USING RARITY AND EVOLUTIONARY DISTINCTIVENESS TO PRIORITIZE PROTECTION OF ANGIOSPERMS IN OLYMPIC NATIONAL PARK

by

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ABSTRACT

Using Rarity and Evolutionary Distinctiveness to Prioritize Protection of Angiosperms in Olympic National Park

Claire N.B. Olson

Climate change and the nature of conservation work make it increasingly unlikely that each species in need of preservation will receive the attention required to prevent its extinction. Conservationists instead must begin to carefully prioritize the allocation of aid to different species. One way to conserve the greatest share of biodiversity is to prioritize species that represent the greatest share of evolutionary history. While this idea has yet to gain much traction in the Pacific Northwest, studies using phylogenetically informed conservation are growing in number outside the United States. In Washington State, the diversity and abundance of habitats across the state has resulted in an overwhelming number of plant species in potential need of conservation. By providing a baseline set of evolutionary distinctiveness scores for the angiosperms of Olympic National Park, a former refugium, this study aims to highlight the utility of phylogenetic information when making conservation decisions between related taxa. Due to the park's potential to act as a refugium again in response to warming, it is imperative we understand the scope of this genetic "ark". By calculating evolutionary distinctiveness and using the RED-E (Regional Evolutionary Distinctiveness and Endangerment) metric, this study aims to 1) quantify the value of currently secure species in terms of their contribution to phylogenetic diversity, 2) examine whether conservation of rare species also conserves a sufficient share of evolutionary history, and 3) make recommendations for species to be prioritized for conservation within the park based on their evolutionary distinctiveness. The findings of this study indicate rarity is a poor proxy for phylogenetic diversity, and that the RED-E metric loses its power when used below the state scale. The findings also show Olympic National Park is host to a diverse array of angiosperm lineages, and that the bulk of that evolutionary history lies within the parks' lowlands. These results provide support for incorporating phylogenetic information into conservation plans and prioritization decisions within Olympic National Park and the Olympic Peninsula and highlight the need for taxonomic inventories and regional studies of phylogenetic diversity.

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Acknowledgements

Thesis projects are like most research: dull, isolating, tasks punctuated by periods of crushing tedium. Losing all the small, spontaneous interactions with faculty, classmates, friends, and loved ones to social distancing exacerbated these traits and threatened to make completing a thesis during the pandemic a particularly lonely affair. Instead, the upwelling of support and kindness I received from my family, friends, and reader made things feel (almost) normal. Without them, this project would have been much, much, more difficult to complete, and might have not been completed at all.

First I would like to extend my deepest gratitude to my thesis reader, John Withey, for his patience, support, and advice throughout this process. Though I did not conduct field work, his faith in my ability to complete this project, and his detailed, considered, answers to my questions were an essential anchor while I did my research. Instead of flailing in the dark, I flailed with a flashlight. I would like to thank Barry Wendling, Mike Williams, and Eric DeChaine of the Pacific Northwest Herbarium at Western Washington University for introducing me to systematic botany, field work, and the state of botanical research on the Olympic Peninsula. The depth and breadth of this education provided the skills I needed to conceive of and complete this thesis project, and without it I would likely have done something very different. I am grateful, too, to a few individuals whom I have never met: Cam Webb and the creators of Phylocom. Collectively, their commitment to providing free, high-quality, and easily accessible software, phylogenies, and user guides allowed me to complete this project at no cost. I would like to thank my aunt, Thea LaCross, for her willingness to provide editorial feedback on my thesis and sheltering me when I had nowhere else to go. I am grateful to my friends and family, for their support and love during this very strange time. I am in Sarah Larson's debt — I am so glad to have met her during MES and could not have completed this thesis without her. I would like to thank my grandparents for pushing me to pursue an education and enabling me to do so despite a pandemic, homelessness, and many, many, crises. While they did not all survive to see me complete this work, I know they would have been proud.

Introduction

Operating under the assumption that all species are inherently special (and therefore have a right to exist in habitat best suited to their needs), conservationists expend enormous amounts of time, energy, and money in their attempts to arrest species' freefall into extinction… unless those species happen to be plants (Leopold, 1949). Though plants comprise nearly 57% of all species listed under the Endangered Species Act, they receive less than 5% of all recovery funding from state and federal agencies (Negrón-Ortiz, 2014; U.S. Fish and Wildlife Service, 2013). These figures are concerning, given the positive relationship between increased spending on recovery plans and their likelihood of success (Miller et al., 2002). While plant species currently go extinct in the United States at a pace of one species every seven years, climate change threatens to dramatically increase that rate in coming decades (Antonelli et al., 2020; Knapp et al., 2020). Due to the intensive nature of conservation programs and the fiscal and physical reality of the organisms, budgets, and people involved in them, implementing an appropriate recovery plan for every species that needs one will not be possible (Isaac et al., 2007; Myers et al., 2000). Instead, conservationists must carefully prioritize the allocation of aid to species so as to provide the greatest conservation value (Withey et al., 2012; Isaac et al., 2007).

To avoid neglecting species without cultural, agricultural, or ornamental importance, and counter the human tendency to ignore plants, it is essential that the metric by which species are prioritized for protection is independent of cultural importance (Balding and Williams, 2016; Hartmann and Andre, 2013; Isaac et al., 2007). A growing consensus suggests evolutionary history (or phylogenetic diversity) is this independent metric, as the traits and features species accrue during their existences comprise an irreplaceable stockpile of the raw materials for speciation, ecosystem services, and other unanticipated benefits of biodiversity (Faith 1992; Isaac et al., 2007; Veron et al., 2015). These unanticipated benefits or “option values,” will be increasingly important as the effects of climate change become more pronounced and present greater challenges to species’ survival (Faith, 1992). Although we cannot know in all cases what those challenges will be, focusing conservation efforts on preserving the greatest share of evolutionary history is our best shot at ensuring the raw material for adapting to those obstacles persists throughout the landscape (Faith, 1992; Veron et al., 2015).

One focus of climate-conscious conservation in specific landscapes has been historical and potential future climatic refugia (Ashcroft, 2010; Morelli et al., 2016; Sedell et al., 1990). Refugia are regions where combination of habitats or environmental factors lessen the impacts of disturbance when combined with the morphological, life history, and behavioral traits of the organisms that live there (Holderegger and Thiel-Egenter, 2009; Morelli et al., 2016; Sedell et al., 1990). During the last glacial maximum, refugia acted as a sort of network of arks, harboring species until the next interglacial period (Holderegger and Thiel-Egenter, 2009; Morelli et al., 2016).

Due to its status as a refugium during the last glacial maximum, and its’ potential to act as one again during our current period of warming, the Olympic Peninsula is of particular interest to scientists looking to understand species’ past responses to warming, the conditions inside the Olympic refugium during the last glacial maximum, and to conservationists looking to prevent the extinctions of temperature-sensitive species (Myers et al.., 2000; Shafer et al., 2010; Wershow and DeChaine, 2018). To help quantify the evolutionary history contained in a former glacial refugium and identify potential candidates for conservation within the region, I used the fair proportion method to calculate evolutionary distinctiveness scores for the angiosperms of Olympic National Park (Isaac et al., 2007; Wershow and Dechaine, 2018).

Literature Review

Studies of Floral Communities on the Olympic Peninsula

Due to its status as a refugium during the last glacial maximum the Olympic Peninsula has high rates of endemism and species richness for its latitude (Figure 1; Morelli et al., 2016; Sedell et al., 1990; Wershow and DeChaine, 2018). Often used as a proxy for conditions inside the Olympic refugium, and imperiled by the temperature shifts of our current period of warming, the floral communities of the Olympic highlands receive the greatest share of scientific attention (Holderegger and Thiel-Egenter, 2009; Wershow and DeChaine, 2018). In response to warming at the end of the last glacial period, the species that now populate the peninsula's highlands retreated with the snowpack to ever higher elevations (Holderegger and Thiel-Egenter, 2009; Lütz, 2012; Wershow and DeChaine, 2018). While this past makes these species of great interest to those studying species' historical responses to warming, the adaptations that allow these taxa to thrive above the tree line have also made them incredibly sensitive to increases in temperature (Lütz, 2012; Wershow and DeChaine, 2018). The imminent loss of alpine species to climate change makes studying these species a particularly urgent priority for scientists working to estimate species' future responses to warming, conditions inside the Olympic refugium during the last glacial maximum, and to conservationists looking to prevent their extinctions (Holderegger and Thiel-Egenter, 2009; Lyons and Kozak, 2019; Shafer et al., 2010; Wershow and DeChaine, 2018).

In contrast, the floral communities of the Olympic lowlands have received little scientific attention since the late 1970s (Bodine and Capaldi, 2016; Consortium of Pacific Northwest Herbaria, available from: https://pnwherbaria.org/data/search.php; Fonda, 1974). Logging,

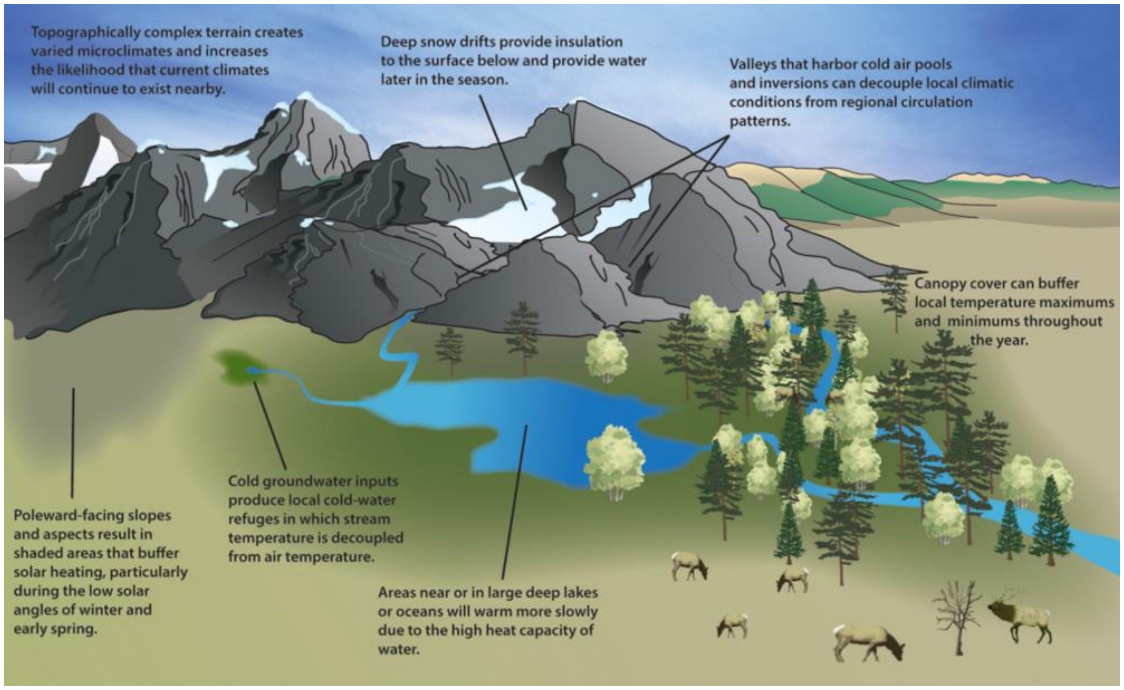

Figure 1. Diagram of a model refugium. A refugium is a combination of habitats or environmental factors that lessen the impact of disturbance when combined with the morphological, life history, and behavioral traits of organisms in a particular area. Adapted from Morelli et al. (2016).

budgetary constraints, the endangered status of the Spotted Owl (*Strix occidentalis carina*), and difficult terrain have resulted in a paucity of research on the contemporary distribution, abundance, or composition of organisms and habitats without commercial importance (Bodine and Capaldi, 2016; Buckingham, 1995; Fonda, 1974; Hitchcock and Cronquist, 2018). Beyond museum collections and documents like *Flora of the Olympic Peninsula* (Buckingham, 1995) or *Flora of the Pacific Northwest* (Hitchcock and Cronquist, 2018), research into the composition or distribution of the flora of the Olympic lowlands published after 1970 focuses almost exclusively on floodplain management or the habitat requirements of Spotted Owls (Bodine and Capaldi, 2016; Fonda, 1974). Though understandable, the focus on the needs of human settlements and those of a small number of animal species means there is a significant gap in the literature as to the composition, distribution, and quality of plant and non-owl animal communities in the Olympic lowlands.

Conservation and the Value of Floral Communities

In a discipline whose practitioners work tirelessly to preserve life, it may seem antithetical that so much of conservation involves ending life. Operating on the idea that all species are inherently special, and therefore have a right to exist in habitat best suited to their needs (Leopold, 1949), conservationists apply a “your rights end where mine begin” approach to preservation. Using culls, herbicide, and other efforts to enforce a definition of ‘habitat best suited to their needs’ as habitat free of threats to the survival or genetic purity of the subject of the conservation effort, like close relatives (as with *Castilleja levisecta*, also known as Golden Paintbrush) or novel competitors from other continents (Beggs et al., 2019; Bodine and Capaldi, 2017; Kaye and Blakeley-Smith, 2008; Kechler and Zedler, 2004).

Combined with the work of early conservationists like John Muir (whose Preservation Ethic popularized the idea that, as God’s creation, nature has inherent value and so should be protected from human activities), Aldo Leopold’s notion that all species are special spurred the creation of many of our country’s habitat protection programs (DeMiller, 1993). Nationally, a patchwork of lands is protected from development to varying degrees by a network of public and private organizations. Some lands, like those designated by the Area of Critical Environmental Concern used by the United States Department of the Interior, Bureau of Land Management’s or Washington’s Natural Resource Conservation Areas are protected from any kind of development indefinitely, or allow some degree of low-density infrastructure (DeMiller, 1993; Washington Department of Natural Resources, 2020). Private lands experience similar protections, administered by organizations like the Center for Natural Lands Management, with or without some kind of internal designation (Center for Natural Lands Management, 2020; The Nature Conservancy, 2020). Whatever their status, conservation organizations generally purchase lands on the assumption that those lands deserve protection because they are high quality examples of a particular habitat for a particular organism (DeMiller, 1993; Washington Department of Natural Resources, 2020). In response to the complexity of natural systems and sometimes dramatic differences in habitat requirements between species, conservationists have struggled to create a uniform means of quantifying habitat quality (McCune and Grace, 2002). Plants' relatively static nature and their often-reciprocal relationship with animals has led to 'habitat quality' being largely defined by how well the ecosystem services offered by a habitat's vegetative community meets the needs of the humans or animals that use it (McCune and Grace, 2002; Swink and Wilhelm, 1979). Over time, the linkage between plants, animals, and environmental conditions led to the development of three primary metrics for quantifying the value of floral communities: 1) number and type of ecosystem services and the degree to which they are provisioned, 2) nativity and endemism, and 3) species richness in terms of native species (Isaac et al., 2007; McCune and Grace, 2007; Swink and Wilhelm, 1979).

Ecosystem services and the ratio of native taxa to non-native taxa first came to popularity in the late 1970s and resulted in the development of the Floral Quality Analysis or FQA (Swink and Wilhelm, 1979). By combining a floral inventory and an index score (the Floral Quality Index, or FQI) based on the characteristics of an ecosystem's idealized plant community, the FQA allowed for quick site comparisons, spurring adoption as a national standard by the 1980s (Rocchio and Crawford, 2013; Swink and Wilhelm, 1979). Due to national variation in habitat types, and the FQA's core assumption (that each plant species has evolved a unique degree of tolerance to disturbance, environmental distress, or reliance on a specific degree of habitat integrity), each state has a unique FQI calculator (Rocchio and Crawford, 2013; Swink and Wilhelm, 1979). However, because all FQI scores (also called C- values for "Coefficient of Conservatism") are calculated the same way, index scores can be compared to each other regardless of habitat type or location (Rocchio and Crawford, 2013; Swink and Wilhelm, 1979).

The FQA can consume large amounts of time and resources; as a result, organizations sometimes use straight measures of species richness or nativity to estimate habitat quality (Swink and Wilhelm, 1979). This practice relies on the assumption that high quality habitats (generally defined as habitats that provide full ecosystem services and intact plant and animal communities) have greater species diversity, or richness, than low quality habitat (Swink and Wilhelm, 1979). Localities boasting both a diverse community of species and a high rate of endemism, often called 'hotspots', have long been prioritized for conservation under this assumption (Cadotte and Davies, 2010). However, as genetic analysis and genome sequencing have become more and more affordable, and extinction rates tick ever higher, some conservationists are calling for a shift toward prioritizing instead regions with high rates of phylogenetic diversity instead, arguing that prioritizing evolutionary history captures a greater share of biodiversity than prioritizing regions with an abundance of species but having overall a low diversity of evolutionary lineages (Buchholz, Hanning, and Schirmel, 2013; Cadotte and Davies, 2010; Faith, 1992; Hansen et al., 2008; Isaac et al., 2007).

Most commonly, phylogenetic information is incorporated into studies through the EDGE (evolutionary distinctiveness and global endangerment) approach, which quantifies species' unrelatedness, or evolutionary distinctiveness (ED) and then weights that number by the species' global risk of extinction (GE), the species' status on the IUCN Red list (Isaac et al., 2007; IUCN, 2017). Prior to the development of ED, evolutionary history was primarily quantified through Faith's (1992) PD (phylogenetic diversity), a summed measure of the evolutionary history contained by groups of species. By dividing PD across all members of a group, Isaac et al. (2007) created a value that allowed for the examination and comparison of individual species' contribution to evolutionary history (Isaac et al., 2007). In the years since its derivation, ED has quickly become the most common means of measuring evolutionary history (Figure 2; Buchholz, Hanning, and Schirmel, 2013; Hansen et al., 2008; Isaac et al., 2007; Isaac et al., 2012).

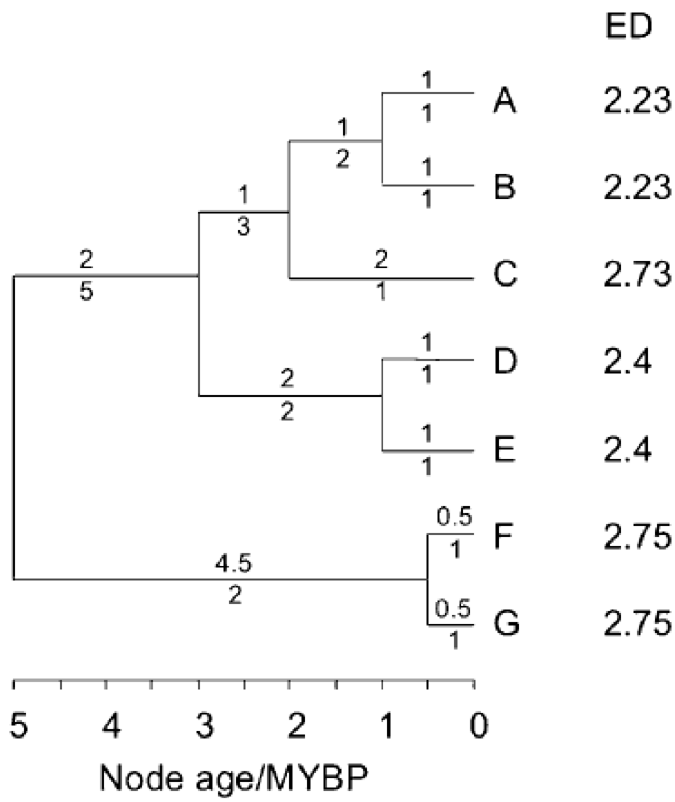

Figure 2. Hypothetical phylogeny from Isaac et al. (2007) showing the results and components of an ED calculation. A-G represent species, numbers below the branches represent branch length, numbers above the branches represent number of descendants, and ED scores for each species are listed to the right. Branch length is represented in millions of years before the present (MYBP). F and G have the highest ED scores and so, under this method, would be prioritized for conservation has the most evolutionarily distinct species within their group.

Thanks to the increasing affordability of genetic sequencing, the advent of the time-calibrated phylogenies necessary for accurate ED calculations has enabled the application of EDGE to a wide variety of taxonomic groups. Corals (Curnick et al., 2015; Huang, Davies, and Gittleman, 2012), Chondrichthyes (cartilaginous fishes; Stein et al., 2018), amphibians (Isaac et al., 2012), reptiles (Gumbs et al., 2018), and birds (Jetz et al., 2014) all have been provided with a comprehensive set of EDGE rankings. Notably, plants are absent from this growing body of work, despite increasingly accurate, time-calibrated phylogenies for angiosperms (Gastaur and Meira-Neto, 2015; The Angiosperm Phylogeny Group, 2016; Zanne et al., 2014).

I was unable to find an explicit rationale for the lack of interest in EDGE among the botanical community, but suspect a lack of familiarity with the calculation, and the overwhelming variety of plant taxa are likely causes. Prioritizing taxa based on their phylogenetic contribution to biodiversity is, after all, a fairly sharp ideological departure from the dominant plant conservation paradigms of 1) applying equal resources to every species, and 2) subscribing to the Leopoldian idea that all species are inherently special, and therefore deserving of habitat that best meets their needs (Leopold, 1949; DeMiller, 1993; Dunwiddie et al. 2014). Sometimes, though, this line of thinking can unintentionally mimic conservation efforts underpinned by phylogenetic information. For example, local efforts to restore the prairies of the southern Puget Sound are stymied by a lack of pre-colonization reference sites, and so have little data to inform the composition of the plantings at their restoration sites (Dunwiddie et al., 2014). To overcome this obstacle, researchers turned to historical occurrence data and museum collections to model reference communities to guide their plantings, hoping maximizing the species diversity present throughout replanted prairies will give them the best odds of finding a community composition that is adaptable to climate change (Dunwiddie et al., 2014; Reed et al., 2019; Mauger et al, 2015). Conducting some sort of analysis, such as EDGE, ED, or PD, for the taxa in their model community of Puget Sound prairie plants would have allowed this group to maximize the number of 'option values' for adaptation present in their master list of species by identifying the species that provided the greatest contribution to phylogenetic diversity within their groups (Faith, 1993; Isaac et al., 2007).

Incorporating evolutionary distinctiveness and other metrics of evolutionary history into conservation programs like the one that exists for Washington's prairies will help conservationists build floral communities with the greatest chance of resilience to climate change. Where single species, rather than whole ecosystems, are at risk of extinction, prioritizing taxa based on their phylogenetic contribution to biodiversity will allow conservationists to perform ecological triage and do the most good with what money, manpower, and political will exists.

Methods

Data Collection and Preparation

I combined an existing Olympic National Park species list (available from: https://irma.nps.gov/Portal) with the results of a 2005 inventory of the park's coastal wetlands (Acker and Olson, 2009) and data from occurrence records in the Consortium of Pacific Northwest Herbaria database (available from: https://pnwherbaria.org/data/search.php) to create a comprehensive list of vascular plants within the park (Appendix A). Because calculating evolutionary distinctiveness requires time-calibrated, well-supported phylogenies for accuracy, I removed bryophytes, pteridophytes, and gymnosperms from my list because their phylogenetic relationships are poorly understood relative to angiosperms (APG IV; Cornwell et al., 2014; Gastaur and Meira-Neto, 2013; Isaac et al., 2007; Shaw, Szovenyi, and Shaw, 2011; Webb and Donoghue, 2005; Zanne et al., 2014). I also removed all non-native taxa from my final species list because they are not generally subject to positive attention from conservation programs.

Phylogeny Selection and Preparation

To generate the most accurate ED scores possible, I chose to use a time-calibrated phylogeny created to examine the evolution of woody tissue in northern hemisphere angiosperms (Zanne et al., 2014). By using mutation rates to determine divergence times, the Zanne et al. (2014) tree provides a more accurate estimate of the evolutionary time, or branch length between taxa, than phylogenies reliant on a secondary branch length adjustment function (Phylocom's BLADJ function is a popular option) to fit the tree to a series of nodes with pre-determined ages (Webb, Ackerly, and Kembel, 2008; Wikstrom, Savolainen, and Chase, 2001). Because Zanne et al. (2014) chose to include nearly 22,000 taxa in their phylogeny, using this tree maximized the likelihood that species within my study area would be included within the tree and therefore available for the ED calculation (2014).

To avoid erroneously dropping tips due to differences in nomenclature (this phylogeny was built prior to the release of APG IV), I cross-referenced each name in my species list with those used by Zanne et al. (The Plant List, available from: http://www.theplantlist.org and the Angiosperm Phylogeny Website, available from: http://www.mobot.org/MOBOT/research/Apweb/) before proceeding to trim their tree to just the taxa within my study area (Gastaur and Meira-Neto, 2015; The Angiosperm Phylogeny Group, 2016; Web and Donoghue, 2005; Zanne et al., 2014). After updating the names of each taxon in my species list, I used the web-based version of Phylocom (the Phylomatic, available from: http://phylodiversity.net/phylomatic/) to access the super tree and drop all species not found within Olympic National Park (Webb and Donoghue, 2005; Zanne et al., 2014).

Calculating Evolutionary Distinctiveness (ED) and Regional Endangerment (RE)

I calculated ED scores for each species with the R package ‘picante’ and the fair proportion ED calculation (Appendix A; Isaac et al., 2007; Kembel et al., 2010; R Core Team, 2021; Webb, Ackerly, and Kembel, 2008). I chose the fair proportion calculation over equal splits and other alternatives because this approach ensures each unit of evolutionary time (1 MY) is weighted equally (Gastaur and Meira-Neto, 2014; Isaac et al, 2007; Redding and Mooers, 2006; Webb, Ackerly, and Kembel, 2008). For those taxa considered species of concern by the Washington Department of Natural Resources, Natural Heritage Program (2019), I took the additional step of calculating Regional Evolutionary Distinctiveness-Endangerment (RED-E) scores by creating a function in R to weight their ED scores by their Washington state Natureserve threat rank (Appendix B; Brantner, 2015). I used the following equation to calculate RED-E in R (adapted from the EDGE equation first published by Isaac et al., 2007 by Brantner, 2015):

$$\text{RED-E} = \ln(1+\text{ED}) + \text{RE} * \ln(2)$$

$$\text{EDGE} = \ln(1+\text{ED}) + \text{GE} * \ln(2)$$

Natureserve is a national science advisory charity that works with states and governments (Washington’s rankings were developed in partnership with the Natural Heritage Program) to create a system for ranking taxa by their risk of extirpation within their borders (Faber-Langendoen et al., 2012; Washington Department of Natural Resources, 2019). Under this system, species with verified occurrence records are ranked from secure (S5) to critically imperiled (S1), while species presumed extirpated, known only from historical records, or those that otherwise cannot be ranked receive designations such as X, H, and U respectively (Faber-Langendoen et al., 2012; Washington Department of Natural Resources, 2019). Taxa with an unresolved conservation status receive an intermediate ranking (S1S2, for example) or a question mark (S3?) if their status is less uncertain (Faber-Langendoen et al., 2012; Washington Department of Natural Resources, 2019). Following Thompson (2020) I converted each state threat ranking into an integer (a Regional Endangerment Score) for use in the RED-E calculation (see Table 1). Under this method, RE scores range from 0 (S5) to 4(S1), and intermediate values are represented by taking the average of their two ranks (S1S2 becomes 1.5; Thompson, 2020). Because question marks represent less uncertainty than intermediate rankings, I chose to disregard question marks entirely and treat those rankings as if the mark was not present (For example, S1? and S1 would both receive an RE score of 4).

Table 1. Conversion of state NatureServe ranks into Regional Endangerment (RE) scores. No species with a threat ranking below S3 existed in this dataset, though one taxon (*Arenaria paludicola*) is presumed extirpated and therefore no RED-E score was calculated for it. Adapted from Thompson (2020).

Threat Level	**NatureServe Ranking**	**RE Score**
Critically Imperiled	S1	4
	S1S2	3.5
Imperiled	S2	3
	S2S3	2.5
Vulnerable	S3	2
	S3S4	1.5
Apparently Secure	S4	1
	S4S5	0.5
Secure	S5	0

Results

ED and RED-E Scores

Olympic National Park is home to 32 orders, 78 families, 363 genera, and 872 species of flowering plants (Appendix A; Figure 4). Of these, ED scores were calculated for 871 species and ranged from 2.91 MY (*Carex phaeocephala* and *Carex praticola*) to 180.93 MY (*Asarum caudatum*) with a median value of 32.14 MY, a standard deviation of 25.24 MY and a geometric mean of 25.99 MY (Figure 5). No score was generated for *Myriophyllum quitense* because it was not included (by this name or any synonyms) in the Zanne et al. (2014) phylogeny.

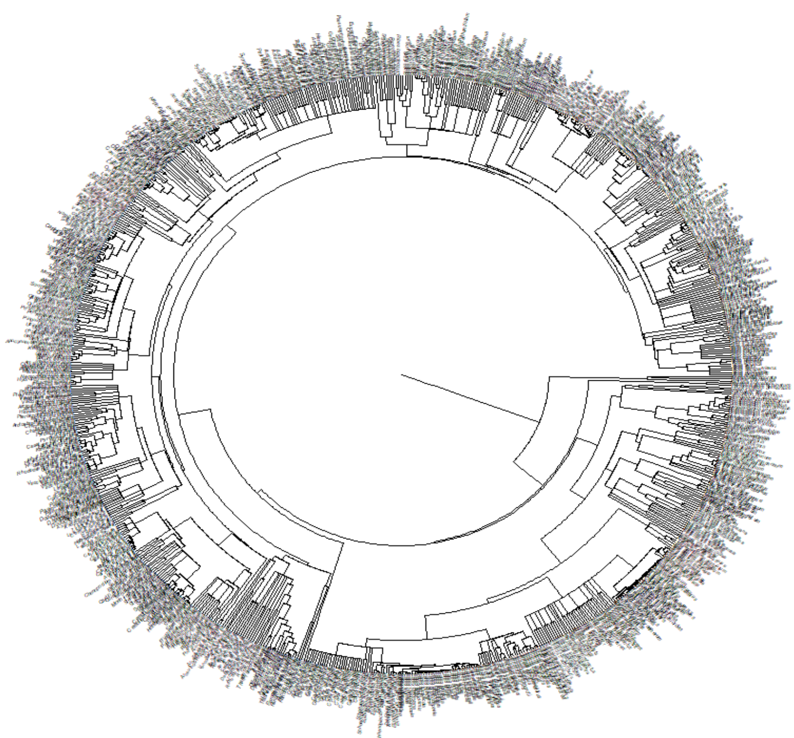

Figure 3. The angiosperms of Olympic National Park. Species are not distributed evenly across the branches of the tree of life. Phylogeny constructed using a tree originally built by Zanne et al. (2014).

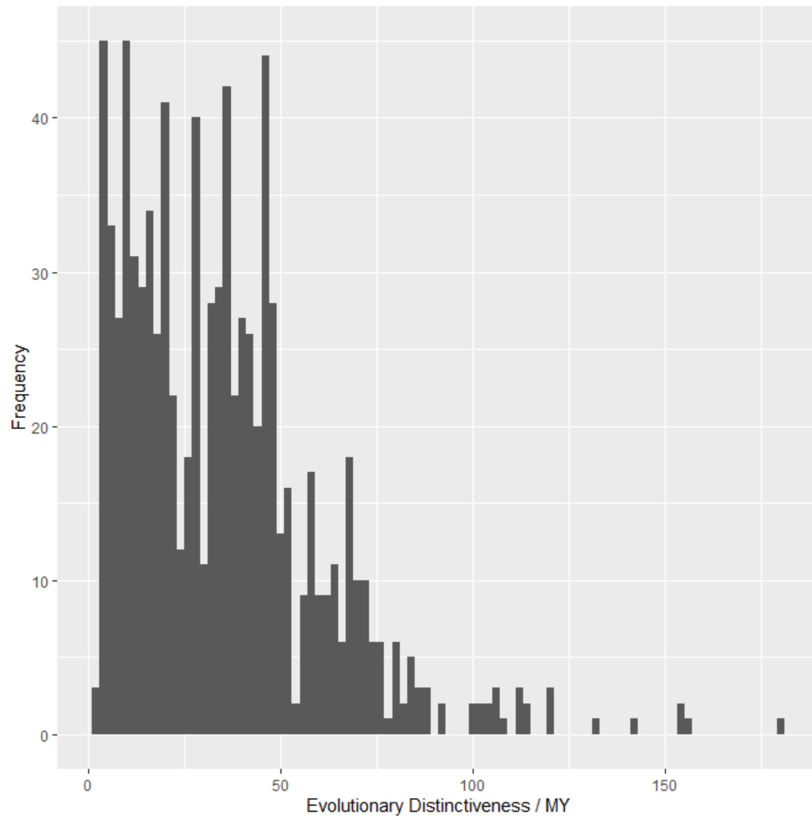

Figure 4. Histogram of the distribution of ED scores of angiosperms (*n* = 871) found within Olympic National Park. A species list with calculated ED scores is provided in Appendix A.

RED-E scores were calculated for the 40 taxa found within the park and on the Special Plants List 2019 (Washington Department of Natural Resources, 2019). Scores ranged from 3.79 (*Carex obtusata*) to 7.45 (*Arcteranthis cooleyae*) with a median value of 5.9, a standard deviation of 0.87 and a geometric mean of 5.67 (Appendix B). The RED-E rankings were relatively homogenous across all 40 species of concern, which was likely the result of most of those species being fairly high priority (S2 rank) taxa (Washington Department of Natural Resources, 2019).

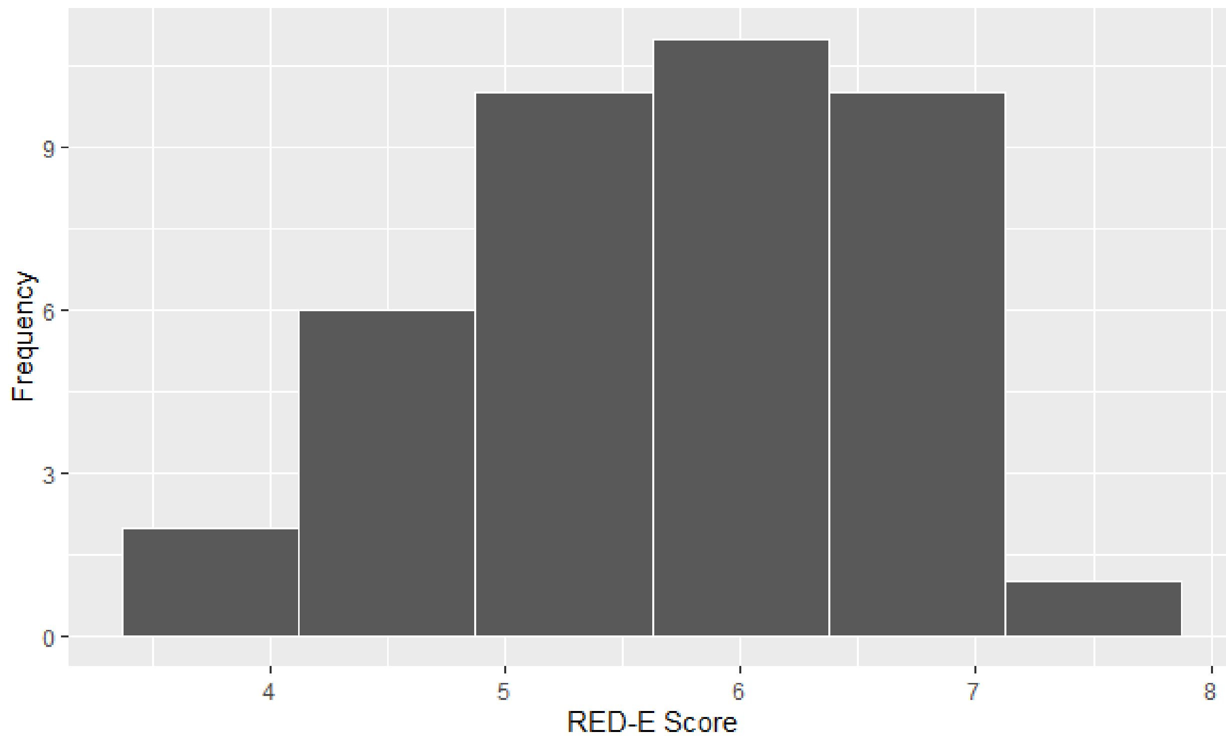

Figure 5. Histogram of RED-E scores for *n* = 40 taxa found within Olympic National Park and the Special Plants List 2019 (Washington Department of Natural Resources, 2019). A species list with calculated RED-E scores, and ED scores, is provided in Appendix B.

Discussion

Angiosperm Diversity in Olympic National Park

Given its proximity to a former glacial refugium, it is not particularly surprising that Olympic National Park is home to such a diverse array of angiosperm lineages (Wershow and DeChaine, 2018; Appendix A). While the ages and distribution of species across genera, families, and orders is, overall, consistent with what's known about angiosperm radiations from the fossil record, calculating ED revealed a few surprises (Cantino et al., 2007; Linkies et al., 2010). First, *Asarum caudatum,* a somewhat uncommon component of Washington's lowland forests, diverged from its closest relative on the peninsula 180.93 MYA, during the Jurassic period and relatively soon after angiosperms first diverged from gymnosperms (Walker et al., 2013; Cantino et al., 2007; Appendix A). Other species familiar from roadsides and parks, like Skunk Cabbage (*Lysichiton americanus*, ED = 131.11 MY), water-lilies (*Nuphar polysepala,* ED = 153.23), and nearly 100 other species within the park have ED scores above 65 MYA, when the K-Pg extinction event wiped out nearly 57% of North American terrestrial plants (Appendix A; Labandeira, Johnson, and Wilf, 2002). Nearly half of the Park's angiosperms, 408 species, arose before or during the Paleocene-Eocene Thermal Maximum (56 MYA to 33.9 MYA), the warmest period in earth's history (Culver and Rawson, 2000; Labandeira, Johnson, and Wilf, 2002; Walker et al., 2013). While this history is no guarantee of survival during our current period of warming, it's encouraging to think that a majority of the Park's angiosperms have already survived some of the worst climate change has to offer and could do so again.

Figure 6. Skunk Cabbage *(Lysichiton americanus)* at Millersylvania State Park, Olympia WA. Common weeds like Skunk Cabbage provide critical winter forage for animals like Deer. Image by Claire Olson.

With the exception of Skunk Cabbage, many of these species are not flashy, notable, or particularly valuable to humans. Who would have ever thought Duck Weed (*Lemna minor,* ED = 103.17) or Oregon Grape (*Berberis nervosa,* ED = 119.42), to be irreplaceable examples of biodiversity? Perhaps counterintuitively, roadside weeds, greenbelt oddities, and smelly spring flowers contain the lion's share of evolutionary history.

RED-E, ED, and the Special Plants List

Boring vegetation is the future of speciation, and we should do more to keep tabs on it. Of the species in my dataset, just 40 were listed by the Washington Natural Heritage Program as species of concern (taxa prioritized for monitoring) (Washington Department of Natural Resources, 2019). Of the 40 listed species, just 2 had ED scores within the top 50 highest ED scores (Appendix A; Washington Department of Natural Resources, 2019). Overall, the species prioritized for monitoring by the Special Plants List that occur within Olympic National Park are no more or less distinctive than other species within the park (average ED score of 38.59 MY), with a tendency to come from large families (Appendix B; Appendix A).

The Cyperaceae (sedges), for example, is particularly well represented in this list, with five of the 23 members of *Carex* up for monitoring: *C. anthoxanthea* (4.72 MY), *C. circinnata* (20.22 MY), *C. obtusata* (4.53 MY), *C. pauciflora* (4.66 MY), and *C. stylosa* (20.21 MY). Sedges are, on the whole, an old lineage of angiosperms, arising around 83 MYA (Cantino et al., 2007). However, unlike some of the Park's other old lineages (Araceae, 130 MY), the Cyperaceae have experienced some relatively recent radiations, with many members (especially *Carex*) diverging between 6 and 2 MYA (Figure 7, Appendix A).

From the perspective of preserving phylogenetic diversity, the Special Plants List does not serve the Cyperaceae particularly well, instead prioritizing visually-distinctive sedges (members of this family are notoriously difficult to identify) like *C. pauciflora* (Figure 8) and neglecting the other genera of sedges (*Dulichium, Eleocharis, Eriophorum, Rhynchospora, Schoenoplectus*, and *Scirpus*) entirely. From the perspective of prioritizing species based on their contribution to evolutionary history, the two species within the genus *Schoenoplectus* (each with an ED score of 28.53 MY) would receive priority, followed by older members of *Carex* such as *C. stylosa*, and single-species genera like *Rhynchospora* (ED score of 16.83 MY) that diverged around the same time as some *Carex*, but represent a distinct branch of the sedge family tree. For the Cyperaceae, rarity alone is a poor proxy for phylogenetic diversity

Figure 7. Species of the genus *Carex* found within Olympic National Park. Species within the polytomy diverged around 4.5 million years ago, and are indistinct from a phylogenetic perspective. Phylogeny adapted from a super tree generated by Zanne et al (2014).

Many of the other families of the special plants list fare the same way upon examination, containing one visually-distinct listed member that has a relatively low ED score, but then also contains numerous older, more phylogenetically important members that are less readily noticeable and hence left without a ranking (Washington Department of Natural Heritage, 2019; Appendix A; Appendix B). For example, a member of the Primulaceae, *Dodecatheon* *austrofrigidum (*RED-E score of 6.39, ED score of 36.37 MY) is prioritized by the Special Plants List but diverged at roughly the same time (36.37 MY) as the other four species of *Dodecatheon* found within the park (Appendix A). Other genera of the Primulaceae represent much more distinctive lineages, such as *Trientalis* (58 MY) or *Androsace* (45 MY), but are much less visually striking or distinctive (Figure 9).

Figure 8. *Carex pauciflora* is not distinctive or valuable from a phylogenetic perspective but is one of the few sedges that can be easily identified without training. Image © 2021 Donald Cameron.

Figure 9. *Trientalis arctica* (Left, © Michael Kesl), which is much less conspicuous than *Dodecatheon austrofrigidum* (Right, © Wilbur Bluhm), but is far more important phylogenetically.

Unfortunately, a species' absence from the Special Plants List does not mean it is not equally at risk of extirpation, especially if you take climate change into consideration. A lack of contemporary range and distribution information for many species (even a quick look at records in the database compiled by the Consortium of Pacific Northwest Herbaria will show a steep decline in collections after 1970) means range and abundance estimates are based off decades-old information that may no longer reflect a species' reality. Without a reference point, it will be nearly impossible to identify declines in species' before (and sometimes even when) they become at risk of extirpation. Without knowing species' starting point, we cannot quantify the impacts of climate change. Shifting monitoring priorities to those species with a high degree of phylogenetic importance, rather than solely monitoring those with small populations, will go the farthest toward preventing a landscape-scale loss of biodiversity, especially when those efforts are focused in potential refugia like Olympic National Park.

As the progenitors of climate change, we have a moral obligation to do our best to ensure that most species have the best shot at persisting through the end of the century, even if they are unattractive, ‘useless’, or have a particularly unpleasant smell. We have a duty to go and look for species that are not attractive, that are difficult to identify, and that occur in inconvenient places, even if it is not particularly cheap to do so, because not looking means risking the disappearance of millions of years of evolutionary history without ever even realizing what could be lost.

Conclusion

Although immediate conservation action is necessary to counteract this century's ever-accelerating rates of extinction, the number of species in need of preservation is all but guaranteed to overwhelm the ability of agencies and organizations to provide aid. Therefore, conservation programs must work to prioritize the allocation of funding to those species who represent the most urgent need and the greatest share of evolutionary history. However, insufficient data on the relative endangerment of plant species at the regional and local levels impedes attempts to determine which taxa are in fact secure, hampering conservationists' ability to make informed decisions. Climate change and urbanization mean we can no longer assume taxa are secure, even when decades-old records indicate a sufficient range and population size. Without clear, contemporary range and abundance information, we cannot know species' threat status. Equally unreasonable is the expectation that up-to-date range and abundance information for all species exists as well as the expectation that vulnerable species will all be provided with sufficient conservation efforts. Centering monitoring efforts on phylogenetically important species makes relevant data collection and support much more feasible. This study provides a basis for prioritizing species for monitoring (and, potentially, conservation) built on their contribution to the phylogenetic diversity of Olympic National Park and the Olympic Peninsula, a study that highlights the diversity of lineages found within the park, and both the need for and value of increased assessments of the threat to and phylogenetic relationships among plants throughout Washington State.

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Appendices

Appendix A

Angiosperms found within Olympic National Park, ranked by ED score. ED scores are rounded to two decimal places, and differences in ranks represent differences in ED scores. Species marked with an asterisk (*) represent recognized infraspecies present in the park that were not included in the Zanne et al. (2014) phylogeny. Synonyms, where applicable, are listed in parentheses.

Rank	Order	Family	Scientific Name	ED Score
1	Piperales	*Aristolochiaceae*	*Asarum caudatum*	180.93
2	Nymphaeales	*Cabombaceae*	*Brasenia schreberi*	156.36
3	Nymphaeales	*Nymphaeaceae*	*Nymphaea odorata*	153.23
4	Nymphaeales	*Nymphaeaceae*	*Nuphar polysepala*	153.23
5	Alismatales	*Tofieldiaceae*	*Triantha occidentalis*	142.99
6	Alismatales	*Araceae*	*Lysichiton americanus*	131.11
7	Ranunculales	*Papaveraceae*	*Dicentra formosa*	120.09
8	Ranunculales	*Berberidaceae*	*Berberis nervosa*	119.42
9	Ranunculales	*Berberidaceae*	*Achlys californica*	119.42
10	Asparagales	*Orchidaceae*	*Epipactus gigantea*	113.05
11	Asparagales	*Orchidaceae*	*Cephalanthera austiniae*	113.05
12	Oxalidales	*Oxalidaceae*	*Oxalis oregana*	111.90
13	Ceratophyllales	*Ceratophyllaceae*	*Ceratophyllum echinatum*	111.89
14	Ceratophyllales	*Ceratophyllaceae*	*Ceratophyllum demersum*	111.89
15	Liliales	*Liliaceae*	*Prosartes smithii*	108.55
16	Ranunculales	*Ranunculaceae*	*Coptis asplenifolia*	106.80
17	Ranunculales	*Ranunculaceae*	*Caltha leptosepala*	106.80

18	Ranunculales	*Ranunculaceae*	*Arcteranthis cooleyae*	106.80
19	Alismatales	*Araceae*	*Spirodela polyrhiza*	103.17
20	Alismatales	*Araceae*	*Lemna minor*	103.17
21	Malphigiales	*Elatinaceae*	*Elatine triandra*	101.57
22	Malvales	*Malvaceae*	*Sidalcea hendersonii*	101.45
23	Ranunculales	*Ranunculaceae*	*Coptis laciniata*	99.38
24	Ranunculales	*Berberidaceae*	*Berberis aquifolium*	99.37
25	Ranunculales	*Papaveraceae*	*Corydalis scouleri*	91.85
26	Ranunculales	*Papaveraceae*	*Corydalis aurea*	91.85
27	Ranunculales	*Berberidaceae*	*Vancouveria hexandra*	87.68
28	Ranunculales	*Berberidaceae*	*Achlys triphylla*	87.68
29	Geraniales	*Geraniaceae*	*Geranium carolinianum*	87.39
30	Caryophyllales	*Droseraceae*	*Drosera rotundifolia*	86.79
31	Asparagales	*Orchidaceae*	*Neottia convallarioides*	85.19
32	Asparagales	*Orchidaceae*	*Neottia banksiana*	85.19
33	Rosales	*Rosaceae*	*Spiraea splendens*	83.29
34	Rosales	*Rosaceae*	*Sorbus sitchensis*	83.29
35	Rosales	*Rosaceae*	*Petrophytum hendersonii*	83.29
36	Rosales	*Rosaceae*	*Geum triflorum*	83.29
37	Rosales	*Rosaceae*	*Aruncus doicus*	83.29
38	Rosales	*Rosaceae*	*Dryas drummondii*	82.49
39	Dipsacales	*Adoxaceae*	*Viburnum edule*	81.61
40	Ranunculales	*Ranunculaceae*	*Ranunculus grayi*	80.44

41	Ranunculales	*Ranunculaceae*	*Ranunculus glaberrimus*	80.44
42	Ranunculales	*Ranunculaceae*	*Delphinium nuttallii*	80.44
43	Ranunculales	*Ranunculaceae*	*Delphinium glareosum*	80.44
44	Rosales	*Rhamnaceae*	*Ceanothus velutinus*	80.09
45	Sapindales	*Anacardiaceae*	*Rhus diversiloba*	79.27
46	Apiales	*Araliaceae*	*Oplopanax horridus*	77.86
47	Asparagales	*Orchidaceae*	*Neottia cordata*	76.88
48	Saxifragales	*Saxifragaceae*	*Chrysosplenium glechomifolium*	76.65
49	Celastrales	*Celastraceae*	*Paxistima myrsinites*	76.47
50	Rosales	*Rhamnaceae*	*Frangula purshiana*	75.23
51	Rosales	*Rhamnaceae*	*Ceanothus sanguineus*	75.23
52	Saxifragales	*Crassulaceae*	*Crassula aquatica*	75.07
53	Asparagales	*Asparagaceae*	*Camassia quamash*	74.93
54	Asparagales	*Amaryllidaceae*	*Allium cernuum*	74.26
55	Rosales	*Urticaceae*	*Urtica dioica*	74.18
56	Rosales	*Elaeagnaceae*	*Shepherdia canadensis*	74.18
57	Solanales	*Convolvulaceae*	*Calystegia soldanella*	73.64
58	Alismatales	*Juncaginaceae*	*Triglochin maritima*	73.09
59	Apiales	*Apiaceae*	*Yabea microcarpa*	72.94
60	Apiales	*Apiaceae*	*Lilaeopsis occidentalis*	72.94
61	Apiales	*Apiaceae*	*Ligusticum apiifolium*	72.94
62	Apiales	*Apiaceae*	*Heracleum lanatum*	72.94

63	Apiales	*Apiaceae*	*Daucus pusillus*	72.94
64	Ranunculales	*Ranunculaceae*	*Trollius laxus*	72.58
65	Liliales	*Melanthiaceae*	*Toxicoscordion venenosum*	72.33
66	Liliales	*Melanthiaceae*	*Anticlea occidentalis*	72.33
67	Ranunculales	*Ranunculaceae*	*Aquilegia formosa*	71.61
68	Ranunculales	*Ranunculaceae*	*Thalictrum occidentale*	71.61
69	Fabales	*Fabaceae*	*Thermopsis gracilis*	70.84
70	Fabales	*Fabaceae*	*Syrmatium decumbens*	70.84
71	Fabales	*Fabaceae*	*Oxytropis viscida*	70.84
72	Fabales	*Fabaceae*	*Lathyrus polyphyllus*	70.84
73	Fabales	*Fabaceae*	*Hedysarum occidentale*	70.84
74	Ericales	*Polemoniaceae*	*Linanthus bicolor*	70.47
75	Ericales	*Polemoniaceae*	*Collomia debilis*	70.47
76	Fagales	*Fagaceae*	*Chrysolepis chrysophylla*	70.11
77	Dipsacales	*Caprifoliaceae*	*Valeriana scouleri*	69.08
78	Dipsacales	*Caprifoliaceae*	*Linnea borealis*	69.08
79	Geraniales	*Geraniaceae*	*Geranium viscosissimum*	68.95
80	Geraniales	*Geraniaceae*	*Geranium bicknellii*	68.95
81	Alismatales	*Alismataceae*	*Sagittaria cuneata*	68.51
82	Asparagales	*Orchidaceae*	*Platanthera unalascensis*	68.47
83	Asparagales	*Orchidaceae*	*Platanthera stricta*	68.47
84	Asparagales	*Orchidaceae*	*Platanthera elongata*	68.47
85	Asparagales	*Orchidaceae*	*Platanthera elegans*	68.47

86	Asparagales	*Orchidaceae*	*Platanthera dilatata*	68.47
87	Cornales	*Cornaceae*	*Cornus sericea*	68.13
88	Asparagales	*Orchidaceae*	*Platanthera hyperborea*	67.51
89	Cornales	*Cornaceae*	*Cornus canadensis*	67.27
90	Cornales	*Cornaceae*	*Cornus nuttallii*	67.27
91	Ranunculales	*Ranunculaceae*	*Anemone oregana*	67.26
92	Ranunculales	*Ranunculaceae*	*Anemone lithophila*	67.26
93	Ranunculales	*Ranunculaceae*	*Anemone grayii*	67.26
94	Ranunculales	*Ranunculaceae*	*Anemone deltoidea*	67.26
95	Asterales	*Menyanthaceae*	*Nephrophyllidium crista-galli*	67.04
96	Asterales	*Menyanthaceae*	*Menyanthes trifoliata*	67.04
97	Alismatales	*Hydrocharitaceae*	*Elodea canadensis*	66.11
98	Asparagales	*Asparagaceae*	*Triteleia hyacinthina*	65.82
99	Malphigiales	*Hydrocharitaceae*	*Hypericum scouleri*	65.79
100	Malphigiales	*Hydrocharitaceae*	*Hypericum anagalloides*	65.79
101	Myrtales	*Onagraceae*	*Ludwigia palustris*	65.74
102	Myrtales	*Onagraceae*	*Oenothera villosa*	65.74
103	Cornales	*Hydrangeaceae*	*Whipplea modesta*	64.99
104	Cornales	*Hydrangeaceae*	*Philadelphus lewisii*	64.99
105	Liliales	*Liliaceae*	*Streptopus streptopoides*	64.54
106	Liliales	*Liliaceae*	*Prosartes hookeri*	64.54
107	Liliales	*Liliaceae*	*Gagea serotina*	64.54
108	Ericales	*Ericaceae*	*Pleuricospora fimbriolata*	63.39

109	Ericales	*Ericaceae*	*Phyllodoce intermedia*	63.39
110	Ericales	*Ericaceae*	*Monotropa hyopitys*	63.39
111	Ericales	*Ericaceae*	*Ledum palustre*	63.39
112	Ericales	*Ericaceae*	*Hemitomes congestum*	63.39
113	Ericales	*Ericaceae*	*Allotropa virgata*	63.39
114	Rosales	*Rosaceae*	*Sanguisorba procumbens*	62.71
115	Rosales	*Rosaceae*	*Sanguisorba menziesii*	62.71
116	Rosales	*Rosaceae*	*Potentilla glandulosa*	62.71
117	Rosales	*Rosaceae*	*Potentilla flabellifolia*	62.71
118	Brassicales	*Brassicaceae*	*Cochlearia groenlandica*	62.63
119	Brassicales	*Brassicaceae*	*Boechera holbellii*	62.63
120	Caryophyllales	*Plumbaginaceae*	*Armeria maritima*	62.26
121	Santales	*Santalaceae*	*Arceuthobium tsugense*	61.52
122	Santales	*Santalaceae*	*Arceuthobium campylopodium*	61.52
123	Alismatales	*Alismataceae*	*Sagittaria latifolia*	60.73
124	Alismatales	*Alismataceae*	*Alisma triviale*	60.73
125	Dipsacales	*Adoxaceae*	*Sambucus cerulea*	60.37
126	Dipsacales	*Adoxaceae*	*Sambucus racemosa*	60.37
127	Rosales	*Rosaceae*	*Geum macrophyllum*	60.30
128	Fagales	*Fagaceae*	*Myrica gale*	59.77
129	Asterales	*Campanulaceae*	*Lobelia dortmanna*	59.76
130	Gentianales	*Rubiaceae*	*Galium oreganum*	59.17

131	Asparagales	*Orchidaceae*	*Calypso bulbosa*	59.16
132	Rosales	*Rosaceae*	*Sanguisorba canadensis*	58.47
133	Ericales	*Primulaceae*	*Trientalis arctica*	57.99
134	Boraginales	*Boraginaceae*	*Plagiobothrys scouleri*	57.86
135	Boraginales	*Boraginaceae*	*Phacelia leptosepala*	57.86
136	Boraginales	*Boraginaceae*	*Mertensia platyphylla*	57.86
137	Boraginales	*Boraginaceae*	*Hydrophyllum fendleri*	57.86
138	Boraginales	*Boraginaceae*	*Cryptantha intermedia*	57.86
139	Boraginales	*Boraginaceae*	*Amsinckia menziesii*	57.86
140	Saxifragales	*Saxifragaceae*	*Lithophragma parviflorum*	57.84
141	Saxifragales	*Saxifragaceae*	*Lithophragma glabrum*	57.84
142	Saxifragales	*Saxifragaceae*	*Heuchera glabra*	57.84
143	Saxifragales	*Saxifragaceae*	*Heuchera chlorantha*	57.84
144	Caryophyllales	*Polygonaceae*	*Persicaria amphibia*	57.60
145	Caryophyllales	*Polygonaceae*	*Eriogonum ovalifolium*	57.60
146	Asparagales	*Amaryllidaceae*	*Allium crenulatum*	57.39
147	Asparagales	*Amaryllidaceae*	*Allium acuminatum*	57.39
148	Lamiales	*Oleaceae*	*Fraxinus latifolia*	57.34
149	Liliales	*Melanthiaceae*	*Xerophyllum tenax*	56.96
150	Liliales	*Melanthiaceae*	*Trillium ovatum*	56.96
151	Gentianales	*Apocynaceae*	*Apocynum androsaemifolium*	55.41
152	Apiales	*Apiaceae*	*Osmorhiza purpurea*	55.08
153	Apiales	*Apiaceae*	*Osmorhiza occidentalis*	55.08

154	Apiales	*Apiaceae*	*Lomatium utriculatum*	55.08
155	Apiales	*Apiaceae*	*Lomatium martindalei*	55.08
156	Apiales	*Apiaceae*	*Angelica hendersonii*	55.08
157	Apiales	*Apiaceae*	*Angelica genuflexa*	55.08
158	Ericales	*Polemoniaceae*	*Phlox hendersonii*	53.32
159	Ericales	*Polemoniaceae*	*Phlox diffusa*	53.32
160	Asparagales	*Orchidaceae*	*Spiranthes romanzoffiana*	52.82
161	Asparagales	*Orchidaceae*	*Goodyera oblongifolia*	52.82
162	Dipsacales	*Caprifoliaceae*	*Lonicera utahensis*	52.68
163	Dipsacales	*Caprifoliaceae*	*Lonicera ciliosa*	52.68
164	Caryophyllales	*Caryophyllaceae*	*Sagina maxima*	52.38
165	Caryophyllales	*Caryophyllaceae*	*Moehringia macrophylla*	52.38
166	Caryophyllales	*Caryophyllaceae*	*Eremogone capillaris*	52.38
167	Caryophyllales	*Caryophyllaceae*	*Cerastium beeringianum*	52.38
168	Caryophyllales	*Caryophyllaceae*	*Cardionema ramosissimum*	52.38
169	Caryophyllales	*Caryophyllaceae*	*Arenaria paludicola*	52.38
170	Asparagales	*Asparagaceae*	*Dichelostemma congestum*	52.38
171	Asparagales	*Asparagaceae*	*Brodiaea coronaria*	52.38
172	Celastrales	*Celastraceae*	*Parnassia palustris*	52.09
173	Celastrales	*Celastraceae*	*Parnassia fimbriata*	52.09
174	Poales	*Typhaceae*	*Typha latifolia*	51.65
175	Liliales	*Melanthiaceae*	*Anticlea elegans*	51.04
176	Saxifragales	*Haloragraceae*	*Myriophyllum verticillatum*	50.94

177	Saxifragales	*Haloragraceae*	*Myriophyllum sibiricum*	50.94
178	Sapindales	*Sapindaceae*	*Acer circinatum*	50.94
179	Myrtales	*Onagraceae*	*Clarkia purpurea*	50.11
180	Myrtales	*Onagraceae*	*Clarkia amoena*	50.11
181	Poales	*Poaceae*	*Trisetum cernuum*	49.07
182	Poales	*Poaceae*	*Puccinellia nutkaensis*	49.07
183	Poales	*Poaceae*	*Pleuropogon refractus*	49.07
184	Poales	*Poaceae*	*Panicum acuminatum*	49.07
185	Poales	*Poaceae*	*Hierochloe odorata*	49.07
186	Poales	*Poaceae*	*Helictotrichon canescens*	49.07
187	Poales	*Poaceae*	*Glyceria leptostachya*	49.07
188	Poales	*Poaceae*	*Deschampsia atropurpurea*	49.07
189	Alismatales	*Hydrocharitaceae*	*Vallisneria americana*	48.55
190	Alismatales	*Hydrocharitaceae*	*Najas flexilis*	48.55
191	Ericales	*Ericaceae*	*Arctostaphylos uva-ursi*	47.87
192	Ericales	*Ericaceae*	*Arctostaphylos media*	47.87
193	Fabales	*Fabaceae*	*Trifolium wormsskjoldii*	47.79
194	Fabales	*Fabaceae*	*Trifolium wildenovii*	47.79
195	Fabales	*Fabaceae*	*Trifolium microdon*	47.79
196	Fabales	*Fabaceae*	*Lupinus lyallii*	47.79
197	Fabales	*Fabaceae*	*Lupinus littoralis*	47.79
198	Fabales	*Fabaceae*	*Lupinus albicaulis*	47.79
199	Fabales	*Fabaceae*	*Astragalus microcystus*	47.79

200	Fabales	*Fabaceae*	*Astragalus lentiginosus*	47.79
201	Fabales	*Fabaceae*	*Astragalus cottonii*	47.79
202	Liliales	*Liliaceae*	*Clintonia uniflora*	47.69
203	Dipsacales	*Caprifoliaceae*	*Valeriana sitchensis*	47.52
204	Dipsacales	*Caprifoliaceae*	*Valeriana samolifolia*	47.52
205	Alismatales	*Potamogetonaceae*	*Stuckenia filiformis*	47.47
206	Caryophyllales	*Nyctaginaceae*	*Abronia latifolia*	47.39
207	Caryophyllales	*Nyctaginaceae*	*Abronia umbellata*	47.39
208	Rosales	*Rosaceae*	*Rubus spectabilis*	47.28
209	Rosales	*Rosaceae*	*Rubus praecox*	47.28
210	Rosales	*Rosaceae*	*Rubus pedatus*	47.28
211	Rosales	*Rosaceae*	*Rubus parviflorus*	47.28
212	Rosales	*Rosaceae*	*Rubus nivalis*	47.28
213	Rosales	*Rosaceae*	*Rubus leucodermis*	47.28
214	Rosales	*Rosaceae*	*Rubus lasiococcus*	47.28
215	Rosales	*Rosaceae*	*Rubus laciniatus*	47.28
216	Rosales	*Rosaceae*	*Potentilla anserina*	47.09
217	Asterales	*Asteraceae*	*Tonestus lyallii*	46.86
218	Asterales	*Asteraceae*	*Symphyotrichum chilense*	46.86
219	Asterales	*Asteraceae*	*Saussurea americana*	46.86
220	Asterales	*Asteraceae*	*Pseudognaphalium canescens*	46.86
221	Asterales	*Asteraceae*	*Pentacalia amplexicaulis*	46.86
222	Asterales	*Asteraceae*	*Oreostemma alpigenum*	46.86

223	Asterales	*Asteraceae*	*Nabalus alatus*	46.86
224	Asterales	*Asteraceae*	*Luina hypoleuca*	46.86
225	Asterales	*Asteraceae*	*Lasthenia maritima*	46.86
226	Asterales	*Asteraceae*	*Hemizonella minima*	46.86
227	Asterales	*Asteraceae*	*Grindelia hirsutula*	46.86
228	Asterales	*Asteraceae*	*Eurybia merita*	46.86
229	Asterales	*Asteraceae*	*Eucephalus paucicapitatus*	46.86
230	Asterales	*Asteraceae*	*Crepis occidentalis*	46.86
231	Asterales	*Asteraceae*	*Cirsium edule*	46.86
232	Asterales	*Asteraceae*	*Askellia pygmaea*	46.86
233	Asterales	*Asteraceae*	*Anisocarpus madioides*	46.86
234	Asterales	*Asteraceae*	*Ambrosia chamissonis*	46.86
235	Asterales	*Asteraceae*	*Packera flettii*	46.86
236	Malphigiales	*Salicaceae*	*Salix sitchensis*	46.85
237	Malphigiales	*Salicaceae*	*Salix sessilifolia*	46.85
238	Malphigiales	*Salicaceae*	*Salix scouleriana*	46.85
239	Malphigiales	*Salicaceae*	*Salix lasiandra*	46.85
240	Malphigiales	*Salicaceae*	*Salix hookeriana*	46.85
241	Malphigiales	*Salicaceae*	*Salix commutata*	46.85
242	Malphigiales	*Salicaceae*	*Salix brachycarpa*	46.85
243	Malphigiales	*Salicaceae*	*Salix barclayi*	46.85
244	Saxifragales	*Saxifragaceae*	*Mitella trifida*	46.55
245	Saxifragales	*Saxifragaceae*	*Mitella pentandra*	46.55

246	Saxifragales	*Saxifragaceae*	*Mitella ovalis*	46.55
247	Saxifragales	*Saxifragaceae*	*Mitella caulescens*	46.55
248	Saxifragales	*Saxifragaceae*	*Mitella breweri*	46.55
249	Asterales	*Campanulaceae*	*Campanula piperi*	46.52
250	Asterales	*Campanulaceae*	*Campanula parryi*	46.52
251	Rosales	*Rosaceae*	*Rubus occidentalis*	46.20
252	Rosales	*Rosaceae*	*Rubus ursinus*	46.20
253	Saxifragales	*Crassulaceae*	*Sedum stenopetalum*	45.79
254	Saxifragales	*Crassulaceae*	*Sedum spathulifolium*	45.79
255	Saxifragales	*Crassulaceae*	*Sedum rupicola*	45.79
256	Saxifragales	*Crassulaceae*	*Sedum oreganum*	45.79
257	Saxifragales	*Crassulaceae*	*Sedum lanceolatum*	45.79
258	Saxifragales	*Crassulaceae*	*Sedum divergens*	45.79
259	Saxifragales	*Saxifragaceae*	*Suksdorfia ranunculifolia*	45.39
260	Saxifragales	*Saxifragaceae*	*Boykinia occidentalis*	45.39
261	Caryophyllales	*Amaranthaceae*	*Chenopodium chenopodioides*	44.63
262	Caryophyllales	*Amaranthaceae*	*Atriplex gmelinii*	44.63
263	Ericales	*Ericaceae*	*Arctostaphylos columbiana*	44.59
264	Ericales	*Ericaceae*	*Arbutus menziesii*	44.59
265	Ericales	*Primulaceae*	*Androsace nivalis*	44.48
266	Ericales	*Primulaceae*	*Androsace laevigata*	44.48
267	Boraginales	*Boraginaceae*	*Romanzoffia tracyi*	43.91

268	Boraginales	*Boraginaceae*	*Romanzoffia sitchensis*	43.91
269	Rosales	*Rosaceae*	*Physocarpus capitatus*	43.89
270	Saxifragales	*Saxifragaceae*	*Saxifraga tolmiei*	43.73
271	Saxifragales	*Saxifragaceae*	*Saxifraga tischii*	43.73
272	Saxifragales	*Saxifragaceae*	*Saxifraga rufidula*	43.73
273	Saxifragales	*Saxifragaceae*	*Saxifraga odontoloma*	43.73
274	Saxifragales	*Saxifragaceae*	*Saxifraga nelsoniana*	43.73
275	Saxifragales	*Saxifragaceae*	*Saxifraga integrifolia*	43.73
276	Saxifragales	*Saxifragaceae*	*Saxifraga ferruginea*	43.73
277	Saxifragales	*Saxifragaceae*	*Saxifraga austromontana*	43.73
278	Rosales	*Rosaceae*	*Sibbaldia procumbens*	43.70
279	Sapindales	*Sapindaceae*	*Acer macrophyllum*	43.05
280	Sapindales	*Sapindaceae*	*Acer glabrum*	43.05
281	Asparagales	*Orchidaceae*	*Corallorhiza maculata*	42.99
282	Ericales	*Ericaceae*	*Vaccinium oxycoccos*	42.70
283	Ericales	*Ericaceae*	*Vaccinium cespitosum*	42.70
284	Ericales	*Ericaceae*	*Vaccinium alaskaense*	42.70
285	Asparagales	*Iridaceae*	*Olsynium douglasii*	42.54
286	Lamiales	*Scrophulariaceae*	*Scrophularia californica*	42.50
287	Brassicales	*Brassicaceae*	*Cardamine occidentalis*	42.38
288	Brassicales	*Brassicaceae*	*Cardamine nuttallii*	42.38
289	Brassicales	*Brassicaceae*	*Cardamine angulata*	42.38
290	Brassicales	*Brassicaceae*	*Arabis furcata*	42.38

291	Brassicales	*Brassicaceae*	*Arabis eschscholtziana*	42.38
292	Brassicales	*Brassicaceae*	*Arabis divaricarpa*	42.38
293	Rosales	*Rosaceae*	*Aphanes arvensis*	42.26
294	Rosales	*Rosaceae*	*Comarum palustre*	42.26
295	Lamiales	*Lentibulariaceae*	*Pinguicula macroceras*	41.89
296	Asparagales	*Orchidaceae*	*Corallorhiza striata*	41.85
297	Asparagales	*Orchidaceae*	*Corallorhiza mertensiana*	41.85
298	Ericales	*Ericaceae*	*Pterospora andromedea*	41.79
299	Ericales	*Ericaceae*	*Monotropa uniflora*	41.79
300	Malphigiales	*Violaceae*	*Viola sempervirens*	41.33
301	Malphigiales	*Violaceae*	*Viola orbiculata*	41.33
302	Malphigiales	*Violaceae*	*Viola langsdorfii*	41.33
303	Malphigiales	*Violaceae*	*Viola howellii*	41.33
304	Malphigiales	*Violaceae*	*Viola flettii*	41.33
305	Ericales	*Primulaceae*	*Lysimachia maritima*	41.17
306	Ericales	*Primulaceae*	*Trientalis borealis*	41.17
307	Poales	*Typhaceae*	*Sparganium natans*	40.89
308	Poales	*Typhaceae*	*Sparganium fluctuans*	40.89
309	Saxifragales	*Saxifragaceae*	*Saxifraga mertensiana*	40.88
310	Saxifragales	*Saxifragaceae*	*Saxifraga cespitosa*	40.88
311	Fagales	*Betulaceae*	*Betula glandulosa*	40.74
312	Fagales	*Betulaceae*	*Corylus cornuta*	40.74
313	Caryophyllales	*Amaranthaceae*	*Salicornia virginica*	40.26

314	Caryophyllales	*Amaranthaceae*	*Atriplex patula*	40.26
315	Liliales	*Melanthiaceae*	*Veratrum viride*	40.17
316	Liliales	*Melanthiaceae*	*Veratrum californicum*	40.17
317	Fagales	*Betulaceae*	*Alnus rubra*	39.90
318	Fagales	*Betulaceae*	*Alnus alnobetula*	39.90
319	Brassicales	*Brassicaceae*	*Draba stenoloba*	39.85
320	Brassicales	*Brassicaceae*	*Draba paysonii*	39.85
321	Brassicales	*Brassicaceae*	*Draba lonchocarpa*	39.85
322	Brassicales	*Brassicaceae*	*Draba juvenilis*	39.85
323	Caryophyllales	*Caryophyllaceae*	*Minuartia rossii*	39.73
324	Caryophyllales	*Caryophyllaceae*	*Minuartia obtusiloba*	39.73
325	Caryophyllales	*Polygonaceae*	*Polygonum douglasii*	39.69
326	Caryophyllales	*Polygonaceae*	*Oxyria digyna*	39.69
327	Caryophyllales	*Polygonaceae*	*Rumex salicifolius*	39.59
328	Caryophyllales	*Polygonaceae*	*Rumex occidentalis*	39.59
329	Caryophyllales	*Polygonaceae*	*Rumex maritimus*	39.59
330	Malphigiales	*Salicaceae*	*Populus tremuloides*	39.32
331	Malphigiales	*Salicaceae*	*Populus trichocarpa*	39.32
332	Saxifragales	*Grossulariaceae*	*Ribes lacustre*	39.26
333	Saxifragales	*Grossulariaceae*	*Ribes howellii*	39.26
334	Ericales	*Polemoniaceae*	*Microsteris gracilis*	38.42
335	Myrtales	*Onagraceae*	*Epilobium oregonense*	38.38
336	Myrtales	*Onagraceae*	*Epilobium mirabile*	38.38

337	Myrtales	*Onagraceae*	*Epilobium luteum*	38.38
338	Myrtales	*Onagraceae*	*Epilobium lanatum*	38.38
339	Myrtales	*Onagraceae*	*Epilobium halleanum*	38.38
340	Myrtales	*Onagraceae*	*Epilobium glaberrimum*	38.38
341	Myrtales	*Onagraceae*	*Epilobium clavatum*	38.38
342	Myrtales	*Onagraceae*	*Epilobium angustifolium*	38.38
343	Myrtales	*Onagraceae*	*Circaea alpina*	38.38
344	Boraginales	*Boraginaceae*	*Myosotis laxa*	38.36
345	Boraginales	*Boraginaceae*	*Mertensia paniculata*	38.36
346	Rosales	*Rosaceae*	*Spiraea douglasii*	38.00
347	Poales	*Cyperaceae*	*Scirpus atrocinctus*	37.60
348	Poales	*Cyperaceae*	*Bolboschoenus fluviatilis*	37.60
349	Asterales	*Asteraceae*	*Sisyrinchium littorale*	37.37
350	Asterales	*Asteraceae*	*Sisyrinchium idahoense*	37.37
351	Lamiales	*Orobanchaceae*	*Orthocarpus imbricatus*	37.36
352	Ranunculales	*Ranunculaceae*	*Actaea rubra*	37.21
353	Ranunculales	*Ranunculaceae*	*Actaea elata*	37.21
354	Poales	*Poaceae*	*Stipa nelsonii*	37.13
355	Poales	*Poaceae*	*Stipa lemmonii*	37.13
356	Alismatales	*Potamogetonaceae*	*Potamogeton amplifolius*	36.98
357	Liliales	*Melanthiaceae*	*Maianthemum dilatatum*	36.84
358	Liliales	*Melanthiaceae*	*Streptopus lanceolatus*	36.77
359	Liliales	*Melanthiaceae*	*Streptopus amplexifolius*	36.77

360	Alismatales	*Zosteraceae*	*Phyllospadix serrulatus*	36.69
361	Saxifragales	*Grossulariaceae*	*Ribes bracteosum*	36.67
362	Saxifragales	*Grossulariaceae*	*Ribes triste*	36.67
363	Ericales	*Primulaceae*	*Dodecatheon pulchellum*	36.37
364	Ericales	*Primulaceae*	*Dodecatheon jeffreyi*	36.37
365	Ericales	*Primulaceae*	*Dodecatheon hendersonii*	36.37
366	Ericales	*Primulaceae*	*Dodecatheon dentatum*	36.37
367	Ericales	*Primulaceae*	*Dodecatheon austrofrigidum*	36.37
368	Ericales	*Ericaceae*	*Chimaphila umbellata*	36.26
369	Rosales	*Rosaceae*	*Oemleria cerasiformis*	36.21
370	Liliales	*Melanthiaceae*	*Maianthemum stellatum*	36.04
371	Liliales	*Melanthiaceae*	*Maianthemum racemosum*	36.04
372	Caryophyllales	*Polygonaceae*	*Polygonum nuttallii*	35.99
373	Caryophyllales	*Polygonaceae*	*Polygonum newberryi*	35.99
374	Caryophyllales	*Polygonaceae*	*Polygonum minimum*	35.99
375	Caryophyllales	*Polygonaceae*	*Polygonum hydropiper*	35.99
376	Caryophyllales	*Polygonaceae*	*Polygonum bistortoides*	35.99
377	Rosales	*Rosaceae*	*Luetkea pectinata*	35.98
378	Rosales	*Rosaceae*	*Holodiscus discolor*	35.98
379	Ericales	*Ericaceae*	*Cassiope mertensiana*	35.79
380	Alismatales	*Zosteraceae*	*Zostera marina*	35.71
381	Rosales	*Rosaceae*	*Potentilla drummondii*	35.63
382	Rosales	*Rosaceae*	*Dasiphora fruticosa*	35.63

383	Lamiales	*Lamiaceae*	*Stachys mexicana*	35.50
384	Lamiales	*Lamiaceae*	*Micromeria douglasii*	35.50
385	Asterales	*Asteraceae*	*Taraxacum olympicum*	35.42
386	Asterales	*Asteraceae*	*Taraxacum campylodes*	35.42
387	Asterales	*Asteraceae*	*Madia gracilis*	35.42
388	Asterales	*Asteraceae*	*Madia exigua*	35.42
389	Asterales	*Asteraceae*	*Hieracium scouleri*	35.42
390	Asterales	*Asteraceae*	*Hieracium froelichianum*	35.42
391	Asterales	*Asteraceae*	*Gnaphalium purpureum*	35.42
392	Asterales	*Asteraceae*	*Gnaphalium palustre*	35.42
393	Asterales	*Asteraceae*	*Artemisia suksdorfii*	35.42
394	Asterales	*Asteraceae*	*Artemisia furcata*	35.42
395	Asterales	*Asteraceae*	*Agoseris monticola*	35.42
396	Asterales	*Asteraceae*	*Agoseris glauca*	35.42
397	Malphigiales	*Violaceae*	*Viola adunca*	35.27
398	Saxifragales	*Grossulariaceae*	*Ribes sanguineum*	34.56
399	Saxifragales	*Grossulariaceae*	*Ribes laxiflorum*	34.56
400	Malphigiales	*Violaceae*	*Viola palustris*	34.25
401	Malphigiales	*Violaceae*	*Viola glabella*	34.25
402	Asterales	*Campanulaceae*	*Campanula scouleri*	34.17
403	Asterales	*Campanulaceae*	*Campanula rotundifolia*	34.17
404	Malphigiales	*Salicaceae*	*Salix reticulata*	34.03
405	Malphigiales	*Salicaceae*	*Salix arctica*	34.03

406	Liliales	*Liliaceae*	*Lilium columbianum*	33.86
407	Liliales	*Liliaceae*	*Fritillaria affinis*	33.86
408	Saxifragales	*Saxifragaceae*	*Leptarrhena pyrolifolia*	33.58
409	Lamiales	*Plantaginaceae*	*Tonella tenantha*	33.48
410	Lamiales	*Plantaginaceae*	*Synthyris schizantha*	33.48
411	Lamiales	*Plantaginaceae*	*Plantago macrocarpa*	33.48
412	Lamiales	*Plantaginaceae*	*Penstemon procerus*	33.48
413	Apiales	*Apiaceae*	*Sanicula graveolens*	33.23
414	Apiales	*Apiaceae*	*Sanicula crassicaulis*	33.23
415	Poales	*Poaceae*	*Melica subulata*	33.15
416	Poales	*Poaceae*	*Melica smithii*	33.15
417	Poales	*Poaceae*	*Melica harfordii*	33.15
418	Poales	*Poaceae*	*Festuca subuliflora*	33.15
419	Poales	*Poaceae*	*Festuca subulata*	33.15
420	Poales	*Poaceae*	*Festuca saximontana*	33.15
421	Poales	*Poaceae*	*Elymus trachycaulis*	33.15
422	Poales	*Poaceae*	*Elymus occidentalis*	33.15
423	Poales	*Poaceae*	*Elymus hirsutus*	33.15
424	Poales	*Poaceae*	*Bromus vulgaris*	33.15
425	Poales	*Poaceae*	*Bromus sitchensis*	33.15
426	Poales	*Poaceae*	*Bromus pacificus*	33.15
427	Ranunculales	*Ranunculaceae*	*Anemone occidentalis*	32.76
428	Poales	*Typhaceae*	*Sparganium eurycarpum*	32.65

429	Dipsacales	*Caprifoliaceae*	*Lonicera involucrata*	32.58
430	Dipsacales	*Caprifoliaceae*	*Lonicera hispidula*	32.58
431	Saxifragales	*Grossulariaceae*	*Ribes lobbii*	32.25
432	Saxifragales	*Grossulariaceae*	*Ribes divaricatum*	32.25
433	Caryophyllales	*Caryophyllaceae*	*Stellaria obtusa*	32.14
434	Caryophyllales	*Caryophyllaceae*	*Stellaria nitens*	32.14
435	Caryophyllales	*Caryophyllaceae*	*Stellaria humifusa*	32.14
436	Caryophyllales	*Caryophyllaceae*	*Stellaria crispa*	32.14
437	Caryophyllales	*Caryophyllaceae*	*Stellaria calycantha*	32.14
438	Ericales	*Ericaceae*	*Moneses uniflora*	32.12
439	Ericales	*Ericaceae*	*Chimaphila menziesii*	32.12
440	Poales	*Juncaceae*	*Luzula multiflora*	32.00
441	Asterales	*Asteraceae*	*Erigeron peregrinus*	31.61
442	Asterales	*Asteraceae*	*Erigeron flettii*	31.61
443	Asterales	*Asteraceae*	*Erigeron aliceae*	31.61
444	Fagales	*Fabaceae*	*Oxytropis campestris*	31.42
445	Rosales	*Rosaceae*	*Prunus emarginata*	31.17
446	Rosales	*Rosaceae*	*Prunus virginiana*	31.17
447	Poales	*Poaceae*	*Calamagrostis sesquiflora*	31.16
448	Poales	*Poaceae*	*Calamagrostis nutkaensis*	31.16
449	Poales	*Poaceae*	*Calamagrostis inexpansa*	31.16
450	Poales	*Poaceae*	*Calamagrostis crassiglumis*	31.16
451	Poales	*Poaceae*	*Agrostis variabilis*	31.16

452	Poales	*Poaceae*	*Agrostis oregonensis*	31.16
453	Poales	*Poaceae*	*Agrostis humilis*	31.16
454	Poales	*Poaceae*	*Agrostis aequivalvis*	31.16
455	Lamiales	*Orobanchaceae*	*Orobanche fasciculata*	30.67
456	Ericales	*Ericaceae*	*Orthilia secunda*	30.18
457	Saxifragales	*Saxifragaceae*	*Saxifraga bronchialis*	29.83
458	Asterales	*Asteraceae*	*Senecio neowebsteri*	29.71
459	Asterales	*Asteraceae*	*Senecio multiradiata*	29.71
460	Asterales	*Asteraceae*	*Senecio lugens*	29.71
461	Asterales	*Asteraceae*	*Senecio fremontii*	29.71
462	Asterales	*Asteraceae*	*Arnica rydbergii*	29.71
463	Asterales	*Asteraceae*	*Arnica parryi*	29.71
464	Asterales	*Asteraceae*	*Arnica ovata*	29.71
465	Asterales	*Asteraceae*	*Arnica nevadensis*	29.71
466	Lamiales	*Orobanchaceae*	*Boschniakia hookeri*	28.82
467	Rosales	*Rosaceae*	*Potentilla gracilis*	28.71
468	Rosales	*Rosaceae*	*Potentilla villosa*	28.71
469	Poales	*Typhaceae*	*Sparganium emersum*	28.68
470	Poales	*Typhaceae*	*Sparganium angustifolium*	28.68
471	Poales	*Cyperaceae*	*Schoenoplectus subterminalis*	28.53
472	Poales	*Cyperaceae*	*Schoenoplectus acutus*	28.53
473	Lamiales	*Orobanchaceae*	*Pedicularis contorta*	28.48
474	Lamiales	*Orobanchaceae*	*Pedicularis bracteosa*	28.48

475	Lamiales	*Orobanchaceae*	*Orobanche pinorum*	28.48
476	Lamiales	*Orobanchaceae*	*Orobance unflora*	28.48
477	Lamiales	*Orobanchaceae*	*Castilleja parviflora*	28.48
478	Lamiales	*Orobanchaceae*	*Castilleja hispida*	28.48
479	Poales	*Poaceae*	*Poa wheeleri*	28.17
480	Poales	*Poaceae*	*Poa suksdorfii*	28.17
481	Poales	*Poaceae*	*Poa stenantha*	28.17
482	Poales	*Poaceae*	*Poa rupicola*	28.17
483	Poales	*Poaceae*	*Poa pacispicula*	28.17
484	Poales	*Poaceae*	*Poa marcida*	28.17
485	Poales	*Poaceae*	*Poa laxiflora*	28.17
486	Poales	*Poaceae*	*Poa confinis*	28.17
487	Asterales	*Asteraceae*	*Antennaria umbrinella*	27.80
488	Asterales	*Asteraceae*	*Antennaria racemosa*	27.80
489	Asterales	*Asteraceae*	*Antennaria neglecta*	27.80
490	Asterales	*Asteraceae*	*Antennaria media*	27.80
491	Asterales	*Asteraceae*	*Antennaria lanata*	27.80
492	Asterales	*Asteraceae*	*Antennaria howellii*	27.80
493	Ranunculales	*Ranunculaceae*	*Myosurus minimus*	27.74
494	Ranunculales	*Ranunculaceae*	*Trautvetteria caroliniensis*	27.63
495	Ranunculales	*Ranunculaceae*	*Halerpestes cymbalaria*	27.63
496	Alismatales	*Zosteraceae*	*Phyllospadix torreyi*	27.57
497	Alismatales	*Zosteraceae*	*Phyllospadix scouleri*	27.57

498	Gentianales	*Gentianaceae*	*Gentiana sceptrum*	27.50
499	Gentianales	*Gentianaceae*	*Gentiana douglasiana*	27.50
500	Gentianales	*Gentianaceae*	*Gentiana calycosa*	27.50
501	Gentianales	*Gentianaceae*	*Gentiana amarella*	27.50
502	Asterales	*Asteraceae*	*Hieracium albiflorum*	27.32
503	Saxifragales	*Saxifragaceae*	*Saxifraga oppositifolia*	27.28
504	Saxifragales	*Saxifragaceae*	*Saxifraga rivularis*	27.28
505	Asterales	*Asteraceae*	*Lactuca biennis*	27.10
506	Ranunculales	*Ranunculaceae*	*Delphinium menziesii*	26.98
507	Ranunculales	*Ranunculaceae*	*Delphinium glaucum*	26.98
508	Poales	*Juncaceae*	*Luzula piperi*	26.19
509	Poales	*Juncaceae*	*Luzula hitchcockii*	26.19
510	Caryophyllales	*Polygonaceae*	*Potamogeton natans*	26.17
511	Apiales	*Apiaceae*	*Cicuta douglasii*	26.16
512	Apiales	*Apiaceae*	*Oenanthe sarmentosa*	25.96
513	Apiales	*Apiaceae*	*Perideridia gairdneri*	25.96
514	Ericales	*Polemoniaceae*	*Polemonium carneum*	25.91
515	Ericales	*Polemoniaceae*	*Collomia heterophylla*	25.82
516	Dipsacales	*Caprifoliaceae*	*Symphoricarpos mollis*	25.59
517	Dipsacales	*Caprifoliaceae*	*Symphoricarpos albus*	25.59
518	Lamiales	*Plantaginaceae*	*Veronica cusickii*	25.55
519	Lamiales	*Plantaginaceae*	*Veronica americana*	25.55
520	Lamiales	*Plantaginaceae*	*Synthyris reniformis*	25.55

521	Lamiales	*Plantaginaceae*	*Synthyris pinnatifida*	25.55
522	Caryophyllales	*Montiaceae*	*Lewisia columbiana*	25.44
523	Ericales	*Ericaceae*	*Empetrum nigrum*	25.39
524	Rosales	*Rosaceae*	*Fragaria vesca*	24.94
525	Poales	*Juncaceae*	*Juncus filiformis*	24.68
526	Caryophyllales	*Caryophyllaceae*	*Spergularia marina*	24.19
527	Alismatales	*Potamogetonaceae*	*Potamogeton epihydrus*	23.85
528	Lamiales	*Phrymaceae*	*Mimulus tilingii*	23.70
529	Lamiales	*Phrymaceae*	*Mimulus dentatus*	23.70
530	Rosales	*Rosaceae*	*Fragaria virginiana*	23.11
531	Rosales	*Rosaceae*	*Fragaria chiloensis*	23.11
532	Ericales	*Ericaceae*	*Pyrola asarifolia*	23.07
533	Ericales	*Ericaceae*	*Pyrola minor*	23.07
534	Poales	*Juncaceae*	*Luzula parviflora*	23.05
535	Gentianales	*Rubiaceae*	*Kelloggia galioides*	23.04
536	Alismatales	*Potamogetonaceae*	*Potamogeton compressus*	22.57
537	Alismatales	*Potamogetonaceae*	*Potamogeton berchtoldii*	22.57
538	Ericales	*Ericaceae*	*Pyrola picta*	22.56
539	Ericales	*Ericaceae*	*Pyrola chlorantha*	22.56
540	Ranunculales	*Ranunculaceae*	*Anemone parviflora*	22.23
541	Ranunculales	*Ranunculaceae*	*Anemone multifida*	22.23
542	Ericales	*Polemoniaceae*	*Collomia linearis*	22.22
543	Ericales	*Polemoniaceae*	*Collomia grandiflora*	22.22

544	Rosales	*Rosaceae*	*Rosa nutkana*	22.20
545	Asterales	*Asteraceae*	*Petasites frigidus*	22.13
546	Asterales	*Asteraceae*	*Crocidium multicaule*	22.13
547	Rosales	*Rosaceae*	*Rosa pisocarpa*	21.79
548	Rosales	*Rosaceae*	*Rosa gymnocarpa*	21.79
549	Asterales	*Asteraceae*	*Anaphalis margaritacea*	21.68
550	Alismatales	*Potamogetonaceae*	*Potamogeton gramineus*	21.60
551	Poales	*Juncaceae*	*Juncus supiniformis*	21.31
552	Poales	*Juncaceae*	*Juncus saximontanus*	21.31
553	Poales	*Juncaceae*	*Juncus orthophyllus*	21.31
554	Poales	*Juncaceae*	*Juncus mertensianus*	21.31
555	Poales	*Juncaceae*	*Juncus acuminatus*	21.31
556	Ericales	*Polemoniaceae*	*Polemonium pulcherrimum*	21.05
557	Ericales	*Polemoniaceae*	*Polemonium californicum*	21.05
558	Alismatales	*Potamogetonaceae*	*Potamogeton robbinsii*	20.80
559	Alismatales	*Potamogetonaceae*	*Potamogeton richardsonii*	20.80
560	Myrtales	*Onagraceae*	*Epilobium ciliatum*	20.52
561	Myrtales	*Onagraceae*	*Epilobium minutum*	20.40
562	Poales	*Cyperaceae*	*Carex utriculata*	20.22
563	Poales	*Cyperaceae*	*Carex stylosa*	20.22
564	Poales	*Cyperaceae*	*Carex spectabilis*	20.22
565	Poales	*Cyperaceae*	*Carex scirpiformis*	20.22
566	Poales	*Cyperaceae*	*Carex preslii*	20.22

567	Poales	*Cyperaceae*	*Carex pluriflora*	20.22
568	Poales	*Cyperaceae*	*Carex petasata*	20.22
569	Poales	*Cyperaceae*	*Carex obnupta*	20.22
570	Poales	*Cyperaceae*	*Carex nigricans*	20.22
571	Poales	*Cyperaceae*	*Carex neurophora*	20.22
572	Poales	*Cyperaceae*	*Carex multimoda*	20.22
573	Poales	*Cyperaceae*	*Carex lenticularis*	20.22
574	Poales	*Cyperaceae*	*Carex interrupta*	20.22
575	Poales	*Cyperaceae*	*Carex inops*	20.22
576	Poales	*Cyperaceae*	*Carex hendersonii*	20.22
577	Poales	*Cyperaceae*	*Carex exsiccata*	20.22
578	Poales	*Cyperaceae*	*Carex engelmanii*	20.22
579	Poales	*Cyperaceae*	*Carex circinnata*	20.22
580	Poales	*Cyperaceae*	*Carex californica*	20.22
581	Poales	*Cyperaceae*	*Carex athrostachya*	20.22
582	Poales	*Cyperaceae*	*Carex arctiformis*	20.22
583	Poales	*Cyperaceae*	*Carex aperta*	20.22
584	Poales	*Cyperaceae*	*Carex albonigra*	20.22
585	Poales	*Cyperaceae*	*Carex ablata*	20.22
586	Caryophyllales	*Montiaceae*	*Claytonia exigua*	20.09
587	Caryophyllales	*Montiaceae*	*Claytonia cordifolia*	20.09
588	Liliales	*Liliaceae*	*Erythronium montanum*	19.92
589	Liliales	*Liliaceae*	*Erythronium grandiflorum*	19.92

590	Liliales	*Liliaceae*	*Erythronium revolutum*	19.91
591	Liliales	*Liliaceae*	*Erythronium oregonum*	19.91
592	Asterales	*Asteraceae*	*Cirsium arvense*	19.79
593	Lamiales	*Lentibulariaceae*	*Utricularia minor*	19.53
594	Rosales	*Rosaceae*	*Sorbus scopulina*	19.24
595	Boraginales	*Boraginaceae*	*Nemophila parviflora*	19.08
596	Boraginales	*Boraginaceae*	*Hydrophyllum tenuipes*	19.08
597	Apiales	*Apiaceae*	*Osmorhiza depauperata*	19.07
598	Apiales	*Apiaceae*	*Osmorhiza berteroi*	19.07
599	Ericales	*Ericaceae*	*Gaultheria shallon*	18.94
600	Ericales	*Ericaceae*	*Gaultheria ovatifolia*	18.94
601	Boraginales	*Boraginaceae*	*Phacelia nemoralis*	18.81
602	Myrtales	*Onagraceae*	*Epilobium anagallidifolium*	18.74
603	Ranunculales	*Ranunculaceae*	*Ranunculus uncinatus*	18.52
604	Ranunculales	*Ranunculaceae*	*Ranunculus flammula*	18.52
605	Asterales	*Asteraceae*	*Adenocaulon bicolor*	18.31
606	Lamiales	*Lentibulariaceae*	*Utricularia vulgaris*	18.16
607	Lamiales	*Lentibulariaceae*	*Utricularia intermedia*	18.16
608	Gentianales	*Rubiaceae*	*Galium trifidum*	18.10
609	Ericales	*Ericaceae*	*Vaccinium uliginosum*	17.89
610	Rosales	*Rosaceae*	*Malus fusca*	17.69
611	Saxifragales	*Saxifragaceae*	*Tolmiea menziesii*	17.57
612	Lamiales	*Lamiaceae*	*Stachys chamissonis*	17.49

613	Lamiales	*Lamiaceae*	*Marrubium vulgare*	17.49
614	Ericales	*Ericaceae*	*Vaccinium ovatum*	17.49
615	Fabales	*Fabaceae*	*Acmispon denticulatus*	17.48
616	Caryophyllales	*Montiaceae*	*Montia parvifolia*	17.41
617	Caryophyllales	*Montiaceae*	*Montia howellii*	17.41
618	Caryophyllales	*Montiaceae*	*Montia diffusa*	17.41
619	Caryophyllales	*Montiaceae*	*Montia dichotoma*	17.41
620	Boraginales	*Boraginaceae*	*Phacelia sericea*	17.38
621	Boraginales	*Boraginaceae*	*Phacelia linearis*	17.38
622	Myrtales	*Onagraceae*	*Epilobium lactiflorum*	17.20
623	Myrtales	*Onagraceae*	*Epilobium hornemannii*	17.20
624	Rosales	*Rosaceae*	*Amelanchier alnifolia*	17.17
625	Poales	*Cyperaceae*	*Rhynchospora alba*	16.98
626	Asterales	*Asteraceae*	*Taraxacum officinale*	16.92
627	Asterales	*Asteraceae*	*Agoseris elata*	16.92
628	Fabales	*Fabaceae*	*Vicia nigricans*	16.77
629	Fabales	*Fabaceae*	*Vicia americana*	16.77
630	Fabales	*Fabaceae*	*Acmispon parviflorus*	16.70
631	Fabales	*Fabaceae*	*Acmispon americanus*	16.70
632	Gentianales	*Rubiaceae*	*Galium aparine*	16.68
633	Gentianales	*Rubiaceae*	*Galium triflorum*	16.68
634	Lamiales	*Phrymaceae*	*Mimulus alsinoides*	16.60
635	Ericales	*Ericaceae*	*Rhododendron macrophyllum*	16.49

636	Poales	*Juncaceae*	*Luzula spicata*	16.34
637	Poales	*Juncaceae*	*Juncus parryi*	16.16
638	Poales	*Juncaceae*	*Juncus drummondii*	16.16
639	Lamiales	*Lamiaceae*	*Mentha arvensis*	16.14
640	Lamiales	*Orobanchaceae*	*Castilleja miniata*	15.85
641	Lamiales	*Orobanchaceae*	*Triphysaria pusilla*	15.85
642	Caryophyllales	*Caryophyllaceae*	*Honckenya peploides*	15.83
643	Lamiales	*Phrymaceae*	*Mimulus moschatus*	15.47
644	Lamiales	*Phrymaceae*	*Mimulus guttatus*	15.47
645	Ranunculales	*Ranunculaceae*	*Ranunculus eschscholtzii*	15.40
646	Ericales	*Ericaceae*	*Menziesia ferruginea*	15.38
647	Ericales	*Ericaceae*	*Rhododendron albiflorum*	15.38
648	Gentianales	*Rubiaceae*	*Galium boreale*	15.35
649	Gentianales	*Rubiaceae*	*Galium bifolium*	15.35
650	Apiales	*Apiaceae*	*Conioselinum vaginatum*	15.14
651	Caryophyllales	*Caryophyllaceae*	*Cerastium glomeratum*	15.13
652	Lamiales	*Orobanchaceae*	*Pedicularis racemosa*	15.08
653	Lamiales	*Orobanchaceae*	*Pedicularis groenlandica*	15.08
654	Ranunculales	*Ranunculaceae*	*Ranunculus trichophyllus*	15.05
655	Ranunculales	*Ranunculaceae*	*Ranunculus aquatilis*	15.05
656	Lamiales	*Lamiaceae*	*Lycopus uniflorus*	15.02
657	Lamiales	*Lamiaceae*	*Prunella vulgaris*	15.02
658	Poales	*Poaceae*	*Phragmites australis*	15.02

659	Lamiales	*Phrymaceae*	*Mimulus primuloides*	14.94
660	Saxifragales	*Saxifragaceae*	*Boykinia intermedia*	14.59
661	Brassicales	*Brassicaceae*	*Subularia aquatica*	14.52
662	Lamiales	*Plantaginaceae*	*Hippuris vulgaris*	14.49
663	Rosales	*Rosaceae*	*Crataegus suksdorfii*	14.28
664	Rosales	*Rosaceae*	*Crataegus douglasii*	14.28
665	Saxifragales	*Saxifragaceae*	*Tiarella trifoliata*	14.26
666	Saxifragales	*Saxifragaceae*	*Elmera racemosa*	14.26
667	Poales	*Juncaceae*	*Juncus canadensis*	14.16
668	Poales	*Juncaceae*	*Juncus bolanderi*	14.16
669	Poales	*Juncaceae*	*Juncus tenuis*	14.16
670	Poales	*Juncaceae*	*Juncus bufonius*	14.16
671	Caryophyllales	*Caryophyllaceae*	*Minuartia rubella*	14.09
672	Saxifragales	*Saxifragaceae*	*Tellima grandiflora*	14.02
673	Saxifragales	*Saxifragaceae*	*Heuchera micrantha*	14.02
674	Poales	*Cyperaceae*	*Dulichium arundinaceum*	13.78
675	Brassicales	*Brassicaceae*	*Smelowskia calycina*	13.65
676	Brassicales	*Brassicaceae*	*Rorippa curvisiliqua*	13.65
677	Ericales	*Ericaceae*	*Elliottia pyroliflora*	13.54
678	Lamiales	*Phrymaceae*	*Mimulus breweri*	13.49
679	Lamiales	*Phrymaceae*	*Mimulus lewisii*	13.49
680	Poales	*Poaceae*	*Panicum capillare*	13.47
681	Fabales	*Fabaceae*	*Lupinus arcticus*	13.40

682	Fabales	*Fabaceae*	*Lupinus rivularis*	13.35
683	Fabales	*Fabaceae*	*Lupinus lepidus*	13.32
684	Fabales	*Fabaceae*	*Lupinus polyphyllus*	13.27
685	Fabales	*Fabaceae*	*Lupinus latifolius*	13.27
686	Poales	*Juncaceae*	*Juncus effusus*	13.23
687	Poales	*Juncaceae*	*Juncus conglomeratus*	13.23
688	Poales	*Juncaceae*	*Luzula congesta*	12.96
689	Poales	*Juncaceae*	*Luzula campestris*	12.96
690	Caryophyllales	*Portulacaceae*	*Calandrinia ciliata*	12.85
691	Poales	*Cyperaceae*	*Schoenoplectus tabernaemontani*	12.54
692	Poales	*Cyperaceae*	*Isolepis cernua*	12.54
693	Poales	*Juncaceae*	*Juncus articulatus*	12.50
694	Caryophyllales	*Caryophyllaceae*	*Stellaria longipes*	12.34
695	Caryophyllales	*Caryophyllaceae*	*Stellaria borealis*	12.34
696	Brassicales	*Brassicaceae*	*Barbarea orthoceras*	12.33
697	Apiales	*Apiaceae*	*Angelica lucida*	12.10
698	Poales	*Cyperaceae*	*Trichophorum cespitosum*	12.05
699	Fabales	*Fabaceae*	*Lathyrus palustris*	11.89
700	Lamiales	*Plantaginaceae*	*Collinsia parviflora*	11.83
701	Lamiales	*Plantaginaceae*	*Collinsia grandiflora*	11.83
702	Caryophyllales	*Montiaceae*	*Lewisia pygmaea*	11.72
703	Fabales	*Fabaceae*	*Lathyrus nevadensis*	11.63

704	Fabales	*Fabaceae*	*Lathyrus japonicus*	11.63
705	Caryophyllales	*Caryophyllaceae*	*Sagina saginoides*	11.56
706	Caryophyllales	*Caryophyllaceae*	*Sagina decumbens*	11.56
707	Fabales	*Fabaceae*	*Trifolium longipes*	11.56
708	Caryophyllales	*Caryophyllaceae*	*Cerastium semidecandrum*	11.41
709	Caryophyllales	*Caryophyllaceae*	*Cerastium arvense*	11.41
710	Apiales	*Apiaceae*	*Glehnia littoralis*	11.41
711	Apiales	*Apiaceae*	*Angelica arguta*	11.41
712	Asterales	*Asteraceae*	*Eriophyllum lanatum*	11.26
713	Asterales	*Asteraceae*	*Microseris borealis*	11.14
714	Ericales	*Ericaceae*	*Vaccinium parvifolium*	11.10
715	Lamiales	*Plantaginaceae*	*Plantago maritima*	11.09
716	Lamiales	*Plantaginaceae*	*Digitalis purpurea*	11.09
717	Fabales	*Fabaceae*	*Trifolium cyathiferum*	11.03
718	Brassicales	*Brassicaceae*	*Cardamine pensylvanica*	11.00
719	Fabales	*Fabaceae*	*Trifolium oliganthum*	11.00
720	Fabales	*Fabaceae*	*Trifolium microcephalum*	11.00
721	Caryophyllales	*Caryophyllaceae*	*Silene antirrhina*	10.98
722	Caryophyllales	*Caryophyllaceae*	*Silene acaulis*	10.98
723	Ericales	*Ericaceae*	*Vaccinium ovalifolium*	10.97
724	Ericales	*Ericaceae*	*Kalmia polifolia*	10.97
725	Ericales	*Ericaceae*	*Kalmia microphylla*	10.97
726	Apiales	*Apiaceae*	*Lomatium dissectum*	10.94

727	Apiales	*Apiaceae*	*Lomatium nudicaule*	10.94
728	Ericales	*Ericaceae*	*Phyllodoce glanduliflora*	10.90
729	Ericales	*Ericaceae*	*Phyllodoce empetriformis*	10.90
730	Lamiales	*Plantaginaceae*	*Nothochelone nemorosa*	10.86
731	Ericales	*Ericaceae*	*Vaccinium membranaceum*	10.73
732	Ericales	*Ericaceae*	*Vaccinium deliciosum*	10.73
733	Lamiales	*Plantaginaceae*	*Callitriche palustris*	10.70
734	Poales	*Poaceae*	*Distichlis spicata*	10.46
735	Brassicales	*Brassicaceae*	*Athysanus pusillus*	10.39
736	Brassicales	*Brassicaceae*	*Arabis hirsuta*	10.39
737	Lamiales	*Plantaginaceae*	*Callitriche stagnalis*	10.24
738	Poales	*Juncaceae*	*Juncus covillei*	10.19
739	Poales	*Juncaceae*	*Juncus balticus*	10.19
740	Lamiales	*Plantaginaceae*	*Callitriche heterophylla*	10.13
741	Lamiales	*Plantaginaceae*	*Callitriche hermaphroditica*	10.13
742	Asterales	*Asteraceae*	*Arnica longifolia*	10.12
743	Caryophyllales	*Caryophyllaceae*	*Silene scouleri*	10.03
744	Asterales	*Asteraceae*	*Madia sativa*	9.95
745	Asterales	*Asteraceae*	*Arnica mollis*	9.95
746	Asterales	*Asteraceae*	*Arnica cordifolia*	9.87
747	Asterales	*Asteraceae*	*Arnica latifolia*	9.87
748	Asterales	*Asteraceae*	*Achillea millefolium*	9.81
749	Poales	*Juncaceae*	*Juncus nevadensis*	9.80

750	Poales	*Juncaceae*	*Juncus ensifolius*	9.80
751	Poales	*Poaceae*	*Glyceria striata*	9.71
752	Caryophyllales	*Caryophyllaceae*	*Silene parryi*	9.64
753	Caryophyllales	*Caryophyllaceae*	*Silene douglasii*	9.64
754	Asterales	*Asteraceae*	*Agoseris aurantiaca*	9.63
755	Lamiales	*Montiaceae*	*Claytonia lanceolata*	9.61
756	Brassicales	*Brassicaceae*	*Cardamine oligosperma*	9.56
757	Asterales	*Asteraceae*	*Agoseris heterophylla*	9.54
758	Asterales	*Asteraceae*	*Agoseris grandiflora*	9.54
759	Lamiales	*Lamiaceae*	*Claytonia sibirica*	9.43
760	Lamiales	*Lamiaceae*	*Claytonia perfoliata*	9.43
761	Caryophyllales	*Montiaceae*	*Montia linearis*	9.25
762	Brassicales	*Brassicaceae*	*Turritis glabra*	9.25
763	Lamiales	*Plantaginaceae*	*Penstemon davidsonii*	9.01
764	Lamiales	*Plantaginaceae*	*Veronica serpyllifolia*	8.73
765	Lamiales	*Plantaginaceae*	*Veronica peregrina*	8.73
766	Caryophyllales	*Montiaceae*	*Montia fontana*	8.70
767	Caryophyllales	*Montiaceae*	*Montia chamissoi*	8.70
768	Brassicales	*Brassicaceae*	*Cardamine breweri*	8.68
769	Lamiales	*Plantaginaceae*	*Penstemon ovatus*	8.62
770	Lamiales	*Plantaginaceae*	*Penstemon serrulatus*	8.62
771	Poales	*Cyperaceae*	*Eleocharis acicularis*	8.59
772	Asterales	*Asteraceae*	*Artemisia arctica*	8.50

773	Lamiales	*Plantaginaceae*	*Veronica wormskjoldii*	8.47
774	Lamiales	*Plantaginaceae*	*Veronica scutellata*	8.47
775	Brassicales	*Brassicaceae*	*Cardamine bellidifolia*	8.40
776	Brassicales	*Brassicaceae*	*Rorippa palustris*	8.40
777	Brassicales	*Brassicaceae*	*Thysanocarpus curvipes*	8.19
778	Poales	*Cyperaceae*	*Carex aquatilis*	8.02
779	Poales	*Cyperaceae*	*Eleocharis palustris*	7.95
780	Poales	*Cyperaceae*	*Eleocharis ovata*	7.95
781	Asterales	*Asteraceae*	*Tanacetum bipinnatum*	7.69
782	Brassicales	*Brassicaceae*	*Thlaspi montanum*	7.56
783	Asterales	*Asteraceae*	*Artemisia ludoviciana*	7.54
784	Brassicales	*Brassicaceae*	*Erysimum capitatum*	7.38
785	Brassicales	*Brassicaceae*	*Erysimum asperum*	7.38
786	Brassicales	*Brassicaceae*	*Boechera stricta*	7.36
787	Brassicales	*Brassicaceae*	*Boechera lyallii*	7.36
788	Asterales	*Asteraceae*	*Artemisia tilesii*	7.20
789	Asterales	*Asteraceae*	*Artemisia campestris*	7.20
790	Poales	*Poaceae*	*Danthonia intermedia*	7.13
791	Poales	*Poaceae*	*Danthonia spicata*	6.88
792	Poales	*Poaceae*	*Danthonia californica*	6.88
793	Poales	*Cyperaceae*	*Carex rossii*	6.85
794	Poales	*Cyperaceae*	*Scirpus microcarpus*	6.82
795	Poales	*Cyperaceae*	*Carex raynoldsii*	6.55

796	Poales	*Cyperaceae*	*Carex buxbaumii*	6.55
797	Asterales	*Asteraceae*	*Eurybia radulina*	6.54
798	Asterales	*Asteraceae*	*Canadanthus modestus*	6.47
799	Poales	*Cyperaceae*	*Eriophorum chamissonis*	6.31
800	Poales	*Cyperaceae*	*Eriophorum angustifolium*	6.31
801	Poales	*Cyperaceae*	*Carex viridula*	6.24
802	Poales	*Poaceae*	*Bromus carinatus*	6.19
803	Brassicales	*Brassicaceae*	*Draba nemorosa*	5.99
804	Poales	*Poaceae*	*Elymus glaucus*	5.84
805	Poales	*Poaceae*	*Hordeum brachyantherum*	5.84
806	Poales	*Poaceae*	*Leymus mollis*	5.81
807	Poales	*Poaceae*	*Elymus elymoides*	5.81
808	Brassicales	*Brassicaceae*	*Draba cana*	5.79
809	Brassicales	*Brassicaceae*	*Draba crassifolia*	5.75
810	Brassicales	*Brassicaceae*	*Draba albertina*	5.75
811	Brassicales	*Brassicaceae*	*Draba praealta*	5.73
812	Brassicales	*Brassicaceae*	*Draba incerta*	5.73
813	Poales	*Cyperaceae*	*Carex amplifolia*	5.71
814	Asterales	*Asteraceae*	*Erigeron compositus*	5.62
815	Asterales	*Asteraceae*	*Symphyotrichum foliaceum*	5.61
816	Asterales	*Asteraceae*	*Symphyotrichum subspicatum*	5.61
817	Poales	*Cyperaceae*	*Carex macrocephala*	5.24
818	Asterales	*Asteraceae*	*Erigeron philadelphicus*	5.24

819	Poales	*Cyperaceae*	*Carex livida*	5.21
820	Poales	*Cyperaceae*	*Carex aurea*	5.21
821	Asterales	*Asteraceae*	*Erigeron acris*	5.10
822	Asterales	*Asteraceae*	*Erigeron subtrinervis*	5.06
823	Asterales	*Asteraceae*	*Erigeron speciosus*	5.06
824	Poales	*Cyperaceae*	*Carex mertensii*	4.91
825	Poales	*Cyperaceae*	*Carex lyngbyei*	4.91
826	Poales	*Cyperaceae*	*Carex anthoxanthea*	4.73
827	Poales	*Cyperaceae*	*Carex pyrenaica*	4.66
828	Poales	*Cyperaceae*	*Carex pauciflora*	4.66
829	Poales	*Cyperaceae*	*Carex obtusata*	4.53
830	Poales	*Cyperaceae*	*Carex nardina*	4.48
831	Poales	*Cyperaceae*	*Carex leptalea*	4.48
832	Poales	*Poaceae*	*Phleum alpinum*	4.41
833	Poales	*Cyperaceae*	*Carex deweyana*	4.31
834	Poales	*Poaceae*	*Cinna latifolia*	4.29
835	Poales	*Cyperaceae*	*Carex vesicaria*	4.16
836	Poales	*Cyperaceae*	*Carex saxatilis*	4.16
837	Poales	*Poaceae*	*Trisetum spicatum*	4.12
838	Poales	*Poaceae*	*Torreyochloa pallida*	4.01
839	Poales	*Poaceae*	*Anthoxanthum odoratum*	3.98
840	Poales	*Poaceae*	*Deschampsia elongata*	3.93
841	Poales	*Poaceae*	*Poa cusickii*	3.91

842	Poales	*Poaceae*	*Poa arctica*	3.91
843	Poales	*Poaceae*	*Alopecurus geniculatus*	3.73
844	Poales	*Poaceae*	*Alopecurus aequalis*	3.73
845	Poales	*Poaceae*	*Deschampsia danthonioides*	3.67
846	Poales	*Poaceae*	*Deschampsia cespitosa*	3.67
847	Poales	*Poaceae*	*Vulpia microstachys*	3.62
848	Poales	*Cyperaceae*	*Carex disperma*	3.58
849	Poales	*Cyperaceae*	*Carex stipata*	3.56
850	Poales	*Cyperaceae*	*Carex illota*	3.48
851	Poales	*Poaceae*	*Festuca occidentalis*	3.43
852	Poales	*Poaceae*	*Festuca idahoensis*	3.43
853	Poales	*Poaceae*	*Vulpia bromoides*	3.43
854	Poales	*Poaceae*	*Festuca rubra*	3.43
855	Poales	*Poaceae*	*Carex leporina*	3.43
856	Poales	*Poaceae*	*Calamagrostis purpurascens*	3.42
857	Poales	*Poaceae*	*Calamagrostis canadensis*	3.42
858	Poales	*Poaceae*	*Agrostis exarata*	3.33
859	Poales	*Poaceae*	*Agrostis scabra*	3.30
860	Poales	*Poaceae*	*Agrostis capillaris*	3.30
861	Poales	*Cyperaceae*	*Carex tumulicola*	3.26
862	Poales	*Cyperaceae*	*Carex hoodii*	3.26
863	Poales	*Cyperaceae*	*Carex laeviculmis*	3.24
864	Poales	*Cyperaceae*	*Carex arcta*	3.24

865	Poales	*Cyperaceae*	*Carex pansa*	3.19
866	Poales	*Cyperaceae*	*Carex cusickii*	3.19
867	Poales	*Cyperaceae*	*Carex interior*	3.17
868	Poales	*Cyperaceae*	*Carex echinata*	3.17
869	Poales	*Cyperaceae*	*Carex microptera*	2.98
870	Poales	*Cyperaceae*	*Carex praticola*	2.91
871	Poales	*Cyperaceae*	*Carex phaeocephala*	2.91

Appendix B

Angiosperms found within Olympic National Park and the Special Plants List (2019) ranked by RED-E score (Washington Department of Natural Resources Natural Heritage Program, 2019). RED-E scores are rounded to two decimal places, and differences in ranks represent actual differences in RED-E scores.

Rank	Scientific Name	NatureServe Rank	ED Score	RED-E Score
1	*Arcteranthis cooleyae (Ranunculus cooleyae)*	S1	106.79	7.45
2	*Whipplea modesta*	S1	64.98	6.96
3	*Coptis aspleniifolia*	S2	106.79	6.76
4	*Oxytropis borealis var. viscida*	S1S2	70.84	6.70
5	*Abronia umbellata var. acutalata (Abronia umbellata ssp. breviflora)*	S1	47.39	6.65
6	*Cochlearia groenlandica*	S1S2	62.6	6.58
7	*Micranthes tischii (Saxifraga tischii)*	S1?	43.73	6.57
8	*Sparganium fluctuans*	S1	40.89	6.51
9	*Dryas drummondii var. drummondii*	S2	82.49	6.50
10	*Epilobium mirabile (E. glandulosum var. macounii)*	S1	38.38	6.44
11	*Dodecatheon austrofrigidum*	S1	36.37	6.39
12	*Potentilla breweri (P. drummondii ssp. b)*	S1	35.62	6.37
13	*Hedysarum occidentale*	S2	70.84	6.35
14	*Chrysolepis chrysophylla var. chrysophylla*	S2	70.11	6.34
15	*Synthyris schizantha*	S1	33.48	6.31
16	*Sanguisorba menziesii*	S2	62.71	6.23
17	*Parnassia palustris*	S2	52.08	6.05
18	*Astragalus microcystis*	S2	47.79	5.96
19	*Astragalus australis var. cottonii*	S2	47.79	5.96
20	*Eurybia merita*	S2	46.86	5.95

21	*Arabis olympica (A. furcata var. olympica)*	S2	42.38	5.85
22	*Carex circinnata*	S1	20.22	5.83
23	*Plantago macrocarpa*	S2	33.48	5.62
24	*Oxytropis campestris var. gracilis (O. monticola)*	S2	31.42	5.56
25	*Erigeron peregrinus var. thompsonii*	S2	31.61	5.56
26	*Erigeron aliceae*	S2	31.61	5.56
27	*Gentiana douglasiana*	S2	27.50	5.43
28	*Polemonium carneum*	S2	25.91	5.37
29	*Montia diffusa*	S1S2	17.41	5.34
30	*Claytonia multiscapa var. pacifica (Claytonia lanceolata var. multiscapa)*	S1	9.61	5.13
31	*Carex stylosa*	S2	20.22	5.13
32	*Actaea elata var. elata (Cimicifuga elata)*	S3	37.21	5.03
33	*Draba cana*	S1	5.79	4.69
34	*Utricularia intermedia*	S2S3	18.16	4.68
35	*Synthyris lanuginosa*	S3?	25.55	4.66
36	*Microseris borealis*	S2	11.14	4.57
37	*Carex anthoxanthea*	S1	4.73	4.52
38	*Erythronium revolutum*	S3	19.91	4.42
39	*Carex pauciflora*	S2	4.66	3.81
40	*Carex obstusata*	S2	4.53	3.79

Appendix C

Code used to calculate ED scores in R.

```
#Load R packages

>library(picante)

#Load phylogeny

>olymztree <- read.tree(file= “olymzanne.txt”)

#Calculate ED for Olympic National Park angiosperms

>olymzed <- evol.distinct(olymztree, type =c(“fair.proportion”),
     scale = FALSE, use.branch.lengths = TRUE)

#Print to .csv file

write.csv(olymzed, ‘olymzed.csv’)
```

Appendix D

Code used to calculate RED-E scores in R.

```
#Load ED scores and RE scores into R

>edspecial<-read.csv("edspecial.csv", header=TRUE)

#Create a function to calculate RED-E scores

>rede <-function(x,y){return((log(1+x))+(y*(log(2))))}

#Name variables and run function

>x<-edspecial$EDScore


>y<-edspecial$REScore

>redespecial <-rede(x,y)

#Print to .csv file

>write.csv(redespecial, "redespecial.csv")
```