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

by

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This Thesis for the Master of Environmental Studies Degree

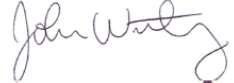
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ABSTRACT

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

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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,

Diagram

Description automatically generatedbudgetary 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.

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).

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).

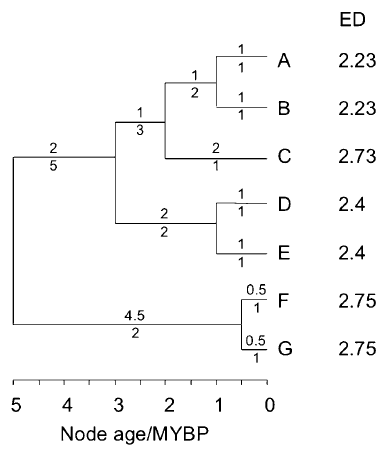


Figure 2. Hypothetical phylogeny from Isaac et al. (2007) showing the results and components of an ED calculation. A-G represent species, numbers below the branches represent branch length, numbers above the branches represent number of descendants, and ED scores for each species are listed to the right. 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](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):

RED-E = ln (1+ED) + RE \* ln(2)

EDGE = ln (1+ED) + 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.

Diagram

Description automatically generated

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).

Chart, histogram

Description automatically generated

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).

Chart, histogram

Description automatically generated

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.

A picture containing grass, outdoor, plant, tree

Description automatically generated

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

Diagram

Description automatically generated with medium confidence

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 A picture containing outdoor, grass, plant, field

Description automatically generatedvisually 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”)