>Linanthus septentrionalis</i>	northern linanthus	Polemoniaceae	Annual	Forb	Native
<i>Linaria dalmatica</i>	Dalmatian toadflax	Scrophulariaceae	Perennial	Forb	Native
<i>Linaria vulgaris</i>	butter and eggs	Scrophulariaceae	Perennial	Forb	Exotic
<i>Linnaea borealis</i>	twinflower	Caprifoliaceae	Perennial	Forb	Native
<i>Linum lewisii</i>	Lewis flax	Linaceae	Perennial	Subshrub	Native
<i>Linum perenne</i>	blue flax	Linaceae	Perennial	Forb	Exotic
<i>Linum usitatissimum</i>	common flax	Linaceae	Annual	Forb	Exotic
<i>Lithospermum incisum</i>	narrowleaf stoneseed	Boraginaceae	Perennial	Forb	Native
<i>Lithospermum ruderae</i>	western stoneseed	Boraginaceae	Perennial	Forb	Native
<i>Lloydia serotina</i>	common alplily	Liliaceae	Perennial	Forb	Native

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<i>Lobelia inflata</i>	Indian-tobacco	Campanulaceae	Annual	Forb	Exotic
<i>Logfia arvensis</i>	field cottonrose	Asteraceae	Annual	Forb	Exotic
<i>Lolium perenne</i>	perennial ryegrass	Poaceae	Perennial	Graminoid	Exotic
<i>Lomatium ambiguum</i>	Wyeth biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium bicolor</i>	Wasatch desertparsley	Apiaceae	Perennial	Forb	Native
<i>Lomatium brandegeei</i>	Brandegee's desertparsley	Apiaceae	Perennial	Forb	Native
<i>Lomatium dissectum</i>	fernleaf biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium farinosum</i>	northern biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium geyeri</i>	Geyer's biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium gormanii</i>	Gorman's biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium grayi</i>	Gray's biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium macrocarpum</i>	bigseed biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium martindalei</i>	cascade desertparsley	Apiaceae	Perennial	Forb	Native
<i>Lomatium nudicaule</i>	barestem biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium piperi</i>	Indian biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium triternatum</i>	nineleaf biscuitroot	Apiaceae	Perennial	Forb	Native
<i>Lomatium utriculatum</i>	common lomatium	Apiaceae	Perennial	Forb	Native
<i>Lonicera ciliosa</i>	orange honeysuckle	Caprifoliaceae	Perennial	Forb	Native
<i>Lonicera conjugialis</i>	purpleflower honeysuckle	Caprifoliaceae	Perennial	Shrub	Native
<i>Lonicera involucrata</i>	twinberry honeysuckle	Caprifoliaceae	Perennial	Shrub	Native
<i>Lonicera tatarica</i>	Tatarian honeysuckle	Caprifoliaceae	Perennial	Shrub	Exotic
<i>Lonicera utahensis</i>	Utah honeysuckle	Caprifoliaceae	Perennial	Shrub	Native
<i>Lotus corniculatus</i>	bird's-foot trefoil	Fabaceae	Perennial	Forb	Exotic
<i>Lotus tenuis</i>	narrowleaf trefoil	Fabaceae	Perennial	Forb	Exotic
<i>Luetkea pectinata</i>	partridgefoot	Rosaceae	Perennial	Subshrub	Native
<i>Luina hypoleuca</i>	littleleaf silverback	Asteraceae	Perennial	Subshrub	Native
<i>Lupinus albicaulis</i>	sicklekeel lupine	Fabaceae	Annual	Forb	Native
<i>Lupinus arbustus</i>	longspur lupine	Fabaceae	Perennial	Subshrub	Native
<i>Lupinus arcticus</i>	arctic lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus argenteus</i>	silvery lupine	Fabaceae	Perennial	Subshrub	Native
<i>Lupinus burkei</i>	largeleaf lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus latifolius</i>	broadleaf lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus lepidus</i>	Pacific lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus leucophyllus</i>	velvet lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus lyallii</i>	dwarf mountain lupine	Fabaceae	Perennial	Subshrub	Native
<i>Lupinus polyphyllus</i>	bigleaf lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus sellulus</i>	Donner Lake lupine	Fabaceae	Perennial	Forb	Native
<i>Lupinus sericeus</i>	silky lupine	Fabaceae	Perennial	Subshrub	Native
<i>Lupinus sulphureus</i>	sulphur lupine	Fabaceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Luzula comosa</i>	Pacific woodrush	Juncaceae	Perennial	Graminoid	Native
<i>Luzula hitchcockii</i>	Hitchcock's smooth woodrush	Juncaceae	Perennial	Graminoid	Native
<i>Luzula multiflora</i>	common woodrush	Juncaceae	Perennial	Graminoid	Exotic
<i>Luzula parviflora</i>	smallflowered woodrush	Juncaceae	Perennial	Graminoid	Native
<i>Luzula piperi</i>	Piper's woodrush	Juncaceae	Perennial	Graminoid	Native
<i>Luzula spicata</i>	spiked woodrush	Juncaceae	Perennial	Graminoid	Native
<i>Lycium barbarum</i>	matrimony vine	Solanaceae	Perennial	Forb	Exotic
<i>Lycopodium alpinum</i>	alpine clubmoss	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lycopodium annotinum</i>	stiff clubmoss	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lycopodium clavatum</i>	running clubmoss	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lycopodium complanatum</i>	groundcedar	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lycopodium dendroideum</i>	tree groundpine	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lycopodium sitchense</i>	Sitka clubmoss	Lycopodiaceae	Perennial	Subshrub	Native
<i>Lygodesmia juncea</i>	rush skeletonplant	Asteraceae	Perennial	Forb	Native
<i>Lysimachia ciliata</i>	fringed loosestrife	Primulaceae	Perennial	Forb	Native
<i>Lysimachia vulgaris</i>	garden yellow loosestrife	Primulaceae	Perennial	Forb	Exotic
<i>Machaeranthera canescens</i>	hoary tansyaster	Asteraceae	Annual	Forb	Native
<i>Machaeranthera pinnatifida</i>	lacy tansyaster	Asteraceae	Perennial	Subshrub	Native
<i>Madia exigua</i>	small tarweed	Asteraceae	Annual	Forb	Native
<i>Madia glomerata</i>	mountain tarweed	Asteraceae	Annual	Forb	Native
<i>Madia gracilis</i>	grassy tarweed	Asteraceae	Annual	Forb	Native
<i>Madia sativa</i>	coast tarweed	Asteraceae	Annual	Forb	Exotic
<i>Maianthemum racemosum</i>	feathery false lily of the valley	Liliaceae	Perennial	Forb	Native
<i>Maianthemum stellatum</i>	starry false lily of the valley	Liliaceae	Perennial	Forb	Native
<i>Malva neglecta</i>	common mallow	Malvaceae	Annual	Forb	Exotic
<i>Malva parviflora</i>	cheeseweed mallow	Malvaceae	Annual	Forb	Exotic
<i>Malva pusilla</i>	low mallow	Malvaceae	Annual	Forb	Exotic
<i>Malvella leprosa</i>	alkali mallow	Malvaceae	Perennial	Forb	Native
<i>Marrubium vulgare</i>	horehound	Lamiaceae	Perennial	Subshrub	Exotic
<i>Matricaria discoidea</i>	disc mayweed	Asteraceae	Annual	Forb	Native
<i>Matteuccia struthiopteris</i>	ostrich fern	Dryopteridaceae	Perennial	Forb	Native
<i>Medicago lupulina</i>	black medick	Fabaceae	Annual	Forb	Exotic
<i>Medicago sativa</i>	alfalfa	Fabaceae	Annual	Forb	Exotic
<i>Melampyrum lineare</i>	narrowleaf cowwheat	Scrophulariaceae	Annual	Forb	Native
<i>Melica bulbosa</i>	oniongrass	Poaceae	Perennial	Graminoid	Native
<i>Melica fugax</i>	little oniongrass	Poaceae	Perennial	Graminoid	Native
<i>Melica spectabilis</i>	purple oniongrass	Poaceae	Perennial	Graminoid	Native
<i>Melica subulata</i>	Alaska oniongrass	Poaceae	Perennial	Graminoid	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Melilotus officinalis</i>	sweetclover	Fabaceae	Annual	Forb	Exotic
<i>Mentha arvensis</i>	wild mint	Lamiaceae	Perennial	Forb	Native
<i>Mentha spicata</i>	spearmint	Lamiaceae	Perennial	Forb	Exotic
<i>Mentzelia aspera</i>	tropical blazingstar	Loasaceae	Annual	Forb	Native
<i>Mentzelia dispersa</i>	bushy blazingstar	Loasaceae	Annual	Forb	Native
<i>Mentzelia laevicaulis</i>	smoothstem blazingstar	Loasaceae	Biennial	Forb	Native
<i>Menziesia ferruginea</i>	rusty menziesia	Ericaceae	Perennial	Shrub	Native
<i>Mertensia longiflora</i>	small bluebells	Boraginaceae	Perennial	Forb	Native
<i>Mertensia oblongifolia</i>	oblongleaf bluebells	Boraginaceae	Annual	Forb	Native
<i>Mertensia paniculata</i>	tall bluebells	Boraginaceae	Perennial	Subshrub	Native
<i>Microseris nutans</i>	nodding microseris	Asteraceae	Perennial	Forb	Native
<i>Mimulus breviflorus</i>	shortflower monkeyflower	Scrophulariaceae	Annual	Forb	Native
<i>Mimulus breweri</i>	Brewer's monkeyflower	Scrophulariaceae	Annual	Forb	Native
<i>Mimulus lewisii</i>	purple monkeyflower	Scrophulariaceae	Perennial	Forb	Native
<i>Mimulus suksdorfii</i>	Suksdorf's monkeyflower	Scrophulariaceae	Annual	Forb	Native
<i>Minuartia biflora</i>	mountain stitchwort	Caryophyllaceae	Perennial	Forb	Native
<i>Minuartia michauxii</i>	Michaux's stitchwort	Caryophyllaceae	Annual	Forb	Native
<i>Minuartia obtusiloba</i>	twinfleur sandwort	Caryophyllaceae	Perennial	Subshrub	Native
<i>Minuartia rubella</i>	beautiful sandwort	Caryophyllaceae	Annual	Forb	Native
<i>Mirabilis albidia</i>	white four o'clock	Nyctaginaceae	Perennial	Forb	Exotic
<i>Mirabilis jalapa</i>	marvel of Peru	Nyctaginaceae	Perennial	Forb	Native
<i>Mirabilis nyctaginea</i>	heartleaf four o'clock	Nyctaginaceae	Perennial	Forb	Exotic
<i>Mitella breweri</i>	Brewer's miterwort	Saxifragaceae	Perennial	Forb	Native
<i>Mitella caulescens</i>	slightstemmed miterwort	Saxifragaceae	Perennial	Forb	Native
<i>Mitella pentandra</i>	fivestamen miterwort	Saxifragaceae	Perennial	Forb	Native
<i>Mitella stauropetala</i>	smallflower miterwort	Saxifragaceae	Perennial	Forb	Native
<i>Mitella trifida</i>	threeparted miterwort	Saxifragaceae	Perennial	Forb	Native
<i>Moehringia lateriflora</i>	bluntleaf sandwort	Caryophyllaceae	Perennial	Forb	Native
<i>Moehringia macrophylla</i>	largeleaf sandwort	Caryophyllaceae	Perennial	Forb	Native
<i>Mollugo verticillata</i>	green carpetweed	Molluginaceae	Annual	Forb	Exotic
<i>Monarda fistulosa</i>	wild bergamot	Lamiaceae	Perennial	Subshrub	Native
<i>Monardella odoratissima</i>	mountain monardella	Lamiaceae	Perennial	Subshrub	Native
<i>Moneses uniflora</i>	single delight	Pyrolaceae	Perennial	Forb	Native
<i>Monolepis nuttalliana</i>	Nuttall's povertyweed	Chenopodiaceae	Annual	Forb	Native
<i>Montia dichotoma</i>	dwarf minerslettuce	Portulacaceae	Annual	Forb	Native
<i>Montia linearis</i>	narrowleaf minerslettuce	Portulacaceae	Annual	Forb	Native
<i>Montia parvifolia</i>	littleleaf minerslettuce	Portulacaceae	Perennial	Forb	Native
<i>Muhlenbergia andina</i>	foxtail muhly	Poaceae	Perennial	Graminoid	Native
<i>Muhlenbergia asperifolia</i>	scratchgrass	Poaceae	Perennial	Graminoid	Native

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<i>Muhlenbergia mexicana</i>	Mexican muhly	Poaceae	Perennial	Graminoid	Native
<i>Muhlenbergia minutissima</i>	annual muhly	Poaceae	Annual	Graminoid	Native
<i>Muhlenbergia racemosa</i>	marsh muhly	Poaceae	Perennial	Graminoid	Native
<i>Muhlenbergia richardsonis</i>	mat muhly	Poaceae	Perennial	Graminoid	Native
<i>Myosotis arvensis</i>	field forget-me-not	Boraginaceae	Annual	Forb	Exotic
<i>Myosotis asiatica</i>	Asian forget-me-not	Boraginaceae	Perennial	Forb	Native
<i>Myosotis discolor</i>	changing forget-me-not	Boraginaceae	Annual	Forb	Exotic
<i>Myosotis stricta</i>	strict forget-me-not	Boraginaceae	Annual	Forb	Exotic
<i>Myosotis sylvatica</i>	woodland forget-me-not	Boraginaceae	Perennial	Forb	Exotic
<i>Myosotis verna</i>	spring forget-me-not	Boraginaceae	Annual	Forb	Native
<i>Myosoton aquaticum</i>	giantchickweed	Caryophyllaceae	Perennial	Forb	Exotic
<i>Nassella viridula</i>	green needlegrass	Poaceae	Perennial	Graminoid	Native
<i>Navarretia divaricata</i>	divaricate navarretia	Polemoniaceae	Annual	Forb	Native
<i>Navarretia intertexta</i>	needleleaf navarretia	Polemoniaceae	Annual	Forb	Native
<i>Nemophila breviflora</i>	basin nemophila	Hydrophyllaceae	Annual	Forb	Native
<i>Nemophila parviflora</i>	smallflower nemophila	Hydrophyllaceae	Annual	Forb	Native
<i>Nepeta cataria</i>	catnip	Lamiaceae	Perennial	Forb	Exotic
<i>Neslia paniculata</i>	ballmustard	Brassicaceae	Annual	Forb	Exotic
<i>Nicotiana acuminata</i>	manyflower tobacco	Solanaceae	Annual	Forb	Native
<i>Nothochelone nemorosa</i>	woodland beardtongue	Scrophulariaceae	Perennial	Subshrub	Native
<i>Oenothera biennis</i>	common evening primrose	Onagraceae	Biennial	Forb	Exotic
<i>Oenothera elata</i>	Hooker's evening primrose	Onagraceae	Biennial	Forb	Native
<i>Oenothera pallida</i>	pale evening primrose	Onagraceae	Biennial	Forb	Native
<i>Oenothera villosa</i>	hairy evening primrose	Onagraceae	Perennial	Forb	Exotic
<i>Olsynium douglasii</i>	Douglas' grasswidow	Iridaceae	Perennial	Forb	Native
<i>Onobrychis viciifolia</i>	sainfoin	Fabaceae	Perennial	Forb	Exotic
<i>Onopordum acanthium</i>	Scotch cottonthistle	Asteraceae	Biennial	Forb	Exotic
<i>Oplopanax horridus</i>	devilsclub	Araliaceae	Perennial	Shrub	Native
<i>Oreostemma alpigenum</i>	tundra aster	Asteraceae	Perennial	Forb	Native
<i>Origanum vulgare</i>	oregano	Lamiaceae	Perennial	Forb	Exotic
<i>Orobanche corymbosa</i>	flat-top broomrape	Orobanchaceae	Annual	Forb	Native
<i>Orobanche fasciculata</i>	clustered broomrape	Orobanchaceae	Annual	Forb	Native
<i>Orobanche uniflora</i>	oneflowered broomrape	Orobanchaceae	Annual	Forb	Native
<i>Orthilia secunda</i>	sidebells wintergreen	Pyrolaceae	Perennial	Subshrub	Native
<i>Orthocarpus luteus</i>	yellow owl's-clover	Scrophulariaceae	Annual	Forb	Native
<i>Oryzopsis asperifolia</i>	roughleaf ricegrass	Poaceae	Perennial	Graminoid	Native
<i>Oryzopsis hymenoides</i>	Indian ricegrass	Poaceae	Perennial	Graminoid	Native
<i>Osmorhiza chilensis</i>	sweetcicely	Apiaceae	Perennial	Forb	Native
<i>Osmorhiza depauperata</i>	bluntseed sweetroot	Apiaceae	Perennial	Forb	Native

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<i>Osmorhiza occidentalis</i>	western sweetroot	Apiaceae	Perennial	Forb	Native
<i>Osmorhiza purpurea</i>	purple sweetroot	Apiaceae	Perennial	Forb	Native
<i>Oxalis corniculata</i>	creeping woodsorrel	Oxalidaceae	Annual	Forb	Exotic
<i>Oxalis dillenii</i>	slender yellow woodsorrel	Oxalidaceae	Perennial	Forb	Exotic
<i>Oxalis stricta</i>	common yellow oxalis	Oxalidaceae	Perennial	Forb	Exotic
<i>Oxyria digyna</i>	alpine mountainsorrel	Polygonaceae	Perennial	Forb	Native
<i>Oxytropis campestris</i>	field locoweed	Fabaceae	Perennial	Forb	Native
<i>Oxytropis deflexa</i>	nodding locoweed	Fabaceae	Perennial	Forb	Native
<i>Oxytropis sericea</i>	white locoweed	Fabaceae	Perennial	Forb	Native
<i>Packera cana</i>	woolly groundsel	Asteraceae	Perennial	Forb	Native
<i>Packera cymbalaria</i>	dwarf arctic ragwort	Asteraceae	Perennial	Forb	Native
<i>Packera indecora</i>	elegant groundsel	Asteraceae	Perennial	Forb	Native
<i>Packera macounii</i>	Siskiyou Mountain ragwort	Asteraceae	Perennial	Forb	Native
<i>Packera pauciflora</i>	alpine groundsel	Asteraceae	Perennial	Forb	Native
<i>Packera paupercula</i>	balsam groundsel	Asteraceae	Perennial	Forb	Native
<i>Packera plattensis</i>	prairie groundsel	Asteraceae	Biennial	Forb	Native
<i>Packera pseud aurea</i>	falsegold groundsel	Asteraceae	Perennial	Forb	Native
<i>Packera streptanthifolia</i>	Rocky Mountain groundsel	Asteraceae	Perennial	Forb	Native
<i>Panicum capillare</i>	witchgrass	Poaceae	Annual	Graminoid	Native
<i>Panicum miliaceum</i>	proso millet	Poaceae	Annual	Graminoid	Exotic
<i>Papaver rhoeas</i>	corn poppy	Papaveraceae	Annual	Forb	Exotic
<i>Parietaria pensylvanica</i>	Pennsylvania pellitory	Urticaceae	Annual	Forb	Native
<i>Parthenocissus quinquefolia</i>	Virginia creeper	Vitaceae	Perennial	Forb	Native
<i>Pascopyrum smithii</i>	western wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Paxistima myrsinites</i>	Oregon boxleaf	Celastraceae	Perennial	Shrub	Native
<i>Pedicularis bracteosa</i>	bracted lousewort	Scrophulariaceae	Perennial	Forb	Native
<i>Pedicularis contorta</i>	coiled lousewort	Scrophulariaceae	Perennial	Forb	Native
<i>Pedicularis langsдорffii</i>	Langsdorf's lousewort	Scrophulariaceae	Perennial	Forb	Native
<i>Pedicularis ornithorhyncha</i>	ducksbill lousewort	Scrophulariaceae	Perennial	Forb	Native
<i>Pedicularis racemosa</i>	sickletop lousewort	Scrophulariaceae	Perennial	Forb	Native
<i>Pellaea atropurpurea</i>	purple cliffbrake	Pteridaceae	Perennial	Forb	Native
<i>Pellaea glabella</i>	smooth cliffbrake	Pteridaceae	Perennial	Forb	Native
<i>Pennisetum glaucum</i>	pearl millet	Poaceae	Annual	Graminoid	Native
<i>Penstemon attenuatus</i>	sulphur penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon barbatus</i>	beardlip penstemon	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon confertus</i>	yellow penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon davidsonii</i>	Davidson's penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon deustus</i>	scabland penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon ellipticus</i>	rocky ledge penstemon	Scrophulariaceae	Perennial	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Penstemon eriantherus</i>	fuzzytongue penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon fruticosus</i>	bush penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon gairdneri</i>	Gairdner's beardtongue	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon glandulosus</i>	stickystem penstemon	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon hirsutus</i>	hairy beardtongue	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon montanus</i>	cordroot beardtongue	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon procerus</i>	littleflower penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon pruinus</i>	Chelan beardtongue	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon richardsonii</i>	cutleaf beardtongue	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon rupicola</i>	cliff beardtongue	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon rydbergii</i>	Rydberg's penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon serrulatus</i>	serrulate penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon speciosus</i>	royal penstemon	Scrophulariaceae	Perennial	Forb	Native
<i>Penstemon triphyllus</i>	Riggin's penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon venustus</i>	Venus penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Penstemon wilcoxii</i>	Wilcox's penstemon	Scrophulariaceae	Perennial	Subshrub	Native
<i>Persicaria longiseta</i>	Oriental lady's thumb	Polygonaceae	Annual	Forb	Exotic
<i>Petasites frigidus</i>	arctic sweet coltsfoot	Asteraceae	Perennial	Forb	Native
<i>Phacelia franklinii</i>	Franklin's phacelia	Hydrophyllaceae	Annual	Forb	Native
<i>Phacelia hastata</i>	silverleaf phacelia	Hydrophyllaceae	Perennial	Forb	Native
<i>Phacelia heterophylla</i>	varileaf phacelia	Hydrophyllaceae	Biennial	Forb	Native
<i>Phacelia humilis</i>	low phacelia	Hydrophyllaceae	Annual	Forb	Native
<i>Phacelia incana</i>	hoary phacelia	Hydrophyllaceae	Annual	Forb	Native
<i>Phacelia leptosepala</i>	narrowsepal phacelia	Hydrophyllaceae	Perennial	Subshrub	Native
<i>Phacelia linearis</i>	threadleaf phacelia	Hydrophyllaceae	Annual	Forb	Native
<i>Phacelia procera</i>	tall phacelia	Hydrophyllaceae	Perennial	Forb	Native
<i>Phacelia ramosissima</i>	branching phacelia	Hydrophyllaceae	Perennial	Subshrub	Native
<i>Phacelia sericea</i>	silky phacelia	Hydrophyllaceae	Biennial	Subshrub	Native
<i>Phalaris canariensis</i>	annual canarygrass	Poaceae	Annual	Graminoid	Exotic
<i>Phalaris paradoxa</i>	hood canarygrass	Poaceae	Annual	Graminoid	Native
<i>Philadelphus lewisii</i>	Lewis' mock orange	Hydrangeaceae	Perennial	Shrub	Native
<i>Phleum alpinum</i>	alpine timothy	Poaceae	Perennial	Graminoid	Native
<i>Phleum pratense</i>	timothy	Poaceae	Perennial	Graminoid	Exotic
<i>Phlox caespitosa</i>	tufted phlox	Polemoniaceae	Perennial	Subshrub	Native
<i>Phlox diffusa</i>	spreading phlox	Polemoniaceae	Perennial	Subshrub	Native
<i>Phlox hoodii</i>	spiny phlox	Polemoniaceae	Perennial	Forb	Native
<i>Phlox longifolia</i>	longleaf phlox	Polemoniaceae	Perennial	Subshrub	Native
<i>Phlox pulvinata</i>	cushion phlox	Polemoniaceae	Perennial	Forb	Native
<i>Phlox speciosa</i>	showy phlox	Polemoniaceae	Perennial	Subshrub	Native

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<i>Phoenicautis cheiranthoides</i>	wallflower phoenicautis	Brassicaceae	Perennial	Forb	Native
<i>Phragmites australis</i>	common reed	Poaceae	Perennial	Subshrub	Exotic
<i>Phyllodoce empetriformis</i>	pink mountainheath	Ericaceae	Perennial	Subshrub	Native
<i>Phyllodoce glanduliflora</i>	yellow mountainheath	Ericaceae	Perennial	Subshrub	Native
<i>Physalis longifolia</i>	longleaf groundcherry	Solanaceae	Perennial	Forb	Native
<i>Physalis philadelphica</i>	Mexican groundcherry	Solanaceae	Annual	Forb	Exotic
<i>Physaria didymocarpa</i>	common twinpod	Brassicaceae	Perennial	Forb	Native
<i>Physocarpus malvaceus</i>	mallow ninebark	Rosaceae	Perennial	Shrub	Native
<i>Picea engelmannii</i>	Engelmann spruce	Pinaceae	Perennial	Tree	Native
<i>Picea glauca</i>	white spruce	Pinaceae	Perennial	Tree	Native
<i>Pinus contorta</i>	lodgepole pine	Pinaceae	Perennial	Tree	Native
<i>Pinus monticola</i>	western white pine	Pinaceae	Perennial	Tree	Native
<i>Pinus ponderosa</i>	ponderosa pine	Pinaceae	Perennial	Tree	Native
<i>Piptatherum micranthum</i>	littleseed ricegrass	Poaceae	Perennial	Graminoid	Native
<i>Piptatherum pungens</i>	mountain ricegrass	Poaceae	Perennial	Graminoid	Native
<i>Pityrogramma triangularis</i>	goldback fern	Pteridaceae	Perennial	Forb	Native
<i>Plagiobothrys scouleri</i>	Scouler's popcornflower	Boraginaceae	Annual	Forb	Native
<i>Plagiobothrys tenellus</i>	Pacific popcornflower	Boraginaceae	Annual	Forb	Native
<i>Plantago lanceolata</i>	narrowleaf plantain	Plantaginaceae	Annual	Forb	Exotic
<i>Plantago patagonica</i>	woolly plantain	Plantaginaceae	Annual	Forb	Native
<i>Plectritis brachystemon</i>	shortspur seablush	Valerianaceae	Annual	Forb	Native
<i>Plectritis macrocera</i>	longhorn plectritis	Valerianaceae	Annual	Forb	Native
<i>Poa alpina</i>	alpine bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa annua</i>	annual bluegrass	Poaceae	Annual	Graminoid	Exotic
<i>Poa arctica</i>	arctic bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa bulbosa</i>	bulbous bluegrass	Poaceae	Perennial	Graminoid	Exotic
<i>Poa compressa</i>	Canada bluegrass	Poaceae	Perennial	Graminoid	Exotic
<i>Poa cusickii</i>	Cusick's bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa fendleriana</i>	muttongrass	Poaceae	Perennial	Graminoid	Native
<i>Poa glauca</i>	glaucous bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa howellii</i>	Howell's bluegrass	Poaceae	Annual	Graminoid	Native
<i>Poa interior</i>	inland bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa nemoralis</i>	wood bluegrass	Poaceae	Perennial	Graminoid	Exotic
<i>Poa nervosa</i>	Wheeler bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa palustris</i>	fowl bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa paucispicula</i>	Alaska bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa pratensis</i>	Kentucky bluegrass	Poaceae	Perennial	Graminoid	Exotic
<i>Poa secunda</i>	Sandberg bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Poa stenantha</i>	northern bluegrass	Poaceae	Perennial	Graminoid	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Poa wheeleri</i>	Wheeler's bluegrass	Poaceae	Perennial	Graminoid	Native
<i>Podagrostis humilis</i>	alpine bentgrass	Poaceae	Perennial	Graminoid	Native
<i>Polemonium californicum</i>	moving polemonium	Polemoniaceae	Perennial	Forb	Native
<i>Polemonium elegans</i>	elegant Jacob's-ladder	Polemoniaceae	Perennial	Forb	Native
<i>Polemonium micranthum</i>	annual polemonium	Polemoniaceae	Annual	Forb	Native
<i>Polemonium occidentale</i>	western polemonium	Polemoniaceae	Perennial	Forb	Native
<i>Polemonium pulcherrimum</i>	Jacob's-ladder	Polemoniaceae	Perennial	Forb	Native
<i>Polemonium viscosum</i>	sticky polemonium	Polemoniaceae	Perennial	Forb	Native
<i>Polygonum achoreum</i>	leathery knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum aviculare</i>	prostrate knotweed	Polygonaceae	Annual	Forb	Exotic
<i>Polygonum douglasii</i>	Douglas' knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum majus</i>	large knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum minimum</i>	broadleaf knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum polygaloides</i>	milkwort knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum ramosissimum</i>	bushy knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum sawatchense</i>	Johnston's knotweed	Polygonaceae	Annual	Forb	Native
<i>Polygonum spargulariiforme</i>	scatter knotweed	Polygonaceae	Annual	Forb	Native
<i>Polypodium glycyrrhiza</i>	licorice fern	Polypodiaceae	Perennial	Forb	Native
<i>Polypodium hesperium</i>	western polypody	Polypodiaceae	Perennial	Forb	Native
<i>Polystichum andersonii</i>	Anderson's hollyfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum imbricans</i>	narrowleaf swordfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum kruckebergii</i>	Kruckeberg's hollyfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum lemmonii</i>	Lemmon's hollyfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum lonchitis</i>	northern hollyfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum munitum</i>	western swordfern	Dryopteridaceae	Perennial	Forb	Native
<i>Polystichum scopulinum</i>	mountain hollyfern	Dryopteridaceae	Perennial	Forb	Native
<i>Populus alba</i>	white poplar	Salicaceae	Perennial	Tree	Native
<i>Populus balsamifera</i>	balsam poplar	Salicaceae	Perennial	Tree	Native
<i>Populus deltoides</i>	eastern cottonwood	Salicaceae	Perennial	Tree	Exotic
<i>Populus nigra</i>	Lombardy poplar	Salicaceae	Perennial	Tree	Exotic
<i>Populus tremuloides</i>	quaking aspen	Salicaceae	Perennial	Tree	Native
<i>Populus trichocarpa</i>	black cottonwood	Salicaceae	Perennial	Tree	Native
<i>Portulaca oleracea</i>	little hogweed	Portulacaceae	Annual	Forb	Exotic
<i>Potentilla argentea</i>	silver cinquefoil	Rosaceae	Perennial	Forb	Exotic
<i>Potentilla biennis</i>	biennial cinquefoil	Rosaceae	Annual	Forb	Native
<i>Potentilla diversifolia</i>	varileaf cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla drummondii</i>	Drummond's cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla flabellifolia</i>	high mountain cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla gracilis</i>	slender cinquefoil	Rosaceae	Perennial	Subshrub	Native

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<i>Potentilla hippiana</i>	woolly cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla hookeriana</i>	Hooker's cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla nivea</i>	snow cinquefoil	Rosaceae	Perennial	Subshrub	Native
<i>Potentilla norvegica</i>	Norwegian cinquefoil	Rosaceae	Annual	Forb	Native
<i>Potentilla pectinisetia</i>	combleaf cinquefoil	Rosaceae	Perennial	Subshrub	Native
<i>Potentilla pensylvanica</i>	Pennsylvania cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla pulcherrima</i>	beautiful cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Potentilla recta</i>	sulphur cinquefoil	Rosaceae	Perennial	Forb	Exotic
<i>Potentilla rivalis</i>	brook cinquefoil	Rosaceae	Annual	Forb	Native
<i>Potentilla uniflora</i>	oneflower cinquefoil	Rosaceae	Perennial	Forb	Native
<i>Prunella vulgaris</i>	common selfheal	Lamiaceae	Perennial	Forb	Exotic
<i>Prunus emarginata</i>	bitter cherry	Rosaceae	Perennial	Tree	Native
<i>Prunus pensylvanica</i>	pin cherry	Rosaceae	Perennial	Tree	Native
<i>Prunus virginiana</i>	chokecherry	Rosaceae	Perennial	Tree	Native
<i>Psathyrostachys juncea</i>	Russian wildrye	Poaceae	Perennial	Graminoid	Exotic
<i>Pseudognaphalium canescens</i>	Wright's cudweed	Asteraceae	Annual	Forb	Native
<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	Poaceae	Perennial	Graminoid	Native
<i>Pseudostellaria jamesiana</i>	tuber starwort	Caryophyllaceae	Perennial	Forb	Native
<i>Pseudotsuga menziesii</i>	Douglas-fir	Pinaceae	Perennial	Tree	Native
<i>Psilocarphus brevissimus</i>	short woollyheads	Asteraceae	Annual	Forb	Native
<i>Psilocarphus elatior</i>	meadow woollyheads	Asteraceae	Annual	Forb	Native
<i>Pteridium aquilinum</i>	western brackenfern	Dennstaedtiaceae	Perennial	Forb	Native
<i>Pterospora andromedea</i>	woodland pinedrops	Monotropaceae	Perennial	Forb	Native
<i>Pteryxia terebinthina</i>	turpentine wavewing	Apiaceae	Perennial	Forb	Native
<i>Purshia tridentata</i>	antelope bitterbrush	Rosaceae	Perennial	Shrub	Native
<i>Pyrola asarifolia</i>	liverleaf wintergreen	Pyrolaceae	Perennial	Subshrub	Native
<i>Pyrola chlorantha</i>	greenflowered wintergreen	Pyrolaceae	Perennial	Subshrub	Native
<i>Pyrola elliptica</i>	waxflower shinleaf	Pyrolaceae	Perennial	Subshrub	Native
<i>Pyrola picta</i>	whiteveined wintergreen	Pyrolaceae	Perennial	Subshrub	Native
<i>Pyrrocoma carthamoides</i>	largeflower goldenweed	Asteraceae	Perennial	Forb	Native
<i>Pyrrocoma hirta</i>	tacky goldenweed	Asteraceae	Perennial	Forb	Native
<i>Quercus garryana</i>	Oregon white oak	Fagaceae	Perennial	Tree	Native
<i>Quercus imbricaria</i>	shingle oak	Fagaceae	Perennial	Tree	Native
<i>Ranunculus abortivus</i>	littleleaf buttercup	Ranunculaceae	Biennial	Forb	Native
<i>Ranunculus acris</i>	tall buttercup	Ranunculaceae	Perennial	Forb	Exotic
<i>Ranunculus eschscholtzii</i>	Eschscholtz's buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus glaberrimus</i>	sagebrush buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus gmelinii</i>	Gmelin's buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus inamoenus</i>	graceful buttercup	Ranunculaceae	Perennial	Forb	Native

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<i>Ranunculus occidentalis</i>	western buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus orthorhynchus</i>	straightbeak buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus pedatifidus</i>	surefoot buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus pygmaeus</i>	pygmy buttercup	Ranunculaceae	Perennial	Forb	Native
<i>Ranunculus repens</i>	creeping buttercup	Ranunculaceae	Perennial	Forb	Exotic
<i>Ranunculus uncinatus</i>	woodland buttercup	Ranunculaceae	Annual	Forb	Native
<i>Raphanus raphanistrum</i>	wild radish	Brassicaceae	Annual	Forb	Exotic
<i>Reseda lutea</i>	yellow mignonette	Resedaceae	Biennial	Forb	Exotic
<i>Rhinanthus minor</i>	little yellow rattle	Scrophulariaceae	Annual	Forb	Native
<i>Rhodiola integrifolia</i>	ledge stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Rhododendron albiflorum</i>	Cascade azalea	Ericaceae	Perennial	Shrub	Native
<i>Rhododendron macrophyllum</i>	Pacific rhododendron	Ericaceae	Perennial	Shrub	Native
<i>Rhus glabra</i>	smooth sumac	Anacardiaceae	Perennial	Tree	Native
<i>Rhus trilobata</i>	skunkbush sumac	Anacardiaceae	Perennial	Shrub	Native
<i>Ribes acerifolium</i>	mapleleaf currant	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes aureum</i>	golden currant	Grossulariaceae	Perennial	Shrub	Exotic
<i>Ribes bracteosum</i>	stink currant	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes cereum</i>	wax currant	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes divaricatum</i>	spreading gooseberry	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes inerme</i>	whitestem gooseberry	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes lacustre</i>	prickly currant	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes laxiflorum</i>	trailing black currant	Grossulariaceae	Perennial	Forb	Native
<i>Ribes oxycanthoides</i>	Canadian gooseberry	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes rubrum</i>	cultivated currant	Grossulariaceae	Perennial	Shrub	Exotic
<i>Ribes sanguineum</i>	redflower currant	Grossulariaceae	Perennial	Shrub	Native
<i>Ribes viscosissimum</i>	sticky currant	Grossulariaceae	Perennial	Shrub	Native
<i>Robinia pseudoacacia</i>	black locust	Fabaceae	Perennial	Tree	Exotic
<i>Romanzoffia sitchensis</i>	Sitka mistmaiden	Hydrophyllaceae	Perennial	Forb	Native
<i>Rorippa tenerrima</i>	Modoc yellowcress	Brassicaceae	Annual	Forb	Native
<i>Rorippa teres</i>	southern marsh yellowcress	Brassicaceae	Annual	Forb	Native
<i>Rosa acicularis</i>	prickly rose	Rosaceae	Perennial	Subshrub	Native
<i>Rosa canina</i>	dog rose	Rosaceae	Perennial	Forb	Exotic
<i>Rosa gymnocarpa</i>	dwarf rose	Rosaceae	Perennial	Subshrub	Native
<i>Rosa nutkana</i>	Nootka rose	Rosaceae	Perennial	Subshrub	Native
<i>Rosa rubiginosa</i>	sweetbriar rose	Rosaceae	Perennial	Subshrub	Exotic
<i>Rosa woodsii</i>	Woods' rose	Rosaceae	Perennial	Subshrub	Native
<i>Rostraria cristata</i>	Mediterranean hairgrass	Poaceae	Annual	Graminoid	Native
<i>Rubus arcticus</i>	arctic raspberry	Rosaceae	Perennial	Subshrub	Native
<i>Rubus idaeus</i>	American red raspberry	Rosaceae	Perennial	Subshrub	Native

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<i>Rubus lasiococcus</i>	roughfruit berry	Rosaceae	Perennial	Forb	Native
<i>Rubus occidentalis</i>	black raspberry	Rosaceae	Perennial	Subshrub	Native
<i>Rubus parviflorus</i>	thimbleberry	Rosaceae	Perennial	Subshrub	Native
<i>Rubus pubescens</i>	dwarf red blackberry	Rosaceae	Perennial	Subshrub	Native
<i>Rubus spectabilis</i>	salmonberry	Rosaceae	Perennial	Forb	Native
<i>Rubus ursinus</i>	California blackberry	Rosaceae	Perennial	Subshrub	Native
<i>Rudbeckia hirta</i>	blackeyed Susan	Asteraceae	Annual	Forb	Exotic
<i>Rudbeckia occidentalis</i>	western coneflower	Asteraceae	Perennial	Forb	Native
<i>Rumex acetosa</i>	garden sorrel	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex acetosella</i>	common sheep sorrel	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex crispus</i>	curly dock	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex obtusifolius</i>	bitter dock	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex patientia</i>	patience dock	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex paucifolius</i>	alpine sheep sorrel	Polygonaceae	Perennial	Forb	Native
<i>Rumex salicifolius</i>	willow dock	Polygonaceae	Perennial	Forb	Native
<i>Rumex stenophyllus</i>	narrowleaf dock	Polygonaceae	Perennial	Forb	Exotic
<i>Rumex triangulivalvis</i>	Mexican dock	Polygonaceae	Perennial	Forb	Native
<i>Rumex venosus</i>	veiny dock	Polygonaceae	Perennial	Forb	Native
<i>Sagina saginoides</i>	arctic pearlwort	Caryophyllaceae	Biennial	Forb	Native
<i>Salix amygdaloides</i>	peachleaf willow	Salicaceae	Perennial	Tree	Native
<i>Salix arctica</i>	arctic willow	Salicaceae	Perennial	Shrub	Native
<i>Salix barrattiana</i>	Barratt's willow	Salicaceae	Perennial	Shrub	Native
<i>Salix bebbiana</i>	Bebb willow	Salicaceae	Perennial	Tree	Native
<i>Salix brachycarpa</i>	shortfruit willow	Salicaceae	Perennial	Shrub	Native
<i>Salix cascadiensis</i>	cascade willow	Salicaceae	Perennial	Shrub	Native
<i>Salix drummondiana</i>	Drummond's willow	Salicaceae	Perennial	Shrub	Native
<i>Salix eriocephala</i>	Missouri River willow	Salicaceae	Perennial	Tree	Native
<i>Salix exigua</i>	narrowleaf willow	Salicaceae	Perennial	Tree	Native
<i>Salix glauca</i>	grayleaf willow	Salicaceae	Perennial	Tree	Native
<i>Salix hookeriana</i>	dune willow	Salicaceae	Perennial	Tree	Native
<i>Salix lasiandra</i>	Pacific willow	Salicaceae	Perennial	Shrub	Native
<i>Salix lasiolepis</i>	arroyo willow	Salicaceae	Perennial	Tree	Native
<i>Salix lucida</i>	shining willow	Salicaceae	Perennial	Shrub	Native
<i>Salix myrtillofolia</i>	blueberry willow	Salicaceae	Perennial	Tree	Native
<i>Salix nivalis</i>	snow willow	Salicaceae	Perennial	Subshrub	Native
<i>Salix pseudomonticola</i>	false mountain willow	Salicaceae	Perennial	Shrub	Native
<i>Salix pseudomyrsinites</i>	firmleaf willow	Salicaceae	Perennial	Shrub	Native
<i>Salix scouleriana</i>	Scouler's willow	Salicaceae	Perennial	Tree	Native
<i>Salix sitchensis</i>	Sitka willow	Salicaceae	Perennial	Tree	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Salix tweedyi</i>	Tweedy's willow	Salicaceae	Perennial	Shrub	Native
<i>Salsola kali</i>	Russian thistle	Chenopodiaceae	Annual	Forb	Native
<i>Salvia dorrii</i>	purple sage	Lamiaceae	Perennial	Subshrub	Native
<i>Sambucus racemosa</i>	red elderberry	Caprifoliaceae	Perennial	Tree	Native
<i>Sanguisorba annua</i>	prairie burnet	Rosaceae	Annual	Forb	Native
<i>Sanguisorba canadensis</i>	Canadian burnet	Rosaceae	Perennial	Forb	Native
<i>Sanguisorba minor</i>	small burnet	Rosaceae	Perennial	Forb	Native
<i>Sanguisorba officinalis</i>	great burnet	Rosaceae	Perennial	Forb	Native
<i>Sanicula graveolens</i>	northern sanicle	Apiaceae	Perennial	Forb	Native
<i>Sanicula marilandica</i>	Maryland sanicle	Apiaceae	Perennial	Forb	Native
<i>Saponaria officinalis</i>	bouncingbet	Caryophyllaceae	Perennial	Forb	Exotic
<i>Saxifraga adscendens</i>	wedgeleaf saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga arguta</i>	brook saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga bronchialis</i>	yellowdot saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga cernua</i>	nodding saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga lyallii</i>	redstem saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga nelsoniana</i>	heartleaf saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga odontoloma</i>	brook saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga oppositifolia</i>	purple mountain saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga tolmiei</i>	Tolmie's saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Saxifraga tricuspidata</i>	three toothed saxifrage	Saxifragaceae	Perennial	Forb	Native
<i>Scirpus acutus</i>	hardstem bulrush	Cyperaceae	Perennial	Graminoid	Native
<i>Scleranthus annuus</i>	German knotgrass	Caryophyllaceae	Annual	Forb	Exotic
<i>Sclerochloa dura</i>	common hardgrass	Poaceae	Annual	Graminoid	Exotic
<i>Scrophularia lanceolata</i>	lanceleaf figwort	Scrophulariaceae	Perennial	Forb	Native
<i>Scutellaria angustifolia</i>	narrowleaf skullcap	Lamiaceae	Perennial	Forb	Native
<i>Secale cereale</i>	cereal rye	Poaceae	Annual	Graminoid	Exotic
<i>Sedum debile</i>	orpine stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Sedum divergens</i>	Pacific stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Sedum lanceolatum</i>	spearleaf stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Sedum oreganum</i>	Oregon stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Sedum rosea</i>	roseroot stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Sedum stenopetalum</i>	wormleaf stonecrop	Crassulaceae	Perennial	Forb	Native
<i>Selaginella densa</i>	lesser spikemoss	Selaginellaceae	Perennial	Forb	Native
<i>Selaginella scopulorum</i>	Rocky Mountain spikemoss	Selaginellaceae	Perennial	Forb	Native
<i>Selaginella wallacei</i>	Wallace's spikemoss	Selaginellaceae	Perennial	Forb	Native
<i>Senecio elmeri</i>	Elmer's ragwort	Asteraceae	Perennial	Forb	Native
<i>Senecio fremontii</i>	dwarf mountain ragwort	Asteraceae	Perennial	Forb	Native
<i>Senecio hydrophiloides</i>	tall groundsel	Asteraceae	Biennial	Forb	Native

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<i>Senecio integerrimus</i>	lambstongue ragwort	Asteraceae	Biennial	Forb	Native
<i>Senecio lugens</i>	small blacktip ragwort	Asteraceae	Perennial	Forb	Native
<i>Senecio sylvaticus</i>	woodland ragwort	Asteraceae	Annual	Forb	Exotic
<i>Senecio vulgaris</i>	old-man-in-the-Spring	Asteraceae	Annual	Forb	Exotic
<i>Setaria verticillata</i>	hooked bristlegrass	Poaceae	Annual	Graminoid	Exotic
<i>Setaria viridis</i>	green bristlegrass	Poaceae	Annual	Graminoid	Exotic
<i>Shepherdia argentea</i>	silver buffaloberry	Elaeagnaceae	Perennial	Tree	Exotic
<i>Shepherdia canadensis</i>	russet buffaloberry	Elaeagnaceae	Perennial	Shrub	Native
<i>Sibbaldia procumbens</i>	creeping sibbaldia	Rosaceae	Perennial	Subshrub	Native
<i>Silene acaulis</i>	moss campion	Caryophyllaceae	Perennial	Forb	Native
<i>Silene antirrhina</i>	sleepy silene	Caryophyllaceae	Annual	Forb	Native
<i>Silene csereii</i>	Balkan catchfly	Caryophyllaceae	Biennial	Forb	Exotic
<i>Silene douglasii</i>	Douglas's catchfly	Caryophyllaceae	Perennial	Forb	Native
<i>Silene drummondii</i>	Drummond's campion	Caryophyllaceae	Perennial	Forb	Native
<i>Silene latifolia</i>	bladder campion	Caryophyllaceae	Biennial	Forb	Exotic
<i>Silene menziesii</i>	Menzies' campion	Caryophyllaceae	Perennial	Forb	Native
<i>Silene noctiflora</i>	nightflowering silene	Caryophyllaceae	Annual	Forb	Exotic
<i>Silene oregana</i>	Oregon silene	Caryophyllaceae	Perennial	Forb	Native
<i>Silene parryi</i>	Parry's silene	Caryophyllaceae	Perennial	Forb	Native
<i>Silene repens</i>	pink campion	Caryophyllaceae	Perennial	Forb	Native
<i>Silene scouleri</i>	simple campion	Caryophyllaceae	Perennial	Forb	Native
<i>Silene suksdorfii</i>	Suksdorf's silene	Caryophyllaceae	Perennial	Forb	Native
<i>Silene vulgaris</i>	maidenstears	Caryophyllaceae	Perennial	Forb	Exotic
<i>Sinapis alba</i>	white mustard	Brassicaceae	Annual	Forb	Exotic
<i>Sinapis arvensis</i>	charlock mustard	Brassicaceae	Annual	Forb	Exotic
<i>Sisymbrium altissimum</i>	tall tumbledmustard	Brassicaceae	Annual	Forb	Exotic
<i>Sisymbrium loeselii</i>	small tumbleweed mustard	Brassicaceae	Annual	Forb	Exotic
<i>Sisymbrium officinale</i>	hedgemustard	Brassicaceae	Annual	Forb	Exotic
<i>Sisyrinchium angustifolium</i>	narrowleaf blue-eyed grass	Iridaceae	Perennial	Forb	Native
<i>Sisyrinchium montanum</i>	strict blue-eyed grass	Iridaceae	Perennial	Forb	Native
<i>Smelowskia calycina</i>	alpine smelowskia	Brassicaceae	Perennial	Forb	Native
<i>Smelowskia ovalis</i>	alpine false candytuft	Brassicaceae	Perennial	Forb	Native
<i>Solanum americanum</i>	American black nightshade	Solanaceae	Annual	Subshrub	Exotic
<i>Solanum dulcamara</i>	climbing nightshade	Solanaceae	Perennial	Subshrub	Exotic
<i>Solanum melongena</i>	eggplant	Solanaceae	Perennial	Subshrub	Native
<i>Solanum physalifolium</i>	hoe nightshade	Solanaceae	Annual	Forb	Exotic
<i>Solanum rostratum</i>	buffalobur nightshade	Solanaceae	Annual	Forb	Exotic
<i>Solanum triflorum</i>	cutleaf nightshade	Solanaceae	Annual	Forb	Exotic
<i>Solidago altissima</i>	Canada goldenrod	Asteraceae	Perennial	Forb	Exotic

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<i>Solidago canadensis</i>	Canada goldenrod	Asteraceae	Perennial	Forb	Exotic
<i>Solidago elongata</i>	rough Canada goldenrod	Asteraceae	Perennial	Forb	Native
<i>Solidago gigantea</i>	giant goldenrod	Asteraceae	Perennial	Forb	Native
<i>Solidago missouriensis</i>	Missouri goldenrod	Asteraceae	Perennial	Forb	Native
<i>Solidago multiradiata</i>	Rocky Mountain goldenrod	Asteraceae	Perennial	Subshrub	Native
<i>Solidago simplex</i>	Mt. Albert goldenrod	Asteraceae	Perennial	Subshrub	Native
<i>Sonchus arvensis</i>	field sowthistle	Asteraceae	Perennial	Forb	Exotic
<i>Sonchus asper</i>	spiny sowthistle	Asteraceae	Annual	Forb	Exotic
<i>Sorbus aucuparia</i>	European mountain ash	Rosaceae	Perennial	Tree	Exotic
<i>Sorbus scopulina</i>	Greene's mountain ash	Rosaceae	Perennial	Tree	Native
<i>Sorbus sitchensis</i>	western mountain ash	Rosaceae	Perennial	Tree	Native
<i>Sorghum bicolor</i>	sorghum	Poaceae	Annual	Graminoid	Exotic
<i>Spartina gracilis</i>	alkali cordgrass	Poaceae	Perennial	Graminoid	Native
<i>Spergula arvensis</i>	corn spurry	Caryophyllaceae	Annual	Forb	Exotic
<i>Spergularia rubra</i>	red sandspurry	Caryophyllaceae	Annual	Forb	Exotic
<i>Sphaeralcea munroana</i>	Munro's globemallow	Malvaceae	Perennial	Subshrub	Native
<i>Sphenopholis intermedia</i>	slender wedgescale	Poaceae	Perennial	Graminoid	Native
<i>Sphenopholis obtusata</i>	prairie wedgescale	Poaceae	Annual	Graminoid	Native
<i>Spiraea betulifolia</i>	white spirea	Rosaceae	Perennial	Shrub	Native
<i>Spiraea densiflora</i>	rose meadowsweet	Rosaceae	Perennial	Shrub	Native
<i>Spiraea douglasii</i>	rose spirea	Rosaceae	Perennial	Shrub	Native
<i>Sporobolus airoides</i>	alkali sacaton	Poaceae	Perennial	Graminoid	Native
<i>Sporobolus compositus</i>	composite dropseed	Poaceae	Perennial	Graminoid	Native
<i>Sporobolus cryptandrus</i>	sand dropseed	Poaceae	Perennial	Graminoid	Native
<i>Sporobolus neglectus</i>	puffsheat dropseed	Poaceae	Annual	Graminoid	Native
<i>Sporobolus vaginiflorus</i>	poverty dropseed	Poaceae	Annual	Graminoid	Exotic
<i>Stachys pilosa</i>	hairy hedgenettle	Lamiaceae	Perennial	Forb	Native
<i>Stellaria calycantha</i>	northern starwort	Caryophyllaceae	Annual	Forb	Native
<i>Stellaria crispa</i>	curled starwort	Caryophyllaceae	Perennial	Forb	Native
<i>Stellaria graminea</i>	grass-like starwort	Caryophyllaceae	Perennial	Forb	Exotic
<i>Stellaria longifolia</i>	longleaf starwort	Caryophyllaceae	Perennial	Forb	Native
<i>Stellaria media</i>	common chickweed	Caryophyllaceae	Annual	Forb	Exotic
<i>Stellaria nitens</i>	shiny chickweed	Caryophyllaceae	Annual	Forb	Native
<i>Stellaria obtusa</i>	Rocky Mountain chickweed	Caryophyllaceae	Perennial	Forb	Native
<i>Stellaria umbellata</i>	umbrella starwort	Caryophyllaceae	Perennial	Forb	Native
<i>Stenanthium occidentale</i>	western featherbells	Liliaceae	Perennial	Forb	Native
<i>Suaeda calceoliformis</i>	Pursh seepweed	Chenopodiaceae	Annual	Forb	Native
<i>Symphoricarpos albus</i>	common snowberry	Caprifoliaceae	Perennial	Subshrub	Native
<i>Symphoricarpos mollis</i>	creeping snowberry	Caprifoliaceae	Perennial	Subshrub	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Symphoricarpos occidentalis</i>	western snowberry	Caprifoliaceae	Perennial	Shrub	Native
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Caprifoliaceae	Perennial	Shrub	Native
<i>Symphyotrichum ascendens</i>	western aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum campestre</i>	western meadow aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum ciliatum</i>	rayless alkali aster	Asteraceae	Annual	Forb	Native
<i>Symphyotrichum ciliolatum</i>	Lindley's aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum eatonii</i>	Eaton's aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum ericoides</i>	white heath aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum falcatum</i>	white prairie aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum foliaceum</i>	alpine leafybract aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum frondosum</i>	short-rayed alkali aster	Asteraceae	Annual	Forb	Native
<i>Symphyotrichum laeve</i>	smooth blue aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum spathulatum</i>	western mountain aster	Asteraceae	Perennial	Forb	Native
<i>Symphyotrichum subspicatum</i>	Douglas aster	Asteraceae	Perennial	Forb	Native
<i>Symphytum asperum</i>	prickly comfrey	Boraginaceae	Perennial	Forb	Exotic
<i>Symphytum officinale</i>	common comfrey	Boraginaceae	Perennial	Forb	Exotic
<i>Syringa vulgaris</i>	common lilac	Oleaceae	Perennial	Shrub	Exotic
<i>Taeniatherum caput-medusae</i>	medusahead	Poaceae	Annual	Graminoid	Native
<i>Tamarix parviflora</i>	smallflower tamarisk	Tamaricaceae	Perennial	Shrub	Native
<i>Tamarix ramosissima</i>	saltcedar	Tamaricaceae	Perennial	Tree	Native
<i>Tanacetum vulgare</i>	common tansy	Asteraceae	Perennial	Forb	Exotic
<i>Taraxacum erythrospermum</i>	rock dandelion	Asteraceae	Perennial	Forb	Exotic
<i>Taraxacum officinale</i>	common dandelion	Asteraceae	Perennial	Forb	Exotic
<i>Taxus brevifolia</i>	Pacific yew	Taxaceae	Perennial	Tree	Native
<i>Teesdalia nudicaulis</i>	barestem teesdalia	Brassicaceae	Annual	Forb	Exotic
<i>Tellima grandiflora</i>	bigflower tellima	Saxifragaceae	Perennial	Forb	Native
<i>Tetradymia canescens</i>	spineless horsebrush	Asteraceae	Perennial	Subshrub	Native
<i>Teucrium canadense</i>	Canada germander	Lamiaceae	Perennial	Forb	Native
<i>Thalictrum occidentale</i>	western meadow-rue	Ranunculaceae	Perennial	Forb	Native
<i>Thalictrum venulosum</i>	veiny meadow-rue	Ranunculaceae	Perennial	Forb	Native
<i>Thelypodium integrifolium</i>	entireleaved thelypody	Brassicaceae	Biennial	Forb	Native
<i>Thelypodium laciniatum</i>	cutleaf thelypody	Brassicaceae	Biennial	Forb	Native
<i>Thelypodium milleflorum</i>	manyflower thelypody	Brassicaceae	Biennial	Forb	Native
<i>Thelypteris quelpaertensis</i>	queen's-veil maiden fern	Thelypteridaceae	Perennial	Forb	Native
<i>Thinopyrum intermedium</i>	intermediate wheatgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Thinopyrum ponticum</i>	tall wheatgrass	Poaceae	Perennial	Graminoid	Exotic
<i>Thlaspi arvense</i>	field pennycress	Brassicaceae	Annual	Forb	Exotic
<i>Thuja plicata</i>	western redcedar	Cupressaceae	Perennial	Tree	Native
<i>Thymus praecox</i>	mother of thyme	Lamiaceae	Perennial	Subshrub	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Thysanocarpus curvipes</i>	sand fringe pod	Brassicaceae	Annual	Forb	Native
<i>Tiarella trifoliata</i>	threeleaf foamflower	Saxifragaceae	Perennial	Forb	Native
<i>Tiarella unifoliata</i>	oneleaf foamflower	Saxifragaceae	Perennial	Forb	Native
<i>Tofieldia pusilla</i>	Scotch false asphodel	Liliaceae	Perennial	Forb	Native
<i>Tolmiea menziesii</i>	youth on age	Saxifragaceae	Perennial	Forb	Native
<i>Torreyochloa pallida</i>	pale false mannagrass	Poaceae	Perennial	Graminoid	Native
<i>Toxicodendron radicans</i>	eastern poison ivy	Anacardiaceae	Perennial	Shrub	Native
<i>Toxicodendron rydbergii</i>	western poison ivy	Anacardiaceae	Perennial	Shrub	Native
<i>Tragopogon dubius</i>	yellow salsify	Asteraceae	Annual	Forb	Exotic
<i>Tragopogon porrifolius</i>	salsify	Asteraceae	Biennial	Forb	Exotic
<i>Trautvetteria carolinensis</i>	Carolina bugbane	Ranunculaceae	Perennial	Forb	Native
<i>Triantha occidentalis</i>	western false asphodel	Liliaceae	Perennial	Forb	Native
<i>Tribulus terrestris</i>	puncturevine	Zygophyllaceae	Annual	Forb	Exotic
<i>Trichostema oblongum</i>	oblong bluecurls	Lamiaceae	Annual	Forb	Native
<i>Trientalis latifolia</i>	broadleaf starflower	Primulaceae	Perennial	Forb	Native
<i>Trifolium aureum</i>	golden clover	Fabaceae	Annual	Forb	Exotic
<i>Trifolium cyathiferum</i>	cup clover	Fabaceae	Annual	Forb	Native
<i>Trifolium dubium</i>	suckling clover	Fabaceae	Annual	Forb	Exotic
<i>Trifolium fragiferum</i>	strawberry clover	Fabaceae	Perennial	Forb	Exotic
<i>Trifolium hybridum</i>	alsike clover	Fabaceae	Annual	Forb	Exotic
<i>Trifolium longipes</i>	longstalk clover	Fabaceae	Perennial	Forb	Native
<i>Trifolium microcephalum</i>	smallhead clover	Fabaceae	Annual	Forb	Native
<i>Trifolium wormskioldii</i>	cows clover	Fabaceae	Annual	Forb	Native
<i>Trillium ovatum</i>	Pacific trillium	Liliaceae	Perennial	Forb	Native
<i>Trillium petiolatum</i>	Idaho trillium	Liliaceae	Perennial	Forb	Native
<i>Triodanis perfoliata</i>	clasping Venus' looking-glass	Campanulaceae	Annual	Forb	Native
<i>Tripleurospermum inodorum</i>	scentless false mayweed	Asteraceae	Annual	Forb	Exotic
<i>Trisetum cernuum</i>	tall trisetum	Poaceae	Perennial	Graminoid	Native
<i>Trisetum spicatum</i>	spike trisetum	Poaceae	Perennial	Graminoid	Native
<i>Triteleia grandiflora</i>	largeflower triteleia	Liliaceae	Perennial	Forb	Native
<i>Triteleia hyacinthina</i>	white brodiaea	Liliaceae	Perennial	Forb	Native
<i>Triticum aestivum</i>	common wheat	Poaceae	Annual	Graminoid	Exotic
<i>Trollius albiflorus</i>	American globe flower	Ranunculaceae	Perennial	Forb	Native
<i>Tropaeolum majus</i>	nasturtium	Tropaeolaceae	Annual	Forb	Native
<i>Tsuga heterophylla</i>	western hemlock	Pinaceae	Perennial	Tree	Native
<i>Tsuga mertensiana</i>	mountain hemlock	Pinaceae	Perennial	Tree	Native
<i>Turritis glabra</i>	tower rockcress	Brassicaceae	Annual	Forb	Native
<i>Ulmus pumila</i>	Siberian elm	Ulmaceae	Perennial	Tree	Exotic
<i>Uropappus lindleyi</i>	Lindley's silverpuffs	Asteraceae	Annual	Forb	Native

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Urtica dioica</i>	stinging nettle	Urticaceae	Perennial	Forb	Exotic
<i>Vaccaria hispanica</i>	cow soapwort	Caryophyllaceae	Annual	Forb	Exotic
<i>Vaccinium caespitosum</i>	dwarf bilberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium deliciosum</i>	Cascade bilberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium membranaceum</i>	thinleaf huckleberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium myrtilloides</i>	velvetleaf huckleberry	Ericaceae	Perennial	Subshrub	Native
<i>Vaccinium myrtillus</i>	whortleberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium ovalifolium</i>	oval-leaf blueberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium parvifolium</i>	red huckleberry	Ericaceae	Perennial	Shrub	Native
<i>Vaccinium scoparium</i>	grouse whortleberry	Ericaceae	Perennial	Subshrub	Native
<i>Vahlodea atropurpurea</i>	mountain hairgrass	Poaceae	Perennial	Graminoid	Native
<i>Valeriana dioica</i>	marsh valerian	Valerianaceae	Perennial	Forb	Native
<i>Valeriana edulis</i>	tobacco root	Valerianaceae	Perennial	Forb	Native
<i>Valeriana officinalis</i>	garden valerian	Valerianaceae	Perennial	Forb	Exotic
<i>Valeriana scouleri</i>	Scouler's valerian	Valerianaceae	Perennial	Forb	Native
<i>Valeriana sitchensis</i>	Sitka valerian	Valerianaceae	Perennial	Forb	Native
<i>Valerianella locusta</i>	Lewiston cornsalad	Valerianaceae	Annual	Forb	Exotic
<i>Ventenata dubia</i>	North Africa grass	Poaceae	Annual	Graminoid	Exotic
<i>Veratrum viride</i>	green false hellebore	Liliaceae	Perennial	Forb	Native
<i>Verbascum blattaria</i>	moth mullein	Scrophulariaceae	Biennial	Forb	Exotic
<i>Verbascum thapsus</i>	common mullein	Scrophulariaceae	Biennial	Forb	Exotic
<i>Verbena bracteata</i>	bigbract verbena	Verbenaceae	Annual	Forb	Native
<i>Verbena hastata</i>	swamp verbena	Verbenaceae	Biennial	Forb	Native
<i>Verbena officinalis</i>	herb of the cross	Verbenaceae	Annual	Forb	Native
<i>Verbena stricta</i>	hoary verbena	Verbenaceae	Annual	Forb	Native
<i>Veronica arvensis</i>	corn speedwell	Scrophulariaceae	Annual	Forb	Exotic
<i>Veronica biloba</i>	twolobe speedwell	Scrophulariaceae	Annual	Forb	Exotic
<i>Veronica cusickii</i>	Cusick's speedwell	Scrophulariaceae	Perennial	Forb	Native
<i>Veronica officinalis</i>	common gypsyweed	Scrophulariaceae	Perennial	Forb	Exotic
<i>Veronica peregrina</i>	neckweed	Scrophulariaceae	Annual	Forb	Exotic
<i>Veronica persica</i>	birdeye speedwell	Scrophulariaceae	Annual	Forb	Exotic
<i>Veronica verna</i>	spring speedwell	Scrophulariaceae	Annual	Forb	Exotic
<i>Veronica wormsjoldii</i>	American alpine speedwell	Scrophulariaceae	Perennial	Forb	Native
<i>Viburnum edule</i>	squashberry	Caprifoliaceae	Perennial	Shrub	Native
<i>Viburnum lentago</i>	nannyberry	Caprifoliaceae	Perennial	Tree	Native
<i>Viburnum opulus</i>	European cranberrybush	Caprifoliaceae	Perennial	Tree	Exotic
<i>Vicia americana</i>	American vetch	Fabaceae	Perennial	Forb	Native
<i>Vicia cracca</i>	bird vetch	Fabaceae	Perennial	Forb	Exotic
<i>Vicia villosa</i>	winter vetch	Fabaceae	Annual	Forb	Exotic

Scientific Name	Common Name	Family	Duration	Growth Form	BC Status
<i>Viola adunca</i>	hookedspur violet	Violaceae	Perennial	Forb	Native
<i>Viola arvensis</i>	European field pansy	Violaceae	Annual	Forb	Exotic
<i>Viola canadensis</i>	Canadian white violet	Violaceae	Perennial	Forb	Native
<i>Viola glabella</i>	pioneer violet	Violaceae	Perennial	Forb	Native
<i>Viola labradorica</i>	alpine violet	Violaceae	Perennial	Forb	Native
<i>Viola nephrophylla</i>	northern bog violet	Violaceae	Perennial	Forb	Native
<i>Viola nuttallii</i>	Nuttall's violet	Violaceae	Perennial	Forb	Native
<i>Viola praemorsa</i>	canary violet	Violaceae	Perennial	Forb	Native
<i>Viola purpurea</i>	goosefoot violet	Violaceae	Perennial	Forb	Native
<i>Viola selkirkii</i>	Selkirk's violet	Violaceae	Perennial	Forb	Native
<i>Viola sempervirens</i>	evergreen violet	Violaceae	Perennial	Forb	Native
<i>Viola septentrionalis</i>	northern woodland violet	Violaceae	Annual	Forb	Native
<i>Viola trinervata</i>	Rainier violet	Violaceae	Perennial	Forb	Native
<i>Viola vallicola</i>	sagebrush violet	Violaceae	Perennial	Forb	Native
<i>Vitis vinifera</i>	wine grape	Vitaceae	Perennial	Forb	Native
<i>Vulpia bromoides</i>	brome fescue	Poaceae	Annual	Graminoid	Exotic
<i>Vulpia microstachys</i>	small fescue	Poaceae	Annual	Graminoid	Native
<i>Vulpia myuros</i>	annual fescue	Poaceae	Annual	Graminoid	Exotic
<i>Vulpia octoflora</i>	sixweeks fescue	Poaceae	Annual	Graminoid	Native
<i>Woodsia oregana</i>	Oregon cliff fern	Dryopteridaceae	Perennial	Forb	Native
<i>Woodsia scopulina</i>	Rocky Mountain woodsia	Dryopteridaceae	Perennial	Forb	Native
<i>Xanthium spinosum</i>	spiny cocklebur	Asteraceae	Annual	Forb	Native
<i>Xanthium strumarium</i>	rough cocklebur	Asteraceae	Annual	Forb	Exotic
<i>Xerophyllum tenax</i>	common beargrass	Liliaceae	Perennial	Forb	Native
<i>Zeltnera exaltata</i>	desert centaury	Gentianaceae	Annual	Forb	Native
<i>Zeltnera muehlenbergii</i>	Muhlenberg's centaury	Gentianaceae	Annual	Forb	Native
<i>Zigadenus elegans</i>	mountain deathcamas	Liliaceae	Perennial	Forb	Native
<i>Zigadenus paniculatus</i>	foothill deathcamas	Liliaceae	Perennial	Forb	Native
<i>Zigadenus venenosus</i>	meadow deathcamas	Liliaceae	Perennial	Forb	Native

A2. Spearman correlation coefficient matrix for current environmental variables and current diversity metrics

Predictor Variables for Current Climate	Species Richness	PD	PD_{ses}	FRic	FRic_{ses}
<i>Annual Mean Temperature (BIO 1)</i>	0.51	0.72	0.77	0.64	0.55
<i>Mean Diurnal Range (BIO 2)</i>	0.48	0.48	0.21	0.32	0.18
<i>Isothermality (BIO 3)</i>	0.38	0.26	-0.17	0.06	-0.10
<i>Temperature Seasonality (BIO 4)</i>	0.39	0.55	0.59	0.48	0.42
<i>Max Temperature of Warmest Month (BIO 5)</i>	0.55	0.72	0.70	0.62	0.51
<i>Min Temperature of Coldest Month (BIO 6)</i>	0.53	0.73	0.76	0.64	0.53
<i>Temperature Annual Range (BIO 7)</i>	0.41	0.51	0.44	0.42	0.35
<i>Mean Temperature of Wettest Quarter (BIO 8)</i>	-0.31	-0.14	0.37	-0.05	0.13
<i>Mean Temperature of Driest Quarter (BIO 9)</i>	0.78	0.73	0.18	0.49	0.17
<i>Mean Temperature of Warmest Quarter (BIO 10)</i>	0.51	0.71	0.76	0.63	0.54
<i>Mean Temperature of Coldest Quarter (BIO 11)</i>	0.52	0.72	0.78	0.66	0.55
<i>Annual Precipitation (BIO 12)</i>	0.16	0.06	-0.21	0.07	-0.07
<i>Precipitation of Wettest Month (BIO 13)</i>	0.34	0.22	-0.18	0.16	-0.05
<i>Precipitation of Driest Month (BIO 14)</i>	-0.07	-0.18	-0.35	-0.11	-0.17
<i>Precipitation Seasonality (BIO 15)</i>	0.66	0.56	0.03	0.36	0.06
<i>Precipitation of Wettest Quarter (BIO 16)</i>	0.34	0.21	-0.18	0.16	-0.05
<i>Precipitation of Driest Quarter (BIO 17)</i>	-0.10	-0.22	-0.37	-0.11	-0.16
<i>Precipitation of Warmest Quarter (BIO 18)</i>	-0.53	-0.53	-0.21	-0.27	-0.11
<i>Precipitation of Coldest Quarter (BIO 19)</i>	0.32	0.19	-0.19	0.14	-0.06
<i>Elevation</i>	-0.44	-0.67	-0.81	-0.65	-0.59
<i>Aspect</i>	-0.04	-0.02	0.05	-0.02	-0.01
<i>Slope</i>	-0.10	-0.07	0.05	0.12	0.17

A3. Spearman correlation coefficient matrix for future environmental variables and future diversity metrics

Predictor Variables for Future Climate	Species Richness	PD	PD_{ses}	FRic	FRic_{ses}
<i>Annual Mean Temperature (BIO 1)</i>	-0.48	-0.25	0.61	0.01	0.18
<i>Mean Diurnal Range (BIO 2)</i>	-0.03	-0.03	0.02	0.001	0.01
<i>Isothermality (BIO 3)</i>	0.13	0.06	-0.18	-0.009	-0.04
<i>Temperature Seasonality (BIO 4)</i>	-0.27	-0.16	0.31	0.01	0.09
<i>Max Temperature of Warmest Month (BIO 5)</i>	-0.35	-0.18	0.47	0.01	0.13
<i>Min Temperature of Coldest Month (BIO 6)</i>	-0.47	-0.23	0.66	-0.003	0.16
<i>Temperature Annual Range (BIO 7)</i>	-0.15	-0.1	0.17	0.02	0.06
<i>Mean Temperature of Wettest Quarter (BIO 8)</i>	-0.58	-0.51	0.27	-0.12	0.12
<i>Mean Temperature of Driest Quarter (BIO 9)</i>	0.25	0.34	0.24	0.12	0.04
<i>Mean Temperature of Warmest Quarter (BIO 10)</i>	-0.43	-0.23	0.55	0.009	0.15
<i>Mean Temperature of Coldest Quarter (BIO 11)</i>	-0.48	-0.24	0.65	0.003	0.17
<i>Annual Precipitation (BIO 12)</i>	0.45	0.48	0.04	0.16	0.01
<i>Precipitation of Wettest Month (BIO 13)</i>	0.52	0.56	0.09	0.22	0.05
<i>Precipitation of Driest Month (BIO 14)</i>	0.26	0.25	-0.05	0.08	-0.01
<i>Precipitation Seasonality (BIO 15)</i>	0.48	0.54	0.16	0.22	0.06
<i>Precipitation of Wettest Quarter (BIO 16)</i>	0.52	0.57	0.10	0.22	0.04
<i>Precipitation of Driest Quarter (BIO 17)</i>	0.22	0.21	-0.07	0.06	-0.01
<i>Precipitation of Warmest Quarter (BIO 18)</i>	-0.06	-0.05	-0.007	-0.02	-0.001
<i>Precipitation of Coldest Quarter (BIO 19)</i>	0.50	0.53	0.07	0.20	0.04
<i>Elevation</i>	0.49	0.25	-0.66	-0.05	-0.22
<i>Aspect</i>	0.06	0.16	0.24	0.27	0.28
<i>Slope</i>	-0.07	-0.06	0.04	-0.05	-0.02

A4. Summary of current and future environmental variables within the Okanagan Ecoregion

Current Predictor Variables	Mean	SD	Min.	Max.
Elevation	1148.88	556.71	-54.00	3114.00
Aspect	179.07	105.15	-1.00	359.98
Slope	7.99	5.64	0.00	34.74
BIO 1 (Annual Mean Temp °C)	4.22	3.21	-6.40	11.30
BIO 2 (Mean Diurnal Range °C)	10.59	1.46	6.00	14.90
BIO 3 (Isothermality)	0.33	0.03	0.27	0.44
BIO 4 (Temp Seasonality °C)	7.33	1.05	3.71	9.18
BIO 5 (Max Temp of Warmest Month °C)	22.11	3.91	9.20	31.80
BIO 6 (Min Temp of Coldest Month °C)	-10.07	4.29	-19.90	2.20
BIO 7 (Temp Annual Range °C)	32.19	4.36	17.80	41.20
BIO 8 (Mean Temp of Wettest Quarter °C)	-1.67	7.00	-13.80	19.90
BIO 9 (Mean Temp of Driest Quarter °C)	7.57	7.79	-11.60	21.50
BIO 10 (Mean Temp of Warmest Quarter °C)	13.64	3.27	2.60	22.10
BIO 11 (Mean Temp of Coldest Quarter °C)	-5.03	3.64	-14.50	5.50
BIO 12 (Annual Precip mm)	761.13	459.77	199.00	3141.00
BIO 13 (Precip of Wettest Month mm)	106.06	76.53	31.00	533.00
BIO 14 (Precip of Driest Month mm)	32.12	12.67	6.00	66.00
BIO 15 (Precip Seasonality mm)	33.38	13.01	14.00	79.00
BIO 16 (Precip of Wettest Quarter mm)	297.74	221.56	82.00	1451.00
BIO 17 (Precip of Driest Quarter mm)	109.97	43.93	23.00	245.00
BIO 18 (Precip of Warmest Quarter mm)	132.95	43.38	30.00	266.00
BIO 19 (Precip of Coldest Quarter mm)	272.85	204.47	72.00	1392.00

Future Predictor Variables	Mean	SD	Min.	Max.
Elevation	1148.88	556.71	-54.00	3114.00
Aspect	7.99	5.64	0.00	34.74
Slope	179.07	105.15	-1.00	359.98
BIO 1 (Annual Mean Temp °C)	8.36	3.09	-1.90	14.90
BIO 2 (Mean Diurnal Range °C)	9.56	1.53	5.20	14.70

Future Predictor Variables	Mean	SD	Min.	Max.
BIO 3 (Isothermality)	31.02	2.98	24.00	42.00
BIO 4 (Temp Seasonality °C)	7.00	1.01	3.67	9.13
BIO 5 (Max Temp of Warmest Month °C)	26.47	4.13	13.70	37.00
BIO 6 (Min Temp of Coldest Month °C)	-3.91	3.86	-12.90	7.10
BIO 7 (Temp Annual Range °C)	30.38	4.08	17.60	40.00
BIO 8 (Mean Temp of Wettest Quarter °C)	1.35	5.04	-9.00	21.90
BIO 9 (Mean Temp of Driest Quarter °C)	13.81	6.78	-5.70	26.20
BIO 10 (Mean Temp of Warmest Quarter °C)	17.57	3.37	6.40	26.50
BIO 11 (Mean Temp of Coldest Quarter °C)	-0.25	3.39	-9.10	9.60
BIO 12 (Annual Precip mm)	817.30	479.84	204.00	3174.00
BIO 13 (Precip of Wettest Month mm)	120.28	84.56	33.00	570.00
BIO 14 (Precip of Driest Month mm)	32.77	13.17	6.00	67.00
BIO 15 (Precip Seasonality mm)	35.45	13.73	11.00	77.00
BIO 16 (Precip of Wettest Quarter mm)	320.37	230.17	83.00	1467.00
BIO 17 (Precip of Driest Quarter mm)	108.98	42.73	21.00	219.00
BIO 18 (Precip of Warmest Quarter mm)	123.50	42.28	26.00	223.00
BIO 19 (Precip of Coldest Quarter mm)	302.31	228.49	71.00	1467.00

A5. Summary of diversity measures from current and future climate projections for the Okanagan Ecoregion

Diversity Measure (Current Climate)	Mean	SD	Min.	Max.
Species Richness	655.63	118.44	283.00	987.00
MNTD (Observed)	19.05	1.85	14.35	31.97
MNTD (SES)	-0.81	0.93	-3.84	3.32
MPD (Observed)	322.55	7.70	297.02	360.11
MPD (SES)	0.76	1.19	-2.96	5.92
Faith's PD (Observed)	13384.56	1408.32	8801.53	17761.91
Faith's PD (SES)	-1.33	1.16	-4.85	3.98
Fric (Observed)	129.05	36.38	40.10	223.22
Fric (SES)	-0.75	1.01	-3.92	2.54
Trait-MNTD (Observed)	0.17	0.01	0.13	0.24
Trait-MNTD (SES)	-1.78	1.47	-7.97	3.47
Trait-MPD (Observed)	1.82	0.07	1.53	2.09
Trait-MPD (SES)	-2.59	0.96	-5.58	1.57

Diversity Measure (Future Climate)	Mean	SD	Min.	Max.
Species Richness	717.63	117.66	284.00	1044.00
MNTD (Observed)	19.62	2.79	13.86	38.66
MNTD (SES)	0.24	1.15	-3.58	3.74
MPD (Observed)	319.62	8.80	295.36	353.47
MPD (SES)	0.50	1.61	-3.10	4.88
Faith's PD (Observed)	14751.23	1110.15	9031.76	17880.51
Faith's PD (SES)	0.23	1.14	-3.52	4.72
Fric (Observed)	135.72	35.24	47.13	219.10
Fric (SES)	-1.05	1.20	-4.92	2.19
Trait-MNTD (Observed)	0.17	0.02	0.13	0.26
Trait-MNTD (SES)	-0.85	1.32	-5.91	4.60
Trait-MPD (Observed)	1.87	0.06	1.63	2.08
Trait-MPD (SES)	-2.12	1.37	-6.47	1.92

A6. Heatmaps and Hotspot Congruence Maps for Standardized Diversity Measures

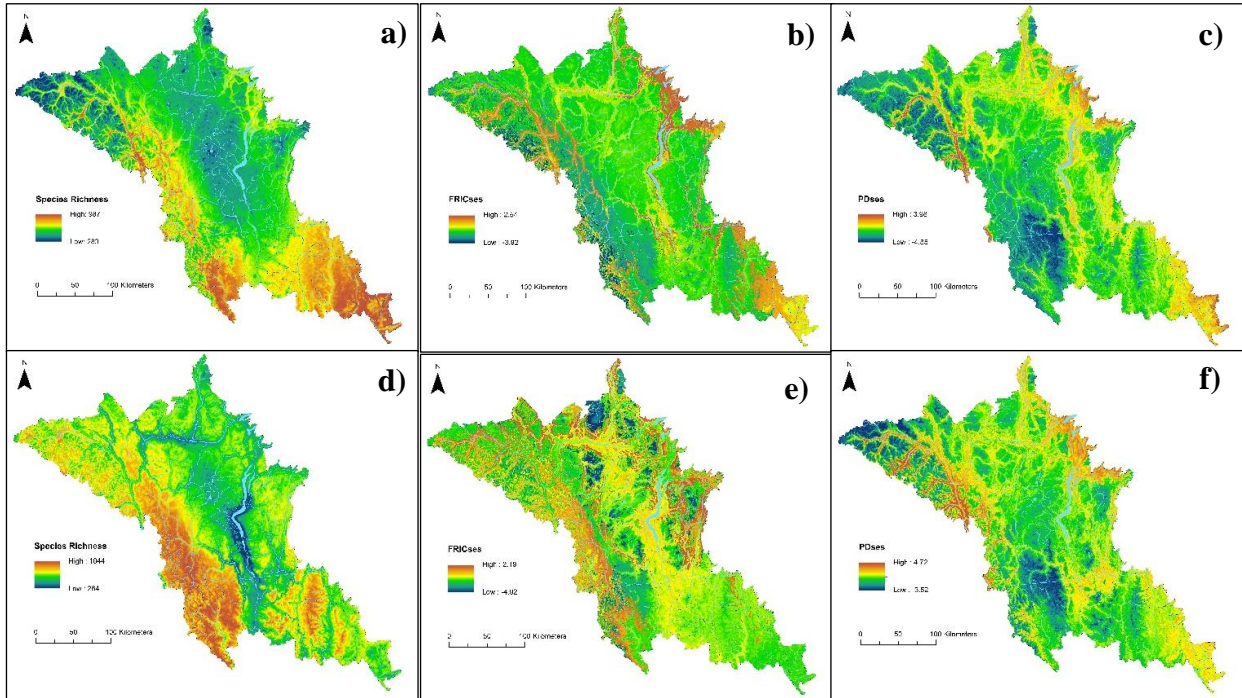


Figure A6.1 Maps heatmaps of a) current SR and FD_{ses} ; b) current SR and PD_{ses} ; c) current FD_{ses} and PD_{ses} ; d) future SR and FD_{ses} ; e) future SR and PD_{ses} ; and f) future FD_{ses} and PD_{ses} , where red colours are high diversity areas and blue colours are low diversity areas.

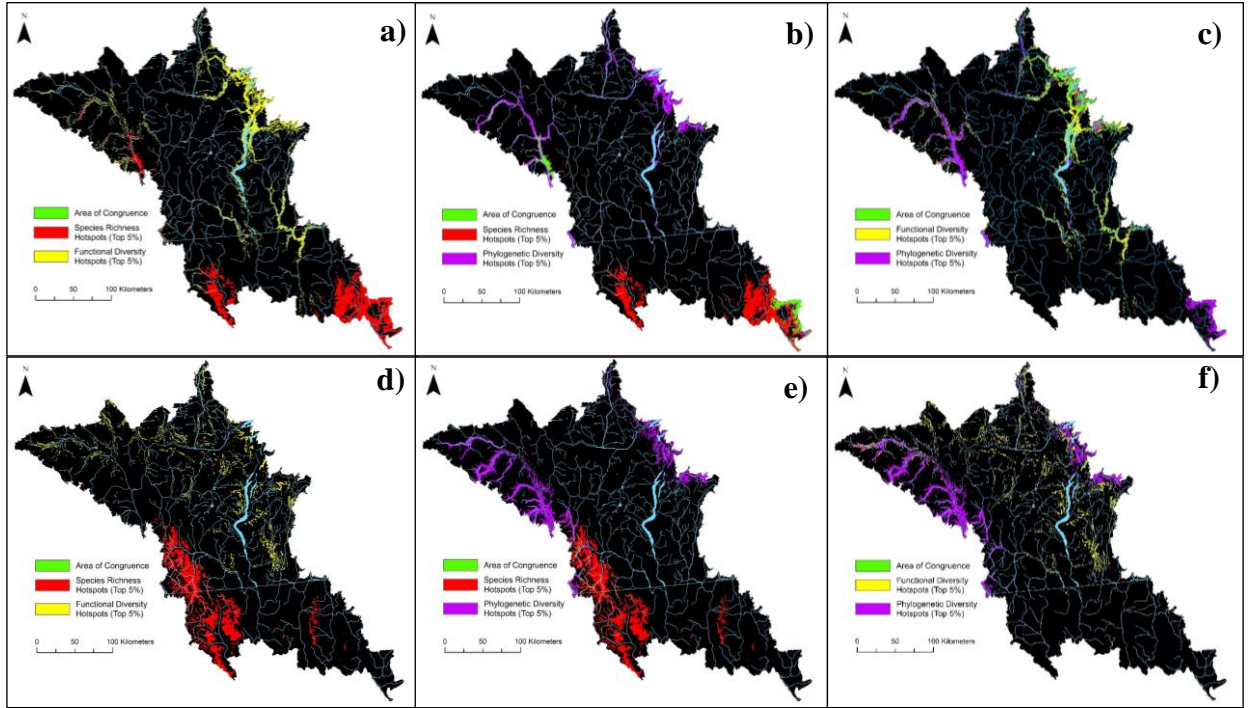


Figure A6.2 Maps showing the congruence between hotspots (top 5% of values) of a) current SR and FD_{ses}; b) current SR and PD_{ses}; c) current FD_{ses} and PD_{ses}; d) future SR and FD_{ses}; e) future SR and PD_{ses}; and f) future FD_{ses} and PD_{ses}.