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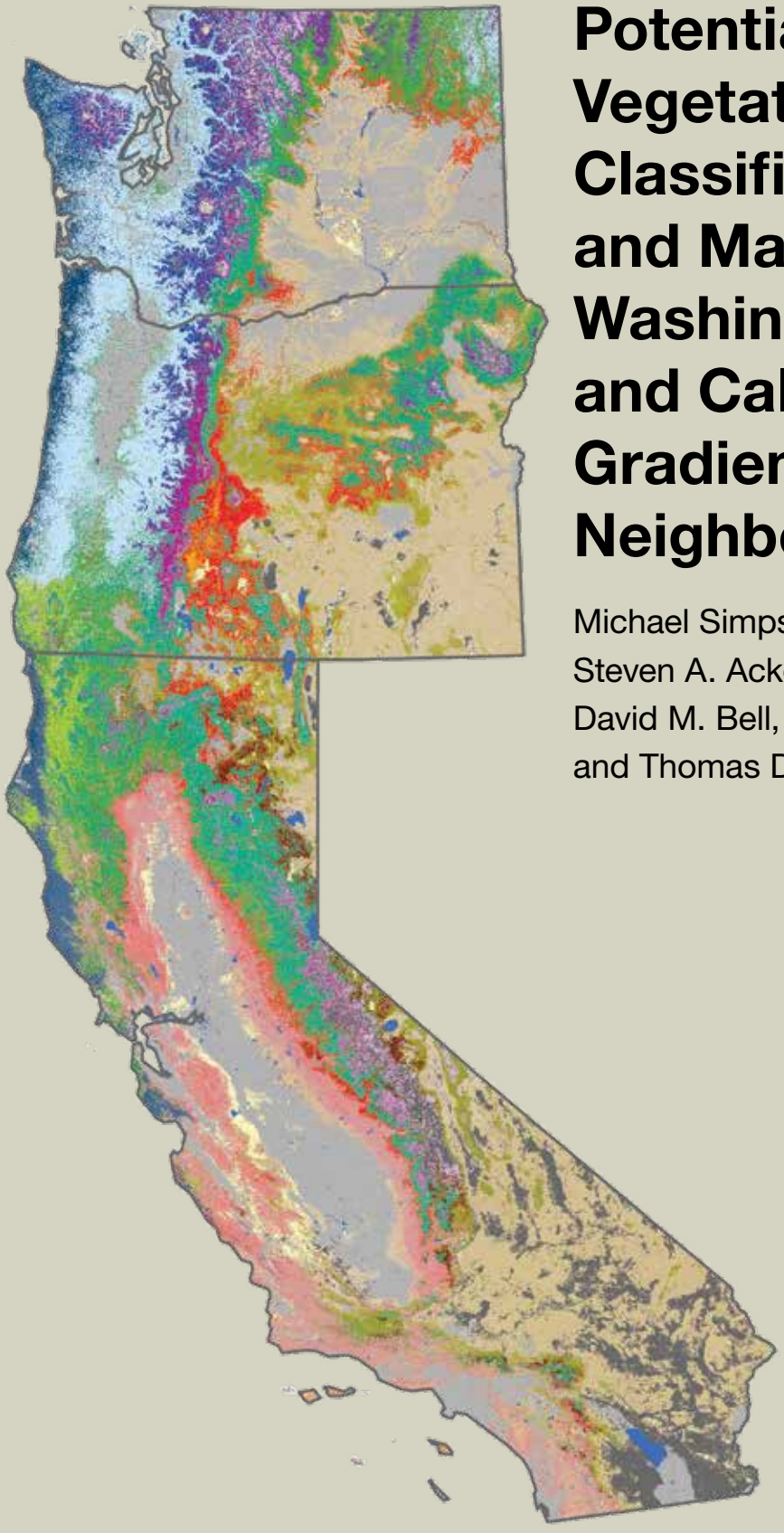

Potential Natural Vegetation Classification and Mapping for Washington, Oregon, and California Using Gradient Nearest Neighbor Imputation

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Cover image: Vegzone distribution among ecoregions across the Potential Natural Vegetation Map project area.

Abstract

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Potential natural vegetation (PNV) classification and mapping are foundational tools in planning in forestry and related fields to identify appropriate biophysical environments for vegetation communities across the landscape. The need for this information has grown over recent decades as attention has shifted to planning over large geographic areas. Our goal of this work is to develop a consistent, continuous potential vegetation map of both forest and nonforest for Washington, Oregon, and California.

We built a PNV map using wall-to-wall, 30-m maps of current forest attributes from the Gradient Nearest Neighbor (GNN) imputation vegetation dataset developed by the Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) group, a collaborative research partnership between the U.S. Department of Agriculture, Forest Service and Oregon State University. The vegetation zone (vegzone) and subvegetation zone (subzone) layers were derived from overstory and understory species composition and abundance (percentage of cover) in the GNN maps. We took advantage of the entire temporal span of GNN (1986–2017) to maximize chances of successfully inferring potential vegetation from current vegetation.

For forest vegzone assignments, we used presence and percentage of cover of tree species. We established a hierarchical ranking of the tree species identified as indicator species within plant association guides and vegetation manuals for the region. The ranking of tree species is based on shade tolerance, ecological amplitude, and longevity. To assign subzones to inventory plots that have already been classified to a vegzone, we considered graminoid, herb, shrub, and tree species that were not used in vegzone assignments. Using both the Forest Service, Forest Inventory and Analysis (FIA) plots and the Pacific Southwest Region and Pacific Northwest Region ecology plots, we examined species distributions with respect to climatic variables and their similarities to one another in species-composition space. Based on this analysis, we established nine species groups indicating different combinations of temperature and moisture regimes and a separate list of species that indicated serpentine substrates.

We developed a standardized classification scheme to create and map potential vegetation units across large, multistate landscapes. Results of an accuracy assessment indicate that the maps also have utility at finer scales (thousand to hundreds of thousands of acres), with appropriate consideration of spatial variation in map accuracy. This PNV product is an appropriate framework for additional, complementary, spatial products that can be used to study existing vegetation, disturbance regimes, and successional pathways.

KEYWORDS:

California
Gradient Nearest Neighbor (GNN)
Oregon
Potential natural vegetation map
Subzone
Vegzone
Washington

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Introduction

Biophysical environments consist of relationships among environmental attributes and abiotic and biotic features that describe the natural setting (Kemp 1998). Defining and mapping biophysical environments as they relate to vegetation has broad utility in applied science. Environmental features, such as climate (e.g., precipitation, temperature) and geology (e.g., landforms, topography, soils), along with disturbance processes (e.g., fire, insects and disease, wind) play a crucial role in plant community composition, structure, and distribution through time. Understanding the key drivers of vegetation composition, structure, and distribution has been a common goal in forest ecology and natural resource management (Franklin and Dyrness 1973, Gholz 1982, Handcock 2022, Handcock and Morris 1999, Hessburg et al. 2000, Oliver and Larson 1990, Spies and Franklin 1996).

The concept of potential natural vegetation (PNV) was developed and refined to classify and synthesize the biophysical environmental influences on vegetation (Härdtle 1995, Kowarik 1987, Tuxen 1956). PNV has been used to describe the capability of land (at all scales) to generate biomass, diversity, forest products, wildlife habitat, successional communities, and other attributes. PNV units from the local site (tens of acres) to landscapes (hundreds to thousands of acres) to biomes (hundreds of thousands of acres or more) have been designed to support management applications in forestry, landscape management, and conservation fields (Tuxen 1956, Zerbe 1998). Because PNV is a measure of vegetative potential, it is not rooted in a specific time and can be used to infer productivity and response to treatments, frame disturbance regimes, and provide a coarse-filter approach to assessing biodiversity at broader scales. PNV can be described and mapped at coarse and fine grains and has proven to be versatile from local-scale use in reforestation and silviculture to broadscale use in wildlife ecology and landscape planning. It serves as shorthand for describing the biophysical environment and effects on vegetation and thus provides a convenient communication device among disciplines (Henderson et al. 2011, Spies et al. 2018). There is a need for a consistent PNV classification and mapping product that can be used at broad scales for supporting landscape characterization. We undertook this project to update existing PNV tools and fill this important need at large landscape scales.

Vegetation communities at a certain point in time (often expressed as existing vegetation) can provide crucial insight into the biophysical environment. Several studies have examined relationships between environmental factors and existing vegetation (Corney et al. 2006, Ohmann and Gregory 2002, Rehfeldt et al. 2006). Tools, such as gradient analysis (Gauch 1982), are used to quantify relationships among environmental variables and vegetation characteristics. Since the advent of geographic information systems (GIS), many spatial models have been developed to predict existing vegetation (e.g., Dark 2004, Franklin 1995). The mapping of existing vegetation provides a snapshot of floristic distribution that is heavily influenced by disturbance as well as environment. It may provide some insight into plant community succession in the biophysical environment, especially if broad temporal mapping exists, but may not include all the potential seral conditions of the biophysical environment (Henderson et al. 2011).

Two methods are widely used to classify and map existing vegetation within the project area—the Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG) and the Gradient Nearest Neighbor (GNN). The U.S. Department of Agriculture (USDA), Forest Service, Pacific Southwest Region (which administers federal forest land in California) developed CALVEG for California vegetation types (USDA FS PSW Region,

Regional Ecology Group 1981). GNN has been adopted for mapping existing vegetation at landscape scales for the Forest Service in Washington and Oregon (hereafter, Pacific Northwest) as well as California. CALVEG (USDA FS PSW Region, Regional Ecology Group 1981) applies a classification system similar to the U.S. National Vegetation Classification (USNVC, n.d.) system hierarchy and imputes existing vegetation in California using a combination of terrain modeling, remote sensing, photo editing, and field-based observations (Sawyer et al. 2009). GNN uses predictive vegetation distribution models to impute forest attributes to unsampled areas using GIS. This approach has produced current vegetation maps across large landscapes (Ohmann and Gregory 2002) and has been applied regionally (e.g., Bell et al. 2021) and nationally (e.g., Wilson et al. 2012) in the United States and regionally outside the United States (e.g., Myroniuk et al. 2022).

Our project purpose is twofold:

1. Create a consistent, hierarchical classification of PNV, building on previous work in Washington, Oregon, and California.
2. Develop a consistent, wall-to-wall PNV map (forest and nonforest) of Washington, Oregon, and California based on the classification using GNN imputation and temporal expressions.

History and Evolution of Project Area Extent

The need for a consistent approach to describing vegetation biophysical environments has grown in scope over recent decades. This project initially focused on forests in the Forest Service, Pacific Northwest Region. In 2013, the Northern Spotted Owl Monitoring Group asked us to include the Northwest Forest Plan area of California (Davis et al. 2015). In 2018, we expanded the area again to include the Lassen and Modoc National Forests, as well as the portion of the Klamath National Forest that lies outside of the Northwest Forest Plan boundary, to cover the entire area of the Bioregional Assessment of Northwest Forests (USDA FS PNW Region 2020). Because the plot and spatial datasets were all consistent across the rest of California, we decided to include the rest of the state of California in the analysis. We also included nonforest elements to create a wall-to-wall approach using the ecological system descriptions to develop indicator species lists. Although we worked with Forest Service ecologists in California and used *A Manual of California Vegetation* (Sawyer et al. 2009) in our process, the approach remained consistent with our original design.

PNV Definitions and Naming Conventions

Tuxen (1956), thought to be the creator of the PNV concept, defined it as "the vegetation that would become established if all successional sequences were completed without major natural or direct human disturbances under present climatic, edaphic, and topographic condition" (adapted from Tuxen [1956] as translated and cited by Mueller-Dombois and Ellenberg [1974] and Kuchler [1964, 1973]). In the mid- to late-1900s, ecologists postulated that physical characteristics, such as climate, soils, and topography, drove vegetation distribution (e.g., Daubenmire 1952, 1968, 1976). This approach to PNV, coined "climate constrained," hypothesized that, although there may be multiple seral pathways with diverse plant communities, the environmental site capacity could be named by the final, or climax, plant community once succession was completed without disturbances (Clements 1916, Daubenmire 1968). The Forest Service, especially within its Northern Rocky Mountain and Pacific Northwest Regions, used this approach by defining and describing plant associations/habitat

types that exhibited repeating characteristic patterns of vegetation composition that were associated with repeating patterns of climate, soil, and topography (e.g., app. 1; McCune and Grace 2002, Mueggler and Stewart 1980, Muldavin et al. 1996).

Plant ecologists realized that in some instances disturbance could arrest succession and produce stable plant communities or secondary PNV (Winthers et al. 2005). This secondary PNV included disclimax conditions, including both pyric PNV (influenced by fire) and zootic PNV (influenced by animal activity, notably grazing). Kuchler (1970) advanced this perspective of PNV by including disturbance in naming the representative plant communities as the basis of PNV, which may not resemble the climax community. Other disturbances beyond fire and animal activity can include forest insects and diseases, soil mass movement, drought, and flooding, among other types, alone or in combination (Brown et al. 1975).

Some federal land management agencies have used disturbance-based PNV as a key vegetation classification. The U.S. Department of the Interior (USDI), Bureau of Land Management, supported in its mission by the USDA Natural Resource Conservation Service, created a historical climax plant community to classify federal rangelands (Habich 2001). For federal lands in California, where fire frequencies are high and representative vegetation does not resemble the named climax plant communities described in the site-capacity approach, a disturbance-based perspective was more appropriate.

It is important to understand how the climate-constrained and disturbance approaches relate to each other. For example, frequent fire may have historically maintained open ponderosa pine (*Pinus ponderosa*) forest on a site, but Douglas-fir (*Pseudotsuga menziesii*) would be the climax tree component under climate, topography, and soil conditions. The climate-constrained PNV convention might name these landscapes as "dry Douglas-fir," whereas the disturbance-constrained convention would name them ponderosa pine. Both names are shorthand for a range of possible vegetation states on that site. Douglas-fir may currently dominate this environment as the result of a century of extractive land use and fire exclusion, and the loss of ponderosa pine in these forests may have negative ramifications for future forest function, wildlife habitat considerations, and fire risk. In this case, knowledge of both climate- and disturbance-constrained PNV is critical for assessing ecosystem integrity, understanding processes that favor one vegetation state over another, and identifying possible management alternatives. The ability to move between both approaches provides a more complete and more useful suite of information that is crucial to understanding site and landscape conditions.

For the purposes of this project, we define PNV with a focus on describing and mapping the vegetation biophysical environment across broad landscapes. This approach provides flexibility to stratify the landscape across multiple grains (vegzones, subzones, or combinations of both) depending on objectives. Although site capacity using climate, soils, and topography are key components in naming vegzones and subzones, we recognize that the climax communities are not always the representative vegetation community because of the role of ecological and management processes (notably disturbance) across landscapes. We view PNV as a landscape stratification tool. Crosswalking our classification and mapping system to disturbance-affected PNVs, such as those produced by LANDFIRE (USGS and USDA FS, n.d.a) (see app. 2), or other systems, such as CALVEG (Sawyer et al. 2009, USDA FS PSW Region, Regional Ecology Group 1981), can connect physical characteristics (used to infer productivity) and natural processes (used to describe fire regimes) to help organize and describe expected successional trajectories, disturbance responses, and wildlife habitat.

PNV Classification and Mapping

Vegetation classification often involves defining plant communities as discrete entities based on their composition. There has long been recognition that individual species distribution exists along environmental gradients (Gleason 1926), but the practical purpose of packaging multiple species into plant communities—and into vegetation units for PNV classification—offers a better way to display and map the relationship between plant communities and the environment. The vegetation unit provides a format to discuss management approaches, evaluate management types and implications, and provide multiscale contexts for planning.

A common approach to PNV classification involves identification of key species as indicators of a setting, based on physical parameters, such as its climate, geology, geomorphology, and soils. Multivariate methods have been used to identify indicator species and classify types (Gauch 1982, Hill 1979, Lucas et al. 2017, McCune and Grace 2002). These methods tie patterns of vegetation distribution to environmental gradients, typically those of moisture and temperature. Plant community types can then be classified and described using key indicator species.

PNV can be classified at multiple grains. Historically, a significant amount of work has gone into forest PNV classification at two hierarchical grains. Key tree species indicators described coarse-grained biophysical environments (e.g., series) across local landscapes, similar to the group level of the USNVC system (Franklin et al. 2012; USNVC, n.d.). At a finer grain, identifying the full suite of indicator species (including shrub, herb, and graminoid species) created plant associations or habitat types similar to lower association and alliance groups in the USNVC system (e.g., Fites 1993; Henderson et al. 1989; Lillybridge et al. 1995; Mueggler and Stewart 1980; Muldavin et al. 1996; Simpson 2007; USNVC, n.d.) (see also app. 1). To address broadscale issues, such as changes in wildfire severity and extent, climate change, and wildlife habitat of late-seral-dependent and wide-ranging animal species, land managers also need to describe and understand PNV at the landscape scale and its management implications, while maintaining fine-grained classifications for local management, such as silvicultural prescriptions and appropriate planting mixes.

Initial development and use of potential vegetation in the Forest Service began with reforestation controversies that led to the National Forest Management Act (NFMA 1976). In the early 1970s, the agency experienced several reforestation failures. To assist in better matching tree species to sites, PNV classifications were developed to synthesize site conditions that identified key tree species to meet the resulting National Forest Management Act requirement for successful reforestation of logged sites within 5 years. The use of PNV classifications and local mapping to communicate differences between sites and their abilities to support tree species became a key tool in writing silvicultural prescriptions (Mueggler and Stewart 1980, Muldavin et al. 1996) (see also app. 1).

PNV mapping in the Forest Service, using the climate-constrained approach, occurred largely in its Pacific Northwest Region, beginning in the 1990s. Although several methods were initiated (e.g., on-the-ground mapping, aerial photo interpretation), they were abandoned because of intensive labor requirements and varying results. Forest Service ecologists in the Pacific Northwest developed a process using polynomial equations relating environmental gradients to ground data. They used this process, with existing spatial data, to generate potential vegetation maps with units of plant association groups (PAGs) that were in similar biophysical environments (Henderson et al. 2011). This method was employed across Washington and in some areas in Oregon but was never fully implemented across the Forest

Service, Pacific Northwest Region. Mapping efforts struggled with edge-matching issues because of the different approaches and indicator species thresholds adopted by each area (app. 1), limiting the utility for broader areas across the region.

A national interagency mapping effort, LANDFIRE (USGS and USDA FS, n.d.a), was created in part to describe and map representative plant community types resulting from natural fire regimes, similar to the USNVC group level (Franklin et al. 2012; USNVC, n.d.). This PNV approach has been adopted in California to map typical plant communities in addition to the existing vegetation layer produced by CALVEG (USDA FS PSW Region, Regional Ecology Group 1981). LANDFIRE (USGS and USDA FS, n.d.a) uses both environment-constrained (environmental site potential, or ESP) and disturbance-constrained (biophysical setting, or BpS) approaches to PNV but heavily emphasizes the disturbance-constrained view (Barrett et al. 2010). It was designed to provide vegetation, fuel, and fire regime information across entire landscapes, regardless of ownership. The classification and mapping for LANDFIRE operates at a very coarse grain, and as a result, vegetation communities and descriptions often deal only with dominant vegetation types and distributions. For instance, the Mediterranean California dry-mesic mixed conifer forest and woodland (BpS 10270) and ESP, found in southwestern Oregon and California, contains 15 plant associations and three PAGs within the Douglas-fir series.

It is critical to first identify the objectives for any classification and mapping effort, keeping these broad enough to meet the range of current resource management information needs but also to anticipate future needs. For example, a critical need in current planning in the Western United States is the capability to define and map disturbance (notably fire) regimes. Because vegetation and fire are intricately linked, knowledge of the relationship between biophysical environments and patterns and fire extent, frequency, and severity requires a broadscale approach. PNV maps at finer scales (e.g., PAGs in the Pacific Northwest) have been developed for smaller landscapes (e.g., Henderson et al. 2011). These are useful for project-level needs at local forests or ecoregions but lack consistency across broad landscapes.

The Integrated Landscape Assessment Project, initiated in 2009, produced consistent, landscape-wide vegetation mapping across Washington and Oregon to assess current conditions, expected trends, and possible implications of alternative policies and management actions (Hemstrom et al. 2012). The PNV layer used to stratify existing vegetation data consisted of the Forest Service, Pacific Northwest Region, Ecology Program's PAG mapping products and spatial modeling in gap areas. The variability in classification thresholds and mapping efforts created some problems with ecological departure interpretations across area boundaries and may have limited use at regional-scale departure assessments. This mapping effort was used within other Forest Service efforts, such as The Decayed Wood Advisor for Managing Snags, Partially Dead Trees, and Down Wood for Biodiversity in Forests of Washington and Oregon (DecAID)—a decaying wood advisory model—as a base stratification layer for wildlife habitat typing (Mellen-McLean et al. 2017).

PNV Applications

Land management agencies, such as the Forest Service, have applied PNV concepts across multiple scales. PNV classification and mapping can be used in a variety of management applications in silviculture, wildlife, fire, soils, and other disciplines.

PNV classification and mapping provides context for describing the variability of successional pathways and forest stand conditions through time and space, which is essential

to understanding forest function (Davis et al. 2015, Reilly and Spies 2015). Stratification by PNV types is useful for large landscape analysis and planning as it provides a practical binning of forest types (Franklin et al. 2002, Mellen-McLean et al. 2017, Quigley et al. 1999, Reilly and Spies 2015, Spies and Franklin 1988, USDA FS PNW Region 2020). This has important considerations for forest management. For instance, while the condition and distribution of older forests are important for management of key wildlife species, such as the northern spotted owl (*Strix occidentalis caurina*), not all types of old forests provide equally suitable habitat, nor are the structural conditions associated with all old forests the same (Davis et al. 2015, 2022). The types and distribution of PNV across the Northwest Forest Plan area have provided information on the components of live and dead forest structure that are important to old-growth-dependent species (Davis et al. 2015, 2022).

Wildlife ecologists and managers have used PNV to describe the role of snags and down wood across the landscape. Forest types in DecAID (Mellen-McLean et al. 2017) are organized by wildlife habitat types, which are intended to capture broad classes of current vegetation with similar patterns of wildlife use (O'Neil and Johnson 2001). Wildlife habitat types are mapped based on a crosswalk to potential vegetation because PNV provides a good metric on biomass productivity of ecosystems. Better use of consistent landscape-scale PNV maps, coupled with information on existing vegetation structure and successional pathways, offer a powerful wildlife habitat planning tool and a more complete understanding of habitat.

The distribution and pattern of potential vegetation types can also be associated with fire regimes, fire effects, and current vegetation departure analyses. Careful consideration of the grain and interaction of associated PNV types, along with the geographic variability in fire regimes within the same PNV type, is necessary to correctly describe the types and spatial distributions of fire regimes across large landscapes. Climate-constrained PNV can be crosswalked to disturbance-constrained PNV (see app. 2) (USDA FS PNW Region 2020), which provides information on fire frequency, severity, and potential response to fire (USDA FS PNW Region 2020). PNV can also provide a critical framework for organizing the landscape for ecological departure assessment, an important measure of landscape resilience and resistance. Landscape assessments on departure from a natural range of variation (NRV) use some form of potential vegetation to stratify the landscape (e.g., Barrett et al. 2010, DeMeo et al. 2018, Haugo et al. 2015, Laughlin et al. 2023, Meyer and North 2019, Safford and Stevens 2017). Our work on this PNV mapping effort has been motivated in part to provide refined map units to support NRV analysis given the need for consistent, broadscale information.

Climate Change Application and Effects

PNV is intended to capture land capability and represents a potential outcome of forest succession under a given set of biophysical conditions. In a changing climate, the PNV of the past may no longer be attainable. With a greater appreciation of the role of disturbance in recent years (notably fire, but also insect outbreaks and other disturbances), ecologists question the very idea of plant community stability. In response to shifting climate and disturbance regimes, previously associated species may migrate at different rates, forming new communities that do not fit into current PNV categories (Halofsky et al. 2020).

Climate change is affecting landscapes across the Pacific Northwest and California, which are trending toward warmer temperatures and more irregular patterns in precipitation (Reilly et al. 2018b) (see also app. 3 for a list of references and resources). PNV classification and mapping provide a substantial body of knowledge about the relationships

between vegetation, land, and ecosystem processes, and serve as a baseline from which to consider the effects of global ecological change and local management (Somodi et al. 2012). PNV mapping provides a useful tool to show how climate change effects, such as changes in higher elevation snowpack, drought patterns, and the size and severity of wildfires, may vary with location and vegzone. PNV maps can be used to identify climate-sensitive forests, analyze the effects of climate change, and suggest responses to these effects (app. 3). What PNV might look like in the future is actively being researched, but so far, relatively little has been published on this.

Project Area

The project area includes all lands within the states of Washington, Oregon, and California (fig. 1). Moisture, temperature, and substrate vary greatly across the project area (Barbour and Billings 1988, Franklin and Dyrness 1973). The landscape is also diverse, with wet coastal and dry interior mountain ranges, miles of coastline, interior valleys and basins, high-desert plateaus, and southern California desert. Climate, geology, and soils have created many distinct and varied environments that support an array of vegetation types across the project area. These broad environmental gradients result in a complex set of ecosystem types. This coarse-grained diversity can be described and mapped by level III ecoregions (Omernik 1987, Omernik and Griffith 2014). The project area contains 20 of these ecoregions, with each ecoregion displaying unique, defining features based on geology, topography, and climate. Additionally, each ecoregion comprises a different total area, from the smallest—Snake River Plain (0.3 percent of the project area)—to the largest—Columbia Plateau (9.5 percent of the project area) (fig. 2, table 1).

Figure 1—Potential Natural Vegetation Map project area. Blue lines represent several rivers within the project area. Data sources: Blue Water GIS (2020), Esri (2015), USDC Census Bureau and Esri (2020)

Mean annual temperature, mean annual precipitation, mean summer precipitation from May through September, and summer moisture stress (ratio of temperature to precipitation from May through September) are important environmental factors and can be very different from northern Washington to southern California as well as from west to east across the project area. Summer precipitation is especially important. Summer moisture stress is based on the ratio of temperature to precipitation (degrees Celsius/natural-log-transformed millimeters) during the months of May through September. Summer moisture stress is an abiotic stress that occurs when the moisture of plant tissues is reduced to suboptimal levels, which is a result of an imbalance between the supply furnished by the soil water and the amount needed by the plant. Where higher summer precipitation occurs, there is less summer moisture stress (fig. 3).

The dominant influences on climatic patterns in the Pacific Northwest are the Pacific Ocean and the Cascade Range. The diurnal temperature range is higher east of the Cascade crest, farther inland from the Pacific Ocean. More precipitation falls west of the Cascade crest, and a prominent rain shadow greatly reduces precipitation

Figure 2—Level III ecoregions across the Potential Natural Vegetation Map project area. Sources: Omernik (1987), Omernik and Griffith (2014). Data sources: Blue Water GIS (2020), USDC Census Bureau and Esri (2020), US EPA (2011).

east of the crest (Halofsky and Peterson 2017). In California, the Pacific Ocean and the diverse topography also influence climatic patterns. Along the west side of the Coast Range, the Pacific Ocean dominates the climate, with warm winters, cool summers, small daily and seasonal temperature ranges, and high relative humidities. With increasing distance from the ocean, the maritime influence decreases. Areas that are well protected from the ocean experience a more continental type of climate, with warmer summers, colder winters, greater daily and seasonal temperature ranges, and generally lower relative humidities.

Table 1—Potential Natural Vegetation Map project area by level III ecoregions in Washington, Oregon, and California

Ecoregion [number]	Project area
	PERCENT
Coast Range [1]	6.5
Puget Lowland [2]	2.0
Willamette Valley [3]	1.8
Cascades [4]	7.0
Sierra Nevada [5]	6.2
Central California Foothills and Coastal Mountains [6]	9.2
Central California Valley [7]	5.6
Southern California Mountains [8]	1.9
Eastern Cascades Slopes and Foothills [9]	6.4
Columbia Plateau [10]	9.5
Blue Mountains [11]	7.7
Snake River Plain [12]	0.3
Central Basin and Range [13]	1.5
Mojave Basin and Range [14]	9.0
Northern Rockies [15]	2.6
North Cascades [77]	3.6
Klamath Mountains/California High North Coast Range [78]	5.8
Northern Basin and Range [80]	7.6
Sonoran Basin and Range [81]	3.4
Southern California/Northern Baja Coast [85]	2.5

Sources: Omernik (1987), Omernik and Griffith (2014).

Climate across the project area varies because of its vastness. The climate in Washington and Oregon, overall, is temperate; coastal areas and the west side of the Cascade Range have a predominantly marine-type climate, while the east side of the Cascade Range experiences continental and semiarid climate (fig. 3).

Climate in the northern Cascade Range is driven by the proximity to the Pacific Ocean and local effects of mountainous topography. Most precipitation falls in the late fall and winter, October through March, while relatively little precipitation falls in late spring through the summer months, with July and August being the driest. The western slopes of the Cascade Range have a maritime climate that is greatly influenced by the Pacific Ocean and Puget Sound, whereas the eastern slopes of the Cascade Range have a continental climate dominated by the orographic effect of the Cascade Range. The maritime climate of the western Cascade Range has relatively warm winters and cool summers compared to the eastern Cascade Range (Raymond et al. 2014).

The western, coastal side of the Olympic Peninsula has a wet and humid maritime climate. The crest of the Olympic Mountains receives >236 inches (>600 cm) of precipitation per year, making it the wettest location in the conterminous United States. In contrast, the northeastern portion of the peninsula, in the rain shadow of the Olympic Mountains, has a drier, more continental climate (Halofsky et al. 2011).

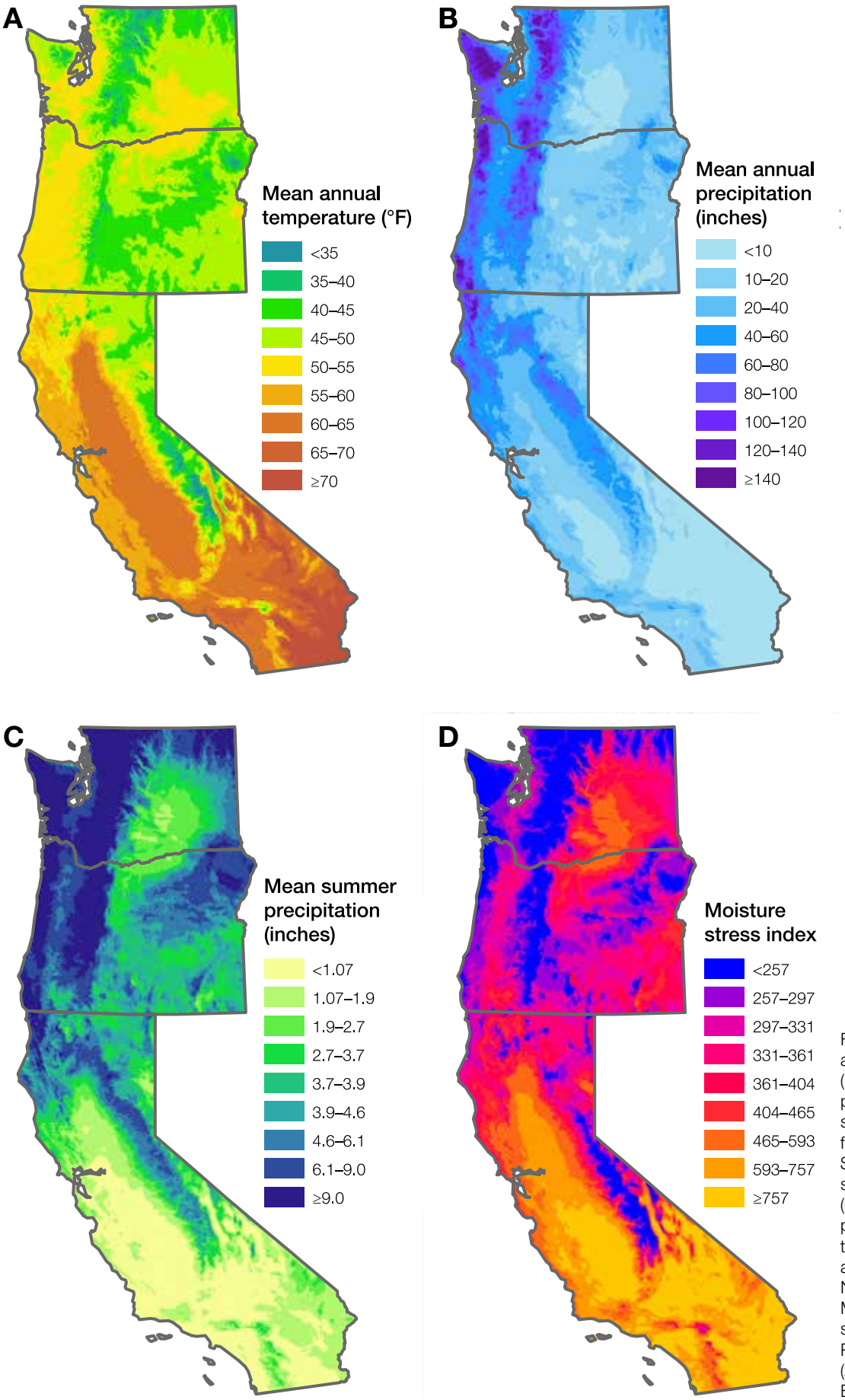

Figure 3—(A) Mean annual temperature, (B) mean annual precipitation, (C) mean summer precipitation from May through September, and (D) summer moisture stress (ratio of temperature to precipitation from May through September) across the Potential Natural Vegetation Map project area. Data source: Esri (2015), PRISM Climate Group (2025), USDC Census Bureau and Esri (2020).

The climate of southwestern Washington is mainly maritime and heavily influenced by the Pacific Ocean and Columbia River Gorge, with secondary orographic effects of the Cascade Range. Summers are relatively cool and dry, and winters are relatively mild and wet (Hudec et al. 2019). Moisture across Washington declines markedly from west to east.

In northwestern Oregon, both the maritime influence of the Pacific Ocean and the Cascade Range moderate temperature extremes on the west side of the mountains result in relatively mild conditions throughout the region. A Mediterranean precipitation pattern marked by wet winters and dry summers occurs throughout, with about 70 percent of annual precipitation observed from November to March (Halofsky et al. 2022a).

The topography of the Blue Mountains of eastern Washington and Oregon results in orographically enhanced local precipitation totals despite being in the lee of the Cascade Range, with greater amounts in higher elevation areas in the region. The surrounding Columbia Plateau and high desert receive less annual precipitation. The temperatures in the Blue Mountains are slightly cooler than those of the entire region, with colder temperatures at higher elevations (Halofsky and Peterson 2017).

In southern Central Oregon, summers are warm and winters are cold, typical of the interior Western United States. In a typical summer, high pressure off the coast deflects storms, resulting in dry summers. In winter, the North Pacific High moves south, and the Aleutian Low brings in winter storms. Diurnal temperature fluctuations, such as the seasonal fluctuations mentioned above, are also relatively high, resulting in cold, snowy winters and hot, dry summers (Halofsky et al. 2019).

A shift in climate occurs moving south into southwestern Oregon and northern California. This region exhibits a Mediterranean climate, with warm to hot, dry summers and cooler, wetter winters. Climate is diverse in southwestern Oregon, with elevations from sea level to 9,500 ft (2894 m). Maritime forests dominate the coastal mountain range where temperatures rarely exceed 75 °F (24 °C) in the summer, and snow is rare in the winter. Maritime climate effects diminish farther inland in this region where summer temperatures often reach 81 to 90 °F (27 to 32 °C). Southwestern Oregon has a Mediterranean precipitation pattern characterized by wet winters and very dry summers. About 75 percent of annual precipitation occurs in the late fall and winter. Summers in the region are among the driest in the United States, with less than 5 percent of the annual precipitation falling from June through August. Summer temperatures vary significantly depending on elevation and coastal proximity, with maximum temperatures averaging around 64 to 68 °F (18 to 20 °C) along the coast, while inland valley temperatures often exceed 86 °F (30 °C). Winter temperatures are generally mild (Halofsky et al. 2022b).

California has the highest interannual variability in precipitation in the continental United States (Gibson et al. 2020). The difference between a wet year versus a dry year is often determined by a few storms, generally occurring in the form of atmospheric rivers (Dettinger 2013). Northern California receives more precipitation than any other part of the state (He and Gautam 2016). Mediterranean climate regions, such as southern California, exhibit high levels of plant richness and endemism (Cowling et al. 1996, Underwood et al. 2009), yet they are also among those most sensitive to climate and land-use change (Molinari et al. 2015, Sala et al. 2000).

The climate of central and southern California varies widely from hot and xeric to cold and wet, depending on latitude, elevation, and proximity to the Pacific Coast. California's coastal regions, the Sierra Nevada foothills, and much of the Central Valley have a Mediterranean

climate, with warm, dry summers and cooler, wetter winters. In coastal areas, the influence of the ocean generally moderates temperature extremes, creating warmer winters and substantially cooler summers. Inland, the climate becomes more continental, even semiarid in some areas, with colder winters and markedly hotter summers. Southwestern California has a subtropical semiarid or steppe climate with drier winters, while southeastern California has a hot, arid climate (fig. 3) (Barbour and Billings 1988).

Methods

We performed a review of the various published plant association classifications throughout Washington, Oregon, and California to guide both the development of our framework as well as the definition of specific classes (app. 1). We identified key indicator species from each plant association guide and *A Manual of California Vegetation* (Sawyer et al. 2009) and used these as representative species to develop a set of indicators for the mapping process.

The 2022 version of the PNV map uses a hierarchical approach to classify and map PNV. The broadest grain, vegzone, is largely synonymous with series as defined in the existing classifications. Vegzones are named for the primary indicator overstory (mainly tree) species. The subzone grain is most similar to, although can be somewhat broader than, a PAG (Franklin and Dyrness 1973, Henderson et al. 2011, Simpson 2007) or an alliance (Franklin et al. 2012). Subzones use key indicator tree, shrub, herb, and graminoid species to identify a range of finer grained biophysical environments that fall within each vegzone. For this step we conducted multivariate analyses from field plots that were used to develop plant association guides (ecology plots), as well as plots from the Forest Service, Forest Inventory and Analysis (FIA) program that are described below.

Early in the process, we decided to simplify the classification of plant species that had been identified to the level of variety and subspecies to the level of species. We did this for all the Pacific Southwest Region and Pacific Northwest Region ecology plot and FIA datasets. This list of species was then analyzed to determine what species would best be used as indicator species for the vegzone and subzone classification for the PNV map.

As with GNN map products, we grouped similar tree species into combined symbols based on the USDA PLANTS Database (USDA NRCS, n.d.) symbols. GNN uses the code ABGRC to represent grand fir (*Abies grandis*—ABGR) and white fir (*Abies concolor*—ABCO). Grand fir interbreeds with white fir, and as a result, the two species are difficult to distinguish (Ott 2014, Ott et al. 2015). Individuals exhibiting characteristics of both species are often referred to as *Abies grandicolor* (sic). The ecological and silvicultural differences are not significant enough to warrant any distinctions (Atzet et al. 1996; Simpson 2007; Zobel 1973, 1974, 1975).

GNN also merges noble fir (*Abies procera*—ABPR), California red fir (*Abies magnifica*—ABMA), and Shasta red fir (*Abies magnifica* var. *shastensis*—ABMAS) into the code ABPRSH. Shasta red fir is a variety of California red fir and is interfertile with noble fir and California red fir. Morphological and genetic characteristics of the trio are similar, thus complicating identification (Oline 2008, Zavarin et al. 1978).

We built a PNV map using wall-to-wall, 30-m maps of current forest attributes from the GNN imputation vegetation dataset. GNN integrates Landsat multispectral remote-sensing data, FIA plot data, and environmental data to assign current compositional and structural attributes from field observations to all land area deemed to have the potential to support forest (see "Glossary" for definition of "forest") (Ohmann and Gregory 2002).

GNN provides some desirable qualities for mapping PNV because of its spatially comprehensive nature, its temporal depth (annual data available from 1986–2017) (Bell et al. 2021, Davis et al. 2022), and its inherent incorporation of environmental drivers of spatial patterns of primary productivity and species composition. A schematic diagram of the two-stage workflow used to create the 2022 PNV map is displayed in figures 4 and 5.

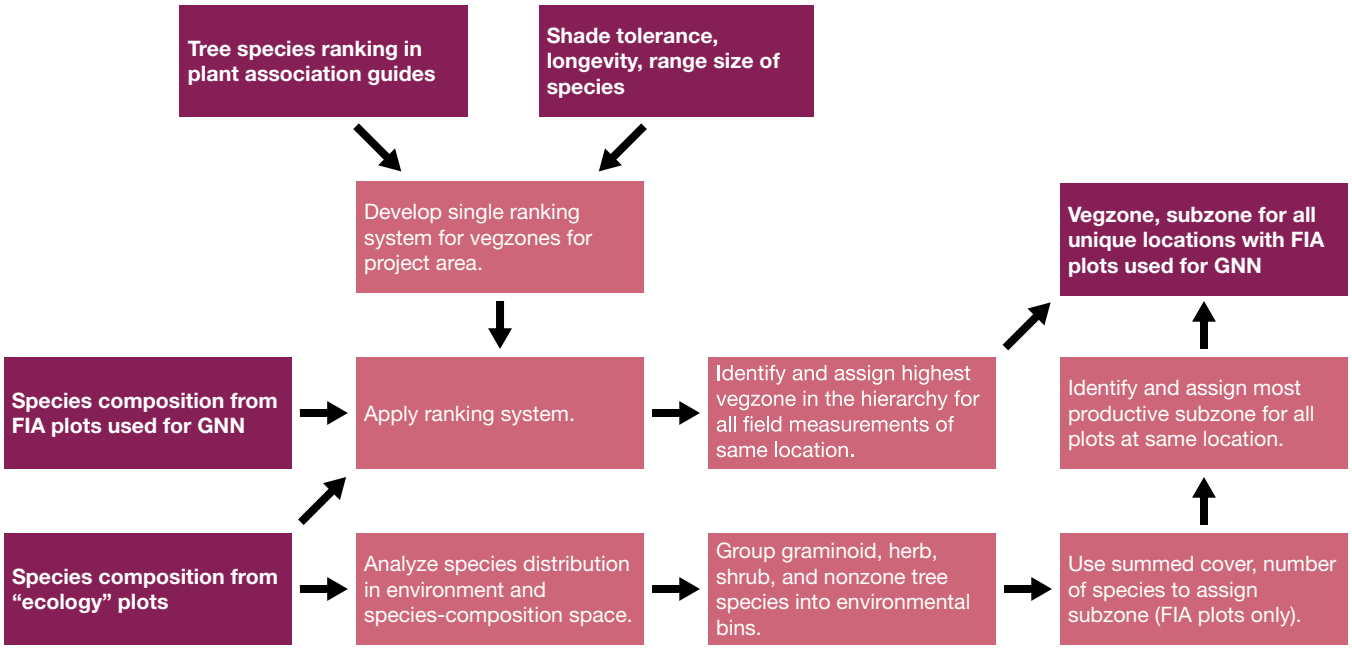

Figure 4—Stage 1 of the workflow to assign vegzone and subzone to each plot location used to create the 2022 potential natural vegetation map. Vegzone is the broadest vegetation classification and is based on the dominant, most shade-tolerant (regenerating) tree species. Subzone is larger vegetation grouping, similar to plant association group. FIA = Forest Inventory and Analysis, GNN = Gradient Nearest Neighbor.

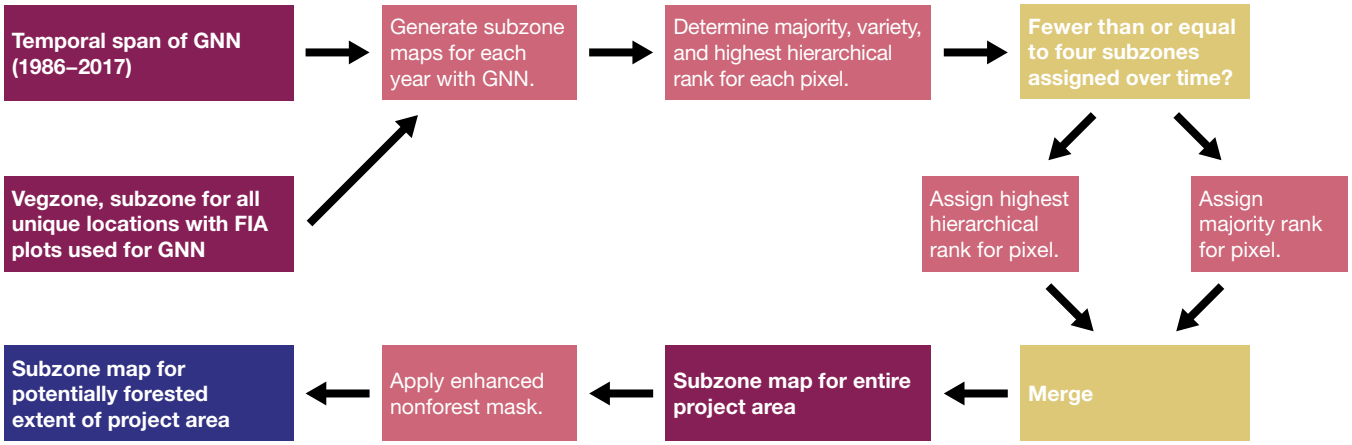

Figure 5—Stage 2 of the workflow to produce vegzone and subzone maps from the temporal stack of Gradient Nearest Neighbor (GNN) plot imputations. Vegzone is the broadest vegetation classification and is based on the dominant, most shade-tolerant (regenerating) tree species. Subzone is larger vegetation grouping, similar to plant association group. Subzone can be aggregated to vegzone because each subzone belongs to only one vegzone. FIA = Forest Inventory and Analysis.

Classification Rules and Ranking for Vegzone and Subzone

We used species composition data from repeated observations of FIA plots (Bechtold and Patterson 2005), which were used in the GNN imputations, as well as the colocated current vegetation survey (Max et al. 1996) plots on federal lands to assign each plot location a vegzone and subzone. FIA plots are distributed across national forests (at least one per 6,000 acres). On these plots, forest vegetation attributes are measured on a 10-year cycle in our project area. Each plot comprises four subplots with a nested design measuring individual tree species, diameter at breast height (DBH), and other attributes for trees of different sizes ($^1/_{300}$-acre microplot for trees ≥1-inch DBH, $^1/_{24}$-acre subplot for trees ≥5-inch DBH, and $^1/_4$-acre macroplot for trees ≥30-inch DBH in western Oregon and western Washington counties or ≥24-inch DBH in California, eastern Oregon, and eastern Washington counties). Understory species percentage of cover and height are also measured on the $^1/_{24}$-acre subplot.

For vegzone assignments, we established a hierarchical ranking of tree species that are identified as indicator species within Oregon, Washington, and California plant association guides (app. 1). Plant association guides developed in the region are all posted on Ecoshare (USDA FS PNW Region, n.d.b). The ranking of tree species (table 2) is based on shade tolerance, ecological amplitude, and longevity of species and adheres as much as possible to the logic used to determine series in the various plant association guides. Shade-tolerant species with the narrowest environmental distribution—e.g., Sitka spruce (*Picea sitchensis*), redwood (*Sequoia sempervirens*), and mountain hemlock (*Tsuga mertensiana*)—are highest in the hierarchy, followed by shade-tolerant species of broader distribution—e.g., Pacific silver fir (*Abies amabilis*), western hemlock (*Tsuga heterophylla*), followed by less shade-tolerant species that represent earlier-seral conditions in many environments—e.g., Douglas-fir, ponderosa pine, and lodgepole pine (*Pinus contorta*).

We used a live-tree canopy cover threshold of 5 percent for roughly half of the indicator tree species, with most others having thresholds of 10 or 20 percent. Percentage of cover thresholds were relaxed for about a third of the indicator species on those inventory plots (i.e., FIA and current vegetation survey, see above) judged to have been recently disturbed (i.e., stand age of <80 years). In the case of Sitka spruce, the percentage of cover threshold was 10 percent for undisturbed plots, while the threshold for disturbed plots was presence of the species. The complete rule set is coded in a series of R scripts (R Core Team 2024) (see app. 4 for rule-set summary) and included many additional contingencies based on the abundance of co-occurring species other than the named indicator species. In most cases, we use common names of tree species from USDA PLANTS Database (USDA NRCS, n.d.) when referring to vegzones, although we use species symbols for brevity where needed. The full set of species symbols, scientific names and authorities, and common names for plant species used in the vegzone and subzone descriptions, and throughout this report, are included in appendix 5.

Because shade-tolerant trees generally become more common as forests develop after disturbance, the repeated FIA field observations (1990–2017) maximized the chance of capturing later seral species for each plot location. These repeated measurements allowed us to understand and accommodate successional development. We evaluated the assigned vegzone for each year of plot measurements at a particular location, selecting the vegzone that represented the highest level in the hierarchy. For example, a location with western hemlock vegzone (shade-tolerant) and Douglas-fir vegzone (intermediate tolerance)

Table 2—Hierarchical rank of vegzone tree indicator species, based on shade tolerance, ecological amplitude, longevity, and live-tree canopy cover thresholds

Rank	Vegzone indicator tree species	Shade tolerance[a]	Ecological amplitude[b]	Longevity[c]	Cover threshold	
					Undisturbed	Disturbed
					PERCENT	
1	Sitka spruce	2	1	2	5	Present
2	Redwood	2	1	1	5	Present
3	Mountain hemlock	1	1	2	10, 20[d]	10
4	Pacific silver fir or noble fir	1	1	3	5	5
5	Western hemlock or western redcedar	1	2	2	5	5
6	Western redcedar[e]	1	2	1	5	5
7	Subalpine fir or Engelmann spruce	1	2	3, 2	10, 20[f]	10
8	White fir or grand fir	1	3	3	5, 20[g]	5
9	Shasta red fir or California red fir	2	3	3	5	5
10	Port Orford cedar	2	1	2	10	10
11	Tanoak	2	3	3	20	20
12	Douglas-fir or bigcone Douglas-fir	3	4	2	5	5
13	Giant sequoia	4	1	1	5	Present
14	Jeffrey pine	4	4	3	5	Present
15	Ponderosa pine	4	4	3	5	5
16	Parklands[h]	3, 4	1	1	10	Present
17	Lodgepole pine	5	5	4	5	Present
18	California foothill pine or Coulter pine	5	3	4	5	Present
19	Knobcone pine	5	4	4	5	Present
20	Riparian hardwoods[i]	3, 4	2	3, 5	5	Present
21	Oak woodlands	3, 4, 5	3	3	5	Present
22	Other hardwoods	3, 4, 5	4	3	5	Present
23	Pinyon, juniper, or cypress	4, 5	4	3	5	Present
24	Desert hardwoods[j]	5	1	4	5	Present

Multiple codes for shade tolerance, longevity, and cover threshold indicate that a species trait depends on geographic location.

[a] Shade tolerance codes: 1 = very tolerant, 2 = tolerant, 3 = intermediate, 4 = intolerant, 5 = very intolerant.

[b] Ecological amplitude codes: 1 = very narrow, 2 = narrow, 3 = moderate, 4 = broad, 5 = very broad.

[c] Longevity codes: 1 = very long lived, 2 = long lived, 3 = intermediate, 4 = short lived, 5 = very short lived.

[d] Pacific silver fir, California red fir, or Shasta red fir ≥5 percent cover threshold.

[e] Western redcedar vegzone is restricted to the Northern Rockies ecoregion only.

[f] White fir or grand fir ≥5 percent cover threshold.

[g] California red fir or Shasta red fir ≥5 percent cover threshold.

[h] Whitebark pine, limber pine, foxtail pine, Great Basin bristlecone pine, western white pine, or subalpine larch.

[i] Oregon ash, alders, aspen, cottonwoods, willows, California sycamore, or bigleaf maple.

[j] Ironwood, paloverde, mesquite.

Sources: Shade tolerance, ecological amplitude, and longevity adapted from Burns and Honkala (1990) and Minore (1979).

assignments at different years would be labeled as the western hemlock vegzone. Thus, all plot measurements in our database for a single location received the same vegzone assignment. This process relied only on the inventory plot data (FIA and current vegetation survey) and was completely independent of mapped GNN predictions.

To assign subzones to inventory plots that have already been classified to vegzone, we considered indicator graminoid, herb, shrub, and tree species that were not used in vegzone assignments, primarily those that were used in the plant association guides (app. 1). Using both the FIA plots and the Forest Service's Pacific Southwest Region and Pacific Northwest Region ecology plots (collected primarily to support development of plant association guides), we examined species distributions with respect to climatic variables (fig. 6) and their similarities to one another in species-composition space. Based on the analysis of the ecology and the inventory plots (FIA and current vegetation survey), we established nine species groups that indicated different combinations of temperature and moisture regimes and a separate list of species that indicated serpentine substrates (app. 6). Because most plot locations have multiple measurement dates, we used the maximum percentage of cover recorded for each species across all observations as a maximum expression of each species to evaluate subzone.

The species groups were ordered hierarchically (table 3) from most productive (e.g., warm and wet) to least productive (warm and xeric), and the total number of species and

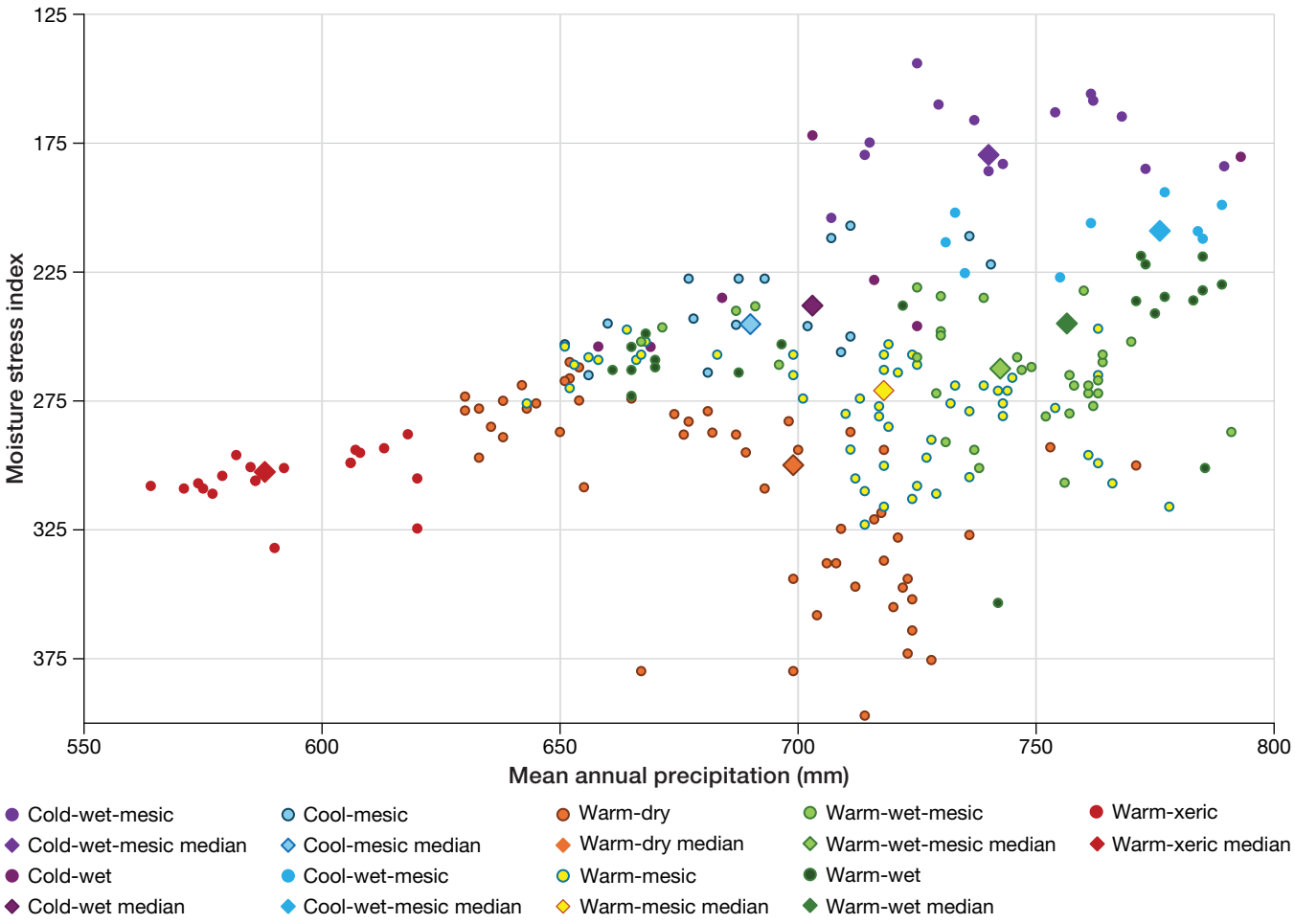

Figure 6—The distributions of species and species groups, color coded by species group, by summer moisture stress (ratio of temperature to precipitation from May through September) and mean annual precipitation. Circles represent individual species median values for each variable. Diamond shapes represent species group median values. See appendix 6 for a list of species in each group.

Table 3—Hierarchical species groups, their ranks (from most to least productive), names, and codes, with number of indicator species and three selected common indicator species for each species group

Rank	Species group name	Species group code	Number of indicator species	Selected common, representative species[a]
1	Warm-wet	WaWt	23	*Athyrium filix-femina*
				Blechnum spicant
				Rubus spectabilis
2	Cold-wet	CdWt	9	*Alnus viridis*
				Ledum glandulosum
				Senecio triangularis
3	Warm-wet-mesic	WaWM	37	*Acer circinatum*
				Linnaea borealis
				Polystichum munitum
4	Cool-wet-mesic	ClWM	10	*Menziesia ferruginea*
				Vaccinium membranaceum
				Vaccinium ovalifolium
5	Cold-wet-mesic	CdWM	19	*Phyllodoce empetriformis*
				Rhododendron albiflorum
				Valeriana sitchensis
6	Warm-mesic	WaMe	54	*Acer glabrum*
				Mahonia nervosa
				Vaccinium parvifolium
7	Cool-mesic	ClMe	16	*Arctostaphylos nevadensis*
				Paxistima myrsinites
				Vaccinium scoparium
8	Warm-dry	WaDr	53	*Calamagrostis rubescens*
				Symphoricarpos albus
				Toxicodendron diversilobum
9	Warm-xeric	WaXe	23	*Artemisia tridentata*
				Festuca idahoensis
				Purshia tridentata

[a] See appendix 5 for a crosswalk of scientific names to common names. See appendix 6 for a complete list of species in each group.

total percentage of cover were calculated for each species group in each plot. In most cases, we used a threshold of ≥25 percent cover for one species or ≥10 percent combined cover for two or more species in the species group to assign plot locations to a single subzone. In cases where understory vegetation was depauperate (<25 percent total cover), we used relative cover instead of absolute cover.

The plot assignment process followed the subzone hierarchy. Species group cover (percent) and threshold values were additive through the process. For example, if percentage of cover and number of species in group one exceeded the assignment threshold, then we assigned the plot to the warm-wet group. If group one species occurred but did not meet

the assignment threshold, we added the number of species and total percentage of cover of species in group one to the totals for species group two and re-evaluated against the assignment thresholds. If the total percentage of cover and number of species exceeded the assignment thresholds at that point, we assigned the plot to the cold-wet species group (group two). If a species group still did not meet the assignment thresholds, we repeated the process until we made an assignment. Table 4 has examples of species group assignments for specific plot locations. Note that the assigned species group is often not the most abundant species group at each location. Location 102407 illustrates an example where a species group assignment was made by adding percentage of cover and number of species for warm-wet and warm-wet-mesic species groups to exceed the assignment thresholds.

After we assigned a species group to all plot locations, we assigned a subzone based on the species group percentage of cover within the vegzone and a minimum number of locations per subzone within the vegzone. We kept the number of assigned subzones per vegzone to three or fewer to maximize the utility for landscape departure analysis. We used the following criteria in the final subzone assignment: (1) more than 50 locations, (2) more than 10 percent of locations within the vegzone, or (3) significant differences in disturbance regimes or response to disturbance. When the plot sample did not meet any of the criteria to assign an individual subzone, we lumped groups that were most closely related in the hierarchy (i.e., warm-wet and cold-wet, warm-wet-mesic and cool-wet-mesic, or warm-dry and warm-xeric). When the number of plots with indicator tree species was low for a specific vegzone (fewer than 50 plots), only one subzone was assigned to the vegzone.

We applied an exception to these rules to the parklands vegzone (30) and the pinyon-juniper-cypress vegzone (6). We split the subzones in the parklands vegzone by the specific indicator tree species present and added mountain hemlock and subalpine fir with cold-wet mesic species group assignments. In the pinyon-juniper-cypress vegzone, we split the subzones by indicator tree species presence—pinyon, juniper, and cypress—and for juniper indicator tree species, we split subzones by indicator understory species of shallow soils—little sagebrush (*Artemisia arbuscula*), scabland sagebrush (*Artemisia rigida*), black sagebrush (*Artemisia nova*), onespike danthonia (*Danthonia unispicata*), and Sandberg bluegrass (*Poa secunda*).

Temporal Stack

With all inventory plot locations used in GNN modeling labeled with a single vegzone and subzone, it was possible to generate provisional PNV maps for each year in the entire temporal span of the GNN data (1986–2017). This is referred to as the "temporal stack." In a GIS exercise, we then determined the majority subzone, number of unique subzones, and the highest hierarchical ranked subzone across 32 years for each pixel in the project area to create a composite subzone map. Where four or fewer subzone types were assigned to a pixel over time, the final label was the majority subzone. Where more than four unique subzones were assigned to a pixel over time (suggesting the location had experienced disturbance), or where there was no majority subzone (i.e., ties), the final label was the subzone with the highest hierarchical rank. We then performed two focal majority filters across the composite map (based on a 3-by-3 grid of 30-m pixels where the center pixel gets the assignment of a 3-by-3 majority and resolution stays at 30 m) to smooth the map and produce the final map product. We produced final vegzone maps from the final subzone maps using the one-to-one relationship between subzone and vegzone.

Table 4—Example species group assignments (shaded), with percentage of cover and number of species by species group, for specific plot locations representing each indicator species group

Location ID	Vegzone name[a]	Vegzone number	Subzone number	Indicator species group[b]	WaWt		CdWt		WaWM		ClWM		CdWM		WaMe		ClMe		WaDr		WaXe	
					Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.	Cov	Spp.
					%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#
140	TSHE	19	84	WaWt	21	2	—	—	70	3	—	—	—	—	48	5	—	—	—	—	—	—
142	PISI	9	47	WaWt	43	2	—	—	66	4	—	—	—	—	25	4	—	—	—	—	—	—
17092	TSME	23	94	CdWt	6	4	23	2	4	2	48	7	10	3	1	1	—	—	0	1	—	—
124	ABAM	22	88	CdWt	2	1	23	1	74	9	5	1	—	—	43	6	7	1	12	3	—	—
10419	ABGRC	20	58	WaWM	—	—	9	1	17	4	—	—	—	—	4	4	—	—	—	—	—	—
102407[c]	TSHE	19	83	WaWM	8	1	—	—	9	3	1	1	—	—	22	6	—	—	—	—	—	—
28841	SESE3	17	49	WaWM	8	2	—	—	69	4	—	—	—	—	61	5	—	—	—	—	—	—
9021	TSME	23	93	ClWM	1	3	—	—	8	6	95	7	1	1	17	4	—	—	1	1	—	—
9608	Parklands	30	65	CdWM	—	—	5	2	0	1	—	—	31	8	1	1	134	4	3	1	—	—
68000	Parklands	30	100	CdWM	—	—	—	—	—	—	—	—	31	4	—	—	3	3	—	—	—	—
22470	LIDE3	15	51	WaMe	5	1	—	—	2	1	2	1	—	—	78	5	—	—	119	3	—	—
16706	PSME	14	42	WaMe	—	—	—	—	—	—	—	—	—	—	65	7	12	3	55	7	1	1
28006	ABMAS	21	71	ClMe	—	—	—	—	4	1	—	—	—	—	—	—	45	2	1	1	—	—
12082	PICO	8	25	ClMe	—	—	—	—	—	—	—	—	—	—	8	2	74	3	14	3	—	—
8772	PSME	14	41	WaDr	—	—	—	—	—	—	—	—	—	—	10	4	—	—	45	8	34	7
10735	PIPO	10	31	WaDr	—	—	—	—	—	—	—	—	—	—	0	1	—	—	38	8	20	9
697	HW_ OAKS	11	18	WaDr	—	—	—	—	—	—	—	—	—	—	0	1	—	—	33	3	—	—
1654	PIPO	10	35	WaXe	—	—	—	—	—	—	—	—	—	—	0	1	—	—	5	1	34	2
23239	PIMO	6	23	WaXe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	13	1
1769	JUOC	6	22	WaXe	—	—	—	—	—	—	—	—	—	—	0	1	—	—	3	1	47	7

Cov is the sum of maximum percentage of cover within the species group over all observations at a single location. Spp is the count of individual species within the species group over all observations at a single location.

[a] Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[b] See table 3 for species group code definitions and appendix 6 for a list of species in each species group.

[c] Location 102407 is an example where the species group WaWM was assigned; adding percentages of cover and number of species for the warm-wet and warm-wet-mesic species groups exceed the assignment threshold therefore assigning it to the WaWM group.

Nonforest Mask Development

We added PNV types other than forested ones to the vegzone and subzone maps based on existing nonforest mapping methods, starting with the 2012 GNN nonforest mask (Davis et al. 2015, 2022). We modified this mask to reduce embedded disturbance artifacts (mostly old fire scars) and to improve the wetlands delineations within the mask. We used a combination of USDI U.S. Geological Survey (USGS) 1992 National Land Cover database (USGS 1992), 2011 USGS continuous forest cover estimates (USGS 2014), and GNN maximum forest cover predictions from 1984–2017 as the basis for this analysis, with the assumption that pixels with ≥20 percent tree cover at any point in time in any data source are forested or woodland types. We also used light detection and ranging (LiDAR) data where it was available and assumed locations (30-m pixels) with ≥10 percent LiDAR first returns above 11.5 ft (3.5 m) currently or previously supported forest and therefore have a forested PNV type. We used the USDI Fish and Wildlife Service national wetlands inventory layer to identify and categorize emergent and palustrine wetlands (US FWS, n.d.).

We used the USGS-LANDFIRE ESP (ecological systems) data layer to populate the vegzones and subzones within the nonforest mask (USGS and USDA FS, n.d.b). We grouped the ecological systems into functional groups for the vegzone layer—parklands, shrublands, grasslands-meadows, ice and snowfields, rock, water, and developed. We created subzones for the nonforest portions of parklands, as well as for the shrublands and grasslands-meadows, using groups of classification unit combinations from both the USGS-LANDFIRE ESP (USGS and USDA FS, n.d.b) and national wetlands inventory wetland classifications (US FWS, n.d.). The final nonforest mask was filtered twice (focal majority assignment based on a 3-by-3 grid of 30-m pixels to smooth the map) and spot checked using historical photomosaic data. We then integrated this mask into the forested map to create the final product.

Subzone Naming Conventions

To develop consistent terminology for subzone names, we used spatial climate data in conjunction with vegetation data (Daly et al. 2015) for most, but not all, vegzones. Three vegzones consisted of single subzones—giant sequoia (*Sequoiadendron giganteum*), knobcone pine (*Pinus attenuata*), and Port Orford cedar (*Chamaecyparis lawsoniana*), thus no additional labels were needed. For four vegzones (pinyon-juniper-cypress, California foothill pine-Coulter pine, hardwoods, and parklands), we elected to label subzones with reference to some combination of species composition, vegetation structure, or habitat.

For the remaining subzones, we summarized mean annual precipitation and temperature by vegzone and subzone. We evaluated variation within vegzones and among subzones within vegzones to determine appropriate labels.

We applied a consistent set of descriptors (see table 5) linked to median values of mean annual precipitation and mean annual temperature for both vegzone and subzone classification units (or in some cases other order statistics where medians did not differ) (tables 5 and 6). For four vegzones—redwood, Sitka spruce, tanoak (*Notholithocarpus densiflorus*), and western hemlock—mean annual temperature was consistent enough that it was possible to label subzones strictly based on mean annual precipitation. For the western redcedar (*Thuja plicata*) vegzone, the mean annual precipitation was consistent, so subzones were labeled strictly based on temperature. We applied labels from median values of both mean annual temperature and mean annual precipitation for some or all subzones in nine vegzones—Douglas-fir, Jeffrey pine (*Pinus jeffreyi*), lodgepole pine, ponderosa pine, mountain hemlock,

Table 5—Descriptors for subzones based on mean annual precipitation

Mean precipitation		Descriptor
Lower limit	Upper limit	
INCHES		
≥80	N/a	Very wet
≥70	<80	Wet
≥50	<70	Very moist
≥30	<50	Moist
≥20	<30	Dry
N/a	<20	Xeric

N/a = not applicable.

Table 6—Descriptors for subzones based on mean annual temperature

Mean temperature		Descriptor
Lower limit	Upper limit	
DEGREES FAHRENHEIT		
≥47.5	N/a	Very warm
≥45.0	<47.5	Warm
≥43.0	<45.0	Mild
≥41.0	<43.0	Cool
N/a	<41.0	Cold

N/a = not applicable.

California red fir-Shasta red fir, Pacific silver fir, subalpine fir (*Abies lasiocarpa*)-Engelmann spruce (*Picea engelmannii*), and white fir-grand fir.

We applied labels for median temperature and 25th percentile of precipitation for one subzone in the Douglas-fir vegzone and two subzones in the Pacific silver fir vegzone. Evaluation of more extreme percentiles of temperature and precipitation were necessary to apply labels to three subzones in the subalpine fir-Engelmann spruce vegzone and two subzones in the white fir-grand fir vegzone. Finally, for three subzones in the ponderosa pine vegzone and one in the lodgepole pine vegzone, we applied labels based on some combination of species composition, vegetation structure, and habitat.

Feedback Sessions

In 2019, we held feedback (expert review) sessions with individuals from each national forest in the Forest Service's Pacific Northwest Region and several ecologists in its Pacific Southwest Region to work through potential local issues with the PNV map at that time. The goals of the sessions were to develop familiarity with the PNV classification and mapping process and products, discuss scale and expected uses, and solicit reviews of the map. An overarching issue appeared to be the names of the subzones at the time. As a result, we developed a process to come up with a common naming convention (see "Subzone Naming Conventions" above).

To capture the comments and concerns from the Forest Service ecologists from California, we made changes to the rule set to refine the boundaries between the white fir-grand fir and California red fir-Shasta red fir vegzones, and the California red fir-Shasta

red fir and mountain hemlock vegzone boundaries. We changed the percentage of cover thresholds for white fir and California red fir in the rule set to increase the extent of the California red fir-Shasta red fir vegzone for the Forest Service's Pacific Southwest Region. We incorporated all suggested nonforest mask changes for the coastal scrub and chaparral subzones within California.

Accuracy Assessment

We evaluated accuracy and uncertainty in the PNV maps using two different approaches based on nearest neighbor concepts from GNN: (1) local-scale accuracy—observed versus predicted vegzone/subzone at model plot locations and (2) area-based regional accuracy using design-based (plot) versus model-based (GNN) area estimates.

Local-Scale Accuracy

We used a nearest independent neighbor approach to assess accuracy of the PNV map at the FIA plot scale (about 2.5 ac) for both vegzone and subzone (Ohmann and Gregory 2002). The nearest independent neighbor approach allowed us to generate a model validation dataset that behaved similarly to an independent validation dataset from the same forest inventory data used to develop GNN maps, thus providing a more reliable assessment of PNV map accuracy. For each inventory plot location used in producing the GNN dataset (referred to as GNN plots), the nearest neighbor plots in gradient space that did not occupy the same geographic location were selected for the nine 30- by 30-m pixels that comprised the spatial extent sampled by that GNN plot. Therefore, for each pixel in the 3-by-3 footprint, we produced a time series of 32 (1986–2017) nearest independent neighbor (plot) predictions. We assigned these plots a subzone classification using the same logic as for the new PNV map.

To get to a single subzone assignment for each pixel, we evaluated the majority (mode) subzone across all 32 observations and the number of distinct subzone assignments across all 32 observations. When the number of distinct subzone assignments was four or fewer (low variation in pixel subzone assignment), we assigned the majority subzone. Otherwise, we assigned the subzone of the highest hierarchical rank. Finally, we took the majority (mode) across all nine pixels in the plot location footprint to represent the predicted subzone for that plot location. To assign predicted vegzones, we applied the vegzone associated with each predicted subzone.

For forested vegzones and subzones, we created confusion matrices based on strict and fuzzy classifications. In the strict version, we recorded an assignment as correct if there was an exact match between the observed plot assignment and the predicted assignment using the nearest independent neighbor method. For fuzzy classification, we constructed lists for each vegzone and subzone of other types sufficiently similar in their environmental relationships and floristic composition for which interpretation of the map would not significantly suffer if the assignments were swapped (apps. 7 and 8).

For example, for the vegzone represented by the largest number of GNN plots (white fir-grand fir), there were 11 vegzones that we judged to constitute a fuzzy match: lodgepole pine, ponderosa pine, Jeffrey pine-knobcone pine, Douglas-fir, giant sequoia, western hemlock, western redcedar, California red fir-Shasta red fir, Pacific silver fir, mountain hemlock, and subalpine fir-Engelmann spruce. Across vegzones and subzones, the number of zones constituting a fuzzy match averaged 4.95 and 5.75 with a maximum of 11 and 13, respectively. Therefore, fuzzy classification accuracy represents relatively coarse-level agreement between PNV observations and predictions.

From the confusion matrices, we calculated overall accuracy, as well as producer's accuracy—the proportion of plots where the observed class (subzone or vegzone) was correctly predicted by the GNN (i.e., the ratio of correctly classified plots in a given class to the total number of observed plots in that class)—and user's accuracy—the proportion of plots where the predicted GNN class matched the observed class (i.e., the ratio of correctly classified plots in a given class to the total number of predicted plots in that class) (Olofsson et al. 2013, 2014).

We also assessed variability in local strict producer's accuracy within the project area. We geographically filtered by GNN modeling region (Ohmann and Spies 1998, Ohmann et al. 2012) (fig. 7, table 7), which is similar to, but not the same as, level III ecoregions (fig. 2) (Omernik 1987, Omernik and Griffith 2014). We developed accuracy values for each vegzone by modeling region and used summary statistics to describe geographic variability by modeling region.

Area-Based Regional Accuracy

To understand how vegzone or subzone areas derived from PNV maps relate to unbiased estimators of area that leverage a forest inventory sampling design, we compared GNN-based PNV maps with design-based (plot) population estimates from 2017 FIA plot evaluations for Washington, Oregon, and California (Bechtold and Patterson 2005). For each vegzone and subzone, we generated a statistical estimate (area and 95-percent confidence interval) to compare to the area predictions generated directly from our PNV maps. This comparison is intended to allow

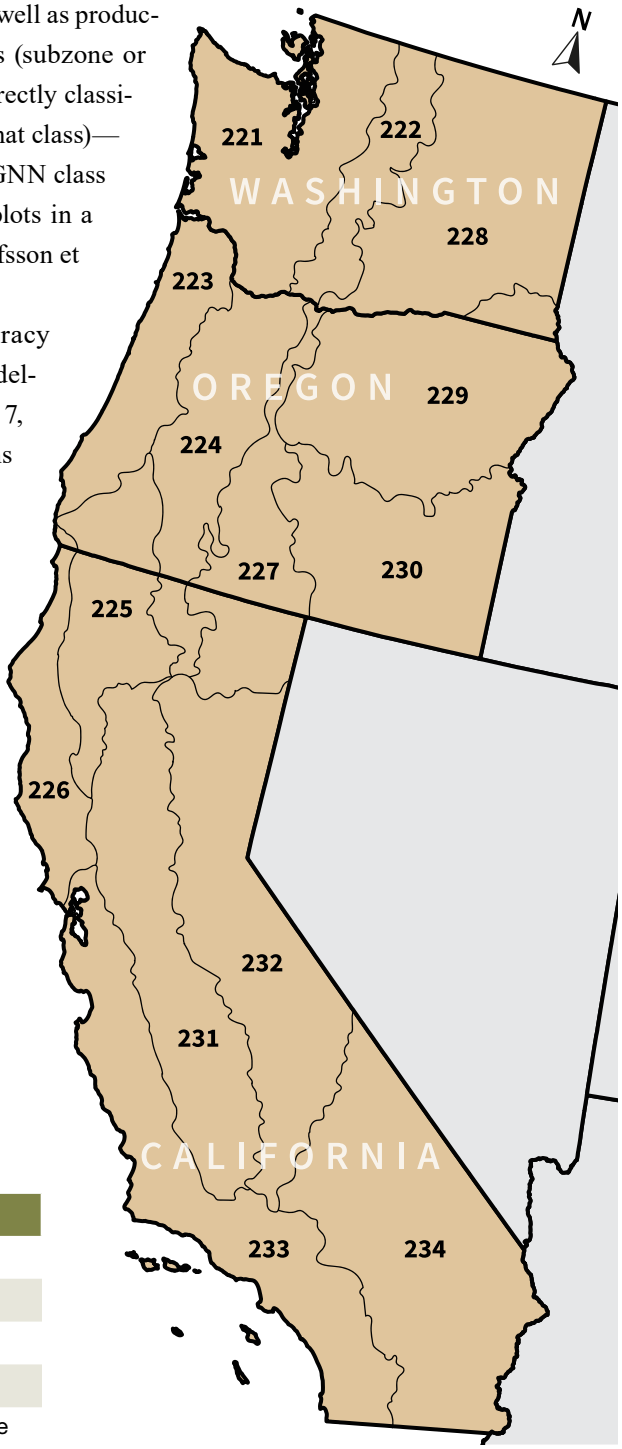

Figure 7—Gradient Nearest Neighbor modeling regions across the Potential Natural Vegetation Map project area. Adapted from LEMMA (n.d.). See table 7 for modeling region numbers and names.

Table 7—Gradient Nearest Neighbor modeling regions

Modeling region number	Name
221	Washington Coast and Cascades
222	Washington Eastern Cascades
223	Oregon Coast Range
224	Oregon and California Cascades
225	Oregon and California Klamath Province
226	California Northern Coast
227	Oregon and California Eastern Cascades
228	Eastern Washington
229	Northeastern Oregon
230	Southeastern Oregon
231	California Central Valley
232	California Sierra Nevada
233	California Southern Coast
234	Southeastern California

us to assess how similar map predictions of vegzone and subzone area are to design-based estimates. Although both the design-based approach and the mapped-based approach have inherent uncertainties, we chose to compare our map predictions to the design-based estimates as a general measure of map accuracy at broad scales. This approach is a standard component of the GNN accuracy assessment approach (Bell et al. 2023).

To determine agreement between the two area estimates, we employed the following methods. For mapped-based predictions, we calculated the sum of mapped area in each vegzone and subzone from our final GNN map. This approach does not provide a measure of uncertainty (e.g., confidence interval). For design-based estimates, we used species composition data from plot locations included in 2017 FIA evaluations (forest evaluation identification codes [EVALIDs] 532017 for Washington, 412017 for Oregon, and 062017 for California) to determine both subzone and vegzone. We used FIA poststratification area expansion factors (i.e., area a given plot or plot location represents) to determine subzone and vegzone class areas across the study region. We grouped plots by vegzone/subzone and calculated total area for each vegzone/subzone as the sum across the plots' area expansion factors. Likewise, we calculated standard errors associated with each vegzone/subzone using FIA poststratification procedures and multiplied by 1.96 to represent the 95-percent confidence interval associated with each class (Bechtold and Patterson 2005).

Results

Classification, mapping and spatial distribution of classified components, and accuracy assessment outcomes are the major results. Because the project area was so large and diverse, we assessed abundance and geographic distribution of vegetated components using the level III ecoregions (Omernik 1987, Omernik and Griffith 2014) (fig. 2) to describe distribution both across the project area and local distribution within each ecoregion. All abundance and distribution data can be found in appendix 9.

Classification and Mapping

Forest and woodland classification resulted in the recognition of 20 vegzones (table 8, app. 10). Each vegzone has between one and eight finer grained biophysical environments, or subzones, for a total of 66 forest and woodland subzones.

The nonforest mask resulted in multiple components. There are two vegetated nonforest vegzones, grasslands-meadows and shrublands. The grasslands-meadows vegzone has four subzones, while the shrublands vegzone has eight subzones. We also identified other nonvegetated elements, such as developed, rock, ice, and water (table 8). Detailed descriptions (indicator species, mean percentage of cover and constancy), and distribution of all vegzones and subzones can be found in appendices 9 and 11.

A digital map layer displaying the distribution of our classified elements can be downloaded from the Forest Service, Pacific Northwest Region's *Terrestrial Ecological Unit Inventory* website (USDA FS PNW Region, n.d.c). Vegzone distribution is depicted in figure 8. For the subzone map, see appendix 12, and for a side-by-side comparison of vegzone and subzone distributions, see figure 10. Forest and woodland vegzones occupy the largest area (55.3 percent) of the landscape (table 8). Nonforest (22.7 percent) and nonvegetated vegzones (22.1 percent) are less common (table 8). Over the entire project area, individual vegzones range from <0.1 percent (ice and snowfields, giant sequoia) to 20.6 percent (shrublands) (fig. 8, table 8).

Table 8—Vegzone abundance and ecoregion distribution in the Potential Natural Vegetation Map project area (≥0.1 percent abundance within an ecoregion)

Vegzone name	Abundance		Ecoregions present
	THOUSANDS OF ACRES	PERCENT OF PROJECT AREA	COUNT
Forest and woodland vegzones	91,736	55.3	N/a
White fir-grand fir	18,496	9.0	16
Western hemlock	17,134	8.3	8
Hardwoods	1,495	7.2	20
Douglas-fir	12,849	6.2	15
Pinyon-juniper-cypress	11,473	5.6	14
Ponderosa pine	9,765	4.7	13
California foothill pine-Coulter pine	4,612	2.2	10
Pacific silver fir	4,346	2.1	6
Mountain hemlock	3,259	1.6	8
Sitka spruce	2,896	1.4	5
Parklands	2,724	1.3	12
Tanoak	2,619	1.3	5
Jeffrey pine	2,545	1.2	9
Redwood	2,304	1.1	3
Subalpine fir-Engelmann spruce	1,672	0.8	5
California red fir-Shasta red fir	1,357	0.7	5
Western redcedar	526	0.3	1
Lodgepole pine	459	0.2	5
Port Orford cedar	160	0.1	2
Giant sequoia	3	0.0	1[a]
Nonforest vegzones	46,893	22.7	N/a
Shrublands	42,630	20.6	17
Grasslands-meadows	4,263	2.1	20
Nonvegetated vegzones	42,627	22.1	N/a
Developed	31,578	15.3	20
Rock	11,049	5.4	18
Water	2,623	1.3	20
Ice and snowfields	147	0.1	2

N/a = not applicable

See appendix 9 for complete vegzone and subzone abundance and distribution data.

[a] Present but occupies less than 0.1 percent of the overall project area.

Individual forest and woodland vegzone abundances vary across the project area (fig. 8, table 8). Although no single vegzone dominates, several occupy at least 10 million acres (5 percent) or more of the project area (e.g., white fir-grand fir, western hemlock) (table 8). Other vegzones are very limited in total area, occupying less than 1 percent of the project area (e.g., subalpine fir-Engelmann spruce, Port Orford cedar) (table 8).

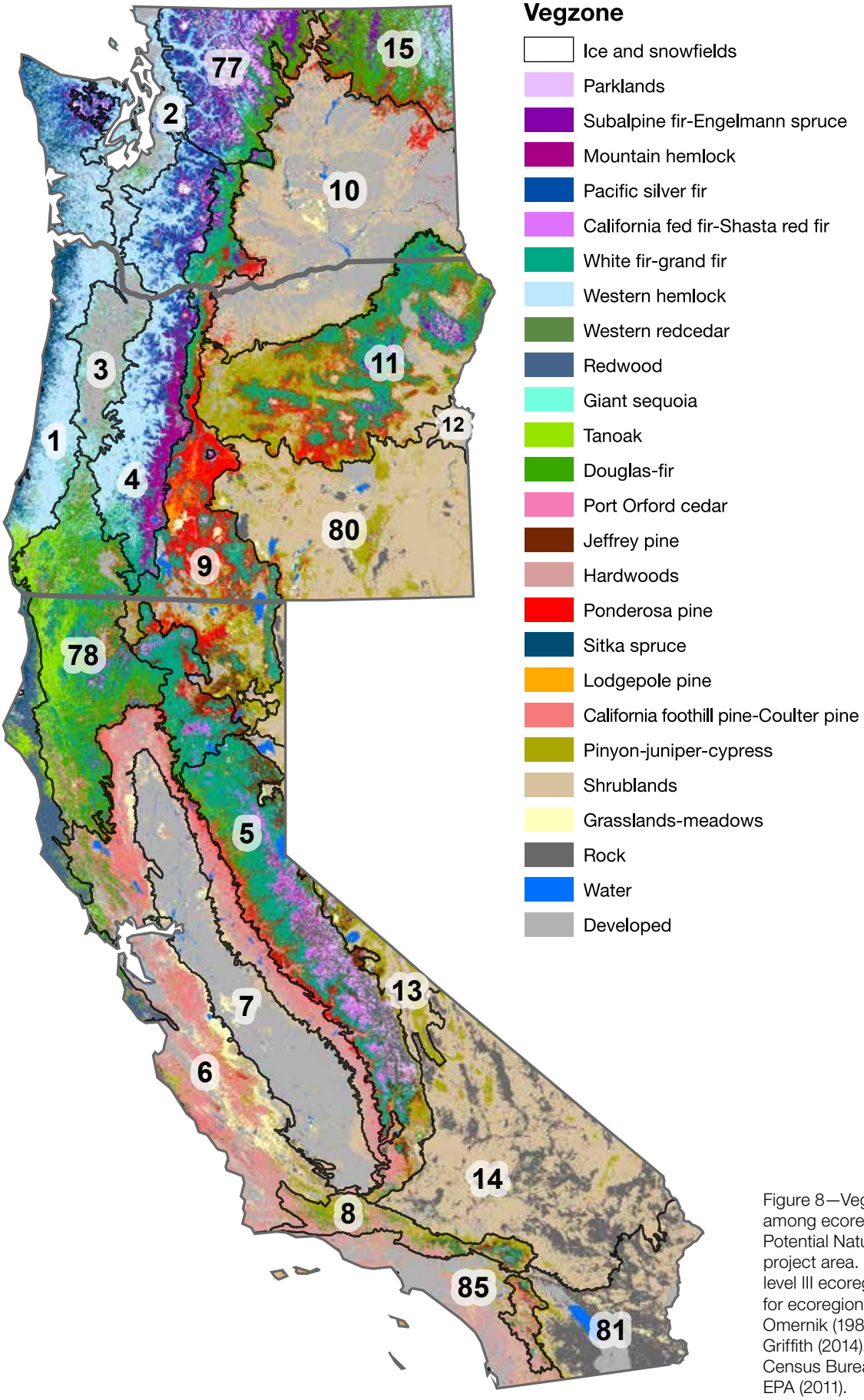

Figure 8—Vegzone distribution among ecoregions across the Potential Natural Vegetation Map project area. Numbers represent level III ecoregions. See figure 2 for ecoregion names. Sources: Omernik (1987), Omernik and Griffith (2014). Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

Forest and woodland subzone abundance generally follows vegzone abundance patterns (app. 9). Thirteen subzones occupy at least 4.34 million acres, or 2 percent of the project area (table 9, app. 9).

A broad range of environmental conditions occur across the project area (fig. 3). The 20 forest and woodland vegzones exhibit variable environmental distribution patterns (fig. 9). The hardwoods and California foothill pine-Coulter pine vegzones occupy the warmest

Table 9—Common forest and woodland subzone abundance in the Potential Natural Vegetation Map project area (≥0.1 percent abundance within an ecoregion)

Vegzone name	Subzone name	Abundance	Ecoregions present
		PERCENT OF PROJECT AREA	COUNT
Western hemlock	Western hemlock/very moist	6.8	8
	Western hemlock/wet	1.4	7
Hardwoods	Oak woodlands	4.5	11
	Other hardwoods	1.6	7
White fir-grand fir	White fir-grand fir/warm-dry	3.5	12
	White fir-grand fir/warm-xeric	3.5	11
	White fir-grand fir/warm-moist	1.6	11
Pinyon-juniper-cypress	Juniper woodlands	3.4	14
	Juniper scablands	1.1	12
	Pinyon woodlands	1.1	6
Douglas-fir	Douglas-fir/very warm-dry	3.0	12
	Douglas-fir/warm-dry	2.2	12
California foothill pine-Coulter pine	California foothill pine-oak	2.0	9

See appendix 9 for complete vegzone and subzone abundance and distribution data.

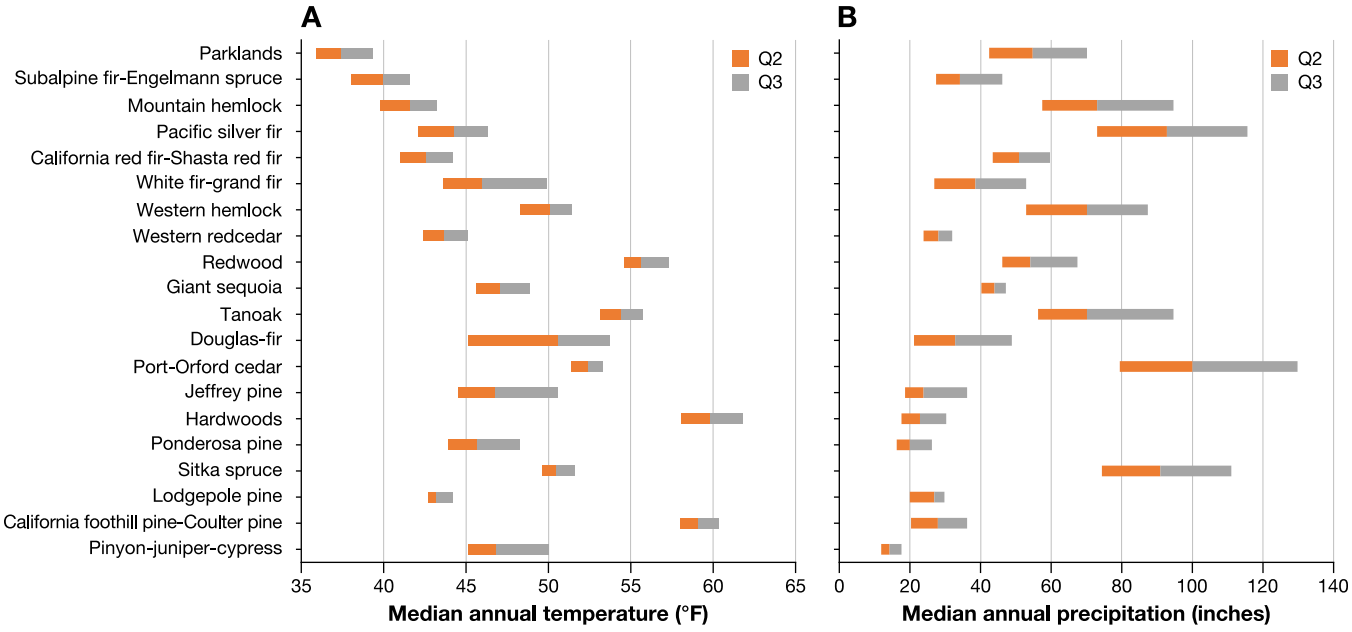

Figure 9—Median and interquartile ranges of annual temperature (A) and precipitation (B) for forest and woodland vegzones. Q2 and Q3 are quartiles 2 and 3, or the inner two of the four quartiles, for each variable. Data source: PRISM Climate Group (2025).

median annual temperature regimes, and the parklands vegzone occupies the coldest. The lowest median annual precipitation is found in the pinyon-juniper-cypress and ponderosa pine vegzones. The Port Orford cedar vegzone has the highest range of median annual precipitation, followed by the Pacific silver fir and Sitka spruce vegzones. Some vegzones occupy very limited temperature/moisture regimes (e.g., lodgepole pine and Port Orford cedar), while others occur across broad biophysical environments (e.g., white fir-grand fir, Douglas-fir) (fig. 9).

Nonforest potential vegetation exhibits variable abundance patterns across the landscape (table 10). The shrublands vegzone dominates nonforest coverage, with the grasslands-meadows vegzone occupying a small percentage of the project area (table 10). Upland shrub and creosote bursage scrub are the most common shrub subzones (table 10). The upland grass subzone occupies the most area in the limited grasslands-meadows vegzone (table 10).

Table 10—Nonforest vegzone and subzone abundance in the Potential Natural Vegetation Map project area (≥0.1 percent abundance within an ecoregion)

Vegzone name	Subzone name	Abundance	Ecoregions present
		PERCENT OF PROJECT AREA	COUNT
Grasslands-meadows	Upland grass	1.3	18
	Wet meadow	0.5	17
	Moist meadow	0.2	15
	Scabland grass	0.1	5
Shrublands	Upland shrub	9.5	11
	Creosote-bursage scrub	4.6	6
	Desert scrub	2.1	6
	Chaparral	1.5	8
	Scabland shrub	1.3	7
	Salt Desert shrub	1.3	10
	Coastal scrub	0.3	4
	Montane shrub	0.0[a]	5
Parklands	Subalpine grassland-forbland	0.1	2
	Subalpine shrub	0.0[a]	2

See appendix 9 for complete vegzone and subzone abundance and distribution data.

[a] Present but occupies less than 0.1 percent of the overall project area.

Geographic Vegetation Distribution Patterns

Overall vegetation geographic distribution patterns are variable in both forest and woodland and nonforest types (fig. 10). There are examples of broad areas where one type is dominant (fig. 10: 1), a strong spatial gradient is evident (fig. 10: 2), or there is high diversity and spatial heterogeneity (fig. 10: 3). All three pattern types are present for most vegzones and subzones across the project area. In this section, we discuss the spatial distribution both across the project area and within ecoregions of each vegetated vegzone and the most common subzone(s) within each vegzone. We use both the ecoregion name and number (inside brackets) (see fig. 2) to facilitate figure interpretation.

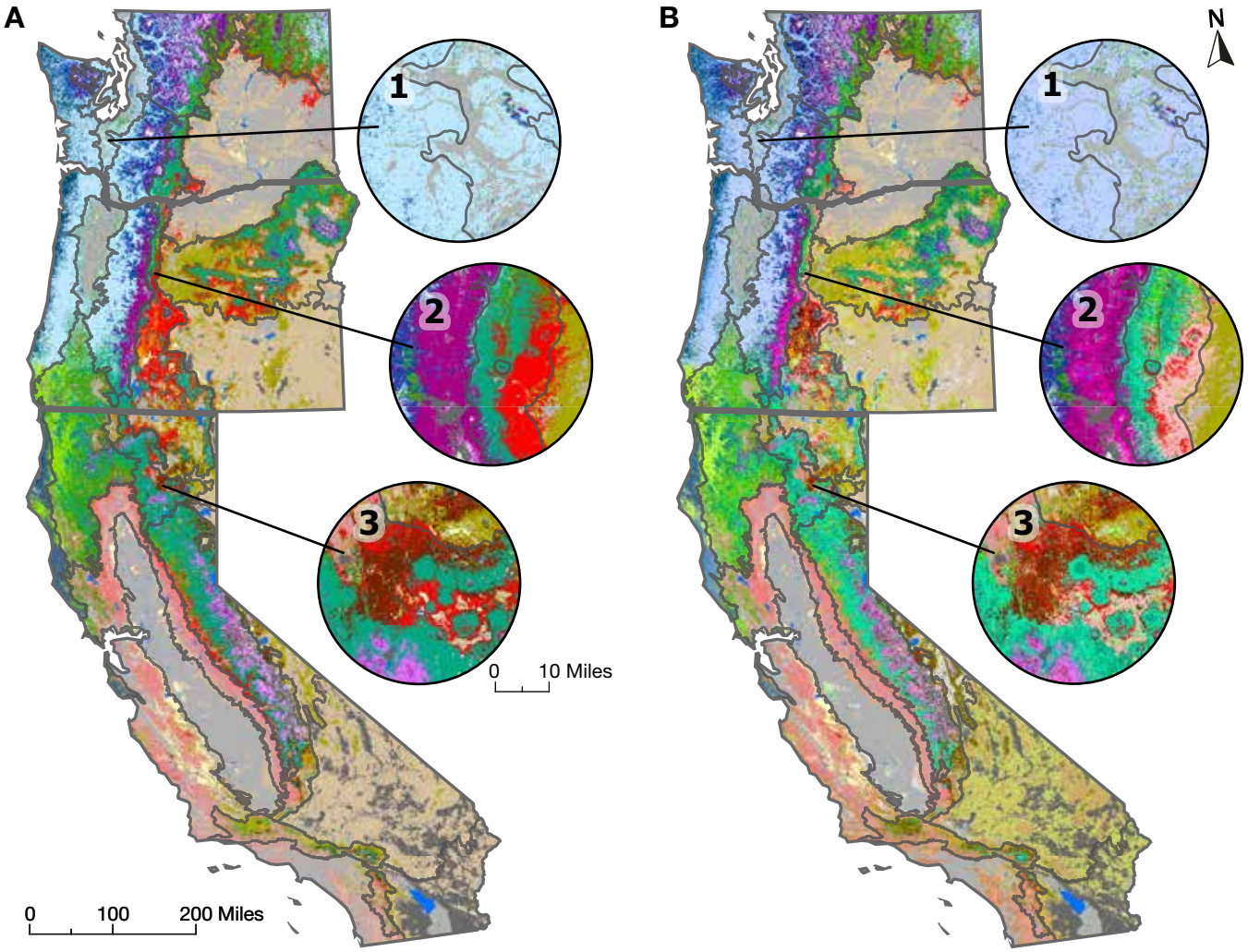

Figure 10—Spatial patterns found in vegzone (A) and subzone (B) maps across the Potential Natural Vegetation Map project area. Patterns may show a single dominant vegzone/subzone (inset 1), a strong spatial gradient of multiple zones (inset 2), or high heterogeneity and diversity within an area (inset 3). See figure 8 and appendix 12 for vegzone and subzone legends. Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

We identified three vegzone abundance levels that translate into variable geographic distribution types. Below we describe the common, moderately represented, and rare forest and woodland vegzones and subzones, as well as nonforest distribution. The vegzones for each distribution type can be viewed in figure 8, with the appropriate subzone distribution figure listed in the heading to aid in the results discussion.

Common Forest and Woodland Vegzones and Subzones

The white fir-grand fir, western hemlock, hardwood, Douglas-fir, and pinyon-juniper-cypress vegzones are fairly well distributed across the project area (fig. 8). These five vegzones have the highest forest and woodland abundance (totaling 36.3 percent of the project area), with each vegzone occurring in 8 to all 20 ecoregions (fig. 8, table 8). The 13 common subzones occupy 35.7 percent of the project area, and each subzone is found in 6 to 14 ecoregions (fig. 11, table 9, app. 9).

The widely distributed Douglas-fir vegzone occurs across Washington, Oregon, and California, where it forms variable distribution patterns (fig. 8). It is the main vegzone in the Northern Rockies [15] and the Klamath Mountains/California High North Coast Range

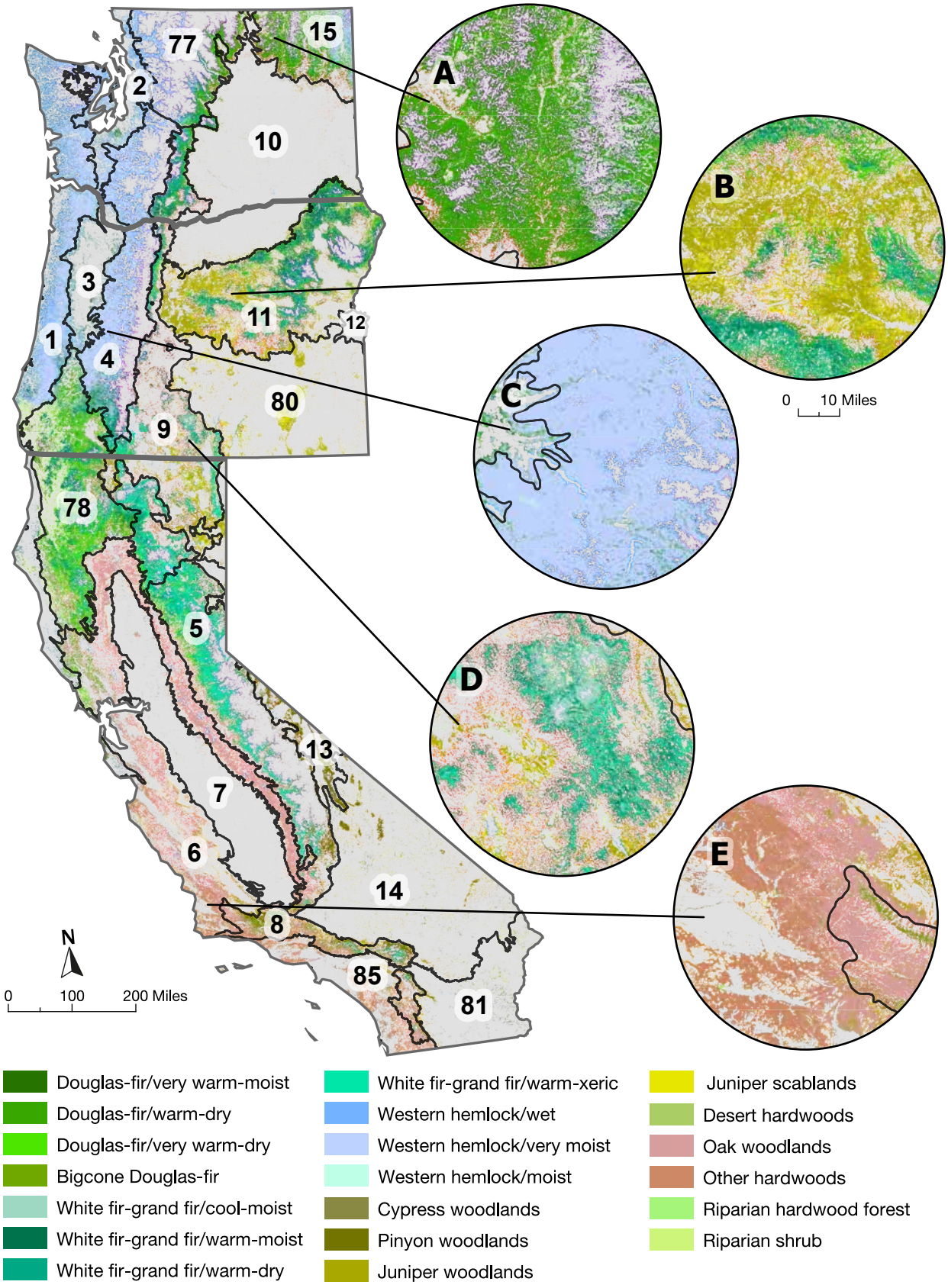

Figure 11—Common subzone distributions and patterns by ecoregion across the Potential Natural Vegetation Map project area: (A) Douglas-fir/warm-dry subzone dominant spatial pattern, (B) juniper woodlands subzone codominant with white fir-grand fir/warm-dry subzone intermixing in a high diversity pattern with juniper scablands and white fir-grand fir/warm-moist subzones, (C) western hemlock/very moist subzone dominant spatial pattern, (D) white fir-grand fir subzones intermixing with juniper woodlands and juniper scablands subzones, (E) oak woodland and other hardwoods subzones dominant spatial pattern and intermixing. Numbers represent level III ecoregions; see figure 2 for ecoregion names. Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

[78] (fig. 8, app. 9). It is dominant in the Northern Rockies [15] (39.6 percent of the ecoregion) or is found in a spatial gradient with the ponderosa pine vegzone, on the drier end, and the western hemlock vegzone, on the more mesic portions of the ecoregion (fig. 8, app. 9). In the Klamath Mountains/California High North Coast Range [78] (34.8 percent), it intermixes with the tanoak vegzone on the west side and the white fir-grand fir vegzone throughout the ecoregion (fig. 8, app. 9). The most common Douglas-fir subzones, Douglas-fir/very warm-dry and Douglas-fir/warm-dry, co-occur across six ecoregions (app. 9). The Douglas-fir/very warm-dry subzone is dominant in the Klamath Mountains/California High North Coast Range [78] (23.6 percent), while the Douglas-fir/warm-dry subzone is dominant in the Northern Rockies [15] (33.1 percent) (fig. 11: A, app. 9).

The hardwoods vegzone is the most widespread of the common vegzones, found in all 20 ecoregions across Washington, Oregon, and California in a variety of patterns (fig. 8, table 8). It is most concentrated in California where it forms a dominant vegzone pattern in the Central California Foothills and Coastal Mountains [6] (38.7 percent), Southern California Mountains [8] (36.5 percent), and Southern California/Northern Baja Coast [85] (32.5 percent), commonly intermixing with the shrublands vegzone (fig. 8, app. 9). The common oak woodlands subzone, although found across Washington, Oregon, and California in 11 ecoregions (table 9), is also most concentrated in California where it is the only hardwood subzone in the Central California Foothills and Coastal Mountains [6] (fig. 11: E, app. 9) and dominates hardwood vegzone cover in the Southern California Mountains [8] (23.8 percent) (fig. 11, app. 9). The other hardwoods subzone occurs across four California ecoregions, including the Central California Foothills and Coastal Mountains [6] (fig. 11: E, app. 9); its highest percentage of cover occurs in the Southern California/Northern Baja Coast [85] (25.9 percent) (app. 9).

The pinyon-juniper-cypress and white fir-grand fir vegzones can be found in conjunction with other vegzones in a spatial gradient, or in codominant conditions across their distributions (fig. 8). The pinyon-juniper-cypress vegzone, found across eastern Washington, eastern Oregon, and most of California, is mostly evenly distributed across the 14 ecoregions in which it occurs (fig. 8, table 8); its highest percentage of cover occurs in the Central Basin and Range [13] (28.7 percent), where it is codominant with the white fir-grand fir vegzone (fig. 8, app. 9). The white fir-grand fir vegzone is found in 16 ecoregions that span most of the project area (fig. 8, table 8). This vegzone has a flexible distribution, found as a spatial gradient component in conjunction with the western hemlock and Pacific silver fir vegzones in the Cascades [4], and codominant (24 percent) with the ponderosa pine vegzone (27.1 percent) in the Eastern Cascades Slopes and Foothills [9] (fig. 8, app. 9). It is the dominant vegzone in the Sierra Nevada [5] (33.8 percent) (fig. 8, app. 9).

The common subzones of the pinyon-juniper-cypress and white fir-grand fir vegzones follow a similar pattern as their associated vegzones. The juniper woodlands and white fir-grand fir/warm-dry subzones can co-occur with other subzones in a spatial gradient or high diversity pattern; this occurs in the Blue Mountains [11] where they are codominant with white fir-grand fir/warm-xeric (4 percent), white fir-grand fir/warm-moist (7.2 percent), and juniper scablands (5.1 percent) subzones (fig. 11: B, app. 9). A similar pattern is found in the Eastern Cascades Slopes and Foothills [9], with white fir-grand fir/warm-xeric (9.4 percent), white fir-grand fir/warm-dry (9.5 percent), and white fir-grand fir/warm-moist (2.6 percent) subzones intermixing with juniper woodlands (11.6 percent) and juniper scablands (2.5 percent) subzones (fig. 11: D, app. 9). The pinyon woodlands subzone is also widespread

and is an important component in the Southern California Mountains [8] (12.3 percent) where it intermixes with the oak woodlands subzone (fig. 11, app. 9).

The western hemlock vegzone contains the most concentrated, uneven distribution of the common vegzones (fig. 8). Although occurring across eight ecoregions (fig. 8, table 8), 65 percent of its distribution is concentrated in the Coast Range [1] and Cascades [4] of western Washington and Oregon, often forming dominant vegetation patterns (fig. 8, app. 9). The western hemlock vegzone is the dominant vegetation type in four ecoregions: Puget Lowland [2] (57.8 percent), Coast Range [1] (45.0 percent), Cascades [4] (35.9 percent), and Willamette Valley [3] (25.4 percent) (fig. 8, app. 9). The common western hemlock/very moist subzone has the highest abundance of all the subzones (table 9, app. 9). It is the dominant subzone in the same four ecoregions where the western hemlock vegzone dominates, and it co-occurs with the less abundant western hemlock/wet subzone (fig. 11: C, app. 9).

Moderately Distributed Vegzones and Subzones of Local Importance

There are 10 vegzones and associated subzones that are less represented across the project area than the common types yet have some dominance within individual ecoregions (figs. 8 and 12, app. 9).

The ponderosa pine vegzone is widely distributed, occurring across 13 ecoregions in eastern Washington and Oregon, as well as throughout California (fig. 8, table 8). It is an important component of the Blue Mountains [11] (14.9 percent) and Northern Rockies [15] (12.6 percent) (fig. 8, app. 9). The ponderosa pine vegzone reaches its highest percentage of cover (27.1 percent) and codominates with the white fir-grand fir vegzone in the Eastern Cascades Slopes and Foothills [9] in a spatial gradient pattern (fig. 8, app. 9). The ponderosa pine/warm-xeric subzone is the most widely distributed subzone in this vegzone, accounting for 77 percent of the ponderosa pine vegzone cover in the Northern Rockies [15] (fig. 12, app. 9). The ponderosa pine-juniper woodlands subzone, another common subzone, occurs in nine ecoregions and is most concentrated in the Eastern Cascades Slopes and Foothills [9] (10.6 percent) intermixed with juniper woodlands, ponderosa pine/warm-xeric, white fir-grand fir/warm-xeric, and white fir-grand fir/warm-dry subzones (fig. 12: C, app. 9).

Four vegzones exhibit more limited distribution patterns, present across five to eight ecoregions in the project area in cooler environments (fig. 3). The Pacific silver fir and subalpine fir-Engelmann spruce vegzones are limited to Washington and Oregon, while the mountain hemlock and parklands vegzones occur in Washington and Oregon as well but also extend into California (fig. 8). The North Cascades [77] contains a complex of vegzones, and the highest percentages of cover of Pacific silver fir (19.9 percent), subalpine fir-Engelmann spruce (9.3 percent), and parklands (15.9 percent) vegzones occur in this ecoregion in a spatial gradient pattern (fig. 8, app. 9). Although common in the North Cascades [77], the highest percentage of mountain hemlock vegzone cover occurs in the Cascades [4] (12.3 percent) in a dominant pattern or in conjunction with Pacific silver fir (14.5 percent), western hemlock (35.9 percent), and white fir-grand fir (20.0 percent) vegzones in a spatial gradient pattern (fig. 8, app. 9).

Subzones in these four vegzones (Pacific silver fir, subalpine fir-Engelmann spruce, mountain hemlock, and parklands) exhibit similar distribution patterns (fig. 12). The most common Pacific silver fir subzones co-occur throughout the range of the Pacific silver fir vegzone; the highest percentage of Pacific silver fir/mild-wet subzone cover occurs in the Cascades [4] (10 percent), while the highest percentage of Pacific silver fir/mild-very wet subzone cover occurs in the North Cascades [77] (10.5 percent) (fig. 12: B, app. 9).

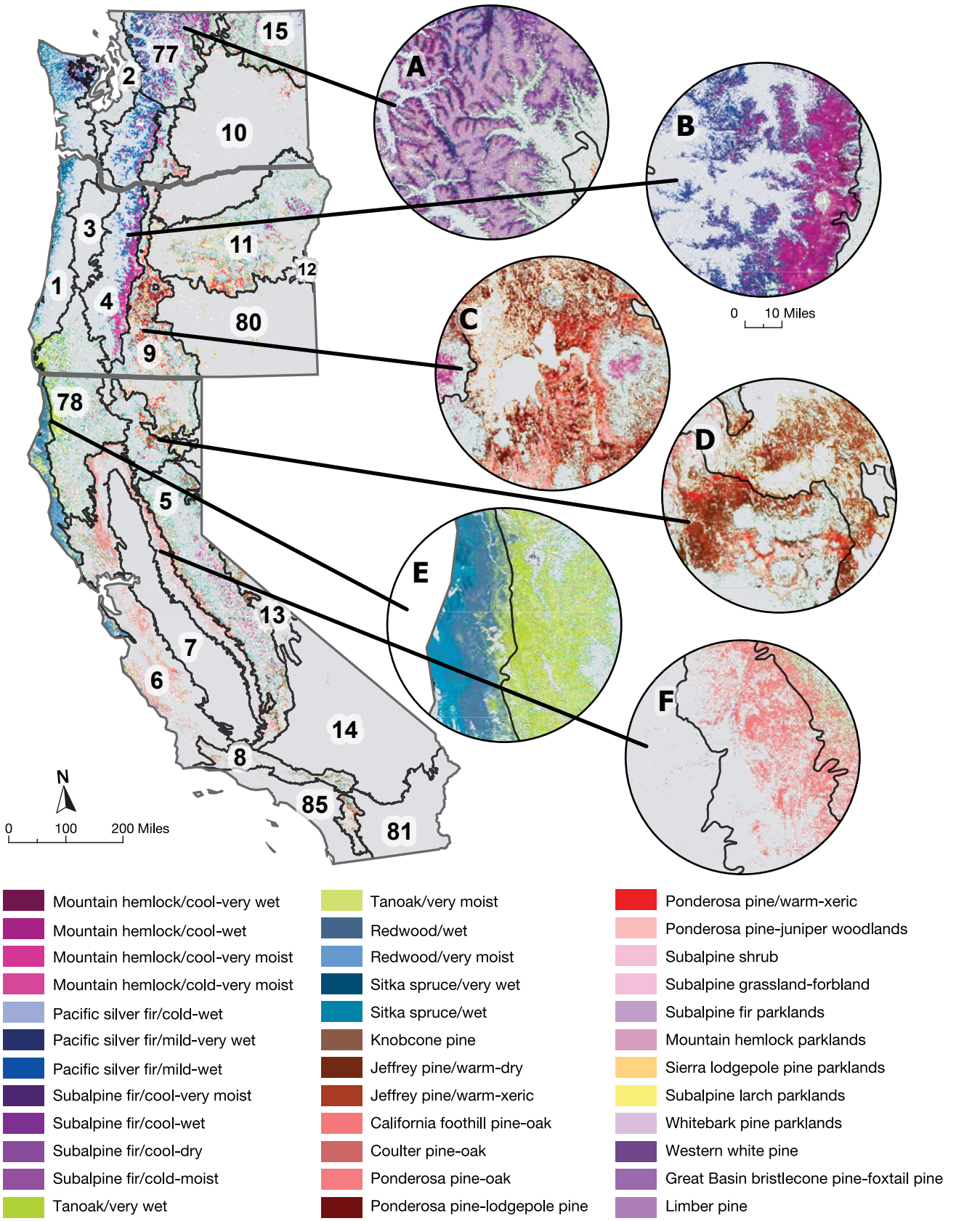

Figure 12—Moderately distributed subzone distributions and patterns by ecoregion across the Potential Natural Vegetation Map project area: (A) subalpine fir parklands and mountain hemlock parklands subzones intermixing, (B) Pacific silver fir/mild-very wet and mountain hemlock/cool-wet subzones dominant spatial patterns, (C) ponderosa pine-juniper woodlands subzone intermixing with ponderosa pine/warm-xeric subzone, (D) Jeffrey pine/warm-dry subzone occurring in a dominant pattern, (E) Sitka spruce/very wet subzone dominant spatial pattern on the coastal side and redwood/very moist subzone intermixing with the redwood/wet subzone to the south and on the inland portion, tanoak/very moist and tanoak/very wet intermingling, (F) California foothill pine-oak subzone dominant spatial pattern. Numbers represent ecoregions; see figure 2 for ecoregion names. Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

The subalpine fir-Engelmann spruce cool-dry and subalpine fir-Engelmann spruce cool-wet common subzones also co-occur across most of the vegzone range, with subalpine fir-Engelmann spruce/cool-wet showing higher local dominance. The highest percentages of cover of subalpine fir-Engelmann spruce/cool-dry and subalpine fir-Engelmann spruce/cool-wet subzones occur in the Northern Rockies [15] (1.1 and 4.3 percent, respectively) and North Cascades [77] (2.6 and 4.2 percent, respectively) (fig.12: A) (note that this subzone is labeled "subalpine fir" in the legend). Two common subzones in the parklands vegzone, subalpine fir parklands (8.1 percent) and mountain hemlock parklands (7.2 percent), are concentrated in the North Cascades [77] (fig. 12: A). The mountain hemlock/cool-wet subzone occupies 62 percent of the mountain hemlock vegzone, and its highest percentages of cover occurs in the Cascades [4] (7.6 percent) and North Cascades [77] (7.4 percent) (fig. 12: B, app. 9).

The Sitka spruce and redwood vegzones and their common subzones have very limited distributions, and high concentrations and are only found within the Coast Range [1], which contains 88 percent of the Sitka spruce vegzone distribution and 84 percent of the redwood vegzone distribution (figs. 8 and 12). Locally, the Sitka spruce and redwood vegzones are important in this ecoregion, contributing 19.2 percent and 14.5 percent cover, respectively, and form dominant patterns along the coastal strip (fig. 8, app. 9). Most of the Sitka spruce vegzone cover in the Coast Range [1] is found in the Sitka spruce/very wet subzone (14.5 percent), which dominates in the northern end of this ecoregion. The redwood vegzone is almost evenly split between the redwood/very moist (6.8 percent) and redwood/wet (7.7 percent) subzones (fig. 12: E, app. 9).

The tanoak vegzone, although occurring across five ecoregions, has most of its cover concentrated in the Klamath Mountains/California High North Coast Range [78] (69 percent) and the Coast Range [1] (23 percent) (fig. 8, table, 8). It reaches its highest local importance in the Klamath Mountains/California High North Coast Range [78] (14.9 percent) where it forms dominant patterns or occurs with the Douglas-fir (34.8 percent) and white fir-grand fir (23.7 percent) vegzones in a spatial gradient pattern (fig. 8, app. 9). The two subzones in this type, tanoak/very moist and tanoak/very wet, co-occur and intermingle throughout the range, being most locally important in the Klamath Mountains/California High North Coast Range [78], where they comprise 8.2 percent and 6.7 percent of cover, respectively (fig. 12: E, app. 9).

The California foothill pine-Coulter pine and Jeffrey pine vegzones display strong geographic concentration (fig. 8). Although the California foothill pine-Coulter pine vegzone occurs across 10 ecoregions centered in California (fig. 8, table 8), most of its cover is in the Central California Foothills and Coastal Mountains [6] (76 percent). Its highest percentage of cover occurs in this ecoregion (18.5 percent), along with the hardwoods vegzone (38.7 percent) (app. 9). In the Central California Foothills and Coastal Mountains [6], the California foothill pine-oak subzone dominates, accounting for 97 percent of the California foothill pine-Coulter pine vegzone cover (fig. 12: F, app. 9). The Jeffrey pine vegzone is widespread, occurring in nine ecoregions in Oregon and California (fig. 8, table 8), with the California ecoregions containing most of its distribution. Locally, the highest percentage of Jeffrey pine vegzone cover occurs in the Sierra Nevada [5] (8.2 percent) where it intermingles with the white fir-grand fir vegzone (33.8 percent) (app. 9). The Jeffrey pine/warm-dry subzone is the most common subzone in the Jeffrey pine vegzone (fig. 12: D). This subzone occurs throughout most of the vegzone range, and in the Sierra Nevada [5], the Jeffrey pine/warm-dry subzone accounts for more than 70 percent of Jeffrey pine vegzone cover (app. 9).

Rare Vegzones

Five vegzones occupy less than 1 percent of the project area and have very limited distribution, occurring sparsely in up to five ecoregions. Because these types are rare, we discuss their distribution at the vegzone grain only.

Although lodgepole pine, Port Orford cedar, and California red fir-Shasta red fir vegzones occupy more than one ecoregion (table 8), each is concentrated within only one (fig. 8). Seventy-nine percent of the lodgepole pine vegzone occurs only in the Oregon portion of the Eastern Cascades Slopes and Foothills [9] and is locally uncommon, accounting for 2.8 percent of the cover in this ecoregion (fig. 13: B, app. 9). Although the Port Orford cedar vegzone is recorded in two ecoregions (table 8), 87 percent of its distribution in the project area occurs in the Klamath Mountains/California High North Coast Range [78], where local coverage is sparse (1.2 percent) (fig. 13: C, app. 9). The California red fir-Shasta red fir vegzone occurs in five southern Oregon and California ecoregions (table 8); however, 74 percent of its distribution in the project area is found within the Sierra Nevada [5], where it accounts for 7.8 percent of the cover in this ecoregion (fig. 13: D, app. 9).

Two rare vegzones occupy only one ecoregion. The western redcedar vegzone is mapped only in the Northern Rockies [15] (see "Methods" section), where it occupies 9.9 percent of the cover in this ecoregion (fig. 13: A, app. 9). The giant sequoia vegzone occupies less than 0.1 percent cover of its only ecoregion, Sierra Nevada [5] (fig. 13: E, app. 9).

Nonforest Vegetation

The two nonforest vegzones, shrublands and grasslands-meadows, with their varied abundance, exhibit broad distribution patterns across the project area (fig. 8). The shrublands vegzone, with the highest percentage of cover in the project area (20.7 percent), is broadly distributed across 17 ecoregions (table 8). Although occupying only 2.1 percent of the project area, the grasslands-meadows vegzone extends across all 20 ecoregions (table 8). The shrublands vegzone dominates cover in three ecoregions: Northern Basin and Range [80] (72.9 percent), Snake River Plain [12] (58.3 percent), and Central Basin and Range [13] (43.1 percent) (fig. 8, app. 9). This vegzone is also an important component in the Columbia Plateau [10] (38.7 percent) (fig. 8, app. 9). The upland shrub subzone accounts for the most shrublands vegzone cover in these areas (fig. 14: B, app. 9). The Mojave Basin and Range [14], an ecoregion where the shrublands vegzone is common (65.5 percent), is composed largely of the common creosote-bursage scrub subzone (fig. 14: E, app. 9). The chaparral subzone is distributed across eight California ecoregions, and locally, it has the highest percentage of shrublands vegzone cover in four ecoregions: Central California Foothills and Coastal Mountains [6] (7.6 percent) (fig. 14: C, app. 9), Central California Valley [7] (4.0 percent), Southern California Mountains [8] (8.5 percent), and Southern California/Northern Baja Coast [85] (9.2 percent) (fig. 14; app. 9).

The grasslands-meadows vegzone is a small component of all ecoregions in the project area and is most prevalent in the Central California Foothills and Coastal Mountains [6] (8.9 percent) and the Central California Valley [7] (4.3 percent) (fig. 8, app. 9). The upland grass subzone is a small component of all but two ecoregions and accounts for 62 percent of the grasslands-meadows vegzone cover; its highest percentage of cover occurs in the Central California Foothills and Coastal Mountains [6] (8.6 percent) (fig. 14: D, app. 9). The wet meadow subzone accounts for 24 percent of the grasslands-meadows vegzone. It provides sparse cover in all but three ecoregions in the project area and is most prevalent in the Eastern Cascades Slopes and Foothills [9] (1.9 percent) and Central Basin and Range [13] (1.7 percent) (fig. 14: A; app. 9).

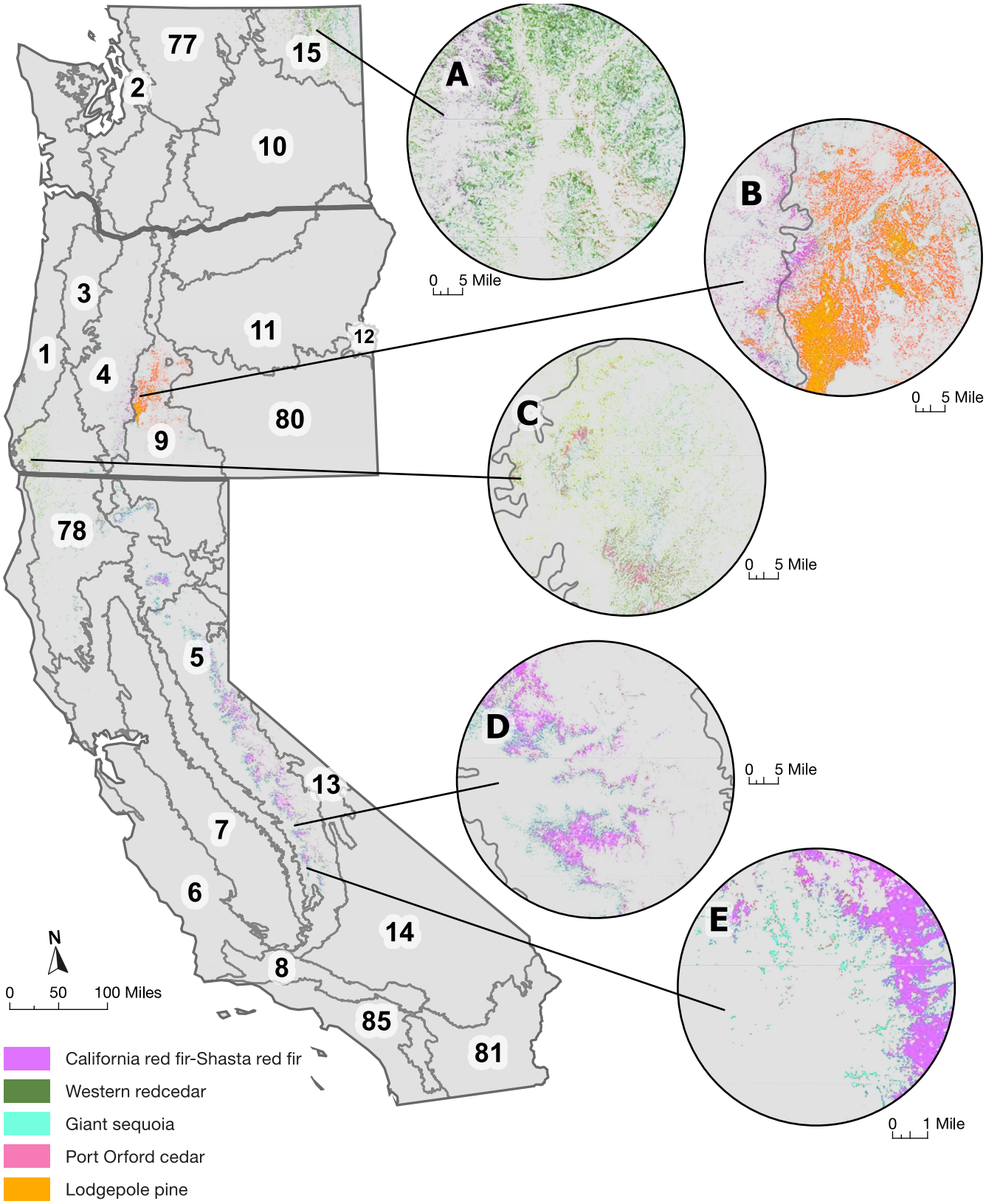

Figure 13—Rare vegzone distributions and patterns across the Potential Natural Vegetation Map project area: (A) western redcedar vegzone, (B) lodgepole pine vegzone, (C) Port Orford cedar vegzone, (D) California red fir-Shasta red fir vegzone, (E) giant sequoia vegzone. Numbers represent ecoregions; see figure 2 for ecoregion names. Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

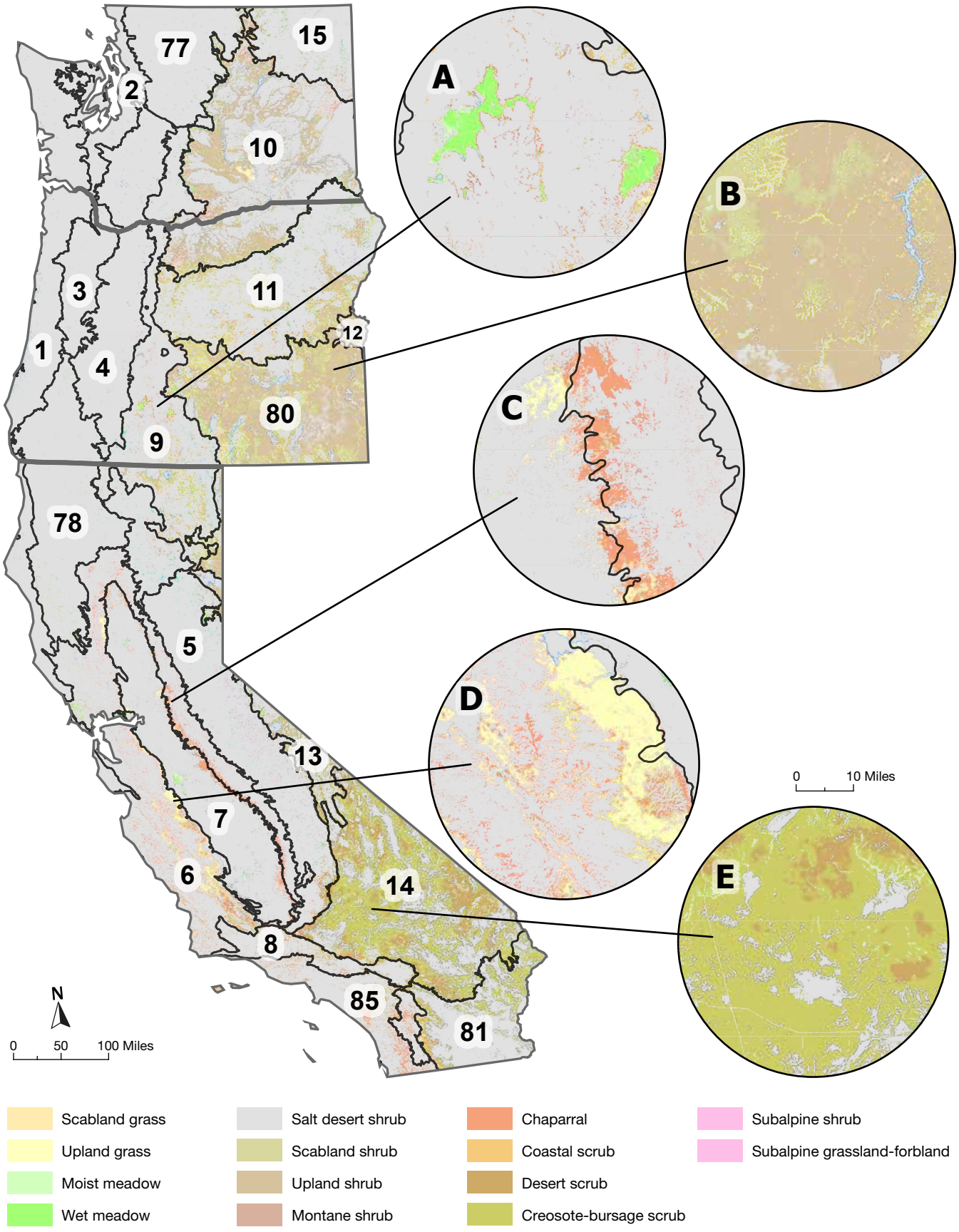

Figure 14—Nonforest subzone distribution and pattern by ecoregion across the Potential Natural Vegetation Map project area: (A) wet meadow subzone, (B) upland shrub subzone dominant pattern, (C) chaparral subzone spatial gradient pattern, (D) upland grass subzone, (E) creosote-bursage scrub subzone dominant pattern. Numbers represent ecoregions; see figure 2 for ecoregion names. Data sources: USDC Census Bureau and Esri (2020), US EPA (2011).

Accuracy Assessment

In this section, we report PNV map accuracies several ways. First, we explored local-scale accuracy in plot-level classifications both across the entire project area (fig. 1) and within different GNN modeling regions (fig. 7). We then compared region-level estimates of vegzone and subzone areas using only plots (design based) and the PNV map (model based and error adjusted).

Local-Scale Accuracy

Vegzones varied in local-scale accuracy. The overall strict vegzone accuracy was 65 percent, and the overall fuzzy accuracy was 97 percent (app. 13). For individual vegzones, strict producer's accuracy ranged from 0 to 89 percent, and fuzzy producer's accuracy ranged from 0 to 100 percent, while strict user's accuracy ranged from 0 to 78 percent, and fuzzy user's accuracy ranged from 0 to 100 percent. The lower values are mostly associated with minimally represented zones, including Port Orford cedar (vegzone 13) with a strict producer's accuracy of 8 percent and a strict user's accuracy of 15 percent, and giant sequoia (vegzone 16) with strict producer's and strict user's accuracies of 0 percent. Each of these vegzones only accounted for at most 0.1 percent of the GNN plots. For the 10 most common vegzones—white fir-grand fir (vegzone 20), western hemlock (19), Douglas-fir (14), ponderosa pine (10), Pacific silver fir (22), pinyon-juniper-cypress (6), mountain hemlock (23), hardwoods (11), subalpine fir-Engelmann spruce (25), and tanoak (15), which together accounted for 87 percent of the GNN plots, strict producer's accuracy ranged from 56 to 82 percent, and fuzzy producer's accuracy ranged from 90 to 99 percent, while strict user's accuracy ranged from 51 to 78 percent, and fuzzy user's accuracy ranged from 92 to 100 percent (app. 13).

For subzones, the overall strict accuracy was 42 percent, and the overall fuzzy accuracy was 84 percent. For individual subzones, strict producer's accuracy ranged from 0 to 88 percent, and fuzzy producer's accuracy ranged from 0 to 100 percent. Strict user's accuracy ranged from 0 to 100 percent, and fuzzy user's accuracy ranged from 19 to 100 percent (excluding the nonforest subzones, indicated by negative subzone numbers). The lower fuzzy values are mostly associated with very minimally represented subzones, while some of the well-represented subzones have strict accuracy values of less than 50 percent. For the western hemlock/very moist subzone (subzone 83), the most common subzone, strict producer's accuracy was 71 percent, fuzzy producer's accuracy was 94 percent, strict user's accuracy was 63 percent, and fuzzy user's accuracy was 91 percent (app. 14). Generally, PNV map accuracies indicated that PNV maps for more abundant vegzones and subzones performed best, while rare classes were poorly predicted.

Local Accuracy by GNN Modeling Regions

Local strict producer's accuracy varied by vegzone (table 11). We only calculated mean values for vegzones in more than one GNN modeling region. Mean strict producer's accuracy ranged from 37 to 86 percent. The redwood and pinyon-juniper-cypress vegzones had the highest mean strict producer's accuracy across their GNN modeling regions, with low standard deviations, as compared with low means and high standard deviations from the Douglas-fir and Jeffrey pine vegzones. Appendices 15 and 16 contain error matrices and strict and fuzzy accuracy values for each vegzone and subzone by GNN modeling region.

Table 11—Mean and standard deviation of strict producer's accuracy for modeling regions with more than 20 Gradient Nearest Neighbor (GNN) plots assigned to the indicated vegzone

Vegzone name	Mean	Standard deviation	Modeling regions[a]
	PERCENT		COUNT
Redwood	85.7	10.9	2
Pinyon-juniper-cypress	85.1	9.5	6
Tanoak	65.9	8.1	3
Sitka spruce	60.3	24.6	2
Western hemlock	60.0	26.1	6
Subalpine fir-Engelmann spruce	57.9	8.3	3
White fir-grand fir	57.2	23.7	9
Hardwoods	53.3	18.0	5
Pacific silver fir	51.7	10.7	3
Ponderosa pine	51.2	21.8	7
Mountain hemlock	51.0	17.6	4
California red fir-Shasta red fir	45.8	15.5	2
Parklands	43.7	21.9	7
California foothill pine-Coulter pine	43.2	15.8	3
Douglas-fir	41.3	21.5	10
Jeffrey pine	36.6	17.2	4

[a] There were 14 modeling regions in which vegzones could occur (see fig. 7).

As an example, the Douglas-fir vegzone is the most broadly distributed vegzone across GNN modeling regions (table 11). It has its highest strict producer's accuracy in Central and Eastern Washington (modeling regions 222 and 228) and the Oregon and California Klamath Province (GNN modeling region 225) where observations are >200 each. Strict producer's accuracy is poor (mean values <45 percent) in the Oregon and California Cascades (GNN modeling region 224) and Northeastern Oregon (GNN modeling region 229), as well as the California Sierra Nevada (GNN modeling region 232), even with >100 observations each (table 12).

Table 12—Strict producer's accuracy for the Douglas-fir vegzone for Gradient Nearest Neighbor modeling regions with more than 20 total observations

Gradient Nearest Neighbor modeling region	Observations	Strict producer's accuracy
	COUNT	PERCENT
221—Washington Coast and Cascades	30	20
222—Washington Eastern Cascades	280	66
223—Oregon Coast Range	34	9
224—Oregon and California Cascades	131	32
225—Oregon and California Klamath Province	553	63
226—California Northern Coast	87	46
228—Eastern Washington	540	75
229—Northeastern Oregon	496	46
232—California Sierra Nevada	123	35
233—California Southern Coast	26	23

Area-Based Regional Accuracy

The differences between FIA (design based) area estimates and the map predictions for area (model based) highlight which classification units in the PNV map were overestimated or underestimated relative to the FIA sample. Results indicate a general close match between design-based estimates and the PNV maps for vegzone (fig. 15), with 50 percent (10 of 20) of mapped PNV areas for the individual forested vegzone classification units falling within the 95-percent confidence intervals (app. 17). The GNN modeling overestimated pinyon-juniper-cypress, California foothill pine-Coulter pine, Sitka spruce, redwood, western hemlock, and mountain hemlock vegzones, while they underestimated lodgepole pine, ponderosa pine, Douglas-fir, and parklands vegzones.

Subzone results were similar to the vegzone results indicating a general close match between design- and model-based estimates, but subzone classification units had a higher percentage of matches within the 95-percent confidence interval than vegzone classification units. The confidence intervals are larger for subzone units than for vegzone units and may partially explain why the percentage of matches is higher for subzones. Results indicate a general close match between design-based estimates and the PNV maps for subzone (app. 17). About two-thirds (41 of 63) of the individual forested subzones were within the design-based 95-percent confidence interval (fig. 16). The GNN modeling overestimated oak woodlands, juniper woodlands, pinyon woodlands, California foothill pine-oak, bigcone Douglas-fir, Sitka spruce/very wet, redwood/very moist, western hemlock/very moist, mountain hemlock/cool-wet subzones, while it underestimated riparian hardwood forest, lodgepole pine/cool-dry, ponderosa pine/warm-xeric, Douglas-fir/very warm-dry, Douglas-fir/warm-dry,

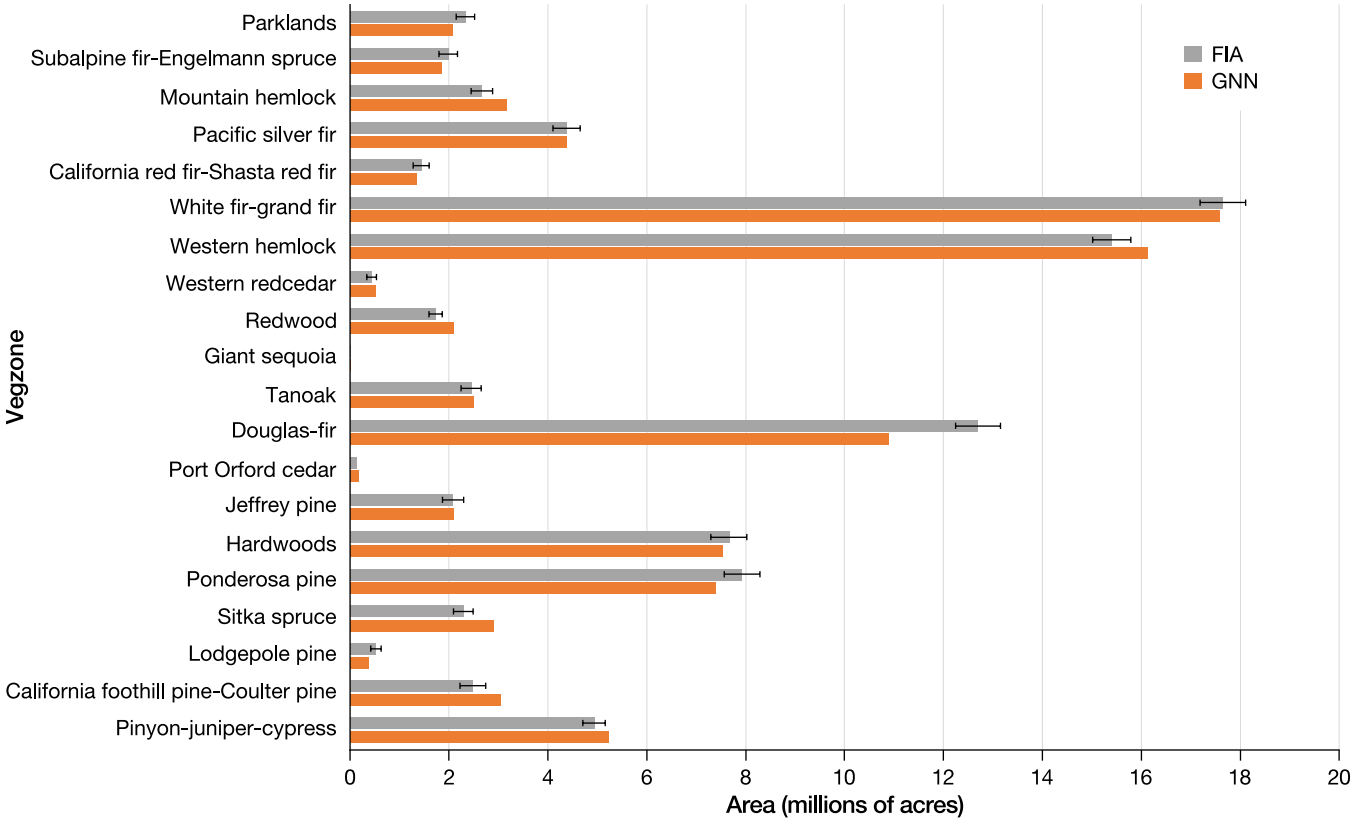

Figure 15—Vegzone areas from Forest Service Forest Inventory and Analysis (FIA) design-based and Gradient Nearest Neighbor (GNN) model estimates (summed across pixels in a potential natural vegetation map), 2022. Whiskers on the FIA estimates denote 95-percent confidence intervals.

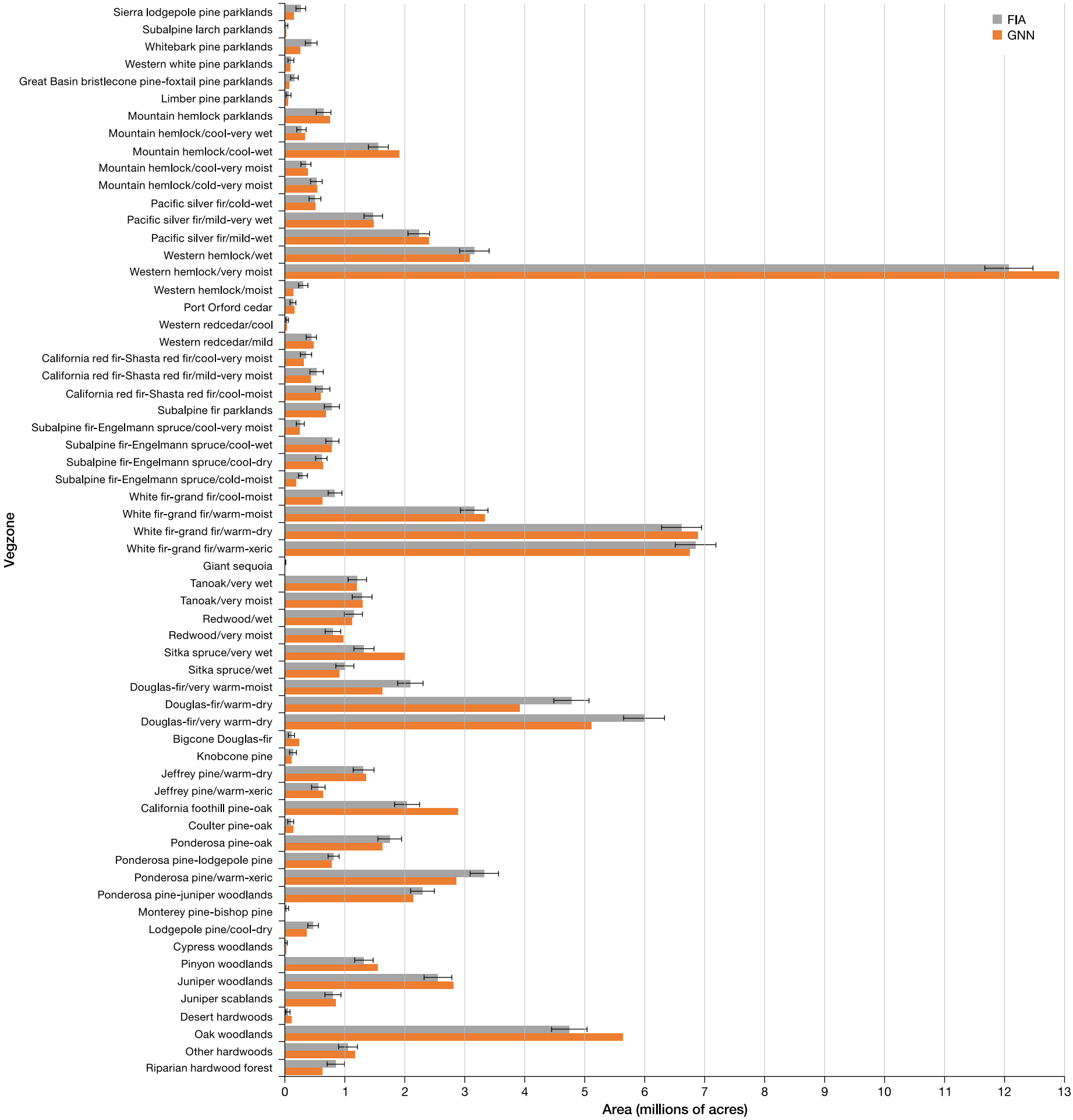

Figure 16—Subzone areas from Forest Service Forest Inventory and Analysis (FIA) design-based and Gradient Nearest Neighbor (GNN) model estimates (summed across pixels in a potential natural vegetation map), 2022. Whiskers on the FIA estimates denote 95-percent confidence intervals.

Douglas-fir/very warm-moist, white fir-grand fir/cool-moist, subalpine fir-Engelmann spruce cold-moist, western hemlock/moist, Great Basin bristlecone pine-foxtail pine parklands, whitebark pine parklands, and Sierra lodgepole pine parklands subzones.

Discussion

We used an existing current vegetation modeling process (GNN) and an extensive body of literature associated with vegetation classification to produce a large landscape-scale PNV classification and mapping product. This section outlines our rationale and understanding of the flexibility and limitations of this approach. We discuss our PNV process, including its relationship with local classification and mapping efforts and interpret the accuracy of the map product. This section also includes a discussion and recommendations for applicability and scale, as well as some discussion about potential use related to climate change adaptation and trends.

PNV Mapping and Classification Process

PNV classification and mapping have long been used as foundational tools for managing sites and landscapes. This PNV suite of products improves upon previous efforts in several ways. Many existing PNV classification and mapping efforts have been created for local areas, using variable indicator species and thresholds (app. 1). Because the need for integrated, comprehensive broadscale mapping has become increasingly prominent in recent years (Davis et al. 2022, Reilly et al. 2018a, USDA FS PNW Region 2020), we focused on a broadscale map to better stratify large landscapes and frame fire regimes, and, in general, address compelling planning needs at this scale. Our PNV process adopted a standardized potential vegetation classification scheme to create vegetation units that could be applied across large, multistate landscapes, therefore eliminating issues of edge matching vegetation types from local classifications, which may lead to misinterpretation of mapped results. In addition, because this is an all-lands large-scale approach, new species groupings were created to develop vegzones and subzones that were never included in previous PNV classification or mapping efforts. This product can now be used to perform very large-scale analyses and planning at both the vegzone and subzone grains.

These improvements also increase the utility of the layers to model disturbance processes and improve estimates of postdisturbance vegetation response. We have correlated disturbance-driven PNV from LANDFIRE to our site capacity PNV for immediate use (USDA FS PNW Region 2020) (app. 2). The types and distributions of biophysical environments at various grains in the hierarchy (vegzone and subzone) can also be linked with environmental spatial data and fire history information to create disturbance regimes (Spies et al. 2018, USDA FS PNW Region 2020). The rich species composition and cover history in the repeated FIA plot measurements and the imputed layers over the 32-year GNN time series can be correlated with the PNV to help understand disturbance effects and extent in a more specific way than the LANDFIRE models and maps currently provide. In addition, GNN existing vegetation maps (Ohmann and Gregory 2002) and predicted potential vegetation (this study) are inherently compatible for use in landscape departure analyses, successional stage modeling, and predictions of present and future wildlife habitat and insect/disease susceptibility. It is important to stress that we view this PNV product as the appropriate framework for these additional spatial products, including the Forest Service, Pacific Northwest Region's annual assessment of ecological departure (USDA FS PNW Region, n.d.a).

The vegetation units used in the mapping effort (vegzone and subzone) represent biophysical environments that we were able to map under the GNN framework. These vegetation units may not correspond directly to other PNV mapping efforts, such as plant association group (PAG) mapping (Henderson et al. 2011) or CALVEG. Crosswalks between PAG, CALVEG, and vegzone/subzone can be created and will vary by local landscape. In addition, there may be a one-to-many relationship between subzone and PAG in some cases due to the scale of classification and inherent inconsistencies between the original PNV plant association classifications for individual national forests. Therefore, local applications of these PNV maps will require local ecological expertise to understand how to effectively leverage the information.

GNN and PNV

GNN is the foundation for mapping PNV in this process. It is important to consider the relevant advantages and disadvantages of GNN relative to vegetation structure and composition mapping of current conditions. Although originally developed for existing vegetation mapping, GNN is a mature, proven predictive mapping method used to populate vegetation characteristics over large geographic areas at the relatively fine spatial resolution needed to support landscape analysis for natural resource planning and policy decisions (Bell et al. 2023, Ohmann and Gregory 2002, Ohmann et al. 2011, Wilson et al. 2012). Current GNN processes and derived products are based on more than 20 years of research and development and use more than 30 years of Landsat imagery, which documents spatial change in existing vegetation over time (apps. 18 and 19).

Key advantages of the GNN method using single nearest neighbor imputation include the following:

- Canonical correspondence analysis methods (ter Braak 1986), the ordination approach used to define distances among plots and pixels for the nearest neighbor imputation, are nonparametric (i.e., they do not rely on any underlying probability distribution) as well as multivariate, in that multiple *x*-variables can be used and multiple *y*-variables can be predicted for any given map unit. These properties allow simultaneous mapping of multiple forest attributes—essentially anything measured on the reference plots—in one step.
- Maps cover all forested lands within the analysis area with high information content. Each pixel is attributed with a list of species; species abundance; tree size; and tree, snag, and down woody debris densities (e.g., Davis et al. 2015, 2022).
- Because species-level detail is maintained at the individual plot/pixel scale, user-defined classification schemes can be applied, maps constructed, and accuracy assessed.
- Covariance of predicted species assemblages and structures within map units are ecologically realistic, potentially improving multivariate vegetation classification (Henderson et al. 2019).
- Modeled data across large regions contains the full diversity and range of variability present in the plot sample (Ohmann et al. 2011).
- Previous results suggest that areal distributions of community type classifications (ecological systems) are consistent with sample-based estimates despite being based on reference data that are not geographically balanced (Henderson et al. 2014, Ohmann

et al. 2011). In addition, the attribution of each map unit with a suite of species that are known to co-occur in nature is especially useful for characterizing landscape conditions as input to landscape models where multispecies information is desired (e.g., wildlife habitat models, insect/disease assessments, conservation planning).

Repeated plot measurements (FIA data) of species composition and structure at the same locations and the 32-year temporal imagery stack improved our ability to estimate potential vegetation based on existing species composition at the plot level as well as reduced the effects of disturbance and successional status at a single point in time at the map level.

Key limitations of GNN using single nearest neighbor imputation include the following:

- Quality of the maps strongly depends on a representative sample of plots, because $k = 1$ imputation will not interpolate nor extrapolate beyond the input plot data (Ohmann and Gregory 2002). Forested species, and thus community types, with poor representation in the FIA plot sample are not mapped as accurately as types with good plot support. In addition, because nonforest community types are largely not included in the FIA plot sample, mapping of these types relies on other sources (Ohmann et al. 2011).
- Prediction accuracy, as assessed at the local (plot) scale, varies greatly among species and community types and may be lower for some species and types than could be achieved with other methods (e.g., Henderson et al. 2014).
- Current implementation of GNN is based on Landsat multispectral imagery, which may result in less accuracy for some aspects of forest structure and composition mapping than maps generated using both multispectral and height information (Bell et al. 2022, Nelson and Steinwand 2015, Strunk et al. 2022, Zald et al. 2014).

This process has some disadvantages for assessing potential vegetation as well. GNN is a current vegetation approach, and although there are repeated plot measurements, the effects of disturbance, time since disturbance, and vegetation conversion may make assessing potential vegetation difficult. Although addressing these limitations in the future will undoubtedly improve the associated PNV maps, we argue that GNN vegetation maps provide a robust, stable, transparent, and reproducible foundation for PNV maps. Still, users should carefully consider the strengths and limitations of both the PNV classification and the underlying GNN vegetation data products when using the PNV maps.

Scale

Scale is essential to understanding patterns and processes across the landscape with the goal to apply this understanding appropriately in management. PNV classification and mapping can be applied at multiple scales, from local site tree regeneration to landscape disturbance processes, with resource management implications for silviculture, wildlife habitat, soils, and fire ecology. PNV classification and mapping can also be used to describe or frame ecological structure—e.g., characteristic tree diameters, canopy layers, biomass, function (disturbance processes, nutrient regimes, and hydrologic processes), and composition (absolute and relative abundances of plant species)—at multiple scales. Some questions are best answered on a particular scale; while some ecological characteristics, such as fire and disturbance regimes, only emerge at broader scales, others, such as subwatershed or individual stand treatment objectives, occur at smaller scales.

This PNV classification and mapping effort was designed to be used at regional and subregional scales. However, given the accuracy assessment results, it has also proven to have

finer scale utility (thousands of acres), especially in areas of high plot-level and region-level agreement. Larger landscapes (tens of thousands to hundreds of thousands of acres in size) serve to decrease bias and increase precision using PNV to stratify old-growth structure index mapping (Ohmann et al. 2014). In addition, Bell et al. (2018) found that GNN-based aboveground biomass estimates stabilized, compared to LiDAR-based aboveground estimates, at aggregate scales between 250 and 2,500 acres, roughly large-stand to multistand scales. While GNN and LiDAR highlighted similar patterns of high versus low biomass forests, biases between the two maps were still common. It is important to note that GNN species data, and thus PNV mapping, is almost certainly less accurately mapped than biomass, but similar accuracy assessments across scales are uncommon.

The consistent classification process employed for this effort makes this product useful at multiple scales. In some areas, however, the environmental variables used in the GNN model may not capture nuances in the environment that finer classifications, such as local plant association level or alliance/association (e.g., CALVEG) revealed (see app. 1). Therefore, because of the inherent uncertainties in the fine-scale use of the PNV map, local evaluation is advised for use at finer scales. Table 13 outlines potential applications of the available PNV mapping efforts.

Table 13—Example of how potential natural vegetation varies with scale and applications

Mapping units	Classification units	Example applications
Vegetation zone, alliance, forest type, vegetation type	Series or groups of series, alliances or groups of alliances	Broadscale planning framework, disturbance (fire regime), wildlife habitat
Subzone	Subseries or subzone, association	Broadscale planning framework, disturbance (fire regime); mid-scale framework (disturbance, treatment types and response)
Plant association group	Subseries	Local planning framework, silvicultural prescriptions
Local plant association, plant community	Plant associations, plant communities	Local planning framework, silvicultural prescriptions

Applications

The PNV classification and mapping products provide consistent landscape vegetation stratification across Washington, Oregon, and California. The intent is to produce a large-scale system that will stand on its own and be compatible with other products that have been developed for smaller landscapes. Key ecosystem analyses can use PNV to group vegetation types at different grains depending on specific ecological questions and smaller scale products; for example, PNV can be linked directly to productivity. Historical fire regimes can be determined by correlating PNV distribution, at vegzone to subzone grains, to fire histories (Agee 1993, Meyer and North 2019, Skinner and Chang 1996) or other related products, such as LANDFIRE (USGS and USDA FS, n.d.a). Vegetation and wildlife habitat departure can be assessed when combining PNV with other inputs (e.g., existing vegetation layers, successional pathway models, historical vegetation layers, wildlife habitat attributes and layers). Below are some examples to clarify utility, application, and correlation with other ecological products.

To illustrate correlations and interactions among PNV types and distributions with climate, productivity, fire regimes, and existing classifications, we will focus on coniferous

vegzones (Douglas-fir, Jeffrey pine, ponderosa pine, and white fir-grand fir) common to two ecoregions—one that spans all three states in our project area, and one that is restricted to California (table 14). We will use the white fir-grand fir vegzone, created in the GNN process because of the mixing and hybridization of the two species in Oregon (see "Methods"), to specifically demonstrate some connections.

Table 14—Forest area and percentage of forest area within selected level III ecoregions by state

Ecoregion [number][a]	Washington	Oregon	California	Forest area
	PERCENT OF FOREST AREA			MILLIONS OF ACRES
Eastern Cascades Slopes and Foothills [9]	18.0	54.1	27.8	13.9
Sierra Nevada [5]	0	0	100	10.9

[a] See figure 2 for spatial configuration and geographic location.

Sources: Omernik (1987), Omernik and Griffith (2014).

Eastern Cascades Slopes and Foothills Ecoregion

The Eastern Cascades Slopes and Foothills ecoregion [9] is located on the east side of the Cascade Range in Washington, Oregon, and California (table 14, fig. 2). The ponderosa pine and white fir-grand fir vegzones codominate in cover across the ecoregion (table 15, fig. 8), occupying 51.1 percent of the ecoregion area. This ecoregion supports the highest percentage of the ponderosa pine vegzone area (36 percent) across the project area (app. 9). The Douglas-fir vegzone is rare, especially in California, and the uncommon Jeffrey pine vegzone only occurs in California in this ecoregion (table 15, fig. 8).

The common fine-grained subzone environments vary geographically as well. The ponderosa pine-juniper woodlands subzone is rare in Washington and uncommon in California but supports the highest percentage of area of the ponderosa pine vegzone (43 percent) across the project area (apps. 7 and 9). The ponderosa pine/warm-xeric subzone, although found in all three states, is limited in Washington. Conversely, the ponderosa pine-lodgepole pine subzone is not found in California. The white fir-grand fir/warm-xeric subzone is limited in Washington and most common in California. The reverse is true with the white fir-grand fir/warm-dry subzone; it is rare in California and dominates the white fir-grand fir vegzone in Washington.

RELATIONSHIP WITH CLIMATE AND ENVIRONMENT—The biophysical environment—climate, as well as physical elements, such as landform, slope, aspect, and soils—is the basis for vegetation habitat. There is limited spatial data on some physical elements; thus, we confine this section to the correlation with climate elements, although we draw inferences on physical properties from known sources.

At the vegzone grain, there is a general trend of cooler, wetter, less-stressed biophysical environments as you move from areas occupied by ponderosa pine to Jeffrey pine to Douglas-fir to white fir-grand fir (table 15). Wet and cold vegzones occupy little area in this ecoregion (table 14). In Washington and Oregon, this is because of a significant rain shadow created by the Cascade Range (Siler et al. 2013). In central Oregon, mean annual precipitation decreases by about 100 inches from the west side of South Sister to Tumalo Reservoir, just west of Bend, Oregon (about 18 mi). This extreme precipitation gradient (>5 inches per mi) restricts

Table 15—Number of Forest Inventory Analysis (FIA) plot locations, mean annual precipitation, mean annual temperature, and mean summer moisture stress by vegzone, subzone, indicator species group, and state in the Eastern Cascades Slopes and Foothills ecoregion

Vegzone[a]	Subzone[a]	Indicator species group[b]	State	Number of FIA plot locations	Area[c]	Mean annual precipitation	Mean annual temperature	Mean summer moisture stress index[d]
					PERCENT OF ECOREGION	INCHES	DEGREES FAHRENHEIT	
PIPO	PIPO-juniper woodlands	WaXe	CA	63	10.6	17.6	46.8	338
			OR	260		17.6	44.3	297
			WA	0		N/a	N/a	N/a
	PIPO-PICO	ClMe	CA	0	6.0	N/a	N/a	N/a
			OR	264		24.2	43.2	273
			WA	5		32.6	46.1	321
	Warm-xeric	WaDr	CA	42	8.6	19.8	46.6	328
			OR	293		21.4	44.1	288
			WA	12		27.9	44.9	315
	PIPO-oak	WaMe + WaDr	CA	8	1.9	19.0	48.1	356
			OR	13		19.0	48.9	372
			WA	14		22.5	47.2	360
	Total PIPO				27.1			
PIJE	Warm-xeric	WaXe	CA	44	2.0	18.1	45.3	313
			OR-WA	0		N/a	N/a	N/a
	Warm-dry	WaDr	CA	21	0.9	19.2	46.6	327
			OR-WA	0		N/a	N/a	N/a
	Total PIJE				2.9			
PSME	Very warm-dry	WaDr	CA	4	1.7	21.1	49.8	372
			OR	31		21.8	46.9	330
			WA	22		35.7	44.3	289
	Warm-dry	WaMe	CA	0	1.7			
			OR	8		26.0	46.8	320
			WA	33		34.1	44.4	293
	Very warm-moist	WaWM	CA	0	0.2			
			OR	2		28.4	49.8	364
			WA	3		34.4	47.9	339
	Total PSME				3.6			

Table 15—Number of Forest Inventory Analysis (FIA) plot locations, mean annual precipitation, mean annual temperature, and mean summer moisture stress by vegzone, subzone, indicator species group, and state in the Eastern Cascades Slopes and Foothills ecoregion (continued)

Vegzone[a]	Subzone[a]	Indicator species group[b]	State	Number of FIA plot locations	Area[c]	Mean annual precipitation	Mean annual temperature	Mean summer moisture stress index[d]
					PERCENT OF ECOREGION	INCHES	DEGREES FAHRENHEIT	
ABGRC	Warm-xeric	WaDr	CA	84	9.4	25.7	44.1	285
			OR	242		24.2	44.1	285
			WA	29		35.4	42.8	268
	Warm-dry	WaMe	CA	6	9.5	27.0	42.3	258
			OR	156		29.8	43.6	270
			WA	113		38.3	43.2	269
	Warm-moist	WaWM	CA	1	2.6	26.2	43.1	267
			OR	34		34.7	44.0	270
			WA	52		43.9	44.8	284
	Cool-moist	ClMe	CA	2	2.5	30.3	40.4	238
			OR	109		32.1	42.3	251
			WA	3		41.0	43.3	272
	Total ABGRC				24.0			

N/a = not applicable.

[a] Vegzone and subzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[b] See table 3 for species group code definitions and appendix 6 for a list of species in each group.

[c] Area equals the percentage of mapped area for each potential natural vegetation type (vegzone/subzone) within the entire ecoregion, including nonforested acres.

[d] This refers to the ratio of temperature to precipitation from May–September (degrees Celsius/natural-log-transformed millimeters).

Data source: Climate data is from PRISM Climate Group (2025).

the expression of the potential vegetation types on the east slope of the Cascade Range into narrow bands often only a few miles wide from west to east. Wet forest vegzones do not occur in California, and cold forest vegzones occupy a limited area (table 14).

In addition to the extreme precipitation gradient, portions of southern and central Oregon are heavily influenced by recent (<7,000 years) pumice and volcanic ash deposits from Mount Mazama (Crater Lake) and other local volcanoes. The coarse-grained soils are extremely well drained and cooler than areas without ash and pumice. Where the deposits are >2-ft deep, herbaceous species are disfavored and woody species composition and cover change. This affects vegetation distribution with the white fir-grand fir vegzone, for example, being restricted to higher elevations and steeper terrain where Mazama ash/pumice deposits are less confining.

Climate conditions and biophysical environments vary at finer subzone grains as well. Within the white fir-grand fir vegzone, for example, mean annual precipitation increases from white fir-grand fir/warm-xeric to white fir-grand fir/cool-mesic types across all three states, with Washington consistently having higher precipitation than Oregon and California (table 15). Conversely, summer moisture stress generally decreases from warm, dry subzones to cool, moist subzones across the ecoregion.

PRODUCTIVITY—There is a strong correlation between the PNV groups and productivity. The series and indicator species groups within each series effectively describe the differences in many of the productivity components in table 16. For example, growth basal area—the basal area at which dominant trees grow 1 inch in diameter at breast height per decade at age 100—varies by vegzone, increasing from ponderosa pine to Douglas-fir to white fir-grand fir. At the subzone grains, with the exception of Oregon ponderosa pine, the indicator species groups effectively split out site classes within vegzones.

Site productivity in Washington white fir-grand fir indicator species groups is one FIA site class higher than equivalent groups in Oregon. This difference is largely due to higher stockability (i.e., growth basal area) and resultant mean annual increment in Washington sites and correlates with higher mean annual precipitation and a higher percentage of Douglas-fir and grand fir site trees (see app. 1 plant association guides).

LINKS TO OTHER VEGETATION CLASSIFICATIONS—It is possible to correlate our PNV classifications to other existing and potential vegetation classifications for the Eastern Cascades Slopes and Foothills [9]. Table 17 provides an example of this using the white fir-grand fir subzones. The plant association classification is commonly used in Washington and Oregon. California more commonly uses biophysical setting as a form of classification, especially when describing representative plant communities.

HISTORICAL FIRE REGIMES AND CURRENT CONDITION—The distribution of biophysical environments can influence fire regimes. Climate, productivity, species composition, and structure play a role in how often and at what severity a fire burns through an area. Ponderosa pine and white fir-grand fir vegzones dominate this ecoregion. The common subzones occur in warm, dry climate conditions (table 15). The most common ponderosa pine biophysical environments support open stands or savannas of ponderosa pine with understories of shrubs and grasses—e.g., Idaho fescue (*Festuca idahoensis*), squirreltail (*Elymus elymoides*)—well adapted to the warm, dry conditions (app. 11). Ponderosa pine is dominant and can be intermixed with Douglas-fir and white fir-grand fir in the common white fir-grand fir forest types. Low percentage of tree cover (mean of 30 to 35 percent in the warm-xeric subzone, for example) and fire-adapted shrubs—greenleaf manzanita (*Arctostaphylos patula*), snowbrush ceanothus (*Ceanothus velutinus*)—and graminoids—western needlegrass (*Achnatherum occidentale*), Ross' sedge (*Carex rossii*)—are present (app. 11). These forest types are often associated with low-severity frequent fire regimes (Bork 1985, Heyerdahl et al. 2019, McNeil 1975, Safford and Stevens 2017, Soeriaatmadja 1966, Weaver 1959, Wright and Agee 2004).

Fire histories from the area validate these relationships. For example, Soeriaatmadja (1966) sampled fire-return intervals based on individual tree data (stumps) across multiple vegzone and subzone boundaries of the east side of the Cascade Range in north-central Oregon. Poststratification of his sample sites using subzones defined by indicator species groups within the white fir-grand fir and Douglas-fir vegzones indicated an increase in fire-return interval as more mesic subzones become more common local neighbors. The units that Soeriaatmadja (1966) sampled in predominantly white fir-grand fir/warm-dry, white fir-grand fir/warm-mesic, and white fir-grand fir/warm-wet mesic species groups had mean fire-return intervals (minimum–maximum intervals) of 30.2 (17.2–54.9) and 24.6 (13.7–44.9) years. The ponderosa pine/warm-xeric and ponderosa pine/warm-dry units had mean fire-return intervals (minimum–maximum intervals) of 16.5 (6.5–36.3) and 14.2 (6.2–28.8) years, respectively.

Table 16—Mean site index, growth basal area, mean annual increment, and site class by vegzone in the Washington and Oregon East Cascades, weighted by abundance of individual site tree species

Vegzone[a]	Indicator species group[b]	Site index100	Site index 95-percent CI	Growth basal area	Growth basal area 95-percent CI	Mean annual increment	Mean annual increment 95-percent CI	FIA site class	Dunning site class
				SQUARE FEET PER ACRE		CUBIC FEET PER ACRE PER YEAR			
Oregon									
PIPO	WaXe	76	2.4	108	4.9	38	3.0	6	IV
	WaDr + WaMe	76	3.5	130	7.6	46	4.5	6	IV
	ClMe	78	2.2	118	4.1	42	2.6	6	IV
PSME	WaDr	87	4.5	136	12.2	54	7.5	5	III
	WaMe	110	6.1	170	17.1	87	13.3	4	II
ABGRC	WaDr	82	2.4	199	4.3	75	4.0	5	III
	WaMe	101	2.2	218	5.1	101	5.1	4	II
	WaWM	121	3.3	283	9.2	158	9.0	3	I
	ClMe	74	5.1	196	10.2	66	8.6	5	IV
Washington									
PIPO	WaXe	69	3.0	104	10.0	34	4.0	6	IV
	WaDr + WaMe	59	6.5	149	20.0	43	8.0	6	V
PSME	WaDr	84	2.2	153	6.0	59	4.2	5	III
	WaMe	100	2.5	200	6.7	92	5.7	4	III
ABGRC	WaDr	102	2.0	250	9.5	117	6.6	4	II
	WaMe	105	1.3	249	9.5	120	5.8	3	II
	WaWM	123	1.6	328	7.2	186	6.5	2	I
	ClMe	83	3.5	187	29.7	75	10.8	5	III

Site index is defined as the height of dominant and codominant trees at some base age. It is a measurement of the potential productivity of a forest site, indicating how tall trees of a specific species will grow at age 100. Growth basal area is the basal area at which dominant trees grow at 1.0 inch in diameter per decade at age 100. It is a field method for estimating site potential for stockability using current stand growth. Mean annual increment refers to the average growth per year a tree or a stand of trees has exhibited up to a specified age. Confidence interval (CI) provides an estimated range of values within which a population parameter (like the mean) is likely to fall, based on a sample of data, and it is expressed with a certain level of confidence.

FIA = Forest Service, Forest Inventory and Analysis.

[a] Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[b] See table 3 for species group code definitions and appendix 6 for a list of species in each group.

Sources: Dunning (1942), John and Tart (1986), John et al. (1988), Lillybridge et al. (1995), Simpson (2007), Topik (1989).

Table 17—White fir-grand fir subzones in the Oregon portion of the Eastern Cascades Slopes and Foothills ecoregion with subzones correlated with plant association group and representative plant association, historical fire regime, and biophysical setting

White fir-grand fir subzone[a]	Indicator species group[b]	Plant association group[c]	Representative plant associations[c]	Historical fire regime[c]	Fire regime group[d]	Biophysical setting[e]
				YEARS		
Warm-xeric	WaDr	White fir-grand fir/dry	ABCO-ABGR/SYAL, ABCO-ABGR/ARPA6	9–25	I	Northern Rocky Mountain dry-mesic montane-mixed conifer forest (10450)
Warm-dry	WaMe	White fir-grand fir/ moist	ABCO-ABGR/CHCH7, ABCO-ABGR/TRBO2	20–50	I/III	Mediterranean California mesic mixed conifer (10280)
Warm-moist	WaWM	White fir-grand fir/wet	ABCO-ABGR/ACTR, ABCO-ABGR/CLUN2	50–90	III	East Cascades mesic montane mixed-conifer forest and woodland (10180)
Cool-moist	ClMe	White fir-grand fir/ cool-dry	ABCO-ABGR/ARNE, ABCO-ABGR/CAIN9	30–50	III	Mediterranean California red fir forest (10320)

[a] See appendix 10 for a list of subzones.

[b] See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group.

[c] Based on Simpson (2007), assuming contiguous distribution (fire regime designations vary depending on subzone abundance and distribution patterns of adjacent potential natural vegetation types). Representative plant association names include USDA PLANTS Database species symbols (USDA NRCS, n.d.); see appendix 5 for symbol definitions.

[d] LANDFIRE fire regime groups: I = high frequency (<30 years), low severity; III = moderate frequency (30–100 years), mixed severity. Source: USGS and USDA FS (n.d.a).

[e] LANDFIRE biophysical settings assuming contiguous distribution. Source: USGS and USDA FS (n.d.a),

Historical fire regimes were used to determine biophysical settings (USGS and USDA FS, n.d.a). Table 17 outlines the relationship among biophysical environments classified by this effort and plant association concepts, biophysical settings (named for representative forest type), and historical fire regimes for subzones within the white fir-grand fir vegzone.

ECOLOGICAL DEPARTURE ASSESSMENTS—Knowledge of ecological departure from a range of reference conditions provides a critical context for managing sustainable ecosystems (Barrett et al. 2006). Methods for developing reference conditions include simulation modeling, expert opinion, historical maps, survey data, and reference sites (Keane et al. 2009, Morgan et al. 1994). When paired with current and historical tree datasets, the vegzone and subzone PNV maps provide a consistent and credible stratification of ecosystems for comparing current and historical forest vegetation attributes at landscape scales. The following analysis example compares recent FIA data and historical General Land Office (GLO) survey data for species composition, tree density, and size-class distribution for a >2.5-million-acre, central Oregon landscape, centered on the Deschutes National Forest (app. 20).

Recent estimates are based on 2007–2016 annual FIA data from 461 plots within the Deschutes National Forest. We excluded all tree samples <4-inch diameter at breast height (DBH) and the tree per acre and basal area per acre of trees <4-inch DBH in the FIA sample to facilitate direct comparison with the historical sample, which had only one observation of a tree <4-inch DBH. We derived historical estimates from the original GLO survey data (USDI BLM, n.d.). The GLO data consists of reference tree attributes (species, DBH, and

distance and azimuth from survey corner) for 6,712 section and quarter-section corners as well as 1,466 meander corners within and adjacent to the Deschutes National Forest. The GLO surveys occurred from 1865–1899 and pre-date the establishment of the national forest, commercial utilization of timber resources, and fire suppression efforts. Since the GLO reference trees have a spatial location tied to the survey corners, we assigned each reference tree to a vegzone and subzone extracted at those locations from the PNV maps.

Tree density and basal area per acre estimates based on GLO survey data for the Deschutes National Forest are consistent with published historical estimates based on early timber inventories and stand reconstructions in the eastern and southern Cascade Range (Hagmann et al. 2013, 2014; Munger 1917; Ritchie 2016; Sensenig et al. 2013). Recent estimates for tree density from the FIA dataset are significantly higher than historical estimates (fig. 17); however, recent basal area per acre estimates, with a few exceptions (juniper and lodgepole pine vegzones and white fir-grand fir/warm-dry subzone), are not significantly different from historical estimates (fig. 18). The dichotomy in outcomes in these two measures of tree density is a good indication that the PNV maps reasonably reflect site capability across the PNV classification units.

Examination of size-class distribution changes from the GLO and FIA datasets indicates a large shift in distributions of size classes in most PNV types (fig. 19). A common theme across most PNV types is increased number of individuals within seedling/sapling, pole, and small tree size classes and decreased number of individuals within medium, large, and extra-large

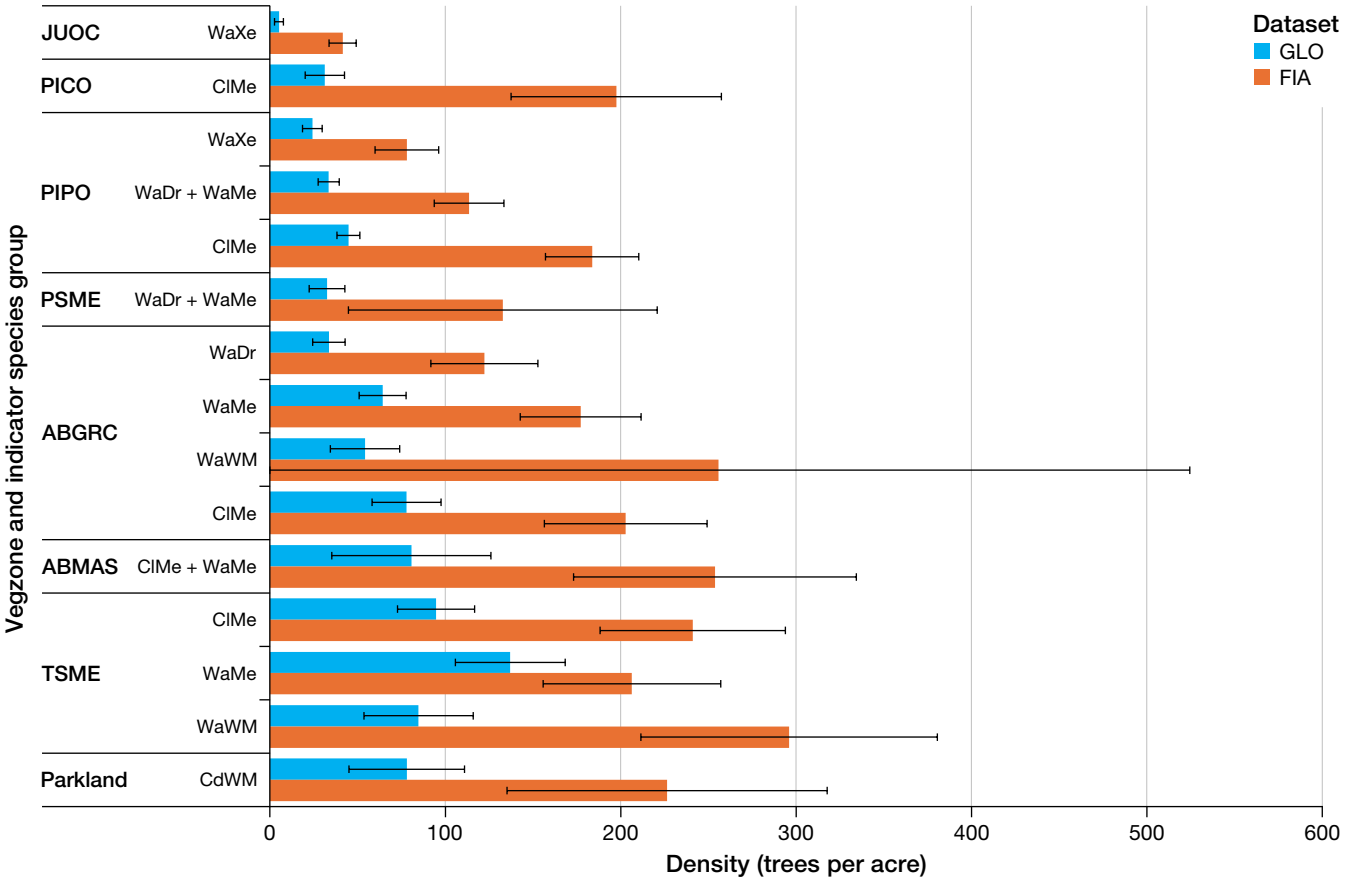

Figure 17—Tree density estimates by vegzone and indicator species group based on historical General Land Office (GLO) and recent Forest Service, Forest Inventory and Analysis (FIA) vegetation datasets. Vegzone names include USDA PLANTS Database (USDA NRCS, n.d.) species symbols; see appendix 5 for symbol definitions. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Whiskers represent the 95-percent confidence interval.

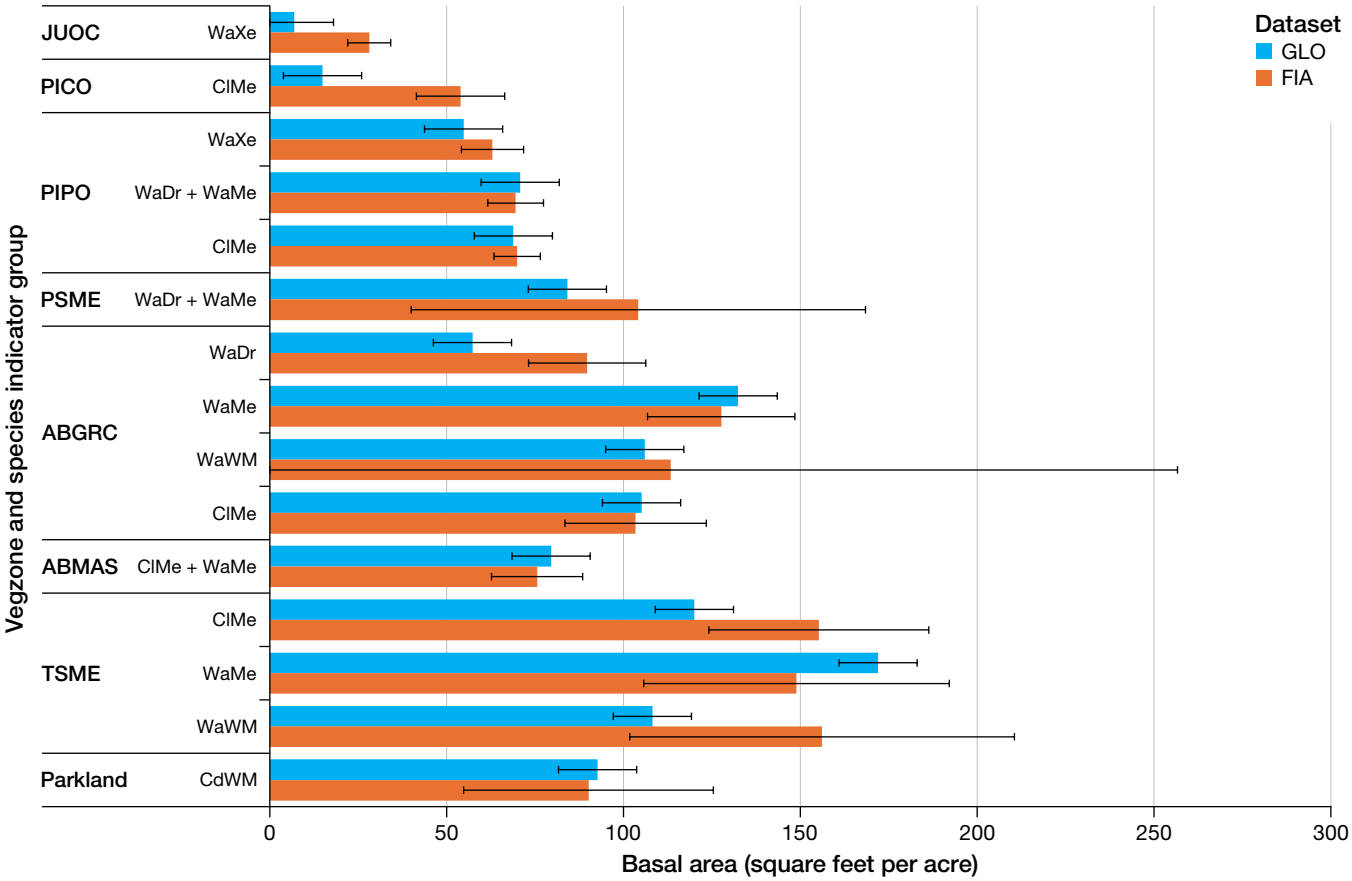

Figure 18—Basal area estimates by vegzone and indicator species group from historical General Land Office (GLO) and recent Forest Service, Forest Inventory and Analysis (FIA) vegetation datasets. Vegzone names include USDA PLANTS Database (USDA NRCS, n.d.) species symbols; see appendix 5 for symbol definitions. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Whiskers represent the 95-percent confidence interval.

tree size classes. The increase in smaller tree size classes is correlated with a change in recent versus historical disturbance regimes. Specifically, decreased mortality of younger tree age classes due to effective fire suppression (1930s–1990s) and longer resultant fire-return intervals, as well as significant harvest of larger tree size classes starting in the late 1910s, have increased the percentage of smaller tree size classes on this central Oregon landscape.

Comparisons of tree species composition from GLO historical reference conditions to FIA recent conditions by PNV type as measured by percentage of trees per acre by species are illustrated in figure 20. At the warm, dry end of the environmental gradient (juniper, lodgepole pine, and ponderosa pine vegzones), little change in tree species composition has occurred since the GLO surveys were completed. These vegzones occur in environments beyond the ecological tolerance of more shade-tolerant species, and the PNV maps effectively depict this pattern. In the middle of the environmental gradient (Douglas-fir and white fir-grand fir vegzones), significant increases in percentages of shade-tolerant Douglas-fir and white fir-grand fir have occurred, mostly at the expense of shade-intolerant ponderosa pine. In the cool, wet portions of the environmental gradient (mountain hemlock vegzone), lodgepole pine is the primary seral species, little ponderosa pine occurred in the GLO historical reference conditions, and essentially 0 percent of ponderosa pine occurs in the FIA dataset. As noted in the Douglas-fir and white fir-grand fir vegzones, shade-tolerant species (predominantly mountain hemlock) increased at the expense of shade-intolerant species (lodgepole pine).

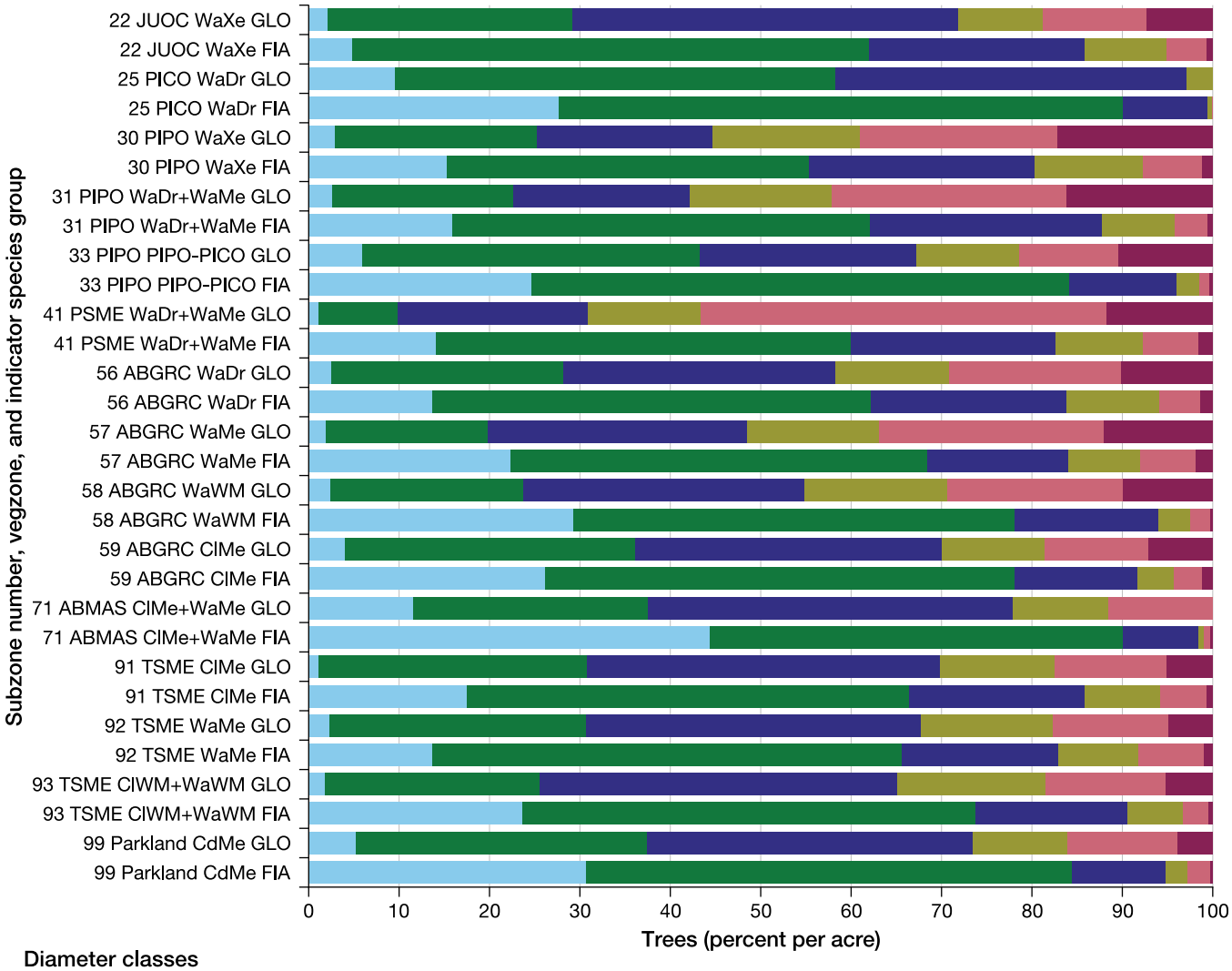

Figure 19—Tree size class distributions by subzone number, vegzone, and indicator species group from historical General Land Office (GLO) and current Forest Service, Forest Inventory and Analysis (FIA) vegetation datasets. Vegzone names include USDA PLANTS Database (USDA NRCS, n.d.) species symbols; see appendix 5 for symbol definitions. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. See table A10.1 for subzone names and numbers. DBH = diameter at breast height.

Tree species composition in the historical estimates stratified by vegzone and subzone indicator species groups reflects the interaction of historical disturbance regimes and differential site productivity between major tree species. The percentage of lodgepole pine in the historical estimates is a good indicator of the amount of historical mixed- to high-severity disturbance regimes in each subzone. In the middle portions of the environmental gradient (Douglas-fir and white fir-grand fir vegzones), the percentages of Douglas-fir and true firs are related to differential site productivity of shade-intolerant ponderosa pine and shade-tolerant Douglas-fir and white fir-grand fir across vegzones and subzones (table 18). Subzones defined by the indicator species groups effectively capture environments where ponderosa pine is less productive—warm-mesic (WaMe) and warm-wet mesic (WaWM) species groups—than Douglas-fir and white fir-grand fir. Based on empirical modeling using the First Order Fire Effects Model (Lutes 2013) and fire mortality estimates by species, and adjusting height and diameter to account for species productivity differences in these subzones, low-severity disturbance (<4-ft flame length) frequencies of less than 20 to 30

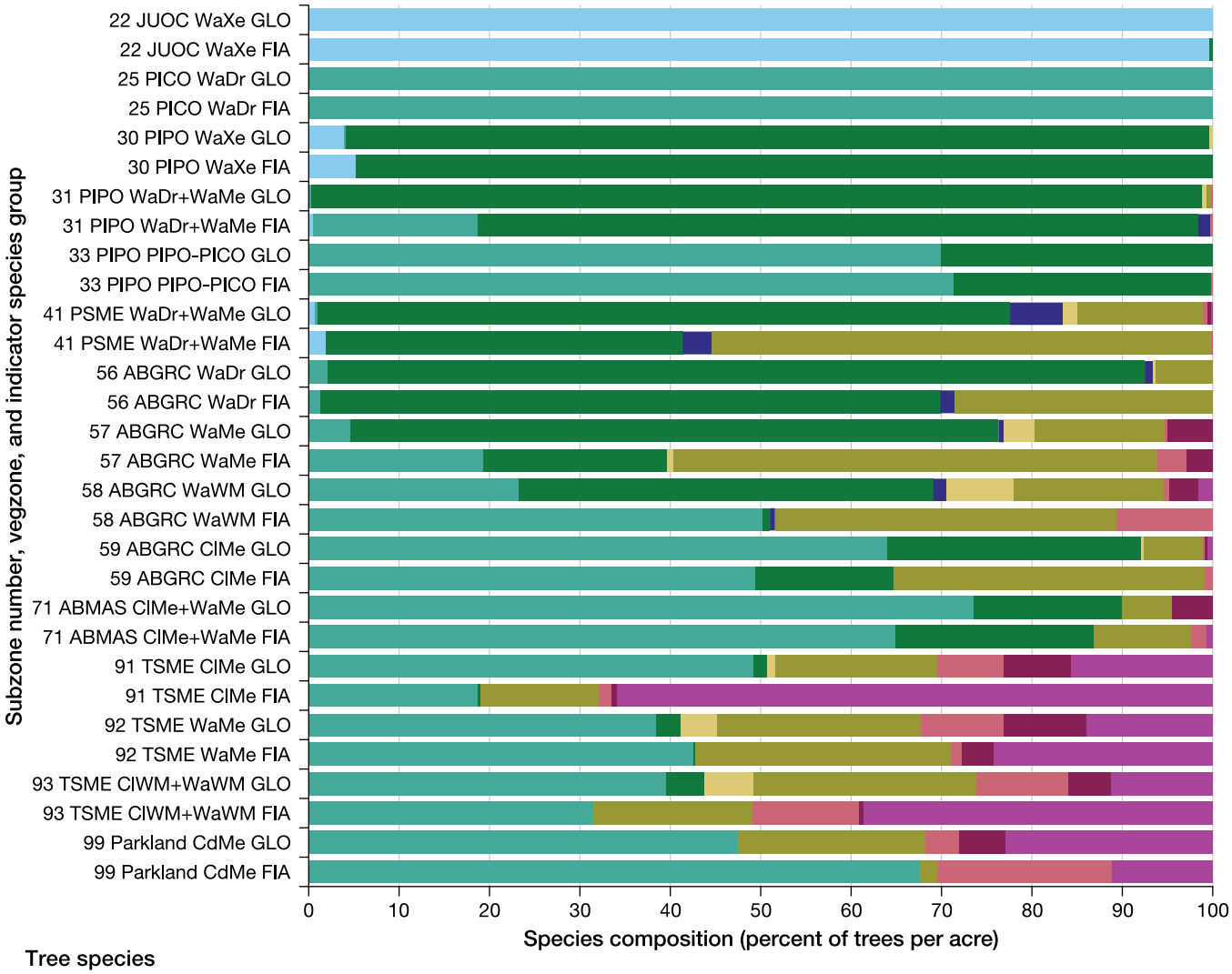

Figure 20—Tree species composition by subzone number, vegzone, and indicator species group based on historical General Land Office (GLO) and recent Forest Service, Forest Inventory and Analysis (FIA) vegetation datasets. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.); see appendix 5 for symbol definitions. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. See table A10.1 for subzone names and numbers.

years are necessary to maintain ponderosa pine as a significant component of the ecosystem and prevent Douglas-fir and white fir-grand fir from outcompeting ponderosa pine.

The historical disturbance frequency of these transitional PNV types at any specific location was substantially influenced by the abundance and disturbance frequency of adjacent PNV types. In locations where the neighboring PNV types are predominantly warmer and drier (ponderosa pine/warm-dry, Douglas-fir/warm-dry, or white fir-grand fir/warm-dry), frequent low-severity fire regimes predominate. In locations where more mesic PNV types are most common as local neighbors, mixed-severity regimes become more important.

There have been significant changes in fire regimes, tree density, species composition, and tree structure based on relative size class distributions across the common vegzones in this central Oregon landscape. Historical fire regimes were more frequent (Bork 1985, McNeil 1975), leading to ponderosa pine dominating much of the landscape. With fire suppression, current landscapes have seen an increase in density of all tree species capable

Table 18—Productivity by vegzone, species group, and species across mixed-conifer potential natural vegetation in the Oregon portion of the Eastern Cascades Slopes and Foothills ecoregion

Vegzone[a]	Indicator species group[b]	Species[a]	Site index$_{100}$	Site index (observed)	Site index$_{100}$ 95-percent CI	Growth basal area	Growth basal area (observed)	Growth basal area 95-percent CI	Mean annual increment	Mean annual increment 95-percent CI
				COUNT		SQUARE FEET PER ACRE			CUBIC FEET PER ACRE PER YEAR	
PSME	WaDr	PIPO	87	59	3.9	141	158	11.8	57	7.3
		PSME	85	10	7.8	110	32	13.7	44	9.3
	WaMe	PIPO	103	41	3.9	174	60	19.6	83	12.4
		PSME	116	51	7.8	167	104	15.7	90	14.4
ABGRC	WaDr	ABGRC	80	293	2.0	244	2096	5.9	90	4.4
		PIPO	82	536	2.0	164	2589	2.0	62	2.2
		PSME	98	30	7.8	205	126	17.6	93	15.4
	WaMe	ABGRC	99	531	2.0	231	2306	3.9	105	3.8
		PIPO	95	615	2.0	178	1934	3.9	78	3.3
		PSME	115	383	2.0	247	1230	5.9	131	5.3
	WaWM	ABGRC	121	282	3.9	283	811	7.8	158	9.5
		PIPO	105	215	3.9	215	288	9.8	104	8.6
		PSME	131	341	2.0	298	1144	7.8	180	7.5

Site index is defined as the height of dominant and codominant trees at a given base age. It is a measurement of the potential productivity of a forest site, indicating how tall trees of a specific species will grow at age 100. Site index (observed) is the number of site trees that the site index$_{100}$ is based on. Growth basal area is the basal area at which dominant trees grow at 1.0 inch in diameter per decade at age 100. It is a field method for estimating site potential for stockability using current stand growth. Mean annual increment refers to the average growth per year a tree or a stand of trees has exhibited up to a specified age. Confidence interval (CI) provides an estimated range of values within which a population parameter (such as the mean) is likely to fall based on a sample of data, and it is expressed with a certain level of confidence.

FIA = Forest Inventory and Analysis.

[a] Vegzone names and species include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[b] See appendix 6 for a list of key indicator species in groups.

Source: Simpson (2007).

of establishing on a given PNV type. The increased density has increased inter-tree competition and increased horizontal and vertical continuity of fuels, which has contributed to higher mortality in larger size classes from both bark beetles and fire. In addition, railroad logging (1918–1952) eliminated much of the larger ponderosa pine in parts of the area. Size class distributions have departed significantly from historical estimates as a result of historical timber harvest and increased large-tree mortality as a result of bark beetles and increased fire severity. Density management that releases ponderosa pine from competition to rebuild open, large-diameter structure and reduces more shade-tolerant species will increase the resilience of stands to bark beetle infestation and reduce susceptibility to mixed- to high-severity fire, ensuring the future health of these landscapes (Halofsky et al. 2019).

Sierra Nevada Ecoregion

The Sierra Nevada ecoregion [5] is located solely in California and encompasses the Sierra Nevada mountain range (fig. 2). White fir is the key indicator species in the white fir-grand fir vegzone in California, and the white fir-grand fir vegzone is the dominant vegzone in the area, occupying 33.8 percent of the ecoregion and making up 24 percent of the project area (table 19, app. 9). This ecoregion also supports the most Jeffrey pine vegzone area across the project area (42 percent), and the Jeffrey pine vegzone occupies 8.2 percent of the ecoregion (table 19, app. 9). The ponderosa pine and Douglas-fir vegzones each occupy less than 10 percent of the area within the ecoregion.

Table 19—Number of Forest Inventory and Analysis (FIA) plot locations, area, mean annual precipitation, mean annual temperature, and mean summer moisture stress by vegzone, subzone, and indicator species group in the Sierra Nevada ecoregion, California

Vegzone[a]	Subzone[a]	Indicator species group[b]	Number of FIA plot locations	Area[c]	Mean annual precipitation	Mean annual temperature	Mean summer moisture stress index[d]
				PERCENT OF ECOREGION	INCHES	DEGREES FAHRENHEIT	
PIPO	PIPO-juniper woodlands	WaXe	4	0.2	32.3	47.5	355
	PIPO-PICO	ClMe	0	N/a	N/a	N/a	N/a
	Warm-xeric	WaDr	50	0.5	45.7	51.0	376
	PIPO-oak	WaDr + WaMe	194	6.6	41.6	55.4	449
	Total PIPO			7.4			
PIJE	Warm-xeric	WaXe	55	2.2	24.6	44.5	317
	Warm-dry	WaDr	279	5.9	32.1	45.7	326
	Total PIJE			8.2			
PSME	Very warm-dry	WaDr	186	4.4	50.5	54.7	417
	Warm-dry	WaMe	55	0.3	49.1	54.4	415
	Very warm-moist	WaWM	13	0.5	55.2	55.1	424
	Total PSME			5.3			
ABGRC	Warm-xeric	WaDr	695	24.5	47.6	48.6	340
	Warm-dry	WaMe	164	7.3	52.1	47.8	323
	Warm-moist	WaWM	30	1.3	54.8	48.9	335
	Cool-moist	ClMe	39	0.6	47.8	44.0	278
	Total ABGRC			33.7			

N/a = not applicable.

[a] Vegzone and subzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[b] See table 3 for species group code definitions and appendix 6 for a list of species in each group.

[c] Area equals the percentage of mapped area for each potential natural vegetation type (vegzone/subzone) within the entire ecoregion, including nonforested acres.

[d] This refers to the ratio of temperature to precipitation from May–September (degrees Celsius/natural-log-transformed millimeters). Data source: Climate data is from PRISM Climate Group (2025).

Fine-grained subzone cover varies as well. The white fir-grand fir/warm-xeric subzone occupies most of the white fir-grand fir vegzone area (72 percent), as well as supporting the highest percentage of cover of total acres across the project area (44 percent) (table 19, app. 9). The warm-dry subzone dominates the Jeffrey pine vegzone, and the ponderosa pine-oak subzone makes up most of the ponderosa pine vegzone area (table 19).

RELATIONSHIP WITH CLIMATE AND ENVIRONMENT—Climate is responsible for some of the physical elements of the biophysical environments, but the climatic elements themselves do not tell the whole story. Other physical elements, such as soil type (e.g., granitic, ultramafic), soil depth, aspect, slope shape and steepness, and landform characteristics play a huge role in the distribution of biophysical environments in the Sierra Nevada (Fites 1993, Safford and Stevens 2017), and variability in physical characteristics operates at multiple scales across this landscape.

Overall elevation gradients vary from north to south across the Sierra Nevada. In general, relief increases from north to south, where the contraction in the width of the range is

partially responsible for increased biophysical diversity. These elements interact with soil, water, and temperature differences to create biophysical diversity across the ecoregion. The ponderosa pine vegzone, for example, narrows in elevational width from north to south, partially because of the interaction of climate and relief (Safford and Stevens 2017).

The interactions between precipitation and other physical features can be seen in the distribution of both vegzone and subzone types. The white fir-grand fir/warm-dry subzone, for example, is more prevalent in the northwestern portion of the ecoregion where precipitation is higher and relief is lower (Safford and Stevens 2017).

The accessibility of water in the summer season is an important contributor to the distribution of biophysical environments in this ecoregion where summer drought can be severe (Safford and Stevens 2017). Rain shadow effects can exacerbate these conditions. The summer moisture stress index can be used to approximate this phenomenon. Summer moisture stress values in this ecoregion are, except for the Jeffrey pine vegzone, higher than those of the Eastern Cascades Slopes and Foothills [9] (tables 15 and 19). The most common subzones in each vegzone illustrate the overall effect of summer drought on the distribution of PNV types across the ecoregion, with the preponderance of the white fir-grand fir/warm-xeric subzone as an example (table 19).

PRODUCTIVITY—There is limited information available that links productivity elements to PNV types in the Sierra Nevada (Fites 1993). However, there has been research documenting the strong relationship between climate and tree diameter growth by species groups in northern California (e.g., Yeh and Wensel 2000) that supports the biophysical environment classification.

Fites (1993) and Smith (1994) collected productivity data for the few plant association guides in the area. They found that the ponderosa pine vegzone is the least productive across the landscape, with Dunning site class values of 4 to 5 (Dunning 1942). The white fir-grand fir/xeric subzone site index values range between 3 and 4, with more mesic subzones displaying values between 1 and 3. This is similar to the ranges in the Eastern Cascades Slopes and Foothills [9].

LINKS TO OTHER VEGETATION CLASSIFICATIONS—There is a correlation between our PNV classification and some of the more widely used classifications in California. Using the white fir-grand fir (or white fir for California) vegzone and associated subzones as an example, one can assign subzones to various grains of California existing vegetation types (e.g., NRV, alliance) (table 20). There is not a clear one-to-one match, but similarities among classifications can be found. White fir-grand fir and some Douglas-fir subzones may act to further stratify the mixed-conifer NRV groups to explain variability within groups. Adding subzones from the ponderosa pine and Douglas-fir vegzones could further describe the variability within the yellow pine NRV group. There are also correlations with more local PNV classifications (plant associations) and biophysical settings.

There are issues with all classifications. Current classifications rely on existing conditions, which may be influenced by human and natural processes. A ponderosa pine vegzone/subzone (or yellow pine mixed conifer for California) provides information on general species composition and current condition but not necessarily specific information on environmental potential, which could be helpful for appropriate management considerations (e.g., prescribed burning, thinning) and fire response (e.g., the probability of white fir or Douglas-fir establishing postdisturbance productivity). The PNV classification from this project relies on the temporal stack in GNN to provide true environmental potential. Given

Table 20—White fir-grand fir subzones within the Sierra Nevada ecoregion, with subzones correlated with California vegetation classifications (representative natural range of variation [NRV] group, alliance, potential plant associations), biophysical setting, and historical fire regimes

White fir-grand fir subzone[a]	Indicator species group[b]	NRV group classification[c]	Alliance[d]	Representative plant associations[e]	Historical fire regime[c]	Historical fire regime mean[c]	Fire regime group[f]	Biophysical setting[g]
					YEARS			
Warm-xeric	WaDr	Moist yellow pine	Ponderosa pine–incense cedar–Douglas-fir forest and woodland	PIPO-CADE27/QUCHN-QUVA; PIPO-PSME/ANRO2-ERNU3	5–40	11	I	Mediterranean California dry-mesic mixed conifer and woodland (610270)
Warm-dry	WaMe	Dry mixed conifer	White fir–Douglas-fir forest and woodland	ABCO-PSME/CONU4-COCO6; ABCO-PSME/ACCI- CHSE11	5–50	11	I	Mediterranean California dry-mesic mixed conifer and woodland (610270)
Warm-moist	WaWM	Moist mixed conifer	White fir forest and woodland	ABCO-MCN/ADBI; PSME-MCN-ACMA3/ADBI; PSME-MCN-LIDE3/COCOC	5–80	16	I/III	Mediterranean California mesic mixed conifer and woodland (610280)

[a] See appendix 10 for a list of vegzones and subzones.
[b] See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group.
[c] Based on Safford and Stevens (2017).
[d] Based on (Sawyer et al. 2009)
[e] Based on Fites (1993) and Smith (1994). Plant association names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.
[f] LANDFIRE fire regime groups: I = high frequency (<30 years), low severity; III = moderate frequency (30–100 years), mixed severity. Source: USGS and USDA FS (n.d.a).
[g] Based on USGS and USDA FS (n.d.a).

the frequent human management and disturbance in this ecoregion, it is possible that the temporal stack may not provide accurate information. It is important to keep this in mind while using any classification.

HISTORICAL FIRE REGIMES AND CURRENT CONDITIONS—Fire is a dominant process in the Sierra Nevada. The interplay between climate, relief, topography, soils, and fire have created a complex distribution of vegetation from within-stand to landscape scales across the ecoregion (Fites-Kaufman et al. 2007, Safford and Stevens 2017). Many recorded fire histories have documented the role of fire across the landscape (e.g., Caprio and Lineback 2002, Fites-Kaufman et al. 2006, Skinner and Chang 1996).

There is a strong relationship between historical fire regimes and stand composition and structure. In general, historical landscapes contained areas that had low-density, large trees with high-fire tolerance (e.g., ponderosa pine, Douglas-fir, Jeffrey pine). Understories had limited seedling cover (high mortality due to frequent fire) and variable cover of fire-tolerant shrub, herb, and graminoid species (Safford and Stevens 2017). Correlations between white fir-grand fir subzones and historical fire regimes are described in table 20. The mean fire-return intervals suggest very frequent, likely low-severity fire regimes. The large ranges among all subzones illustrate the concept that fire regime classification cannot be assigned in an aspatial context and requires landscape vegetation type, abundance, and distribution information. PNV may offer a finer delineation of site capacity types and distribution. The spatial distribution of subzones may have affected the variability in fire frequency, fire severity, or both, across the landscape. The preponderance of white fir-grand fir/warm-moist subzone distribution, especially in the northern Sierra Nevada, may have affected both fire frequency and severity patterns. In 1902, prior to major fire suppression efforts, Leiberg (1902) noticed different patterns of tree species composition, density, and size within the northern Sierra Nevada:

> In the eastern and trans-Sierran districts… the old-growth forests… are generally open on all slopes except the northern and on tracts with much seepage… In the central district, outside the canyon areas, the forest is of moderate density and is rarely what might be called open, except in stands of very old growth. Elsewhere large quantities of white fir and Douglas-fir with oak combine to form thickset stands. On the rocky slopes of canyons and in the great gorges of the rivers the forest is always very open and scattered.

Greeley (1907) (as quoted in Safford and Stevens 2017) further describes the spatial variability in stand composition and structure and directly relates it to environmental conditions:

> …[I]n deep, moist soils… and on the north slopes, one sees bunch after bunch of six or eight mature sugar pines of nearly the same size. Where… seedlings and saplings occur at all they are usually in groups under broken cover or in narrow openings in the stand. On the same sites fir and cedar crowd the sugar pine closely and bunches or large patches of these species occur in among the groups of sugar pine. Yellow pine… seeks the drier and warmer sites…. Here it is also commonly found in large even-aged groups, from open bunches of mature trees to dense thickets of saplings and seedlings."

Understory composition is a key component of the PNV classification and played/plays a role in fire dynamics and postfire development. Shrub fields can be a seral expression across the yellow pine and mixed-conifer Sierran forests. Snowbrush ceanothus and greenleaf manzanita are common key indicators in the white fir-grand fir/warm-xeric subzone and can also occur as seral species in the white fir-grand fir/warm-dry subzone. Frequent fire may maintain shrub fields in these PNV types. Bush chinquapin (*Chrysolepis sempervirens*), Pacific dogwood (*Cornus nuttallii)*, and beaked hazelnut (*Corylus cornuta*), indicators in the white fir-grand fir/warm-dry mixed-conifer and white fir-grand fir/warm-dry PNV types, are tall shrubs that may serve as fuel ladders, thereby influencing fire severity patterns.

To further specify these concepts, the lower-mid elevations of the northern Sierra Nevada (and adjacent California Cascade Range) are a mosaic of the white fir-grand fir/warm-dry and white fir-grand fir/warm-xeric subzones and have the highest concentration of the white fir-grand fir/warm-moist subzone in this ecoregion (app. 12). This landscape block is a more productive landscape than to the south (Safford and Stevens 2017), with trees growing faster and taller. With the advent of fire suppression, current conditions contain many stands with more smaller trees. The longer the time between modern fires, the greater the tree density, dominance, and fire tolerance of white fir, Douglas-fir, and incense cedar (*Calocedrus decurrens*). These conditions may lead to a higher proportion of mixed-severity, or even high-severity, fires. More recent fire suppression efforts may cause fire regime shifts from low and moderate severity to high severity (Safford and Stevens 2017). If ponderosa pine, Jeffrey pine, or sugar pine dominated stands are desired in this area, more frequent disturbance/management will be necessary. Strategically located white fir-dominated stands or patches can be considered for wildlife habitat needs.

The white fir-grand fir/warm-xeric subzone dominates the lower-mid elevations of the central-southern Sierra Nevada. Productivity is lower here. The dominance of ponderosa pine, coupled with shorter fire-return intervals, decreases the probability of white fir-dominated stands (white fir is less competitive so there are fewer seed sources). If ponderosa pine-dominated stands are preferred, then less frequent management/disturbance may maintain those conditions.

Applications Conclusions

There is strong evidence that PNV classification and distribution can be used at various grains to describe variability in climate, productivity, and fire regimes. Correlations can be made with local products to boost the utility of this product to describe, for example, wildlife habitat and departure from NRV.

Use at Various Grains

The accuracy assessment of this PNV product confirms the utility of this product for its initial intended purpose as a foundation for planning and management over broad regional extents. A prime example of such an application is the recent effort that highlights overarching issues for updating management plans for national forests in Washington, Oregon, and California (USDA FS PNW Region 2020). While the ultimate goal is new management plans for individual national forests, the intent of Forest Service, National Forest System leadership is to keep the larger geographic context in the foreground, because of compelling issues "that are shared across the broad landscape, such as species habitat and wildland fire" (USDA FS PNW Region 2020).

Another relevant example is the ongoing monitoring of habitat for the northern spotted owl in the geographic area of the Northwest Forest Plan (Davis et al. 2022). This monitoring depends on comprehensive spatial data for much of Washington, Oregon, and northern California. As described above, this PNV product could be used to link to other data sources to illuminate fire regimes, tree species composition, and likely successional trajectories, all of which can help in detecting habitat trends and modeling possible future changes (Davis et al. 2022). This product should similarly be useful for monitoring late-successional and old-growth forest in the area of the Northwest Forest Plan (Davis et al. 2015), as well as areas east of the Cascade crest (Hessburg et al. 2020).

Accuracy assessment results, including confusion matrices for subzones, also suggest that this PNV product will have utility at finer scales, such as individual national forests or large project areas (e.g., hundreds of thousands of acres). For such applications, it will be important to consider where model stability results indicate heightened uncertainty, and whether fuzzy matches generate groupings with consistent management implications.

Conserving Biodiversity

In the coarse-filter approach, understanding the geographic distribution of ecosystem types is central to efficiently conserving large numbers of species across regions (Crosby et al. 2020). While relevant national-level products have been developed, such as the USGS Gap Analysis Program (USGS 2016), we think the PNV product described here will be an important complement to existing datasets. This product includes finer delineations of ecosystem types (see Faber-Langendoen et al. [2009], noting that the finest division in the Gap Analysis Program's product is the group level of the U.S. National Vegetation Classification standard) and is grounded in systematically designed and consistently collected data on vegetation composition and structure.

This PNV product can contribute to coarse-filter conservation efforts both by elucidating the abundance and distribution of ecosystem types and by depicting landscape patterns at a regional scale. For example, some vegzones or subzones may be sufficiently abundant and widespread that active restoration (e.g., Haugo et al. 2015) is a reasonable focus for regional-scale conservation efforts. By contrast, for extremely rare vegzones and subzones, in situ preservation efforts may be more appropriate. The distribution of the developed zone may

affect regional-scale conservation efforts because the presence of transportation corridors and other infrastructure enhances potential for spread of contaminants and invasive species, as well as malign human activities, such as arson. The spatial patterns of all nonvegetated and nonforest vegetated zones may have implications for migration and gene flow of native biota, as well as spread of disturbance processes, such as wildfire.

Adaptation to Climate Change

Researchers are beginning to identify the plausible effects of climate change in the next few decades and suitable adaptation actions by vegetation type within the project area (e.g., Halofsky et al. 2022a). For example, similar products (though based on existing vegetation rather than potential vegetation) in California have been used to examine the exposure of differing vegetation types to projected climate change (Thorne et al. 2017). We think this PNV product will thus provide an essential first approximation of trends to watch and management activities to consider. In addition, it may be possible to combine fine-grained climate predictions with the PNV map to suggest where management intervention is most needed within vegzones or subzones.

Climate change is likely to drive more frequent and extensive wildfires (Halofsky et al. 2020). We think this PNV product will help identify where the most fire-sensitive vegetation types occur as well as point to likely postfire vegetation development, including type conversions (Halofsky et al. 2020, 2022b). Combining the PNV map with the emerging understanding of fuels management may help direct management activities where they are most likely to be effective (Halofsky et al. 2020).

Abundance, distribution, and successional stage of vegetation influence habitat suitability for wildlife species and are likely to change with the changing climate (e.g., Halofsky et al. 2022b). The utility of this PNV product for vegetation management to aid the conservation of biodiversity described above is equally relevant to management intended to maintain habitat for wildlife species adapting to climate change.

It is important to note that climate change has already had profound effects on forests in the project area (e.g., Thorne et al. 2017, Still et al. 2023, Young et al. 2017). The overlay of spatial patterns of tree damage and mortality to date on the PNV map would be additional means of identifying the vegetation types and biophysical environments at the greatest risk.

Finally, the aspects of spatial distribution of forested, nonforested, and nonvegetated zones addressed with respect to biodiversity become more significant from the perspective of a changing climate. Migration of species will become more important, so grasping the location and character of barriers will be critical. In this regard, it will also be important to take advantage of spatial data for existing vegetation to capture areas with the potential for forests that are temporarily occupied by nonforest vegetation following disturbance.

Conclusions

We developed a standardized classification scheme to create and map potential vegetation units across large, multistate landscapes, thus supporting an all-lands, large-scale approach to land management planning. Results from an accuracy assessment indicate that the product also has utility at finer scales (thousands to hundreds of thousands of acres), with appropriate consideration of spatial variation in map accuracy. This PNV product is the appropriate framework for additional, complementary spatial products, such as those for examining existing vegetation, disturbance regimes, and successional pathways. The product has already shown its value for large-scale planning, vulnerability assessment, and monitoring. Going forward, we anticipate many more such applications, especially in conjunction with the relevant complementary spatial data.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet (ft)	.305	Meters
Miles (mi)	1.609	Kilometers
Acres	.405	Hectares
Square feet per acre	.229	Square meters per hectare
Cubic feet per acre	.07	Cubic meters per hectare
Degrees Fahrenheit	.56(°F – 32)	Degrees Celsius

References

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 490 p.

Atzet, T.; White, D.E.; McCrimmon, L.A. [et al.]. 1996. Field guide to the forested plant associations of southwestern Oregon. Tech. Pap. R6-NR-ECOL-TP-17-96. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 372 p. https://www.fs.usda.gov/sites/nfs/files/r06/publication/fseprd1178143.pdf. (March 24, 2025).

Barbour, M.G.; Billings, W.D., eds. 1988. North American terrestrial vegetation. Cambridge, UK: Cambridge University Press. 448 p.

Barrett, S.W.; DeMeo, T.; Jones, J.L. [et al.]. 2006. Assessing ecological departure from reference conditions with the Fire Regime Condition Class (FRCC) mapping tool. In: Andrews, P.L.; Butler, B.W., comps. 2006. Fuels management—how to measure success: conference proceedings. Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 575–585.

Barrett, S.; Havlina, D.; Jones, J. [et al.]. 2010. Interagency fire regime condition class (FRCC) guidebook, version 3.0. U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior; and The Nature Conservancy. 126 p. https://www.fs.usda.gov/rm/pubs/rmrs_gtr292/2010_barrett.pdf. (March 24, 2025).

Blue Water GIS. 2020. Rivers [Vector; no scale provided]. USA major rivers. https://www.arcgis.com/home/item.html?id=a333ad74fb114e409b95aade6da5c1e0. (February 22, 2023).

Bechtold, W.A.; Patterson, P.L., eds. 2005. The enhanced forest inventory and analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p. https://doi.org/10.2737/SRS-GTR-80.

Bell, D.M.; Acker, S.A.; Gregory, M.J. [et al.]. 2021. Quantifying regional trends in large live tree and snag availability in support of forest management. Forest Ecology and Management. 479: 118554. https://doi.org/10.1016/j.foreco.2020.118554.

Bell, D.M.; Gregory, M.J.; Kane, V. [et al.]. 2018. Multiscale divergence between Landsat- and lidar-based biomass mapping is related to regional variation in canopy cover and composition. Carbon Balance and Management. 13: 15. https://doi.org/10.1186/s13021-018-0104-6.

Bell, D.M.; Gregory, M.J.; Ohmann, J.L. 2015. Imputed forest structure uncertainty varies across elevational and longitudinal gradients in the western Cascade Mountains, Oregon, USA. Forest Ecology and Management. 358: 154–164. https://doi.org/10.1016/j.foreco.2015.09.007.

Bell, D.M.; Gregory, M.J.; Palmer, M.; Davis, R.J. 2023. Guidance for forest management and landscape ecology applications of recent Gradient Nearest Neighbor imputation maps in California, Oregon, and Washington. Gen. Tech. Rep. PNW-GTR-1018. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 41 p. https://doi.org/10.2737/PNW-GTR-1018.

Bell, D.M.; Wilson, B.T.; Werstak, C.E., Jr. [et al.]. 2022. Examining k-nearest neighbor estimation across scales using national forest inventory data. Frontiers in Forests and Global Change 5:763422. https://doi.org/10.3389/ffgc.2022.763422.

Bork, J.L. 1985. Fire history in three vegetation types on the eastern side of the Oregon Cascades. Corvallis, OR: Oregon State University. 94 p. Ph.D. dissertation.

Brown, R.L.; Durbin, J.; Evans, J.M. 1975. Techniques for testing the constancy of regression relationships over time. Journal of the Royal Statistical Society: Series B (Methodological). 37(2): 149–163. https://doi.org/10.1111/j.2517-6161.1975.tb01532.x

Burns, R.M.; Honkala, B.H., tech. coords. 1990. Silvics of North America. 1: Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 675 p.

Burns, R.M.; Honkala, B.H., tech. coords. 1990. Silvics of North America. 2: Hardwoods Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 877 p.

California Chaparral Institute. [N.d.]. Chaparral. https://californiachaparral.org/chaparral/. (April 1, 2025).

Caprio, A.C.; Lineback, P. 2002. Pre-twentieth century fire history of Sequoia and Kings Canyon National Park: a review and evaluation of our knowledge. Association for Fire Ecology, Misc. Pub. 1: 180–199.

Clements, F.E. 1916. Plant succession: an analysis of the development of vegetation. Washington, DC: Carnegie Institution for Science. 652 p. https://doi.org/10.5962/bhl.title.56234.

Corney, P.M.; Le Duc, M.G.; Smart, S.M. [et al.]. 2006. Relationships between the species composition of forest field-layer vegetation and environmental drivers, assessed using a national scale survey. Journal of Ecology. 94(2): 383–401. https://doi.org/10.1111/j.1365-2745.2006.01094.x.

Cowling, R.M.; Rundel, P.W.; Lamont, B.B. [et al.]. 1996. Plant diversity in Mediterranean-climate regions. Trends in Ecology and Evolution. 11(9): 362–366. https://doi.org/10.1016/0169-5347(96)10044-6.

Crosby, A.D.; Porter, W.F.; Roloff, G.J. [et al.]. 2020. Combining conservation value with conservation filters to guide forest management for avian biodiversity. Forest Ecology and Management. 466: 118131. https://doi.org/10.1016/j.foreco.2020.118131.

Daly, C.; Smith, J.I.; Olson, K.V. 2015. Mapping atmospheric moisture climatologies across the conterminous United States. PloS ONE. 10(10): e0141140. https://doi.org/10.1371/journal.pone.0141140.

Dark, S.J. 2004 The biogeography of invasive alien plants in California: an application of GIS and spatial regression analysis. Diversity and Distributions. 10(1): 1–9. https://doi.org/10.1111/j.1472-4642.2004.00054.x.

Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecological Monographs. 22(4): 301–330. https://doi.org/10.2307/1948472.

Daubenmire, R. 1968. Plant communities: a textbook of plant synecology. New York, Evanston, London: Harper and Row. 270 p.

Daubenmire, R. 1976. The use of vegetation in assessing the productivity of forest lands. The Botanical Review. 42(2): 115–143. https://doi.org/10.1007/BF02860720.

Davis, R.J.; Lesmeister, D.B.; Yang, Z. [et al.]. 2022. Northwest Forest Plan—the first 25 years (1994–2018): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-1003. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p. https://doi.org/10.2737/PNW-GTR-1003.

Davis, R.J.; Ohmann, J.L.; Kennedy, R.E. [et al.]. 2015. Northwest Forest Plan—the first 20 years (1994–2013): status and trends of late-successional and old-growth forests. Gen. Tech. Rep. PNW-GTR-911. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 112 p. https://doi.org/10.2737/PNW-GTR-911.

DeMeo, T.; Haugo, R.; Ringo, C. [et al.]. 2018. Expanding our understanding of forest structural restoration needs in the Pacific Northwest. Northwest Science. 92(1): 18–35. https://doi.org/10.3955/046.092.0104.

Dettinger, M.D. 2013. Atmospheric rivers as drought busters on the U.S. west coast. Journal of Hydrometeorology. 14(6): 1721–1732. https://doi.org/10.1175/JHM-D-13-02.1.

Dunning, D. 1942. A site classification for the mixed-conifer selection forests of the Sierra Nevada. Res. Note 28. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station. 19 p. https://doi.org/10.5962/bhl.title.70288.

EcoAdapt. [N.d.]. Northern California Climate Adaptation Project https://ecoadapt.org/projects/16/Northern-California-Climate-Adaptation-Project/products. (May 19, 2025.

Esri. 2015. Hillshade [Basemap]. Scale not given. World hillshade. https://www.arcgis.com/home/item.html?id=1b243539f4514b6ba35e7d995890db1d. (February 22, 2023).

Faber-Langendoen, D.; Tart, D.L.; Crawford, R.H. 2009. Contours of the revised U.S. National Vegetation Classification standard. Bulletin of the Ecological Society of America. 90(1): 87–93. https://doi.org/10.1890/0012-9623-90.1.87.

Fites, J.A. 1993. Ecological guide to mixed conifer plant associations—northern Sierra Nevada and southern Cascades: Lassen, Plumas, Tahoe, and Eldorado National Forests. Tech. Pap. R5-ECOL-TP-001. Placerville, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 120 p.

Fites-Kaufman, J.A.; Bradley, A.F.; Merrill, A.G. 2006. Fire and plant interactions. In: Sugihara, N.G.; van Wagtendonk, J.W.; Shaffer, K.E. [et al.], eds. Fire in California's ecosystems. Oakland, CA: University of California: 94–117. Chapter 6. https://doi.org/10.1525/california/9780520246058.003.0006.

Fites-Kaufman, J.A.; Rundel, P.; Stephenson, N.; Weixelman, D.A., 2007. Montane and subalpine vegetation of the Sierra Nevada and Cascade Ranges. In: Barbour, M., ed. Terrestrial vegetation of California. 3rd ed. Berkeley, CA: University of California Press: 456–501. Chapter 17. https://doi.org/10.1525/california/9780520249554.003.0017.

Foody, G.M. 2020. Explaining the unsuitability of the kappa coefficient in the assessment and comparison of the accuracy of thematic maps obtained by image classification. Remote Sensing of Environment. 239: 111630. https://doi.org/10.1016/j.rse.2019.111630.

Franklin, J. 1995. Predictive vegetation mapping: geographic modelling of biospatial patterns in relation to environmental gradients. Progress in Physical Geography. 19(4): 474–499. https://doi.org/10.1177/030913339501900403.

Franklin, J.F.; Dyrness, C.T. 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 417 p.

Franklin, J.F.; Spies, T.A.; Pelt, R.V. [et al.]. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management. 155: 399–423. https://doi.org/10.1016/S0378-1127(01)00575-8.

Franklin, S.; Faber-Langendoen, D; Jennings, M. [et al.]. 2012. Building the United States National Vegetation Classification. Annali di Botanica: 2: 1–9.

Gauch, H.G., Jr. 1982. Multivariate analysis in community ecology. Cambridge, UK: Cambridge University Press. 298 p. https://doi.org/10.1017/CBO9780511623332.

Gholz, H.L. 1982. Environmental limits on aboveground net primary production, leaf area, and biomass in vegetation zones of the Pacific Northwest. Ecology. 63(2): 469–481. https://doi.org/10.2307/1938964.

Gibson, P.B.; Waliser, D.E.; Guan, B. [et al.]. 2020. Ridging associated with drought across the Western and Southwestern United States: characteristics, trends, and predictability sources. Journal of Climate 33(7): 2485–2508. https://doi.org/10.1175/JCLI-D-19-0439.1.

Gleason, H.A. 1926. The individualistic concept of the plant association. Bulletin of the Torrey Botanical Club. 53(1): 7–26. https://doi.org/10.2307/2479933.

Habich, E.F. 2001. Ecological site inventory. Inventory and Monitoring Tech. Ref. 1734-7. Denver, CO: U.S. Department of the Interior, Bureau of Land Management. 112 p.

Hagmann, R.K.; Franklin, J.F.; Johnson, K.N. 2013. Historical structure and composition of ponderosa pine and mixed-conifer forests in south-central Oregon. Forest Ecology and Management. 304: 492–504. https://doi.org/10.1016/j.foreco.2013.04.005.

Hagmann, R.K.; Franklin, J.F.; Johnson, K.N. 2014. Historical conditions in mixed-conifer forests on the eastern slopes of the northern Oregon Cascade Range, USA. Forest Ecology and Management. 330: 158–170. https://doi.org/10.1016/j.foreco.2014.06.044.

Halofsky, J.E.; Peterson, D.L., eds. 2017. Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-939. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 331 p. https://doi.org/10.2737/PNW-GTR-939.

Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022a. Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 469 p. https://doi.org/10.2737/PNW-GTR-1001.

Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022b. Climate change vulnerability and adaptation in southwest Oregon. Gen. Tech. Rep. PNW-GTR-995. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 445 p. https://doi.org/10.2737/PNW-GTR-995.

Halofsky, J.E.; Peterson, D.L.; Harvey, B.J. 2020. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology. 16: 4. https://doi.org/10.1186/s42408-019-0062-8.

Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019. Climate change vulnerability and adaptation in south-central Oregon. Gen. Tech. Rep. PNW-GTR-974. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 473 p. https://doi.org/10.2737/PNW-GTR-974.

Halofsky, J.E.; Peterson, D.L.; O'Halloran, K.A.; Hawkins Hoffman, C., eds. 2011. Adapting to climate change at Olympic National Forest and Olympic National Park. Gen. Tech. Rep. PNW-GTR-844. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p. https://doi.org/10.2737/PNW-GTR-844.

Handcock, M.S. 2023. Relative distribution methods. Version 1.7-2. https://CRAN.R-project.org/package=reldist.

Handcock, M.S.; Morris, M. 1999. Relative distribution methods in the social sciences. New York: Springer. 265 p.

Härdtle, W. 1995. On the theoretical concept of the potential natural vegetation and proposals for an up-to-date modification. Folia Geobotanica & Phytotaxonomica. 30: 263–276. https://doi.org/10.1007/BF02803708.

Haugo, R.; Zanger, C.; DeMeo, T. [et al.]. 2015. A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA. Forest Ecology and Management. 335: 37–50. https://doi.org/10.1016/j.foreco.2014.09.014.

He, M.; Gautam, M. 2016. Variability and trends in precipitation, temperature and drought indices in the state of California. Hydrology. 3(2): 14. https://doi.org/10.3390/hydrology3020014.

Hemstrom, M.A., Salwasser, J., Halofsky, J. [et al.]. 2012. The integrated landscape assessment project. In: Kerns, B.K.; Shlisky, A.J.; Daniel, C.J., tech. eds. Proceedings of the First Landscape State-and-Transition Simulation Modeling Conference, June 14–16, 2011, Portland, Oregon. Gen. Tech. Rep. PNW-GTR-869. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 57–72.

Henderson, E.B.; Bell, D.M.; Gregory, M.J. 2019. Vegetation mapping to support greater sage-grouse habitat monitoring and management: multi- or univariate approach? Ecosphere 10(8): e02838. https://doi.org/10.1002/ecs2.2838.

Henderson, E.B.; Ohmann, J.L.; Gregory, M.J. [et al.]. 2014. Species distribution modelling for plant communities: stacked single species or multivariate modelling approaches? Applied Vegetation Science. 17(3): 516–527. https://doi.org/10.1111/avsc.12085.

Henderson, J.A.; Lesher, R.D.; Peter, D.H.; Ringo, C.D. 2011. A landscape model for predicting potential natural vegetation of the Olympic Peninsula USA using boundary equations and newly developed environmental variables. Gen. Tech. Rep. PNW-GTR-841. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 35 p. https://doi.org/10.2737/PNW-GTR-841.

Henderson, J.A.; Lesher, R.D.; Peter, D.H.; Shaw, D.C. 1992. Field guide to the forested plant associations of the Mt. Baker-Snoqualmie National Forest. Tech. Pap. R6-ECOL-TP-028-91. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 196 p.

Henderson, J.A.; Peter, D.H.; Lesher, R.D.; Shaw, D.C. 1989. Forested plant associations of the Olympic National Forest. Tech. Pap. R6-ECOL-TP-001-88. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 502 p.

Hessburg, P.F.; Charnley, S.; Wendel, K.L. [et al.]. 2020. The 1994 eastside screens large-tree harvest limit: review of science relevant to forest planning 25 years later. Gen. Tech. Rep. PNW-GTR-990. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 114 p.

Hessburg, P.F.; Salter, R.B.; Richmond, M.B.; Smith, B.G. 2000. Ecological subregions of the interior Columbia Basin, USA. Applied Vegetation Science. 3(2): 163–180. https://doi.org/10.2307/1478995.

Heyerdahl, E.K.; Loehman, R.A.; Falk, D.A. 2019. A multi-century history of fire regimes along a transect of mixed-conifer forests in central Oregon, U.S.A. Canadian Journal of Forest Research. 49: 76–86. https://doi.org/10.1139/cjfr-2018-0193.

Hill, M.O. 1979. TWINSPAN, a FORTAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and the attributes. Ithaca, New York: Cornell University, Department of Ecology and Systematics. 90 p.

Hudec, J.L.; Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019. Climate change vulnerability and adaptation in southwest Washington. Gen. Tech. Rep. PNW-GTR-977. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 249 p. https://doi.org/10.2737/PNW-GTR-977.

John, T.; Tart, D. 1986. Forested plant associations of the Yakima Drainage within the Yakima Indian Reservation. Review copy. Toppenish, WA: Yakima Indian Nation. 195p.

John, T.; Tart, D.; Clausnitzer, R. 1988. Forested plant associations of the Yakima Indian Reservation. Draft. Toppenish WA: Yakima Indian Nation. 182p.

Johnson, C.G., Jr.; Clausnitzer, R.R. 1992. Plant associations of the Blue and Ochoco Mountains. Tech. Pap. R6-ERW-TP-036-92. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 164 p. + app.

Keane, R.E.; Hessburg, P.F.; Landres, P.B.; Swanson, F.J. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management. 258: 1025–1037. https://doi.org/10.1016/j.foreco.2009.05.035.

Kemp, D.D. 1998. The environment dictionary. London and New York: Routledge. 482 p.

Kowarik, I. 1987. Kritische Anmerkungen zum theoretischen Konzept der potentiellen natürlichen Vegetation mit Anregungen zu einer zeitgemäßen Modifikation. Tuexenia. 7: 53–67.

Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States, Special Publication No. 36. New York: American Geographical Society. 116 p. https://doi.org/10.2307/1935336.

Kuchler, A.W. 1970. Potential natural vegetation. In: U.S. Department of the Interior, U.S. Geological Survey. National atlas of the United States. Washington, DC.

Kuchler, A.W. 1973. Problems in classifying and mapping vegetation for ecological regionalization. Ecology. 54(3): 512–523. https://doi.org/10.2307/1935336.

Laughlin, M.M.; Bakker, J.D.; Churchill, D.J. [et al.]. 2023. Trends in forest structure restoration need over three decades with increasing wildfire activity in the interior Pacific Northwest US. Forest Ecology and Management. 527 p. https://doi.org/10.1016/j.foreco.2022.120607.

Leiberg, J.B. 1902. Forest conditions in the northern Sierra Nevada, California. Professional Pap. No. 8. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 194 p. https://doi.org/10.3133/pp8.

LEMMA. [N.d.]. Landscape ecology, modeling, mapping, and analysis. https://lemma.forestry.oregonstate.edu/. (March 28, 2025).

Lillybridge, T.R.; Kovalchik, B.L.; Williams, C.K.; Smith, B.G. 1995. Field guide for forested plant associations of the Wenatchee National Forest. Gen. Tech. Rep. PNW-GTR-359. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 335 p. https://doi.org/10.2737/PNW-GTR-359.

Liu, J.; Dietz, T.; Carpenter, S.R. [et al.]. 2007. Complexity of coupled human and natural systems. Science. 317(5844): 1513–1516. https://doi.org/10.1126/science.1144004.

Lucas, R.; Groeneveld, J.; Harms, H. [et al.]. 2017. A critical evaluation of ecological indices for the comparative analysis of microbial communities based on molecular datasets. FEMS Microbiology Ecology. 93(1): fiw209. https://doi.org/10.1093/femsec/fiw209.

Lutes, D.C. 2013. First Order Fire Effects Model (FOFEM) 6.0 user's guide. Missoula, MT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 66 p.

Max, T.A.; Schreuder, H.T.; Hazard, J.W. [et al.]. 1996. The Pacific Northwest Region vegetation and inventory monitoring system. Res. Pap. PNW-RP-493. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p. https://doi.org/10.5962/bhl.title.87980.

McCain, C.; Diaz, N. 2002. Field guide to the forested plant associations of the westside central Cascades of northwest Oregon. Tech. Pap. R6-NR-ECOL-TP-02-02. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 403 p.

McCune, B.; Grace, J.B. 2002. Analysis of ecological communities. Gleneden Beach, OR: MjM Software Design. 302 p.

McNeil, R.C. 1975. Vegetation and fire history of a ponderosa pine-white fir forest in Crater Lake National Park. Corvallis, OR: Oregon State University. 171 p. M.S. thesis.

Mellen-McLean, K.; Marcot, B.G.; Ohmann, J.L. [et al.]. 2017. DecAID, the decayed wood advisor for managing snags, partially dead trees, and down wood for biodiversity in forests of Washington and Oregon. Version 3.0. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region and Pacific Northwest Research Station; U.S. Department of the Interior, Fish and Wildlife Service, Oregon State Office.

Meyer, M.D.; North, M.P. 2019. Natural range of variation of red fir and subalpine forests in the Sierra Nevada bioregion. Gen Tech. Rep. PSW-GTR-263. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 135 p. https://doi.org/10.2737/PSW-GTR-263.

Minore, D. 1979. Comparative autecological characteristics of northwestern tree species—a literature review. Gen. Tech. Rep. PNW-GTR-087. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 72 p.

Mitchell, K. 2007. Quantitative analysis by the point-centered quarter method. Geneva, NY: Hobart and William Smith Colleges, Department of Mathematics and Computer Science. 34 p. https://people.hws.edu/mitchell/PCQMv1.pdf. (September 3, 2025).

Molinari, N.; Sawyer, S.; Safford, H. 2015. A summary of current trends and probable future trends in climate and climate-driven processes in the Los Padres National Forest and neighboring lands. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Los%20Padres%20Climate%20Trend%20Summary%202016.pdf. (March 28, 2025).

Morgan, P.; Aplet, G.H.; Haufler, J.B. [et al.]. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. Journal of Sustainable Forestry. 2(1–2): 87–111. https://doi.org/10.1300/J091v02n01_04.

Mueggler, W.F.; Stewart, W.L. 1980. Grassland and shrubland habitat types of western Montana. Gen. Tech. Rep. INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 154 p. https://doi.org/10.5962/bhl.title.100640.

Mueller-Dombois, D.; Ellenberg, H. 1974. Aims and methods of vegetation ecology. New York: John Wiley and Sons, Inc.

Muldavin, E.H.; DeVelice, R.L.; Ronco, F., Jr. 1996. A classification of forest habitat types southern Arizona and portions of the Colorado Plateau. Gen. Tech. Rep. RM-GTR-287. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 130 p. https://doi.org/10.5962/bhl.title.99312.

Munger, T.T. 1917. Western yellow pine in Oregon. Bulletin No. 418. Washington, DC: U.S. Department of Agriculture. 48 p. https://doi.org/10.5962/bhl.title.108047.

Myroniuk, V.; Bell, D.M.; Gregory, M.J. [et al.]. 2022. Uncovering forest dynamics using historical forest inventory data and Landsat time series. Forest Ecology and Management. 513: 120184. https://doi.org/10.1016/j.foreco.2022.120184.

National Forest Management Act [NFMA] of 1976; 90 Stat. 2949; 16 U.S.C.

Nelson, K.J.; Steinwand, D. 2015. A Landsat data tiling and compositing approach optimized for change detection in the conterminous United States. Photogrammetric Engineering and Remote Sensing. 81(7): 573–586. https://doi.org/10.14358/PERS.81.7.573.

Ohmann, J.L.; Gregory, M.J. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, USA. Canadian Journal of Forest Research. 32(4): 725–741. https://doi.org/10.1139/x02-011.

Ohmann, J.L.; Gregory, M.J.; Henderson, E.B.; Roberts, H.M. 2011. Mapping gradients of community composition with nearest-neighbor imputation: extending plot data for landscape analysis. Journal of Vegetation Science. 22(4): 660–676. https://doi.org/10.1111/j.1654-1103.2010.01244.x.

Ohmann, J.L.; Gregory, M.J.; Roberts, H.M. 2014. Scale considerations for integrating forest inventory plot data and satellite image data for regional forest mapping. Remote Sensing of Environment. 151: 3–15. https://doi.org/10.1016/j.rse.2013.08.048.

Ohmann, J.L.; Gregory, M.J.; Roberts, H.M. [et al.]. 2012. Mapping change of older forest with nearest-neighbor imputation and Landsat time-series. Forest Ecology and Management. 272: 13–25. https://doi.org/10.1016/j.foreco.2011.09.021.

Ohmann, J.L; Spies, T.A. 1998. Regional gradient analysis and spatial pattern of woody plant communities of Oregon forests. Ecological Monographs. 68(2): 151–182. https://doi.org/10.1890/0012-9615(1998)068[0151:RGAASP]2.0.CO;2.

Oline, D.K. 2008. Geographic variation in chloroplast haplotypes in the California red fir-noble fir species complex and the status of Shasta red fir. Canadian Journal of Forest Research. 38(10): 2705–2710. https://doi.org/10.1139/X08-097.

Oliver, C.D.; Larson, B.C. 1990. Forests stand dynamics. New York: McGraw-Hill. 467 p.

Olofsson, P.; Foody, G.M.; Stehman, S.V.; Woodcock, C.E. 2013. Making better use of accuracy data in land change studies: estimating accuracy and area and quantifying uncertainty using stratified estimation. Remote Sensing of Environment. 129: 122–131. https://doi.org/10.1016/j.rse.2012.10.031.

Olofsson, P.; Foody, G.M.; Herold, M. [et al.]. 2014. Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment. 148: 42–57. https://doi.org/10.1016/j.rse.2014.02.015.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers. 77(1): 118–125. https://doi.org/10.1111/j.1467-8306.1987.tb00149.x.

Omernik, J.M.; Griffith, G.E. 2014. Ecoregions of the conterminous United States: evolution of a hierarchical spatial framework. Environmental Management. 54: 1249–1266. https://doi.org/10.1007/s00267-014-0364-1.

O'Neil, T.A.; Johnson, D.H. 2001. Oregon and Washington wildlife species and their habitats. In: Johnson, D.H.; O'Neil, T.A., eds., Wildlife-habitat relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press: 1–21. Chapter 1.

Ott, T.M. 2014. The geographic and ecological patterns of genetic variation of the *Abies grandis–Abies concolor* complex. Moscow, ID: University of Idaho. 122 p. Ph.D. dissertation.

Ott, T.M.; Strand, E.K.; Anderson, C.L. 2015. Niche divergence of *Abies grandis–Abies concolor* hybrids. Plant Ecology. 216: 479–490. doi:10.1007/s11258-015-0452-1. https://doi.org/10.1007/s11258-015-0452-1.

Patil, S.A.; Kovner, J.L.; Burnham, K.P. 1982. Optimum nonparametric estimation of population density based on ordered distances. Biometrics. 38(1): 243–248. https://doi.org/10.2307/2530307.

Pontius, R.G., Jr.; Millones, M. 2011. Death to Kappa: birth of quantity disagreement and allocation disagreement for accuracy assessment. International Journal of Remote Sensing. 32(15): 4407–4429. https://doi.org/10.1080/01431161.2011.552923.

PRISM Climate Group. 2025. PRISM climate data. Corvallis, OR: Oregon State University, Northwest Alliance for Computational Science & Engineering. https://prism.oregonstate.edu. (December 16, 2020).

Quigley, T.M.; Gravenmier, R.A.; Arbelbide, S.J., tech. eds. 1999. The interior Columbia Basin ecosystem management project: scientific assessment. CD-ROM. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Raymond, C.L.; Peterson, D.L.; Rochefort, R.M., eds. 2014. Climate change vulnerability and adaptation in the North Cascades region, Washington. Gen. Tech. Rep. PNW-GTR-892. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 279 p. https://doi.org/10.2737/PNW-GTR-892.

R Core Team (2024). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Rehfeldt, G.E.; Crookston, N.L.; Warwell, M.V.; Evans, J.S. 2006. Empirical analyses of plant-climate relationships for the Western United States. International Journal of Plant Sciences. 167(6): 1123–1150. https://doi.org/10.1086/507711.

Reilly, M.J.; Elia, M.; Spies, T.A. [et al.]. 2018a. Cumulative effects of wildfires on forest dynamics in the eastern Cascade Mountains, USA. Ecological Applications. 28(2): 291–308. https://doi.org/10.1002/eap.1644.

Reilly, M.J.; Spies, T.A. 2015. Regional variation in stand structure and development in forests of Oregon, Washington, and inland northern California. Ecosphere. 6(10): 192. https://doi.org/10.1890/ES14-00469.1.

Reilly, M.J.; Spies, T.A.; Littell, J. [et al.]. 2018b. Climate, disturbance, and vulnerability to vegetation change in the Northwest Forest Plan area. In Spies, T.A.; Stine, P.A.; Gravenmier, R.; Long, J.W.; Reilly, M.J., tech. coords. Synthesis of science to inform land management within the Northwest Forest Plan area. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 29–93. Chapter 2.

Ritchie, M.W. 2016. Multi-scale reference conditions in an interior pine-dominated landscape in northeastern California. Forest Ecology and Management. 378: 233–243. https://doi.org/10.1016/j.foreco.2016.07.017.

Safford, H.D.; Stevens, J.T. 2017. Natural range of variation for yellow pine and mixed-conifer forests in the Sierra Nevada, southern Cascades, and Modoc and Inyo National Forests, California, USA. Gen. Tech. Rep. PSW-GTR-256. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 229 p. https://doi.org/10.2737/PSW-GTR-256.

Sala, O.E.; Chapin, F.S., III; Armesto, J.J. [et al.]. 2000. Global biodiversity scenarios for the year 2100. Science. 287(5459): 1770–1774. https://doi.org/10.1126/science.287.5459.1770.

Särndal, C.-E.; Swensson, B.; Wretman, J. 1992. Model assisted survey sampling. New York: Springer. 695 p.

Sawyer, J.O.; Keeler-Wolf, T.; Evens, J.M. 2009. A manual of California vegetation. 2nd ed. Sacramento, CA: California Native Plant Society. 1300 p.

Sensenig, T.; Bailey, J.D.; Tappeiner, J.C. 2013. Stand development, fire and growth of old-growth and young forests in southwestern Oregon, USA. Forest Ecology and Management. 291: 96–109. https://doi.org/10.1016/j.foreco.2012.11.006.

Siler, N., Roe, G.; Durran, D. 2013. On the dynamical causes of variability in the rain-shadow effect: a case study of the Washington Cascades. Journal of Hydrometeorology. 14: 122–139. https://doi.org/10.1175/JHM-D-12-045.1.

Simpson, M. 2007. Forested plant associations of the Oregon East Cascades. Tech. Pep. R6-NR-ECOL-TP-03-2007. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Skinner, C.N.; Chang, C. 1996. Fire regimes, past and present. In: Sierra Nevada ecosystem project: final report to Congress. Vol. II. Assessments and scientific basis for management options. Wildland Resources Center Rep. No. 37. Davis, CA: University of California, Centers for Water and Wildland Resources: 1041–1069.

Smith, S. 1994. Ecological guide to eastside pine plant associations; northeastern California: Modoc, Lassen, Klamath, Shasta-Trinity, Plumas, and Tahoe National Forests. Tech. Pub. R5-ECOL-TP-004. Alturas, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 174 p.

Soeriaatmadja, R.E. 1966. Fire history of the ponderosa pine forests of the Warm Springs Indian Reservation, Oregon. Corvallis, OR: Oregon State University. 123 p. Ph.D. dissertation.

Somodi, I.; Molnár, Z.; Ewald, J. 2012. Towards a more transparent use of the potential natural vegetation concept—an answer to Chiarucci et al. Journal of Vegetation Science. 23(3): 590–595. https://doi.org/10.1111/j.1654-1103.2011.01378.x.

Spies, T.A.; Franklin, J.F. 1988. Old growth and forest dynamics in the Douglas-fir region of western Oregon and Washington. Natural Areas Journal. 8(3): 190–201.

Spies, T.A.; Franklin, J.F. 1996. The diversity and maintenance of old-growth forests. In: Szaro, R.C.; Johnson, D.W., eds. Biodiversity in managed landscapes: theory and practice. New York: Oxford University Press: 296–314. Chapter 20.

Spies, T.A.; Hessburg, P.F.; Skinner, C.N. [et al.]. 2018. Old growth, disturbance, forest succession, and management in the area of the Northwest Forest Plan. In: Spies T.A; Stine P.A.; Gravenmier, R.A. [et al.], tech. coords. Synthesis of science to inform land management within the Northwest Forest Plan area. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region: 95–243. Chapter 3. https://doi.org/10.2737/PNW-GTR-966.

Stehman, S.V. 1997. Selecting and interpreting measures of thematic classification accuracy. Remote Sensing of Environment. 62(1). 77–89. https://doi.org/10.1016/S0034-4257(97)00083-7.

Still, C.J.; Sibley, A.; DePinte, D. [et al.]. 2023. Causes of widespread foliar damage from the June 2021 Pacific Northwest heat dome: more heat than drought. Tree Physiology. 43(2): 203–209. https://doi.org/10.1093/treephys/tpac143.

Strunk, J.L.; Bell, D.M.; Gregory, M.J. 2022. Pushbroom photogrammetric heights enhance state-level forest attribute mapping with Landsat and environmental gradients. Remote Sensing 14(14): 3433. https://doi.org/10.3390/rs14143433.

ter Braak, C.J.F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology. 67(5): 1167–1179. https://doi.org/10.2307/1938672.

Thorne, J.H.; Choe, H.; Boynton, R.M. [et al.]. 2017. The impact of climate change uncertainty on California's vegetation and adaptation management. Ecosphere. 8(12): e02021. https://doi.org/10.1002/ecs2.2021.

Topik, C. 1989. Plant association and management guide for the grand fir zone: Gifford Pinchot National Forest. Tech. Pap. R6-ECOL-TP-006-88. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 110 p.

Tuxen, R. 1956. Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. Angewandte Pflanzensoziologie. 13: 5–42.

Underwood, E.C.; Viers, J.H.; Klausmeyer, K.R. [et al.]. 2009. Threats and biodiversity in the mediterranean biome. Diversity and Distributions. 15(2): 188–197. https://doi.org/10.1111/j.1472-4642.2008.00518.x.

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region [USDA FS PNW Region]. 2020. Bioregional assessment of northwest forests. 89 p.

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region [USDA FS PNW Region]. [N.d.a]. Ecological departure. Portland, OR. https://www.fs.usda.gov/r06/natural-resources/ecoshare-ecological-departure. (March 31, 2025).

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region [USDA FS PNW Region]. [N.d.b]. Region 6 Ecoshare. Portland, OR. https://www.fs.usda.gov/ecoshare. (March 31, 2025).

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region [USDA FS PNW Region]. [N.d.c]. Region 6 Terrestrial Ecological Unit Inventory (TEUI) data hubsite and portal. https://teui-region6-usfs.hub.arcgis.com/. (March 31, 2025).

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station [USDA FS PNW Research Station]. [N.d.]. Climate change vulnerability assessments. https://research.fs.usda.gov/pnw/products/dataandtools/climate-change-vulnerability-assessments. (August 27, 2025).

U.S. Department of Agriculture, Forest Service, Pacific Southwest Region [USDA Forest Service PSW Region]. [N.d.]. Natural resources, ecology. https://www.fs.usda.gov/r05/natural-resources/ecology. (August 27, 2025).

U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Regional Ecology Group [USDA FS PSW Region, Regional Ecology Group]. 1981. CALVEG: a classification of California vegetation. San Francisco, CA. 168 p.

U.S. Department of Agriculture, Natural Resources and Conservation Service [USDA NRCS]. [N.d.]. USDA PLANTS Database. https://plants.usda.gov/. (March 20, 2025).

U.S. Department of Commerce, Census Bureau and Esri [USDC Census Bureau and Esri]. 2020. State boundaries [Feature layer]. Scale not given. 2020 USA state-level demographics: population density, median age, median household income. https://www.arcgis.com/home/item.html?id=916e1c1d7e4c468aa9164185edfb0e81. (January 13, 2023).

U.S. Department of the Interior, Bureau of Land Management [USDI BLM]. [N.d.]. Land status and cadastral survey records: Willamette meridian—Oregon and Washington states. https://www.blm.gov/or/landrecords/landsurvey/gSrvy1.php. (August 26, 2025).

U.S. Department of the Interior, Fish and Wildlife Service [US FWS]. [N.d.]. National wetlands inventory. https://www.fws.gov/program/national-wetlands-inventory. (August 11, 2023).

U.S. Department of the Interior, U.S. Geological Survey [USGS]. 1992. National land cover database. https://www.usgs.gov/centers/eros/science/national-land-cover-database. (March 31, 2025).

U.S. Department of the Interior, U.S. Geological Survey [USGS]. 2014. 2011 USGS continuous forest cover estimates. https://www.usgs.gov/data/national-land-cover-database-nlcd-2011-land-cover-conterminous-united-states-ver-20-may-2024. (September 26, 2025).

U.S. Department of the Interior, U.S. Geological Survey [USGS]. 2016. Gap Analysis Project/LANDFIRE national terrestrial ecosystems 2011. https://www.usgs.gov/data/gaplandfire-national-terrestrial-ecosystems-2011.

U.S. Department of the Interior, U.S. Geological Survey, Explorer, Science Analytics and Synthesis Program [USGS ESASP] 2025. USNVC (United States National Vegetation Classification) Database. Version 3.0. Washington, DC.

U.S. Department of the Interior, U.S. Geological Survey; U.S. Department of Agriculture, Forest Service [USGS and USDA FS]. [N.d.a]. LANDFIRE. https://landfire.gov/. (March 31, 2025).

U.S. Department of the Interior, U.S. Geological Survey; U.S. Department of Agriculture, Forest Service [USGS and USDA FS]. [N.d.b]. LANDFIRE—Environmental site potential layer, 2.0.0. https://landfire.gov/vegetation/esp. (August 11, 2023).

U.S. Environmental Protection Agency [US EPA]. 2011. Ecoregions [1:3,000,000] [Polygon]. Level III Ecoregions of the Conterminous United States. https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states. (February 22, 2023).

U.S. Environmental Protection Agency [US EPA]. [N.d.]. Level III and IV ecoregions of the continental United States. Ecosystems Research. https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states. (April 7, 2025).

Weaver, H. 1959. Ecological changes in the ponderosa pine forest of the Warm Springs Indian Reservation in Oregon. Journal of Forestry. 57(1): 15–20. https://doi.org/10.1093/jof/57.1.15.

Williams, C.K.; Lillybridge, T.R. 1983. Forested plant associations of the Okanogan National Forest. R6-ECOL-132b-1983. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 116 p.

Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182–198. https://doi.org/10.1016/j.foreco.2012.02.002.

Winthers, E.; Fallon, D.; Haglund, J. [et al.]. 2005. Terrestrial ecological unit inventory technical guide. Gen. Tech. Rep. WO-68. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office, Ecosystem Management Coordination. 254 p. https://doi.org/10.2737/WO-GTR-68.

Wright, C.S.; Agee, J.K. 2004. Fire and vegetation history in the eastern Cascade Mountains, Washington. Ecological Applications. 14(2): 443–459. https://doi.org/10.1890/02-5349.

Yeh, H.Y.; Wensel, L.C. 2000. The relationship between tree diameter growth and climate for coniferous species in northern California. Canadian Journal of Forest Research. 30: 1463–1471. https://doi.org/10.1139/x00-074.

Young, D.J.N.; Stevens, J.T.; Earles, J.M. [et al.]. 2017. Long-term climate and competition explain forest mortality patterns under extreme drought. Ecology Letters. 20(1): 78–86. https://doi.org/10.1111/ele.12711.

Zald, H.S.J.; Ohmann, J.L.; Roberts, H.M. [et al.]. 2014. Influence of LiDAR, Landsat imagery, disturbance history, plot location accuracy, and plot size on accuracy of imputation maps of forest composition and structure. Remote Sensing of Environment. 143: 26–38. https://doi.org/10.1016/j.rse.2013.12.013.

Zavarin, E.; Critchfield, W.B.; Snajberk, K. 1978. Geographic differentiation of monoterpenes from *Abies procera* and *Abies magnifica*. Biochemical Systemics and Ecology. 6(4): 267–278. https://doi.org/10.1016/0305-1978(78)90044-3.

Zerbe, S. 1998. Potential natural vegetation: validity and applicability in landscape planning and nature conservation. Applied Vegetation Science. 1(2): 165–172. https://doi.org/10.2307/1478945.

Zobel, D.B. 1973. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades: needle morphology and periderm color. Botanical Gazette. 134(3): 209–220. https://doi.org/10.1086/336706.

Zobel, D.B. 1974. Local variation in intergrading *Abies grandis-A. concolor* populations in the central Oregon Cascades. II. Stomatal reaction to moisture stress. Botanical Gazette. 135(3): 200–210. https://doi.org/10.1086/336753.

Zobel, D.B. 1975. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades. III. Timing of growth and stomatal characteristics in relation to environment. Botanical Gazette. 136(1): 63–71. https://doi.org/10.1086/336783.

Glossary

ABGRC—a code that represents white fir (*Abies concolor*) and grand fir (*Abies grandis*), either alone or in combination, as well as hybrids and back crosses between the two species.

ABPRSH—a code that represents red fir (*Abies magnifica*), Shasta red fir (*Abies magnifica* var. *shastensis*), and noble fir (*Abies procera*), either alone or in combination.

biophysical environment—the physical, chemical, and biological factors that interact to shape the natural world.

biophysical setting (BpS)—represents the vegetation system that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. It is used as a classification system in LANDFIRE (USGS and USDA FS, n.d.a).

chaparral—vegetation dominated by hard-leaved shrubs (see California Chaparral Institute, n.d.).

Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG)—a classification and mapping system developed for California vegetation types (USDA FS PSW Region, Regional Ecology Group 1981).

ecological amplitude—the limits or range of environmental conditions within which an organism can live and function. It is the degree of adaptation of a living organism to changes in its environment. This ecological amplitude is expressed quantitatively as the range of environmental changes within which a given species can carry on its normal vital activities.

ecology plots—U.S. Department of Agriculture, Forest Service, Pacific Northwest and Pacific Southwest Region ecologists established ecology data plots in the 1970s through early 2000s that were used to create typologies of potential vegetation (plant associations), allowing forest managers to infer site conditions (e.g., topographic, climatic, edaphic) from the existing overstory and understory composition. They developed plant association guides for groups of national forests and adjacent lands across Forest Service, Pacific Northwest and Pacific Southwest Regions.

The ecology plots were not gridded or randomized but placed with as little preconceived bias as possible within relatively undisturbed, mature stands. Within each $^{1}/_{10}$- to $^{1}/_{5}$-acre plot, some variable and some fixed-radius (depending on what area the data were collected in), the goal was to have consistent vegetation composition, aspect, and slope, as well as position on the slope. Ecotones or other variations in the landscape were avoided if possible. Plot locations were selected to avoid disturbance and tended toward fully stocked, mature stands. All vascular plant species (trees, shrubs, herbs, and grasses), as well as cover, were surveyed and documented over the entire plot, with percentage of cover estimated visually. Not all data were collected the same, and precise methods of data collection varied across the project area. For detailed plot data collection information, see the methods section in each plant association guide (app. 1).

ecoregion—an area where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. The framework used in this project is derived from Omernik (1987) and from mapping done in collaboration with Environmental Protection Agency regional offices, other federal agencies, state resource management agencies, and neighboring North American countries. Ecoregions denote areas of similarity in the mosaic of biotic, abiotic, terrestrial, and aquatic ecosystem components with humans being considered as part of the biota (Omernik and Griffith 2014). See figure 2 for map of the level III ecoregions.

existing vegetation—the plant community or floristic composition and vegetation structure occurring at a given location at the current time; the species composition observed at a specific point in time.

extent—the size of your project area and the largest resolvable unit. Extent is the overall size of the landscape or area encompassed by the observation.

forest—The starting point for defining forest comes from the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program: "land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and not currently developed for a nonforest use" (Ohmann et al. 2014). We implemented this definition by starting with the nonforest mask from the Gradient Nearest Neighbor method, i.e., a map layer that excludes urbanized areas, major roads, agricultural areas, water, lands above tree line, snow, rock, and other nonforested features (Davis et al. 2022). We modified the nonforest mask by identifying all 30-m pixels with ≥20-percent tree cover at any point in time in any of a variety of data sources (see "Methods") as forested or woodland types. We also used LiDAR data where it was available and assumed that 30-m pixels with ≥10 percent LiDAR first returns above 3.5 m have currently or previously supported forest and therefore have a forested potential vegetation type.

Forest Inventory and Analysis (FIA)—a program of the U.S. Department of Agriculture, Forest Service that has been in continuous operation since 1930 with a mission to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of, and requirements for, the renewable resources of the forest and rangelands of the U.S."

The FIA program collects, analyzes, and reports information on the status and trends of America's forests: how much forest exists, where it exists, who owns it, and how it is changing, as well as how the trees and other forest vegetation are growing and how much has died or has been removed in recent years. This information can be used in many ways, such as in evaluating wildlife habitat conditions, assessing the sustainability of ecosystem management practices, and supporting planning and decision-making activities undertaken by public and private enterprises.

Gradient Nearest Neighbor method (GNN)—Nearest neighbor imputation methods have proven to be an effective tool for characterizing vegetation structure and species composition in forested landscapes across large regions. Nearest neighbor models are particularly well suited for creating detailed vegetation maps for a variety of reasons: they produce spatially explicit maps over large areas spanning all ownerships and land uses, they describe multiple attributes of composition and structure, and they maintain covariance among vegetation components (when $k = 1$); and the maps retain the range of variability present in the reference data used to develop the map (LEMMA, n.d.).

grain—the size of your pixel and the smallest resolvable unit. The spatial grain of the landscape is the smallest resolution of the data.

indicator species—an organism whose presence, absence, or abundance reflects a specific environmental condition, in this case, a plant species that serves as a measure of the environmental conditions that exist in a given locale.

LANDFIRE—a program that provides ≥25 national geospatial layers (e.g., vegetation, fuel, disturbance, etc.), databases, and ecological models that are available to the public for the United States and insular areas. LANDFIRE uses biophysical setting to depict reference conditions of vegetation across landscapes.

Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA)—an informal team composed of employees of the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station and Oregon State University (OSU), Department of Forest Ecosystems and Society (LEMMA, n.d.).

map zone—(e.g., map zones 2, 7, 8, 9) specific, delineated geographical areas within the Pacific Northwest used to structure the modeling and mapping of ecological systems (land cover) (LEMMA, n.d.).

Parameter-elevation Regressions on Independent Slopes Model (PRISM)—The PRISM Climate Group gathers climate observations from a wide range of monitoring networks, applies sophisticated quality-control measures, and develops spatial climate datasets to reveal short- and long-term climate patterns. The resulting datasets incorporate a variety of modeling techniques and are available at multiple spatial and temporal resolutions, covering the period from 1895 to the present (PRISM Climate Group 2025).

parklands—vegetated areas above the elevation of continuous forest. Trees (e.g., mountain hemlock, subalpine fir) may or may not be present.

plant association—a grouping of plant species, or a plant community, that recurs across the landscape. Plant associations are used as indicators of environmental conditions, such as elevation and aspect.

plant association group (PAG)—five to ten closely related plant associations or groupings of plant species that occur together in similar environments. These environments are typically defined by their climates (temperature and moisture); soils; and history of natural disturbances, such as wildfires, diseases, and insect outbreaks. Plant associations vary from tens to hundreds of acres in size. Plant association groups typically occur over hundreds to thousands of acres. Thus, PAGs provide a general picture of major vegetation patterns across a forest or landscape.

potential natural vegetation (PNV)—the vegetation that would be expected given environmental constraints (climate, geomorphology, geology) without human intervention or a hazard event. The vegetation that would be present under climax conditions, if the site were allowed to grow undisturbed by fire, insects, diseases, flood, wind, erosion, or humans.

> **disturbance-constrained PNV—**land delineations based on the geographic area, physical setting, and vegetation community that can occupy the setting. Physical characteristics include climate, geology, geomorphology, and soils. Vegetation includes the area's native species and associated successional stages, determined according to our best understanding of the historical or natural range of variation, including disturbances. In ecology, potential natural vegetation (see above) is the vegetation that would be expected given environmental constraints (climate, geomorphology, geology) and includes disturbances.
>
> **environment-constrained PNV—**In ecology, potential natural vegetation (see above) is the vegetation that would be expected given environmental constraints (climate, geomorphology, geology) without human intervention or a hazard event.

scale—the relationship between a distance on a map and the corresponding distance on the Earth; or the degree of resolution at which ecological processes, structures, and changes across space and time are observed and measured; or the proportion that defines the relationship of a map, image, or photograph to that which it represents, such as distance on the ground.

series—a vegetation designation based on the dominant, most shade-tolerant, regenerating tree species on the site using the concept of potential natural vegetation (the vegetation that would be present under climax conditions).

subzone—similar to plant association group but overall, a larger grouping and used in developing our potential natural vegetation map.

U.S. National Vegetation Classification Standard (USNVCS)—a consistent national approach to the classification of existing vegetation. It is intended to facilitate collaboration between state and federal agencies engaged in the collection of vegetation data and to support vegetation map consistency. USNVCS is a hierarchical system designed to classify existing vegetation (i.e., plant cover, floristic composition, and vegetation structure occurring in a specific place at a specific time) based on both physiognomic and floristic criteria.

vegzone—synonymous with series; the broadest vegetation classification, based on the dominant, most shade-tolerant (regenerating) tree species and used in developing our potential natural vegetation map.

woodland—a lower density forest. Differences between forest and woodland can be low conifer and/or hardwood percentage of cover.

Appendix 1: Plant Association and Ecological Type Guides and Example of Variable Thresholds and Criteria for Series/Vegzone Assignment

This appendix includes references for the plant association and ecological type guides for the U.S. Department of Agriculture, Forest Service, Pacific Southwest Region—California—and Pacific Northwest Region—Washington and Oregon. Table A1.1 following the references is an example showing how each region (from select plant association/ecological guides) used different percentage of cover thresholds to get to the same series/vegzone.

Adamson, B. 1988. Ecological type classification for California: mixed conifer of the Trinity ultramafic sheet; Zone 3.

Alexander, R.R. 1988. Forest vegetation on national forests in the Rocky Mountain and Intermountain Regions: habitat types and community types. Gen. Tech. Rep. RM-GTR-162. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 47 p. https://doi.org/10.5962/bhl.title.99935.

Allen, B.H. 1987. Ecological type classification for California: the Forest Service approach. Gen. Tech. Rep. PSW-GTR-98. Berkeley CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 8 p. https://doi.org/10.2737/PSW-GTR-98.

Atzet, T.; White, D.E.; McCrimmon, L.A. [et al.], tech. coords. 1996. Field guide to the forested plant associations of southwestern Oregon. Tech. Pap. R6-NR-ECOL-TP-17-96. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Bell, D.M.; Gregory, M.J.; Ohmann, J.L. 2015. Imputed forest structure uncertainty varies across elevational and longitudinal gradients in the western Cascade Mountains, Oregon, USA. Forest Ecology and Management 358:154-164. https://doi.org/10.1016/j.foreco.2015.09.007.

Benson, G. 1988. Westside mixed conifer ecosystems—Plumas, Lassen, and Tahoe National Forests; Zone 4.

Borchert, M.I.; Cunha, N.D.; Kross, P.C.; Lawrence, M.L. 1993. Blue oak plant communities of southern San Luis Obispo and northern Santa Barbara Counties, California. Gen. Tech. Rep. PSW-GTR-139. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 49 p. https://doi.org/10.2737/PSW-GTR-139.

Borchert, M.; Lopez, A.; Bauer, C.; Knowd, T. 2004. Field guide to coastal sage scrub and chaparral alliances of Los Padres National Forest. Tech. Pap. R5-TP-019. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Borchert, M.; Segotta, D.; Purser, M.D. 1988. Coast redwood ecological types of southern Monterey County, California. Gen. Tech. Rep. PSW-GTR-107. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 27 p. https://doi.org/10.2737/PSW-GTR-107.

Brockway, D.G.; Topik, C.; Hemstrom, M.A.; Emmingham, W.H. 1983. Plant association and management guide for the Pacific silver fir zone, Gifford Pinchot National Forest. Misc. Pub. R6-ECOL-130A-1983. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 122 p.

Burrill, E.A.; Christensen, G.A.; Conkling, B.L. [et al.]. 2024. Forest Inventory and Analysis database user guide: database description and user guide for phase 2 (version 9.1). U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. https://research.fs.usda.gov/sites/default/files/2023-11/wo-fiadb_user_guide_p2_9-1_final.pdf. (August 27, 2025).

Chappell, C.B. 2006. Upland plant associations of the Puget Trough ecoregion, Washington. Natural Heritage Rep. 2006-01. Olympia, WA: Washington Department of Natural Resources, Natural Heritage Program. 143 p.

Christy, J.A.; Kagen, J.S.; Wiedemann, A.M. 1986. Plant associations of the Oregon Dunes National Recreation Area. Tech. Rep. R6-NR-ECOL-TP-09-98. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 183 p.

Clausnitzer, R.R.; Zamora, B.A. 1987. Forest habitat types of the Colville Indian Reservation. Publ. No. MISC0110. Pullman, WA: Washington State University, Agriculture Research Center. 110 p.

Cole, D.N. 1982. Vegetation of two drainages in Eagle Cap Wilderness, Wallowa Mountains, Oregon. Res. Pap. INT-288. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 42 p.

Cooper, S.V.; Neiman, K.E.; Roberts, D.W. 1991. Forest habitat types of northern Idaho: a second approximation. Gen. Tech. Rep. INT-GTR-236. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 143 p. https://doi.org/10.2737/INT-GTR-236.

Crowe, E.A.; Clausnitzer, R.R. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman National Forests. Tech. Pap. R6-NR-ECOL-TP-22-97. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 299 p.

Daubenmire, R.F. 1970. Steppe vegetation of Washington. Tech. Bull. 62. Pullman, WA: Washington State University, Washington Agriculture Experiment Station. 131 p.

Daubenmire, R.; Daubenmire, J.B. 1968. Forest Vegetation of eastern Washington and northern Idaho. Tech. Bull. 60. Pullman, WA: Washington State University, Washington Agriculture Experiment Station. 104 p.

Diaz, N.M.; High, C.T.; Mellen, T.K.; Smith, D.E.; Topik, C. 1997. Plant association and management guide for the mountain hemlock zone, Gifford Pinchot and Mt. Hood National Forests. Tech. Pap. R6-MTH-GP-TP-08-95. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 101 p.

Diaz, N.M.; Mellen, T.K. 1996. Riparian ecological types, Gifford Pinchot and Mt. Hood National Forests, Columbia River Gorge National Scenic Area. Tech. Pap. R6-NR-TP-10-96. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 203 p.

Driscoll, R.S. 1964. Vegetation-soil units in the central Oregon juniper zone. Res. Pap. PNW-RP-19. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 60 p. https://doi.org/10.5962/bhl.title.87971.

Dyrness, C.T.; Franklin, J.F.; Moir, W.H. 1974. A preliminary classification of forest communities in the central portion of the western Cascades in Oregon. Coniferous Forest Biome Bull. 4. Seattle, WA: Coniferous Forest Biome, Ecosystem Analysis Studies, United States/International Biological Program. 123 p.

Eyre, F.H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Fites, J. 1993. Ecological guide to mixed conifer plant associations northern Sierra Nevada and southern Cascades: Lassen, Plumas, Tahoe, and Eldorado National Forests. Tech. Pap. R5-ECOL-TP-001. Placerville, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Franklin, J.F.; Moir, W.H.; Hemstrom, M.A.; Greene, S.E.; Smith, B.G. 1988. The forest communities of Mount Rainier National Park. Scientific Monograph Series No. 19. Washington, DC: U.S. Department of the Interior, National Park Service. 194 p.

Gordon, H.; White, T.C. 1994. Ecological guide to southern California chaparral plant series, Transverse and Peninsular Ranges: Angeles, Cleveland, and San Bernardino National Forests. Tech. Pap. R5-ECOL-TP-005. San Diego, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. R6 Area Guide AG 3-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 62 p. https://doi.org/10.5962/bhl.title.107481.

Hall, F.C. 1998. Pacific Northwest ecoclass codes for seral and potential natural communities. Gen. Tech. Rep. PNW-GTR-418. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, and Pacific Northwest Region. 290 p. https://doi.org/10.2737/PNW-GTR-418.

Halverson, N.M., comp. 1986. Major indicator shrubs and herbs on national forests of western Oregon and southwestern Washington. R6-TM-229-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Halverson, N.M.; Topik, C.; VanVickle, R. 1986. Plant association and management guide for the western hemlock zone: Mt. Hood National Forest. R6-ECOL-232A-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 111 p.

Hemstrom, M.A.; Emmingham, W.H.; Halverson, N.M.; Logan, S.E.; Topik, C. 1982. Plant association and management guide for the Pacific silver fir zone, Mt. Hood and Willamette National Forests. R6-ECOL-100-1982a. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 104 p.

Hemstrom, M.A.; Logan, S.E. 1986. Plant association and management guide, Siuslaw National Forest. R6-ECOL-220-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 121 p.

Hemstrom, M.A.; Logan, S.E.; Pavlat, W. 1986. Plant association and management guide, Willamette National Forest. R6-ECOL-257-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 312 p.

Henderson, J.A.; Lesher, R.D.; Peter, D.H.; Shaw, D.C. 1992. Field guide to the forested plant associations of the Mt. Baker-Snoqualmie National Forest. Tech. Pap. R6-ECOL-TP-028-91. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 196 p.

Henderson, J.A.; Peter, D.H.; Lesher, R.D.; Shaw, D.C. 1988. Forested plant associations of the Olympic National Forest. Tech. Pap. R6-ECOL-TP-001-88. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 502 p.

Hironaka, M.; Fosberg, M.A.; Winward, A.H. 1983. Sagebrush-grass habitat types of southern Idaho. Bull. No. 35. Moscow, ID: University of Idaho, Wildlife and Range Experiment Station. 44 p.

Hopkins, W.E. 1979. Plant associations of south Chiloquin and Klamath Ranger Districts, Winema National Forest. R6-ECOL-79-005. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 96 p.

Hopkins, W.E. 1979. Plant associations of the Fremont National Forest. R6-ECOL-79-004. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 106 p.

Hopkins, W.E.; Kovalchik, B.L. 1983. Plant associations of the Crooked River National Grassland, Ochoco National Forest. R6-ECOL-133-1983. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 98 p. https://doi.org/10.5962/bhl.title.149888.

Hopkins, W.E.; Rawlings, R.C. 1985. Major indicator shrubs and herbs on national forests of eastern Oregon. R6-TM-190-1985. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Jimerson, T.M. 1994. A field guide to Port-Orford-cedar plant associations in northern California. Tech. Pap. R5-ECOL-TP-002. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 109 p. https://doi.org/10.5962/bhl.title.149782.

Jimerson, T.M.; Hoover, L.D.; McGee, E.A. [et al.]. 1995. A field guide to serpentine plant associations and sensitive plants in northwestern California. Tech. Pap. R5-ECOL-TP-006. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Jimerson, T.M.; McGee, E.A.; Jones, D.W. [et al.]. 1996. A field guide to the tanoak and the Douglas-fir plant associations in northwestern California. Tech. Pap. R5-ECOL-TP-009. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Johnson, C.G., Jr. 2004. Alpine and subalpine vegetation of the Wallowa, Seven Devils, and Blue Mountains. Tech. Pap. R6-NR-ECOL-TP-03-04. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 611 p. + app.

Johnson, C.G., Jr.; Clausnitzer, R.R. 1992. Plant associations of the Blue and Ochoco Mountains. Tech. Pap. R6-ERW-TP-036-92. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 164 p. + app.

Johnson, C.G., Jr.; Simon, S.A. 1987. Plant associations of the Wallowa-Snake Province, Wallowa-Whitman National Forest. Tech. Pap. R6-ECOL-TP-255A-86. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 399 p.

Kovalchik, B.L. 1987. Riparian zone associations, Deschutes, Ochoco, Fremont, and Winema National Forests. Tech. Pap. R6-ECOL-TP-279-87. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 171 p.

Kovalchik, B.L.; Clausnitzer R.R. 2004. Classification and management of aquatic, riparian, and wetland sites on the national forests of eastern Washington: series description. Gen. Tech. Rep. PNW-GTR-593. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 354 p. https://doi.org/10.2737/PNW-GTR-593.

Kovalchik, B.L.; Hopkins, W.E.; Brunsfeld, S.J. 1988. Major indicator shrubs and herbs in riparian zones on national forests of central Oregon. Tech. Pap. R6-ECOL-TP-005-88. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Lillybridge, T.R.; Kovalchik, B.L.; Williams, C.K.; Smith, B.G. 1995. Field guide for forested plant associations of the Wenatchee National Forest. Gen. Tech. Rep. PNW-GTR-359. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 335 p. https://doi.org/10.2737/PNW-GTR-359.

Mahoney, T.M.; Stuart, J.D. 2000. Old-growth forest associations in the northern range of coastal redwood. Madrona. 47(1): 53–60.

Mahoney, T.M.; Stuart, J.D. 2007. Status of vegetation classification in redwood ecosystems. In: Standiford, R.B.; Giusti, G.A.; Valachovic, Y.; Zielinski, W.J.; Furniss, M.J., tech. eds. Proceedings of the redwood region forest science symposium: What does the future hold? Gen. Tech. Rep. PSW-GTR-194. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region: 207–214.

Manning, M.E.; Padgett, W.G. 1995. Riparian community type classification for Humboldt and Toiyabe National Forests, Nevada and eastern California. R4-ECOL-95-01. U.S. Department of Agriculture, Forest Service.

Marsh, F.; Helliwell, R.; Rodgers, J. 1987. Plant associations of the commercial forest of the Warm Springs Indian Reservation. Warm Springs, OR: Warm Springs Indian Reservation. 142 p.

McCain, C.; Diaz, N. 2002. Field guide to the forested plant associations of the westside central Cascades of northwest Oregon. Tech. Pap. R6-NR-ECOL-TP-02-02. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 403 p.

McCain, C.; Diaz, N. 2002. Field guide to the forested plant associations of the northern Oregon Coast Range. Tech. Pap. R6-NR-ECOL-TP-03-02. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 218 p. + app.

McCain, C.; Halpern, C.B.; Lovtang, S. 2014. Non-forested plant communities of the northern Oregon Cascades. Gen. Tech. Rep. PNW-GTR-R6-ECOL-TP-01-14. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 273 p. + app.

Meyer, M.D.; North, M.P. 2019. Natural range of variation of red fir and subalpine forests in the Sierra Nevada bioregion. Gen. Tech. Rep. PSW-GTR-263. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 135 p. https://doi.org/10.2737/PSW-GTR-263.

Miles, P.D.; Brand, G.J.; Alerich, C.L. [et al.]. 2001. The forest inventory and analysis database description and user's manual version 1.0. Gen. Tech. Rep. NC-GTR-218. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 130 p. https://doi.org/10.2737/NC-GTR-218.

Mueggler, W.F. 1988. Aspen community types of the Intermountain Region. INT-GTR-250. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 134 p. https://doi.org/10.5962/bhl.title.100147.

Pinto, C. 1972. The Oregon Dunes NRA resource inventory, Siuslaw National Forest. Unpublished report. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 294 p. https://archive.org/details/CAT81757533/page/n3/mode/2up. (August 27, 2025).

Potter, D.A. 1994. Guide to forested communities of the upper montane in the central and southern Sierra Nevada. R5-ECOL-TP-003. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Potter, D.A. 1998. Forested communities of the upper montane in the central and southern Sierra Nevada. Gen. Tech. Rep. PSW-GTR-169. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 319 p. https://doi.org/10.2737/PSW-GTR-169.

Potter, D.A. 2005. Riparian plant community classification: west slope, central and southern Sierra Nevada, California. Tech. Pap. R5-TP-022. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 640 p.

Safford, H.D.; Stevens, J.T. 2017. Natural range of variation for yellow pine and mixed-conifer forests in the Sierra Nevada, southern Cascades, Modoc, and Inyo National Forests, California, USA. Gen. Tech. Rep. PSW-GTR-256. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 229 p. https://doi.org/10.2737/PSW-GTR-256.

Seda, A.; Atzet, T.; Wheeler, D. 1997. Key species for plant associations on the Rogue River, Siskiyou, and Umpqua National Forests. Tech. Pap. R6-NR-ECOL-TP-026-97. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Simpson, M. 2007. Forested plant associations of the Oregon East Cascades. Tech. Pap. R6-NR-ECOL-TP-03-2007. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 515 p. + app.

Smith, S. 1994. Ecological guide to eastside pine plant associations, northeastern California: Modoc, Lassen, Klamath, Shasta-Trinity, Plumas, and Tahoe National Forests. Tech. Pap. R5-ECOL-TP-004. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 174 p.

Steele, R.; Cooper, S.V.; Ondov, D.M.; Roberts, D.W.; Pfister, R.D. 1983. Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-GTR-144. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experimental Station. 122 p. https://doi.org/10.2737/INT-GTR-144.

Steele, R.; Pfister, R.D.; Ryker, R.A.; Kittams, J.A. 1981. Forest habitat types of central Idaho. Gen. Tech. Rep. INT-GTR-114. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experimental Station. 138 p. https://doi.org/10.2737/INT-GTR-114.

Swanson, D.K.; Schmitt, C.L.; Shirley, D.M. [et al.]. 2010. Aspen biology, community classification, and management in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-806. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 117 p. https://doi.org/10.2737/PNW-GTR-806.

Tisdale, E.W. 1986. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. Bull. No. 40. Moscow, ID: University of Idaho, Wildlife and Range Experiment Station. 42 p.

Topik, C. 1988. Plant association and management guide for the grand fir zone, Gifford Pinchot National Forest. R6-ECOL-TP-006-88. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 110 p.

Topik, C.; Halverson, N.M.; Brockway, D.G. 1986. Plant association and management guide for the western hemlock zone, Gifford Pinchot National Forest. R6-ECOL-230A-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 133 p.

Topik, C.; Halverson, N.M.; High, T. 1988. Plant association and management guide for the ponderosa pine, Douglas-fir, and grand fir zones, Mt. Hood National Forest. Tech. Pap. R6-NR-ECOL-TP-004-88. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 136 p.

U.S. Department of Agriculture, Forest Service. 1992. Timber management information system handbook. FSH 2409.14. Amend. 2409.14-92-15. Washington, DC.

Volland, L.A. 1985. Plant associations of the central Oregon pumice zone. R6-ECOL-104-1985. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 138 p.

Weixelman, D.A; Zumudio, D.C.; Zamudio, K.A. 1999. Eastern Sierra Nevada riparian field guide. R4-ECOL-99-01. U.S. Department of Agriculture, Forest Service, Intermountain Region.

Wells, A.F. 2006. Deep canyon and subalpine riparian and wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman National Forests. Gen. Tech. Rep. PNW-GTR-682. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 277 p. https://doi.org/10.2737/PNW-GTR-682.

West, N.E.; Tausch, R.J.; Tueller, P.T. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. Gen. Tech. Rep. RMRS-GTR-12. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 42 p. https://doi.org/10.2737/RMRS-GTR-12.

Williams, C.K.; Kelley, B.F.; Smith, B.G.; Lillybridge, T.R. 1995. Forested plant associations of the Colville National Forest. Gen. Tech. Rep. PNW-GTR-360. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 375 p. https://doi.org/10.2737/PNW-GTR-360.

Williams, C.K.; Lillybridge, T.R. 1983. Forested plant associations of the Okanogan National Forest. R6-ECOL-132b-1983. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 116 p.

Zamora, B.A. 1983. Forest habitat types of the Spokane Indian Reservation. Res. Bull. XB-0936. Pullman, WA: Washington State University, Agriculture Resource Center. 65 p.

Table A1.1—Example applications of different percentage-of-cover thresholds used to obtain the same vegzone (or series) assignments by region

	Plant association guide (region)							
Series	*Field Guide to the Forested Plant Associations of the Mt. Baker-Snoqualmie National Forest* (western Washington)	*Forested Plant Associations of the Okanogan National Forest* (eastern Washington)	*Field Guide to the Forested Plant Associations of the Westside Central Cascades of Northwest Oregon* (northwestern Oregon)	*Field Guide to the Forested Plant Associations of Southwestern Oregon* (southwestern Oregon)	*Forested Plant Associations of the Oregon East Cascades* (central Oregon)	*Plant Associations of the Blue and Ochoco Mountains* (northeastern Oregon)	*Ecological Guide to Mixed Conifer Plant Associations* (California—northern Sierra Nevada, southern Cascades)	*A Field Guide to the Tanoak and the Douglas-Fir Plant Associations in Northwestern California* (northwestern California)
Mountain hemlock	Mountain hemlock ≥10 percent cover	N/a	Mountain hemlock ≥20 percent canopy cover or ≥2 percent in regeneration layer	Mountain hemlock is the dominant regenerating species	Mountain hemlock ≥10 percent cover	N/a	Mountain hemlock dominates regeneration layer	Mountain hemlock >10 percent cover and the primary regenerating species
Western hemlock	Western hemlock ≥10 percent cover	N/a	Western hemlock is the most abundant regenerating species	Western hemlock is the dominant regenerating species	Western hemlock ≥10 percent cover, western redcedar ≥10 percent cover	N/a	N/a	N/a
White fir-grand fir	N/a	N/a	Grand fir regeneration at least as abundant as Douglas-fir or western hemlock, and species indicating dry sites present	White fir is the dominant regenerating species	White fir ≥10 percent cover	Grand fir present and reproducing with total coverage ≥10 percent	White fir dominates regeneration layer; incense cedar regeneration <2 percent	White fir >20 percent cover and primary regenerating species
Douglas-fir	N/a	Douglas-fir, western larch, or ponderosa pine, separately or in combination, sufficiently abundant to have 10 or more trees per acre	Douglas-fir and incense cedar regeneration more abundant than western hemlock regeneration	Douglas-fir is the dominant regenerating species	Douglas-fir ≥10 percent cover	Douglas-fir present and reproducing with total coverage ≥10 percent	Douglas-fir dominates regeneration layer; regeneration of other species (white fir, incense cedar, ponderosa pine, Jeffrey pine) <2 percent	Douglas-fir dominant in the overstory and reproducing successfully
Ponderosa pine	N/a	N/a	N/a	Ponderosa pine is the dominant regenerating species	Ponderosa pine ≥10 percent cover	Ponderosa pine present and reproducing with total coverage ≥10 percent	Ponderosa pine or Jeffrey pine dominate regeneration layer	N/a

N/a = not applicable.

Sources: southwestern Oregon (Atzet et al. 1996), northern Sierra Nevada and southern Cascade Range (Fites 1993), western Washington (Henderson et al. 1992), northwestern California (Jimerson et al. 1996), northeastern Oregon (Johnson and Clausnitzer 1992), northwestern Oregon (McCain and Diaz 2002), central Oregon (Simpson 2007), eastern Washington (Williams and Lillybridge 1983).

Appendix 2: Potential Natural Vegetation Crosswalk of Vegzones and Associated Subzones

Climate-constrained potential natural vegetation (PNV) can be crosswalked to disturbance-constrained PNV, such as LANDFIRE.

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
1	Developed	–1	Developed	–	–	–	–
2	Water	–2	Water	–	–	–	–
3	Rock	–3	Rock	–	–	–	–
4	Grasslands-meadows	–9	Wet meadow	–	3, 4, 6	11370	Mediterranean California subalpine meadow
4	Grasslands-meadows	–9	Wet meadow	–	7, 8, 9, 10	11600	Rocky Mountain subalpine/upper montane riparian systems
4	Grasslands-meadows	–8	Moist meadow	–	3, 4, 6	11370	Mediterranean California subalpine meadow
4	Grasslands-meadows	–8	Moist meadow	–	7, 8, 9, 10,	11450	Rocky Mountain subalpine-montane mesic meadow
4	Grasslands-meadows	–7	Dry meadow	–	1, 3, 5, 7	11380	North Pacific montane grassland
4	Grasslands-meadows	–6	Upland grass	–	8, 9, 10	11420	Columbia Basin Palouse prairie
4	Grasslands-meadows	–5	Scabland grass	–	7, 8, 9	10650	Columbia Plateau scabland shrubland
5	Shrublands	–17	Creosote-bursage scrub	–	13	10870	Sonora-Mojave creosotebush-white bursage desert scrub
5	Shrublands	–16	Desert scrub	–	12, 13	10820	Mojave mid-elevation mixed desert scrub
5	Shrublands	–15	Coastal scrub	–	3, 4	11280	Northern California coastal scrub
5	Shrublands	–14	Chaparral	–	3, 6, 7	11050	Northern and Central California dry-mesic chaparral
5	Shrublands	–13	Montane shrub	–	8, 9, 10	11060	Northern Rocky Mountain montane-foothill deciduous shrubland
5	Shrublands	–12	Upland shrub	–	7, 8, 9, 12	11260	Inter-mountain basins montane sagebrush steppe
5	Shrublands	–11	Scabland shrub	–	1, 7, 8, 9, 10, 12	10650	Columbia Plateau scabland shrubland
5	Shrublands	–10	Salt desert shrub	–	8, 9. 10, 12	11530	Inter-mountain basins greasewood flat
6	Pinyon-juniper-cypress	21	Juniper scablands	–	2, 7, 8, 9, 10	11150	Inter-mountain basins juniper savanna
6	Pinyon-juniper-cypress	22	Juniper woodlands	–	6, 7, 8, 9, 10, 12, 18	10170	Columbia Plateau western juniper woodland and savanna

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
6	Pinyon-juniper-cypress	22	Juniper woodlands	–	2, 3	10210	Klamath-Siskiyou lower montane serpentine mixed conifer woodland
6	Pinyon-juniper-cypress	23	Pinyon woodlands	–	6, 12	10190	Great Basin pinyon-juniper woodland
6	Pinyon-juniper-cypress	24	Cypress woodlands	–	3, 4, 7	11770	California coastal closed-cone conifer forest and woodland
7	California foothill pine-Coulter pine	35	Coulter pine-oak	–	4	11770	California coastal closed-cone conifer forest and woodland
7	California foothill pine-Coulter pine	36	California foothill pine-oak	–	2, 3, 4, 5, 6, 7	11140	California lower montane blue oak-California foothill pine woodland and savanna
8	Lodgepole pine	25	Lodgepole pine/cool-dry	Excludes 77	1, 2, 3	10360	North Pacific hypermaritime Sitka spruce forest
8	Lodgepole pine	25	Lodgepole pine/cool-dry	Excludes 7701–7705	1	10412	North Pacific mountain hemlock forest-xeric
8	Lodgepole pine	25	Lodgepole pine/cool-dry	7701, 7702, 7703, 7704, 7705	1	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
8	Lodgepole pine	25	Lodgepole pine/cool-dry	–	8, 9, 10	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
8	Lodgepole pine	25	Lodgepole pine/cool-dry	–	7	10580	Sierra Nevada subalpine lodgepole pine forest and woodland
8	Lodgepole pine	27	Lodgepole pine wetlands	–	7, 8, 9	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
8	Lodgepole pine	27	Lodgepole pine wetlands	–	1 ,2, 7	11570	North Pacific swamp systems
8	Monterey pine-bishop pine	29	Monterey pine-bishop pine	–	3, 4	11770	California coastal closed-cone conifer forest and woodland
9	Sitka spruce	46	Sitka spruce/wet	–	1, 2, 3, 7	10360	North Pacific hypermaritime Sitka spruce forest
9	Sitka spruce	47	Sitka spruce/very wet	–	1, 2, 3, 7	10360	North Pacific hypermaritime Sitka spruce forest
10	Ponderosa pine	30	Ponderosa pine-juniper woodlands	–	2, 3, 10	10531	Northern Rocky Mountain ponderosa pine woodland and savanna-mesic
10	Ponderosa pine	30	Ponderosa pine-juniper woodlands	–	1, 7, 8, 9	10532	Northern Rocky Mountain ponderosa pine woodland and savanna-xeric
10	Ponderosa pine	31	Ponderosa pine/warm-xeric	–	1, 2, 3, 6, 7, 8, 9, 10	10531	Northern Rocky Mountain ponderosa pine woodland and savanna-mesic

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
10	Ponderosa pine	33	Ponderosa pine-lodgepole pine	–	7, 9	10532	Northern Rocky Mountain ponderosa pine woodland and savanna-xeric
10	Ponderosa pine	34	Ponderosa pine-oak	–	2, 3, 6	10300	Mediterranean California lower montane black oak-conifer forest and woodland
10	Ponderosa pine	34	Ponderosa pine-oak	–	1, 7, 8, 9	10600	East Cascades oak-ponderosa pine forest and woodland
11	Hardwoods	15	Riparian shrub	–	3 ,4, 5, 6	11520	California montane riparian systems
11	Hardwoods	15	Riparian shrub	–	8, 9, 10, 12, 18	11540	Inter-mountain basins montane riparian systems
11	Hardwoods	15	Riparian shrub	–	1, 2, 7	11582	North Pacific montane riparian woodland and shrubland-dry
11	Hardwoods	16	Riparian hardwood forest	–	3, 4, 5, 6	11520	California montane riparian systems
11	Hardwoods	16	Riparian hardwood forest	–	1, 2, 7	11560	North Pacific lowland riparian forest and shrubland
11	Hardwoods	16	Riparian hardwood forest	–	8, 9, 10	11590	Rocky Mountain montane riparian systems
11	Hardwoods	17	Other hardwoods	–	2, 3, 4, 5, 6, 7	11130	California coastal live oak woodland and savanna
11	Hardwoods	18	Oak woodlands	–	1, 2, 8	10080	North Pacific oak woodland
11	Hardwoods	18	Oak woodlands	–	3, 4, 5, 6, 7, 9	10290	Mediterranean California mixed oak woodland
11	Hardwoods	19	Desert hardwoods	–	13	11090	Sonoran paloverde-mixed cacti desert scrub
12	Jeffrey Pine	37	Jeffrey pine/warm-xeric	–	2, 3	10210	Klamath-Siskiyou lower montane serpentine mixed conifer woodland
12	Jeffrey Pine	37	Jeffrey pine/warm-xeric	4, 78	7	10210	Klamath-Siskiyou lower montane serpentine mixed conifer woodland
12	Jeffrey Pine	37	Jeffrey pine/warm-xeric	–	4, 6, 9, 12	10310	California montane Jeffrey pine (-ponderosa pine) woodland
12	Jeffrey Pine	37	Jeffrey pine/warm-xeric	Excludes 4, 78	7	10310	California montane Jeffrey pine (-ponderosa pine) woodland
12	Jeffrey Pine	38	Jeffrey pine/warm-dry	–	2, 3, 7	10220	Klamath-Siskiyou upper montane serpentine mixed conifer woodland
12	Jeffrey pine-knobcone pine	39	Knobcone pine	–	2, 3, 7	10220	Klamath-Siskiyou upper montane serpentine mixed conifer woodland

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
13	Port Orford cedar	79	Port Orford cedar	–	2, 3, 7	10210	Klamath-Siskiyou lower montane serpentine mixed conifer woodland
14	Douglas-fir	40	Bigcone Douglas-fir	–	4	10270	Mediterranean California dry-mesic mixed conifer forest and woodland
14	Douglas-fir	41	Douglas-fir/very warm-dry	78, 107, 108, 109	2, 3, 7	10270	Mediterranean California dry-mesic mixed conifer forest and woodland
14	Douglas-fir	41	Douglas-fir/very warm-dry	Except for 78, 107, 108, 109	2, 3, 7	10350	North Pacific dry Douglas-fir forest and woodland
14	Douglas-fir	41	Douglas-fir/very warm-dry	Except 78	1, 7, 8, 9, 10	10450	Northern Rocky mountain dry-mesic montane mixed conifer forest
14	Douglas-fir	42	Douglas-fir/warm-dry	–	2, 3, 6, 7	10270	Mediterranean California dry-mesic mixed conifer forest and woodland
14	Douglas-fir	42	Douglas-fir/warm-dry	1, 2, 3, 4	1	10350	North Pacific dry Douglas-fir forest and woodland
14	Douglas-fir	42	Douglas-fir/warm-dry	9, 10, 77	1	10450	Northern Rocky mountain dry-mesic montane mixed conifer forest
14	Douglas-fir	42	Douglas-fir/warm-dry	–	8, 9, 10	10450	Northern Rocky mountain dry-mesic montane mixed conifer forest
14	Douglas-fir	43	Douglas-fir/very warm-moist	78	2, 3, 7	10280	Mediterranean California mesic mixed conifer forest and woodland
14	Douglas-fir	43	Douglas-fir/very warm-moist	Except 78	1, 2, 7	10350	North Pacific dry Douglas-fir forest and woodland
14	Douglas-fir	43	Douglas-fir/very warm-moist	–	8, 9, 10	10470	Northern Rocky mountain mesic montane mixed conifer forest
15	Tanoak	51	Tanoak/very moist	–	2, 3, 6, 7	10431	Mediterranean California mixed evergreen forest-interior
15	Tanoak	52	Tanoak/very wet	–	2, 3, 6, 7	10432	Mediterranean California mixed evergreen forest-coastal
16	Giant sequoia	54	Giant sequoia	–	6	10280	Mediterranean California mesic mixed conifer forest and woodland
17	Redwood	48	Redwood/very moist	–	2, 3, 4	10432	Mediterranean California mixed-evergreen forest-coastal
17	Redwood	49	Redwood/wet	–	2, 3, 4	10432	Mediterranean California mixed-evergreen forest-coastal

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
18	Western redcedar	76	Western redcedar/ mild	–	1, 7, 8, 10	10180	East Cascades mesic montane mixed-conifer forest and woodland
18	Western redcedar	77	Western redcedar/ cool	–	1, 8, 10	10472	Northern Rocky mountain mesic montane mixed conifer forest-cedar groves
19	Western hemlock	82	Western hemlock/ moist	–	1, 2, 3, 7, 8	10370	North Pacific maritime dry-mesic Douglas-fir-western hemlock forest
19	Western hemlock	82	Western hemlock/ moist	–	10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
19	Western hemlock	83	Western hemlock/very moist	–	1, 2, 3, 7, 8	10370	North Pacific maritime dry-mesic Douglas-fir-western hemlock forest
19	Western hemlock	83	Western hemlock/very moist	–	10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
19	Western hemlock	84	Western hemlock/wet	–	1, 2, 3, 7	10390	North Pacific maritime mesic-wet Douglas-fir-western hemlock forest
19	Western hemlock	84	Western hemlock/wet	–	8, 10	10472	Northern Rocky mountain mesic montane mixed conifer forest-cedar groves
20	White fir-grand fir	56	White fir-grand fir/ warm-xeric	78	2, 3, 7	10270	Mediterranean California dry-mesic mixed conifer forest and woodland
20	White fir-grand fir	56	White fir-grand fir/ warm-xeric	1, 2, 3, 4	2	10350	North Pacific dry Douglas-fir forest and woodland
20	White fir-grand fir	56	White fir-grand fir/ warm-xeric	Except 78	1, 7, 8, 9, 10	10450	Northern Rocky Mountain dry-mesic montane mixed conifer forest
20	White fir-grand fir	57	White fir-grand fir/ warm-dry	–	2, 3, 7	10280	Mediterranean California mesic mixed conifer forest and woodland
20	White fir-grand fir	57	White fir-grand fir/ warm-dry	1, 2, 3, 4	1	10350	North Pacific dry Douglas-fir forest and woodland
20	White fir-grand fir	57	White fir-grand fir/ warm-dry	9, 10	1	10450	Northern Rocky Mountain dry-mesic montane mixed conifer forest
20	White fir-grand fir	57	White fir-grand fir/ warm-dry	–	8, 9, 10	10450	Northern Rocky Mountain dry-mesic montane mixed conifer forest
20	White fir-grand fir	57	White fir-grand fir/ warm-dry	77	1	10470	Northern Rocky Mountain mesic montane mixed conifer forest
20	White fir-grand fir	58	White fir-grand fir/ warm-moist	9	1, 7, 8, 9	10180	East Cascades mesic montane mixed-conifer forest and woodland

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
20	White fir-grand fir	58	White fir-grand fir/ warm-moist	78	2, 3, 7	10280	Mediterranean California mesic mixed conifer forest and woodland
20	White fir-grand fir	58	White fir-grand fir/ warm-moist	Except 9 and 78	1, 2, 7, 8, 9, 10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
20	White fir-grand fir	59	White fir-grand fir/ cool-moist	–	2, 3, 7	10320	Mediterranean California red fir forest
20	White fir-grand fir	59	White fir-grand fir/ cool-moist	–	1, 8, 9, 10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
20	White fir-grand fir	59	White fir-grand fir/ cool-moist	–	12	10580	Sierra Nevada subalpine lodgepole pine forest and woodland
21	California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	–	2, 3, 7	10320	Mediterranean California red fir forest
21	California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	–	6	10322	Mediterranean California red fir forest-southern Sierra
21	California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	–	2, 3, 6, 7	10320	Mediterranean California red fir forest
21	California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	–	2, 3, 7	10320	Mediterranean California red fir forest
21	California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	–	6	10322	Mediterranean California red fir forest-southern Sierra
22	Pacific silver fir	87	Pacific silver fir/mild-wet	–	8, 10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
22	Pacific silver fir	87	Pacific silver fir/mild-wet	–	1, 2, 7	11740	North Pacific dry-mesic silver fir-western hemlock-Douglas-fir forest
22	Pacific silver fir	88	Pacific silver fir/mild-very wet	–	1, 2, 7	10420	North Pacific mesic western hemlock-silver fir forest
22	Pacific silver fir	89	Pacific silver fir/cold-wet	–	8, 10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
22	Pacific silver fir	89	Pacific silver fir/cold-wet	–	1, 2, 7	11740	North Pacific dry-mesic silver fir-western hemlock-Douglas-fir forest

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
23	Mountain hemlock	91	Mountain hemlock/ cold-very moist	–	1, 2, 7, 8, 9	10412	North Pacific mountain hemlock forest-xeric
23	Mountain hemlock	92	Mountain hemlock/ cool-very moist	–	1, 2, 3, 7	10412	North Pacific mountain hemlock forest-xeric
23	Mountain hemlock	92	Mountain hemlock/ cool-very moist	–	8, 10	10470	Northern Rocky Mountain mesic montane mixed conifer forest
23	Mountain hemlock	93	Mountain hemlock/ cool-wet	–	1, 2, 3, 7	10412	North Pacific mountain hemlock forest-xeric
23	Mountain hemlock	93	Mountain hemlock/ cool-wet	–	8	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
23	Mountain hemlock	93	Mountain hemlock/ cool-wet	–	9	10560	Rocky Mountain subalpine mesic-wet spruce-fir forest and woodland
23	Mountain hemlock	94	Mountain hemlock/ cool-very wet	–	1	10411	North Pacific mountain hemlock forest-wet
23	Mountain hemlock	94	Mountain hemlock/ cool-very wet	–	2, 7	10412	North Pacific mountain hemlock forest-xeric
25	Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/ cold-moist	–	2	10321	Mediterranean California red fir forest-Cascades
25	Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/ cold-moist	–	1, 7, 9, 8, 10	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
25	Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/ cool-dry	–	2	10321	Mediterranean California red fir forest-Cascades
25	Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/ cool-dry	–	1, 7, 9, 8, 10	10560	Rocky Mountain subalpine mesic-wet spruce-fir forest and woodland
25	Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/ cool-wet	–	1, 7	10412	North Pacific mountain hemlock forest-xeric
25	Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/ cool-wet	–	8	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
25	Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/ cool-wet	–	9, 10	10560	Rocky Mountain subalpine mesic-wet spruce-fir forest and woodland

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
25	Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	–	1, 7	10411	North Pacific mountain hemlock forest-xeric
25	Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	–	8	10550	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland
25	Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	–	9, 10	10560	Rocky Mountain subalpine mesic-wet spruce-fir forest and woodland
30	Parklands	–114	Subalpine grassland-forbland	–	3, 4, 6	10670	Mediterranean California alpine fell-field
30	Parklands	–114	Subalpine grassland-forbland	–	9, 10	11430	Rocky Mountain alpine fell-field
30	Parklands	–114	Subalpine grassland-forbland	–	1, 7	11710	North Pacific alpine and subalpine dry grassland
30	Parklands	–113	Subalpine shrub	–	1, 2, 7	10680	North Pacific dry and mesic alpine dwarf-shrubland or fell-field or meadow
30	Parklands	–113	Subalpine shrub	–	9, 10	10700	Rocky Mountain alpine dwarf-shrubland
30	Parklands	–113	Subalpine shrub	–	3, 6	10710	Sierra Nevada alpine dwarf-shrubland
30	Parklands	65	Subalpine fir parklands	–	2	10412	North Pacific mountain hemlock forest-xeric
30	Parklands	65	Subalpine fir parklands	–	1, 7, 8, 9, 10	10460	Northern Rocky Mountain subalpine woodland and parkland
30	Parklands	95	Mountain hemlock parklands	–	2, 3, 6	10330	Mediterranean California subalpine woodland
30	Parklands	95	Mountain hemlock parklands	–	1, 7	10380	North Pacific maritime mesic subalpine parkland
30	Parklands	95	Mountain hemlock parklands	–	8, 9	10460	Northern Rocky Mountain subalpine woodland and parkland
30	Parklands	96	Limber pine parklands	–	6, 12	10200	Inter-mountain basins subalpine limber-Great Basin bristlecone pine woodland
30	Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	–	6, 12	10200	Inter-mountain basins subalpine limber-Great Basin bristlecone pine woodland

Table A2.1—Crosswalk of vegzones, associated subzones, level III ecoregions, and LANDFIRE biophysical setting (BpS) numbers (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name	Level III ecoregion number[a]	LANDFIRE mapzone tied to BpS	BpS number	BpS name
30	Parklands	98	Western white pine parklands	–	2, 3, 6, 7, 12	10330	Mediterranean California subalpine woodland
30	Parklands	99	Whitebark pine parklands	–	2	10330	Mediterranean California subalpine woodland
30	Parklands	99	Whitebark pine parklands	–	1, 7, 9, 10	10460	Northern Rocky Mountain subalpine woodland and parkland
30	Parklands	100	Subalpine larch parklands	–	1, 10	10460	Northern Rocky Mountain subalpine woodland and parkland
30	Parklands	101	Sierra lodgepole pine parklands	–	6, 12	10582	Sierra Nevada subalpine lodgepole pine forest and woodland-dry
40	Ice and snowfields	–4	Ice and snowfields	–	–	–	–

This crosswalk is centric to the U.S. Department of Agriculture, Forest Service, Pacific Northwest Region and has not been thoroughly reviewed by the agency's Pacific Southwest Region (California) ecologists. It has been updated with a regional crosswalk by a Pacific Northwest Region ecologist. See (USDA FS PNW Region 2020) for the latest version.

– = vegzone, subzone crosswalk to BpS is not specific to an ecoregion.

[a] See table 1 and figure 2 for level III ecoregions within the project area.

Sources: level III ecoregions (Omernik 1987, Omernik and Griffith 2014); mapzones and BpS (USGS and USDA FS, n.d.a).

Appendix 3: Climate Trend Summaries and Climate Change Vulnerability Assessments

U.S. Department of Agriculture, Forest Service, Pacific Southwest Region climate trend summaries and Pacific Northwest Region climate change vulnerability assessments synthesize and summarize current trends and projected future trends related to climate change. These summaries begin with local and regional trends in temperature and precipitation, then examine how these trends are affecting hydrology, fire, vegetation, and wildlife in the project area. Effort is made to update them for each forest at 5-year intervals. See USDA FS PSW Region (n.d.) and USDA FS PNW Research Station (n.d.).

Table A3.1—Forest Service, Pacific Southwest Region current and projected trends related to climate change

Forest Service unit	Reference
Pacific Southwest Region	**U.S. Department of Agriculture, Forest Service, Pacific Southwest Region [USDA FS PSW Region]. [N.d.].** Natural resources, ecology. https://www.fs.usda.gov/r05/natural-resources/ecology.
Angeles and San Bernardino National Forests	**Sawyer, S.; Hooper, J.; Safford, H. 2014.** A summary of current trends and probable future trends in climate and climate-driven processes for the Angeles and San Bernardino National Forests. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Climate%20Trend%20Summary%20Angeles%20and%20San%20Bernardino.pdf
Cleveland National Forest	**Molinari, N.; Sawyer, S.; Safford, H. 2016.** A summary of current trends and probable future trends in climate and climate-driven processes in the Cleveland National Forest and neighboring lands. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Cleveland%20Climate%20Trend%20Summary%202016.pdf.
Eldorado National Forest	**Estes, B.; Gross, S., coords. 2020.** Eldorado National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/2021%20Eldorado%20Climate%20Change%20Summary.pdf.
Inyo National Forest	**Wuenschel, A., coord. 2021.** Inyo National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Revised_2021InyoNF_ClimateSummary.pdf.
Klamath National Forest	**Butz, R.J.; Bohlman, G.N.; Johnson, C.M. 2022.** Klamath National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Klamath%20NF%20Climate%20Change%20Trends_2022.pdf.
Lake Tahoe Basin Management Unit	**Estes, B.; Gross, S. 2020.** Lake Tahoe Basin Management Unit climate change summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/2021%20LTBMU%20Climate%20Change%20Summary.pdf.
Lassen National Forest	**Merriam, K., coord. 2022.** Lassen National Forestclimate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Lassen%20National%20Forest%20Climate%20Trend%20Summary%202022.pdf.
Los Padres National Forest	**Molinari, N.; Sawyer, S.; Safford, H. [N.d.].** A summary of current trends and probable future trends in climate and climate-driven processes in the Los Padres National Forest and neighboring lands. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Los%20Padres%20Climate%20Trend%20Summary%202016.pdf.
Mendocino National Forest	**Butz, R.J.; Bohlman, G.N.; Johnson, C.M. 2022.** Mendocino National Forest change trend summary. U.S. Department of Agriculture. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Mendocino%20NF%20climate%20change%20trends_2022.pdf.
Modoc National Forest	**Merriam, K., coord. 2022.** Modoc National Forest climate change trend summary. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Modoc%20National%20Forest%20Climate%20Trend%20Summary%202022.pdf.
Plumas National Forest	**Merriam, K., coord. 2022.** Plumas National Forest climate change trend summary. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Plumas%20National%20Forest%20Climate%20Trend%20Summary.pdf.
Sequoia National Forest	**Wuenschel, A., coord. 2021.** Sequoia National Forest climate change trend summary. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Revised_2021Sequoia_ClimateSummary.pdf.

Table A3.1—Forest Service, Pacific Southwest Region current and projected trends related to climate change (continued)

Forest Service unit	Reference
Shasta-Trinity National Forest	**Butz, R.J.; Bohlman, G.N.; Johnson, C.M. 2022.** Shasta-Trinity National Forest. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Shasta%20Trinity%20NF%20climate%20change%20trends_2022.pdf.
Sierra National Forest	**Wuenschel, A., coord. 2021.** Sierra National Forest climate change trend summary. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Revised_2021Sierra_ClimateSummary.pdf.
Six Rivers National Forest	**Butz, R.J.; Bohlman, G.N.; Johnson, C.M. 2022.** Six Rivers National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/Six%20Rivers%20NF%20Climate%20Change%20trends_2022.pdf.
Stanislaus National Forest	**Estes, B.; Gross, S. 2020.** Stanislaus National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/2021%20Stanislaus%20Climate%20Change%20Summary.pdf.
Tahoe National Forest	**Estes, B.; Gross, S. 2020.** Tahoe National Forest climate change trend summary. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r05/2021%20Tahoe%20Climate%20Change%20Summary.pdf.

Table A3.2—Forest Service, Pacific Northwest Region climate change vulnerability assessments

Forest Service unit	Reference
Pacific Northwest Region	**U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station [USDA FS PNW Research Station]. [N.d.].** Climate change vulnerability assessments. https://research.fs.usda.gov/pnw/products/dataandtools/climate-change-vulnerability-assessments.
Columbia River Gorge National Scenic Area	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022.** Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. https://doi.org/10.2737/PNW-GTR-1001.
Colville National Forest	**Gaines, W.L.; Peterson, D.W.; Thomas, C.A.; Harrod, R.J. 2012.** Adaptations to climate change: Colville and Okanogan-Wenatchee National Forests. Gen. Tech. Rep. PNW-GTR-862. https://doi.org/10.2737/PNW-GTR-862.
Deschutes National Forest	**Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019.** Climate change vulnerability and adaptation in south-central Oregon. Gen. Tech. Rep. PNW-GTR-974. https://doi.org/10.2737/PNW-GTR-974.
Fremont-Winema National Forest	**Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019.** Climate change vulnerability and adaptation in south-central Oregon. Gen. Tech. Rep. PNW-GTR-974. https://doi.org/10.2737/PNW-GTR-974.
Gifford-Pinchot National Forest	**Hudec, J.L.; Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019.** Climate change vulnerability and adaptation in southwest Washington. Gen. Tech. Rep. PNW-GTR-977. https://doi.org/10.2737/PNW-GTR-977.
Malheur National Forest	**Halofsky, J.E.; Peterson, D.L., eds. 2017.** Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-939. https://doi.org/10.2737/PNW-GTR-939.
Mt. Baker-Snoqualmie National Forest	**Raymond, C.L.; Peterson, D.L.; Rochefort, R.M., eds. 2014.** Climate change vulnerability and adaptation in the North Cascades region, Washington. Gen. Tech. Rep. PNW-GTR-892. https://doi.org/10.2737/PNW-GTR-892.
Mt. Hood National Forest	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022.** Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. https://doi.org/10.2737/PNW-GTR-1001.
Ochoco National Forest and Crooked River National Grassland	**Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019.** Climate change vulnerability and adaptation in south-central Oregon. Gen. Tech. Rep. PNW-GTR-974. https://doi.org/10.2737/PNW-GTR-974.

Table A3.2—Forest Service, Pacific Northwest Region climate change vulnerability assessments (continued)

Forest Service unit	Reference
Okanogan-Wenatchee National Forest	**Gaines, W.L.; Peterson, D.W.; Thomas, C.A.; Harrod, R.J. 2012.** Adaptations to climate change: Colville and Okanogan-Wenatchee National Forests. Gen. Tech. Rep. PNW-GTR-862. https://doi.org/10.2737/PNW-GTR-862. **Raymond, C.L.; Peterson, D.L.; Rochefort, R.M., eds. 2014.** Climate change vulnerability and adaptation in the North Cascades region, Washington. Gen. Tech. Rep. PNW-GTR-892. https://doi.org/10.2737/PNW-GTR-892.
Olympic National Forest	**Halofsky, J.E.; Peterson, D.L.; O'Halloran, K.A.; Hawkins Hoffmann, C., eds. 2011.** Adapting to climate change at Olympic National Forest and Olympic National Park. Gen. Tech. Rep. PNW-GTR-844. https://doi.org/10.2737/PNW-GTR-844.
Rogue River-Siskiyou National Forest	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022.** Climate change vulnerability and adaptation in southwest Oregon. Gen. Tech. Rep. PNW-GTR-995. https://doi.org/10.2737/PNW-GTR-995.
Siuslaw National Forest	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2024.** Climate change vulnerability and adaptation in coastal Oregon. Gen. Tech. Rep. PNW-GTR-1024. https://doi.org/10.2737/pnw-gtr-1024.
Umatilla National Forest	**Halofsky, J.E.; Peterson, D.L., eds. 2017.** Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-939. https://doi.org/10.2737/PNW-GTR-939.
Umpqua National Forest	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022.** Climate change vulnerability and adaptation in southwest Oregon. Gen. Tech. Rep. PNW-GTR-995. https://doi.org/10.2737/PNW-GTR-995.
Wallowa-Whitman National Forest	**Halofsky, J.E.; Peterson, D.L., eds. 2017.** Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-939. https://doi.org/10.2737/PNW-GTR-939.
Willamette National Forest	**Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. 2022.** Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. https://doi.org/10.2737/PNW-GTR-1001.

Additional Resources for Pacific Southwest Region

Northern California Climate Adaptation Project Products

The goal of the Northern California Climate Adaptation Project is to increase the understanding of, and capacity to, reduce climate-related vulnerabilities of habitats and species of natural and cultural importance in northwestern California. For more information about the project, visit the Northern California Climate Adaptation Project webpage (EcoAdapt, n.d.). Northern California Climate Adaptation Project products include the following:

- **Buluc, L.; Graham, L.; Sawyer, S. 2022.** Climate change policy and context and northwest forests and plan revision. U.S. Department of Agriculture, Forest Service. https://ecoadapt.org/data/documents/NorCalWebinar_USFSPresentation_3May2022.pdf.

- **EcoAdapt. 2021.** Northern California Climate Adaptation Project: adaptation implementation workshop proceedings. Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_NorCalAdaptationImplementationWorkshopProceedings_Jan2022.pdf.

  This product summarizes the activities and outcomes of the Northern California Adaptation Implementation Workshops held for the Redding and Eureka/Arcata regions in November 2021. The report includes an overview of climate adaptation planning and a description of the workshop activities, then presents adaptation implementation plans created by workshop participants for six priority sites within the northwestern California project area.

- **EcoAdapt. 2022.** Supporting incorporation of climate change into federal plan revisions for northern California [Video]. https://www.youtube.com/watch?v=yQtG56HfJ08.

  This video includes a recording of a webinar presented on May 3, 2022. It is an overview of the Northern California Climate Adaptation Project. The following are associated slides:

  - **Hilberg, L. 2022.** Introduction and overview of the Northern California Climate Adaptation Project. Bainbridge Island, WA: EcoAdapt. https://ecoadapt.org/data/documents/NorCalWebinar_EcoAdapt_3May2022-compressed.pdf.
  - **Hilberg, L.E.; Kershner, J.M. 2021.** Overview of climate trends and projections for the Northern California Climate Adaptation Project. Version 1.0. Bainbridge Island, WA: EcoAdapt. https://ecoadapt.org/data/documents/EcoAdapt_NorCalClimateImpactsOverview_FINAL_Sept2021.pdf.

    This product summarizes observed changes and expected future conditions for the project area.
  - **Weigand, J.; Flahive, K. 2022.** Climate change policy and context and planning applications. U.S. Department of the Interior, Bureau of Land Management. https://ecoadapt.org/data/documents/NorCalWebinar_BLMPresentation_3May2022.pdf.
- **EcoAdapt. [N.d.].** Adaptation strategies and actions table. Available to download at https://ecoadapt.org/data/documents/EcoAdapt_NorthernCaliforniaAdaptationStrategiesActions_Jan2022.xlsx.

  This product presents a suite of potential adaptation strategies and actions for the northern California project area, which were generated by area stakeholders and supplemented by strategies and actions from previous EcoAdapt workshops and sources in the scientific literature. Adaptation actions are provided for the four major habitat groups, and action listed in the table has been evaluated by several criteria meant to assist land managers in identifying and prioritizing actions for implementation (e.g., effectiveness, feasibility, potential cobenefits and consequences).
- **Habitat vulnerability/adaptation summaries** provide a high-level overview of vulnerability for habitats and associated species within the four major habitat groups (coastal habitats, forest and woodland habitats, freshwater habitats, and shrubland and grassland habitats), as well as a table of adaptation strategies and actions linked to those vulnerabilities. Links for specific habitat groups are provided below.
  - **EcoAdapt. [N.d.].** Coastal habitats. Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_NorCal_VAASBrief_Coastal_Aug2021.pdf.
  - **EcoAdapt. [N.d.].** Forest and woodland habitats. Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_NorCal_VAASBrief_ForestsWoodlands_Aug2021.pdf.
  - **EcoAdapt. [N.d.].** Shrubland and grassland habitats. Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_NorCal_VAASBrief_ShrublandsGrasslands_Apr2022.pdf.
  - **EcoAdapt. [N.d.].** Freshwater habitats. Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_NorCal_VAASBrief_Freshwater_Aug2021.pdf.

- **Vulnerability assessment syntheses** provide an indepth review of how climate change will likely affect habitats and species and include information gathered from regional experts, the scientific literature, and peer-review comments and revisions. Each synthesis examines the sensitivity of a given habitat, species, or species group to climate change, its exposure to projected changes, and its capacity to adapt. The aim of these syntheses is to expand understanding of habitat and species vulnerability to changing climate conditions, and to provide a foundation for developing appropriate adaptation responses. Links for specific habitats are provided below.

COASTAL HABITATS—

- **Hilberg, L.; Kershner, J. 2023.** Coastal habitats: climate change vulnerability and adaptation strategies for northwestern California. https://www.cakex.org/documents/coastal-habitats-climate-change-vulnerability-and-adaptation-strategies-northwestern-california.
- **Hilberg, L.; Kershner, J. 2023.** Coastal dune systems: Northern California climate change vulnerability assessment synthesis. https://www.cakex.org/documents/coastal-dune-systems-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J. 2023.** Coastal bluffs and scrub: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/coastal-bluffs-scrub-climate-change-vulnerability-assessment-northern-california.

FOREST AND WOODLAND HABITATS—

- **Hilberg, L.; Kershner, J. 2023.** Forest and woodland habitats: climate change vulnerability and adaptation strategies for northwestern California. https://www.cakex.org/documents/forest-and-woodland-habitats-climate-change-vulnerability-and-adaptation-strategies-northwestern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Black oak and tanoak woodlands: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/black-oak-tanoak-woodlands-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Coastal conifer-hardwood forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/coastal-conifer-hardwood-forests-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Coastal redwood forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/coastal-redwood-forests-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Late-successional-dependent species (e.g., Pacific fisher): a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/late-successional-dependent-species-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Marbled murrelet: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/marbled-murrelet-climate-change-vulnerability-assessment-northern-california.

- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Mixed conifer and ponderosa forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/mixed-conifer-ponderosa-forests-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Mixed evergreen forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/mixed-evergreen-forests-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Native ungulates: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/native-ungulates-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Oak savannas and open woodlands: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/oak-savannas-open-woodlands-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Subalpine forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/subalpine-forests-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Sugar pine: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/sugar-pine-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** True fir forests: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/true-fir-forests-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Knobcone pine and cypress species: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/knobcone-pine-cypress-species-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Pacific yew: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/pacific-yew-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Salamanders: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/salamanders-climate-change-vulnerability-assessment-northern-california.

SHRUBLAND AND GRASSLAND HABITATS—

- **Hilberg, L.; Kershner, J. 2023.** Shrubland and grassland habitats: climate change vulnerability and adaptation strategies for northwestern California. https://www.cakex.org/documents/shrubland-and-grassland-habitats-climate-change-vulnerability-and-adaptation-strategies-northwestern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Alpine grasslands and shrublands: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/alpine-grasslands-shrublands-climate-change-vulnerability-assessment-northern-california.

- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Chaparral shrublands: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/chaparral-shrublands-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Migratory birds: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/migratory-birds-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Mixed grasslands: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/mixed-grasslands-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Native insect pollinators: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/native-insect-pollinators-climate-change-vulnerability-assessment-northern-california.

FRESHWATER HABITATS—

- **Hilberg, L.; Kershner, J. 2023.** Freshwater habitats: climate change vulnerability and adaptation strategies for northwestern California. https://www.cakex.org/documents/freshwater-habitats-climate-change-vulnerability-and-adaptation-strategies-northwestern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Frogs: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/frogs-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Port-Orford-cedar: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/port-orford-cedar-climate-change-vulnerability-assessment-northern-california.
- **Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Riparian-nesting birds: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/riparian-nesting-birds-climate-change-vulnerability-assessment-northern-california.
- **Loose, E.; Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Rivers, streams, and floodplains: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/rivers-streams-floodplains-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Freshwater marshes: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/freshwater-marshes-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Lakes and ponds: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/lakes-ponds-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Native freshwater mussels: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/native-freshwater-mussels-climate-change-vulnerability-assessment-northern-california.

- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Northwestern pond turtle: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/northwestern-pond-turtle-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Seeps and springs: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/seeps-springs-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Wet meadows and fens: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/wet-meadows-fens-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Vernal pools: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/vernal-pools-climate-change-vulnerability-assessment-northern-california.

ENDEMIC HABITATS—

- **Hilberg, L.; Kershner, J. 2023.** Bats: a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/bats-climate-change-vulnerability-assessment-northern-california.
- **Sims, S.; Hilberg, L.; Kershner, J.; Reynier, W. 2023.** Endemic habitats (e.g., caves, cliffs and talus slopes, etc.): a climate change vulnerability assessment for northern California. https://www.cakex.org/documents/endemic-habitats-climate-change-vulnerability-assessment-northern-california.

Appendix 4: Comprehensive General Classification Rules and Ranking for Assigning Vegzone

The overall approach to assigning vegzone is described in the text. As noted, the complete rule set included many additional contingencies based on the abundance of co-occurring species, other than the named indicator species and is described below.

The code ABGRC, seen throughout this document, represents grand fir (*Abies grandis*) and white fir (*Abies concolor*). The white fir-grand fir vegzone is a major mid-elevation potential vegetation type throughout Washington, Oregon, and California. This vegzone is defined by both white fir and grand fir because grand fir interbreeds with white fir and, as a result, are difficult to distinguish.

The code ABPRSH represents noble fir (*Abies procera*), California red fir (*Abies magnifica*), and Shasta red fir (*Abies magnifica* var. *shastensis*). The California red fir-Shasta red fir vegzone is found in southwestern Oregon and northern California and is widespread in the Sierra Nevada Mountains of California. Shasta red fir is a variety of California red fir that is found in southwestern Oregon and northern California. It is interfertile with noble fir and California red fir.

The comprehensive logic for assigning vegzone to plots with a stand age of at least 80 years is represented in following table.

Table A4.1—Detailed rule set for assigning vegzone to plots with a stand age of at least 80 years

Rule statement	Vegzone assigned
Sitka spruce cover ≥10 percent	Sitka spruce
Location near the coast[a] and Sitka spruce present	Sitka spruce
Redwood cover ≥10 percent	Redwood
Mountain hemlock cover between 10 and 20 percent and Pacific silver fir cover ≥5 percent	Pacific silver fir
Mountain hemlock cover between 10 and 20 percent, and sum of Pacific silver fir, noble fir, Shasta red fir cover ≥5 percent, and location in Washington or northern Oregon[b]	Pacific silver fir
Mountain hemlock cover ≥10 percent and Pacific silver fir exceptions not met	Mountain hemlock
Pacific silver fir cover ≥5 percent, or sum of Pacific silver fir and noble fir/Shasta red fir cover ≥5 percent, and location in Washington or northern Oregon[b]	Pacific silver fir
Western hemlock present, and sum of western redcedar and western hemlock cover ≥10 percent, and location outside Northern Rockies ecoregion	Western hemlock
Western redcedar cover ≥10 percent, and location in level III ecoregion 15 (Northern Rockies portion of northeastern Washington), and western hemlock absent	Western redcedar
Subalpine fir cover ≥20 percent, or grand fir/white fir present with <5 percent cover, and subalpine fir cover ≥10 percent, or sum of subalpine fir and Englemann spruce cover ≥10 percent	Subalpine fir-Engelmann spruce
Subalpine fir cover ≥10 percent, or subalpine fir cover <10 percent and sum of subalpine fir and Englemann spruce cover ≥10 percent, or Englemann spruce cover ≥10 percent, and grand fir/white fir cover ≥5 percent	White fir-grand fir
Sum of subalpine fir and Englemann spruce cover ≥10 percent	Subalpine fir-Engelmann spruce
Grand fir/white fir cover ≥5 percent; except if there is <20 percent cover of grand fir/white fir and one of the two following combinations of geography and cover of other indicator tree species is true: (1) the location is in the Klamath Mountains ecoregion and there is >5 percent cover of Jeffrey pine; or (2) the location is outside Washington or northern Oregon[b] and there is ≥5 percent cover of noble fir/Shasta red fir.	White fir-grand fir
Noble fir/Shasta red fir cover ≥5 percent and location outside Washington and northern Oregon[b] and not in Klamath Mountains ecoregion, and Jeffrey pine cover ≥5 percent	California red fir-Shasta red fir

Table A4.1—Detailed rule set for assigning vegzone to plots with a stand age of at least 80 years (continued)

Rule statement	Vegzone assigned
Port Orford cedar cover ≥10 percent, and if in the Klamath Mountains ecoregion, ≥20 percent cover, with Jeffrey pine cover ≥5 percent	Port Orford cedar
Tanoak cover ≥20 percent	Tanoak
Douglas-fir cover ≥5 percent, and if in the Klamath Mountains ecoregion, ≥20 percent cover, with Jeffrey pine cover ≥5 percent	Douglas-fir
Bigcone Douglas-fir cover ≥5 percent	Bigcone Douglas-fir
Jeffrey pine cover ≥5 percent	Jeffrey pine
Ponderosa pine cover ≥5 percent	Ponderosa pine
Whitebark pine, subalpine larch, limber pine, Great Basin bristlecone pine, or foxtail pine present	Parklands
Lodgepole pine present and none of the above indicator species present	Lodgepole pine
California foothill pine cover ≥5 percent	California foothill pine
Coulter pine cover ≥5 percent	Coulter pine
Knobcone pine cover ≥5 percent	Knobcone pine
Riparian hardwood[c] cover present and none of the above indicator species present	Riparian hardwood forest
Oak[d] cover present and none of the above indicator species (including riparian hardwoods) present	Oak woodlands
Desert hardwoods[e] present and none of the above indicator species present	Desert hardwoods
Other hardwoods[f] present and none of the above indicator species present	Other hardwoods
Singleleaf pinyon present and none of the above indicator species present	Pinyon
Western, California, Utah, or Rocky Mountain juniper present and none of the above indicator species present	Juniper
Sargent's cypress present and none of the above indicator species present	Cypress

Rule statements are evaluated in the order listed.

[a] Locations near the coast are identified using the coastal proximity index of Bell et al. (2015). The index ranges from 0 to 1,000 and is intended to represent penetration of marine air through complex terrain, based on minimum and maximum temperatures. We used values of 275 and below to identify locations near the coast.

[b] Northern Oregon consists of the following Oregon counties: Benton, Clackamas, Clatsop, Columbia, Hood River, Jefferson, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Wasco, Washington, and Yamhill.

[c] Riparian hardwood species are bigleaf maple, boxelder, white alder, red alder, water birch, paper birch, Oregon ash, California sycamore, balsam poplar, Fremont cottonwood, quaking aspen, Bebb willow, undergreen willow, Drummond's willow, dune willow, red willow, arroyo willow, shining willow, dusky willow, and Sitka willow.

[d] Oak species are blue oak, Engelmann oak, Oregon white oak, California black oak, valley oak, and interior live oak.

[e] The only desert hardwood species is desert ironwood.

[f] Other hardwood species are California buckeye, tree of heaven, Pacific madrone, giant chinquapin, Tasmanian bluegum, southern California walnut, northern California walnut, sweet cherry, California live oak, canyon live oak , and California laurel.

Source: Common names are from the USDA PLANTS Database (USDA NRCS, n.d.).

For plots that were still unassigned at this point, we relaxed the percentage of cover cutoffs and assigned the vegzone as the first conifer species in the hierarchy above (excluding pinyon, juniper, and cypress) that was present on the plot. Where both mountain hemlock and Pacific silver fir were present, we assigned the Pacific silver fir vegzone. Same restrictions were applied regarding location. Thus, where western hemlock or western redcedar were present, we assigned the western hemlock vegzone, except if western hemlock was absent, and the location was in the Northern Rockies ecoregion. Similarly, both noble/Shasta red/red fir and Pacific silver fir counted toward the Pacific silver fir category in Washington and northern Oregon where the Shasta red fir-California red fir vegzone was never assigned. If Englemann spruce was present, we assigned the location to the subalpine fir-Engelmann spruce vegzone, unless grand fir and/or white fir was present and subalpine fir was absent.

The next step in the process was to reevaluate the vegzone assignments for all plots initially assigned to Douglas-fir or ponderosa pine vegzones, on account of the common occurrence of these species as early-seral species in vegzones with greater precipitation and potential productivity (e.g., western hemlock, white fir-grand fir). For the Douglas-fir vegzone plots, we assembled all vascular plant species that occurred in at least 100 plots in the western hemlock, white fir-grand fir, and Douglas-fir vegzones combined and evaluated their frequency in the three vegzones to identify species with high fidelity to one of the vegzones. For plots initially assigned to the Douglas-fir vegzone with at least 10 percent cover of species with high fidelity to the western hemlock or white fir-grand fir vegzones, we reassigned vegzone using a combination of plant association calls made by field crews and presence of all tree indicator species for vegzones higher in the hierarchy. For the ponderosa pine vegzone plots, we applied an analogous process including plots assigned to white fir-grand fir and Douglas-fir vegzones.

For plots that were still unassigned, we exploited additional data sources. First, we examined seedling data and assigned the highest-ranking vegzone of any indicator species present. Then, we used snags and removed trees (along with any relevant live trees) of indicator species only and assigned the vegzone based on relative density. For any remaining unassigned plots, we assigned the vegzone based on plant association calls made by field crews, if possible. For the last few unassigned plots, we examined all available information and applied professional judgement.

As a final step, we reexamined plots initially assigned to the lodgepole pine vegzone, on account of the common occurrence of the species as early-seral species in other vegzones (e.g., ponderosa pine, subalpine fir-Engelmann spruce). First, we examined seedling data and assigned the highest ranking vegzone of any indicator species present. Then, we used snags and removed trees (along with any relevant live trees) of indicator species only and assigned vegzone based on relative density. For any remaining unassigned plots, we assigned the vegzone based on plant association calls made by field crews.

The comprehensive logic for assigning vegzone to plots with a stand age of less than 80 years is represented in table A4.2.

For plots that were still unassigned at this point, we relaxed the percentage of cover cutoffs and assigned the vegzone as the first conifer species in the hierarchy above (excluding pinyon, juniper, and cypress) that were present on the plot. Where both mountain hemlock and Pacific silver fir were present, we assigned the Pacific silver fir vegzone. Same restrictions applied regarding location:

- Both noble fir/Shasta red fir and Pacific silver fir counted toward the Pacific silver fir vegzone category in Washington and northern Oregon where California red fir-Shasta red fir vegzone was never assigned.
- We only assigned the western redcedar vegzone in the Northern Rockies ecoregion.
- If Englemann spruce was present, we assigned the subalpine fir-Engelmann spruce vegzone unless grand fir/white fir was present and subalpine fir was absent.

Subsequent steps for assigning, or reassigning, vegzone for plots less than 80 years old parallel the process for older plots described above.

Table A4.2—Detailed rule set for assigning vegzone to plots with a stand age of less than 80 years

Rule statement	Vegzone assigned
Sitka spruce present	Sitka spruce
Redwood present	Redwood
Mountain hemlock cover ≥10 percent but <20 percent, and Pacific silver fir cover ≥5 percent	Pacific silver fir
Mountain hemlock cover ≥10 percent but <20 percent, and sum of Pacific silver fir and noble fir/Shasta red fir cover ≥5 percent, and location in Washington or northern Oregon[a]	Pacific silver fir
Mountain hemlock cover ≥10 percent, and Pacific silver fir and noble fir/Shasta red fir exceptions not met	Mountain hemlock
Pacific silver fir cover ≥5 percent, or sum of Pacific silver fir and noble fir/Shasta red fir cover ≥5 percent, and location in Washington or northern Oregon[a]	Pacific silver fir
Western hemlock present, and sum of western redcedar and western hemlock cover ≥10 percent, and location outside Northern Rockies ecoregion	Western hemlock
Western redcedar cover ≥10 percent, and location in level III ecoregion 15 (Northern Rockies portion of northeastern Washington), and western hemlock absent	Western redcedar
Subalpine fir cover ≥10 percent, or grand fir/white fir present with <2 percent cover, and subalpine fir cover ≥5 percent or sum of subalpine fir and Englemann spruce cover ≥10 percent	Subalpine fir-Engelmann spruce
Sum of subalpine fir and Englemann spruce cover ≥10 percent or Englemann spruce cover ≥10 percent, and grand fir/white fir cover ≥2 percent	White fir-grand fir
Grand fir/white fir cover ≥5 percent; except if there is <20 percent cover of grand fir/white fir and one of the two following combinations of geography and cover of other indicator tree species is true: (1) the location is in the Klamath Mountains ecoregion and there is >5 percent cover of Jeffrey pine; or (2) the location is outside Washington or northern Oregon[a] and there is ≥5 percent cover of noble fir/Shasta red fir.	White fir-grand fir
Grand fir/white fir present, and location outside Washington and northern Oregon, and either Port Orford cedar or tanoak present with cover <5 percent	White fir-grand fir
Noble fir/Shasta red fir cover ≥5 percent and location outside Washington and northern Oregon[a]	California red fir-Shasta red fir
Port Orford cedar cover ≥5 percent	Port Orford cedar
Tanoak cover at least 20 percent, or tanoak cover ≥5 percent and grand fir/white fir present	Tanoak
Tanoak present and western white pine cover ≥5 percent	Douglas-fir
Douglas-fir cover ≥5 percent, and mountain hemlock cover ≥5 percent and <10 percent	Mountain hemlock
Douglas-fir cover ≥5 percent and Pacific silver fir present	Pacific silver fir
Douglas-fir cover ≥5 percent, western hemlock, western redcedar present, and location outside the Northern Rockies ecoregion	Western hemlock
Douglas-fir cover ≥5 percent, and western hemlock and/or western redcedar present, and location in the Northern Rockies ecoregion	Western redcedar
Douglas-fir cover ≥5 percent, and subalpine fir or Englemann spruce present	Subalpine fir-Engelmann spruce
Douglas-fir cover ≥5 percent and grand fir/white fir present	White fir-grand fir
Douglas-fir cover ≥5 percent and noble fir/Shasta red fir present	California red fir-Shasta red fir
Douglas-fir cover ≥5 percent and Port Orford cedar cover ≥5 percent	Port Orford cedar
Douglas-fir cover ≥5 percent and tanoak cover ≥5 percent	Tanoak
Douglas-fir cover ≥5 percent	Douglas-fir
Bigcone Douglas-fir cover ≥5 percent and grand fir/white fir present	White fir-grand fir
Bigcone Douglas-fir cover ≥5 percent	Bigcone Douglas-fir
Jeffrey pine cover ≥5 percent	Jeffrey pine
Ponderosa pine cover ≥5 percent and mountain hemlock cover ≥5 percent and <10 percent	Mountain hemlock
Ponderosa pine cover ≥5 percent and Pacific silver fir present	Pacific silver fir

Table A4.2—Detailed rule set for assigning vegzone to plots with a stand age of less than 80 years (continued)

Rule statement	Vegzone assigned
Ponderosa pine cover ≥5 percent and western hemlock, western redcedar present	Western hemlock
Ponderosa pine cover ≥5 percent and subalpine fir or Englemann spruce and/or western redcedar present	Subalpine fir-Engelmann spruce
Ponderosa pine cover ≥5 percent and grand fir/white fir present	White fir-grand fir
Ponderosa pine cover ≥5 percent and noble fir/Shasta red fir present	California red fir-Shasta red fir
Ponderosa pine cover ≥5 percent and Port Orford cedar cover ≥5 percent	Port Orford cedar
Ponderosa pine cover ≥5 percent and tanoak cover ≥5 percent	Tanoak
Ponderosa pine cover ≥5 percent and Douglas-fir present	Douglas-fir
Ponderosa pine cover ≥5 percent	Ponderosa pine
Whitebark pine, subalpine larch, limber pine, Great Basin bristlecone pine, and/or foxtail pine present	Parklands
Lodgepole pine present and none of the above indicator species present	Lodgepole pine
California foothill pine present	California foothill pine
Coulter pine cover ≥5 percent and grand fir/white fir present	White fir-grand fir
Coulter pine cover ≥5 percent and bigcone Douglas-fir present	Bigcone Douglas-fir
Coulter pine cover ≥5 percent	Coulter pine
Knobcone pine cover ≥5 percent	Knobcone pine
Riparian hardwood[b] cover present and none of the above indicator species present	Riparian hardwood forest
Oak[c] cover present and none of the above indicator species (including riparian hardwoods) present	Oak woodlands
Desert hardwoods[d] present and none of the above indicator species present	Desert hardwoods
Other hardwoods[e] present and none of the above indicator species present	Other hardwoods
Singleleaf pinyon present and none of the above indicator species present	Pinyon
Western, California, Utah, or Rocky Mountain juniper present and none of the above indicator species present	Juniper
Sargent's cypress present and none of the above indicator species present	Cypress

Rule statements are evaluated in the order listed.

[a] Northern Oregon consists of the following Oregon counties: Benton, Clackamas, Clatsop, Columbia, Hood River, Jefferson, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Wasco, Washington, and Yamhill.

[b] Riparian hardwood species are bigleaf maple, boxelder, white alder, red alder, water birch, paper birch, Oregon ash, California sycamore, balsam poplar, Fremont cottonwood, quaking aspen, Bebb willow, undergreen willow, Drummond's willow, dune willow, red willow, arroyo willow, shining willow, dusky willow, and Sitka willow.

[c] Oak species are blue oak, Engelmann oak, Oregon white oak, California black oak, valley oak, and interior live oak.

[d] The only desert hardwood species is desert ironwood.

[e] Other hardwood species are California buckeye, tree of heaven, Pacific madrone, giant chinquapin, Tasmanian bluegum, Southern California walnut, Northern California walnut, sweet cherry, California live oak, canyon live oak, and California laurel.

Source: Common names and species symbols are from the USDA PLANTS Database (USDA NRCS, n.d.).

Appendix 5: Species List

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report

Life form	Species symbol	Common name	Scientific name and authority
Tree:	ABAM	Pacific silver fir	*Abies amabilis* (Douglas ex Loudon) Douglas ex Forbes
	ABCO	White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
	ABGR	Grand fir	*Abies grandis* (Douglas ex D. Don) Lindl.
	ABGRC	Grand fir-white fir	*Abies grandis-Abies concolor*
	ABLA	Subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
	ABMA	California red fir	*Abies magnifica* A. Murray bis
	ABMAS	Shasta red fir	*Abies magnifica* A. Murray bis var. *shastensis* Lemmon
	ABPR	Noble fir	*Abies procera* Rehder
	ABPRSH	Noble fir-Shasta red fir	*Abies procera-Abies magnifica* var. *shastensis*
	ACGL	Rocky Mountain maple	*Acer glabrum* Torr.
	ACGR3	Bigtooth maple	*Acer grandidentatum* Nutt.
	ACMA3	Bigleaf maple	*Acer macrophyllum* Pursh
	ACNE2	Boxelder	*Acer negundo* L.
	ADSP	Redshank	*Adenostoma sparsifolium* Torr.
	AECA	California buckeye	*Aesculus californica* (Spach) Nutt.
	AIAL	Tree of heaven	*Ailanthus altissima* (Mill.) Swingle
	ALIN2	Gray alder	*Alnus incana* (L.) Moench
	ALRH2	White alder	*Alnus rhombifolia* Nutt.
	ALRU2	Red alder	*Alnus rubra* Bong.
	ALVI5	Green alder	*Alnus viridis* (Chaix) DC.
	ARME	Pacific madrone	*Arbutus menziesii* Pursh
	BEGL2	Bog birch	*Betula glandulifera* (Regel) Butler
	BEOC2	Water birch	*Betula occidentalis* Hook.
	BEPA	Paper birch	*Betula papyrifera* Marshall
	BEPAC	Western paper birch	*Betula papyrifera* Marshall var. *commutata* (Regel) Fernald
	BEPU4	Bog birch	*Betula pumila* L.
	BEUT	Birch	*Betula* × *utahensis* Britton (pro sp.) [*occidentalis* × *papyrifera*]
	CANO9	Alaska cedar	*Callitropsis nootkatensis* (D. Don) Oerst. Ex D.P. Little
	CADE27	Incense cedar	*Calocedrus decurrens* (Torr.) Florin
	CHLA	Port Orford cedar	*Chamaecyparis lawsoniana* (A. Murray bis) Parl.
	CHCH7	Giant chinquapin	*Chrysolepis chrysophylla* (Douglas ex Hook.) Hjelmqvist
	EUGL	Tasmanian bluegum	*Eucalyptus globulus* Labill.
	FRDI2	California ash	*Fraxinus dipetala* Hook. & Arn.
	FRLA	Oregon ash	*Fraxinus latifolia* Benth.
	FRVE2	Velvet ash	*Fraxinus velutina* Torr.
	HEBA5	Modoc cypress	*Hesperocyparis bakeri* (Jeps.) Bartel
	HEGO3	Gowen cypress	*Hesperocyparisgoveniana* (Gordon) Bartel
	HEMA21	McNab's cypress	*Hesperocyparis macnabiana* (A. Murray bis) Bartel

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	HEMA22	Monterey cypress	*Hesperocyparis macrocarpa* (Hartw.) Bartel
	HEPI11	Pygmy cypress	*Hesperocyparis pigmaea* (Lemmon) Bartel
	HESA17	Sargent's cypress	*Hesperocyparis sargentii* (Jeps.) Bartel
	JUCA	Southern California walnut	*Juglans californica* S. Watson
	JUHI	Northern California walnut	*Juglans hindsii* (Jeps.) Jeps. ex R.E. Sm.
	JUCA7	California juniper	*Juniperus californica* Carrière
	JUGR7	Western juniper	*Juniperus grandis* R.P. Adams
	JUMO	Oneseed juniper	*Juniperus monosperma* (Engelm.) Sarg.
	JUOC	Western juniper	*Juniperus occidentalis* Hook.
	JUOS	Utah juniper	*Juniperus osteosperma* (Torr.) Little
	JUSC2	Rocky mountain juniper	*Juniperus scopulorum* Sarg.
	LALY	Subalpine larch	*Larix lyallii* Parl.
	LAOC	Western larch	*Larix occidentalis* Nutt.
	LIST2	Sweetgum	*Liquidambar styraciflua*
	LIDE3 (NODE3)[1]	Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehder
	NODE3 (LIDE3)[1]	Tanoak	*Notholithocarpus densiflorus* (Hook. & Arn.) P.S. Manos, C.H. Cannon, & S.H. Oh
	PIBR	Brewer spruce	*Picea breweriana* S. Watson
	PIEN	Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
	PISI	Sitka spruce	*Picea sitchensis* (Bong.) Carrière
	PIAL	Whitebark pine	*Pinus albicaulis* Engelm.
	PIAT	Knobcone pine	*Pinus attenuata* Lemmon
	PIBA	Foxtail pine	*Pinus balfouriana* Balf.
	PICO	Lodgepole pine	*Pinus contorta* Douglas ex Loudon
	PICOM	Sierra lodgepole pine	*Pinus contorta* Douglas ex Loudon var. *murrayana* (Balf.) Engelm.
	PICO3	Coulter pine	*Pinus coulteri* D. Don
	PIFL2	Limber pine	*Pinus flexilis* James
	PIJE	Jeffrey pine	*Pinus jeffreyi* Balf.
	PILA	Sugar pine	*Pinus lambertiana* Douglas
	PILO	Great Basin bristlecone pine	*Pinus longaeva* D.K. Bailey
	PIMO	Singleleaf pinyon	*Pinus monophylla* Torr. & Frém.
	PIMO3	Western white pine	*Pinus monticola* Douglas ex D. Don
	PIMU	Bishop pine	*Pinus muricata* D. Don
	PIPOW2	Washoe pine	*Pinus ponderosa* Lawson & C. Lawson var. *washoensis* (H. Mason & Stockw.) J.R. Haller & Vivrette
	PIPO	Ponderosa pine	*Pinus ponderosa* Lawson & C. Lawson
	PIRA2	Monterey pine	*Pinus radiata* D. Don
	PISA2	California foothill pine	*Pinus sabiniana* Douglas ex Douglas
	PLRA	California sycamore	*Platanus racemosa* Nutt.
	POAN3	Narrowleaf cottonwood	*Populus angustifolia* James

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	POBA2	Balsam poplar	*Populus balsamifera* L.
	POBAT	Black cottonwood	*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw
	POFR2	Fremont cottonwood	*Populus fremontii* S. Watson
	POPUL	Cottonwood spp.	*Populus* L.
	POTR5	Quaking aspen	*Populus tremuloides* Michx.
	PRAM	American plum	*Prunus americana* Marshall
	PRAV	Sweet cherry	*Prunus avium* (L.) L.
	PREM	Bitter cherry	*Prunus emarginata* (Douglas ex Hook.) D. Dietr.
	PRIL	Hollyleaf cherry	*Prunus ilicifolia* (Nutt. ex Hook. & Arn.) D. Dietr.
	PRSU2	Klamath plum	*Prunus subcordata* Benth.
	PRVI	Chokecherry	*Prunus virginiana* L.
	PSMA	Bigcone Douglas-fir	*Pseudotsuga macrocarpa* (Vasey) Mayr
	PSME	Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
	PYCO	Common pear	*Pyrus communis* L.
	QUAG	California live oak	*Quercus agrifolia* Née
	QUBE5	Scrub oak	*Quercus berberidifolia* Liebm.
	QUCH2	Canyon live oak	*Quercus chrysolepis* Liebm.
	QUCO7	Muller oak	*Quercus cornelius-mulleri* Nixon & Steele
	QUDO	Blue oak	*Quercus douglasii* Hook. & Arn.
	QUDU4	Leather oak	*Quercus durata* Jeps.
	QUEN	Engelmann oak	*Quercus engelmannii* Greene
	QUGA	Gambel oak	*Quercus gambelii* Nutt.
	QUGA4	Oregon white oak	*Quercus garryana* Douglas ex Hook.
	QUGAB	Brewer oak	*Quercus garryana* Douglas ex Hook. var. *breweri* (Engelm.) Jeps.
	QUJO3	Tucker oak	*Quercus john-tuckeri* Nixon & C.H. Mull.
	QUKE	California black oak	*Quercus kelloggii* Newberry
	QULO	Valley oak	*Quercus lobata* Née
	QUSA2	Deer (Sadler's) oak	*Quercus sadleriana* R. Br. ter
	QUTO	Island live oak	*Quercus tomentella* Engelm.
	QUVA	Huckleberry oak	*Quercus vacciniifolia* Kellogg
	QUWI2	Interior live oak	*Quercus wislizeni* A. DC.
	ROPS	Black locust	*Robinia pseudoacacia* L.
	SAAL2	White willow	*Salix alba* L.
	SAAM2	Peachleaf willow	*Salix amygdaloides* Andersson
	SABE2	Bebb willow	*Salix bebbiana* Sarg.
	SACO2	Undergreen willow	*Salix commutata* Bebb
	SAEA	Mountain willow	*Salix eastwoodiae* Cockerell ex A. Heller
	SAEX	Narrowleaf willow	*Salix exigua* Nutt.
	SAGE2	Geyer willow	*Salix geyeriana* Andersson

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	SAGL	Grayleaf willow	*Salix glauca* L.
	SAGO	Goodding's willow	*Salix gooddingii* C.R. Ball
	SAHO	Dune willow	*Salix hookeriana* Barratt ex Hook.
	SALA3	Red willow	*Salix laevigata* Bebb
	SALA6	Arroyo willow	*Salix lasiolepis* Benth.
	SALE	Lemmon's willow	*Salix lemmonii* Bebb
	SALU	Shining willow	*Salix lucida* Muhl.
	SALUL	Pacific willow	*Salix lucida* Muhl. ssp. *lasiandra* (Benth.) A.E. Murray
	SALU2	Yellow willow	*Salix lutea* Nutt.
	SAME2	Dusky willow	*Salix melanopsis* Nutt.
	SAPL2	Diamondleaf willow	*Salix planifolia* Pursh
	SASC	Scouler's willow	*Salix scouleriana* Barratt ex Hook.
	SASI2	Sitka willow	*Salix sitchensis* Sanson ex Bong.
	SALIX	Willow spp.	*Salix* L.
	SAWO	Wolf's willow	*Salix wolfii* Bebb
	SALE9	Mexican bush sage	*Salvia leucophylla* Greene
	SCMO	Peruvian peppertree	*Schinus molle* L.
	SESE3	Redwood	*Sequoia sempervirens* (Lamb. ex D. Don) Endl.
	SEGI2	Giant sequoia	*Sequoiadendron giganteum* (Lindl.) J. Buchholz
	SOSC2	Greene's mountain ash	*Sorbus scopulina* Greene
	SOSI2	Western mountain ash	*Sorbus sitchensis* M. Roem.
	TABR2	Pacific yew	*Taxus brevifolia* Nutt.
	THPL	Western redcedar	*Thuja plicata* Donn ex D. Don
	TOCA	California nutmeg	*Torreya californica* Torr.
	TSHE	Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
	TSME	Mountain hemlock	*Tsuga mertensiana* (Bong.) Carrière
	UMCA	California laurel	*Umbellularia californica* (Hook. & Arn.) Nutt.
	WAFI	California fan palm	*Washingtonia filifera* (Linden ex André) H. Wendl.
Shrub:	ACCI	Vine maple	*Acer circinatum* Pursh
	ADFA	Chamise	*Adenostoma fasciculatum* Hook. & Arn.
	AMDU2	Burrobush	*Ambrosia dumosa* (A. Gray) Payne
	AMER	Wooly fruit bur ragweed	*Ambrosia eriocentra* (A. Gray) Payne
	AMSA7	Burrobrush	*Ambrosia salsola* (Torr. & A. Gray) Strother & B.G. Baldw.
	AMAL2	Saskatoon serviceberry	*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem.
	AMUT	Utah serviceberry	*Amelanchier utahensis* Koehne
	AMFR2	Fremont's chaffbush	*Amphipappus fremontii* Torr. & A. Gray ex A. Gray
	ARBA4	Baker's manzanita	*Arctostaphylos bakeri* Eastw.
	ARCA5	Hoary manzanita	*Arctostaphylos canescens* Eastw.
	ARGL3	Eastwood's manzanita	*Arctostaphylos glandulosa* Eastw.
	ARGL4	Bigberry manzanita	*Arctostaphylos glauca* Lindl.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	ARHO3	Hooker's manzanita	*Arctostaphylos hookeri* G. Don
	ARMA	Whiteleaf manzanita	*Arctostaphylos manzanita* Parry
	ARMO5	Montara manzanita	*Arctostaphylos montaraensis* J.B. Roof
	ARNE	Pinemat manzanita	*Arctostaphylos nevadensis* A. Gray
	ARNU3	Glossyleaf manzanita	*Arctostaphylos nummularia* A. Gray
	ARPA3	Pajaro manzanita	*Arctostaphylos pajaroensis* (J.E. Adams ex McMinn) J.E. Adams
	ARPA6	Greenleaf manzanita	*Arctostaphylos patula* Greene
	ARSI	Bonny Doon manzanita	*Arctostaphylos silvicola* Jeps. & Wies. ex Jeps.
	ARST	Stanford's manzanita	*Arctostaphylos stanfordiana* Parry
	ARTO2	Woollyleaf manznaita	*Arctostaphylos tomentosa* (Pursh) Lindl.
	ARUV	Kinnikinnick	*Arctostaphylos uva-ursi* (L.) Spreng.
	ARVI4	Sticky whiteleaf manzanita	*Arctostaphylos viscida* Parry
	ARAR8	Little sagebrush	*Artemisia arbuscula* Nutt.
	ARBI3	Bigelow sage	*Artemisia bigelovii* A. Gray
	ARCA11	Coastal sagebrush	*Artemisia californica* Less.
	ARCA13	Silver sagebrush	*Artemisia cana* Pursh
	ARDR4	Tarragon	*Artemisia dracunculus* L.
	ARFR4	Prairie sagewort	*Artemisia frigida* Willd.
	ARLO7	Longleaf wormwood	*Artemisia longifolia* Nutt.
	ARNO4	Black sagebrush	*Artemisia nova* A. Nelson
	ARPY3	Beach wormwood	*Artemisia pycnocephala* (Less.) DC.
	ARRI2	Scabland sagebrush	*Artemisia rigida* (Nutt.) A. Gray
	ARRO4	Timberline sagebrush	*Artemisia rothrockii* A. Gray
	ARTR2	Big sagebrush	*Artemisia tridentata* Nutt.
	ARTR4	Threetip sagebrush	*Artemisia tripartita* Rydb.
	ATCA2	Fourwing saltbush	*Atriplex canescens* (Pursh) Nutt.
	ATCO	Shadscale saltbush	*Atriplex confertifolia* (Torr. & Frém.) S. Watson
	ATGA	Gardner's saltbush	*Atriplex gardneri* (Moq.) D. Dietr.
	ATHY	Desertholly	*Atriplex hymenelytra* (Torr.) S. Watson
	ATNU2	Nuttall's saltbush	*Atriplex nuttallii* S. Watson
	ATPO	Cattle saltbush	*Atriplex polycarpa* (Torr.) S. Watson
	BAPI	Coyotebrush	*Baccharis pilularis* DC.
	BEJU	Sweetbush	*Bebbia juncea* (Benth.) Greene
	CAER	Fairyduster	*Calliandra eriophylla* Benth.
	CAME7	Western moss heather	*Cassiope mertensiana* (Bong.) G. Don
	CECO	Whitethorn ceanothus	*Ceanothus cordulatus* Kellogg
	CECR	Hoaryleaf ceanothus	*Ceanothus crassifolius* Torr.
	CECU	Buckbrush	*Ceanothus cuneatus* (Hook.) Nutt.
	CEFE2	Coyote ceanothus	*Ceanothus ferrisiae* McMinn
	CEGR	Desert ceanothus	*Ceanothus greggii* A. Gray

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	CEGR2	Carmel ceanothus	*Ceanothus griseus* (Trel.) McMinn
	CEIN3	Deerbrush	*Ceanothus integerrimus* Hook. & Arn.
	CELE2	Chaparral whitethorn	*Ceanothus leucodermis* Greene
	CEMA3	Mason's ceanothus	*Ceanothus masonii* McMinn
	CEOL	Hairy ceanothus	*Ceanothus oliganthus* Nutt.
	CEPR	Prostrate ceanothus	*Ceanothus prostratus* Benth.
	CEPU	Dwarf ceanothus	*Ceanothus pumilus* Greene
	CESA	Redstem ceanothus	*Ceanothus sanguineus* Pursh
	CESP	Redheart	*Ceanothus spinosus* Nutt.
	CETH	Blueblossom	*Ceanothus thyrsiflorus* Eschsch.
	CETO	Woolyleaf ceanothus	*Ceanothus tomentosus* Parry
	CEVE	Snowbrush ceanothus	*Ceanothus velutinus* Douglas ex Hook.
	CEVE2	Barranca brush	*Ceanothus verrucosus* Nutt.
	CELA	Sugarberry	*Celtis laevigata* Willd.
	CESO3	Yellow star-thistle	*Centaurea solstitialis* L.
	CEOC2	Common buttonbush	*Cephalanthus occidentalis* L.
	CEIN7	Littleleaf mountain mahogany	*Cercocarpus intricatus* S. Watson
	CELE3	Curl-leaf mountain mahogany	*Cercocarpus ledifolius* Nutt.
	CEMO2	Alderleaf mountain mahogany	*Cercocarpus montanus* Raf.
	CEMOG	Birchleaf mountain mahogany	*Cercocarpus montanus* Raf. var. *glaber* (S. Watson) F.L. Martin
	CHFO	Mountain misery	*Chamaebatia foliolosa* Benth.
	CHLI2	Desert willow	*Chilopsis linearis* (Cav.) Sweet
	CHSE11	Bush chinquapin	*Chrysolepis sempervirens* (Hook.) Nutt.
	CHVI8	Yellow rabbitbrush	*Chrysothamnus viscidiflorus* (Hook.) Nutt.
	CORA	Blackbrush	*Coleogyne ramosissima* Torr.
	COCA18	Las Animas nakedwood	*Colubrina californica* I.M. Johnst.
	COCA13	Bunchberry dogwood	*Cornus canadensis* L.
	CONU4	Pacific dogwood	*Cornus nuttallii* Audubon ex Torr. & A. Gray
	COSE16	Redosier dogwood	*Cornus sericea* L.
	COCO6	Beaked hazelnut	*Corylus cornuta* Marshall
	CRDO2	Black hawthorn	*Crataegus douglasii* Lindl.
	CRCA5	California croton	*Croton californicus* Müll. Arg.
	CYAC8	Buck-horn cholla	*Cylindropuntia acanthocarpa* (Engelm. & J.M. Bigelow) F.M. Knuth
	CYBI9	Teddybear cholla	*Cylindropuntia bigelovii* (Engelm.) F.M. Knuth
	CYRA9	Branched pencil cholla	*Cylindropuntia ramosissima* (Engelm.) F.M. Knuth
	DERI	Tree poppy	*Dendromecon rigida* Benth.
	DIAU	Orange bush monkeyflower	*Diplacus aurantiacus* (W. Curtis) Jeps.
	ECPO2	Cottontop cactus	*Echinocactus polycephalus* Engelm. & J.M. Bigelow
	ELAN	Russian olive	*Elaeagnus angustifolia* L.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	ELPY	Copperbush	*Elliottia pyroliflora* (Bong.) S.W. Brim & P.F. Stevens
	ENCA	California brittlebush	*Encelia californica* Nutt.
	ENFA	Brittlebush	*Encelia farinosa* A. Gray ex Torr.
	ENVI	Virgin River brittlebush	*Encelia virginensis* A. Nelson
	EPCA2	California jointfir	*Ephedra californica* S. Watson
	EPNE	Nevada jointfir	*Ephedra nevadensis* S. Watson
	EPTO	Torrey's jointfir	*Ephedra torreyana* S. Watson
	EPVI	Mormon tea	*Ephedra viridis* Coville
	ERBL2	Rabbitbush	*Ericameria bloomeri* (A. Gray) J.F. Macbr.
	ERCO23	Cooper's goldenbush	*Ericameria cooperi* (A. Gray) H.M. Hall
	ERDI14	Whitestem goldenbush	*Ericameria discoidea* (Nutt.) G.L. Nesom
	ERER11	California goldenbush	*Ericameria ericoides* (Less.) Jeps.
	ERLI6	Narrowleaf goldenbush	*Ericameria linearifolia* (DC.) Urbatsch & Wussow
	ERNA10	Rubber rabbitbrush	*Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & Baird
	ERTE18	Green rabbitbrush	*Ericameria teretifolia* (Durand & Hilg.) Jeps.
	ERCA6	California yerba santa	*Eriodictyon californicum* (Hook. & Arn.) Torr.
	ERIOG	Buckwheat spp.	*Eriogonum* Michx.
	ERCI5	Coastal buckwheat	*Eriogonum cinereum* Benth.
	ERCO12	Arrowleaf buckwheat	*Eriogonum compositum* Douglas ex Benth.
	ERCO14	Crispleaf buckwheat	*Eriogonum corymbosum* Benth.
	ERDO	Douglas' buckwheat	*Eriogonum douglasii* Benth.
	EREL5	Tall woolly buckwheat	*Eriogonum elatum* Douglas ex Benth.
	ERFA2	Eastern Mojave buckwheat	*Eriogonum fasciculatum* Benth.
	ERIN9	Frosted buckwheat	*Eriogonum incanum* Torr. & A. Gray
	ERLA5	Seaside buckwheat	*Eriogonum latifolium* Sm.
	ERMI4	Slender buckwheat	*Eriogonum microthecum* Nutt.
	ERNI2	Snow buckwheat	*Eriogonum niveum* Douglas ex Benth.
	ERNU3	Naked buckwheat	*Eriogonum nudum* Douglas ex Benth.
	ERPA8	Seacliff buckwheat	*Eriogonum parvifolium* Sm.
	ERPE6	Waldo buckwheat	*Eriogonum pendulum* S. Watson
	ERSP7	Rock buckwheat	*Eriogonum sphaerocephalum* Douglas ex Benth.
	ERST4	Blue Mountain buckwheat	*Eriogonum strictum* Benth.
	ERTH4	Thymeleaf buckwheat	*Eriogonum thymoides* Benth.
	ERUM	Sulphur-flower buckwheat	*Eriogonum umbellatum* Torr.
	FECY	California barrel cactus	*Ferocactus cylindraceus* (Engelm.) Orcutt
	FOSP2	Ocotilla	*Fouquieria splendens* Engelm.
	FRCA12	California buckthorn	*Frangula californica* (Eschsch.) A. Gray
	FRPU7	Cascara buckthorn	*Frangula purshiana* (DC.) A. Gray
	FRCA6	California flannelbush	*Fremontodendron californicum* (Torr.) Coville
	GABU2	Dwarf silktassel	*Garrya buxifolia* A. Gray

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	GACO9	Chaparral silktassel	*Garrya congdonii* Eastw.
	GAFR	Bearbrush	*Garrya fremontii* Torr.
	GAOV2	Western teaberry	*Gaultheria ovatifolia* A. Gray
	GASH	Salal	*Gaultheria shallon* Pursh
	GLTR	Honeylocust	*Gleditsia triacanthos* L.
	GRSP	Spiny hopsage	*Grayia spinosa* (Hook.) Moq.
	GUMI	Threadleaf snakeweed	*Gutierrezia microcephala* (DC.) A. Gray
	HASQ2	Sawtooth goldenbush	*Hazardia squarrosa* (Hook. & Arn.) Greene
	HEWH	Chaparral yucca	*Hesperoyucca whipplei* (Torr.) Baker
	HEAR5	Toyon	*Heteromeles arbutifolia* (Lindl.) M. Roem.
	HODI	Oceanspray	*Holodiscus discolor* (Pursh) Maxim.
	HYEM	Desert lavender	*Hyptis emoryi* Torr.
	ISME5	Menzies' goldenbush	*Isocoma menziesii* (Hook. & Arn.) G.L. Nesom
	JUCO6	Common juniper	*Juniperus communis* L.
	JUCA8	Beloperone	*Justicia californica* (Benth.) D. Gibson
	KAMI	Alpine laurel	*Kalmia microphylla* (Hook.) A. Heller
	KRLA2	Winterfat	*Krascheninnikovia lanata* (Pursh) A. Meeuse & Smit
	LATR2	Creosote bush	*Larrea tridentata* (DC.) Coville
	LEGL	Western Labrador tea	*Ledum glandulosum* Nutt.
	LEFR2	Desert pepperweed	*Lepidium fremontii* S. Watson
	LIDEE (NODEE)[1]	Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehder var. *echinoides* (R. Br. ter) Abrams
	LOHI2	Pink honeysuckle	*Lonicera hispidula* (Lindl.) Douglas ex Torr. & A. Gray
	LOUT2	Utah honeysuckle	*Lonicera utahensis* S. Watson
	LOSC2	Common deerweed	*Lotus scoparius* (Nutt.) Ottley
	LUPE	Partridgefoot	*Luetkea pectinata* (Pursh) Kuntze
	LYAN	Water jacket	*Lycium andersonii* A. Gray
	LYBR	Baja desert-thorn	*Lycium brevipes* Benth.
	MAAQ2	Hollyleaved barberry	*Mahonia aquifolium* (Pursh) Nutt.
	MANE2	Cascade barberry	*Mahonia nervosa* (Pursh) Nutt.
	MARE11	Creeping barberry	*Mahonia repens* (Lindl.) G. Don
	MAFA	Mendocino bushmallow	*Malacothamnus fasciculatus* (Nutt. ex Torr. & A. Gray) Greene
	MESP2	Spiny menodora	*Menodora spinescens* A. Gray
	MEFE	Rusty menziesia	*Menziesia ferruginea* Sm.
	NOBI	Bigelow's nolina	*Nolina bigelovii* (Torr.) S. Watson
	NOMI	Sacahuista	*Nolina microcarpa* S. Watson
	NOPA	Parry's beargrass	*Nolina parryi* S. Watson
	NODEE (LIDEE)[1]	Tanoak	*Notholithocarpus densiflorus* (Hook. & Arn.) P.S. Manos, C.H. Cannon, & S.H. Oh var. *echinoides* (R.BR. ter) P.S. Manos, C.h. Cannon & S.H. Oh
	OECE	Indian plum	*Oemleria cerasiformis* (Torr. & A. Gray ex Hook. & Arn.) Landon

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	OLTE	Desert ironwood	*Olneya tesota* A. Gray
	OPHO	Devilsclub	*Oplopanax horridus* (Sm.) Miq.
	OPBA2	Beavertail pricklypear	*Opuntia basilaris* Engelm. & J.M. Bigelow
	OPLI3	Coastal pricklypear	*Opuntia littoralis* (Engelm.) Cockerell
	OPPOE	Grizzlybear pricklypear	*Opuntia polyacantha* Haw. var. *erinacea* (Engelm. & J.M. Bigelow ex Engelm.) Parfitt
	PAFL6	Blue paloverde	*Parkinsonia florida* (Benth. ex A. Gray) S. Watson
	PAMY	Oregon boxleaf	*Paxistima myrsinites* (Pursh) Raf.
	PERA4	Wild crab apple	*Peraphyllum ramosissimum* Nutt.
	PHLE4	Lewis' mock orange	*Philadelphus lewisii* Pursh
	PHBR4	Purple mountainheath	*Phyllodoce breweri* (A. Gray) A. Heller
	PHEM	Pink mountainheath	*Phyllodoce empetriformis* (Sm.) D. Don
	PHMA5	Mallow ninebark	*Physocarpus malvaceus* (Greene) Kuntze
	PIMO5	Chaparral pea	*Pickeringia montana* Nutt. ex Torr. & A. Gray
	PIDE4	Bud sagebrush	*Picrothamnus desertorum* Nutt.
	POCO4	Sierra milkwort	*Polygala cornuta* Kellogg
	PRGL2	Honey mequite	*Prosopis glandulosa* Torr.
	PRGLT	Western honey mesquite	*Prosopis glandulosa* Torr. var. *torreyana* (L.D. Benson) M.C. Johnst.
	PRPU	Screwbean mesquite	*Prosopis pubescens* Benth.
	PSSP3	Smoketree	*Psorothamnus spinosus* (A. Gray) Barneby
	PUGL2	Desert bitterbrush	*Purshia glandulosa* Curran
	PUST	Stansbury cliffrose	*Purshia stansburiana* (Torr.) Henrickson
	PUTR2	Antelope bitterbrush	*Purshia tridentata* (Pursh) DC.
	RHIL	Hollyleaf redberry	*Rhamnus ilicifolia* Kellogg
	RHAL2	Cascade azalea	*Rhododendron albiflorum* Hook.
	RHMA3	Pacific rhododendron	*Rhododendron macrophyllum* D. Don ex G. Don
	RHOC	Western azalea	*Rhododendron occidentale* (Torr. & A. Gray) A. Gray
	RHGL	Smooth sumac	*Rhus glabra* L.
	RHIN2	Lemonade sumac	*Rhus integrifolia* (Nutt.) W.H. Brewer & S. Watson
	RHOV	Sugar sumac	*Rhus ovata* S. Watson
	RHTR	Skunkbush sumac	*Rhus trilobata* Nutt.
	RICE	Wax current	*Ribes cereum* Douglas
	RICR	Shinyleaf currant	*Ribes cruentum* Greene
	RILA	Prickly currant	*Ribes lacustre* (Pers.) Poir.
	RIMO2	Gooseberry currant	*Ribes montigenum* McClatchie
	RIRO	Sierra gooseberry	*Ribes roezlii* Regel
	RIVE	Desert gooseberry	*Ribes velutinum* Greene
	RIVI3	Sticky currant	*Ribes viscosissimum* Pursh
	ROGY	Dwarf rose	*Rosa gymnocarpa* Nutt.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	RUDI2	Himalayan blackberry	*Rubus discolor* Weihe & Nees
	RULA2	Roughfruit berry	*Rubus lasiococcus* A. Gray
	RULE	Whitebark raspberry	*Rubus leucodermis* Douglas ex Torr. & A. Gray
	RUNI2	Snow raspberry	*Rubus nivalis* Douglas ex Hook.
	RUPA	Thimbleberry	*Rubus parviflorus* Nutt.
	RUPE	Stawberryleaf raspberry	*Rubus pedatus* Sm.
	RUSP	Salmonberry	*Rubus spectabilis* Pursh
	RUUR	California blackberry	*Rubus ursinus* Cham. & Schltdl.
	SAME	Mexican bladdersage	*Salazaria mexicana* Torr.
	SADR	Drummond's willow	*Salix drummondiana* Barratt ex Hook.
	SAAP2	White sage	*Salvia apiana* Jeps.
	SADO4	Purple sage	*Salvia dorrii* (Kellogg) Abrams
	SAME3	Black sage	*Salvia mellifera* Greene
	SARA2	Red elderberry	*Sambucus racemosa* L.
	SAVE4	Greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.
	SEGR4	Catclaw acacia	*Senegalia greggii* (A. Gray) Britton & Rose
	SEAR8	Desert senna	*Senna armata* (S. Watson) Irwin & Barneby
	SHCA	Russet buffaloberry	*Shepherdia canadensis* (L.) Nutt.
	SICH	Jojoba	*Simmondsia chinensis* (Link) C.K. Schneid.
	SPBE2	White spirea	*Spiraea betulifolia* Pall.
	SPDO	Rose spirea	*Spiraea douglasii* Hook.
	SPSP2	Rose meadowsweet	*Spiraea splendens* Baumann ex K. Koch
	SYAL	Common snowberry	*Symphoricarpos albus* (L.) S.F. Blake
	SYMO	Creeping snowberry	*Symphoricarpos mollis* Nutt.
	SYOR2	Mountain snowberry	*Symphoricarpos oreophilus* A. Gray
	TESP2	Shortspine horsebrush	*Tetradymia spinosa* Hook. & Arn.
	THMO	Turpentinebroom	*Thamnosma montana* Torr. & Frém.
	TODI	Pacific poison oak	*Toxicodendron diversilobum* (Torr. & A. Gray) Greene
	VACA13	Dwarf bilberry	*Vaccinium caespitosum* Michx., orth. var.
	VADE	Cascade bilberry	*Vaccinium deliciosum* Piper
	VAME	Thinleaf huckleberry	*Vaccinium membranaceum* Douglas ex Torr.
	VAMY2	Whortleberry	*Vaccinium myrtillus* L.
	VAOV	Oval-leaf blueberry	*Vaccinium ovalifolium* Sm.
	VAOV2	California huckleberry	*Vaccinium ovatum* Pursh
	VAPA	Red huckleberry	*Vaccinium parvifolium* Sm.
	VASC	Grouse whortleberry	*Vaccinium scoparium* Leiberg ex Coville
	VAUL	Bog blueberry	*Vaccinium uliginosum* L.
	VIPA14	Parish's goldeneye	*Viguiera parishii* Greene
	WHMO	Common whipplea	*Whipplea modesta* Torr.
	XYBI	Misson manzanita	*Xylococcus bicolor* Nutt.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	YUBA	Banana yucca	*Yucca baccata* Torr.
	YUBR	Joshua tree	*Yucca brevifolia* Engelm.
	YUSC2	Mojave yucca	*Yucca schidigera* Roezl ex Ortgies
Graminoid:	ACHY	Indian ricegrass	*Achnatherum hymenoides* (Roem. & Schult.) Barkworth
	ACNE9	Columbia needlegrass	*Achnatherum nelsonii* (Scribn.) Barkworth
	ACOC3	Western needlegrass	*Achnatherum occidentale* (Thurb.) Barkworth
	ACRI8	Richardson's needlegrass	*Achnatherum richardsonii* (Link) Barkworth
	ACSC11	Scribner needlegrass	*Achnatherum scribneri* (Vasey) Barkworth
	ACTH7	Thurber's needlegrass	*Achnatherum thurberianum* (Piper) Barkworth
	ACRU2	Red baneberry	*Actaea rubra* (Aiton) Willd.
	AGSC5	Rough bentgrass	*Agrostis scabra* Willd.
	AVFA	Wild oat	*Avena fatua* L.
	BOGR2	Blue grama	*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths
	BRCA5	California brome	*Bromus carinatus* Hook. & Arn.
	BRDI3	Ripgut brome	*Bromus diandrus* Roth
	BRHO2	Soft brome	*Bromus hordeaceus* L.
	BRTE	Cheatgrass	*Bromus tectorum* L.
	BRVU	Columbia brome	*Bromus vulgaris* (Hook.) Shear
	CABR	Shorthair reedgrass	*Calamagrostis breweri* Thurb.
	CACA4	Bluejoint	*Calamagrostis canadensis* (Michx.) P. Beauv.
	CANU	Pacific reedgrass	*Calamagrostis nutkaensis* (J. Presl) J. Presl ex Steud.
	CARU	Pinegrass	*Calamagrostis rubescens* Buckley
	CAAM10	Bigleaf sedge	*Carex amplifolia* Boott
	CAAN15	Widefruit sedge	*Carex angustata* Boott
	CAAQ	Water sedge	*Carex aquatilis* Wahlenb.
	CAAQD	Sitka sedge	*Carex aquatilis* Wahlenb. var. *dives* (T. Holm) Kük.
	CABR12	Brewer's sedge	*Carex breweri* Boott
	CACO11	Northwestern sedge	*Carex concinnoides* Mack.
	CAEX4	Shorthair sedge	*Carex exserta* Mack.
	CAEX5	Western inflated sedge	*Carex exsiccata* L.H. Bailey
	CAGE2	Geyer's sedge	*Carex geyeri* Boott
	CAHEC	Holm sedge	*Carex heteroneura* W. Boott var. *chalciolepis* (T. Holm) F.J. Herm.
	CAHO5	Hood's sedge	*Carex hoodii* Boott
	CAIL	Sheep sedge	*Carex illota* L.H. Bailey
	CAIN9	Long-stolon sedge	*Carex inops* L.H. Bailey
	CALA10	Twotipped sedge	*Carex lachenalii* Schkuhr
	CAMI7	Smallwing sedge	*Carex microptera* Mack.
	CANE2	Nebraska sedge	*Carex nebrascensis* Dewey
	CANI2	Black alpine sedge	*Carex nigricans* C.A. Mey.
	CAOB4	Obtuse sedge	*Carex obtusata* Lilj.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	CAPA14	Chamisso sedge	*Carex pachystachya* Cham. ex Steud.
	CARO5	Ross' sedge	*Carex rossii* Boott
	CASC10	Northern singlespike sedge	*Carex scirpoidea* Michx.
	CASC11	Broom sedge	*Carex scoparia* Schkuhr ex Willd.
	CASI2	Analogue sedge	*Carex simulata* Mack.
	CASI3	Sitka sedge	*Carex sitchensis* Prescott ex Bong.
	CASP5	Showy sedge	*Carex spectabilis* Dewey
	CASU7	Nearlyblack sedge	*Carex subnigricans* Stacey
	CAUT	Northwest Territory sedge	*Carex utriculata* Boott
	CAVE5	Native sedge	*Carex vernacula* L.H. Bailey
	CYEC	Bristly dogstail grass	*Cynosurus echinatus* L.
	DAUN	Onespike danthonia	*Danthonia unispicata* (Thurb.) Munro ex Macoun
	DECE	Tufted hairgrass	*Deschampsia cespitosa* (L.) P. Beauv.
	DISP	Saltgrass	*Distichlis spicata* (L.) Greene
	ELMO2	Sand spikerush	*Eleocharis montevidensis* Kunth
	ELPA	Black sand spikerush	*Eleocharis pachycarpa* Desv.
	ELQU2	Fewflower spikerush	*Eleocharis quinqueflora* (Hartmann) O. Schwarz
	ELYMU	Wildrye spp.	*Elymus* L.
	ELEL5	Squirreltail	*Elymus elymoides* (Raf.) Swezey
	ELGL	Blue wildrye	*Elymus glaucus* Buckley
	ELLA3	Thickspike wheatgrass	*Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould
	ELTR7	Slender wheatgrass	*Elymus trachycaulus* (Link) Gould ex Shinners
	FECA	California fescue	*Festuca californica* Vasey
	FECA4	Rough fescue	*Festuca campestris* Rydb.
	FEID	Idaho fescue	*Festuca idahoensis* Elmer
	FEOC	Western fescue	*Festuca occidentalis* Hook.
	FERU2	Red fescue	*Festuca rubra* L.
	FEVI	Greenleaf fescue	*Festuca viridula* Vasey
	GLST	Fowl mannagrass	*Glyceria striata* (Lam.) Hitchc.
	HECO26	Needle and thread	*Hesperostipa comata* (Trin. & Rupr.) Barkworth
	JUARL	Mountain rush	*Juncus arcticus* Willd. ssp. *littoralis* (Engelm.) Hultén
	JUDR	Drummond's rush	*Juncus drummondii* E. Mey.
	JUME3	Mertens' rush	*Juncus mertensianus* Bong.
	KOMA	Prairie Junegrass	*Koeleria macrantha* (Ledeb.) Schult.
	LECI4	Basin wildrye	*Leymus cinereus* (Scribn. & Merr.) Á. Löve
	LECO12	Giant wildrye	*Leymus condensatus* (J. Presl) Á. Löve
	LEIN6	Downy ryegrass	*Leymus innovatus* (Beal) Pilg.
	LESA4	Saline wildrye	*Leymus salinus* (M.E. Jones) Á. Löve
	LUCA2	Field woodrush	*Luzula campestris* (L.) DC.
	LUDI	Forked woodrush	*Luzula divaricata* S. Watson

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	LUGL2	Smooth woodrush	*Luzula glabrata* (Hoppe ex Rostk.) Desv.
	MECA2	California melicgrass	*Melica californica* Scribn.
	NACE	Nodding needlegrass	*Nassella cernua* (Stebbins & R.M. Love) Barkworth
	NALE2	Foothill needlegrass	*Nassella lepida* (Hitchc.) Barkworth
	NAPU4	Purple needlegrass	*Nassella pulchra* (Hitchc.) Barkworth
	PASM	Western wheatgrass	*Pascopyrum smithii* (Rydb.) Á. Löve
	PHAL	Icegrass	*Phippsia algida* (Sol.) R. Br.
	PLRI3	Big galleta	*Pleuraphis rigida* Thurb.
	POBO	Bolander's bluegrass	*Poa bolanderi* Vasey
	POBU	Bulbous bluegrass	*Poa bulbosa* L.
	POCU3	Cusick's bluegrass	*Poa cusickii* Vasey
	POPR	Kentucky bluegrass	*Poa pratensis* L.
	POSE	Sandberg bluegrass	*Poa secunda* J. Presl
	POWH2	Wheeler's bluegrass	*Poa wheeleri* Vasey
	PSSP6	Bluebunch wheatgrass	*Pseudoroegneria spicata* (Pursh) Á. Löve
	SCMI2	Panicled bulrush	*Scirpus microcarpus* J. Presl & C. Presl
	SPAI	Alkali sacaton	*Sporobolus airoides* (Torr.) Torr.
	TACA8	Medusahead	*Taeniatherum caput-medusae* (L.) Nevski
	TRSP2	Spike trisetum	*Trisetum spicatum* (L.) K. Richt.
	VUMI	Small fescue	*Vulpia microstachys* (Nutt.) Munro
Forb:	ACMI2	Common yarrow	*Achillea millefolium* L.
	ACMIO	Western yarrow	*Achillea millefolium* L. var. *occidentalis* DC.
	ACTR	Sweet after death	*Achlys triphylla* (Sm.) DC.
	ACONI	Monkshood spp.	*Aconitum* L.
	ADBI	American trailplant	*Adenocaulon bicolor* Hook.
	ADPE	Northern maidenhair	*Adiantum pedatum* L.
	AGUR	Nettleleaf giant hyssop	*Agastache urticifolia* (Benth.) Kuntze
	ALLIU	Onion spp.	*Allium* L.
	ALFA3	Scytheleaf onion	*Allium falcifolium* Hook. & Arn.
	AMME	Menzies' fiddleneck	*Amsinckia menziesii* (Lehm.) A. Nelson & J.F. Macbr.
	ANMA	Western pearly everlasting	*Anaphalis margaritacea* (L.) Benth.
	ANDE3	Columbian windflower	*Anemone deltoidea* Hook.
	ANAR3	Lyall's angelica	*Angelica arguta* Nutt.
	ANBR5	Brewer's angelica	*Angelica breweri* A. Gray
	ANTEN	Pussytoes spp.	*Antennaria* Gaertn.
	ANME2	Rocky mountain pussytoes	*Antennaria media* Greene
	APAN2	Spreading dogbane	*Apocynum androsaemifolium* L.
	ARSU	Klamath rockcress	*Arabis subpinnatifida* S. Watson
	ARCA2	California spikenard	*Aralia californica* S. Watson
	ARNU2	Wild sarsaparilla	*Aralia nudicaulis* L.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	ARCA7	Slender mountain sandwort	*Arenaria capillaris* Poir.
	ARCO9	Heartleaf arnica	*Arnica cordifolia* Hook.
	ARLA8	Broadleaf arnica	*Arnica latifolia* Bong.
	ARSP4	Klamath arnica	*Arnica spathulata* Greene
	ASCA2	British Columbia wildginger	*Asarum caudatum* Lindl.
	ASHA	Hartweg's wildginger	*Asarum hartwegii* S. Watson
	ASDE6	Indian's dream	*Aspidotis densa* (Brack.) Lellinger
	ATFI	Common ladyfern	*Athyrium filix-femina* (L.) Roth
	BASA3	Arrowleaf balsamroot	*Balsamorhiza sagittata* (Pursh) Nutt.
	BALSA	Balsamroot spp.	*Balsamorhiza* Nutt.
	BLSP	Deer fern	*Blechnum spicant* (L.) Sm.
	BRCO3	Crown brodiaea	*Brodiaea coronaria* (Salisb.) Engl.
	CATO	Tolmie star-tulip	*Calochortus tolmiei* Hook. & Arn.
	CALE4	White marsh marigold	*Caltha leptosepala* DC.
	CAMPA	Bellflower spp.	*Campanula* L.
	CARO2	Bluebell bellflower	*Campanula rotundifolia* L.
	CANU17	Nuttall's toothwort	*Cardamine nuttallii* Greene
	CHAN9	Fireweed	*Chamerion angustifolium* (L.) Holub
	CHME	Little prince's pine	*Chimaphila menziesii* (R. Br. ex D. Don) Spreng.
	CHUM	Pipsissewa	*Chimaphila umbellata* (L.) W.P.C. Barton
	CIVU	Bull thistle	*Cirsium vulgare* (Savi) Ten.
	CIUM	Mt. Hood pussypaws	*Cistanthe umbellata* (Torr.) Hershkovitz
	CLGR	Slender clarkia	*Clarkia gracilis* (Piper) A. Nelson & J.F. Macbr.
	CLSI2	Siberian springbeauty	*Claytonia sibirica* L.
	CLDO2	Yerba buena	*Clinopodium douglasii* (Benth.) Kuntze
	CLAN2	Andrew's clintonia	*Clintonia andrewsiana* Torr.
	CLUN2	Bride's bonnet	*Clintonia uniflora* (Menzies ex Schult. & Schult. f.) Kunth
	COLI2	Tiny trumpet	*Collomia linearis* Nutt.
	COTE3	Slender bird's beak	*Cordylanthus tenuis* A. Gray
	DAMO2	Soft prairie clover	*Dalea mollissima* (Rydb.) Munz
	DACA5	California pitcherplant	*Darlingtonia californica* Torr.
	DAPE	Indian rhubarb	*Darmera peltata* (Torr. ex Benth.) Voss
	DAFR6	Shrubby cinquefoil	*Dasiphora fruticosa* (L.) Rydb.
	DELPH	Larkspur spp.	*Delphinium* L.
	DOAL	Alpine shootingstar	*Dodecatheon alpinum* (A. Gray) Greene
	DRAR3	Coastal woodfern	*Dryopteris arguta* (Kaulf.) Watt
	DRCA11	Spinulose woodfern	*Dryopteris carthusiana* (Vill.) H.P. Fuchs
	DREX2	Spreading woodfern	*Dryopteris expansa* (C. Presl) Fraser-Jenkins & Jermy
	EQAR	Field horsetail	*Equisetum arvense* L.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	ERIGE2	Fleabane spp.	*Erigeron* L.
	ERAL18	Stalked fleabane	*Erigeron algidus* Jeps.
	ERGL3	Seaside fleabane	*Erigeron glaucus* Ker Gawl.
	ERCO12	Arrowleaf buckwheat	*Eriogonum compositum* Douglas ex Benth.
	ERCO25	Golden-yarrow	*Eriophyllum confertiflorum* (DC.) A. Gray
	ERST9	Seaside woolly sunflower	*Eriophyllum stoechadifolium* Lag.
	ERCA15	California fawnlily	*Erythronium californicum* Purdy
	ERHE7	Henderson's fawnlily	*Erythronium hendersonii* S. Watson
	ERMO8	White avalanche-lily	*Erythronium montanum* S. Watson
	FRVE	Woodland strawberry	*Fragaria vesca* L.
	FRVI	Virginia strawberry	*Fragaria virginiana* Duchesne
	GAAM2	Yolla bolly bedstraw	*Galium ambiguum* W. Wight
	GAAN	Phloxleaf bedstraw	*Galium andrewsii* A. Gray
	GABO	Bolander's bedstraw	*Galium bolanderi* A. Gray
	GASE2	Intermountain bedstraw	*Galium serpenticum* Dempster
	GATR3	Fragrant bedstraw	*Galium triflorum* Michx.
	GADI2	Spreading groundsmoke	*Gayophytum diffusum* Torr. & A. Gray
	GEVI2	Sticky purple geranium	*Geranium viscosissimum* Fisch. & C.A. Mey. ex C.A. Mey.
	GOOB2	Western rattlesnake plantain	*Goodyera oblongifolia* Raf.
	GYDR	Western oakfern	*Gymnocarpium dryopteris* (L.) Newman
	HACKE	Stickseed spp.	*Hackelia* Opiz
	HEBI	Bigelow's sneezeweed	*Helenium bigelovii* A. Gray
	HELIA	Helianthella spp.	*Helianthella* Torr. & A. Gray
	HEMA80	Common cowparsnip	*Heracleum maximum* W. Bartram
	HEMI9	Smallflower dwarf-flax	*Hesperolinon micranthum* (A. Gray) Small
	HIAL2	White hawkweed	*Hieracium albiflorum* Hook.
	HIBO	Bolander's hawkweed	*Hieracium bolanderi* A. Gray
	HICY	Houndstongue hawkweed	*Hieracium cynoglossoides* Arv.-Touv.
	HOSE	Silky horkelia	*Horkelia sericata* S. Watson
	HOTR	Threetooth horkelia	*Horkelia tridentata* Torr.
	HOPU8	Purple false horkelia	*Horkeliella purpurascens* (S. Watson) Rydb.
	IRBR	Siskiyou iris	*Iris bracteata* S. Watson
	IRCH	Yellowleaf iris	*Iris chrysophylla* Howell
	IRIN	Del Norte County iris	*Iris innominata* L.F. Hend.
	IRTE3	Longtube iris	*Iris tenuissima* Dykes
	KEGA	Milk kelloggia	*Kelloggia galioides* Torr.
	LEPU	Granite prickly phlox	*Leptodactylon pungens* (Torr.) Torr. ex Nutt.
	LIPU11	Granite prickly phlox	*Linanthus pungens* (Torr.) J.M. Porter & L.A. Johnson
	LEPY2	Alpine lewisia	*Lewisia pygmaea* (A. Gray) B.L. Rob.
	LERE7	Bitter root	*Lewisia rediviva* Pursh

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	LIGUS	Licorice-root spp.	*Ligusticum* L.
	LIGR	Gray's licorice-root	*Ligusticum grayi* J.M. Coult. & Rose
	LIBO	Bolander's lily	*Lilium bolanderi* S. Watson
	LIBO2	Bolander's linanthus	*Linanthus bolanderi* (A. Gray) Greene
	LIBO3	Twinflower	*Linnaea borealis* L.
	LOMA3	Bigseed biscuitroot	*Lomatium macrocarpum* (Nutt. ex Torr. & A. Gray) J.M. Coult. & Rose
	LOMAT	Desertparsley spp.	*Lomatium* Raf.
	LOTR2	Nineleaf biscuitroot	*Lomatium triternatum* (Pursh) J.M. Coult. & Rose
	LOCR	Big deervetch	*Lotus crassifolius* (Benth.) Greene
	LOUN	American bird's-foot trefoil	*Lotus unifoliolatus* (Hook.) Benth.
	LUPIN	Lupine spp.	*Lupinus* L.
	LUAR	Yellow bush lupine	*Lupinus arboreus* Sims
	LUCA	Tailcup lupine	*Lupinus caudatus* Kellogg
	LUCH	Chamisso bush lupine	*Lupinus chamissonis* Eschsch.
	LULA4	Broadleaf lupine	*Lupinus latifolius* Lindl. ex J. Agardh
	LULE2	Pacific lupine	*Lupinus lepidus* Douglas ex Lindl.
	LUSE4	Silky lupine	*Lupinus sericeus* Pursh
	LYAM3	American skunkcabbage	*Lysichiton americanus* Hultén & H. St. John
	MADI	False lily of the valley	*Maianthemum dilatatum* (Alph. Wood) A. Nelson & J.F. Macbr.
	MARA7	Feathery false lily of the valley	*Maianthemum racemosum* (L.) Link
	MAST4	Starry false lily of the valley	*Maianthemum stellatum* (L.) Link
	MERTE	Bluebells spp.	*Mertensia* Roth
	MIDO3	Douglas' stitchwort	*Minuartia douglasii* (Fenzl ex Torr. & A. Gray) Mattf.
	MINU4	Nuttall's sandwort	*Minuartia nuttallii* (Pax) Briq.
	MOAN	San Antonio Hills monardella	*Monardella antonina* Hardham
	MOOD	Mountain monardella	*Monardella odoratissima* Benth.
	NEST5	Narrowleaf mock goldenweed	*Nestotus stenophyllus* (A. Gray) R.P. Roberts, Urbatsch & Neubig
	ORAL4	Tundra aster	*Oreostemma alpigenum* (Torr. & A. Gray) Greene
	ORSE	Sidebells wintergreen	*Orthilia secunda* (L.) House
	OSBE	Sweetcicely	*Osmorhiza berteroi* DC.
	OSMOR	Sweetroot spp.	*Osmorhiza* Raf.
	OXOR	Redwood-sorrel	*Oxalis oregana* Nutt.
	PAFI3	Fringed grass of Parnassus	*Parnassia fimbriata* K.D. Koenig
	PESE2	Pinewoods lousewort	*Pedicularis semibarbata* A. Gray
	PEDE	Indian warrior	*Pedicularis densiflora* Benth. ex Hook.
	PEAZ	Azure penstemon	*Penstemon azureus* Benth.
	PENST	Beardtongue spp.	*Penstemon* Schmidel
	PHPR	Pringle's phacelia	*Phacelia pringlei* A. Gray
	PHDI3	Spreading phlox	*Phlox diffusa* Benth.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	PLNO	Rusty popcornflower	*Plagiobothrys nothofulvus* (A. Gray) A. Gray
	PLMA3	Goose tongue	*Plantago maritima* L.
	POPU3	Jacob's-ladder	*Polemonium pulcherrimum* Hook.
	POBI6	American bistort	*Polygonum bistortoides* Pursh
	PODA	Davis' knotweed	*Polygonum davisiae* W.H. Brewer ex A. Gray
	PODO4	Douglas' knotweed	*Polygonum douglasii* Greene
	POPH	Poke knotweed	*Polygonum phytolaccifolium* Meisn. ex Small
	POCA12	California polypody	*Polypodium californicum* Kaulf.
	POLE5	Lemmon's hollyfern	*Polystichum lemmonii* Underw.
	POMU	Western swordfern	*Polystichum munitum* (Kaulf.) C. Presl
	PODR	Drummond's cinquefoil	*Potentilla drummondii* Lehm.
	PRHO2	Drops-of-gold	*Prosartes hookeri* Torr.
	PRHOH	Drops-of-gold	*Prosartes hookeri* Torr. var. *hookeri*
	PRSM	Largeflower fairybells	*Prosartes smithii* (Hook.) Utech, Shinwari & Kawano
	PRTR4	Roughfruit fairybells	*Prosartes trachycarpa* S. Watson
	PTAQ	Western brackenfern	*Pteridium aquilinum* (L.) Kuhn
	PYAS	Liverleaf wintergreen	*Pyrola asarifolia* Michx.
	PYPI2	Whiteveined wintergreen	*Pyrola picta* Sm.
	ROAL	Alpine yellowcress	*Rorippa alpina* (S. Watson) Rydb.
	RUCA3	California coneflower	*Rudbeckia californica* A. Gray
	RUOC2	Western coneflower	*Rudbeckia occidentalis* Nutt.
	SELA2	Roseflower stonecrop	*Sedum laxum* (Britton) A. Berger
	SEOB	Sierra stonecrop	*Sedum obtusatum* A. Gray
	SEIN2	Lambstongue ragwort	*Senecio integerrimus* Nutt.
	SENEC	Ragwort spp.	*Senecio* L.
	SETR	Arrowleaf ragwort	*Senecio triangularis* Hook.
	SIPR	Creeping sibbaldia	*Sibbaldia procumbens* L.
	SIOR	Oregon checkerbloom	*Sidalcea oregana* (Nutt. ex Torr. & A. Gray) A. Gray
	SOMU	Rocky Mountain goldenrod	*Solidago multiradiata* Aiton
	SOLID	Goldenrod spp.	*Solidago* L.
	SPGR2	Gooseberryleaf globemallow	*Sphaeralcea grossulariifolia* (Hook. & Arn.) Rydb.
	STBA2	Pacific jewelflower	*Streptanthus barbatus* S. Watson
	STBA3	Bearded jewelflower	*Streptanthus barbiger* Greene
	STAM2	Claspleaf twistedstalk	*Streptopus amplexifolius* (L.) DC.
	STLA16	Twistedstalk	*Streptopus lanceolatus* (Aiton) Reveal
	SYRE	Snowqueen	*Synthyris reniformis* (Douglas ex Benth.) Benth.
	THFE	Fendler's meadow-rue	*Thalictrum fendleri* Engelm. ex A. Gray var. fendleri
	THOC	Western meadow-rue	*Thalictrum occidentale* A. Gray
	THALI2	Meadow-rue spp.	*Thalictrum* L.
	TITR	Threeleaf foamflower	*Tiarella trifoliata* L.

Table A5.1—Life form, species symbol, common name, scientific name and authority of all species mentioned in this report (continued)

Life form	Species symbol	Common name	Scientific name and authority
	TOME	Youth on age	*Tolmiea menziesii* (Pursh) Torr. & A. Gray
	TOAR	Spreading hedgeparsley	*Torilis arvensis* (Huds.) Link
	TRCA	Carolina bugbane	*Trautvetteria caroliniensis* (Walter) Vail
	TRBO2	Starflower	*Trientalis borealis* Raf.
	TRPA5	Parry's clover	*Trifolium parryi* A. Gray
	TRVA	Whitetip clover	*Trifolium variegatum* Nutt.
	TROV2	Pacific trillium	*Trillium ovatum* Pursh
	TRIX	Prettyface	*Triteleia ixioides* (W.T. Aiton) Greene
	TRLA14	American globeflower	*Trollius laxus* Salisb.
	URDI	Stinging nettle	*Urtica dioica* L.
	VASI	Sitka valerian	*Valeriana sitchensis* Bong.
	VALER	Valerian spp.	*Valeriana* L.
	VACH2	Golden insideout flower	*Vancouveria chrysantha* Greene
	VECA2	California false hellebore	*Veratrum californicum* Durand
	VERAT	False hellebore spp.	*Veratrum* L.
	VECA9	Red Hills vervain	*Verbena californica* Moldenke
	VIGL	Pioneer violet	*Viola glabella* Nutt.
	VIOC	Pinto violet	*Viola ocellata* Torr. & A. Gray
	VIOR	Darkwoods violet	*Viola orbiculata* Geyer ex Holz.
	VIPU4	Goosefoot violet	*Viola purpurea* Kellogg
	VISE3	Evergreen violet	*Viola sempervirens* Greene
	VISH	Shelton's violet	*Viola sheltonii* Torr.
	WOFI	Giant chainfern	*Woodwardia fimbriata* Sm.
	WYMO	Woolly mule-ears	*Wyethia mollis* A. Gray
	WYETH	Mule-ears spp.	*Wyethia* Nutt.
	XETE	Common beargrass	*Xerophyllum tenax* (Pursh) Nutt.
	XYGL	Smooth woodyaster	*Xylorhiza glabriuscula* Nutt.
	ZIMI2	Smallflower deathcamas	*Zigadenus micranthus* Eastw.

[1] The current scientific name of tanoak is *Notholithocarpus densiflorus* (NODE3), and the former scientific name was *Lithocarpus densiflorus* (LIDE3). LIDEE and NODEE are the shrub form of tanoak. Both current and former names are listed because maps may reference the former names.

Source: Common names, scientific names, and species symbols are from USDA PLANTS Database (USDA NRCS, n.d.).

Appendix 6: Species Groups and Key Indicator Species (Bin Species)

Using both the U.S. Department of Agriculture, Forest Service's Forest Inventory and Analysis plots and Pacific Southwest and Pacific Northwest Regions' ecology plots (collected primarily to support development of plant association guides), we examined species distributions with respect to climatic variables and their similarities to one another in species-composition space. Based on the analysis of the ecology and inventory plots, we established nine species groups indicating different combinations of temperature and moisture regimes and a separate list of species that indicated serpentine substrates. We identified key indicator species from each plant association guide and used representative species to develop a set of indicators for the potential natural vegetation mapping process. See the "Methods" section and table 3 for more information. This spreadsheet shows the species groups and key indicator species that we used for subzone classification. The species groups were ordered hierarchically (left to right) from most productive (e.g., warm and wet) to least productive (e.g., xeric). Scientific names and species symbols are from USDA PLANTS Database (USDA NRCS, n.d.)

Download appendix 6 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 7: Vegzone Fuzzy Match Set

We created confusion matrices based on both "strict" and "fuzzy" classifications. In the strict version, an assignment was recorded as correct if there was an exact match between the observed plot assignment and the predicted assignment using the nearest-independent neighbor method (therefore we do not provide a confusion matrix for strict match classifications). For fuzzy classification, we constructed lists for each vegzone of other types sufficiently similar in their environmental relationships and floristic composition that interpretation of the map would not significantly suffer if the assignments were swapped.

Table A7.1—Confusion matrix for fuzzy match classifications of vegzones

Vegzone number	Vegzone name	Vegzone number—fuzzy match	Vegzone name—fuzzy match
4	Grasslands-meadows	4	Grasslands-meadows
5	Shrublands	5	Shrublands
6	Pinyon-juniper-cypress	6	Pinyon-juniper-cypress
6	Pinyon-juniper-cypress	10	Ponderosa pine
6	Pinyon-juniper-cypress	12	Jeffrey pine
6	Pinyon-juniper-cypress	30	Parklands
7	California foothill pine-Coulter pine	7	California foothill pine-Coulter pine
7	California foothill pine-Coulter pine	10	Ponderosa pine
7	California foothill pine-Coulter pine	11	Hardwoods
7	California foothill pine-Coulter pine	14	Douglas-fir
8	Lodgepole pine	8	Lodgepole pine
8	Lodgepole pine	10	Ponderosa pine
8	Lodgepole pine	11	Hardwoods
8	Lodgepole pine	20	White fir-grand fir
8	Lodgepole pine	21	California red fir-Shasta red fir
8	Lodgepole pine	23	Mountain hemlock
9	Sitka spruce	9	Sitka spruce
9	Sitka spruce	17	Redwood
9	Sitka spruce	19	Western hemlock
10	Ponderosa pine	6	Pinyon-juniper-cypress
10	Ponderosa pine	7	California foothill pine-Coulter pine
10	Ponderosa pine	8	Lodgepole pine
10	Ponderosa pine	10	Ponderosa pine
10	Ponderosa pine	11	Hardwoods
10	Ponderosa pine	12	Jeffrey pine
10	Ponderosa pine	14	Douglas-fir
10	Ponderosa pine	20	White fir-grand fir
10	Ponderosa pine	21	California red fir-Shasta red fir
11	Hardwoods	7	California foothill pine-Coulter pine
11	Hardwoods	8	Lodgepole pine
11	Hardwoods	10	Ponderosa pine

Table A7.1—Confusion matrix for fuzzy match classifications of vegzones (continued)

Vegzone number	Vegzone name	Vegzone number—fuzzy match	Vegzone name—fuzzy match
11	Hardwoods	11	Hardwoods
11	Hardwoods	12	Jeffrey pine
11	Hardwoods	14	Douglas-fir
12	Jeffrey pine	6	Pinyon-juniper-cypress
12	Jeffrey pine	10	Ponderosa pine
12	Jeffrey pine	11	Hardwoods
12	Jeffrey pine	12	Jeffrey pine
12	Jeffrey pine	13	Port Orford cedar
12	Jeffrey pine	14	Douglas-fir
12	Jeffrey pine	15	Tanoak
12	Jeffrey pine	16	Giant sequoia
12	Jeffrey pine	20	White fir-grand fir
12	Jeffrey pine	21	California red fir-Shasta red fir
12	Jeffrey pine	30	Parklands
13	Port Orford cedar	12	Jeffrey pine
13	Port Orford cedar	13	Port Orford cedar
13	Port Orford cedar	14	Douglas-fir
13	Port Orford cedar	15	Tanoak
13	Port Orford cedar	19	Western hemlock
14	Douglas-fir	7	California foothill pine-Coulter pine
14	Douglas-fir	10	Ponderosa pine
14	Douglas-fir	11	Hardwoods
14	Douglas-fir	12	Jeffrey pine
14	Douglas-fir	13	Port Orford cedar
14	Douglas-fir	14	Douglas-fir
14	Douglas-fir	15	Tanoak
14	Douglas-fir	18	Western redcedar
14	Douglas-fir	19	Western hemlock
14	Douglas-fir	20	White fir-grand fir
14	Douglas-fir	25	Subalpine fir-Engelmann spruce
15	Tanoak	12	Jeffrey pine
15	Tanoak	13	Port Orford cedar
15	Tanoak	14	Douglas-fir
15	Tanoak	15	Tanoak
15	Tanoak	17	Redwood
15	Tanoak	19	Western hemlock
16	Giant sequoia	12	Jeffrey pine-knobcone pine
16	Giant sequoia	16	Giant sequoia
16	Giant sequoia	20	White fir-grand fir
17	Redwood	9	Sitka spruce

Table A7.1—Confusion matrix for fuzzy match classifications of vegzones (continued)

Vegzone number	Vegzone name	Vegzone number—fuzzy match	Vegzone name—fuzzy match
17	Redwood	15	Tanoak
17	Redwood	17	Redwood
18	Western redcedar	14	Douglas-fir
18	Western redcedar	18	Western redcedar
18	Western redcedar	19	Western hemlock
18	Western redcedar	20	White fir-grand fir
19	Western hemlock	9	Sitka spruce
19	Western hemlock	13	Port Orford cedar
19	Western hemlock	14	Douglas-fir
19	Western hemlock	15	Tanoak
19	Western hemlock	18	Western redcedar
19	Western hemlock	19	Western hemlock
19	Western hemlock	20	White fir-grand fir
19	Western hemlock	22	Pacific silver fir
20	White fir-grand fir	8	Lodgepole pine
20	White fir-grand fir	10	Ponderosa pine
20	White fir-grand fir	12	Jeffrey pine
20	White fir-grand fir	14	Douglas-fir
20	White fir-grand fir	16	Giant sequoia
20	White fir-grand fir	18	Western redcedar
20	White fir-grand fir	19	Western hemlock
20	White fir-grand fir	20	White fir-grand fir
20	White fir-grand fir	21	California red fir-Shasta red fir
20	White fir-grand fir	22	Pacific silver fir
20	White fir-grand fir	23	Mountain hemlock
20	White fir-grand fir	25	Subalpine fir-Engelmann spruce
21	California red fir-Shasta red fir	8	Lodgepole pine
21	California red fir-Shasta red fir	10	Ponderosa pine
21	California red fir-Shasta red fir	12	Jeffrey pine
21	California red fir-Shasta red fir	20	White fir-grand fir
21	California red fir-Shasta red fir	21	California red fir-Shasta red fir
21	California red fir-Shasta red fir	23	Mountain hemlock
21	California red fir-Shasta red fir	30	Parklands
22	Pacific silver fir	19	Western hemlock
22	Pacific silver fir	20	White fir-grand fir
22	Pacific silver fir	22	Pacific silver fir
22	Pacific silver fir	23	Mountain hemlock
23	Mountain hemlock	8	Lodgepole pine
23	Mountain hemlock	20	White fir-grand fir
23	Mountain hemlock	21	California red fir-Shasta red fir

Table A7.1—Confusion matrix for fuzzy match classifications of vegzones (continued)

Vegzone number	Vegzone name	Vegzone number—fuzzy match	Vegzone name—fuzzy match
23	Mountain hemlock	22	Pacific silver fir
23	Mountain hemlock	23	Mountain hemlock
23	Mountain hemlock	25	Subalpine fir-Engelmann spruce
23	Mountain hemlock	30	Parklands
25	Subalpine fir-Engelmann spruce	14	Douglas-fir
25	Subalpine fir-Engelmann spruce	20	White fir-grand fir
25	Subalpine fir-Engelmann spruce	23	Mountain hemlock
25	Subalpine fir-Engelmann spruce	25	Subalpine fir-Engelmann spruce
25	Subalpine fir-Engelmann spruce	30	Parklands
30	Parklands	6	Pinyon-juniper-cypress
30	Parklands	12	Jeffrey pine
30	Parklands	21	California red fir-Shasta red fir
30	Parklands	23	Mountain hemlock
30	Parklands	25	Subalpine fir-Engelmann spruce
30	Parklands	30	Parklands

Source: Common names are from USDA PLANTS Database (USDA NRCS, n.d.).

Appendix 8: Subzone Fuzzy Match Set

We created confusion matrices based on both "strict" and "fuzzy" classifications. In the strict version, an assignment was recorded as correct if there was an exact match between the observed plot assignment and the predicted assignment using the nearest-independent neighbor method (therefore we do not provide a confusion matrix for strict match classifications). For fuzzy classification, we constructed lists for each subzone of other types sufficiently similar in their environmental relationships and floristic composition that interpretation of the map would not significantly suffer if the assignments were swapped.

Table A8.1—Confusion matrix for fuzzy match classifications of subzones

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Shrublands	–17	Creosote-bursage scrub	–17	Creosote-bursage scrub
Shrublands	–14	Chaparral	–14	Chaparral
Shrublands	–13	Montane shrub	–13	Montane shrub
Shrublands	–12	Upland shrub	–12	Upland shrub
Grasslands-meadows	–6	Upland grass	–6	Upland grass
Rock	3	Rock	3	Rock
Hardwoods	15	Riparian shrub	15	Riparian shrub
Hardwoods	15	Riparian shrub	16	Riparian hardwood forest
Hardwoods	16	Riparian hardwood forest	15	Riparian shrub
Hardwoods	16	Riparian hardwood forest	16	Riparian hardwood forest
Hardwoods	17	Other hardwoods	17	Other hardwoods
Hardwoods	17	Other hardwoods	18	Oak woodlands
Hardwoods	17	Other hardwoods	29	Monterey pine-bishop pine
Hardwoods	17	Other hardwoods	35	Coulter pine-oak
Hardwoods	17	Other hardwoods	36	California foothill pine-oak
Hardwoods	18	Oak woodlands	17	Other hardwoods
Hardwoods	18	Oak woodlands	18	Oak woodlands
Hardwoods	18	Oak woodlands	34	Ponderosa pine-oak
Hardwoods	18	Oak woodlands	35	Coulter pine-oak
Hardwoods	18	Oak woodlands	36	California foothill pine-oak
Hardwoods	18	Oak woodlands	39	Knobcone pine
Hardwoods	18	Oak woodlands	40	Bigcone Douglas-fir
Hardwoods	19	Desert hardwoods	19	Desert hardwoods
Pinyon-juniper-cypress	21	Juniper scablands	21	Juniper scablands
Pinyon-juniper-cypress	21	Juniper scablands	22	Juniper woodlands
Pinyon-juniper-cypress	21	Juniper scablands	30	Ponderosa pine-juniper woodlands
Pinyon-juniper-cypress	21	Juniper scablands	37	Jeffrey pine/warm-xeric
Pinyon-juniper-cypress	22	Juniper woodlands	21	Juniper scablands
Pinyon-juniper-cypress	22	Juniper woodlands	22	Juniper woodlands
Pinyon-juniper-cypress	22	Juniper woodlands	23	Pinyon woodlands
Pinyon-juniper-cypress	22	Juniper woodlands	30	Ponderosa pine-juniper woodlands

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Pinyon-juniper-cypress	22	Juniper woodlands	37	Jeffrey pine/warm-xeric
Pinyon-juniper-cypress	23	Pinyon woodlands	22	Juniper woodlands
Pinyon-juniper-cypress	23	Pinyon woodlands	23	Pinyon woodlands
Pinyon-juniper-cypress	23	Pinyon woodlands	37	Jeffrey pine/warm-xeric
Pinyon-juniper-cypress	23	Pinyon woodlands	38	Jeffrey pine/warm-dry
Pinyon-juniper-cypress	23	Pinyon woodlands	96	Limber pine parklands
Pinyon-juniper-cypress	24	Cypress woodlands	24	Cypress woodlands
Lodgepole pine	25	Lodgepole pine/cool-dry	25	Lodgepole pine/cool-dry
Lodgepole pine	25	Lodgepole pine/cool-dry	33	Ponderosa pine-lodgepole pine
Lodgepole pine	25	Lodgepole pine/cool-dry	59	White fir-grand fir/cool-moist
Lodgepole pine	25	Lodgepole pine/cool-dry	71	California red fir-Shasta red fir/cool-moist
Lodgepole pine	25	Lodgepole pine/cool-dry	91	Mountain hemlock/cold-very moist
Monterey pine-bishop pine	29	Monterey pine-bishop pine	17	Other hardwoods
Monterey pine-bishop pine	29	Monterey pine-bishop pine	29	Monterey pine-bishop pine
Ponderosa pine	30	Ponderosa pine-juniper woodlands	21	Juniper scablands
Ponderosa pine	30	Ponderosa pine-juniper woodlands	22	Juniper woodlands
Ponderosa pine	30	Ponderosa pine-juniper woodlands	30	Ponderosa pine-juniper woodlands
Ponderosa pine	30	Ponderosa pine-juniper woodlands	31	Ponderosa pine/warm-xeric
Ponderosa pine	30	Ponderosa pine-juniper woodlands	33	Ponderosa pine-lodgepole pine
Ponderosa pine	30	Ponderosa pine-juniper woodlands	37	Jeffrey pine/warm-xeric
Ponderosa pine	30	Ponderosa pine-juniper woodlands	38	Jeffrey pine/warm-dry
Ponderosa pine	31	Ponderosa pine/warm-xeric	30	Ponderosa pine-juniper woodlands
Ponderosa pine	31	Ponderosa pine/warm-xeric	31	Ponderosa pine/warm-xeric
Ponderosa pine	31	Ponderosa pine/warm-xeric	33	Ponderosa pine-lodgepole pine
Ponderosa pine	31	Ponderosa pine/warm-xeric	34	Ponderosa pine-oak
Ponderosa pine	31	Ponderosa pine/warm-xeric	37	Jeffrey pine/warm-xeric
Ponderosa pine	31	Ponderosa pine/warm-xeric	38	Jeffrey pine/warm-dry
Ponderosa pine	31	Ponderosa pine/warm-xeric	41	Douglas-fir/very warm-dry
Ponderosa pine	31	Ponderosa pine/warm-xeric	42	Douglas-fir/warm-dry
Ponderosa pine	31	Ponderosa pine/warm-xeric	56	White fir-grand fir/warm-xeric
Ponderosa pine	33	Ponderosa pine-lodgepole pine	25	Lodgepole pine/cool-dry
Ponderosa pine	33	Ponderosa pine-lodgepole pine	30	Ponderosa pine-juniper woodlands

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Ponderosa pine	33	Ponderosa pine-lodgepole pine	31	Ponderosa pine/warm-xeric
Ponderosa pine	33	Ponderosa pine-lodgepole pine	33	Ponderosa pine-lodgepole pine
Ponderosa pine	33	Ponderosa pine-lodgepole pine	59	White fir-grand fir/cool-moist
Ponderosa pine	33	Ponderosa pine-lodgepole pine	71	California red fir-Shasta red fir/cool-moist
Ponderosa pine	34	Ponderosa pine-oak	18	Oak woodlands
Ponderosa pine	34	Ponderosa pine-oak	31	Ponderosa pine/warm-xeric
Ponderosa pine	34	Ponderosa pine-oak	34	Ponderosa pine-oak
Ponderosa pine	34	Ponderosa pine-oak	36	California foothill pine-oak
Ponderosa pine	34	Ponderosa pine-oak	39	Knobcone pine
Ponderosa pine	34	Ponderosa pine-oak	41	Douglas-fir/very warm-dry
Ponderosa pine	34	Ponderosa pine-oak	42	Douglas-fir/warm-dry
California foothill pine-Coulter pine	35	Coulter pine-oak	17	Other hardwoods
California foothill pine-Coulter pine	35	Coulter pine-oak	18	Oak woodlands
California foothill pine-Coulter pine	35	Coulter pine-oak	35	Coulter pine-oak
California foothill pine-Coulter pine	35	Coulter pine-oak	40	Bigcone Douglas-fir
California foothill pine-Coulter pine	36	California foothill pine-oak	17	Other hardwoods
California foothill pine-Coulter pine	36	California foothill pine-oak	18	Oak woodlands
California foothill pine-Coulter pine	36	California foothill pine-oak	34	Ponderosa pine-oak
California foothill pine-Coulter pine	36	California foothill pine-oak	36	California foothill pine-oak
California foothill pine-Coulter pine	36	California foothill pine-oak	41	Douglas-fir/very warm-dry
Jeffrey pine	37	Jeffrey pine/warm-xeric	21	Juniper scablands
Jeffrey pine	37	Jeffrey pine/warm-xeric	22	Juniper woodlands
Jeffrey pine	37	Jeffrey pine/warm-xeric	23	Pinyon woodlands
Jeffrey pine	37	Jeffrey pine/warm-xeric	30	Ponderosa pine-juniper woodlands
Jeffrey pine	37	Jeffrey pine/warm-xeric	31	Ponderosa pine/warm-xeric
Jeffrey pine	37	Jeffrey pine/warm-xeric	37	Jeffrey pine/warm-xeric
Jeffrey pine	37	Jeffrey pine/warm-xeric	38	Jeffrey pine/warm-dry
Jeffrey pine	37	Jeffrey pine/warm-xeric	56	White fir-grand fir/warm-xeric
Jeffrey pine	37	Jeffrey pine/warm-xeric	97	Great Basin bristlecone pine-foxtail pine parklands
Jeffrey pine	38	Jeffrey pine/warm-dry	23	Pinyon woodlands
Jeffrey pine	38	Jeffrey pine/warm-dry	30	Ponderosa pine-juniper woodlands

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Jeffrey pine	38	Jeffrey pine/warm-dry	31	Ponderosa pine/warm-xeric
Jeffrey pine	38	Jeffrey pine/warm-dry	37	Jeffrey pine/warm-xeric
Jeffrey pine	38	Jeffrey pine/warm-dry	38	Jeffrey pine/warm-dry
Jeffrey pine	38	Jeffrey pine/warm-dry	40	Bigcone Douglas-fir
Jeffrey pine	38	Jeffrey pine/warm-dry	41	Douglas-fir/very warm-dry
Jeffrey pine	38	Jeffrey pine/warm-dry	42	Douglas-fir/warm-dry
Jeffrey pine	38	Jeffrey pine/warm-dry	51	Tanoak/very moist
Jeffrey pine	38	Jeffrey pine/warm-dry	54	Giant sequoia
Jeffrey pine	38	Jeffrey pine/warm-dry	56	White fir-grand fir/warm-xeric
Jeffrey pine	38	Jeffrey pine/warm-dry	71	California red fir-Shasta red fir/cool-moist
Jeffrey pine	38	Jeffrey pine/warm-dry	79	Port Orford cedar
Jeffrey pine	38	Jeffrey pine/warm-dry	97	Great Basin bristlecone pine-foxtail pine parklands
Jeffrey pine-knobcone pine	39	Knobcone pine	18	Oak woodlands
Jeffrey pine-knobcone pine	39	Knobcone pine	34	Ponderosa pine-oak
Jeffrey pine-knobcone pine	39	Knobcone pine	39	Knobcone pine
Jeffrey pine-knobcone pine	39	Knobcone pine	41	Douglas-fir/very warm-dry
Douglas-fir	40	Bigcone Douglas-fir	18	Oak woodlands
Douglas-fir	40	Bigcone Douglas-fir	35	Coulter pine-oak
Douglas-fir	40	Bigcone Douglas-fir	38	Jeffrey pine/warm-dry
Douglas-fir	40	Bigcone Douglas-fir	40	Bigcone Douglas-fir
Douglas-fir	41	Douglas-fir/very warm-dry	31	Ponderosa pine/warm-xeric
Douglas-fir	41	Douglas-fir/very warm-dry	34	Ponderosa pine-oak
Douglas-fir	41	Douglas-fir/very warm-dry	36	California foothill pine-oak
Douglas-fir	41	Douglas-fir/very warm-dry	38	Jeffrey pine/warm-dry
Douglas-fir	41	Douglas-fir/very warm-dry	39	Knobcone pine
Douglas-fir	41	Douglas-fir/very warm-dry	41	Douglas-fir/very warm-dry
Douglas-fir	41	Douglas-fir/very warm-dry	42	Douglas-fir/warm-dry
Douglas-fir	41	Douglas-fir/very warm-dry	43	Douglas-fir/very warm-moist
Douglas-fir	41	Douglas-fir/very warm-dry	51	Tanoak/very moist
Douglas-fir	41	Douglas-fir/very warm-dry	56	White fir-grand fir/warm-xeric
Douglas-fir	42	Douglas-fir/warm-dry	31	Ponderosa pine/warm-xeric
Douglas-fir	42	Douglas-fir/warm-dry	34	Ponderosa pine-oak
Douglas-fir	42	Douglas-fir/warm-dry	38	Jeffrey pine/warm-dry
Douglas-fir	42	Douglas-fir/warm-dry	41	Douglas-fir/very warm-dry
Douglas-fir	42	Douglas-fir/warm-dry	42	Douglas-fir/warm-dry
Douglas-fir	42	Douglas-fir/warm-dry	43	Douglas-fir/very warm-moist

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Douglas-fir	42	Douglas-fir/warm-dry	51	Tanoak/very moist
Douglas-fir	42	Douglas-fir/warm-dry	52	Tanoak/very wet
Douglas-fir	42	Douglas-fir/warm-dry	57	White fir-grand fir/warm-dry
Douglas-fir	42	Douglas-fir/warm-dry	62	Subalpine fir-Engelmann spruce/ cool-dry
Douglas-fir	42	Douglas-fir/warm-dry	79	Port Orford cedar
Douglas-fir	42	Douglas-fir/warm-dry	82	Western hemlock/moist
Douglas-fir	43	Douglas-fir/very warm-moist	41	Douglas-fir/very warm-dry
Douglas-fir	43	Douglas-fir/very warm-moist	42	Douglas-fir/warm-dry
Douglas-fir	43	Douglas-fir/very warm-moist	43	Douglas-fir/very warm-moist
Douglas-fir	43	Douglas-fir/very warm-moist	52	Tanoak/very wet
Douglas-fir	43	Douglas-fir/very warm-moist	58	White fir-grand fir/warm-moist
Douglas-fir	43	Douglas-fir/very warm-moist	63	Subalpine fir-Engelmann spruce/ cool-wet
Douglas-fir	43	Douglas-fir/very warm-moist	76	Western redcedar/mild
Douglas-fir	43	Douglas-fir/very warm-moist	77	Western redcedar/cool
Douglas-fir	43	Douglas-fir/very warm-moist	79	Port Orford cedar
Douglas-fir	43	Douglas-fir/very warm-moist	83	Western hemlock/very moist
Sitka spruce	46	Sitka spruce/wet	46	Sitka spruce/wet
Sitka spruce	46	Sitka spruce/wet	47	Sitka spruce/very wet
Sitka spruce	46	Sitka spruce/wet	48	Redwood/very moist
Sitka spruce	46	Sitka spruce/wet	49	Redwood/wet
Sitka spruce	46	Sitka spruce/wet	83	Western hemlock/very moist
Sitka spruce	46	Sitka spruce/wet	84	Western hemlock/wet
Sitka spruce	47	Sitka spruce/very wet	46	Sitka spruce/wet
Sitka spruce	47	Sitka spruce/very wet	47	Sitka spruce/very wet
Sitka spruce	47	Sitka spruce/very wet	49	Redwood/wet
Sitka spruce	47	Sitka spruce/very wet	83	Western hemlock/very moist
Sitka spruce	47	Sitka spruce/very wet	84	Western hemlock/wet
Redwood	48	Redwood/very moist	46	Sitka spruce/wet
Redwood	48	Redwood/very moist	48	Redwood/very moist
Redwood	48	Redwood/very moist	49	Redwood/wet
Redwood	48	Redwood/very moist	51	Tanoak/very moist
Redwood	49	Redwood/wet	46	Sitka spruce/wet
Redwood	49	Redwood/wet	47	Sitka spruce/very wet
Redwood	49	Redwood/wet	48	Redwood/very moist
Redwood	49	Redwood/wet	49	Redwood/wet
Redwood	49	Redwood/wet	52	Tanoak/very wet
Tanoak	51	Tanoak/very moist	38	Jeffrey pine/warm-dry
Tanoak	51	Tanoak/very moist	41	Douglas-fir/very warm-dry

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Tanoak	51	Tanoak/very moist	42	Douglas-fir/warm-dry
Tanoak	51	Tanoak/very moist	48	Redwood/very moist
Tanoak	51	Tanoak/very moist	51	Tanoak/very moist
Tanoak	51	Tanoak/very moist	52	Tanoak/very wet
Tanoak	51	Tanoak/very moist	79	Port Orford cedar
Tanoak	51	Tanoak/very moist	82	Western hemlock/moist
Tanoak	51	Tanoak/very moist	83	Western hemlock/very moist
Tanoak	52	Tanoak/very wet	42	Douglas-fir/warm-dry
Tanoak	52	Tanoak/very wet	43	Douglas-fir/very warm-moist
Tanoak	52	Tanoak/very wet	49	Redwood/wet
Tanoak	52	Tanoak/very wet	51	Tanoak/very moist
Tanoak	52	Tanoak/very wet	52	Tanoak/very wet
Tanoak	52	Tanoak/very wet	79	Port Orford cedar
Tanoak	52	Tanoak/very wet	83	Western hemlock/very moist
Tanoak	52	Tanoak/very wet	84	Western hemlock/wet
Giant sequoia	54	Giant sequoia	38	Jeffrey pine/warm-dry
Giant sequoia	54	Giant sequoia	54	Giant sequoia
Giant sequoia	54	Giant sequoia	56	White fir-grand fir/warm-xeric
White fir-grand fir	56	White fir-grand fir/warm-xeric	31	Ponderosa pine/warm-xeric
White fir-grand fir	56	White fir-grand fir/warm-xeric	37	Jeffrey pine/warm-xeric
White fir-grand fir	56	White fir-grand fir/warm-xeric	38	Jeffrey pine/warm-dry
White fir-grand fir	56	White fir-grand fir/warm-xeric	41	Douglas-fir/very warm-dry
White fir-grand fir	56	White fir-grand fir/warm-xeric	54	Giant sequoia
White fir-grand fir	56	White fir-grand fir/warm-xeric	56	White fir-grand fir/warm-xeric
White fir-grand fir	56	White fir-grand fir/warm-xeric	57	White fir-grand fir/warm-dry
White fir-grand fir	56	White fir-grand fir/warm-xeric	58	White fir-grand fir/warm-moist
White fir-grand fir	57	White fir-grand fir/warm-dry	42	Douglas-fir/warm-dry
White fir-grand fir	57	White fir-grand fir/warm-dry	56	White fir-grand fir/warm-xeric
White fir-grand fir	57	White fir-grand fir/warm-dry	57	White fir-grand fir/warm-dry
White fir-grand fir	57	White fir-grand fir/warm-dry	58	White fir-grand fir/warm-moist
White fir-grand fir	57	White fir-grand fir/warm-dry	59	White fir-grand fir/cool-moist
White fir-grand fir	57	White fir-grand fir/warm-dry	62	Subalpine fir-Engelmann spruce/cool-dry
White fir-grand fir	57	White fir-grand fir/warm-dry	72	California red fir-Shasta red fir/mild-very moist
White fir-grand fir	57	White fir-grand fir/warm-dry	82	Western hemlock/moist
White fir-grand fir	58	White fir-grand fir/warm-moist	43	Douglas-fir/very warm-moist
White fir-grand fir	58	White fir-grand fir/warm-moist	56	White fir-grand fir/warm-xeric
White fir-grand fir	58	White fir-grand fir/warm-moist	57	White fir-grand fir/warm-dry

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
White fir-grand fir	58	White fir-grand fir/warm-moist	58	White fir-grand fir/warm-moist
White fir-grand fir	58	White fir-grand fir/warm-moist	59	White fir-grand fir/cool-moist
White fir-grand fir	58	White fir-grand fir/warm-moist	63	Subalpine fir-Engelmann spruce/cool-wet
White fir-grand fir	58	White fir-grand fir/warm-moist	73	California red fir-Shasta red fir/cool-very moist
White fir-grand fir	58	White fir-grand fir/warm-moist	76	Western redcedar/mild
White fir-grand fir	58	White fir-grand fir/warm-moist	77	Western redcedar/cool
White fir-grand fir	58	White fir-grand fir/warm-moist	83	Western hemlock/very moist
White fir-grand fir	58	White fir-grand fir/warm-moist	87	Pacific silver fir/mild-wet
White fir-grand fir	58	White fir-grand fir/warm-moist	93	Mountain hemlock/cool-wet
White fir-grand fir	59	White fir-grand fir/cool-moist	25	Lodgepole pine/cool-dry
White fir-grand fir	59	White fir-grand fir/cool-moist	33	Ponderosa pine-lodgepole pine
White fir-grand fir	59	White fir-grand fir/cool-moist	57	White fir-grand fir/warm-dry
White fir-grand fir	59	White fir-grand fir/cool-moist	58	White fir-grand fir/warm-moist
White fir-grand fir	59	White fir-grand fir/cool-moist	59	White fir-grand fir/cool-moist
White fir-grand fir	59	White fir-grand fir/cool-moist	61	Subalpine fir-Engelmann spruce/cold-moist
White fir-grand fir	59	White fir-grand fir/cool-moist	71	California red fir-Shasta red fir/cool-moist
White fir-grand fir	59	White fir-grand fir/cool-moist	91	Mountain hemlock/cold-very moist
White fir-grand fir	59	White fir-grand fir/cool-moist	92	Mountain hemlock/cool-very moist
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	59	White fir-grand fir/cool-moist
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	61	Subalpine fir-Engelmann spruce/cold-moist
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	62	Subalpine fir-Engelmann spruce/cool-dry
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	63	Subalpine fir-Engelmann spruce/cool-wet
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	65	Subalpine fir parklands
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	91	Mountain hemlock/cold-very moist
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	95	Mountain hemlock parklands
Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist	99	Whitebark pine parklands
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	42	Douglas-fir/warm-dry

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	57	White fir-grand fir/warm-dry
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	61	Subalpine fir-Engelmann spruce/cold-moist
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	62	Subalpine fir-Engelmann spruce/cool-dry
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	63	Subalpine fir-Engelmann spruce/cool-wet
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	64	Subalpine fir-Engelmann spruce/cool-very moist
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	92	Mountain hemlock/cool-very moist
Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry	99	Whitebark pine parklands
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	43	Douglas-fir/very warm-moist
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	58	White fir-grand fir/warm-moist
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	61	Subalpine fir-Engelmann spruce/cold-moist
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	62	Subalpine fir-Engelmann spruce/cool-dry
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	63	Subalpine fir-Engelmann spruce/cool-wet
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	64	Subalpine fir-Engelmann spruce/cool-very moist
Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet	93	Mountain hemlock/cool-wet
Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	62	Subalpine fir-Engelmann spruce/cool-dry
Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	63	Subalpine fir-Engelmann spruce/cool-wet
Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	64	Subalpine fir-Engelmann spruce/cool-very moist
Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist	94	Mountain hemlock/cool-very wet
Parklands	65	Subalpine fir parklands	61	Subalpine fir-Engelmann spruce/cold-moist
Parklands	65	Subalpine fir parklands	65	Subalpine fir parklands
Parklands	65	Subalpine fir parklands	91	Mountain hemlock/cold-very moist
Parklands	65	Subalpine fir parklands	93	Mountain hemlock/cool-wet
Parklands	65	Subalpine fir parklands	95	Mountain hemlock parklands
Parklands	65	Subalpine fir parklands	99	Whitebark pine parklands
Parklands	65	Subalpine fir parklands	100	Subalpine larch parklands
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	25	Lodgepole pine/cool-dry

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	33	Ponderosa pine-lodgepole pine
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	38	Jeffrey pine/warm-dry
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	59	White fir-grand fir/cool-moist
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	71	California red fir-Shasta red fir/cool-moist
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	72	California red fir-Shasta red fir/mild-very moist
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	73	California red fir-Shasta red fir/cool-very moist
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	91	Mountain hemlock/cold-very moist
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	97	Great Basin bristlecone pine-foxtail pine parklands
California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist	101	Sierra lodgepole pine parklands
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	57	White fir-grand fir/warm-dry
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	71	California red fir-Shasta red fir/cool-moist
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	72	California red fir-Shasta red fir/mild-very moist
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	73	California red fir-Shasta red fir/cool-very moist
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	92	Mountain hemlock/cool-very moist
California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist	101	Sierra lodgepole pine parklands
California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	58	White fir-grand fir/warm-moist
California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	71	California red fir-Shasta red fir/cool-moist
California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	72	California red fir-Shasta red fir/mild-very moist
California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	73	California red fir-Shasta red fir/cool-very moist
California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist	93	Mountain hemlock/cool-wet
Western redcedar	76	Western redcedar/mild	43	Douglas-fir/very warm-moist
Western redcedar	76	Western redcedar/mild	58	White fir-grand fir/warm-moist
Western redcedar	76	Western redcedar/mild	76	Western redcedar/mild
Western redcedar	76	Western redcedar/mild	77	Western redcedar/cool
Western redcedar	76	Western redcedar/mild	82	Western hemlock/moist
Western redcedar	76	Western redcedar/mild	83	Western hemlock/very moist
Western redcedar	77	Western redcedar/cool	43	Douglas-fir/very warm-moist

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Western redcedar	77	Western redcedar/cool	58	White fir-grand fir/warm-moist
Western redcedar	77	Western redcedar/cool	76	Western redcedar/mild
Western redcedar	77	Western redcedar/cool	77	Western redcedar/cool
Western redcedar	77	Western redcedar/cool	84	Western hemlock/wet
Port Orford cedar	79	Port Orford cedar	38	Jeffrey pine/warm-dry
Port Orford cedar	79	Port Orford cedar	42	Douglas-fir/warm-dry
Port Orford cedar	79	Port Orford cedar	43	Douglas-fir/very warm-moist
Port Orford cedar	79	Port Orford cedar	51	Tanoak/very moist
Port Orford cedar	79	Port Orford cedar	52	Tanoak/very wet
Port Orford cedar	79	Port Orford cedar	79	Port Orford cedar
Port Orford cedar	79	Port Orford cedar	82	Western hemlock/moist
Port Orford cedar	79	Port Orford cedar	83	Western hemlock/very moist
Port Orford cedar	79	Port Orford cedar	84	Western hemlock/wet
Western hemlock	82	Western hemlock/moist	42	Douglas-fir/warm-dry
Western hemlock	82	Western hemlock/moist	51	Tanoak/very moist
Western hemlock	82	Western hemlock/moist	57	White fir-grand fir/warm-dry
Western hemlock	82	Western hemlock/moist	76	Western redcedar/mild
Western hemlock	82	Western hemlock/moist	79	Port Orford cedar
Western hemlock	82	Western hemlock/moist	82	Western hemlock/moist
Western hemlock	82	Western hemlock/moist	83	Western hemlock/very moist
Western hemlock	82	Western hemlock/moist	84	Western hemlock/wet
Western hemlock	83	Western hemlock/very moist	43	Douglas-fir/very warm-moist
Western hemlock	83	Western hemlock/very moist	46	Sitka spruce/wet
Western hemlock	83	Western hemlock/very moist	47	Sitka spruce/very wet
Western hemlock	83	Western hemlock/very moist	51	Tanoak/very moist
Western hemlock	83	Western hemlock/very moist	52	Tanoak/very wet
Western hemlock	83	Western hemlock/very moist	58	White fir-grand fir/warm-moist
Western hemlock	83	Western hemlock/very moist	76	Western redcedar/mild
Western hemlock	83	Western hemlock/very moist	79	Port Orford cedar
Western hemlock	83	Western hemlock/very moist	82	Western hemlock/moist
Western hemlock	83	Western hemlock/very moist	83	Western hemlock/very moist
Western hemlock	83	Western hemlock/very moist	84	Western hemlock/wet
Western hemlock	83	Western hemlock/very moist	87	Pacific silver fir/mild-wet
Western hemlock	84	Western hemlock/wet	46	Sitka spruce/wet
Western hemlock	84	Western hemlock/wet	47	Sitka spruce/very wet
Western hemlock	84	Western hemlock/wet	52	Tanoak/very wet
Western hemlock	84	Western hemlock/wet	77	Western redcedar/cool
Western hemlock	84	Western hemlock/wet	79	Port Orford cedar
Western hemlock	84	Western hemlock/wet	82	Western hemlock/moist
Western hemlock	84	Western hemlock/wet	83	Western hemlock/very moist

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Western hemlock	84	Western hemlock/wet	84	Western hemlock/wet
Western hemlock	84	Western hemlock/wet	88	Pacific silver fir/mild-very wet
Pacific silver fir	87	Pacific silver fir/mild-wet	58	White fir-grand fir/warm-moist
Pacific silver fir	87	Pacific silver fir/mild-wet	83	Western hemlock/very moist
Pacific silver fir	87	Pacific silver fir/mild-wet	87	Pacific silver fir/mild-wet
Pacific silver fir	87	Pacific silver fir/mild-wet	88	Pacific silver fir/mild-very wet
Pacific silver fir	87	Pacific silver fir/mild-wet	89	Pacific silver fir/cold-wet
Pacific silver fir	87	Pacific silver fir/mild-wet	93	Mountain hemlock/cool-wet
Pacific silver fir	88	Pacific silver fir/mild-very wet	84	Western hemlock/wet
Pacific silver fir	88	Pacific silver fir/mild-very wet	87	Pacific silver fir/mild-wet
Pacific silver fir	88	Pacific silver fir/mild-very wet	88	Pacific silver fir/mild-very wet
Pacific silver fir	88	Pacific silver fir/mild-very wet	89	Pacific silver fir/cold-wet
Pacific silver fir	88	Pacific silver fir/mild-very wet	94	Mountain hemlock/cool-very wet
Pacific silver fir	89	Pacific silver fir/cold-wet	87	Pacific silver fir/mild-wet
Pacific silver fir	89	Pacific silver fir/cold-wet	88	Pacific silver fir/mild-very wet
Pacific silver fir	89	Pacific silver fir/cold-wet	89	Pacific silver fir/cold-wet
Pacific silver fir	89	Pacific silver fir/cold-wet	93	Mountain hemlock/cool-wet
Mountain hemlock	91	Mountain hemlock/cold-very moist	25	Lodgepole pine/cool-dry
Mountain hemlock	91	Mountain hemlock/cold-very moist	59	White fir-grand fir/cool-moist
Mountain hemlock	91	Mountain hemlock/cold-very moist	61	Subalpine fir-Engelmann spruce/cold-moist
Mountain hemlock	91	Mountain hemlock/cold-very moist	65	Subalpine fir parklands
Mountain hemlock	91	Mountain hemlock/cold-very moist	71	California red fir-Shasta red fir/cool-moist
Mountain hemlock	91	Mountain hemlock/cold-very moist	91	Mountain hemlock/cold-very moist
Mountain hemlock	91	Mountain hemlock/cold-very moist	92	Mountain hemlock/cool-very moist
Mountain hemlock	91	Mountain hemlock/cold-very moist	93	Mountain hemlock/cool-wet
Mountain hemlock	91	Mountain hemlock/cold-very moist	94	Mountain hemlock/cool-very wet
Mountain hemlock	91	Mountain hemlock/cold-very moist	95	Mountain hemlock parklands
Mountain hemlock	91	Mountain hemlock/cold-very moist	98	Western white pine parklands
Mountain hemlock	91	Mountain hemlock/cold-very moist	99	Whitebark pine parklands
Mountain hemlock	91	Mountain hemlock/cold-very moist	101	Sierra lodgepole pine parklands
Mountain hemlock	92	Mountain hemlock/cool-very moist	59	White fir-grand fir/cool-moist

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Mountain hemlock	92	Mountain hemlock/cool-very moist	62	Subalpine fir-Engelmann spruce/cool-dry
Mountain hemlock	92	Mountain hemlock/cool-very moist	72	California red fir-Shasta red fir/mild-very moist
Mountain hemlock	92	Mountain hemlock/cool-very moist	91	Mountain hemlock/cold-very moist
Mountain hemlock	92	Mountain hemlock/cool-very moist	92	Mountain hemlock/cool-very moist
Mountain hemlock	92	Mountain hemlock/cool-very moist	93	Mountain hemlock/cool-wet
Mountain hemlock	92	Mountain hemlock/cool-very moist	94	Mountain hemlock/cool-very wet
Mountain hemlock	92	Mountain hemlock/cool-very moist	95	Mountain hemlock parklands
Mountain hemlock	92	Mountain hemlock/cool-very moist	101	Sierra lodgepole pine parklands
Mountain hemlock	93	Mountain hemlock/cool-wet	58	White fir-grand fir/warm-moist
Mountain hemlock	93	Mountain hemlock/cool-wet	63	Subalpine fir-Engelmann spruce/cool-wet
Mountain hemlock	93	Mountain hemlock/cool-wet	65	Subalpine fir parklands
Mountain hemlock	93	Mountain hemlock/cool-wet	73	California red fir-Shasta red fir/cool-very moist
Mountain hemlock	93	Mountain hemlock/cool-wet	87	Pacific silver fir/mild-wet
Mountain hemlock	93	Mountain hemlock/cool-wet	89	Pacific silver fir/cold-wet
Mountain hemlock	93	Mountain hemlock/cool-wet	91	Mountain hemlock/cold-very moist
Mountain hemlock	93	Mountain hemlock/cool-wet	92	Mountain hemlock/cool-very moist
Mountain hemlock	93	Mountain hemlock/cool-wet	93	Mountain hemlock/cool-wet
Mountain hemlock	93	Mountain hemlock/cool-wet	94	Mountain hemlock/cool-very wet
Mountain hemlock	93	Mountain hemlock/cool-wet	95	Mountain hemlock parklands
Mountain hemlock	93	Mountain hemlock/cool-wet	98	Western white pine parklands
Mountain hemlock	94	Mountain hemlock/cool-very wet	64	Subalpine fir-Engelmann spruce/cool-very moist
Mountain hemlock	94	Mountain hemlock/cool-very wet	88	Pacific silver fir/mild-very wet
Mountain hemlock	94	Mountain hemlock/cool-very wet	91	Mountain hemlock/cold-very moist
Mountain hemlock	94	Mountain hemlock/cool-very wet	92	Mountain hemlock/cool-very moist
Mountain hemlock	94	Mountain hemlock/cool-very wet	93	Mountain hemlock/cool-wet
Mountain hemlock	94	Mountain hemlock/cool-very wet	94	Mountain hemlock/cool-very wet
Mountain hemlock	94	Mountain hemlock/cool-very wet	95	Mountain hemlock parklands
Parklands	95	Mountain hemlock parklands	61	Subalpine fir-Engelmann spruce/cold-moist

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Parklands	95	Mountain hemlock parklands	65	Subalpine fir parklands
Parklands	95	Mountain hemlock parklands	91	Mountain hemlock/cold-very moist
Parklands	95	Mountain hemlock parklands	92	Mountain hemlock/cool-very moist
Parklands	95	Mountain hemlock parklands	93	Mountain hemlock/cool-wet
Parklands	95	Mountain hemlock parklands	94	Mountain hemlock/cool-very wet
Parklands	95	Mountain hemlock parklands	95	Mountain hemlock parklands
Parklands	95	Mountain hemlock parklands	97	Great Basin bristlecone pine-foxtail pine parklands
Parklands	95	Mountain hemlock parklands	99	Whitebark pine parklands
Parklands	95	Mountain hemlock parklands	100	Subalpine larch parklands
Parklands	95	Mountain hemlock parklands	101	Sierra lodgepole pine parklands
Parklands	96	Limber pine parklands	23	Pinyon woodlands
Parklands	96	Limber pine parklands	96	Limber pine parklands
Parklands	96	Limber pine parklands	97	Great Basin bristlecone pine-foxtail pine parklands
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	37	Jeffrey pine/warm-xeric
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	38	Jeffrey pine/warm-dry
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	71	California red fir-Shasta red fir/cool-moist
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	95	Mountain hemlock parklands
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	96	Limber pine parklands
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	97	Great Basin bristlecone pine-foxtail pine
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	99	Whitebark pine parklands
Parklands	97	Great Basin bristlecone pine-foxtail pine parklands	101	Sierra lodgepole pine parklands
Parklands	98	Western white pine parklands	91	Mountain hemlock/cold-very moist
Parklands	98	Western white pine parklands	93	Mountain hemlock/cool-wet
Parklands	98	Western white pine parklands	98	Western white pine parklands
Parklands	98	Western white pine parklands	99	Whitebark pine parklands
Parklands	98	Western white pine parklands	101	Sierra lodgepole pine parklands
Parklands	99	Whitebark pine parklands	61	Subalpine fir-Engelmann spruce/cold-moist
Parklands	99	Whitebark pine parklands	62	Subalpine fir-Engelmann spruce/cool-dry
Parklands	99	Whitebark pine parklands	65	Subalpine fir parklands
Parklands	99	Whitebark pine parklands	91	Mountain hemlock/cold-very moist
Parklands	99	Whitebark pine parklands	95	Mountain hemlock parklands

Table A8.1—Confusion matrix for fuzzy match classifications of subzones (continued)

Vegzone name	Subzone number	Subzone name	Subzone number—fuzzy match	Subzone name—fuzzy match
Parklands	99	Whitebark pine parklands	97	Great Basin bristlecone pine-foxtail pine parklands
Parklands	99	Whitebark pine parklands	98	Western white pine parklands
Parklands	99	Whitebark pine parklands	99	Whitebark pine parklands
Parklands	99	Whitebark pine parklands	100	Subalpine larch parklands
Parklands	99	Whitebark pine parklands	101	Sierra lodgepole pine parklands
Parklands	100	Subalpine larch parklands	65	Subalpine fir parklands
Parklands	100	Subalpine larch parklands	95	Mountain hemlock parklands
Parklands	100	Subalpine larch parklands	99	Whitebark pine parklands
Parklands	100	Subalpine larch parklands	100	Subalpine larch parklands
Parklands	101	Sierra lodgepole pine parklands	71	California red fir-Shasta red fir/cool-moist
Parklands	101	Sierra lodgepole pine parklands	72	California red fir-Shasta red fir/mild-very moist
Parklands	101	Sierra lodgepole pine parklands	91	Mountain hemlock/cold-very moist
Parklands	101	Sierra lodgepole pine parklands	92	Mountain hemlock/cool-very moist
Parklands	101	Sierra lodgepole pine parklands	95	Mountain hemlock parklands
Parklands	101	Sierra lodgepole pine parklands	97	Great Basin bristlecone pine-foxtail pine parklands
Parklands	101	Sierra lodgepole pine parklands	98	Western white pine parklands
Parklands	101	Sierra lodgepole pine parklands	99	Whitebark pine parklands
Parklands	101	Sierra lodgepole pine parklands	101	Sierra lodgepole pine parklands

Source: Common names are from USDA PLANTS Database (USDA NRCS, n.d.).

Appendix 9: Vegzone and Subzone Abundance and Distribution in Level III Ecoregions

Because the project area is so large and diverse, we assessed abundance and geographic distribution of vegetated components using level III ecoregions (fig. 2) (Omernik 1987, Omernik and Griffith 2014) to describe distribution both across the project area and local distribution within an ecoregion. This spreadsheet includes worksheets containing all vegzone and subzone abundance and distribution data, data summaries (pivot tables), and a table with ecoregion names. Subzone abundance patterns generally follow vegzone abundance patterns. The worksheet "READ ME" provides examples to help interpret the data in each of the worksheets.

Download appendix 9 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 10: Vegzones and Subzones (Crosswalk)

Table A10.1—Vegzones and their associated subzones along with the vegzone number and subzone number

Vegzone number	Vegzone name	Subzone number	Subzone name
1	Developed	–1	Developed
2	Water	–2	Water
3	Rock	–3	Rock
4	Grasslands-meadows	–9	Wet meadow
4	Grasslands-meadows	–8	Moist meadow
4	Grasslands-meadows	–7	Dry meadow
4	Grasslands-meadows	–6	Upland grass
4	Grasslands-meadows	–5	Scabland grass
5	Shrublands	–17	Creosote-bursage scrub
5	Shrublands	–16	Desert scrub
5	Shrublands	–15	Coastal scrub
5	Shrublands	–14	Chaparral
5	Shrublands	–13	Montane shrub
5	Shrublands	–12	Upland shrub
5	Shrublands	–11	Scabland shrub
5	Shrublands	–10	Salt desert shrub
6	Pinyon-juniper-cypress	21	Juniper scablands
6	Pinyon-juniper-cypress	22	Juniper woodlands
6	Pinyon-juniper-cypress	23	Pinyon woodlands
6	Pinyon-juniper-cypress	24	Cypress woodlands
7	California foothill pine-Coulter pine	35	Coulter pine-oak
7	California foothill pine-Coulter pine	36	California foothill pine-oak
8	Lodgepole pine	25	Lodgepole pine cool dry
8	Lodgepole pine	27	Lodgepole pine wetlands
8	Monterey pine-bishop pine	29	Monterey pine-bishop pine
9	Sitka spruce	46	Sitka spruce/wet
9	Sitka spruce	47	Sitka spruce/very wet
10	Ponderosa pine	30	Ponderosa pine-juniper woodlands
10	Ponderosa pine	31	Ponderosa pine/warm-xeric
10	Ponderosa pine	33	Ponderosa pine-lodgepole pine
10	Ponderosa pine	34	Ponderosa pine-oak
11	Hardwoods	15	Riparian shrub
11	Hardwoods	16	Riparian hardwood forest
11	Hardwoods	17	Other hardwoods
11	Hardwoods	18	Oak woodlands
11	Hardwoods	19	Desert hardwoods
12	Jeffrey pine	37	Jeffrey pine/warm-xeric
12	Jeffrey pine	38	Jeffrey pine/warm-dry

Table A10.1—Vegzones and their associated subzones along with the vegzone number and subzone number (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name
12	Jeffrey pine-knobcone pine	39	Knobcone pine
13	Port Orford cedar	79	Port Orford cedar
14	Douglas-fir	40	Bigcone Douglas-fir
14	Douglas-fir	41	Douglas-fir/very warm-dry
14	Douglas-fir	42	Douglas-fir/warm-dry
14	Douglas-fir	43	Douglas-fir/very warm-moist
15	Tanoak	51	Tanoak/very moist
15	Tanoak	52	Tanoak/very wet
16	Giant sequoia	54	Giant sequoia
17	Redwood	48	Redwood/very moist
17	Redwood	49	Redwood/wet
18	Western redcedar	76	Western redcedar/mild
18	Western redcedar	77	Western redcedar/cool
19	Western hemlock	82	Western hemlock/moist
19	Western hemlock	83	Western hemlock/very moist
19	Western hemlock	84	Western hemlock/wet
20	White fir-grand fir	56	White fir-grand fir/warm-xeric
20	White fir-grand fir	57	White fir-grand fir/warm-dry
20	White fir-grand fir	58	White fir-grand fir/warm-moist
20	White fir-grand fir	59	White fir-grand fir/cool-moist
21	California red fir-Shasta red fir	71	California red fir-Shasta red fir/cool-moist
21	California red fir-Shasta red fir	72	California red fir-Shasta red fir/mild-very moist
21	California red fir-Shasta red fir	73	California red fir-Shasta red fir/cool-very moist
22	Pacific silver fir	87	Pacific silver fir/mild-wet
22	Pacific silver fir	88	Pacific silver fir/mild-very wet
22	Pacific silver fir	89	Pacific silver fir/cold-wet
23	Mountain hemlock	91	Mountain hemlock/cold-very moist
23	Mountain hemlock	92	Mountain hemlock/cool-very moist
23	Mountain hemlock	93	Mountain hemlock/cool-wet
23	Mountain hemlock	94	Mountain hemlock/cool-very wet
25	Subalpine fir-Engelmann spruce	61	Subalpine fir-Engelmann spruce/cold-moist
25	Subalpine fir-Engelmann spruce	62	Subalpine fir-Engelmann spruce/cool-dry
25	Subalpine fir-Engelmann spruce	63	Subalpine fir-Engelmann spruce/cool-wet
25	Subalpine fir-Engelmann spruce	64	Subalpine fir-Engelmann spruce/cool-very moist
30	Parklands	–114	Subalpine grassland-forbland
30	Parklands	–113	Subalpine shrub
30	Parklands	65	Subalpine fir parklands
30	Parklands	95	Mountain hemlock parklands
30	Parklands	96	Limber pine parklands

Table A10.1—Vegzones and their associated subzones along with the vegzone number and subzone number (continued)

Vegzone number	Vegzone name	Subzone number	Subzone name
30	Parklands	97	Great Basin bristlecone pine-foxtail pine parklands
30	Parklands	98	Western white pine parklands
30	Parklands	99	Whitebark pine parklands
30	Parklands	100	Subalpine larch parklands
30	Parklands	101	Sierra lodgepole pine parklands
40	Ice and snowfields	–4	Ice and snowfields

Source: Common names are from USDA PLANTS Database (USDA NRCS, n.d.).

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Introduction to the Vegzone/Subzone Descriptions

This appendix provides general descriptions for the potential vegetation types represented in the 2022 potential natural vegetation (PNV) map (see vegzone and subzone maps of this report, fig. 8 and app. 12). The vegzones are ordered as they are in the rule set, based on ecological amplitude, shade tolerance, and longevity of species, and adhere as much as possible to the logic used to determine series in the community type classifications and plant association guides used in the Pacific Southwest Region and Pacific Northwest Region of the U.S. Department of Agriculture, Forest Service. Shade-tolerant species with the narrowest environmental distribution—e.g., Sitka spruce (*Picea sitchensis*), redwood (*Sequoia sempervirens*), and mountain hemlock (*Tsuga mertensiana*)—are first in the hierarchy, followed by shade-tolerant species of broader distribution—e.g., Pacific silver fir (*Abies amabilis*), western hemlock (*Tsuga heterophylla*)—followed by less shade-tolerant species that represent earlier-seral conditions in many environments—e.g., Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*).

We derived the vegzone and subzone layers from overstory and understory species composition and abundance (percentage of cover) in existing Gradient Nearest Neighbor (GNN) vegetation maps developed by the Forest Service, Pacific Northwest Research Station, Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) group (USDA FS, n.d.). We determined species composition in the imputations from Forest Inventory and Analysis (FIA) plot data (1990–2019). We used a combination of FIA-periodic, FIA-annual, and R5/R6 current vegetation survey (CVS) plot designs to determine potential vegetation type at the vegzone (series) and subzone (subseries or plant association group [PAG]) grains. We used FIA-periodic and R5/R6 CVS inventory plots where they were colocated with FIA-annual plots to help interpret previous or subsequent disturbance and succession.

Early in the process, we reviewed various published plant association and community type classifications throughout Washington, Oregon, and California to guide the development of our framework and the definition of specific classes (see app. 1). We identified key indicator species from each plant association or community type guide and used these key indicator species as representative species to develop a set of indicator species for the mapping process.

We used presence and percentage of cover of tree species to infer potential forest vegetation zones. To assign subzones to inventory plots that had already been classified to a vegzone, we considered other indicator species (shrubs, forbs, graminoids, and trees not used in vegzone delineation) and grouped them by moisture and temperature regimes. The abundance and number of species in a group served as indicators for moisture and temperature subzones within a vegzone. This delineation often indicated different disturbance regimes, rates of development after disturbance, and ultimately what type of forest would dominate in the absence of disturbance. See the "Methods" section of this report for more information.

Using both the FIA inventory plots and the R5/R6 ecology plots (collected primarily to support development of plant association guides), we examined species distributions with respect to climatic variables (see fig. 6 of this report) and their similarities to one another in species-composition space. Based on the analysis of the ecology and the inventory plots, we established nine species groups indicating different combinations of temperature and moisture regimes and a separate list of species that indicated serpentine substrates (see table 3 and app. 6 of this report). Because most plot locations have multiple measurement dates, we

used the maximum percentage of cover recorded for each species across all observations as a maximum expression of each species to evaluate subzone.

We established the nine species groups—warm-wet (WaWt), cold-wet (CdWt), warm-wet mesic (WaWM), cool-wet mesic (ClWM), cold-wet mesic (CdWM), warm-mesic (WaMe), cool-mesic (ClMe), warm-dry (WaDr), and warm-xeric (WaXe)—using the set of key indicator species. Each indicated different combinations of temperature and moisture regimes. We also added a separate list of species that indicated serpentine substrates (see app. 6).

The species groups were ordered hierarchically from most productive (e.g., warm and wet) to least productive (xeric), and the total number of species and total percentage of cover were calculated for each group for each plot. To get to the assigned group used to classify the subzone, at least one species from the indicator species list with at least 25 percent cover, or two or more species with greater than 10 percent combined total cover, had to be present, starting with the most productive (warm and wet) species group and moving towards the least productive (xeric) (see app. 6). Species and species percentage of cover are additive as you move from the most productive to the least productive indicator species groups. The representative group is the final group used to classify the subzone, but there could be species from all groups to the left of the final group that helped move it to the last group used, or the representative group.

The plot assignment process proceeded in a sequential order that followed the subzone hierarchy. Species group percentage of cover and threshold values were additive through the process. For example, if percentage of cover and number of species in group one exceeded the assignment threshold, then the plot was assigned to the warm-wet group (group one). If group one species occurred but did not meet the assignment threshold, the number of species and total percentage of cover of species in group one was added to the totals for species group two and re-evaluated against the assignment thresholds. If the total percentage of cover and number of species exceeded the assignment thresholds at that point, the plot was assigned to the cold-wet species group (group two). If a species group still did not meet the assignment thresholds, the process was repeated until an assignment was made.

To develop consistent terminology for subzone names, we used spatial climate data in conjunction with vegetation data. We summarized environmental data by vegzone and subzone for the ecology plots and FIA inventory plots as a basis for naming subzones. For most vegzone/subzone combinations, we were able to assign labels using values of environmental variables associated with the plots (tables A11.1 and A11.2). We summarized mean annual precipitation and temperature by vegzone and subzone. We evaluated variation within vegzones and between subzones within vegzones to determine appropriate labels.

Table A11.1—Descriptor terms for subzones based on mean annual precipitation

Mean precipitation		Descriptor term
Lower limit	Upper limit	
INCHES		
≥80	N/a	Very wet
≥70	<80	Wet
≥50	<70	Very moist
≥30	<50	Moist
≥20	<30	Dry
N/a	<20	Xeric

Cutoff values were based on the median of mean annual precipitation for all vegetation zone/subzone combinations in the 2020 map of potential natural vegetation.

N/a = not applicable.

We applied a consistent set of descriptors linked to median values of mean annual precipitation and mean annual temperature for both vegzone and subzone classification units. To arrive at mean annual temperature and mean annual precipitation, we calculated the 25th and 75th percentile for each subzone for temperature and precipitation using PRISM data (PRISM Climate Group 2025). The six precipitation descriptors we used were very wet, wet, very moist, moist, dry, and xeric and five temperature descriptors were very warm, warm, mild, cool, and cold (see tables A11.1 and A11.2, and refer to the "Methods" section of this report for additional information related to groups and naming conventions). Order of precedence, or rank order for this classification, was warm-wet, cold-wet, warm-wet mesic, cool-wet mesic, cold-wet mesic, warm-mesic, cool-mesic, warm-dry, and warm-xeric. See the "Methods" section in this report for additional information.

Table A11.2—Descriptor terms for subzones based on mean annual temperature

Mean temperature		Descriptor term
Lower limit	Upper limit	
DEGREES FAHRENHEIT		
≥47.5	N/a	Very warm
≥45	<47.5	Warm
≥43	<45	Mild
≥41	<43	Cool
N/a	<41	Cold

Descriptor terms were based on the median of mean annual temperature for vegetation zone/subzone combinations in the 2022 map of potential natural vegetation.

N/a = not applicable.

PNV types other than forest (negative subzone numbers indicate nonforest) were added to the vegzone and subzone maps based on existing nonforest mapping methods, starting with the 2012 GNN nonforest overlay (mask) (Davis et al. 2015, 2022a, 2022b). We modified this mask to reduce embedded disturbance artifacts (mostly old fire scars) and to improve the wetlands delineations within the mask. We used a combination of U.S. Department of the Interior (USDI), Geological Survey (USGS) 1992 National Land Cover Database (USGS 1992) and 2011 USGS continuous

forest cover estimates (USGS 2014) and GNN maximum forest cover predictions from 1984–2017 as the basis for this analysis, with the assumption that pixels with ≥20 percent tree cover at any point in time in any data source are forested or woodland types. We also used LiDAR data where it was available and assumed locations (30-m pixels) with ≥10 percent LiDAR first returns above 11.5 ft (3.5 m) currently or previously supported forest and therefore have a forested PNV. We used the USDI Fish and Wildlife Service national wetlands inventory layer to identify and categorize emergent and palustrine wetlands (USFWS 2018).

We used the USGS-LANDFIRE ESP (ecological systems) data layer to populate the vegzones and subzones within the nonforest mask (USGS and USDA FS, n.d.). We grouped the ecological systems into functional groups for the vegzone layer—parklands, shrublands, grasslands-meadows, ice and snowfields, rock, water, and developed. Subzones were created for the nonforest portions of parklands, shrublands, and grasslands-meadows using groups of classification unit combinations from both the USGS-LANDFIRE ESP and national wetlands inventory classifications (USFWS 2018). The final nonforest mask was filtered twice (focal majority assignment based on a 3-by-3 cell matrix to smooth the map) and spot checked using historical photomosaic data. We then integrated this mask into the forested map to create the final product. For a complete description of methods, see the "Methods" section in this report.

Constancy Tables

We exploited species composition data from repeated observations of FIA inventory plots used in the GNN imputations to assign each plot location a potential vegzone and subzone. We used repeated field observations corresponding to the entire temporal span of GNN (1986–2017) to maximize the chance of capturing later-seral species for each plot location. As a result, all data used for the constancy tables are from the inventory plots. Plant common names, scientific names, authorities, and symbols are listed in appendix 5 and follow USDA NRCS (n.d.).

As in the GNN map products, we grouped similar tree species into combined symbols based on USDA PLANTS Database (USDA NRCS, n.d.) symbols. The GNN modeling method uses the code ABGRC to represent grand fir (*Abies grandis*—ABGR) and white fir (*Abies concolor*—ABCO). Grand fir interbreeds with white fir, and as a result, the two species are difficult to distinguish (Ott 2014, Ott et al. 2015). Individuals exhibiting characteristics of both species are often referred to as *Abies grandicolor* (sic). The ecological and silvicultural differences are not significant enough to warrant any distinctions (Atzet et al. 1996; Simpson 2007; Zobel 1973, 1974, 1975).

The GNN modeling method also merges noble fir (*Abies procera*—ABPR), California red fir (*Abies magnifica*—ABMA), and Shasta red fir (*Abies magnifica* var. *shastensis*—ABMAS) into the code ABPRSH. Shasta red fir is a variety of California red fir and is interfertile with noble fir and California red fir. Morphological and genetic characteristics of the trio are similar, thus complicating identification (Oline 2008, Zavarin et al. 1978).

In the example below (table A11.3), for the Douglas-fir vegzone, the '*N* value' represents the number of FIA plots, constancy indicates that for the Douglas-fir vegzone, 95 percent of the 3,649 plots had Douglas-fir present, with a mean cover within those plots of 41 percent. Ponderosa pine was present on 60 percent of the 3,649 plots, with a mean cover of 15 percent within those plots. To be included in the constancy table within the descriptions, a minimum of 33 percent constancy was needed, along with a minimum cover of 10 percent for trees, 5 percent for shrubs, and 1 percent for forbs or graminoids.

Table A11.3—Example constancy table for Douglas-fir vegzone (*N* = 3,649) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	95	41
Ponderosa pine	PIPO	60	15

In a few cases, the constancy tables showed differences in species among level III ecoregions (table A11.4, fig. A11.1), which were derived from Omernik (1987) and Omernik and Griffith (2014). Those cases are noted within the descriptions by vegzone and subzone.

Table A11.4—Project area by level III ecoregions of Washington, Oregon, and California

Ecoregion name (and number)	Project area
	PERCENT
Coast Range (1)	6.5
Puget Lowland (2)	2.0
Willamette Valley (3)	1.8
Cascades (4)	7.0
Sierra Nevada (5)	6.2
Central California Foothills and Coastal Mountains (6)	9.2
Central California Valley (7)	5.6
Southern California Mountains (8)	1.9
Eastern Cascades Slopes and Foothills (9)	6.4
Columbia Plateau (10)	9.5
Blue Mountains (11)	7.7
Snake River Plain (12)	0.3
Central Basin and Range (13)	1.5
Mojave Basin and Range (14)	9.0
Northern Rockies (15)	2.6
North Cascades (77)	3.6
Klamath Mountains/California High North Coast Range (78)	5.8
Northern Basin and Range (80)	7.6
Sonoran Basin and Range (81)	3.4
Southern California/Northern Baja Coast (85)	2.5

Sources: Omernik (1987), Omernik and Griffith (2014).

Figure A11.1—Level III ecoregions across the Potential Natural Vegetation Map project area.
Sources: Omernik (1987), Omernik and Griffith (2014).

Potential Natural Vegetation Map Vegzone and Subzone Descriptions

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Sitka Spruce Vegzone (9)

Table A11.5—Sitka spruce vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
9	Sitka spruce	46	Wet
9	Sitka spruce	47	Very wet

Sitka spruce (*Picea sitchensis*, PISI) extends in a narrow band along the west coast of North America from Alaska into northern California and is restricted to areas of maritime climate with abundant moisture throughout the year. The Sitka spruce vegzone, located in the Coast Range ecoregion, is typified by small annual temperature variation, minor summer plant moisture stress, and very high precipitation. In northwestern Washington, the Sitka spruce vegzone occurs in lowland, wetter areas. It generally represents very productive lands because of the warm, moist soils and low atmospheric drought where it occurs. In northwestern Oregon, this vegzone occurs in the strongly maritime climate near the ocean and follows the coastal fog up river valleys. This vegzone extends much farther inland toward the northern part of the Coast Range than in the south, where ridge systems intercept the fog layer. Southwestern Oregon is near the southern end of the species range.

Although the species extends farther inland along major drainages, most of the vegzone can be found within 1 mile of the Pacific Ocean, in the wet and mild climate of the coastal plains and headlands. North of Port Orford, the Sitka spruce vegzone widens and abuts the western hemlock (TSHE) vegzone on its eastern flank, while south of Brookings, the Sitka spruce vegzone becomes narrow and discontinuous. In southwestern Oregon, tanoak (NODE3) replaces Sitka spruce as the potential climax species on inland sites as marine influence wanes (McCain and Diaz 2002, Atzet et al. 1996).

This vegzone is characterized by the potential presence of Sitka spruce at a minimum of 10 percent cover. Sitka spruce is present in the overstory of most stands and averages more than 20 percent cover. Western hemlock and red alder (ALRU2) are frequently present as well. Sitka spruce grows in dense stands dominating the overstory or in association with western hemlock, red alder, and Douglas-fir (PSME). Occasionally, dense pockets of lodgepole pine (or shore pine) (PICO), as well as western redcedar (THPL), are interspersed among the spruce.

The shrub layer is often salmonberry (RUSP), red huckleberry (VAPA), salal (GASH), cascara buckthorn (FRPU7), California blackberry (RUUR), red elderberry (SARA2), vine maple (ACCI), rusty menziesia (MEFE), and California huckleberry (VAOV2). Western swordfern (POMU), deer fern (BLSP), redwood-sorrel (OXOR), common ladyfern (ATFI), and western brackenfern (PTAQ) are common in the herb layer.

Table A11.6—Sitka spruce vegzone (*N* = 481) constancy and cover

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Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Sitka spruce	PISI	94	20
Western hemlock	TSHE	74	47
Red alder	ALRU2	73	29
Douglas-fir	PSME	69	40
Shrubs			
Salmonberry	RUSP	86	19
Salal	GASH	63	15
Cascara buckthorn	FRPU7	50	7
Vine maple	ACCI	40	13
Forbs/graminoids			
Western swordfern	POMU	90	21
Deer fern	BLSP	61	3
Redwood-sorrel	OXOR	51	15
Common ladyfern	ATFI	37	2

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Sitka Spruce Subzones

Sitka spruce/wet (46)—

This subzone represents environments of this vegzone farther inland from the coast. It is most frequently found along the southern Oregon and northern California coast, and occasionally along the northern Oregon and Washington coast where it is slightly drier. Mean annual temperature ranges from 47 to 53 °F, and mean annual precipitation ranges from 63 to 99 inches (PRISM Climate Group 2025).

Sitka spruce (PISI), along with Douglas-fir (PSME), red alder (ALRU2), and western hemlock (TSHE) dominate the overstory. Western redcedar (THPL), if present, may have high percentage of cover. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), salal (GASH), red alder (ALRU2), redwood-sorrel (OXOR), vine maple (ACCI), and Siberian springbeauty (CLSI2).

Table A11.7—Sitka spruce/wet subzone (*N* = 198) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Sitka spruce	PISI	89	22
Douglas-fir	PSME	66	45
Red alder	ALRU2	64	26
Western hemlock	TSHE	62	47
Shrubs			
Salmonberry	RUSP	68	5
Salal	GASH	66	17
Cascara buckthorn	FRPU7	51	7
California blackberry	RUUR	46	5
California huckleberry	VAOV2	40	15
Vine maple	ACCI	34	14
Forbs/graminoids			
Western swordfern	POMU	85	19
Deer fern	BLSP	42	2
Redwood-sorrel	OXOR	42	14
Western brackenfern	PTAQ	39	2

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Sitka spruce/very wet (47)—

This subzone represents the wettest environments of the Sitka spruce (PISI) vegzone and makes up most of the vegzone. It is concentrated around the Olympic Peninsula, along the Washington coast, and south along the coast of Oregon. This subzone is found less frequently along the southern Oregon and northern California coast, where the wet subzone is more common. Mean annual temperature ranges from 47 to 51 °F, and mean annual precipitation ranges from 79 to 116 inches (PRISM Climate Group 2025).

Sitka spruce, western hemlock (TSHE), red alder (ALRU2), Douglas-fir (PSME), and western redcedar (THPL) are the most common overstory tree species. Indicator species used to classify this subzone, using the representative warm-wet group, include salmonberry (RUSP), deer fern (BLSP), common ladyfern (ATFI), false lily of the valley (MADI), and American skunkcabbage (LYAM3).

Table A11.8—Sitka spruce/very wet subzone (*N* = 283) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Sitka spruce	PISI	97	19
Western hemlock	TSHE	83	46
Red alder	ALRU2	79	30
Douglas-fir	PSME	71	37
Western redcedar	THPL	34	24
Shrubs			
Salmonberry	RUSP	99	26
Salal	GASH	61	14
Cascara buckthorn	FRPU7	50	7
Vine maple	ACCI	44	13
Forbs/graminoids			
Western swordfern	POMU	94	22
Deer fern	BLSP	75	4
Redwood-sorrel	OXOR	57	16
Common ladyfern	ATFI	51	2
False lily of the valley	MADI	36	6
Siberian springbeauty	CLSI2	35	3

Redwood Vegzone (17)

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Table A11.9—Redwood vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
17	Redwood	48	Very moist
17	Redwood	49	Wet

Redwood (*Sequoia sempervirens*, SESE3) is the tallest, heaviest, and among the oldest trees on earth, with some individuals exceeding 2,000 years (Fettig et al. 2019). This vegzone, located in the Coast Range ecoregion of California, occurs along a narrow coastal belt, influenced by moisture availability, from southwestern Oregon south to the Big Sur coast in central California (Carroll et al. 2014), which provides the relatively stable temperature, moisture, and fog that redwoods need.

These forests depend on a maritime mediterranean climate where the winters are cool and rainy, and the summers are dry. The mean annual precipitation is 70 inches, with 90 percent falling between October and May. The dry summers are mitigated by a heavy fog belt (Griffith 1992). Coastal redwood forest composition and stand structure vary widely across the range because of changes in moisture availability from north to south (Van Pelt et al. 2016), as well as elevation, coastal proximity, soil type, and topographic position (e.g., slope, aspect) (Mooney and Dawson 2016).

This vegzone is characterized by the potential presence of redwood at a minimum of 10 percent cover. Redwood averages more than 60 percent cover in the overstory. Tanoak (NODE3) and Douglas-fir (PSME) are also frequently present. The canopy of the redwood forest is often multilayered; commonly associated species in lower layers of the canopy include western hemlock (TSHE), Douglas-fir, tanoak, grand fir (ABGR), western redcedar (THPL), and Sitka spruce (PISI).

The understory ranges from sparse to dense and is comprised of shrubs and herbaceous species such as western azalea (RHOC), Pacific rhododendron (RHMA3), beaked hazelnut (COCO6), salmonberry (RUSP), California huckleberry (VAOV2), red huckleberry (VAPA), western swordfern (POMU), common ladyfern (ATFI), deer fern (BLSP), and redwood-sorrel (OXOR) (Van Pelt et al. 2016).

Table A11.10—Redwood vegzone (*N* = 327) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Redwood	SESE3	100	62
Tanoak	NODE3	87	46
Douglas-fir	PSME	86	34
Pacific madrone	ARME	45	11
Shrubs			
California huckleberry	VAOV2	62	16
Pacific poison oak	TODI	40	5
Forbs/graminoids			
Western swordfern	POMU	69	10
Western brackenfern	PTAQ	47	3

Redwood/very moist (48)—

This subzone is most commonly found south of Eureka, within the Coast Range of northern California. This subzone represents the drier, slightly more inland redwood (SESE3) environments. Mean annual temperature ranges from 51 to 57 °F, and mean annual precipitation ranges from 45 to 63 inches (PRISM Climate Group 2025).

Common overstory species within this subzone include redwood, tanoak (NODE3), Douglas-fir (PSME), and Pacific madrone (ARME). California live oak (QUAG), canyon live oak (QUCH2), and California laurel (UMCA) may also be present. Indicator species used to classify this subzone, using the representative warm-mesic group, include California huckleberry (VAOV2), common whipplea (WHMO), starflower (TRBO2), and California blackberry (RUUR).

Table A11.11—Redwood/very moist subzone (*N* = 136) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Redwood	SESE3	100	52
Tanoak	NODE3	92	54
Douglas-fir	PSME	89	37
Pacific madrone	ARME	74	13
Shrubs			
California huckleberry	VAOV2	58	17
Poison oak	TODI	46	5
Common whipplea	WHMO	38	4
Forbs/graminoids			
Western brackenfern	PTAQ	53	3
Western swordfern	POMU	49	2

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Redwood/wet (49)—

This subzone represents the wetter redwood (SESE3) sites and is found most frequently north of Eureka along the California coast within the Klamath Mountains. Mean annual temperature ranges from 50 to 57 °F, and mean annual precipitation ranges from 46 to 73 inches (PRISM Climate Group 2025).

Common overstory species include redwood, Douglas-fir (PSME), tanoak (NODE3), California laurel (UMCA), Pacific madrone (ARME), and red alder (ALRU2). Western hemlock (TSHE) and white fir (ABCO) may also be present. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), salal (GASH), redwood-sorrel (OXOR), Pacific rhododendron (RHMA3), California laurel (UMCA), and red alder (ALRU2).

Table A11.12—Redwood/wet subzone (*N* = 191) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Redwood	SESE3	99	69
Douglas-fir	PSME	84	33
Tanoak	NODE3	83	40
Shrubs			
California huckleberry	VAOV2	65	15
Salal	GASH	46	7
Pacific poison oak	TODI	36	4
Forbs/graminoids			
Western swordfern	POMU	83	13
Redwood-sorrel	OXOR	43	5
Western brackenfern	PTAQ	42	2

Mountain Hemlock Vegzone (23)

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Table A11.13—Mountain hemlock vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
23	Mountain hemlock	91	Cold-very moist
23	Mountain hemlock	92	Cool-very moist
23	Mountain hemlock	93	Cool-wet
23	Mountain hemlock	94	Cool-very wet

The mountain hemlock (*Tsuga mertensiana,* TSME) vegzone, present in the Cascades and Sierra Nevada ecoregions, forms a continuous band at higher elevations in the western Olympic Mountains and Cascade Range from Washington to central and southern Oregon. In the Klamath and Siskiyou Mountains, northern California Coast Range, southern Cascade Range of California, and Sierra Nevada, the vegzone can be more scattered, occurring on northerly aspects and environments that favor persistent snowpack. Isolated occurrences of the vegzone east of the Cascade Range are known from the western Wallowa Mountains in northeastern Oregon and Newberry Crater and Yamsey Mountain in central Oregon.

The mountain hemlock vegzone occurs in cool to cold and moist to wet environments. This vegzone is found at higher elevations and may be the highest elevation forest vegzone in some settings. Environments are characterized by deep, persistent snowpacks, with frequent summer frosts. Cooler temperatures continue far into spring and early summer. Growing seasons are short, and productivity is relatively low.

At the highest elevations, this vegzone usually grades quickly into subalpine parklands. However, subalpine fir (ABLA) or whitebark pine (PIAL) associations can be found at the upper fringe of the vegzone on some sites. At lower elevations, it grades into the Pacific silver fir (ABAM) vegzone in a complex fashion on sites with high maritime influences, or into the white fir-grand fir (ABGRC) vegzone or California red fir-Shasta red fir (ABMA-ABMAS) vegzone on sites with more continental influence or those that are excessively drained. At its driest fringe, it grades into the subalpine fir or whitebark pine vegzones. Similar environments farther east in the Blue Mountains usually support the subalpine fir vegzone.

This vegzone is characterized by the potential presence of mountain hemlock (TSME) at a minimum of 10 percent cover. Mountain hemlock is present in the overstory of most stands and averages more than 50 percent cover. Pacific silver fir, a common associate, is found in about 60 percent of the canopies and can occur with high percentage of cover where present. Subalpine fir, California red fir or Shasta red fir, lodgepole pine (PICO), and occasionally whitebark pine are found within the higher elevation (often transitional to parklands) portion of this vegzone. Stands at the upper elevational limits may also consist of nearly pure canopies of mountain hemlock, with crowns heavily festooned by lichens. These stands often have a uniform size-class structure, giving the false impression of an even-aged stand. More moderate conditions support an abundance of other tree species, including western hemlock (TSHE), western redcedar (THPL), Douglas-fir (PSME), western larch (LAOC), and western white pine (PIMO3).

Understory characteristics in this vegzone vary from dense herbaceous or shrub layers to depauperate conditions characterized by a few scattered plants and deep litter. Thinleaf huckleberry (VAME) is a consistent shrub, and sidebells wintergreen (ORSE) and bride's bonnet (CLUN2) are herbs found in about a third of the plots.

Table A11.14—Mountain hemlock vegzone (*N* = 824) constancy and cover

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Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	99	53
Pacific silver fir	ABAM	61	48
Lodgepole pine	PICO	40	20
Noble fir, California red fir, Shasta red fir	ABPR, ABMA, ABMAS	35	26
Shrubs			
Thinleaf huckleberry	VAME	60	15
Forbs/graminoids			
Sidebells wintergreen	ORSE	38	1
Bride's bonnet	CLUN2	33	2

Mountain hemlock/cold-very moist (91)—

This subzone occurs south of Snoqualmie Pass in the Washington Cascade Range to the central Sierra Nevada of California. It is absent in the Klamath and Siskiyou Mountains and northern Coast Range of southwestern Oregon and northwestern California. The mountain hemlock (TSME)/cold-very moist subzone is best expressed from Santiam Pass in central Oregon to the Mount McLoughlin area in southern Oregon, where it occurs on coarse ash/pumice-derived soils. It is also common, although much more scattered, in the central and southern Sierra Nevada in California.

This subzone occurs where topographic positions and/or soils do not hold moisture (either deep coarse pumice/ash deposits or shallow bedrock). The effective moisture is expected to be less in the cold-very moist subzone than the cool-very moist subzone and the temperatures colder in environments supporting the cold-very moist subzone than in environments supporting the cool-very moist subzone. This subzone occurs in cold, relatively dry environments. Mean annual temperature ranges from 38 to 42 °F, and mean annual precipitation ranges from 50 to 69 inches (PRISM Climate Group 2025).

Plant communities in this group are extremely depauperate. Lodgepole pine (PICO) is the dominant early-seral conifer (high percentage of cover), although western white pine (PIMO3) may be present. Subalpine fir (ABLA), noble fir (ABPR), and Pacific silver fir (ABAM) may also be occasionally present. Very few understory species are consistently found. Percentage of shrub and herb covers are low and not very diverse. Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine, grouse whortleberry (VASC), pinemat manzanita (ARNE), and long-stolon sedge (CAIN9).

Table A11.15—Mountain hemlock/cold-very moist subzone (*N* = 163) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	97	58
Lodgepole pine	PICO	83	27
Shrubs			
Grouse whortleberry	VASC	60	16
Pinemat manzanita	ARNE	42	7
Forbs/graminoids			
Long-stolon sedge	CAIN9	42	2

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Mountain hemlock/cool-very moist (92)—

This subzone occurs south of Snoqualmie Pass in the Washington Cascade Range to the central Sierra Nevada of California. It is the most common mountain hemlock (TSME) subzone in the Klamath and Siskiyou Mountains and northern Coast Range of southwestern Oregon and northwestern California. Locations west of the Cascade crest in Oregon and Washington and throughout California usually occur where topographic positions or soils do not hold moisture. The cool-very moist subzone often borders the white fir-grand fir (ABGRC) or California red fir-Shasta red fir (ABMA-ABMAS) vegzones from central Oregon to central Sierra Nevada. This subzone occurs in moderate environments. Mean annual temperature ranges from 39 to 44 °F, and mean annual precipitation ranges from 52 to 77 inches (PRISM Climate Group 2025). This subzone's environment falls between the cool-wet and the cold-very moist subzones.

Mountain hemlock may occur as a single species overstory in some places, with white fir (ABCO) and/or grand fir (ABGR) and California red fir or Shasta red fir associated in warmer microsites. Early-seral conifers include lodgepole pine (PICO), western white pine (PIMO3), and Douglas-fir (PSME). The shrub layer is varied and has relatively low percentage of cover. Indicator species used to classify this subzone, using the representative warm-mesic group, include pipsissewa (CHUM), white hawkweed (HIAL2), whiteveined wintergreen (PYPI2), common beargrass (XETE), western rattlesnake plantain (GOOB2), and vanillaleaf (ACTR).

Table A11.16—Mountain hemlock/cool-very moist subzone (*N* = 105) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	97	46
Lodgepole pine	PICO	53	22
Noble fir, California red fir, Shasta red fir	ABPR, ABMA, ABMAS	50	43
Douglas-fir	PSME	37	26
White fir, grand fir	ABCO, ABGR	36	29
Shrubs			
Pinemat manzanita	ARNE	41	6
Grouse whortleberry	VASC	34	9
Forbs/graminoids			
Sidebells wintergreen	ORSE	50	1
White hawkweed	HIAL2	39	1

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Mountain hemlock/cool-wet (93)—

This subzone is the most common subzone within the mountain hemlock (TSME) vegzone and occurs throughout the described vegzone distribution. In the central and southern Oregon Cascade Range, the cool-wet subzone is usually found west of the Cascade crest and borders warmer vegzones—Pacific silver fir (ABAM), western hemlock (TSHE), white fir-grand fir (ABGRC), or California red fir-Shasta red fir (ABMA-ABMAS). The cool-wet subzone represents the warmest and most productive environment in the mountain hemlock vegzone. Mean annual temperature ranges from 39 to 43 °F, and mean annual precipitation ranges from 61 to 97 inches (PRISM Climate Group 2025).

Pacific silver fir, western hemlock, and subalpine fir (ABLA) are common associates. Early-seral communities can contain western white pine (PIMO3) and noble fir (ABPR) or Shasta red fir, with Douglas-fir (PSME) a significant component of overstory canopies in warmer microsites. Diverse shrub layers often form after disturbance. Oregon boxleaf (PAMY), rusty menziesia (MEFE), and grouse whortleberry (VASC) were found in at least a quarter of the FIA plots. This subzone typically has a variable, diverse, herb-rich understory. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include sidebells wintergreen (ORSE), western white pine (PIMO3), bride's bonnet (CLUN2), threeleaf foamflower (TITR), twinflower (LIBO3), and starry false lily of the valley (MAST4).

Table A11.17—Mountain hemlock/cool-wet subzone (*N* = 473) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	100	53
Pacific silver fir	ABAM	77	49
Douglas-fir	PSME	40	31
Noble fir, California red fir, Shasta red fir	ABPR, ABMA, ABMAS	38	21
Western hemlock	TSHE	36	28
Subalpine fir	ABLA	34	21
Shrubs			
Thinleaf huckleberry	VAME	78	18
Oval-leaf blueberry	VAOV	39	13
Forbs/graminoids			
Sidebells wintergreen	ORSE	45	1
Common beargrass	XETE	41	15
Bride's bonnet	CLUN2	37	2

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Mountain hemlock/cool-very wet (94)—

This subzone most commonly occurs in the western Olympic Mountains and western Cascade Range of Washington from Canada south to Mount Rainier. South of Mount Rainier and east of the Cascade crest into central Oregon, the subzone distribution is scattered and patchy. This subzone occurs in cool, wet environments, often adjacent to riparian areas or in more poorly drained sites. Mean annual temperature ranges from 39 to 44 °F, and mean annual precipitation ranges from 89 to 142 inches (PRISM Climate Group 2025).

Mountain hemlock (TSME) and Pacific silver fir (ABAM) are often found together in these environments. This is a shrub-rich subzone, with many cool-wet indicator shrubs. Wet site herb indicators are also found in the herb layer. Indicator species used to classify this subzone, using the representative warm-wet group, include common ladyfern (ATFI), salmonberry (RUSP), deer fern (BLSP), western oakfern (GYDR), devilsclub (OPHO), bunchberry dogwood (COCA13), and false lily of the valley (MADI).

Table A11.18—Mountain hemlock/cool-very wet subzone (*N* = 83) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	100	50
Pacific silver fir	ABAM	92	53
Western hemlock	TSHE	49	36
Green alder	ALVI5	35	14
Shrubs			
Oval-leaf blueberry	VAOV	83	25
Thinleaf huckleberry	VAME	82	8
Salmonberry	RUSP	72	7
Stawberryleaf raspberry	RUPE	71	5
Rusty menziesia	MEFE	70	6
Forbs/graminoids			
Common ladyfern	ATFI	76	5
Bride's bonnet	CLUN2	73	2
Threeleaf foamflower	TITR	70	3
Deer fern	BLSP	64	3
Twistedstalk	STLA16	57	2
Western oakfern	GYDR	53	4
Sitka valerian	VASI	47	4
Starry false lily of the valley	MAST4	36	2
False lily of the valley	MADI	34	5

Table A11.19—Pacific silver fir vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
22	Pacific silver fir	87	Mild-wet
22	Pacific silver fir	88	Mild-very wet
22	Pacific silver fir	89	Cold-wet

The Pacific silver fir (*Abies amabilis,* ABAM) vegzone occurs in the Olympic Mountains and the Cascade Range from northern Washington to the Rogue-Umpqua Divide in southern Oregon, occurring in the North Cascades and the Cascades ecoregions. This vegzone is found only in areas of strong maritime climatic influence, usually within a few miles of the Cascade crest. This vegzone is found on sites that rarely, if ever, experience soil drought. Snowpacks are high and temperatures are cool to cold, but sites rarely experience intense, long-lasting cold temperatures.

Pacific silver fir climax sites are more moderate than those in the mountain hemlock (TSME) vegzone. This vegzone is normally bounded by the mountain hemlock and California red fir-Shasta red fir (ABMA-ABMAS) vegzones on yet cooler sites with deeper snowpacks, or by the western hemlock or the white fir-grand fir (ABGRC) vegzones on warmer, less snowy sites.

This vegzone is characterized by the potential presence of Pacific silver fir at a minimum of 5 percent cover. Pacific silver fir is present in the overstory of most stands and averages 36 percent cover, with western hemlock (TSHE) almost as frequent with an average of 52 percent cover.

Common tree species in the Pacific silver fir vegzone include western hemlock, western redcedar (THPL), Douglas-fir (PSME), noble fir (ABPR), and Shasta red fir. The seral role of each species varies by location and environment. For example, western hemlock is more important on warmer sites, and noble fir and western larch (LAOC) are only components north of Santiam Pass.

Mature stands characteristically have two or more tree canopy layers, with species such as Douglas-fir, noble fir, and western larch, forming a tall, emergent canopy above a layer made up of more shade-tolerant and slower-growing species such as Pacific silver fir, western hemlock, and white fir (ABCO) and/or grand fir (ABGR).

The shrub and herb layers are floristically rich and varied, but heavily shaded stands are characterized by very low percentage of understory plant cover (depauperate). Very dense canopies, deep litter layers, and low light levels at the forest floor all appear to reduce the numbers and amounts of shrubs and herbs. Most frequently found understory species include thinleaf huckleberry (VAME), oval-leaf blueberry (VAOV), western swordfern (POMU), bride's bonnet (CLUN2), red huckleberry (VAPA), and bunchberry dogwood (COCA13).

Table A11.20—Pacific silver fir vegzone (*N* = 1,450) constancy and cover

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Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Pacific silver fir	ABAM	89	36
Western hemlock	TSHE	83	52
Douglas-fir	PSME	74	40
Noble fir, California red fir, Shasta red fir	ABPR, ABMA, ABMAS	39	19
Western redcedar	THPL	39	27
Shrubs			
Thinleaf huckleberry	VAME	66	9
Oval-leaf blueberry	VAOV	64	10
Vine maple	ACCI	45	14
Cascade barberry	MANE2	51	5
Salmonberry	RUSP	43	5
Forbs/graminoids			
Western swordfern	POMU	60	3
Bride's bonnet	CLUN2	57	2
Threeleaf foamflower	TITR	54	2
Twinflower	LIBO3	50	4
Vanillaleaf	ACTR	47	3
Pipsissewa	CHUM	43	1
Common ladyfern	ATFI	42	3
Starry false lily of the valley	MAST4	42	2
Deer fern	BLSP	40	3
Common beargrass	XETE	39	8
Sidebells wintergreen	ORSE	38	1
White hawkweed	HIAL2	34	1

Pacific silver fir/mild-wet (87)—

This subzone is the most common subzone within the Pacific silver fir (ABAM) vegzone and occurs in the Olympic Mountains and the Cascade Range from northern Washington to the Rogue-Umpqua Divide in southern Oregon. Mean annual temperature ranges from 41 to 47 °F, and mean annual precipitation ranges from 72 to 109 inches (PRISM Climate Group 2025).

Sites have herb-rich understory vegetation. Overstory species frequently found within this subzone include Pacific silver fir, Douglas-fir (PSME), western hemlock (TSHE); and noble fir (ABPR), California red fir (ABMA), or Shasta red fir (ABMAS). Western redcedar (THPL) may be present. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), twinflower (LIBO3), bride's bonnet (CLUN2), vine maple (ACCI), three-leaf foamflower (TITR), Pacific trillium (TROV2), starry false lily of the valley (MAST4), sidebells wintergreen (ORSE), salal (GASH), Pacific rhododendron (RHMA3), and evergreen violet (VISE3).

Within the Coast Range ecoregion, species composition indicates a wetter environment than that of the overall Pacific silver fir/mild-wet subzone. Overstory species include western hemlock, Pacific silver fir, Douglas-fir, and western redcedar. Understory species include red huckleberry (VAPA), western swordfern, salal, oval-leaf blueberry (VAOV), deer fern (BLSP), Cascade barberry (MANE2), threeleaf foamflower, redwood-sorrel (OXOR), vanillaleaf (ACTR), and salmonberry (RUSP).

Table A11.21—Pacific silver fir/mild-wet subzone (*N* = 805) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	87	45
Pacific silver fir	ABAM	86	33
Western hemlock	TSHE	84	48
Noble fir, California red fir, Shasta red fir	ABPR, ABMA, ABMAS	51	19
Western redcedar	THPL	38	25
Shrubs			
Thinleaf huckleberry	VAME	70	8
Cascade barberry	MANE2	70	6
Oval-leaf blueberry	VAOV	56	9
Vine maple	ACCI	52	15
Salal	GASH	33	10
Forbs/graminoids			
Western swordfern	POMU	61	2
Twinflower	LIBO3	61	4
Pipsissewa	CHUM	58	1
Vanillaleaf	ACTR	57	3
Bride's bonnet	CLUN2	55	2
Common beargrass	XETE	50	9
Threeleaf foamflower	TITR	48	1
Starry false lily of the valley	MAST4	42	2
White hawkweed	HIAL2	41	1
Sidebells wintergreen	ORSE	40	1
Western brackenfern	PTAQ	33	4

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Pacific silver fir/mild-very wet (88)—

This subzone is somewhat common within the Pacific silver fir (ABAM) vegzone and occurs in the Olympic Mountains and the Cascade Range from northern Washington to the Rogue-Umpqua Divide in southern Oregon. The mild-very wet subzone represents the warm-moderate environments that typically have high precipitation with moderate snowpack. As a result, these are the most productive environments within the Pacific silver fir vegzone. Mean annual temperature ranges from 41 to 46 °F, and mean annual precipitation ranges from 84 to 130 inches (PRISM Climate Group 2025). This subzone occurs on lower to middle slopes within the Pacific silver fir vegzone.

These sites typically have herb-rich understory vegetation. Western hemlock (TSHE) is almost always present, with a mean cover of 59 percent, and Douglas-fir (PSME) is also often a significant component of overstory canopies and is a primary early-seral conifer. The shrub layer is variable, with the most common species being oval-leaf blueberry (VAOV), salmonberry (RUSP), bunchberry dogwood (COCA13), devilsclub (OPHO), red huckleberry (VAPA), and vine maple (ACCI). Diverse shrub layers often form after disturbance. Indicator species used to classify this subzone, using the representative warm-wet group, include salmonberry (RUSP), common ladyfern (ATFI), deer fern (BLSP), bunchberry dogwood (COCA13), devilsclub (OPHO), western oakfern (GYDR), and false lily of the valley (MADI).

Table A11.22—Pacific silver fir/mild-very wet subzone (*N* = 498) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Pacific silver fir	ABAM	94	39
Western hemlock	TSHE	91	59
Douglas-fir	PSME	58	31
Western redcedar	THPL	48	30
Green alder	ALVI5	35	15
Shrubs			
Oval-leaf blueberry	VAOV	83	12
Salmonberry	RUSP	82	8
Bunchberry dogwood	COCA13	65	5
Devilsclub	OPHO	65	5
Thinleaf huckleberry	VAME	53	7
Vine maple	ACCI	46	13
Forbs/graminoids			
Common ladyfern	ATFI	76	4
Threeleaf foamflower	TITR	75	3
Western swordfern	POMU	71	3
Bride's bonnet	CLUN2	70	2
Deer fern	BLSP	69	4
Starry false lily of the valley	MAST4	51	2
Western oakfern	GYDR	47	2
Fragrant bedstraw	GATR3	45	1
Twinflower	LIBO3	42	4
Twistedstalk	STLA16	41	1
False lily of the valley	MADI	40	2
Vanillaleaf	ACTR	40	4
Sidebells wintergreen	ORSE	34	1

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Pacific silver fir/cold-wet (89)—

This is the least common subzone within the Pacific silver fir (ABAM) vegzone. It mostly occurs along the western slopes of the Cascade Range in Washington and northern Oregon and the Olympic Mountains in Washington. Sites represent the colder, higher elevation environments within this vegzone. These sites are often adjacent to, and transitional to, mountain hemlock (TSME) or subalpine parklands subzones. Mean annual temperature ranges from 38 to 42 °F, and mean annual precipitation ranges from 61 to 99 inches (PRISM Climate Group 2025).

Overstory species frequently found within this subzone include Pacific silver fir, Douglas-fir (PSME), western hemlock (TSHE), mountain hemlock, and less frequently, noble fir (ABPR) and/or California red fir (ABMA), or Shasta red fir (ABMAS). Indicator species used to classify this subzone, using the representative cool-wet mesic group, include thin-leaf huckleberry (VAME), roughfruit berry (RULA2), oval-leaf blueberry (VAOV), rusty menziesia (MEFE), strawberryleaf raspberry (RUPE), western mountain ash (SOSI2), and western teaberry (GAOV2).

Table A11.23—Pacific silver fir/cold-wet subzone (*N* = 147) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Pacific silver fir	ABAM	95	45
Douglas-fir	PSME	57	32
Western hemlock	TSHE	53	48
Subalpine fir	ABLA	39	34
Shrubs			
Thinleaf huckleberry	VAME	91	17
Roughfruit berry	RULA2	58	5
Oval-leaf blueberry	VAOV	47	11
Cascade azalea	RHAL2	40	9
Forbs/graminoids			
Sidebells wintergreen	ORSE	47	1
Common beargrass	XETE	39	11

Western Hemlock Vegzone (19)

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Table A11.24—Western hemlock vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
19	Western hemlock	82	Moist
19	Western hemlock	83	Very moist
19	Western hemlock	84	Wet

Western hemlock (*Tsuga heterophylla,* TSHE), like Pacific silver fir (ABAM), is one of the most shade-tolerant and environmentally restricted conifers. This vegzone, located in the Coast Range, Puget Lowland, North Cascades, Cascades, Northern Rockies, and the Klamath Mountains/California High North Coast Range ecoregions, is found in areas with the strongest maritime climatic influence where Pacific silver fir and mountain hemlock (TSME) are absent. On the east side of the Cascade Range, the western hemlock vegzone is most extensive on the Warm Springs Indian Reservation and the Mount Hood National Forest. There are considerable intergradations between the western hemlock, Pacific silver fir, and white fir-grand fir (ABGRC) vegzones. White fir (ABCO) and grand fir (ABGR) occupy drier environments, while Pacific silver fir prefers cooler, more maritime environments.

This vegzone is extensive in the Pacific Northwest, from northern Washington to southwestern Oregon, where it transitions to the tanoak (NODE3) and Douglas-fir (PSME) vegzones. South of the Metolius River, the distribution of the vegzone becomes discontinuous and is rare south of Santiam Pass on the east side of the Cascade crest. Small amounts of the western hemlock vegzone occur as far south as Cache Mountain and Willamette Pass on the Deschutes National Forest.

Western hemlock is considered the climax dominant on sites too warm for Pacific silver fir and mountain hemlock. On cool sites that support Pacific silver fir or mountain hemlock, western hemlock functions as a long-lived, shade-tolerant seral species. Pacific silver fir and mountain hemlock both tolerate cooler temperatures and deeper snowpacks better than western hemlock. Sites with western redcedar (THPL) that lack western hemlock represent warm-dry environments within the western hemlock vegzone. Consequently, in areas where western redcedar is present and western hemlock is absent, the sites are typically placed within the western hemlock vegzone, except in the Northern Rockies ecoregion in Washington, where the western redcedar vegzone occurs. Mid-seral stands often have abundant, vigorous grand fir under a canopy of long-lived seral species, such as western larch (LAOC) or western white pine (PIMO3).

On the west side of the Cascade Range of northwestern Oregon, the western hemlock-very moist subzone dominates the landscape. It spans a wide range in precipitation and temperature but generally lies above the Douglas-fir and white fir-grand fir vegzones and below the Pacific silver fir vegzone. Precipitation falls as rain or snow, but winter snowpacks are not deep or long lasting (McCain and Diaz 2002).

Southwestern Oregon is the southern end of the range of the western hemlock vegzone, which is abundant on the Umpqua National Forest. It is likely limited by dry conditions and is replaced by the white fir-grand fir vegzone to the south. In the coast range of the Rogue River-Siskiyou National Forest, this vegzone extends south to the Gold Beach Ranger District, where it is replaced by the tanoak vegzone where temperatures are warmer. As a

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result of frequent disturbances in southwestern Oregon, Douglas-fir is the dominant overstory tree species in the western hemlock vegzone, with western hemlock being the dominant understory species (Atzet et al. 1996).

This vegzone is characterized by the presence of western hemlock at a minimum of 10 percent cover or a minimum of 10 percent cover when western redcedar and western hemlock covers are combined. Douglas-fir is found on nearly all sites within the western hemlock vegzone. Ponderosa pine (PIPO) is typically found only on the warmest sites.

Understory species most commonly found include western swordfern (POMU), Cascade barberry (MANE2), red huckleberry (VAPA), California blackberry (RUUR), vine maple (ACCI), salal (GASH), western brackenfern (PTAQ), red alder (ALRU2), dwarf rose (ROGY), salmonberry (RUSP), oceanspray (HODI), and twinflower (LIBO3).

Table A11.25—Western hemlock vegzone (*N* = 4,219) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	95	56
Western hemlock	TSHE	70	34
Western redcedar	THPL	43	28
Red alder	ALRU2	43	22
Shrubs			
Cascade barberry	MANE2	72	9
California blackberry	RUUR	69	5
Vine maple	ACCI	66	17
Salal	GASH	66	16
Salmonberry	RUSP	38	11
Forbs/graminoids			
Western swordfern	POMU	87	17
Western brackenfern	PTAQ	52	4
Twinflower	LIBO3	35	4
Redwood-sorrel	OXOR	33	10

Western hemlock/moist (82)—

This subzone represents the driest environment where western hemlock (TSHE) and western redcedar (THPL) are climax tree species. It is a minor subzone within Washington and Oregon. Sites on the east side of the Cascade crest north of McKenzie Pass, apparently beyond the warmer ecological limits of western hemlock that support western redcedar, are grouped into the western hemlock/moist subzone, which is the driest subzone within the western hemlock vegzone. Mean annual temperature ranges from 40 to 48 °F, and mean annual precipitation ranges from 36 to 57 inches (PRISM Climate Group 2025).

Western hemlock/moist subzone locations are often adjacent to and transitional to white fir-grand fir (ABGRC) vegzone sites. Douglas-fir (PSME) is common on almost all sites within this subzone. Indicator species used to classify this subzone, using the representative warm-mesic group, include Cascade barberry (MANE2), dwarf rose (ROGY), California blackberry (RUUR), pipsissewa (CHUM), white hawkweed (HIAL2), oceanspray (HODI), darkwoods violet (VIOR), starflower (TRBO2), vanillaleaf (ACTR), beaked hazelnut (COCO6), red huckleberry (VAPA), thimbleberry (RUPA), Rocky Mountain maple (ACGL), American trailplant (ADBI), fragrant bedstraw (GATR3), western rattlesnake plantain (GOOB2), western larch (LAOC), and common whipplea (WHMO).

Table A11.26—Western hemlock/moist subzone (*N* = 102) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	91	55
Western hemlock	TSHE	70	34
Western redcedar	THPL	52	36
White fir, grand fir	ABCO, ABGR	37	28
Shrubs			
Cascade barberry	MANE2	60	8
Forbs/graminoids			
Pipsissewa	CHUM	46	1
Western brackenfern	PTAQ	43	7
Twinflower	LIBO3	41	2
Western swordfern	POMU	41	1
White hawkweed	HIAL2	39	1

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Western hemlock/very moist (83)—

This is the most common subzone within the western hemlock (TSHE) vegzone. In Washington, this subzone occurs in the rain shadow of the Olympic Mountains, in the Puget trough, and in lower montane elevations on the west side of the Cascade Range. In Oregon, it occurs in the eastern Coast Range, Willamette Valley, and western slopes of the Cascade Range, and as far south as southwestern Oregon. Sites typically have rich herbaceous understory vegetation. These types represent warm-moderate environments and the most productive sites in the western hemlock vegzone. Mean annual temperature ranges from 46 to 51 °F, and mean annual precipitation ranges from 53 to 86 inches (PRISM Climate Group 2025). Diverse shrub layers often form following disturbance.

Douglas-fir (PSME) is a significant component of overstory canopies and a primary early-seral conifer. Western redcedar (THPL) is also commonly present. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), salal (GASH), vine maple (ACCI), twinflower (LIBO3), red alder (ALRU2), Pacific trillium (TROV2), bigleaf maple (ACMA3), redwood-sorrel (OXOR), Pacific rhododendron (RHMA3), starry false lily of the valley (MAST4), and drops-of-gold (PRHO2).

Table A11.27—Western hemlock/very moist subzone (*N* = 3,340) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	97	59
Western hemlock	TSHE	69	33
Western redcedar	THPL	41	27
Red alder	ALRU2	39	19
Shrubs			
Cascade barberry	MANE2	79	10
California blackberry	RUUR	73	5
Salal	GASH	71	17
Vine maple	ACCI	69	17
Beaked hazelnut	COCO6	34	5
Forbs/graminoids			
Western swordfern	POMU	88	16
Western brackenfern	PTAQ	56	5
Twinflower	LIBO3	39	4
Starflower	TRBO2	36	1

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Western hemlock/wet (84)—

This subzone occupies low montane elevations of western Washington and Oregon. In Washington, it occurs on the north, south, and west side of the Olympic Peninsula and along the low- to moderate-elevation western slopes of the Cascade Range. In Oregon, this subzone is found most frequently within the Coast Range ecoregion and scattered throughout, in minor amounts, on the west side of the Cascade Range. This type is found in mesic to wet microsites on northerly slopes and upper elevations. This subzone generally occurs between the Sitka spruce (PISI) vegzone and the western hemlock (TSHE)/very moist subzone. Sites represent the wettest environments within the western hemlock vegzone. This subzone is often adjacent to riparian areas or poorly drained sites. Mean annual temperature ranges from 46 to 51 °F, and mean annual precipitation ranges from 55 to 99 inches (PRISM Climate Group 2025).

Overstory species frequently include Douglas-fir (PSME), western hemlock, and western redcedar (THPL). Indicator species used to classify this subzone, using the representative warm-wet group, include salmonberry (RUSP), common ladyfern (ATFI), deer fern (BLSP), devilsclub (OPHO), and false lily of the valley (MADI).

Table A11.28—Western hemlock/wet subzone (*N* = 777) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	85	42
Western hemlock	TSHE	75	40
Red alder	ALRU2	65	28
Western redcedar	THPL	51	32
Shrubs			
Salmonberry	RUSP	86	21
Vine maple	ACCI	61	17
California blackberry	RUUR	54	5
Salal	GASH	50	11
Cascara buckthorn	FRPU7	38	7
Forbs/graminoids			
Western swordfern	POMU	90	24
Common ladyfern	ATFI	61	3
Deer fern	BLSP	57	3
Redwood-sorrel	OXOR	44	16
Western brackenfern	PTAQ	40	3
Fragrant bedstraw	GATR3	38	1
Threeleaf foamflower	TITR	36	3

Western Redcedar Vegzone (18)

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Table A11.29—Western redcedar vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
18	Western redcedar	76	Mild
18	Western redcedar	77	Cool

The western redcedar (*Thuja plicata,* THPL) vegzone is only mapped to areas of the Northern Rockies ecoregion (fig. A1.1) where environment and species composition otherwise indicate the western hemlock (TSHE) vegzone, but western hemlock is absent and western redcedar (THPL) is present with a minimum cover of 5 percent.

Compared to western hemlock, western redcedar is more tolerant of high soil moisture, summer drought, and temperature extremes (Minore 1979). The western redcedar vegzone, where western redcedar is the indicated climax dominant, occurs only on that part of the species' range beyond the environmental and geographic range of western hemlock. Western redcedar regeneration without western hemlock indicates the western redcedar vegzone. Only minor amounts of western hemlock, confined to moist microsites, are acceptable in the western redcedar vegzone (Williams et al. 1995).

The western redcedar vegzone is a very species-rich vegzone, with about 30 species being present at least 50 percent of the time—the highest number across all vegzones. The most common overstory species are western redcedar, Douglas-fir (PSME), western larch (LAOC), white fir (ABCO) and/or grand fir (ABGR), and lodgepole pine (PICO).

The most common understory species include twinflower (LIBO3), common snowberry (SYAL), Rocky Mountain maple (AGCL), thimbleberry (RUPA), bride's bonnet (CLUN2), Oregon boxleaf (PAMY), dwarf rose (ROGY), Saskatoon serviceberry (AMAL2), pinegrass (CARU), hollyleaved barberry (MAAQ2), white spirea (SPBE2), pipsissewa (CHUM), Scouler's willow (SASC), Utah honeysuckle (LOUT2), white hawkweed (HIAL2), starry false lily of the valley (MAST4), oceanspray (HODI), feathery false lily of the valley (MARA7), sidebells wintergreen (ORSE), darkwoods violet (VIOR), mallow ninebark (PHMA5), sweetcicely (OSBE), thinleaf huckleberry (VAME), green alder (ALVI5), fragrant bedstraw (GATR3), northwestern sedge (CACO11), and American trailplant (ADBI).

Table A11.30—Western redcedar vegzone (*N* = 149) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western redcedar	THPL	100	40
Douglas-fir	PSME	97	40
Western larch	LAOC	84	11
White fir, grand fir	ABCO, ABGR	67	25
Paper birch	BEPA	36	15

Table A11.30—Western redcedar vegzone (*N* = 149) constancy and cover (continued) Back to Index

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Common snowberry	SYAL	83	6
Oregon boxleaf	PAMY	77	6
Oceanspray	HODI	62	6
Mallow ninebark	PHMA5	57	9
Forbs/graminoids			
Twinflower	LIBO3	85	11
Bride's bonnet	CLUN2	79	2
Pinegrass	CARU	75	7
Pipsissewa	CHUM	73	2
White hawkweed	HIAL2	66	1
Starry false lily of the valley	MAST4	64	2
Feathery false lily of the valley	MARA7	61	1
Sidebells wintergreen	ORSE	60	1
Darkwoods violet	VIOR	58	1
Sweetcicely	OSBE	56	1
Fragrant bedstraw	GATR3	52	1
Northwestern sedge	CACO11	51	1
American trailplant	ADBI	50	2
Woodland strawberry	FRVE	47	2
Heartleaf arnica	ARCO9	44	2
Western fescue	FEOC	44	1
Roughfruit fairybells	PRTR4	40	1
Ross' sedge	CARO5	38	1
Western meadow-rue	THOC	37	1
Drops-of-gold	PRHO2	36	1

Western redcedar/mild (76)—

This subzone occupies maritime-influenced environments in eastern Washington. This subzone represents the warmer western redcedar (THPL) sites, and like the western redcedar vegzone, it is very species rich. Mean annual temperature ranges from 41 to 45 °F, and mean annual precipitation ranges from 24 to 32 inches (PRISM Climate Group 2025).

The most common overstory species are western redcedar, Douglas-fir (PSME), western larch (LAOC), white fir (ABCO) and/or grand fir (ABGR), and lodgepole pine (PICO). Paper birch (BEPA) may be present. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include twinflower (LIBO3), bride's bonnet (CLUN2), starry false lily of the valley (MAST4), sidebells wintergreen (ORSE), drops-of-gold (PRHO2), prickly currant (RILA), and threeleaf foamflower (TITR).

Table A11.31—Western redcedar/mild subzone (*N* = 133) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western redcedar	THPL	100	41
Douglas-fir	PSME	96	41
Western larch	LAOC	83	10
White fir, grand fir	ABCO, ABGR	66	27
Paper birch	BEPA	38	15
Shrubs			
Common snowberry	SYAL	83	6
Oregon boxleaf	PAMY	76	6
Oceanspray	HODI	65	6
Mallow ninebark	PHMA5	62	9
Forbs/graminoids			
Twinflower	LIBO3	86	10
Bride's bonnet	CLUN2	77	2
Pinegrass	CARU	77	7
Pipsissewa	CHUM	73	2
White hawkweed	HIAL2	64	1
Starry false lily of the valley	MAST4	62	2
Feathery false lily of the valley	MARA7	59	1
Sidebells wintergreen	ORSE	59	1
Darkwoods violet	VIOR	56	1
Sweetcicely	OSBE	53	1
Northwestern sedge	CACO11	49	1
Fragrant bedstraw	GATR3	47	1
American trailplant	ADBI	47	1
Woodland strawberry	FRVE	47	2
Western fescue	FEOC	44	1
Heartleaf arnica	ARCO9	43	2
Roughfruit fairybells	PRTR4	41	1
Ross' sedge	CARO5	36	1
Western meadow-rue	THOC	36	1
Drops-of-gold	PRHO2	35	1

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Western redcedar/cool (77)—

This subzone occupies maritime-influenced environments in eastern Washington. This subzone represents the cooler western redcedar sites, and like the overall western redcedar (THPL) vegzone, it is very species rich. Mean annual temperature ranges from 39 to 43 °F, and mean annual precipitation ranges from 27 to 35 inches (PRISM Climate Group 2025).

Eight tree species are present at least 50 percent of the time. The most common overstory species are Douglas-fir (PSME), western redcedar, western larch (LAOC), Engelmann spruce (PIEN), and white fir (ABCO) and/or grand fir (ABGR). Indicator species used to classify this subzone, using the representative warm-wet group, include common ladyfern (ATFI), bunchberry dogwood (COCA13), claspleaf twistedstalk (STAM2), western oakfern (GYDR), and devilsclub (OPHO).

Table A11.32—Western redcedar/cool subzone (*N* = 16) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	100	27
Western redcedar	THPL	100	30
Green alder	ALVI5	94	16
Western larch	LAOC	88	16
Engelmann spruce	PIEN	88	11
White fir, grand fir	ABCO, ABGR	75	14
Lodgepole pine	PICO	69	12
Subalpine fir	ABLA	56	31
Balsam poplar	POBA2	44	12
Shrubs			
Thimbleberry	RUPA	100	7
Oregon boxleaf	PAMY	81	8
Common snowberry	SYAL	75	9
Thinleaf huckleberry	VAME	75	7
Bunchberry dogwood	COCA13	63	5
Russet buffaloberry	SHCA	50	6
Forbs/graminoids			
Bride's bonnet	CLUN2	88	4
Fragrant bedstraw	GATR3	88	2
White hawkweed	HIAL2	81	1
Starry false lily of the valley	MAST4	81	3
Sweetcicely	OSBE	81	1
Darkwoods violet	VIOR	81	2
American trailplant	ADBI	75	2
Common ladyfern	ATFI	75	2
Pipsissewa	CHUM	75	3

Table A11.32—Western redcedar/cool subzone (*N* = 16) constancy and cover (continued) Back to Index

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Feathery false lily of the valley	MARA7	75	1
Sidebells wintergreen	ORSE	75	1
Pioneer violet	VIGL	75	2
Twinflower	LIBO3	69	22
Pinegrass	CARU	63	4
Threeleaf foamflower	TITR	63	1
Liverleaf wintergreen	PYAS	56	2
Pacific trillium	TROV2	56	1
Heartleaf arnica	ARCO9	50	1
Field horsetail	EQAR	50	1
Woodland strawberry	FRVE	50	2
British Columbia wildginger	ASCA2	44	1
Western oakfern	GYDR	44	2
Western brackenfern	PTAQ	44	3
Western meadow-rue	THOC	44	2
Carolina bugbane	TRCA	38	8

Subalpine Fir-Engelmann Spruce Vegzone (25)

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Table A11.33—Subalpine fir-Engelmann spruce vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
25	Subalpine fir-Engelmann spruce	61	Cold-moist
25	Subalpine fir-Engelmann spruce	62	Cool-dry
25	Subalpine fir-Engelmann spruce	63	Cool-wet
25	Subalpine fir-Engelmann spruce	64	Cool-very moist

The subalpine fir-Engelmann spruce (*Abies lasiocarpa-Picea engelmannii,* ABLA-PEIN) vegzone occurs in the Olympic and Blue Mountains of Washington, the Blue and Ochoco Mountains in Oregon, and on both slopes of the Cascade Range as far south as southern Oregon.

This vegzone occurs in the coolest and wettest forested areas at high elevations. Subalpine fir is the climax in the harshest/driest environments where the other species cannot grow. It generally occupies sites with a short growing season caused by cold winters, cool summers, frequent summer frosts, and heavy snowpack. The cool summers and cold winters, along with the deep winter snowpack, are more important than total precipitation in differentiating where subalpine fir grows in relation to other species. Engelmann spruce is usually associated with subalpine fir and occurs as either a climax codominant or as a persistent, long-lived seral species in most subalpine fir habitat types.

This vegzone is characterized by the presence of subalpine fir at a minimum of 20 percent cover or a minimum of 10 percent cover when subalpine fir and Englemann spruce covers are combined. At lower elevations, the subalpine fir-Engelmann spruce vegzone transitions into the mountain hemlock (TSME) vegzone or the Shasta red fir (ABMAS) vegzone. Lodgepole pine (PICO), Engelmann spruce, Douglas-fir (PSME), and western larch (LAOC) are species most commonly associated with subalpine fir.

Common understory species frequently found within the vegzone include white hawkweed (HIAL2), heartleaf arnica (ARCO9), pinegrass (CARU), Oregon boxwood (PAMY), sidebells wintergreen (ORSE), northwestern sedge (CACO11), pipsissewa (CHUM), thinleaf huckleberry (VAME), grouse whortleberry (VASC), prickly currant (RILA), and Ross' sedge (CARO5).

Table A11.34—Subalpine fir-Engelmann spruce vegzone (*N* = 715) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Subalpine fir	ABLA	81	34
Lodgepole pine	PICO	76	22
Engelmann spruce	PIEN	68	17
Douglas-fir	PSME	61	34
Western larch	LAOC	44	11

Table A11.34—Subalpine fir-Engelmann spruce vegzone (*N* = 715) constancy and cover (continued)

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Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Thinleaf huckleberry	VAME	54	10
Grouse whortleberry	VASC	53	15
Scouler's willow	SASC	48	6
Forbs/graminoids			
White hawkweed	HIAL2	66	1
Pinegrass	CARU	64	15
Sidebells wintergreen	ORSE	57	1
Northwestern sedge	CACO11	57	2
Pipsissewa	CHUM	56	2
Ross' sedge	CARO5	51	2
Common yarrow	ACMI2	49	1
Western meadow-rue	THOC	42	2
Sweetcicely	OSBE	41	1
Geyer's sedge	CAGE2	38	4
Twinflower	LIBO3	36	9
Silky lupine	LUSE4	33	3

Subalpine fir-Engelmann spruce/cold-moist (61)—

This subzone occurs in northern Washington, the Blue Mountains of Washington, and the Blue and Ochoco Mountains in Oregon. It represents the coldest and slightly drier environments within the subalpine fir-Engelmann spruce (ABLA-PEIN) vegzone. Mean annual temperature ranges from 36 to 40 °F, and mean annual precipitation ranges from 33 to 60 inches (PRISM Climate Group 2025).

This subzone is the least species-rich of the four subzones. The most common overstory species are subalpine fir, lodgepole pine (PICO), Engelmann spruce, and Douglas-fir (PSME). Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine (PICO), grouse whortleberry (VASC), Oregon boxwood (PAMY), silky lupine (LUSE4), whortleberry (VAMY2), broadleaf lupine (LULA4), and pinemat manzanita (ARNE).

Table A11.35—Subalpine fir-Engelmann spruce/cold-moist subzone (*N* = 97) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	84	30
Subalpine fir	ABLA	70	38
Engelmann spruce	PIEN	41	14
Douglas-fir	PSME	32	23
Shrubs			
Grouse whortleberry	VASC	77	17
Forbs/graminoids			
Northwestern sedge	CACO11	57	2
Ross' sedge	CARO5	56	5
Common yarrow	ACMI2	54	2
Pinegrass	CARU	51	10
Geyer's sedge	CAGE2	43	4
White hawkweed	HIAL2	42	1
Silky lupine	LUSE4	37	5

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Subalpine fir-Engelmann spruce/cool-dry (62)—

This subzone occurs in the Blue and Wallowa Mountains of northeastern Oregon and southeastern Washington and east of the Cascade Range from northern to southern Washington. Mean annual temperature ranges from 37 to 42 °F, and mean annual precipitation ranges from 28 to 43 inches (PRISM Climate Group 2025). This subzone represents the driest environments within the subalpine fir-Engelmann spruce (ABLA-PEIN) vegzone.

The most common overstory species are subalpine fir, lodgepole pine (PICO), Engelmann spruce, Douglas-fir (PSME), and western larch (LAOC). Indicator species used to classify this subzone, using the representative warm-mesic group, include heartleaf arnica (ARCO9), pipsissewa (CHUM), Scouler's willow (SASC), white spirea (SPBE2), western larch (LAOC), sticky currant (RIVI3), western meadow-rue (THOC), sweetcicely (OSBE), and kinnikinnick (ARUV).

Table A11.36—Subalpine fir-Engelmann spruce/cool-dry subzone (*N* = 229) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Subalpine fir	ABLA	83	32
Lodgepole pine	PICO	76	24
Douglas-fir	PSME	64	35
Engelmann spruce	PIEN	57	13
Western larch	LAOC	42	10
Shrubs			
Grouse whortleberry	VASC	52	17
Scouler's willow	SASC	50	6
Forbs/graminoids			
Pinegrass	CARU	74	15
White hawkweed	HIAL2	69	1
Ross' sedge	CARO5	59	2
Common yarrow	ACMI2	55	2
Northwestern sedge	CACO11	53	1
Pipsissewa	CHUM	51	1
Sidebells wintergreen	ORSE	49	1
Geyer's sedge	CAGE2	49	5
Western meadow-rue	THOC	38	2
Sweetcicely	OSBE	36	1
Silky lupine	LUSE4	35	4

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Subalpine fir-Engelmann spruce/cool-wet (63)—

This subzone occurs in the Blue and Wallowa Mountains of northeastern Oregon and southeastern Washington and east of the Cascade Range from northern to southern Washington. This subzone represents the cool, wet environments within the subalpine fir-Engelmann spruce (ABLA-PEIN) vegzone. Mean annual temperature ranges from 37 to 42 °F, and mean annual precipitation ranges from 26 to 48 inches (PRISM Climate Group 2025).

This subzone is one of the most species-rich subzones in the subalpine fir-Engelmann spruce vegzone. The most common overstory species are subalpine fir, lodgepole pine (PICO), Engelmann spruce, Douglas-fir (PSME), and western larch (LAOC). Indicator species used to classify this subzone, using the representative warm-wet mesic group, include sidebells wintergreen (ORSE), prickly currant (RILA), twinflower (LIBO3), bride's bonnet (CLUN2), starry false lily of the valley (MAST4), and threeleaf foamflower (TITR).

Table A11.37—Subalpine fir-Engelmann spruce/cool-wet subzone (*N* = 296) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Subalpine fir	ABLA	86	34
Engelmann spruce	PIEN	80	18
Lodgepole pine	PICO	74	17
Douglas-fir	PSME	68	36
Western larch	LAOC	53	12
Shrubs			
Thinleaf huckleberry	VAME	76	14
Oregon boxleaf	PAMY	67	5
Scouler's willow	SASC	52	5
Grouse whortleberry	VASC	49	13
Whortleberry	VAMY2	37	9
Kinnikinnick	ARUV	34	6
Forbs/graminoids			
White hawkweed	HIAL2	75	1
Sidebells wintergreen	ORSE	72	1
Pipsissewa	CHUM	70	2
Pinegrass	CARU	61	18
Northwestern sedge	CACO11	58	2
Western meadow-rue	THOC	56	2
Sweetcicely	OSBE	49	1
Ross' sedge	CARO5	49	1
Common yarrow	ACMI2	47	1
Twinflower	LIBO3	47	12
Bride's bonnet	CLUN2	38	2
Darkwoods violet	VIOR	37	1
Geyer's sedge	CAGE2	33	2
Fragrant bedstraw	GATR3	33	1
Western fescue	FEOC	33	1
Silky lupine	LUSE4	33	2

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Subalpine fir-Engelmann spruce/cool-very moist (64)—

This subzone occurs in the Blue and Wallowa Mountains of northeastern Oregon and southeastern Washington and east of the Cascade Range from northern to southern Washington. This subzone is somewhat minor and represents the wettest environments within this vegzone. Mean annual temperature ranges from 37 to 42 °F, and mean annual precipitation ranges from 24 to 38 inches (PRISM Climate Group 2025).

This is the most species-rich subzone within the subalpine fir-Engelmann spruce (ABLA-PEIN) vegzone, often found in areas that accumulate moisture. The most common overstory species are Engelmann spruce, lodgepole pine (PICO), subalpine fir, Douglas-fir (PSME), western larch (LAOC), and green alder (ALVI5). Indicator species used to classify this subzone, using the representative warm-wet group, include claspleaf twistedstalk (STAM2), bunchberry dogwood (COCA13), common ladyfern (ATFI), gray alder (ALIN2), and western oakfern (GYDR).

Table A11.38—Subalpine fir-Engelmann spruce/cool-very moist subzone (*N* = 92) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Engelmann spruce	PIEN	83	21
Lodgepole pine	PICO	79	23
Green alder	ALVI5	76	16
Subalpine fir	ABLA	74	31
Douglas-fir	PSME	63	27
Western larch	LAOC	46	11
Shrubs			
Thinleaf huckleberry	VAME	62	7
Oregon boxleaf	PAMY	60	5
Scouler's willow	SASC	57	8
Thimbleberry	RUPA	55	5
Grouse whortleberry	VASC	48	11
Bunchberry dogwood	COCA13	42	7
Whortleberry	VAMY2	41	10
Redosier dogwood	COSE16	36	5
Common snowberry	SYAL	34	6
Forbs/graminoids			
Sidebells wintergreen	ORSE	68	2
Northwestern sedge	CACO11	61	2
Pipsissewa	CHUM	61	2
Sweetcicely	OSBE	61	2

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Table A11.38—Subalpine fir-Engelmann spruce/cool-very moist subzone (*N* = 92) constancy and cover (continued)

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Fragrant bedstraw	GATR3	60	1
Twinflower	LIBO3	60	9
Pinegrass	CARU	59	7
White hawkweed	HIAL2	57	1
Darkwoods violet	VIOR	54	1
Starry false lily of the valley	MAST4	53	1
Bride's bonnet	CLUN2	50	3
Western meadow-rue	THOC	50	2
Pioneer violet	VIGL	48	2
Liverleaf wintergreen	PYAS	47	1

White Fir-Grand Fir Vegzone (20) Back to Index

Table A11.39—White fir-grand fir vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
20	White fir-grand fir	56	Warm-xeric
20	White fir-grand fir	57	Warm-dry
20	White fir-grand fir	58	Warm-moist
20	White fir-grand fir	59	Cool-moist

The white fir-grand fir (*Abies concolor-Abies grandis,* ABGRC) vegzone is a major mid-elevation potential vegetation type throughout Washington, Oregon, and California, found in the North Cascades, Cascades, Eastern Cascades Slopes and Foothills, Blue Mountains, Klamath Mountains/California High North Coast Range, and Sierra Nevada ecoregions. This vegzone is defined by both white fir (ABCO) and grand fir (ABGR). Grand fir interbreeds with white fir and is difficult to distinguish. Zobel (1973, 1974) has described a zone of morphological and physiological intergradation between the two species. The overlap occurs in a diagonal band extending from the Blue Mountains (northeastern Oregon and west-central Idaho) through the southern Oregon Cascade Range into the Klamath Mountain Province (northwestern California and southwestern Oregon) (Steinhoff 1978). Individuals exhibiting characteristics of both species are often referred to as *Abies grandicolor* (sic). The ecological and silvicultural differences are not significant enough to warrant any distinctions (Atzet et al. 1996).

White fir, compared to grand fir, appears to have slightly greater amplitude in moisture requirements (tolerates somewhat drier conditions) and also appears to have slightly earlier development of fire-resistant bark. Overall, however, the two species appear to have similar successional relationships with their associated species. South and east of Klamath Falls, populations of mid-elevation true firs more readily fit typical white fir descriptions. The distribution of white fir continues south through the Modoc Plateau, southern Cascade Range into northern California, and through mid-elevations of the Sierra Nevada south to southern California. This distribution suggests that the white fir-grand fir vegzone sites have an affinity for modified maritime climates. White fir and grand fir do not tolerate dry conditions or extended cold temperatures well, although they tolerate drier conditions better than western hemlock (TSHE) or western redcedar (THPL), which share a similar geographical distribution across Oregon and Washington.

In eastern Washington, the white fir-grand fir vegzone is largely missing north of Lake Chelan to the United States-Canada border and east to the Kettle Range of northeastern Washington, where it is replaced by the Douglas-fir (PSME) vegzone. West of the Cascade crest, the white fir-grand fir vegzone is absent in Washington, and in Oregon, the white fir-grand fir vegzone forms a narrow band in the foothills on both sides of the Willamette Valley and in small, scattered patches at higher elevations in the Cascades north of Santiam Pass. South of the Willamette Valley and Santiam Pass, prevalence of the white fir-grand fir vegzone gradually increases, eventually replacing the western hemlock vegzone in the southern Cascade Range and Klamath and Siskiyou Mountains.

The white fir-grand fir vegzone occurs across an environmental range from cool to very warm, and dry to very moist. Climax white fir or grand fir stands are a major component of the east-slope Cascade Range forests and at higher elevations in southwestern Oregon. In the Cascade Range, the white fir-grand fir vegzone occurs at elevations above 4,900 ft where

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white fir is clearly dominant in nearly pure stands with Douglas-fir, sugar pine (PILA), ponderosa pine (PIPO), western white pine (PIMO3), and lodgepole pine (PICO) as associates. The Douglas-fir vegzone often intermingles with the white fir-grand fir vegzone on harsh sites in warm, dry environments, and the western hemlock vegzone may intermingle in moist, cool valleys in the foothills (McCain and Diaz 2002).

In California, the white fir-grand fir vegzone (white fir is present here) occurs in the northern Coast Range, Klamath and Siskiyou Mountains, and southern Cascade Range, Warner Mountains, and Sierra Nevada, and the southern California Transverse and Peninsular Ranges. Within California's northern Coast Range, Klamath and Siskiyou Mountains, southern Cascade Range, and central to northern Sierra Nevada, white fir-grand fir vegzone sites usually occur between the tanoak (NODE3) vegzone (west side) or Douglas-fir vegzone (east side) at lower elevations and the California red fir-Shasta red fir (ABMA-ABMAS) vegzone at higher elevations. On the eastern slopes of the California Cascade Range, Sierra Nevada, and throughout the Modoc Plateau, warmer and drier environments transition directly to either ponderosa pine or Jeffrey pine (PIJE) vegzones.

This vegzone is characterized by the presence of white fir and/or grand fir at a minimum of 5 percent cover. White fir and/or grand fir is present in most stands with a mean cover of 32 percent. Douglas-fir, ponderosa pine, or both, dominate the overstory canopy of most stands in the vegzone, in part because of environmental and frequent disturbance conditions. White fir and/or grand fir often occur as codominants, especially in the moister associations and community types but is less often found as a dominant. Incense cedar (CADE27) is frequently present as well. Western larch (LAOC) and lodgepole pine are seral species found in some habitats. Western white pine is a significant component only in wetter and cooler types.

Many understory species are common in this vegzone and almost never found in the drier Douglas-fir, ponderosa pine, or hardwoods (oak) vegzones. Generally, stands containing starry false lily of the valley (MAST4), bride's bonnet (CLUN2), drops-of-gold (PRHO2), vine maple (ACCI), Cascade barberry (MANE2), twinflower (LIBO3), or vanillaleaf (ACTR) are able to support a vegzone moister than the Douglas-fir, ponderosa pine, or lodgepole pine vegzones. Common understory species include common snowberry (SYAL), white hawkweed (HIAL2), pipsissewa (CHUM), pinegrass (CARU), Geyer's sedge (CAGE2), heartleaf arnica (ARCO9), dwarf rose (ROGY), and common yarrow (ACMI2).

Table A11.40—White fir-grand fir vegzone (*N* = 5,596) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
White fir, grand fir	ABCO, ABGR	96	32
Douglas-fir	PSME	61	35
Ponderosa pine	PIPO	58	15
Shrubs			
Common snowberry	SYAL	34	5
Forbs/graminoids			
White hawkweed	HIAL2	33	1

White fir-grand fir/warm-xeric (56)—

This is a common subzone within the white fir-grand fir (ABGRC) vegzone. This subzone is most abundant in the eastern Cascade Range and Blue Mountains of Oregon and Washington, eastern portions of the Klamath and Siskiyou Mountains and northern Coast Range of California and throughout the Cascade Range and Sierra Nevada of California. It is also prominent at higher elevations of the Transverse and Peninsular Ranges of southern California. In California, most sites within this subzone have been called California mixed conifer in other classifications.

These sites occupy the warmest, driest true fir climax communities in the Pacific Northwest. Mean annual temperature ranges from 42 to 50 °F, and mean annual precipitation ranges from 25 to 52 inches (PRISM Climate Group 2025).

Adjacent sites with less effective moisture transition to Douglas-fir (PSME) or ponderosa pine (PIPO) vegzones. The dominant seral conifer in these locations is ponderosa pine. Incense cedar (CADE27), Douglas-fir, and sugar pine (PILA) are also often present. Jeffrey pine (PIJE) and California black oak (QUKE) may be occasionally present. This subzone tends to be depauperate. Indicator species used to classify this subzone, using the representative warm-dry group, include incense cedar, sugar pine, greenleaf manzanita (ARPA6), common snowberry (SYAL), and snowbrush ceanothus (CEVE).

Within the Eastern Cascades Slopes and Foothills ecoregion, the species composition indicates a drier environment than that of the overall white fir-grand fir/warm-xeric subzone. White fir (ABCO) and/or grand fir (ABGR) and ponderosa pine are the most frequent overstory species, with incense cedar and Douglas-fir present about 25 percent of the time. Understory species most frequently seen include squirreltail (ELEL5), greenleaf manzanita, snowbrush ceanothus, Ross' sedge (CARO5), and western needlegrass (ACOC3).

Within the Blue Mountains ecoregion, the species composition also indicates a drier environment from that of the overall white fir-grand fir/warm-xeric subzone. Overstory species include white fir and/or grand fir, Douglas-fir, and ponderosa pine. The most common understory species include Geyer's sedge (CAGE2), pinegrass (CARU), heartleaf arnica (ARCO9), common yarrow (ACMI2), common snowberry, creeping Oregongrape (MARE11), houndstongue hawkweed (HICY), Wheeler's bluegrass (POWH2), California brome (BRCA5), western fescue (FEOC), white hawkweed (HIAL2), western needlegrass, Idaho fescue (FEID), Ross' sedge, and bluebunch wheatgrass (PSSP6).

Table A11.41—White fir-grand fir/warm-xeric subzone (*N* = 2,266) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
White fir, grand fir	ABCO, ABGR	98	30
Ponderosa pine	PIPO	63	19
Incense cedar	CADE27	42	18
Douglas-fir	PSME	41	30

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White fir-grand fir/warm-dry (57)—

This is a common subzone within the white fir-grand fir (ABGRC) vegzone and occurs throughout the described vegzone distribution. This subzone is most abundant in the Blue Mountains and eastern Cascade Range of Oregon and Washington, the Klamath and Siskiyou Mountains and northern Coast Range of California and southwestern Oregon, and the western slopes of the southern Cascade Range to central Sierra Nevada in California and Oregon. These sites occupy moderate environments within the white fir-grand fir vegzone. Mean annual temperature ranges from 41 to 49 °F, and mean annual precipitation ranges from 27 to 53 inches (PRISM Climate Group 2025).

Douglas-fir (PSME) is an important component of these types outside the deep ash/pumice deposits of the Mazama ash plume. Typical species on colder sites transition to California red fir-Shasta red fir (ABMA-ABMAS) (south of Lookout Mountain on the Deschutes National Forest) or to mountain hemlock (TSME) vegzones. Many sites have high precipitation but are well drained, especially within the Mazama ash/pumice deposits.

Ponderosa pine (PIPO) and Douglas-fir are frequently present alongside white fir (ABCO) and/or grand fir (ABGR). Indicator species used to classify this subzone, using the representative warm-mesic group, include white hawkweed (HIAL2), pipsissewa (CHUM), heartleaf arnica (ARCO9), dwarf rose (ROGY), white spirea (SPBE2), oceanspray (HODI), western larch (LAOC), Cascade barberry (MANE2), American trailplant (ADBI), Columbia brome (BRVU), Scouler's willow (SASC), western rattlesnake plantain (GOOB2), creeping snowberry (SYMO), and Rocky Mountain maple (ACGL).

Within the Klamath Mountains ecoregion, the species composition indicates a more variable environment from that of the overall white fir-grand fir/warm-dry subzone. Along with the overstory species of white fir and/or grand fir, Douglas-fir, and ponderosa pine, incense cedar (CADE27) and sugar pine (PILA) are also frequently present. Common understory species include pipsissewa, Cascade barberry, dwarf rose, starflower (TRBO2), creeping snowberry, and western brackenfern (PTAQ).

Table A11.42—White fir-grand fir/warm-dry subzone (*N* = 1,946) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
White fir, grand fir	ABCO, ABGR	96	34
Douglas-fir	PSME	76	37
Ponderosa pine	PIPO	63	13
Shrubs			
Common snowberry	SYAL	46	6
Forbs/graminoids			
White hawkweed	HIAL2	47	1
Pinegrass	CARU	45	15
Geyer's sedge	CAGE2	43	8
Heartleaf arnica	ARCO9	41	5
Common yarrow	ACMI2	35	1

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White fir-grand fir/warm-moist (58)—

This subzone occurs from northeastern Washington to the central Sierra Nevada in California. The warm-moist subzone is best developed on the east side of the Columbia River Gorge and in the northern Blue Mountains and is prominent in the foothills surrounding the Willamette Valley, southwestern Oregon, and northwestern California. This type represents the wettest and most productive environments in the white fir-grand fir (ABGRC) vegzone. Mean annual temperature ranges from 42 to 52 °F, and mean annual precipitation ranges from 31 to 59 inches (PRISM Climate Group 2025).

The shrub layer is variable; the most common species in mid- to late-seral stands are dwarf rose (ROGY), thinleaf huckleberry (VAME), common snowberry (SYAL), Cascade barberry (MANE2), and oceanspray (HODI). Douglas-fir (PSME) is typically a significant component of overstory canopies and is a primary early-seral conifer. These sites are often transitional to western hemlock (TSHE), Pacific silver fir (ABAM), or mountain hemlock (TSME) vegzones. This subzone typically has an herb-rich understory. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include twinflower (LIBO3), bride's bonnet (CLUN2), western swordfern (POMU), starry false lily of the valley (MAST4), prickly currant (RILA), vine maple (ACCI), sidebells wintergreen (ORSE), drops-of-gold (PRHO2), and Pacific trillium (TROV2).

Within the Coast Range ecoregion, species composition indicates a wetter environment than that of the overall white fir-grand fir/warm-moist subzone. Understory species include western swordfern as the most dominant species, along with the presence of California blackberry (RUUR), oceanspray, Cascade barberry, salal (GASH), Pacific poison oak (TODI), red alder (ALRU2), red huckleberry (VAPA), western brackenfern (PTAQ), beaked hazelnut (COCO6), California huckleberry (VAOV2), vine maple, and bigleaf maple (ACMA3).

Within the Blue Mountains ecoregion, species composition indicates a drier environment from that of the overall white fir-grand fir/warm-moist subzone. Additional overstory species include western larch (LAOC), Engelmann spruce (PIEN), lodgepole pine (PICO), and ponderosa pine (PIPO). Understory species include thinleaf huckleberry, Geyer's sedge (CAGE2), heartleaf arnica (ARCO9), pinegrass (CARU), white spirea (SPBE2), twinflower, white hawkweed (HIAL2), Columbia brome (BRVU), western fescue (FEOC), common snowberry (SYAL), northwestern sedge (CACO11), prickly current, American trailplant (ADBI), western meadow-rue (THOC), woodland strawberry (FRVE), and pipsissewa (CHUM).

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Table A11.43—White fir-grand fir/warm-moist subzone (*N* = 1,044) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
White fir, grand fir	ABCO, ABGR	97	34
Douglas-fir	PSME	88	40
Shrubs			
Thinleaf huckleberry	VAME	50	11
Common snowberry	SYAL	46	6
Cascade barberry	MANE2	40	7
Oceanspray	HODI	38	5
Forbs/graminoids			
Twinflower	LIBO3	56	10
White hawkweed	HIAL2	54	1
American trailplant	ADBI	48	2
Pinegrass	CARU	41	11
Woodland strawberry	FRVE	41	2
Heartleaf arnica	ARCO9	38	5
Western brackenfern	PTAQ	38	3
Bride's bonnet	CLUN2	38	2
Western swordfern	POMU	38	7
Geyer's sedge	CAGE2	38	4
Western fescue	FEOC	35	1
Columbia brome	BRVU	33	3

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White fir-grand fir/cool-moist (59)—

This subzone is a minor subzone within the white fir-grand fir (ABGRC) vegzone. This subzone is most abundant in the eastern slopes of the Cascade Range of Oregon and California with scattered distributions of this subzone within the Blue Mountains and Sierra Nevada. This subzone occupies cold, dry environments within the white fir-grand fir vegzone. Mean annual temperature ranges from 40 to 44 °F, and mean annual precipitation ranges from 27 to 40 inches (PRISM Climate Group 2025).

These sites are often transitional to mountain hemlock (TSME) or subalpine fir (ABLA) vegzones. Although mean precipitation on some of these sites is relatively high, effective moisture is much lower than the white fir-grand fir/warm-dry subzone sites because of excessively drained soils. Plant communities in this group are extremely species poor. These environments are generally too cold to support high constancy or cover of Douglas-fir (PSME). Lodgepole pine (PICO) is the dominant early-seral conifer on these sites. The white fir-grand fir/cool-moist subzone may support Shasta red fir (ABMAS) south of Lookout Mountain on the Deschutes National Forest. Overstory species include lodgepole pine, white fir (ABCO) and/or grand fir (ABGR), and ponderosa pine (PIPO). Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine, pinemat manzanita (ARNE), long-stolon sedge (CAIN9), and grouse whortleberry (VASC).

Table A11.44—White fir-grand fir/cool-moist subzone (*N* = 340) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	93	27
White fir, grand fir	ABCO, ABGR	87	31
Ponderosa pine	PIPO	54	16
Shrubs			
Pinemat manzanita	ARNE	47	9
Snowbrush ceanothus	CEVE	33	11
Forbs/graminoids			
Ross' sedge	CARO5	45	2
Virginia strawberry	FRVI	41	1
Western needlegrass	ACOC3	41	2
Squirreltail	ELEL5	36	1

California Red Fir-Shasta Red Fir Vegzone (21)

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Table A11.45—California red fir-Shasta red fir vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
21	California red fir-Shasta red fir	71	Cool-moist
21	California red fir-Shasta red fir	72	Mild-very moist
21	California red fir-Shasta red fir	73	Cool-very moist

The California red fir-Shasta red fir (*Abies magnifica-Abies magnifica* var. *shastensis*, ABMA-ABMAS) vegzone is found in southwestern Oregon, northern California, and is widespread in the Sierra Nevada of California. Shasta red fir is a variety of California red fir that is found in southwestern Oregon and northern California. It is interfertile with noble fir (ABPR) and California red fir. Morphological and genetic characteristics of the trio are similar, thus complicating identification in southwestern Oregon. Populations north of the McKenzie River are recognizable as noble fir and south of Mount Lassen as California red fir. Shasta red fir grows best in areas with cold, wet winters and warm, dry summers. The growing season is short, with snow often on the ground in July. California red fir-Shasta red fir is generally found at high elevations where the climate is cool to cold and moist; however, it is able to tolerate summer dry spells common to the mediterranean environment of southwestern Oregon and northern California (Atzet et al. 1996).

Shasta red fir is more common in southwestern Oregon and northern California, and California red fir often exists in extensive high-elevation stands in the Sierra Nevada. Its range extends from the central and southern Cascade Range of Oregon southward to Lake County in the Coast Range of northwestern California and Kern County in the southern Sierra Nevada. Northern California and southern Oregon populations appear to be closely related to noble fir (Franklin 1982, Zavarin et al. 1978). In the central and southern Sierra Nevada of California, California red fir is clearly a climax dominant in subalpine forests of the Sierra Nevada. From the southern Cascade Range in California north into Oregon and west into the California Coast Range, Shasta red fir begins to lose its clear climax status, perhaps as a result of taking on characteristics of noble fir, which is never a climax species in the northern Cascade Range (Laacke 1990). Shasta red fir is replaced successionally by white fir (ABCO) at lower elevations and by mountain hemlock (TSME) at upper elevations.

This vegzone is characterized by the potential presence of California red fir-Shasta red fir at a minimum of 5 percent cover and location outside of Washington and northern Oregon. This is a depauperate vegzone. Major associated conifer species include western white pine (PIMO3), lodgepole pine (PICO), and white fir (ABCO), with Jeffrey pine (PIJE) occasionally present. Pinemat manzanita (ARNE) is the most frequently seen shrub. Jeffrey pine appears in California in the California red fir-Shasta red fir vegzone, and ponderosa pine (PIPO) appears on the east side within this vegzone. Douglas-fir (PSME) is largely missing from this vegzone, occurring in less than 5 percent of the plots. The absence of Douglas-fir appears related to the predominance of deep ash/pumice derived soils from Mount Mazama within the California red fir-Shasta red fir vegzone.

Table A11.46—California red fir-Shasta red fir vegzone (*N* = 444) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California red fir, Shasta red fir	ABMA, ABMAS	100	44
Western white pine	PIMO3	51	10
Lodgepole pine	PICO	49	27

California red fir-Shasta red fir/cool-moist (71)—

This subzone represents the driest subzone of the California red fir-Shasta red fir (ABMA-ABMAS) vegzone and occurs from Diamond Lake, Oregon south through the Cascade Range and Klamath Mountains, into northern California, to the Great Basin and Sierra Nevada. Mean annual temperature ranges from 40 to 44 °F, and mean annual precipitation ranges from 43 to 59 inches (PRISM Climate Group 2025).

Lodgepole pine (PICO) is the primary seral species in the tree layer. Western white pine (PIMO3) and white fir (ABCO) are often present at covers less than 10 percent. Jeffrey pine (PIJE) may also be present within California forests. Shrub and herbaceous layers have low diversity and relatively low percentages of cover despite much less tree canopy cover than California red fir-Shasta red fir/mild-very moist subzone sites. Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine and pinemat manzanita (ARNE).

Table A11.47—California red fir-Shasta red fir/cool-moist subzone (*N* = 197) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California red fir, Shasta red fir	ABMA, ABMAS	99	36
Lodgepole pine	PICO	69	31

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California red fir-Shasta red fir/mild-very moist (72)—

This subzone occurs from Diamond Lake, Oregon south through the Cascade Range and Klamath Mountains, into northern California, to the Great Basin and the Sierra Nevada. Sites within this subzone have the most moderate environments within the California red fir-Shasta red fir (ABMA-ABMAS) vegzone. This is the warmest subzone within this vegzone. Mean annual temperature ranges from 40 to 45 °F, and mean annual precipitation ranges from 44 to 63 inches (PRISM Climate Group 2025).

Common overstory species, along with California red fir, or Shasta red fir, include white fir (ABCO), western white pine (PIMO3), and lodgepole pine (PICO). Jeffrey pine (PIJE) may also be present in California forests. Percentages of canopy cover of tree layers is often high and significantly reduces the percentages of cover and species richness in shrub and herbaceous layers. Indicator species used to classify this subzone, using the representative warm-mesic group, include mountain monardella (MOOD), bush chinquapin (CHSE11), and whiteveined wintergreen (PYPI2).

Table A11.48—California red fir-Shasta red fir/mild-very moist subzone (*N* = 101) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California red fir, Shasta red fir	ABMA, ABMAS	100	51
White fir	ABCO	47	10
Lodgepole pine	PICO	41	22
Shrubs			
Pinemat manzanita	ARNE	40	11
Forbs/graminoids			
Mountain monardella	MOOD	39	3

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California red fir-Shasta red fir/cool-very moist (73)—

This subzone occurs from Diamond Lake, Oregon south through the Cascade Range and Klamath Mountains, into northern California, to the Great Basin and the Sierra Nevada. This subzone is relatively minor. Sites represent the coolest and wettest environments of the California red fir-Shasta red fir (ABMA-ABMAS) vegzone. Mean annual temperature ranges from 39 to 44 °F, and mean annual precipitation ranges from 43 to 61 inches (PRISM Climate Group 2025).

Western white pine (PIMO3) is frequently present. Lodgepole pine (PICO), white fir (ABCO), and mountain hemlock (TSME) may also be present, along with Jeffrey pine (PIJE) in California. Shrub and herbaceous layers have low diversity and relatively low percentages of cover. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western white pine (PIMO3) and sidebells wintergreen (ORSE).

Table A11.49—California red fir-Shasta red fir/cool-very moist subzone (*N* = 146) constancy and cover

Layer/common name	Species symbol	Constancy	Mean Cover
		PERCENT	
Trees			
California red fir, Shasta red fir	ABMA, ABMAS	100	49
Western white pine	PIMO3	77	13

Giant Sequoia Vegzone (16)

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Table A11.50—Giant sequoia vegzone and subzone

Vegzone number	Vegzone name	Subzone number	Subzone name
16	Giant sequoia	54	Giant sequoia

The giant sequoia (*Sequoiadendron giganteum*, SEGI2) vegzone is only found in California, mainly restricted to a limited area of the western Sierra Nevada. Giant sequoia is usually found in a humid climate characterized by dry summers and snowy winters. Mean annual temperature ranges from 43 to 49 °F, and mean annual precipitation ranges from 40 to 47 inches (PRISM Climate Group 2025).

Giant sequoias generally occur on the south-facing sides of northern mountains and on the northern faces of more southerly slopes. Species commonly found with giant sequoia are white fir (ABCO) and sugar pine (PILA). Cones are serotinous.

There are no subzones for the giant sequoia vegzone. This vegzone is characterized by the presence of giant sequoia at a minimum of 10 percent cover. The most common species present include giant sequoia, Jeffrey pine (PIJE), and ponderosa pine (PIPO). Crested wheatgrass (AGCR) and bitter cherry (PREM) may be present. Indicator species used to classify this subzone, using the representative warm-dry group, include spreading dogbane (APAN2), incense cedar (CADE27), whitethorn ceanothus (CECO), sugar pine (PILA), and wax current (RICE).

Table A11.51—Giant sequoia vegzone (*N* = 5) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Giant sequoia	SEGI2	100	48
Jeffrey pine	PIJE	40	9
Ponderosa pine	PIPO	40	5

Port Orford Cedar Vegzone (13)

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Table A11.52—Port Orford cedar vegzone and subzone

Vegzone	Vegzone name	Subzone	Subzone name
13	Port Orford cedar	79	Port Orford cedar

The Port Orford cedar (*Chamaecyparis lawsoniana*, CHLA) vegzone is located in the Klamath Mountains, the southern end of the Coast Range in Oregon, and the northern end of the Coast Range in California. Port Orford cedar occurs where moisture stress is dampened by summer fog (topographically protected drainages, on northerly aspects). This vegzone occupies a restricted range, as a result of Port Orford cedar being native only to southwestern Oregon and northwestern California (Little 1971). The Port Orford cedar vegzone may occur in various topographic conditions throughout the landscape. In northern California and inland southwestern Oregon, this vegzone is restricted to bottoms and lower slope positions (Jimerson 1994). Port Orford cedar also grows in the margins of fens and riparian zones with serpentine soils.

The climate in the Port Orford cedar vegzone is characterized by warm, dry summers and cool, wet winters. Precipitation across the range varies between 35 to 140 inches annually. California environments receive at least 59 inches of precipitation annually. At high elevations on the west side of the Rogue River-Siskiyou National Forest in southwestern Oregon (formerly the Siskiyou National Forest), Port Orford cedar stands receive a mean of 90 inches of annual precipitation. Inland disjunct stands in the eastern Klamath Mountains of California receive at least 49 inches of precipitation annually (Atzet et al. 1996).

Throughout its range, Port Orford cedar occurs on ultramafic parent material, particularly where the water table is close to the surface (perched). Scattered, perched water tables are characteristic of ultramafic parent material. Indicator species for this vegzone are frequently the dominant species on these ultramafic substrates (e.g., serpentinite, peridotite) where competition from other species is reduced because of the ultramafic soils (Atzet et al. 1996). At lower elevations, particularly in California, it is often restricted to these nutrient-poor soils (Hawk 1977, Zobel et al. 1985). Common habitats for this vegzone include streamsides, bogs, and other wet areas. It is an important component of these riparian zones as the long-lasting wood provides persistent structure to these riparian areas for fish, amphibians, and other aquatic organisms.

This vegzone is characterized by the presence of Port Orford cedar at a minimum of 10 percent cover. Port Orford cedar is present in all stands with a mean cover of 19 percent. Douglas-fir (PSME) is almost always present within the stand, with a mean cover of 45 percent. This ecosystem is characterized by long-lived stands, which may have relatively open canopies where serpentine soils or soil saturation reduce site potential.

Infection of large Port Orford cedar trees with *Phytophthora lateralis* root disease may result in a reduction of the proportion of late-seral states and canopy closure, especially if Port Orford cedar individuals grew in areas too wet for Douglas-fir to successfully replace them (Jules et al. 2014).

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There are no subzones for the Port Orford cedar vegzone. The most common tree species present include Port Orford cedar, Douglas-fir, western white pine (PIMO3), and tanoak (NODE3). Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), salal (GASH), drops-of-gold (PRHO2), western white pine, Pacific rhododendron (RHMA3), twinflower (LIBO3), and California laurel (UMCA).

Table A11.53—Port Orford cedar vegzone (*N* = 48) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Port Orford cedar	CHLA	100	19
Douglas-fir	PSME	96	45
Western white pine	PIMO3	46	17
Tanoak	NODE3	42	28
Shrubs			
Salal	GASH	63	19
Huckleberry oak	QUVA	52	21
California huckleberry	VAOV2	48	9
Western azalea	RHOC	46	7
Pacific rhododendron	RHMA3	38	15
Pinemat manzanita	ARNE	35	5
Forbs/graminoids			
Western swordfern	POMU	73	7
Common beargrass	XETE	69	3
Starflower	TRBO2	60	1
Pipsissewa	CHUM	35	1
Western brackenfern	PTAQ	35	1
Twinflower	LIBO3	33	1

Tanoak Vegzone (15)

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Table A11.54—Tanoak vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
15	Tanoak	51	Very moist
15	Tanoak	52	Very wet

The tanoak (*Notholithocarpus densiflorus,* NODE3; *Lithocarpus densiflorus*, LIDE3)[1] vegzone is limited to southwestern Oregon and northwestern California. It is most common in the Coast Range and Siskiyou Mountains in California and Oregon and inland, where it ranges east to the Siskiyou and Klamath Mountains. This vegzone is found in coastal areas where marine air softens severe frosts and reduces summer evapotranspiration demand, in an inland mid-slope elevational belt below the high-elevation cold but above cold-air accumulation in the valleys (mostly 2,000 to 4,000 ft), in protected inland and often north-facing coves, and on ultramafic sites heavily modified by precipitation or by other normal rock types (Atzet et al. 1996). In southwestern Oregon, this vegzone is found in the moist middle of southwestern Oregon's environmental gradient, where it is bracketed by the western hemlock (TSHE) and the Douglas-fir (PSME) vegzones. It is most common just above the redwood (SESE3) vegzone in coastal locations in California.

The tanoak vegzone occurs in areas with relatively high moisture levels and mild temperatures. It is best adapted to a mediterranean climate modified by cool, moist coastal air currents, with rainy winters and dry summers and falls. Productive sites within this vegzone are found in areas of high humidity, with plentiful moisture from soil, rain, fog, low clouds, or high humidity. In some areas, such as redwood forests of coastal Monterey County, California, tanoak attains greatest abundance and largest size on mesic sites above the fog zone. Soils supporting this vegzone are typically deep and well drained. Frost and drought limit its range (Atzet et al. 1996, Jimerson et al. 1995).

This vegzone is characterized by the potential presence of tanoak at a minimum of 20 percent cover. Tanoak is present in all plots with a mean cover of 52 percent. Douglas-fir (PSME) is almost always present with a mean cover of 47 percent, as well as Pacific madrone (ARME) with a mean cover of 14 percent. The most frequently found understory species in this vegzone include western swordfern (POMU), western brackenfern (PTAQ), Pacific poison oak (TODI), canyon live oak (QUCH2), Cascade barberry (MANE2), California huckleberry (VAOV2), common whipplea (WHMO), and salal (GASH).

[1] The current scientific name of tanoak is *Notholithocarpus densiflorus* (NODE3), and the former scientific name was *Lithocarpus densiflorus* (LIDE3). Maps may reference tanoak by its former scientific name.

Table A11.55—Tanoak vegzone (*N* = 659) constancy and cover

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Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Tanoak	NODE3	99	52
Douglas-fir	PSME	94	47
Pacific madrone	ARME	73	14
Canyon live oak	QUCH2	44	21
Shrubs			
California huckleberry	VAOV2	41	21
Salal	GASH	38	11
Forbs/graminoids			
Western swordfern	POMU	62	5
Western brackenfern	PTAQ	56	2

Tanoak/very moist (51)—

This subzone represents the inland, drier environments of the tanoak (NODE3) vegzone. Mean annual temperature ranges from 50 to 56 °F, and mean annual precipitation ranges from 53 to 82 inches (PRISM Climate Group 2025).

Tanoak and Douglas-fir (PSME) are codominants, with Pacific madrone (ARME) frequently present. Sugar pine (PILA), California black oak (QUKE), and giant chinquapin (CHCH7) may also be present. Indicator species used to classify this subzone, using the representative warm-mesic group, include common whipplea (WHMO), Cascade barberry (MANE2), starflower (TRBO2), dwarf rose (ROGY), California huckleberry (VAOV2), California blackberry (RUUR), western rattlesnake plantain (GOOB2), and giant chinquapin.

Species composition shifts in the more southerly range of this subzone, within the Central California Foothills and Coastal Mountains ecoregion. Douglas-fir is not as frequent; however, there are more species of oak present. Tanoak, Pacific madrone, canyon live oak (QUCH2), California live oak (QUAG), interior live oak (QUWI2), California black oak, and California laurel (UMCA) are common. Ponderosa pine (PIPO) and Coulter pine (PICO3) may also be present. The most common understory species include Pacific poison oak (TODI), western brackenfern (PTAQ), and western swordfern (POMU). California huckleberry may be present with high percentage of cover.

Table A11.56—Tanoak/very moist subzone (*N* = 348) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Tanoak	NODE3	98	50
Douglas-fir	PSME	91	45
Pacific madrone	ARME	83	16
Canyon live oak	QUCH2	53	24
Forbs/graminoids			
Western brackenfern	PTAQ	49	3
Western swordfern	POMU	45	1

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Tanoak/very wet (52)—

This subzone occurs along the coastal side of the tanoak (NODE3) vegzone, where precipitation is higher and temperatures are warmer. Mean annual temperature ranges from 50 to 55 °F, and mean annual precipitation ranges from 62 to 105 inches (PRISM Climate Group 2025).

Tanoak and Douglas-fir (PSME) are codominants, with Pacific madrone (ARME) frequently present. Bigleaf maple (ACMA3) and California laurel (UMCA) are common. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU), salal (GASH), bigleaf maple, California laurel (UMCA), Pacific rhododendron (RHMA3), drops-of-gold (PRHO2), redwood-sorrel (OXOR), and red alder (ALRU2).

Table A11.57—Tanoak/very wet subzone (*N* = 311) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Tanoak	NODE3	100	55
Douglas-fir	PSME	98	49
Pacific madrone	ARME	62	11
Bigleaf maple	ACMA3	41	16
California laurel	UMCA	38	16
Canyon live oak	QUCH2	33	17
Shrubs			
Salal	GASH	61	14
California huckleberry	VAOV2	59	21
Pacific rhododendron	RHMA3	35	14
Forbs/graminoids			
Western swordfern	POMU	80	8
Western brackenfern	PTAQ	62	2
Starflower	TRBO2	36	1

Table A11.58—Douglas-fir vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
14	Douglas-fir	40	Bigcone Douglas-fir
14	Douglas-fir	41	Very warm-dry
14	Douglas-fir	42	Warm-dry
14	Douglas-fir	43	Very warm-moist

Douglas-fir (*Pseudotsuga menziesii*, PSME) is the dominant tree species west of the Cascade Range in the Pacific Northwest, occurring in the North Cascades, Northern Rockies, Blue Mountains (minor), Willamette Valley, Klamath Mountains/California High North Coast Range, Coast Range, and Central California Foothills and Coastal Mountains ecoregions, and is the dominant seral or climax species over a very broad range of habitats. It is the climax tree species on habitats either too dry for, or beyond the geographic range of, more shade-tolerant species, such as western hemlock (TSHE), western redcedar (THPL), white fir (ABCO) and/or grand fir (ABGR), and mountain hemlock (TSME).

The Douglas-fir vegzone is present in northern Washington on the east side of the Cascade Range, scattered throughout most of Oregon, and is prominent in southwestern Oregon and northern California. This vegzone is essentially missing in central and south-central Oregon where deep pumice deposits from Mount Mazama, the South and Middle Sisters, Shasta, and Lassen occur. Within these ash/pumice deposits, the vegzone is found only on steep slopes where ash and pumice did not accumulate. On warmer, drier sites, the Douglas-fir vegzone grades into nonforest communities or into the ponderosa pine (PIPO) vegzone on the east side of the Cascade Range. On the west side of the Cascade Range, this vegzone grades into the white fir-grand fir (ABGRC) vegzone and the western hemlock and tanoak (NODE3) vegzones in southwestern Oregon. In California, the Douglas-fir vegzone is replaced with the white fir-grand fir vegzone at higher elevations where there is more effective moisture, and the ponderosa pine vegzone at lower elevations where the environment is drier.

The presence and dominance of Douglas-fir in the understory may indicate hot, dry conditions characteristic of the vegzone. In southwestern Oregon, this vegzone occurs in the hottest, driest forest environments, except for the isolated occurrences of climax stands of Oregon white oak (QUGA4) and ponderosa pine (Atzet et al. 1996). Because mediterranean ecosystems are hotter, drier, and have more clear days and nights (temperature extremes not dampened by cloud cover or high humidity) than temperate systems, Douglas-fir has the potential to attain climax status on a wide variety of soil conditions across the landscape. In southwestern Oregon, this vegzone distribution is not totally associated with a particular elevational band or continuum like the white fir-grand fir vegzone. Instead, the Douglas-fir vegzone can be found on the hotter, drier sites at high elevations or on the coastal side of the Coastal crest mixed with the western hemlock or tanoak vegzones (Atzet et al. 1996).

In central Oregon, ponderosa pine is a major seral species throughout the Douglas-fir vegzone. Incense cedar (CADE27) is a minor climax species from Sisters north to the White River east of Mount Hood and from Chiloquin though the Klamath River Canyon into northern California. Oregon white oak is a common early successional species from the Mutton

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Mountains north to Hood River and in the Klamath River Canyon. Understory vegetation is similar to moist and dry white fir-grand fir vegzone sites minus roughfruit berry (RULA2), Cascade barberry (MANE2), starry false lily of the valley (MAST4), and Oregon boxleaf (PAMY). These species are replaced by dry site species, such as heartleaf arnica (ARCO9), arrowleaf balsamroot (BASA3), antelope bitterbrush (PUTR2), and Geyer's sedge (CAGE2).

This vegzone is characterized by the presence of Douglas-fir at a minimum of 5 percent cover. Ponderosa pine is frequently found in this vegzone. California black oak (QUKE), canyon live oak (QUCH2), and incense cedar are common. Common understory species include common snowberry (SYAL), common yarrow (ACMI2), pinegrass (CARU), Saskatoon serviceberry (AMAL2), dwarf rose (ROGY), white spirea (SPBE2), white hawkweed (HIAL2), oceanspray (HODI), heartleaf arnica (ARCO9), Idaho fescue (FEID), Pacific poison oak (TODI), and bluebunch wheatgrass (PSSP6).

Table A11.59—Douglas-fir vegzone (*N* = 3,649) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	95	41
Ponderosa pine	PIPO	60	15
Shrubs			
Common snowberry	SYAL	43	8
Forbs/graminoids			
Common yarrow	ACMI2	38	2
Pinegrass	CARU	38	17

Bigcone Douglas-fir (40)—

This subzone is only found in California. Low-elevation bigcone Douglas-fir (PSMA) forest communities are disjunct, surrounded by extensive areas of chamise (ADFA) chaparral or coastal sage scrub. In canyon bottoms, bigcone Douglas-fir communities intergrade with riparian forest. As elevation increases, stands of bigcone Douglas-fir are more widespread. Canyon live oak (QUCH2) is almost always found in these stands. Coulter pine (PICO3) replaces bigcone Douglas-fir on more xeric sites at these elevations. Bigcone Douglas-fir grows in a mediterranean climate, characterized by hot summers and wet, mild winters. Mean annual temperature ranges from 52 to 59 °F, and mean annual precipitation ranges from 20 to 32 inches (PRISM Climate Group 2025). It is one of only a few western conifers capable of sprouting following fire. Mature trees sprout vigorously from the branches and bole after burning (Burns and Honkala 1990).

Canyon live oak is frequently present alongside bigcone Douglas-fir. Sugar pine (PILA), Coulter pine, singleleaf pinyon (PIMO), Jeffrey pine (PIJE), interior live oak (QUWI2), and California black oak (QUKE) are somewhat common. Indicator species used to classify this subzone, using the representative warm-dry group, include canyon live oak, alderleaf mountain mahogany (CEMO2), and sugar pine.

Table A11.60—Bigcone Douglas-fir vegzone (*N* = 68) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Bigcone Douglas-fir	PSMA	99	18
Canyon live oak	QUCH2	85	37

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Douglas-fir/very warm-dry (41)—

This subzone is scattered throughout Washington and is very prevalent in southwestern Oregon and California. It is the most common subzone within the Douglas-fir (PSME) vegzone. This subzone represents the warmest and driest Douglas-fir environments. Mean annual temperature ranges from 44 to 55 °F, and mean annual precipitation ranges from 23 to 51 inches (PRISM Climate Group 2025).

This subzone is found across the range of the vegzone, generally at lower elevations. Tree layers are various mixtures of Douglas-fir and ponderosa pine (PIPO), with California black oak (QUKE), canyon live oak (QUCH2), incense cedar (CADE27), sugar pine (PILA), and Oregon white oak (QUGA4) also common. Disturbance of the overstory will dramatically increase the total cover of the understory. Indicator species used to classify this subzone, using the representative warm-dry group, include common snowberry (SYAL), Pacific poison oak (TODI), canyon live oak, pinegrass (CARU), Geyer's sedge (CAGE2), Saskatoon serviceberry (AMAL2), sugar pine, and incense cedar.

Within the Central California Foothills and Coastal Mountains ecoregion, species composition indicates a drier environment than that of the overall Douglas-fir/very warm-dry subzone. This ecoregion includes the presence of more oaks, such as California black oak, canyon live oak, California live oak (QUAG), interior live oak (QUWI2), Oregon white oak, and valley oak (QULO). California laurel (UMCA) is also commonly found within this ecoregion. Common understory species include Pacific poison oak, Pacific madrone (ARME), and toyon (HEAR5).

Within the Blue Mountains ecoregion, species composition lacks the oaks but includes many graminoids, also indicating a drier environment than that of the overall Douglas-fir/very warm-dry subzone. The only tree species frequently present are Douglas-fir and ponderosa pine, with western juniper (JUOC) occasionally present. Common understory species include Geyer's sedge, common snowberry, common yarrow (ACMI2), bluebunch wheatgrass (PSSP6), Idaho fescue (FEID), pinegrass, heartleaf arnica (ARCO9), Wheeler's bluegrass (POWH2), California brome (BRCA5), creeping Oregongrape (MARE11), houndstongue hawkweed (HICY), Saskatoon serviceberry (AMAL2), Sandberg bluegrass (POSE), and arrowleaf balsamroot (BASA3).

Table A11.61—Douglas-fir/very warm-dry subzone (*N* = 68) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	96	34
Ponderosa pine	PIPO	71	16
California black oak	QUKE	38	18
Shrubs			
Common snowberry	SYAL	33	6
Forbs/graminoids			
Common yarrow	ACMI2	33	2

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Douglas-fir/warm-dry (42)—

This subzone represents the warm, dry Douglas-fir (PSME) environments. It appears less often than the very warm-dry subzone and is more prevalent in northern Washington. Mean annual temperature ranges from 42 to 48 °F, and mean annual precipitation ranges from 19 to 36 inches (PRISM Climate Group 2025).

The tree layers are dominated by Douglas-fir, with ponderosa pine (PIPO) very common. Indicator species used to classify this subzone, using the representative warm-mesic group, include white spirea (SPBE2), oceanspray (HODI), heartleaf arnica (ARCO9), white hawkweed (HIAL2), dwarf rose (ROGY), Scouler's willow (SASC), kinnikinnick (ARUV), Rocky Mountain maple (ACGL), Cascade barberry (MANE2), and feathery false lily of the valley (MARA7).

Within the Klamath Mountains ecoregion, species composition is somewhat different from the overall Douglas-fir/warm-dry subzone. Graminoids are mostly absent in this ecoregion, and ponderosa pine is not found as frequently as in the overall subzone (38 versus 62 percent constancy). Canyon live oak (QUCH2), California black oak (QUKE), incense cedar (CADE27), and sugar pine (PILA) are also commonly found. Understory species frequently found include Pacific poison oak (TODI), common whipplea (WHMO), Pacific madrone (ARME), dwarf rose, western swordfern (POMU), starflower (TRBO2), pink honeysuckle (LOHI2), beaked hazelnut (COCO6), California blackberry (RUUR), oceanspray (HODI), western brackenfern (PTAQ), Cascade barberry, white hawkweed, hollyleaved barberry (MAAQ2), and creeping snowberry (SYMO).

Table A11.62—Douglas-fir/warm-dry (*N* = 1,402) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	97	46
Ponderosa pine	PIPO	62	14
Shrubs			
Common snowberry	SYAL	60	10
White spirea	SPBE2	54	6
Oceanspray	HODI	49	6
Forbs/graminoids			
Pinegrass	CARU	62	20
Common yarrow	ACMI2	55	2
Heartleaf arnica	ARCO9	46	7
White hawkweed	HIAL2	44	1
Idaho fescue	FEID	33	5

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Douglas-fir/very warm-moist (43)—

This subzone represents a wetter environment than the other Douglas-fir (PSME) subzones. It is found south of Olympia, along the fringes of the Willamette Valley, in southwestern Oregon and northern California, and is scattered farther south into California. Mean annual temperature ranges from 48 to 55 °F, and mean annual precipitation ranges from 41 to 66 inches (PRISM Climate Group 2025).

Ponderosa pine (PIPO) is less frequently found, while bigleaf maple (ACMA3) becomes common. Indicator species used to classify this subzone, using the representative warm-wet mesic group, include western swordfern (POMU) and bigleaf maple.

Within the Northern Rockies ecoregion, species composition is slightly different than that of the overall Douglas-fir/very warm-moist subzone. It is a species-rich ecoregion within this subzone, with 40 species having constancies greater than 40 percent. Overstory species include Douglas-fir and western larch (LAOC), with ponderosa pine and lodgepole pine (PICO) common. The most common understory species include pinegrass (CARU), common snowberry (SYAL), white spirea (SPBE2), Saskatoon serviceberry (AMAL2), twinflower (LIBO3), Oregon boxleaf (PAMY), kinnikinnick (ARUV), Rocky Mountain maple (ACGL), pipsissewa (CHUM), heartleaf arnica (ARCO9), thimbleberry (RUPA), hollyleaved barberry (MAAQ2), dwarf rose (ROGY), Scouler's willow (SASC), feathery false lily of the valley (MARA7), common yarrow (ACMI2), and white hawkweed (HIAL2).

Table A11.63—Douglas-fir/very warm-moist (*N* = 497) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Douglas-fir	PSME	99	50
Bigleaf maple	ACMA3	46	22
Shrubs			
Pacific poison oak	TODI	43	7
Beaked hazelnut	COCO6	42	7
Oceanspray	HODI	39	5
California blackberry	RUUR	38	7
Common snowberry	SYAL	35	6
Forbs/graminoids			
Western swordfern	POMU	61	8
Western brackenfern	PTAQ	36	4

Jeffrey Pine Vegzone (12)

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Table A11.64—Jeffrey pine vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
12	Jeffrey pine	37	Warm-xeric
12	Jeffrey pine	38	Warm-dry
12	Jeffrey pine-knobcone pine	39	Knobcone pine

The Jeffrey pine (*Pinus jeffreyi,* PIJE) vegzone occurs throughout southwestern Oregon, the Klamath Mountains, and south through much of California, including the Sierra Nevada, Coast Range, Transverse and Peninsular Ranges, to northern Baja California. Southwestern Oregon is the northern extent of the range of Jeffrey pine (Burns and Honkala 1990).

Environments within the Jeffrey pine vegzone are characterized by shallow, rocky, infertile soils and dry pumice and bare granitic substrates. About 20 percent of Jeffrey pine's distribution occurs on ultramafic soils; the rest occurs on volcanic and granitic parent materials. In southwestern Oregon and northwestern California, Jeffrey pine is most typical of ultramafic soils, including serpentine. Ultramafic bedrock, mainly serpentine and peridotite, is high in ferromagnesium silicate minerals with an unusually high proportion of nickel and chromium. This chemical composition, toxic to most plants, results in a unique and diverse flora. Soils weathered from ultramafic rock strongly reflect the elemental composition of the parent rock with high concentrations of magnesium, iron, and silica (Kruckeberg 1984). Jeffrey pine is tolerant of short growing seasons, drought, and cold.

Jeffrey pine is often the dominant tree species on soils derived from ultramafic parent material, especially in interior valleys and foothills. Tanoak (NODE3), western hemlock (TSHE), or Port Orford cedar (CHLA) may replace Jeffrey pine as the stand dominant near the coast.

This vegzone is characterized by the presence of Jeffrey pine at a minimum of 5 percent cover. As a result of the serpentine/peridotite parent material influence, there are many unique species found in this vegzone, e.g., Indian's dream (ASDE6), dwarf ceanothus (CEPU), Tolmie star-tulip (CATO), dwarf silktassel (GABU2), California buckthorn (FRCA12), huckleberry oak (QUVA), and common beargrass (XETE). These species may be frequently found yet may have low percentages of cover. Douglas-fir (PSME) and incense cedar (CADE27), and ponderosa pine (PIPO) in California, are consistently present in the overstory and the understory.

In California, the Jeffrey pine vegzone is also found on nonserpentine soils, and it incorporates ponderosa pine and white fir (ABCO). Big sagebrush (ARTR2), antelope bitterbrush (PUTR2), and squirreltail (ELEL5) are also more common in California than in Oregon. The Jeffrey pine vegzone has the highest frequency of sensitive and rare plants of forest zones in northwestern California (Jimerson et al. 1995).

Table A11.65—Jeffrey pine vegzone (*N* = 751) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Jeffrey pine	PIJE	96	23

Jeffrey pine/warm-xeric (37)—

This subzone is found along the eastern edge of California along the Sierra Nevada and farther south into southern California. This subzone represents the driest Jeffrey pine (PIJE) environments. Mean annual temperature ranges from 42 to 48 °F, and mean annual precipitation ranges from 16 to 22 inches (PRISM Climate Group 2025).

Jeffrey pine is always present in this subzone, with ponderosa pine (PIPO) and singleleaf pinyon (PIMO) occasionally present. Indicator species used to classify this subzone, using the representative warm-xeric group, include western juniper (JUOC), big sagebrush (ARTR2), antelope bitterbrush (PUTR2), squirreltail (ELEL5), and curl-leaf mountain mahogany (CELE3).

Species composition in the Southern California Mountains ecoregion is somewhat different than the northern variant of the warm-xeric subzone. There are fewer species overall; Jeffrey pine, singleleaf pinyon, and western juniper (JUOC) are the most common tree species. White fir (ABCO) may also be common. Ponderosa pine and California black oak (QUKE) may be occasionally present. The only somewhat common understory species are big sagebrush and curl-leaf mountain mahogany.

Table A11.66—Jeffrey pine/warm-xeric subzone (*N* = 195) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Jeffrey pine	PIJE	100	22
Western juniper	JUOC	65	13
Shrubs			
Big sagebrush	ARTR2	37	11
Antelope bitterbrush	PUTR2	34	8

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Jeffrey pine/warm-dry (38)—

This subzone is found in southwestern Oregon and northern California and represents dry environments that receive more annual precipitation than the Jeffrey pine (PIJE)/warm-xeric subzone. Mean annual temperature ranges from 43 to 51 °F, and mean annual precipitation ranges from 21 to 43 inches (PRISM Climate Group 2025).

Jeffrey pine, incense cedar (CADE27), ponderosa pine (PIPO), and white fir (ABCO) and/or grand fir (ABGR) are the most frequently found overstory species. Indicator species used to classify this subzone, using the representative warm-dry group, include sticky whiteleaf manzanita (ARVI4), incense cedar, and prostrate ceanothus (CEPR).

Species composition in the Southern California Mountains ecoregion is somewhat different than that of the northern warm-dry subzone. The most frequently occurring species include Jeffrey pine, California black oak (QUKE), canyon live oak (QUCH2), singleleaf pinyon (PIMO), sugar pine (PILA), white fir, and Coulter pine (PICO3). Interior live oak (QUWI2), sticky whiteleaf manzanita, incense cedar, and whitethorn ceanothus (CECO) may be occasionally present.

Species composition in the Klamath Mountains ecoregion is also somewhat different from that of the overall Jeffrey pine/warm-dry subzone. Jeffrey pine, incense cedar, Douglas-fir (PSME), and sugar pine are the most common overstory species. Frequently found understory species include huckleberry oak (QUVA), sticky whiteleaf manzanita, common yarrow (ACMI2), Indian's dream (ASDE6), California buckthorn (FRCA12), and Idaho fescue (FEID).

Table A11.67—Jeffrey pine/warm-dry subzone (*N* = 532) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Jeffrey pine	PIJE	99	23

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Knobcone pine (39)—

This subzone represents those sites that are climax to knobcone pine (PIAT) and is found in California and Oregon in minor amounts. Knobcone pine is always present on these sites, while Jeffrey pine (PIJE) is mostly absent. This subzone was placed within this vegzone because of its serpentine affinity. Mean annual temperature ranges from 51 to 58 °F, and mean annual precipitation ranges from 31 to 45 inches (PRISM Climate Group 2025).

Ponderosa pine (PIPO) may be present. Canyon live oak (QUCH2), interior live oak (QUWI2), California black oak (QUKE), scrub oak (QUBE5), and California live oak (QUAG) are commonly found in this subzone. Common understory species include sticky whiteleaf manzanita (ARVI4), chamise (ADFA), Pacific poison oak (TODI), toyon (HEAR5), greenleaf manzanita (ARPA6), whiteleaf manzanita (ARMA), buckbrush (CECU), deerbrush (CEIN3), and alderleaf mountain mahogany (CEMO2).

Species composition in the Cascades ecoregion is somewhat different than that of the overall knobcone pine subzone. Knobcone pine, bitter cherry (PREM), California black oak, greenleaf manzanita, prostrate ceanothus (CEPR), snowbrush ceanothus (CEVE), squirreltail (ELEL5), and antelope bitterbrush (PUTR2) are the most common species.

Species composition in the Klamath Mountains ecoregion is also somewhat different than that of the overall knobcone pine subzone. Knobcone pine is the only common conifer, with ponderosa pine possibly present. Understory species include sticky whiteleaf manzanita, Pacific poison oak, canyon live oak, California black oak, chamise, greenleaf manzanita, and alderleaf mountain mahogany.

Table A11.68—Knobcone pine (*N* = 24) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Knobcone pine	PIAT	100	19
Canyon live oak	QUCH2	50	27
Interior live oak	QUWI2	42	28
California black oak	QUKE	38	23
Shrubs			
Pacific poison oak	TODI	50	4
Sticky whiteleaf manzanita	ARVI4	63	18
Chamise	ADFA	54	8
Toyon	HEAR5	33	7

Ponderosa Pine Vegzone (10) Back to Index

Table A11.69—Ponderosa pine vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
10	Ponderosa pine	30	Ponderosa pine-juniper woodlands
10	Ponderosa pine	31	Warm-xeric
10	Ponderosa pine	33	Ponderosa pine-lodgepole pine
10	Ponderosa pine	34	Ponderosa pine-oak

Ponderosa pine (*Pinus ponderosa*, PIPO) forests are widely distributed on the east slopes of the Oregon and Washington Cascade Range, and extensively scattered throughout California on the Modoc, Lassen, and Plumas National Forests and on the eastern edge of the Central Valley. Climax ponderosa pine forests occupy a narrow band, 5 to 10 miles wide, on the eastern flanks of the Cascade Range from the Columbia River south to Bend. South of Bend, within the pumice/ash deposits from Mount Mazama, the ponderosa pine vegzone is up to 35 to 40 miles wide.

The climate of the ponderosa pine vegzone is characterized by a short growing season and minimal summer precipitation (Franklin and Dyrness 1973). Because ponderosa pine occupies drier sites than any other forest type, except western juniper (JUOC) or occasionally lodgepole pine (PICO), its distribution is tied closely to available soil moisture. Sites with high mean annual precipitation have low effective moisture due to excessive soil drainage (ash/pumice, cinder deposits) or shallow soils (lava flows).

While ponderosa pine behaves as a fast growing, seral species on hot, dry sites with shallow, droughty soils, it is the climax species on only a few sites in the Klamath and Cascade Province in southwestern Oregon (Atzet and Martin 1992). Ponderosa pine can be found in frost pockets and on vertisols, soils with high shrink-swell characteristics (Atzet et al. 1996).

Climax ponderosa pine stands outside the pumice/ash deposits typically grow as very open forests or woodlands. Ponderosa pine is often the only tree species present, although minor amounts of Douglas-fir (PSME) or white fir (ABCO) and/or grand fir (ABGR) can be found; however, sites are generally too dry for Douglas-fir or white fir and/or grand fir to assume dominance. Outside the pumice/ash deposits, ponderosa pine, incense cedar (CADE27), western juniper, and Oregon white oak (QUGA4) are usually the only tree species regenerating.

Within the deep recent pumice/ash deposits, lodgepole pine is an important seral species in this vegzone and may never be completely excluded, especially in flat areas and depressions that accumulate cold air. Sugar pine (PILA) may also be found in association with ponderosa pine, especially on slopes with good, cold-air drainage within the Mount Mazama deposits. Where sugar pine occurs, it indicates more effective moisture and slightly cooler temperatures and often a transition to the white fir-grand fir (ABGRC) vegzone.

This vegzone is characterized by the presence of ponderosa pine at a minimum of 5 percent cover. Shrubs are important in some ponderosa pine subzones, but typically shrubs do not form a continuous layer. The most common shrub is antelope bitterbrush (PUTR2). Squirreltail (ELEL5), Ross' sedge (CARO5), Idaho fescue (FEID), and western needlegrass

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(ACOC3) are the most dominant graminoids of the vegzone. Many of the important forbs and graminoids found in the vegzone are species also characteristic of nearby shrublands and grasslands that occur under conditions too harsh for trees. Some important taxa include Sandberg bluegrass (POSE), Wheeler's bluegrass (POWH2), bluebunch wheatgrass (PSSP6), and common yarrow (ACMI2).

Table A11.70—Ponderosa pine vegzone (*N* = 2,615) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Ponderosa pine	PIPO	96	25
Shrubs			
Antelope bitterbrush	PUTR2	55	11
Forbs/graminoids			
Squirreltail	ELEL5	52	2
Ross' sedge	CARO5	45	2
Idaho fescue	FEID	44	10
Western needlegrass	ACOC3	44	2
Common yarrow	ACMI2	43	1

Ponderosa pine-juniper woodlands (30)—

This subzone is found in northeastern Washington, through eastern and central Oregon, and into northern California. This subzone is transitional to western juniper (JUOC) or shrub-steppe vegzones. Mean annual temperature ranges from 42 to 47 °F, and mean annual precipitation ranges from 15 to 20 inches (PRISM Climate Group 2025).

Ponderosa pine (PIPO) forms an open forest to savanna over an understory of antelope bitterbrush (PUTR2), western juniper, big sagebrush (ARTR2), curl-leaf mountain mahogany (CELE3), and wax current (RICE). Indicator species used to classify this subzone, using the representative warm-xeric group, include antelope bitterbrush, Idaho fescue (FEID), squirreltail (ELEL5), western juniper, bluebunch wheatgrass (PSSP6), Sandberg bluegrass (POSE), big sagebrush, curl-leaf mountain mahogany, and little sagebrush (ARAR8).

Within the Columbia Plateau ecoregion, species composition is somewhat different than that of the overall ponderosa pine-juniper woodlands subzone. Western juniper is rarely present in this subzone. Common shrubs include Saskatoon serviceberry (AMAL2), wax current (RICE), antelope bitterbrush, common snowberry (SYAL), and big sagebrush. Common forbs and graminoids include arrowleaf balsamroot (BASA3), bluebunch wheatgrass, Idaho fescue, common yarrow (ACMI2), silky lupine (LUSE4), and bulbous bluegrass (POBU).

Table A11.71—Ponderosa pine-juniper woodlands subzone (*N* = 731) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Ponderosa pine	PIPO	96	25
Western juniper	JUOC	49	12
Shrubs			
Antelope bitterbrush	PUTR2	71	10
Big sagebrush	ARTR2	36	7
Forbs/graminoids			
Idaho fescue	FEID	68	14
Squirreltail	ELEL5	64	2
Common yarrow	ACMI2	53	1
Ross' sedge	CARO5	46	2
Bluebunch wheatgrass	PSSP6	44	8
Western needlegrass	ACOC3	42	1
Sandberg bluegrass	POSE	42	5

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Ponderosa pine/warm-xeric (31)—

This subzone is found interspersed throughout the vegzone from eastern Washington, into central and eastern Oregon, to northern California. Mean annual temperature ranges from 42 to 47 °F, and mean annual precipitation ranges from 17 to 23 inches (PRISM Climate Group 2025).

Ponderosa pine (PIPO) forms an open forest to savanna. This subzone has an average total tree cover of 30 to 35 percent and an average total shrub cover of 10 to 20 percent. The most common species is antelope bitterbrush (PUTR2), found 50 percent of the time. Herbaceous cover averages less than 10 percent. Forbs only contribute about 1 percent cover in mid- to late-seral conditions; graminoids comprise the rest of the herbaceous cover. Indicator species used to classify this subzone, using the representative warm-dry group, include Ross' sedge (CARO5), western needlegrass (ACOC3), wax current (RICE), common snowberry (SYAL), Wheeler's bluegrass (POWH2), Geyer's sedge (CAGE2), snowbrush ceanothus (CEVE), greenleaf manzanita (ARPA6), Saskatoon serviceberry (AMAL2), and pinegrass (CARU).

Within the Columbia Plateau ecoregion, species composition is somewhat different than that of the overall ponderosa pine/warm-xeric subzone. There are fewer overall species present with 30 percent constancy, and fewer graminoids present overall, with more forbs present. The most common understory species include common snowberry, Saskatoon serviceberry, common yarrow (ACMI2), pinegrass, bluebunch wheatgrass (PSSP6), Idaho fescue (FEID), and arrowleaf balsamroot (BASA3).

Table A11.72—Ponderosa pine/warm-xeric subzone (*N* = 1,122) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Ponderosa pine	PIPO	98	29
Shrubs			
Antelope bitterbrush	PUTR2	50	8
Common snowberry	SYAL	34	5
Forbs/graminoids			
Common yarrow	ACMI2	53	1
Squirreltail	ELEL5	51	2
Ross' sedge	CARO5	47	2
Idaho fescue	FEID	46	7
Western needlegrass	ACOC3	45	2
Bluebunch wheatgrass	PSSP6	35	7

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Ponderosa pine-lodgepole pine (33)—

This subzone is found in central Oregon, interspersed with and along the edges of the lodgepole pine (PICO) vegzone. This subzone occurs on deep (>2 ft) ash/pumice deposits. Mean annual temperature ranges from 41 to 44 °F, and mean annual precipitation ranges from 20 to 29 inches (PRISM Climate Group 2025).

Both ponderosa pine (PIPO) and lodgepole pine occur in various mixtures in the tree layers. In hummocky topography, lodgepole pine dominates in swales, while ponderosa pine is more prominent on microridges (Volland 1985). Shrub cover averages 10 to 15 percent. Shrub layers are dominated by antelope bitterbrush (PUTR2). Western needlegrass (ACOC3) typically comprises most of the herbaceous cover in a depauperate understory. Graminoid cover averages 5 to 10 percent. Ross' sedge (CARO5) and squirreltail (ELEL5) have high constancies but generally low percentages of cover. Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine and long-stolon sedge (CAIN9).

Table A11.73—Ponderosa pine-lodgepole pine subzone (*N* = 357) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	99	37
Ponderosa pine	PIPO	89	21
Shrubs			
Antelope bitterbrush	PUTR2	92	15
Forbs/graminoids			
Western needlegrass	ACOC3	90	2
Ross' sedge	CARO5	90	2
Squirreltail	ELEL5	83	1
Virginia strawberry	FRVI	43	1

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Ponderosa pine-oak (34)—

This subzone is found east of the Cascade Range in southern Washington and northern Oregon north and south of the Columbia River, scattered throughout the Rogue Valley of southwestern Oregon, and throughout northern California near the edge of the California foothill pine-oak and oak woodlands subzones. There is a band of this subzone on the west side of the Sierra Nevada in California, between the oak woodlands and California foothill pine-oak subzones on the west side and the white fir-grand fir (ABGRC) and Douglas-fir (PSME) vegzones on the east side of this subzone. This subzone is transitional to Oregon white oak (QUGA4) woodlands or nonforest communities. These sites are the warmest environments that support ponderosa pine (PIPO). Mean annual temperature ranges from 48 to 58 °F, and mean annual precipitation ranges from 27 to 44 inches (PRISM Climate Group 2025).

Total tree cover averages 40 to 50 percent, and shrub cover averages 5 to 10 percent in mid- to late-seral conditions. Frequently found overstory species include ponderosa pine, California black oak (QUKE), canyon live oak (QUCH2), incense cedar (CADE27), and Oregon white oak. Indicator species used to classify this subzone, using the representative warm-mesic group, include creeping snowberry (SYMO), California buckthorn (FRCA12), oceanspray (HODI), white hawkweed (HIAL2), California blackberry (RUUR), Cascade barberry (MANE2), dwarf rose (ROGY), and common whipplea (WHMO).

Within the Central California Foothills and Coastal Mountains ecoregion, species composition is somewhat different than that of the overall ponderosa pine-oak subzone. More species of oak are present, including California black oak, interior live oak (QUWI2), canyon live oak, and blue oak (QUDO). California foothill pine (PISA2) is also common. The most common understory species include Pacific poison oak (TODI), toyon (HEAR5), sticky whiteleaf manzanita (ARVI4), bristly dogstail grass (CYEC), and buckbrush (CECU).

Within the Eastern Cascades Slopes and Foothills ecoregion, species composition is also somewhat different than that of the overall ponderosa pine-oak subzone. The only commonly found oaks are Oregon white oak and California black oak. Common understory species include common yarrow (ACMI2), bulbous bluegrass (POBU), antelope bitterbrush (PUTR2), Idaho fescue (FEID), common snowberry (SYAL), Geyer's sedge (CAGE2), and squirreltail (ELEL5).

Table A11.74—Ponderosa pine-oak subzone (*N* = 405) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Ponderosa pine	PIPO	100	17
California black oak	QUKE	71	19
Canyon live oak	QUCH2	40	28
Incense cedar	CADE27	36	16
Shrubs			
Pacific poison oak	TODI	35	10

Parklands Vegzone (30)

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Table A11.75—Parklands vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
30	Parklands	–114	Subalpine grassland-forbland parklands
30	Parklands	–113	Subalpine shrub parklands
30	Parklands	65	Subalpine fir parklands
30	Parklands	95	Mountain hemlock parklands
30	Parklands	96	Limber pine parklands
30	Parklands	97	Great Basin bristlecone pine-foxtail pine parklands
30	Parklands	98	Western white pine parklands
30	Parklands	99	Whitebark pine parklands
30	Parklands	100	Subalpine larch parklands
30	Parklands	101	Sierra lodgepole pine parklands

The parklands vegzone occurs in the highest mountain ranges of Washington, Oregon, and California, occurring in the North Cascades, Cascades, Eastern Cascades Slopes and Foothills, and Sierra Nevada ecoregions. This vegzone constitutes a broad ecotone where tree dominance gives way to alpine meadows. Tree cover is typically between 10 and 30 percent, with highly variable openings. Often this vegzone appears as a mosaic of tree patches and meadow communities with the tree patches becoming smaller in size and stature as elevations increase. Climate is characterized by cool summers and cold winters with deep snowpack. Summer soil drought may be possible in rain shadow parklands (east of the mountain crest) but is rare in westside areas. The species that are most frequently present include whitebark pine (PIAL), lodgepole pine (PICO), subalpine fir (ABLA), mountain hemlock (TSME), Ross' sedge (CARO5), pink mountainheath (PHEM), grouse whortleberry (VASC), and thinleaf huckleberry (VAME).

To map to parklands, the following species needed to be present: whitebark pine, subalpine larch (LALY), limber pine (PIFL2), Great Basin bristlecone pine (PILO), or foxtail pine (PIBA). The upper elevational boundary of this vegzone is defined by the National Landcover Dataset nonforest mask (USGS 2014, see "Methods" in this report).

Table A11.76—Parklands vegzone (*N* = 570) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Whitebark pine	PIAL	50	18
Lodgepole pine	PICO	47	28
Subalpine fir	ABLA	44	41
Forbs/graminoids			
Ross' sedge	CARO5	33	2

Subalpine grassland-forbland parklands (−114)—

This subzone occurs in the eastern Cascade Range and Olympic Mountains. It is also found in California on Mount Shasta, in the Sierra Nevada, and as far south as the Peninsular Ranges and White Mountains. This is a high-elevation grassland system dominated by perennial grasses and forbs, on dry sites, particularly south-facing slopes, typically embedded in or above subalpine forests and woodlands. Subalpine grasslands are small meadows to large, open parks surrounded by conifer trees but lacking continuous tree cover within them. Sites are dominated by herbaceous vegetation. Snowpack is retained for much of the year and the growing season is short with few days warm enough for plant growth. Exposure is extreme with high insolation and severe desiccating winds. The mean daily minimum temperatures are very low. Low temperatures mean slow organic decomposition, so nutrients tend to be locked up in organic matter for relatively long periods of time (LANDFIRE biophysical settings 10670 and 11710) (USGS and USDA FS, n.d.).

This subzone includes subalpine sedge meadows, grasslands, and elements of alpine fellfields. The mosaic of meadow, grassland, and fellfield communities is an intricate and sharp response to local variations in substrate, moisture conditions, and durations of winter snowpack (Franklin and Dyrness 1973). Fellfields are a type of alpine ecosystem characterized by flat relief; stony soil; and low, often widely spaced, cushion plants that occur in areas where wind scour limits snow accumulation. Plants occupying these sites are adapted to strong winds, ice shearing, and drought-induced desiccation. To cope with these extreme environments, cushion plants are matted or cushioned; low in stature; and are either succulent, hairy, or heavily cutinized to reduce transpiration loss (Johnson 2004). Understory species that define the subzone include Davis' knotweed (PODA), white avalanche-lily (ERMO8), partridgefoot (LUPE), greenleaf fescue (FEVI), black alpine sedge (CANI2), showy sedge (CASP5), Brewer's sedge (CABR12), broom sedge (CASC11), Drummond's rush (JUDR), and tufted hairgrass (DECE).

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Subalpine shrub parklands (−113)—

This subzone occurs throughout the mountains of the Pacific Northwest and above upper timberline throughout the Sierra Nevada and southern Cascade Range, including alpine areas in California and Oregon. It occurs at the transition zone of forest to alpine, forming a subalpine forest-shrub-meadow ecotone. Fellfields often intermingle with alpine dwarf-shrubland. These systems are controlled by snow retention, wind desiccation, and permafrost. When vegetation is present (averaging <35 percent cover), it is typically prostrate shrubs and lichens. Sites vary from heather communities dominated by dense, closed-canopy, ericaceous shrubs in moister maritime portions of the Pacific Northwest to open, sagebrush grasslands in southern interior areas with a more continental climate (LANDFIRE biophysical settings 10680 and 10710) (USGS and USDA FS, n.d.).

Understory species that define the subzone include pink mountainheath (PHEM), Cascade bilberry (VADE), western moss heather (CAME7), and partridgefoot (LUPE).

Table A11.77—Subalpine shrub parklands subzone (*N* = 1) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Pink mountainheath	PHEM	100	35
Western moss heather	CAME7	100	24

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Subalpine fir parklands (65)—

This subzone represents the coldest environments that support subalpine fir (ABLA) in the Blue Mountains, Wallowa Mountains, Oregon and Washington Cascade Range, and Northern Rockies. These sites are transitional between closed forest and subalpine meadows. Subalpine fir parklands occur in areas with a more continental climate, colder in winter and warmer in summer, than sites that support mountain hemlock (TSME). Mean annual temperature ranges from 34 to 38 °F, and mean annual precipitation ranges from 48 to 72 inches (PRISM Climate Group 2025).

Common overstory species are subalpine fir, whitebark pine (PIAL), Engelmann spruce (PIEN), and lodgepole pine (PICO). Indicator species used to classify this subzone, using the representative cold-wet mesic group, include whitebark pine, smooth woodrush (LUGL2), pink mountainheath (PHEM), Sitka valerian (VASI), Cascade azalea (RHAL2), Jacob's-ladder (POPU3), and subalpine larch (LALY).

Table A11.78—Subalpine fir parklands subzone (*N* = 184) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Subalpine fir	ABLA	93	45
Whitebark pine	PIAL	64	15
Engelmann spruce	PIEN	61	14
Lodgepole pine	PICO	44	20
Shrubs			
Grouse whortleberry	VASC	59	19
Pink mountainheath	PHEM	40	6
Thinleaf huckleberry	VAME	40	7
Forbs/graminoids			
Ross' sedge	CARO5	61	2
Common yarrow	ACMI2	49	1
Smooth woodrush	LUGL2	46	5
Broadleaf arnica	ARLA8	41	3
Northwestern sedge	CACO11	41	2
Sitka valerian	VASI	38	5
Broadleaf lupine	LULA4	36	5
Silky lupine	LUSE4	34	5
Geyer's sedge	CAGE2	33	5

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Mountain hemlock parklands (95)—

This subzone occurs in mountains of the Pacific Northwest—the Blue Mountains and Oregon and Washington Cascade Range. Sites represent the coldest environments that support forested vegetation in the Oregon Cascades. Mean annual temperature ranges from 36 to 40 °F, and mean annual precipitation ranges from 59 inches to 109 inches (PRISM Climate Group 2025).

Plant communities in the mountain hemlock (TSME) parklands are often adjacent to subalpine meadows and form either a forest-meadow mosaic or the upper boundary of closed forest. These associations are generally too cold for Douglas-fir (PSME), white fir (ABCO), or grand fir (ABGR). The most common overstory species are mountain hemlock, subalpine fir (ABLA), Pacific silver fir (ABAM), and whitebark pine (PIAL). Indicator species used to classify this subzone, using the representative cold-wet mesic group, include pink mountainheath (PHEM), Cascade azalea (RHAL2), whitebark pine, Cascade bilberry (VADE), partridgefoot (LUPE), smooth woodrush (LUGL2), Sitka valerian (VASI), western moss heather (CAME7), and Alaska cedar (CANO9).

Within the Sierra Nevada ecoregion, species composition varies slightly from the other ecoregions where this subzone occurs. The most common tree species are mountain hemlock, whitebark pine, and lodgepole pine (PICO), but the understory is much more depauperate, with purple mountainheath (PHBR4) and squirreltail (ELEL5) being most common.

Table A11.79—Mountain hemlock parklands subzone (*N* = 154) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Mountain hemlock	TSME	96	52
Subalpine fir	ABLA	50	35
Pacific silver fir	ABAM	49	32
Whitebark pine	PIAL	42	16
Shrubs			
Pink mountainheath	PHEM	58	20
Thinleaf huckleberry	VAME	56	10
Cascade azalea	RHAL2	44	15
Cascade bilberry	VADE	41	19
Grouse whortleberry	VASC	33	10
Forbs/graminoids			
Partridgefoot	LUPE	36	5
Smooth woodrush	LUGL2	36	5

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Limber pine parklands (96)—

This subzone occurs in eastern California, on the eastern slopes of the Sierra Nevada and the Great Basin. Limber pine (PIFL2) is most extensive on upper slopes, crests, ridges, summits, and upper high-elevation slopes to timberline. Mean annual temperature ranges from 36 to 41 °F, and mean annual precipitation ranges from 16 to 21 inches (PRISM Climate Group 2025). Soils are often rocky.

Tree stands are open (usually less than 20 percent overall vegetative cover) with scattered shrubs and grasses. The most common overstory species are limber pine, lodgepole pine (PICO), and singleleaf pinyon (PIMO). The only indicator species present used to classify this subzone, using the representative cold-wet mesic group, is limber pine.

Table A11.80—Limber pine parklands subzone (*N* = 14) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Limber pine	PIFL2	100	18
Lodgepole pine	PICO	36	27
Shrubs			
Big sagebrush	ARTR2	57	11
Curl-leaf mountain mahogany	CELE3	36	11

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Great Basin bristlecone pine-foxtail pine parklands (97)—

This subzone is found in eastern California. Mean annual temperature ranges from 35 to 39 °F, and mean annual precipitation ranges from 18 to 26 inches (PRISM Climate Group 2025). Soils are nutrient deficient. The surface of the ground is composed of peridotite rock and bare mineral soil in varying degrees of serpentinization.

Great Basin bristlecone pine (PILO) and foxtail pine (PIBA) appear on all slopes, especially ridges and upper slopes, at and below the forest tree line. Great Basin bristlecone-pine is the timberline tree of high desert ranges, where it endures harsh, dry, high-elevation conditions (LANDFIRE biophysical setting 10200) (USGS and USDA FS, n.d.). Foxtail pines exist in scattered, open woodlands. The understory is composed of a scattering of shrubs and herbs within a mosaic of extensive, rocky, bare ground.

The most common overstory species are foxtail pine, lodgepole pine (PICO), limber pine (PIFL2), Great Basin bristlecone pine, and western white pine (PIMO3). Indicator species used to classify this subzone, using the representative cold-wet mesic group, include foxtail pine, limber pine, and Great Basin bristlecone pine.

Table A11.81—Great Basin bristlecone pine-foxtail pine parklands subzone (N = 24) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Foxtail pine	PIBA	79	33
Lodgepole pine	PICO	38	20

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Western white pine parklands (98)—

This subzone can occur in a variety of climates, ranging from warm and wet to cool and dry. Mean annual temperature ranges from 37 to 48°F, and mean annual precipitation ranges from 43 to 64 inches (PRISM Climate Group 2025). In the Siskiyou Mountains, western white pine as a vegzone is found primarily on ultramafic soils.

The most common overstory species include western white pine (PIMO3) and lodgepole pine (PICO). The only indicator species used to classify this subzone, using the representative warm-wet mesic group, is western white pine.

Table A11.82—Western white pine parklands subzone (*N* = 26) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western white pine	PIMO3	100	16
Lodgepole pine	PICO	69	31
Shrubs			
Pinemat manzanita	ARNE	35	6

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Whitebark pine parklands (99)—

This subzone occurs in the Oregon and Washington Cascade Range, Blue Mountains, and southern Sierra Nevada in California. Whitebark pine (PIAL) sites occur between mountain hemlock (TSME) parklands or subalpine fir (ABLA) parklands subzones and subalpine shrub parklands or subalpine grassland-forbland parklands subzones. In the Blue Mountains of eastern Oregon and Washington, whitebark pine codominates with subalpine fir and assumes increasing dominance with elevation; it is the only tree species at the highest elevations. In Washington, whitebark pine communities in the Cascade Range are often mixed with or adjacent to big sagebrush (ARTR2) or mountain grassland communities. In California, pure or nearly pure whitebark pine communities occur at tree line in the Sierra Nevada and Cascade Range.

Whitebark pine grows in the highest elevation forests in cold, snowy, moist to semiarid climates and is common on ridges and near timberline, where trees are exposed to strong, desiccating winds (Burns and Honkala 1990). Mean annual temperature ranges from 35 to 39 °F, and mean annual precipitation ranges from 31 to 50 inches (PRISM Climate Group 2025). The species, and therefore subzone, is most common on rocky, well-drained sites. These environments are too cold, snowy, or effectively dry for mountain hemlock (TSME) or subalpine fir to attain a minimum of 10 percent cover and are transitional to subalpine nonforest subzones or to true alpine vegetation types.

In south-central Oregon, precipitation and temperatures on these sites appear suitable to support mountain hemlock or subalpine fir, but these species are missing, presumably because the effective moisture on the ash/pumice deposits is inadequate to support them. Common overstory species are whitebark pine and lodgepole pine (PICO). Indicator species used to classify this subzone, using the representative cold-wet mesic group, include whitebark pine and purple mountainheath (PHBR4).

Within the Blue Mountains ecoregion, species composition differs slightly than the overall subzone with only whitebark pine being present, as well as the presence of pink mountainheath (PHEM) and poke knotweed (POPH).

Table A11.83—Whitebark pine parklands subzone (*N* = 102) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Whitebark pine	PIAL	95	23
Lodgepole pine	PICO	60	34
Forbs/graminoids			
Squirreltail	ELEL5	34	1

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Subalpine larch parklands (100)—

Subalpine larch (LALY) occurs in the northern Cascade Range. Typical subalpine larch stands are often isolated pockets of open, parklike groves. Subalpine larch is a dominant species occupying the timberline habitat type and may be interspersed with the subalpine fir-Engelmann spruce (ABLA-PIEN) vegzone. Subalpine larch is most commonly found in very cold, moist, high-elevation environments. Mean annual temperature ranges from 33 to 35 °F, and mean annual precipitation ranges from 52 to 65 inches (PRISM Climate Group 2025). It commonly grows on slopes covered with granite or quartzite talus, not previously occupied by vascular plants. This tree species will also establish itself in cracks between big boulders. Soil development on subalpine larch sites is extremely poor because of low temperatures and short growing seasons.

The most common overstory species include subalpine larch and whitebark pine (PIAL), along with subalpine fir and Engelmann spruce. Indicator species used to classify this subzone, using the representative cold-wet mesic group, include subalpine larch, smooth woodrush (LUGL2), pink mountainheath (PHEM), partridgefoot (LUPE), whitebark pine (PIAL), and western moss heather (CAME7).

Table A11.84—Subalpine larch parklands subzone (*N* = 7) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Subalpine larch	LALY	100	27
Whitebark pine	PIAL	43	8
Shrubs			
Grouse whortleberry	VASC	43	13
Forbs/graminoids			
Smooth woodrush	LUGL2	86	2
Ross' sedge	CARO5	71	2
Northwestern sedge	CACO11	57	2
Western Labrador tea	LEGL	43	5
Partridgefoot	LUPE	43	3

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Sierra lodgepole pine parklands (101)—

Sierra lodgepole pine (PICOM) occurs in the Cascade Range of southern Washington, Oregon, and California and in the Sierra Nevada and Klamath Mountains (Cope 1993). Sierra lodgepole pine is dominant or codominant variety in upper montane and subalpine forests. Sierra lodgepole pine grows in areas with cold, wet winters and dry, warm summers. Mean annual temperature ranges from 36 to 41 °F, and mean annual precipitation ranges from 24 to 48 inches (PRISM Climate Group 2025). In the southern part of its range, Sierra lodgepole pine grows under xeric conditions. It grows in a variety of site conditions, including cold-air drainages, streambanks, lakeshores, wet meadows, and dry, upland settings.

This is a species-depauperate subzone. The most common overstory species is lodgepole pine. Indicator species used to classify this subzone, using the representative cold-wet mesic group, include purple mountainheath (PHBR4) and whitebark pine (PIAL).

Table A11.85—Sierra lodgepole pine parklands subzone (*N* = 59) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	100	39

Lodgepole Pine Vegzone (8)

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Table A11.86—Lodgepole pine vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
8	Lodgepole pine	25	Cool-dry
8	Lodgepole pine	27	Lodgepole pine wetlands
8	Lodgepole pine	29	Monterey pine-bishop pine

Pure or nearly pure stands of lodgepole pine (*Pinus contorta*, PICO) are widely distributed throughout forested areas of eastern Oregon and Washington. Lodgepole pine is a fire-dependent species, requiring wildfires to maintain healthy populations of diverse ages. The species' thin bark minimizes the tree's resistance to fire; however, the heat of fire opens the cones to release the seeds. This allows the species to regenerate and maintain its place in the forest habitat. Most lodgepole pine stands are seral and developed following stand replacement fire or timber harvest (Franklin and Dyrness 1973).

In central and southwestern Oregon, distribution of the lodgepole pine vegzone is tied directly to ash/pumice deposits, mostly from Mount Mazama. Lodgepole pine is considered an edaphic or topo-edaphic climax species on deep ash/pumice deposits, especially where slope positions allow cold air to accumulate. Lodgepole pine in California grows in a variety of site conditions, including cold-air drainages, streambanks, lakeshores, wet meadows, and dry, upland settings. Stands are most common and extensive in the Sierra Nevada. Montane stands are associated with moist meadow and lake margins; subalpine stands occupy upland settings on glaciated surfaces and till with skeletal soils (Fites-Kaufman et al. 2007). Lodgepole pine (shore pine) is also often found along the northwestern coast and is generally found on nutrient-poor or exposed sites, like bogs, dunes, rocky crests, and exposed shorelines.

Three situations occur with lodgepole pine as a major climax tree species. The first situation (edaphic) has poorly drained sites with deep ash/pumice deposits. These sites are either inundated through much of the growing season or are subirrigated with water tables within 2 ft of the soil surface for extended times during the growing season. The second situation (topo-edaphic) has deep ash/pumice deposits that are excessively well-drained and enclosed small basins that trap cold air and create frost pockets. In the third situation (edaphic), lodgepole pine occurs with whitebark pine (PIAL) at high elevations on deep ash/pumice deposits that are excessively well-drained. Precipitation and temperatures on these sites appear suitable to support mountain hemlock (TSME) or subalpine fir (ABLA), but these species are missing presumably because the effective moisture on the ash/pumice deposits is inadequate to support them.

Lodgepole pine has the widest ecologic amplitude of all the conifers that occur in central Oregon. It dominates environments that are either too wet or dry for its competitors, such as ponderosa pine (PIPO), white fir (ABCO) and/or grand fir (ABGR), Shasta red fir (ABMAS), and mountain hemlock.

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In the southern Oregon Cascade Range, it occurs as a pioneer on young soils developed from deep pumice in cold environments. Lodgepole pine is usually succeeded by more tolerant species, such as white fir, as the increasing canopy ameliorates the frosty conditions. In areas with deep pumice soils, cold-air ponding, and frequent frosts, lodgepole pine remains the dominant climax tree species due to its tolerance of cold temperatures, resistance to drought, and minimal need for mineralized elements (Atzet et al. 1996).

This vegzone is characterized by the presence of lodgepole pine and no other climax conifers present. The most common species found in the overall lodgepole pine vegzone include western needlegrass (ACOC3), Ross' sedge (CARO5), antelope bitterbrush (PUTR2), squirreltail (ELEL5), wax current (RICE), common yarrow (ACMI2), Virginia strawberry (FRVI), and Idaho fescue (FEID).

Table A11.87—Lodgepole pine vegzone (*N* = 160) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	95	46
Shrubs			
Antelope bitterbrush	PUTR2	68	13
Forbs/graminoids			
Western needlegrass	ACOC3	69	2
Ross' sedge	CARO5	69	2
Squirreltail	ELEL5	67	1
Common yarrow	ACMI2	42	2
Virginia strawberry	FRVI	36	2

Lodgepole pine/cool-dry (25)—

This subzone occurs east of the Cascade Range in central Oregon. It may also occur in the Blue Mountains of Washington, and the Blue and Ochoco Mountains in Oregon. These environments have depauperate understory vegetation due to excessively drained soils. Mean annual temperature ranges from 41 to 43 °F, and mean annual precipitation ranges from 22 to 31 inches (PRISM Climate Group 2025).

Generally, this subzone consists of a single forest canopy of lodgepole pine (PICO) with an average of 45 percent cover. Shrubs and graminoids typically average about 2 percent cover each, except for antelope bitterbrush (PUTR2), with an average cover of 13 percent. Forbs are not well represented, averaging less than 1 percent cover. Indicator species used to classify this subzone, using the representative cool-mesic group, include lodgepole pine, long-stolon sedge (CAIN9), and pinemat manzanita (ARNE).

Table A11.88—Lodgepole pine/cool-dry subzone (*N* = 156) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Lodgepole pine	PICO	97	46
Shrubs			
Antelope bitterbrush	PUTR2	69	13
Forbs/graminoids			
Western needlegrass	ACOC3	71	2
Ross' sedge	CARO5	71	2
Squirreltail	ELEL5	69	1
Common yarrow	ACMI2	43	2
Virginia strawberry	FRVI	37	2

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Lodgepole pine wetlands (27)—

This subzone occurs in western Washington to southwestern Oregon, up to the Cascade crest. Sites have a higher effective moisture regime than the other two subzones in this vegzone. The increased moisture is a result of subirrigation by adjacent streams or riparian zones. Within the deep ash/pumice deposits from Mount Mazama, the ecotones between the riparian lodgepole pine communities and dry lodgepole pine communities may be very abrupt.

Riparian lodgepole pine (PICO) sites average 20 to 25 percent cover of lodgepole pine over a well-developed understory. The understory vegetation typically has 15 to 20 percent shrub cover and 25 to 35 percent cover in sedges and grasses. Forb layers are diverse, but only average 1 to 5 percent cover. Common understory taxa include kinnikinnick (ARUV), bog birch (BEGL2), Geyer willow (SAGE2), Lemmon's willow (SALE), rose spirea (SPDO), bog blueberry (VAUL), woodland or Virginia strawberry (FRVE or FRVI), bluejoint (CACA4), widefruit sedge (CAAN15), analogue sedge (CASI2), Sitka sedge (CAAQD), tufted hairgrass (DECE), sand spikerush (ELMO2), blue wildrye (ELGL), mountain rush (JUARL), and Kentucky bluegrass (POPR).

The mapped extent of the lodgepole pine wetlands subzone comes from the national wetlands inventory data (USFWS 2018). The type was described by Kovalchik and Clausnitzer (2004) in the eastern Washington riparian guide and in the eastern Cascade Range plant association guide (Simpson 2007). Plots within the FIA data were lacking (very few), and as a result, it was mapped using the palustrine conifer classes in the national wetlands inventory layer (USFWS 2018).

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Monterey pine-bishop pine (29)—

This subzone only occurs in California, from Monterey Bay to Baja California, Mexico, including the Channel Islands. Habitats include dry ridges, headlands, maritime terraces, rocky ridges, and sand dunes. It is limited to coastal areas with a moderate maritime climate and likely receives more annual precipitation than nearby coastal chaparral. Mean annual temperature ranges from 53 to 62 °F, and mean annual precipitation ranges from 13 to 17 inches (PRISM Climate Group 2025).

If dominated by Monterey pine (PIRA2), the soils may be well drained, nutrient poor, and acidic. It is found in maritime zones with summer fog. Bishop pine (PIMU) grows in areas with spring and summer fog, which is important to its survival, and sometimes occurs in palustrine habitats (LANDFIRE biophysical setting 11770) (USGS and USDA FS, n.d.). Overall, this subzone is species depauperate. The most common species found within this subzone are California live oak (QUAG), Monterey pine, California blackberry (RUUR), and Pacific poison oak (TODI).

Table A11.89—Monterey pine-bishop pine subzone (*N* = 4) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California live oak	QUAG	100	29
Monterey pine	PIRA2	75	34
Shrubs			
California blackberry	RUUR	75	7
Pacific poison oak	TODI	75	4

California Foothill Pine-Coulter Pine Vegzone (7)

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Table A11.90—California foothill pine-Coulter pine vegzone and subzone

Vegzone number	Vegzone name	Subzone number	Subzone name
7	California foothill pine-Coulter pine	35	Coulter pine-oak
7	California foothill pine-Coulter pine	36	California foothill pine-oak

The California foothill pine-Coulter pine (*Pinus sabiniana-Pinus coulteri*, PISA2-PICO3) vegzone occurs in California from Siskiyou County south through the foothills of the Klamath Mountains, Cascade Range, and Coast Range, to the Sierra Nevada and the Transverse and Peninsular Ranges of southern California.

This vegzone is characterized by the presence of either California foothill pine or Coulter pine at a minimum of 5 percent cover and in the absence of dominant tree species that would indicate another vegzone. The most common overstory species for the vegzone include California foothill pine, blue oak (QUDO), interior live oak (QUWI2), and canyon live oak (QUCH2). Common understory species include Pacific poison oak (TODI), buckbrush (CECU), toyon (HEAR5), and alderleaf mountain mahogany (CEMO2).

Table A11.91—California foothill pine-Coulter pine vegzone (*N* = 399) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California foothill pine	PISA2	90	7
Blue oak	QUDO	51	25
Interior live oak	QUWI2	42	29
Shrubs			
Pacific poison oak	TODI	48	7

Coulter pine-oak (35)—

This is a minor subzone and represents a generally drier environment than that of ponderosa pine (PIPO) or Jeffrey pine (PIJE) vegzones. This subzone occurs in a mediterranean environment, from Contra Costa County south through the Coast, Transverse, and Peninsular Ranges in California. Communities that are dominated by Coulter pine (PICO3) intergrade with chaparral and lower montane coniferous forest. Coulter pine is an indicator of serpentine soils, although it also occurs on a variety of other substrates. Mean annual temperature ranges from 52 to 58 °F, and mean annual precipitation ranges from 18 to 30 inches (PRISM Climate Group 2025). These environments are transitional to oak-pine woodlands.

Coulter pine is the most common overstory species, with canyon live oak (QUCH2), interior live oak (QUWI2), California live oak (QUAG), California black oak (QUKE), and scrub oak (QUBE5) also common. Understory species include chamise (ADFA), chaparral whitethorn (CELE2), and chaparral yucca (HEWH). Indicator species used to classify this subzone, using the representative warm-dry group, include canyon live oak, incense cedar (CADE27), Pacific poison oak (TODI), buckbrush (CECU), and alderleaf mountain mahogany (CEMO2).

Table A11.92—Coulter pine-oak subzone (*N* = 33) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Coulter pine	PICO3	97	11
Canyon live oak	QUCH2	52	38

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California foothill pine-oak (36)—

This subzone occurs from Siskiyou County south through the foothills of the Klamath Mountains, Cascade Range, Coast Range, and Sierra Nevada to Ventura County in California. California foothill pine (PISA2) is common in the northern and interior portions of California. Mean annual temperature ranges from 54 to 60 °F, and mean annual precipitation ranges from 21 to 36 inches (PRISM Climate Group 2025).

California foothill pine and blue oak (QUDO) occur together over much of California's oak woodlands. At lower elevations, this vegzone grades into chaparral, valley oak (QULO) or Oregon white oak (QUGA4) woodland. At higher elevations it transitions with California black oak (QUKE) or ponderosa pine (PIPO) forests. The species is adapted to long, hot and dry summers with a wide range in precipitation. It prefers rocky, well-drained soils, but also grows on serpentine soil and heavy, poorly drained clay soils.

California foothill pine is the most common overstory species, with blue oak, interior live oak (QUWI2), and canyon live oak (QUCH2) also common. California black oak, California live oak (QUAG), valley oak, scrub oak (QUBE5), and California laurel (UMCA) may also be present. Common understory species include Pacific poison oak (TODI), buckbrush (CECU), toyon (HEAR5), alderleaf mountain mahogany (CEMO2), ripgut brome (BRDI3), and hollyleaf redberry (RHIL). Indicator species used to classify this subzone, using the representative warm-dry group, include Pacific poison oak, buckbrush, alderleaf mountain mahogany, canyon live oak, sticky whiteleaf manzanita (ARVI4), and greenleaf manzanita (ARPA6).

Table A11.93—California foothill pine-oak subzone (*N* = 366) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California foothill pine	PISA2	98	7
Blue oak	QUDO	55	25
Interior live oak	QUWI2	43	29
Shrubs			
Pacific poison oak	TODI	52	7

Pinyon-Juniper-Cypress Vegzone (6)

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Table A11.94—Pinyon-juniper-cypress vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
6	Pinyon-juniper-cypress	21	Juniper scablands
6	Pinyon-juniper-cypress	22	Juniper woodlands
6	Pinyon-juniper-cypress	23	Pinyon woodlands
6	Pinyon-juniper-cypress	24	Cypress woodlands

The pinyon-juniper-cypress vegzone occurs throughout central and southeastern Oregon, the Modoc Plateau, and eastern and southern California. This vegzone is most frequently found in the following ecoregions: Blue Mountains, Northern Basin and Range, southern part of Eastern Cascades Slopes and Foothills, Central Basin and Range, and Southern California Mountains, with minor amounts in the Mojave Basin and Range, Sonoran Basin and Range, and Southern California/Northern Baja Coast. This vegzone generally has an open woodland to savanna structure and occupies environments intermediate in moisture between ponderosa pine (PIPO) forests and steppe or shrub-steppe communities. This is the most xeric tree-dominated vegzone in the Pacific Northwest (Franklin and Dyrness 1973).

The most common species in the vegzone include western juniper (JUOC), big sagebrush (ARTR2), squirreltail (ELEL5), Sandberg bluegrass (POSE), Idaho fescue (FEID), antelope bitterbrush (PUTR2), bluebunch wheatgrass (PSSP6), and yellow rabbitbrush (CHVI8).

Table A11.95—Pinyon-juniper-cypress vegzone (*N* = 1,089) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western juniper	JUOC	67	15
Shrubs			
Big sagebrush	ARTR2	62	8
Forbs/graminoids			
Squirreltail	ELEL5	42	2
Sandberg bluegrass	POSE	41	6
Idaho fescue	FEID	40	8
Bluebunch wheatgrass	PSSP6	34	8

Juniper scablands (21)—

This subzone is scattered throughout eastern Oregon and the Modoc Plateau. It occurs on shallow, fine-textured claypan soils, often at higher elevations, with more precipitation, but less effective moisture, and surrounded by more mesic forest types on deeper soils. Mean annual temperature ranges from 42 to 48 °F, and mean annual precipitation ranges from 12 to 18 inches (PRISM Climate Group 2025).

Juniper cover is much sparser on these sites than in the juniper woodland subzone, averaging 5 to 20 percent (Miller et al. 2005). Indicator species used to classify this subzone, using the representative warm-xeric group, include western juniper (JUOC), Sandberg bluegrass (POSE), Idaho fescue (FEID), little sagebrush (ARAR8), squirreltail (ELEL5), big sagebrush (ARTR2), bluebunch wheatgrass (PSSP6), antelope bitterbrush (PUTR2), and yellow rabbitbrush (CHVI8).

Table A11.96—Juniper scablands subzone (*N* = 214) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western juniper	JUOC	90	15
Shrubs			
Little sagebrush	ARAR8	58	9
Big sagebrush	ARTR2	48	6
Forbs/graminoids			
Sandberg bluegrass	POSE	64	6
Idaho fescue	FEID	64	7
Squirreltail	ELEL5	50	1
Bluebunch wheatgrass	PSSP6	44	7

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Juniper woodlands (22)—

This subzone occurs in eastern Washington, eastern Oregon, northeastern California, and scattered throughout southern California. This is the most extensive subzone of the pinyon-juniper-cypress vegzone. It is found on rocky outcrops, lava blisters and flows, and soils that are shallow and rocky and on deep, well-drained, loamy to sandy soils. Mean annual temperature ranges from 43 to 49 °F, and mean annual precipitation ranges from 12 to 17 inches (PRISM Climate Group 2025).

Juniper cover on these sites ranges from a low of 10 to 15 percent to a high of 35 to 60 percent (Miller et al. 2005). Indicator species used to classify this subzone, using the representative warm-xeric group, include western juniper (JUOC), big sagebrush (ARTR2), Idaho fescue (FEID), Sandberg bluegrass (POSE), bluebunch wheatgrass (PSSP6), squirreltail (ELEL5), antelope bitterbrush (PUTR2), yellow rabbitbrush (CHVI8), and rubber rabbitbrush (ERNA10).

The juniper woodlands subzone is defined by the presence of California juniper (JUCA7), western juniper, Rocky Mountain juniper (JUSC2), Utah juniper (JUOS), and absence of other tree species.

Table A11.97—Juniper woodlands subzone (*N* = 612) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Western juniper	JUOC	84	16
Shrubs			
Big sagebrush	ARTR2	68	8
Forbs/graminoids			
Idaho fescue	FEID	49	9
Sandberg bluegrass	POSE	49	7
Bluebunch wheatgrass	PSSP6	44	8
Squirreltail	ELEL5	43	2

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Pinyon woodlands (23)—

This subzone occurs on dry mountain ranges in the Great Basin, the Sierra Nevada, and southern California. Singleleaf pinyon (PIMO) grows under xeric conditions. Pinyon woodlands occur primarily on shallow rocky soils or rock-dominated sites, such as rocky ridges, steep slopes, broken topography, and mesa tops. Mean annual temperature ranges from 43 to 53 °F, and mean annual precipitation ranges from 11 to 17 inches (PRISM Climate Group 2025).

Singleleaf pinyon, Utah juniper (JUOS), California juniper (JUCA7), and western juniper (JUOC) may occasionally be present. Indicator species used to classify this subzone, using the representative warm-xeric group, include big sagebrush (ARTR2), antelope bitterbrush (PUTR2), and squirreltail (ELEL5).

Within the Southern California Mountains ecoregion, species composition differs slightly from the other ecoregions. Chaparral yucca (HEWH) is present and Eastern Mojave buckwheat (ERFA2) is more common.

Table A11.98—Pinyon woodlands subzone (*N* = 260) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Singleleaf pinyon	PIMO	98	23
Shrubs			
Big sagebrush	ARTR2	59	9
Antelope bitterbrush	PUTR2	33	5
Forbs/graminoids			
Squirreltail	ELEL5	32	1

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Cypress woodlands (24)—

This subzone only occurs in California, is a minor subzone, and is species depauperate. Mean annual temperature ranges from 52 to 58 °F, and mean annual precipitation ranges from 40 to 49 inches (PRISM Climate Group 2025).

This subzone is defined by the presence of Sargent's cypress (HESA17), Modoc cypress (HEBA5), McNab's cypress (HEMA21), or Monterey cypress (HEMA22). Species present in this subzone include Sargent's cypress, leather oak (QUDU4), scrub oak (QUBE5), Indian warrior (PEDE), Oregon boxleaf (PAMY), buckbrush (CECU), sticky whiteleaf manzanita (ARVI4), and chamise (ADFA). Indicator species used to classify this subzone, using the representative warm-dry group, include sticky whiteleaf manzanita and buckbrush.

Within the Coast Range ecoregion, there were only two species present in the data, Sargent's cypress and Oregon boxleaf.

Table A11.99—Cypress woodlands (*N* = 3) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Sargent's cypress	HESA17	100	15
Scrub oak	QUBE5	33	25
Leather oak	QUDU4	33	10
Shrubs			
Chamise	ADFA	33	11
Sticky whiteleaf manzanita	ARVI4	33	33
Forbs/graminoids			
Indian warrior	PEDE	33	0

Hardwoods Vegzone (11)

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Table A11.100—Hardwoods vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
11	Hardwoods	15	Riparian shrub
11	Hardwoods	16	Riparian hardwood forest
11	Hardwoods	17	Other hardwoods
11	Hardwoods	18	Oak woodlands
11	Hardwoods	19	Desert hardwoods

The hardwoods vegzone is scattered throughout Washington and Oregon but is common in California. This vegzone becomes increasingly common from north to south towards the Central Valley of California, where large concentrations can be found between the grassland-meadow vegzone and the California foothill pine-Coulter pine (PISA2-PICO3) vegzone on the west side of the Central Valley and between the shrublands (shrub-steppe) vegzone and the California foothill pine-Coulter pine vegzone to the east. The vegzone is most frequently located in the Central California Foothills and Coastal Mountains, Southern California Mountains, and Southern California/Northern Baja Coast ecoregions, and occurs in lesser amounts in the Cascades, Northern Basin and Range, Klamath Mountains/California High North Coast Range, Central California Valley, Mojave Basin and Range, west side of the Sierra Nevada, and the Sonoran Basin and Range ecoregions.

The hardwoods vegzone includes environments dominated by deciduous and evergreen hardwoods. This vegzone includes upland forests of aspen and oaks and riparian habitats dominated by deciduous hardwood trees or shrubs without a significant conifer component. The most common overall species for this vegzone includes blue oak (QUDO), Pacific poison oak (TODI), California live oak (QUAG), interior live oak (QUWI2), and canyon live oak (QUCH2), with California black oak (QUKE), Oregon white oak (QUGA4), and California laurel (UMCA) being somewhat common.

Table A11.101—Hardwoods vegzone (*N* = 1,219) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Blue oak	QUDO	36	29
Shrubs			
Pacific poison oak	TODI	37	9

Riparian shrub (15)—

This subzone is associated with riverine or other poorly drained sites subject to annual flooding that do not support a significant tree component. This subzone is found in eastern Oregon and Washington, the Great Basin, and the eastern slopes of the Sierra Nevada of California. Mean annual temperature ranges from 41 to 45 °F, and mean annual precipitation ranges from 31 to 38 inches (PRISM Climate Group 2025). The riparian shrub subzone requires periodic flooding and bare, moist substrates, such as gravels, for reestablishment.

Common species include willows, such as Goodding's willow (SAGO), red willow (SALA3), and Pacific willow (SALUL), as well as water birch (BEOC2), gray alder (ALIN2), white alder (ALRH2), Saskatoon serviceberry (AMAL2), Lewis' mock orange (PHLE4), black hawthorn (CRDO2), and redosier dogwood (COSE16).

Table A11.102—Riparian shrub subzone (*N* = 2) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Black hawthorn	CRDO2	50	16
Bog blueberry	VAUL	50	5
Forbs/graminoids			
Water sedge	CAAQ	50	59
Bull thistle	CIVU	50	1
American skunkcabbage	LYAM3	50	1

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Riparian hardwood forest (16)—

This subzone is found in the central and inner northern Coast Ranges of California and north into the Klamath Mountains. These systems also occur throughout the Pacific Northwest and are more abundant in the central and southern portions of the Pacific Northwest coast. Mean annual temperature ranges from 49 to 62°F, and mean annual precipitation ranges from 22 to 36 inches (PRISM Climate Group 2025).

This subzone consists of riparian woody vegetation, dependent upon annual or periodic flooding and associated sediment scour or annual rise in the water table for growth and reproduction. Stands occur on streambanks and flood plains and consist of open to closed woodlands with tall deciduous trees and shrubs, forming linear bands following stream and river courses and alluvial flood plains. This includes springs, seeps, and perennial and intermittent streams in both nonserpentine and serpentine substrates. This subzone often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component (LANDFIRE biophysical settings 11520 and 11560) (USGS and USDA FS, n.d.). This subzone includes upland aspen sites without conifers.

Riparian hardwood forests are characterized by the presence of tree cover at a minimum of 10 percent. Tree species that are common within this subzone include bigleaf maple (ACMA3), Oregon ash (FRLA), California live oak (QUAG), and California laurel (UMCA). Canyon live oak (QUCH2), red alder (ALRU2), balsam poplar (POBA2), California black oak (QUKE), quaking aspen (POTR5), interior live oak (QUWI2), white alder (ALRH2), and Oregon white oak (QUGA4) may be present. The most common understory species include Pacific poison oak (TODI) and common snowberry (SYAL).

Species composition within this subzone varies substantially among ecoregions. Within the Willamette Valley ecoregion, there are fewer overall tree species, predominantly Oregon ash, Oregon white oak, bigleaf maple, red alder, balsam poplar, and bitter cherry (PREM). Understory species include beaked hazelnut (COCO6), western swordfern (POMU), Indian plum (OECE), common snowberry, California blackberry (RUUR), stinging nettle (URDI), and red elderberry (SARA2).

Within the Sierra Nevada ecoregion, species composition reflects drier conditions. The most common tree species include canyon live oak, California black oak, quaking aspen, and California laurel. Understory species include big sagebrush (ARTR2), sticky whiteleaf manzanita (ARVI4), deerbrush (CEIN3), Pacific poison oak (TODI), mountain monardella (MOOD), and squirreltail (ELEL5).

Within the Northern Basin and Range ecoregion, quaking aspen is the only common tree species. Common understory species include common snowberry, big sagebrush, little sagebrush (ARAR8), yellow rabbitbrush (CHVI8), blue wildrye (ELGL), curl-leaf mountain mahogany (CELE3), and squirreltail.

Within the Southern California/Northern Baja Coast ecoregion, characteristic species include California live oak, scrub oak (QUBE5), Pacific poison oak, coastal woodfern (DRAR3), Oregon ash, toyon (HEAR5), common deerweed (LOSC2), California sycamore (PLRA), and hollyleaf redberry (RHIL).

Table A11.103—Riparian hardwood forest subzone (*N* = 172) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Pacific poison oak	TODI	31	8

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Other hardwoods (17)—

Hardwood forests, woodlands, and savannas, dominated by California live oak (QUAG), form a minor subzone scattered along the western edge of southern California in the Coast, Transverse, and Peninsular Ranges from Sonoma County to northern Baja California. This subzone occurs mainly in foothill environments (LANDFIRE biophysical setting 11130) (USGS and USDA FS, n.d.). Mean annual temperature ranges from 54 to 63 °F, and mean annual precipitation ranges from 16 to 25 inches (PRISM Climate Group 2025).

For the most part, it is found between the coast and the oak woodlands vegzone. The most common species found include California live oak, Pacific poison oak (TODI), canyon live oak (QUCH2), toyon (HEAR5), California laurel (UMCA), ripgut brome (BRDI3), chamise (ADFA), and birchleaf mountain mahogany (CEMOG).

This subzone is defined by the absence of species that would indicate another vegzone or subzone, and the presence of indicator species California buckeye (AECA), tree of heaven (AIAL), Pacific madrone (ARME), giant chinquapin (CHCH7), Tasmanian bluegum (EUGL), Southern California walnut (JUCA), Northern California walnut (JUHI), sweet cherry (PRAV), California live oak, canyon live oak, or California laurel.

Table A11.104—Other hardwoods (*N* = 225) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
California live oak	QUAG	59	42
Canyon live oak	QUCH2	35	53
Shrubs			
Pacific poison oak	TODI	50	11

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Oak woodlands (18)—

This subzone includes forest stands, groves, and savannas dominated by deciduous oaks. In Washington, this subzone is rare west of the Cascade Range but forms a prominent zone on the east side of the Columbia Gorge north to the lower Yakima Valley. In Oregon, it is generally found at lower elevations within the Willamette, Umpqua, and Rogue River Valleys and the eastern Columbia Gorge south to the Confederated Tribes of Warm Springs Reservation. It is most frequently found in California, scattered throughout, but primarily surrounding the Sacramento and San Joaquin Valleys. On the eastern edge of the two valleys, it is generally between the shrublands vegzone and the California foothill pine-Coulter pine (PISA2-PICO3) vegzone. On the western side of the valleys, it is generally between the grasslands vegzone and the California foothill pine-Coulter pine vegzone. Soils are characteristically poor, drought prone, and moderately to excessively well drained. Climate is mediterranean, with hot, dry summers and cool, wet winters. Mean annual temperature ranges from 54 to 61 °F, and mean annual precipitation ranges from 19 to 32 inches (PRISM Climate Group 2025).

The primary species that define the subzone include blue oak (QUDO), interior live oak (QUWI2), California black oak (QUKE), and Oregon white oak (QUGA4). Canyon live oak (QUCH2), California live oak (QUAG), valley oak (QULO), scrub oak (QUBE5), and California laurel (UMCA) may also be present. Understory species include Pacific poison oak (TODI), ripgut brome (BRDI3), and buckbrush (CECU).

Within the Klamath Mountains/California High North Coast Range ecoregion, species composition is different than that of the overall oak woodlands subzone. The most common oaks include Oregon white oak and California black oak, with canyon live oak occasionally present, as well as Pacific madrone (ARME). Common understory species include Pacific poison oak, bristly dogstail grass (CYEC), buckbrush, alderleaf mountain mahogany (CEMO2), common yarrow (ACMI2), and sticky whiteleaf manzanita (ARVI4).

Table A11.105—Oak woodlands subzone (*N* = 809) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Trees			
Blue oak	QUDO	54	29
Shrubs			
Pacific poison oak	TODI	35	8

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Desert hardwoods (19)—

This is a very minor subzone and is only located in southern California. Mean annual temperature ranges from 64 to 74 °F, and mean annual precipitation ranges from 3 to 5 inches.

Species present include desert ironwood (OLTE), creosote bush (LATR2), fourwing saltbush (ATCA2), white sage (SAAP2), sawtooth goldenbush (HASQ2), and winterfat (KRLA2). This subzone is defined by the absence of species that would indicate another vegzone or subzone, and the presence of indicator species desert ironwood, western honey mesquite (PRGLT), or screwbean mesquite (PRPU).

Table A11.106—Desert hardwoods subzone (*N* = 11) constancy and cover

Layer/common name	Species symbol	Constancy	Mean cover
		PERCENT	
Shrubs			
Desert ironwood	OLTE	73	17

Grasslands-Meadows Vegzone (4)

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Table A11.107—Grasslands-meadows vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
4	Grasslands-meadows	–9	Wet meadow
4	Grasslands-meadows	–8	Moist meadow
4	Grasslands-meadows	–7	Dry meadow
4	Grasslands-meadows	–6	Upland grass
4	Grasslands-meadows	–5	Scabland grass

The grasslands-meadows vegzone indicates environments where trees and shrubs are not capable of becoming dominant, often because of edaphic or topo-edaphic factors. This vegzone is most frequently found in the Columbia Plateau, Eastern Cascades Slopes and Foothills, Central California Foothills and Coastal Mountains, and the Central California Valley ecoregions. The grasslands-meadows vegzone includes mountain meadows, which are conspicuous, essentially permanent, herbaceous habitats found on gentle topography along and near the heads of streams (Franklin and Dyrness 1973).

The most common species include soft brome (BRHO2), wild oat (AVFA), Idaho fescue (FEID), big sagebrush (ARTR2), and ripgut brome (BRDI3).

Wet meadow (−9)—

This subzone of perennial herbaceous wet meadows is found in montane, subalpine, and lower alpine elevations in the Pacific Northwest and California. Wet meadow environments are meadows that remain wet at or near the surface throughout the growing season, and the soil surfaces remain damp to wet into the late fall. Wet meadows occur in open depressions, basins, and flats with low-velocity surface and subsurface flows. They can be large meadows in montane or subalpine valleys, or occur as narrow strips bordering ponds, lakes and streams, or along toe-slope seeps. They are typically found on flat areas or gentle slopes but may also occur on subirrigated sites with slopes up to 10 percent. In alpine regions, sites typically are small depressions located below late-melting snow patches. They may have surface water for part of the year, but depths rarely exceed a few centimeters. Wet meadows can be tightly associated with snowmelt and typically are not subjected to high-velocity disturbance but can be flooded by slow-moving waters (NatureServe 2017).

Common shrubs include bog birch (BEPU4), bog blueberry (VAUL), yellow willow (SALU2), diamondleaf willow (SAPL2), Wolf's willow (SAWO), grayleaf willow (SAGL), undergreen willow (SACO2), mountain willow (SAEA), timberline sagebrush (ARRO4), shrubby cinquefoil (DAFR6), and alpine laurel (KAMI). Wetland graminoids may include bluejoint (CACA4), Holm sedge (CAHEC), water sedge (CAAQ), sheep sedge (CAIL), twotipped sedge (CALA10), black alpine sedge (CANI2), native sedge (CAVE5), nearly-black sedge (CASU7), shorthair reedgrass (CABR), shorthair sedge (CAEX4), tufted hairgrass (DECE), Drummond's rush (JUDR), and Mertens' rush (JUME3). Characteristic forbs include western yarrow (ACMIO), tundra aster (ORAL4), Mt. Hood pussypaws (CIUM), frosted buckwheat (ERIN9), purple false horkelia (HOPU8), spike trisetum (TRSP2), Rocky Mountain pussytoes (ANME2), Drummond's cinquefoil (PODR), alpine lewisia (LEPY2), stalked fleabane (ERAL18), alpine shootingstar (DOAL), Rocky Mountain goldenrod (SOMU), Pacific lupine (LULE2), white marsh marigold (CALE4), American globeflower (TRLA14), fringed grass of Parnassus (PAFI3), icegrass (PHAL), American bistort (POBI6), alpine yellowcress (ROAL), creeping sibbaldia (SIPR), and Parry's clover (TRPA5) (LANDFIRE biophysical settings 11370 and 11600) (NatureServe 2017; USGS and USDA FS, n.d.).

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Moist meadow (−8)—

This subzone is found in the Oregon Cascade Range, northern California, and the Sierra Nevada, generally at subalpine elevations. These upland communities occur on gentle- to moderate-gradient slopes. These environments are wet to moist in the spring and are subirrigated or have freely available water within the rooting zone throughout the growing season. Soil surfaces generally dry by mid- to late summer. Forb communities found on talus and scree slopes with subsurface moisture are included here, in particular when they are not sparsely vegetated.

This subzone represents typically lush meadows dominated by a diversity of tall forbs with grasses intermingled in many of them. Grasses and sedges are common, typically being taxa with broad and soft blades, such as tufted hairgrass (DECE), prairie Junegrass (KOMA), smooth woodrush (LUGL2), perennial brome species, and a number of sedge species, such as shorthair reedgrass (CABR), shorthair sedge (CAEX4), nearlyblack sedge (CASU7), and native sedge (CAVE5). Taller forbs found in this subzone may include common yarrow (ACMI2), nettleleaf giant hyssop (AGUR), arrowleaf balsamroot (BASA3), sticky purple geranium (GEVI2), western coneflower (RUOC2), western meadow-rue (THOC), Sitka valerian (VASI), common beargrass (XETE), tundra aster (ORAL4), Mt. Hood pussypaws (CIUM), frosted buckwheat (ERIN9), purple false horkelia (HOPU8), spike trisetum (TRSP2), Rocky Mountain pussytoes (ANME2), Drummond's cinquefoil (PODR), alpine lewisia (LEPY2), stalked fleabane (ERAL18), alpine shootingstar (DOAL), Rocky Mountain goldenrod (SOMU), and Pacific lupine (LULE2) (LANDFIRE biophysical setting 11370) (NatureServe 2017; USGS and USDA FS, n.d.).

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Dry meadow (−7)—

This subzone includes open, dry meadows and grasslands on the west side of the Cascade Range and northern Sierra Nevada that generally occur in montane elevations. These meadows are moist to wet in the spring but dry moderately to severely by the fall. These sites do not have a perched water table or freely available water within the rooting zone throughout the growing season.

Species that define the subzone include Cusick's bluegrass (POCU3), Kentucky bluegrass (POPR), Idaho fescue (FEID), nodding needlegrass (NACE), and wildrye (ELYMU) (LANDFIRE biophysical setting 11380) (USGS and USDA FS, n.d.).

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Upland grass (−6)—

This subzone occurs in eastern Washington, Oregon, and California. Within the Pacific Northwest, upland grassland subzone communities are not as common in eastern Oregon as in the Columbia Basin and may often be found mixed in a mosaic with shrub-steppe and forest vegzones. The upland grass subzone is characterized by rolling topography composed of loess hills and plains over basalt plains. These sites often have deep, loamy ash or loess-influenced soils and are typically dominated by perennial bunchgrasses. Climate of this region has warm to hot, dry summers and cool, wet winters (LANDFIRE biophysical setting 11420) (USGS and USDA FS, n.d.). Mean annual temperature ranges from 55 to 62 °F, and mean annual precipitation ranges from 14 to 23 inches (PRISM Climate Group 2025).

These environments rarely have a shrub component and few forbs of consequence (Franklin and Dyrness 1973). Characteristic species include bluebunch wheatgrass (PSSP6), Idaho fescue (FEID), needle and thread (HECO26), Scribner needlegrass (ACSC11), giant wildrye (LECO12), basin wildrye (LECI4), prairie Junegrass (KOMA), western wheatgrass (PASM), Sandberg bluegrass (POSE), Saskatoon serviceberry (AMAL2), common snowberry (SYAL), and black hawthorn (CRDO2).

In California, this subzone ranges from the coast to the lower foothills of Sierra Nevada. These annual grasslands and meadows occur on upland slopes, broad valleys, and ocean bluffs. Soils are generally fine textured from loam to clay soils, especially those of volcanic and serpentine parent materials.

This subzone is dominated by graminoids, such as downy ryegrass (LEIN6), western needlegrass (ACOC3), Richardson's needlegrass (ACRI8), slender wheatgrass (ELTR7), Hood's sedge (CAHO5), obtuse sedge (CAOB4), northern singlespike sedge (CASC10), small fescue (VUMI), giant wildrye, California melicgrass (MECA2), nodding needlegrass (NACE), foothill needlegrass (NALE2), and purple needlegrass (NAPU4). Menzies' fiddleneck (AMME), spreading groundsmoke (GADI2), American bird's-foot trefoil (LOUN), rusty popcornflower (PLNO), and whitetip clover (TRVA) may also be present (NatureServe 2017).

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Scabland grass (−5)—

This subzone is found in the Channeled Scablands of the Columbia Plateau in Washington, between the Spokane, Columbia, and Snake Rivers. Soils are very shallow skeletal basalt soils with limited water-holding capacity over fractured basalt and a high rock content. This xeric subzone occurs under relatively extreme soil-moisture conditions. Because of poor drainage through basalt, these soils are often saturated from fall to spring by winter precipitation but typically dry out completely to bedrock by mid-summer. Frost heaving in winter is also common. Precipitation ranges from 6 to 20 inches, mostly falling as winter snow at higher elevations (LANDFIRE biophysical setting 10650) (NatureServe 2017; USGS and USDA FS, n.d.).

Total vegetation cover is typically low, generally less than 50 percent and often much less. Characteristic species include scabland sagebrush (ARRI2), arrowleaf buckwheat (ERCO12), Douglas' buckwheat (ERDO), slender buckwheat (ERMI4), snow buckwheat (ERNI2), rock buckwheat (ERSP7), Blue Mountain buckwheat (ERST4), thymeleaf buckwheat (ERTH4), and purple sage (SADO4). These stands are characterized by low percentage of cover of perennial bunch grasses, primarily Sandberg bluegrass (POSE), but may include onespike danthonia (DAUN), squirreltail (ELEL5), Idaho fescue (FEID), or bluebunch wheatgrass (PSSP6). Forbs may be present, usually with low percentage of cover, including bitter root (LERE7), desertparsley (LOMAT), narrowleaf mock goldenweed (NEST5), onion (ALLIU), pussytoes (ANTEN), and balsamroot (BALSA). Other species that may be present in pockets of deeper soil include big sagebrush (ARTR2), threetip sagebrush (ARTR4), and yellow rabbitbrush (CHVI8) (LANDFIRE biophysical setting 10650) (NatureServe 2017; USGS and USDA FS, n.d.).

Shrublands (Shrub-Steppe) Vegzone (5)

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Table A11.108—Shrublands (shrub-steppe) vegzone and subzones

Vegzone number	Vegzone name	Subzone number	Subzone name
5	Shrublands	–17	Creosote-bursage scrub
5	Shrublands	–16	Desert scrub
5	Shrublands	–15	Coastal scrub
5	Shrublands	–14	Chaparral
5	Shrublands	–13	Montane shrub
5	Shrublands	–12	Upland shrub
5	Shrublands	–11	Scabland shrub
5	Shrublands	–10	Salt desert shrub

The shrublands (shrub-steppe) vegzone occurs in the rain shadow between the Cascade Range and Sierra Nevada, and extends from northeastern Washington, through eastern Oregon, and into eastern California. This vegzone is dominated by low-lying shrubs, with too little rain for tree growth. This environment has a continental climate and occurs in arid to semiarid areas with warm to hot, dry summers and cold winters. In most of central and southeastern Washington and much of eastern Oregon, shrub-steppe communities occur in areas with low precipitation or where soil texture or soil depth limit forest vegzone community development.

The most frequently found species include big sagebrush (ARTR2), squirreltail (ELEL5), chamise (ADFA), curl-leaf mountain mahogany (CELE3), and Sandberg bluegrass (POSE).

Creosote-bursage scrub (−17)—

This subzone is found in broad valleys, lower bajadas, plains, and low hills in the Mojave, western Sonoran, and Lower Colorado Deserts where winter (cool-season) precipitation prevails. It is typically found on well-drained alluvial flats and slopes above the saltbrush zone, where available water capacity is very low, and runoff is moderate to rapid. Mean annual precipitation is 4 inches, and mean annual temperature ranges from 64 to 74 °F.

This subzone is characterized by a sparse to moderately dense layer (2 to 50 percent cover) of xeromorphic, microphyllous, and broad-leaved shrubs. Creosote bush (LATR2) and burrobush (AMDU2) typically dominate, but many different shrubs, dwarf-shrubs, and cacti may codominate or form typically sparse understory layers. Associated species may include brittlebush (ENFA), Nevada jointfir (EPNE), ocotillo (FOSP2), water jacket (LYAN), beavertail pricklypear (OPBA2), and teddybear cholla (CYBI9). The herbaceous layer is typically sparse but may be seasonally abundant with ephemerals (NatureServe 2017).

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Desert scrub (−16)—

This subzone is in the transition zone above the creosote-bursage scrub subzone and below the lower montane woodlands that occurs in the eastern and central Mojave Desert. Precipitation ranges from 5 to 12 inches, with most occurring from November through April. Summers are hot and dry with many days reaching above 100 °F (LANDFIRE biophysical setting 10820) (USGS and USDA FS, n.d.).

The vegetation in this group is quite variable. Creosote bush (LATR2) may be absent or present but typically does not dominate. Characteristic species include wooly fruit bur ragweed (AMER), greenleaf manzanita (ARPA6), blackbrush (CORA), Cooper's goldenbush (ERCO23), Eastern Mojave buckwheat (ERFA2), California jointfir (EPCA2), Nevada jointfir (EPNE), Torrey's jointfir (EPTO), mormon tea (EPVI), crispleaf buckwheat (ERCO14), spiny hopsage (GRSP), water jacket (LYAN), spiny menodora (MESP2), Bigelow's nolina (NOBI), sacahuista (NOMI), Parry's beargrass (NOPA), buck-horn cholla (CYAC8), desert bitterbrush (PUGL2), Stansbury cliffrose (PUST), Mexican bladdersage (SAME), turpentinebroom (THMO), Parish's goldeneye (VIPA14), Joshua tree (YUBR), and Mojave yucca (YUSC2) (NatureServe 2017).

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Coastal scrub (−15)—

This subzone occurs from the central California coast in Monterey and San Luis Obispo Counties north to about the Oregon border. The subzone is usually within 5 to 10 miles of the coast and is within the zone of summer fog. This subzone occurs on sea bluffs and rocky headlands well above the tidal zone throughout rugged portions of the Pacific coast and on coastal sand dunes and beaches and may extend inland from the maritime zone in hotter, drier (less fog-drenched) conditions than northern shrublands (NatureServe 2017).

Plant communities along these often-vertical slopes are typically sparse, with many succulents and prostrate shrubs, along with species that readily withstand salt spray, saline soils, and seasonal drought. This subzone may be dominated by drought-deciduous shrubs but at times may have characteristic resprouting, deep-rooted sclerophyllous shrubs. Characteristic species include coyotebrush (BAPI), coastal sagebrush (ARCA11), Eastern Mojave buckwheat (ERFA2), California jointfir (EPCA2), Mexican bush sage (SALE9), white sage (SAAP2), black sage (SAME3), seaside woolly sunflower (ERST9), California brittlebush (ENCA), yellow bush lupine (LUAR), coastal pricklypear (OPLI3), seaside fleabane (ERGL3), seacliff buckwheat (ERPA8), goose tongue (PLMA3), sawtooth goldenbush (HASQ2), coastal buckwheat (ERCI5), lemonade sumac (RHIN2), beach wormwood (ARPY3), California goldenbush (ERER11), Menzies' goldenbush (ISME5), and Chamisso bush lupine (LUCH) (NatureServe 2017).

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Chaparral (−14)—

This subzone represents a shrubland community primarily found in California and southern Oregon, away from the fog belt. In Sierra Nevada, chaparral occurs in the foothills on the western slopes. In the coast ranges, chaparral is found largely on interior slopes and in large patches in the Cascade Range and Siskiyou and Klamath Mountains. The northern limits are the dry areas of the Rogue River watershed in Oregon. Chaparral is shaped by a mediterranean climate of mild, wet winters and hot, dry summers, along with infrequent, high-intensity fires, generally in the late summer and early fall (LANDFIRE biophysical setting 11050) (USGS and USDA FS, n.d.). Mean annual temperature ranges from 55 to 63 °F, and mean annual precipitation ranges from 17 to 25 inches (PRISM Climate Group 2025).

This subzone is characterized by a combination of locally endemic species of manzanita and ceanothus that primarily reproduce by seed rather than resprouting. Examples include woollyleaf manzanita (ARTO2), glossyleaf manzanita (ARNU3), Hooker's manzanita (ARHO3), Pajaro manzanita (ARPA3), Montara manzanita (ARMO5), Baker's manzanita (ARBA4), Bonny Doon manzanita (ARSI), Mason's ceanothus (CEMA3), Carmel ceanothus (CEGR2), barranca brush (CEVE2), Stanford's manzanita (ARST), California flannelbush (FRCA6), tree poppy (DERI), whiteleaf manzanita (ARMA), bigberry manzanita (ARGL4), Eastwood's manzanita (ARGL3), Mendocino bushmallow (MAFA), and chaparral pea (PIMO5). Additional species that occur in Jackson and Josephine Counties in Oregon include buckbrush (CECU), birchleaf mountain mahogany (CEMOG), bearbush (GAFR), Klamath plum (PRSU2), and Pacific poison oak (TODI) (LANDFIRE biophysical setting 11050) (NatureServe 2017; USGS and USDA FS, n.d.).

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Montane shrub (−13)—

Montane shrub ecosystems include chaparral and open, shrubby woodlands found among montane forests from the southern Cascade Range of Oregon, the northern Great Basin, Columbia Basin, and Blue Mountains of northeastern Oregon, to the Peninsular Ranges of California. This subzone generally occurs between the steppe or shrub-steppe ecotone and the forest (LANDFIRE biophysical setting 11060) (USGS and USDA FS, n.d.). It is often located on steep, exposed slopes with rocky or shallow soils, often glaciated, but with some soil development, either loess deposits or volcanic clays. Sites may be located on ridgetops and upper to middle mountain slopes and are more common on sunny southerly aspects. Soils tend to be moist but will typically dry out in the late spring or summer. Much of the annual precipitation occurs as snow (LANDFIRE biophysical setting 11060) (NatureServe 2017; USGS and USDA FS, n.d.). Mean annual temperature ranges from 41 to 59 °F, and mean annual precipitation ranges from 7 to 30 inches (PRISM Climate Group 2025).

Rocky Mountain maple (ACGL) and quaking aspen (POTR5) may be present, and common shrub species include mountain snowberry (SYOR2), common snowberry (SYAL), Saskatoon serviceberry (AMAL2), bitter cherry (PREM), chokecherry (PRVI), snowbrush ceanothus (CEVE), antelope bitterbrush (PUTR2), curl-leaf mountain mahogany (CELE3), wax current (RICE), yellow rabbitbrush (CHVI8), oceanspray (HODI), mallow ninebark (PHMA5), white spirea (SPBE2), Lewis' mock orange (PHLE4), smooth sumac (RHGL), prickly currant (RILA), thimbleberry (RUPA), rose meadowsweet (SPSP2), grouse whortleberry (VASC), and thinleaf huckleberry (VAME) (LANDFIRE biophysical setting 11060) (NatureServe 2017; USGS and USDA FS, n.d.).

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Upland shrub (−12)—

This subzone occurs across the Great Basin, Snake River Plain, Modoc Plateau, and the more xeric portions of the Columbia Plateau. Sites typically occur on deeper soils that are typically well drained, and that do not have the potential for tree dominance. Mean annual temperature ranges from 42 to 51 °F, and mean annual precipitation ranges from 13 to 22 inches (PRISM Climate Group 2025). Most precipitation is in the winter and spring.

Big sagebrush (ARTR2) is the dominant shrub, with antelope bitterbrush (PUTR2) a common codominant on the warmer sites. In some cases, xeric shrubs, such as fourwing saltbush (ATCA2), shadescale saltbush (ATCO), Nevada jointfir (EPNE), mormon tea (EPVI), rubber rabbitbrush (ERNA10), spiny hopsage (GRSP), and greasewood (SAVE4) may also be codominants. On cooler sites, Saskatoon serviceberry (AMAL2) and mountain snowberry (SYOR2) may also be present. Herbaceous diversity is typically high, with deep-rooted bunchgrasses common, e.g., Idaho fescue (FEID), rough fescue (FECA4), bluebunch wheatgrass (PSSP6), and Columbia needlegrass (ACNE9) (LANDFIRE biophysical setting 11260) (NatureServe 2017; USGS and USDA FS, n.d.).

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Scabland shrub (−11)—

This subzone is most common in the Channeled Scablands of the Columbia Plateau of Washington, between the Spokane, Columbia, and Snake Rivers, and small, isolated inclusions in other sagebrush types and within forested types of the Blue Mountains in southeastern Oregon. This subzone is also found in the Sierra Nevada and forms extensive low stature shrublands. It typically occurs on mountain ridges and flanks and broad terraces. These environments are generally xeric and may be on wind-blown, shallow substrates; poorly drained clays; and very stony, gravelly, or finer-textured alkaline soils. Soils may include shrink-swell clays that annually strip fine roots. These xeric shrublands also occur in soils with limited water-holding capacity over fractured basalt. Because of poor drainage through basalt, these soils are often saturated from fall to spring by winter precipitation but typically dry out completely to bedrock by midsummer (LANDFIRE biophysical setting 10650) (NatureServe 2017; USGS and USDA FS, n.d.). Precipitation ranges from 6 to 20 inches, mostly falling as winter snow at higher elevations.

Total vegetation cover is typically low, generally less than 50 percent, and often much less. Vegetation is characterized by an open, dwarf-shrub canopy dominated by scabland sagebrush (ARRI2), purple sage (SADO4), black sagebrush (ARNO4), little sagebrush (ARAR8), Bigelow sage (ARBI3), threetip sagebrush (ARTR4), and prairie sagewort (ARFR4). Other dwarf-shrub species, particularly diagnostic buckwheat species, such as arrowleaf buckwheat (ERCO12), Douglas' buckwheat (ERDO), slender buckwheat (ERMI4), snow buckwheat (ERNI2), rock buckwheat (ERSP7), Blue Mountain buckwheat (ERST4), and thymeleaf buckwheat (ERTH4) may also be present. Sandberg bluegrass (POSE), squirreltail (ELEL5), bitter root (LERE7), narrowleaf mock goldenweed (NEST5), and other dry-site grasses and forbs may be present, usually with low percentages of cover (LANDFIRE biophysical setting 10650) (NatureServe 2017; USGS and USDA FS, n.d.).

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Salt desert shrub (−10)—

Salt desert shrub communities are most frequent in the Great Basin of southeastern Oregon and south-central Oregon where interior drainage and large historic lake basins support significant patches of salt desert habitat. This subzone is semiarid and is found on wind-swept basins and plains. Stands occur on gentle slopes and rolling plains. Substrates are shallow, typically saline, alkaline, fine-textured soils developed often from marine shale or alluvium that may be associated with shale badlands. Infiltration rate is typically low. The water table is generally shallow, and these areas remain dry through most growing seasons. Mean annual precipitation ranges from 5 to 8 inches, and mean temperature ranges from 45 to 50 °F (LANDFIRE biophysical setting 11530) (NatureServe 2017; USGS and USDA FS, n.d.).

These sites are often intermingled in a mosaic with upland shrub communities dominated by big sagebrush (ARTR2). The vegetation is characterized by an open canopy of dwarf-shrubs. Dominant or codominant dwarf-shrubs may include longleaf wormwood (ARLO7), or bud sagebrush (PIDE4), sometimes with a mix of other low shrubs, such as winterfat (KRLA2) or shortspine horsebrush (TESP2). The herbaceous layer is typically sparse, with scattered perennial forbs, such as smooth woodyaster (XYGL) and gooseberryleaf globemallow (SPGR2). Perennial grasses, such as Indian ricegrass (ACHY), blue grama (BOGR2), squirreltail (ELEL5), thickspike wheatgrass (ELLA3), western wheatgrass (PASM), Sandberg bluegrass (POSE), or alkali sacaton (SPAI) may dominate the herbaceous layer. In less saline areas, there may be inclusions of grasslands dominated by needle and thread (HECO26), saline wildrye (LESA4), or bluebunch wheatgrass (PSSP6) (NatureServe 2017).

Literature Cited

Atzet, T.; Martin, R. 1992. Natural disturbance regimes in the Klamath Province. In: Harris, R.R.; Erman, D.C., tech. coords.; Kerner, H.M., ed. Symposium on biodiversity of northwestern California. Wildland Resources Center Report 29. Berkeley, CA: University of California.

Atzet, T.; White, D.E.; McCrimmon, L.A. [et al.]. 1996. Field guide to the forested plant associations of southwestern Oregon. Tech. Pap. R6-NR-ECOL-TP-17-96. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Burns, R.M.; Honkala, B.H., tech. coords. 1990. Silvics of North America: 1. Conifers. Agric. Handb. 654. U.S. Department of Agriculture, Forest Service. 675 p.

Carroll, A.L.; Sillett, S.C.; Kramer, R.D. 2014. Millennium-scale crossdating and inter-annual climate sensitivities of standing California redwoods. PLoS ONE 9(7): e102545. https://doi.org/10.1371/journal.pone.0102545.

Cope, A.B. 1993. *Pinus contorta* var. *murrayana*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (producer). https://www.fs.usda.gov/database/feis/plants/tree/pinconm/all.html. (May 27, 2025).

Davis, R.J.; Bell, D.M.; Gregory, M.J. [et al.]. 2022a. Northwest Forest Plan—the first 25 years (1994–2018): status and trends of late-successional and old-growth forests. Gen. Tech. Rep. PNW-GTR-1004. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 82 p. https://doi.org/10.2737/PNW-GTR-1004.

Davis, R.J.; Lesmeister, D.B.; Yang, Z. [et al.]. 2022b. Northwest Forest Plan—the first 25 years (1994–2018): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-1003. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p. https://doi.org/10.2737/PNW-GTR-1003.

Davis, R.J.; Ohmann, J.L.; Kennedy, R.E. [et al.]. 2015. Northwest Forest Plan—the first 20 years (1994–2013): status and trends of late-successional and old-growth forests. Gen Tech. Rep. PNW-GTR-911. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 112 p. https://doi.org/10.2737/PNW-GTR-911.

Fettig, C.J.; Wuenschel, A.; Balachowski, J. [et al.]. 2019. Managing effects of drought in California. In: Vose, J.; Peterson, D.L.; Luce, C.H. [et al.], eds. Effects of drought on forests and rangelands in the United States: translating science into management responses. Gen. Tech. Rep. WO-GTR-98. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office.

Fites-Kaufman, J.; Rundel, P.; Stephenson, N.; Weixelman, D.A. 2007. Montane and subalpine vegetation of the Sierra Nevada and Cascade ranges. In: Barbour, M.G.; Keeler-Wolf, T.; Schoenherr, A.A., eds. Terrestrial vegetation of California. 3rd ed. Berkeley and Los Angeles, CA: University of California Press: 456–501. Chapter 17. https://doi.org/10.1525/california/9780520249554.003.0017.

Franklin, J.F. 1982. The true fir resource. In: Oliver, C.D.; Kenady, R.M., eds. Biology and management of true fir in the Pacific Northwest: proceedings of the symposium. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.

Franklin, J.F.; Dyrness, T.C. 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 417 p.

Griffith, R.S. 1992. *Sequoia sempervirens*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. https://www.fs.usda.gov/database/feis/plants/tree/seqsem/all.html. (May 2, 2025).

Hawk, G.M. 1977. Comparative study of temperate *Chamaecyparis* forests. Corvallis, OR: Oregon State University. 195 p. Ph.D. dissertation.

Jimerson, T.M. 1994. A field guide to Port Orford cedar plant associations in northwest California. Tech. Pap. R5-ECOL-TP-002. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. https://doi.org/10.5962/bhl.title.149782.

Jimerson, T.M.; Hoover, L.D.; McGee, E.A. [et al.]. 1995. A field guide to serpentine plant associations and sensitive plants in northwestern California. Tech. Pap. R5-ECOL-TP-006. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Johnson, C.G., Jr. 2004. Alpine and subalpine vegetation of the Wallowa, Seven Devils, and Blue Mountains. Tech. Pap. R6-NR-ECOL-TP-03-04. [Baker City, OR]: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 326 p.

Jules, E.S.; Carroll, A.L.; Garcia, A.M. [et al.]. 2014. Host heterogeneity influences the impact of a non-native disease invasion on populations of a foundation tree species. Ecosphere 5(9): 105. https://doi.org/10.1890/ES14-00043.1.

Kovalchik, B.L.; Clausnitzer, R.R. 2004. Classification and management of aquatic, riparian, and wetland sites on the national forests of eastern Washington: series description. Gen. Tech. Rep. PNW-GTR-593. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 354 p. https://doi.org/10.2737/PNW-GTR-593.

Kruckeberg, A.R. 1984. California serpentines: flora, vegetation, geology, soils, and management problems. Berkeley, CA: University of California Press. 180 p.

Laacke, R.J. 1990. *Abies magnifica* A. Murr. California red fir. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America: 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 71–79.

Little, E.L., Jr. 1971. Atlas of the United States trees: conifers and important hardwoods. Washington, DC: U.S. Department of Agriculture, Forest Service. https://doi.org/10.5962/bhl.title.130546.

McCain, C.; Diaz, N. 2002. Field guide to the forested plant associations of the northern Oregon Coast Range. Tech. Pap. R6-NR-ECOL-TP-03-02. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 250 p.

Miller, R.F.; Bates, J.D.; Svejcar, T.J. [et al.]. 2005. Biology, ecology, and management of western juniper (*Juniperus occidentalis*). Tech. Bull. 152. Corvallis, OR: Oregon State University, Agricultural Experiment Station. 77 p.

Minore, D. 1979. Comparative autecological characteristics of northwestern tree species—a literature review. Gen. Tech. Rep. PNW-87. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 72 p.

Mooney, H.; Dawson, T.E. 2016. Coast redwood forests. In: Mooney, H.; Zavaleta, E., eds. Ecosystems of California. Berkeley, CA: University of California Press: 535–552. Chapter 26. https://doi.org/10.1525/9780520962170.

NatureServe. 2017. Terrestrial ecological systems of the United States. NatureServe Central Databases. Arlington, VA. https://www.natureserve.org/products/terrestrial-ecological-systems-united-states. (May 27, 2025).

Oline, D.K. 2008. Geographic variation in chloroplast haplotypes in the California red fir-noble fir species complex and the status of Shasta red fir. Canadian Journal of Forest Research. 38(10): 2705–2710. https://doi.org/10.1139/X08-097.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers. 77(1): 118–125. https://doi.org/10.1111/j.1467-8306.1987.tb00149.x.

Omernik, J.M.; Griffith, G.E. 2014. Ecoregions of the conterminous United States: evolution of a hierarchical spatial framework. Environmental Management. 54: 1249–1266. https://doi.org/10.1007/s00267-014-0364-1.

Ott, T.M. 2014. The geographic and ecological patterns of genetic variation of the *Abies grandis–Abies concolor* complex. Moscow, ID: University of Idaho. 122 p. Ph.D. dissertation.

Ott, T.M.; Strand, E.K.; Anderson, C.L. 2015. Niche divergence of *Abies grandis–Abies concolor* hybrids. Plant Ecology. 216: 479–490. https://doi.org/10.1007/s11258-015-0452-1.

PRISM Climate Group. 2025. Corvallis, OR: Oregon State University, Northwest Alliance for Computational Science & Engineering. https://prism.oregonstate.edu. (December 16, 2020).

Simpson, M. 2007. Forested plant associations of the Oregon East Cascades. Tech. Pap. R6-NR-ECOL-TP-03-2007. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Steinhoff, R.J. 1978. Distribution, ecology, silvicultural characteristics, and genetics of the *Abies grandis-Abies concolor* complex. In Proceedings of the IUFRO joint meeting of working parties. Vol. 2: lodgepole pine, Sitka spruce, and *Abies* provenances. Vancouver, BC: British Columbia Ministry of Forests: 123–132.

U.S. Department of Agriculture, Forest Service [USDA FS]. [N.d.]. Landscape ecology, modeling, mapping, and analysis (LEMMA). https://lemma.forestry.oregonstate.edu/. (May 27, 2025).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. [N.d.]. PLANTS Database. http://plants.usda.gov. (May 27, 2025).

U.S. Department of the Interior, Fish and Wildlife Service [USFWS]. [N.d.]. National wetlands inventory. https://www.fws.gov/program/national-wetlands-inventory. (May 27, 2025).

U.S. Department of the Interior, Geological Survey [USGS]. 2014. National Land Cover Database (NLCD) 2011 Land Cover Conterminous United States (ver. 2.0, May 2024). https://www.usgs.gov/data/national-land-cover-database-nlcd-2011-land-cover-conterminous-united-states-ver-20-may-2024. (March 26, 2026).

U.S. Department of the Interior, Geological Survey [USGS]. 2018. National land cover database. https://www.usgs.gov/centers/eros/science/national-land-cover-database. (March 26, 2026).

Van Pelt, R.; Sillett, S.C.; Kruse, W.A. [et al.]. 2016. Emergent crowns and light-use complementarity lead to global maximum biomass and leaf area in *Sequoia sempervirens* forests. Forest Ecology and Management 375: 279–308. https://doi.org/10.1016/j.foreco.2016.05.018.

Volland. 1985. Plant associations of the central Oregon pumice zone. R6-ECOL-104-1985. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Williams, C.K.; Kelley, B.F.; Smith, B.G.; Lillybridge, T.R. 1995. Forested plant associations of the Colville National Forest. Gen. Tech. Rep. PNW-GTR-360. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 405 p. https://doi.org/10.2737/PNW-GTR-360.

Zavarin, E.; Critchfield, W.B.; Snajberk, K. 1978. Geographic differentiation of monoterpenes from *Abies procera* and *Abies magnifica*. Biochemical Systematics and Ecology. 6(4): 267–278. https://doi.org/10.1016/0305-1978(78)90044-3.

Zobel, D.B. 1973. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades: needle morphology and periderm color. Botanical Gazette. 134(3): 209–220. https://doi.org/10.1086/336706.

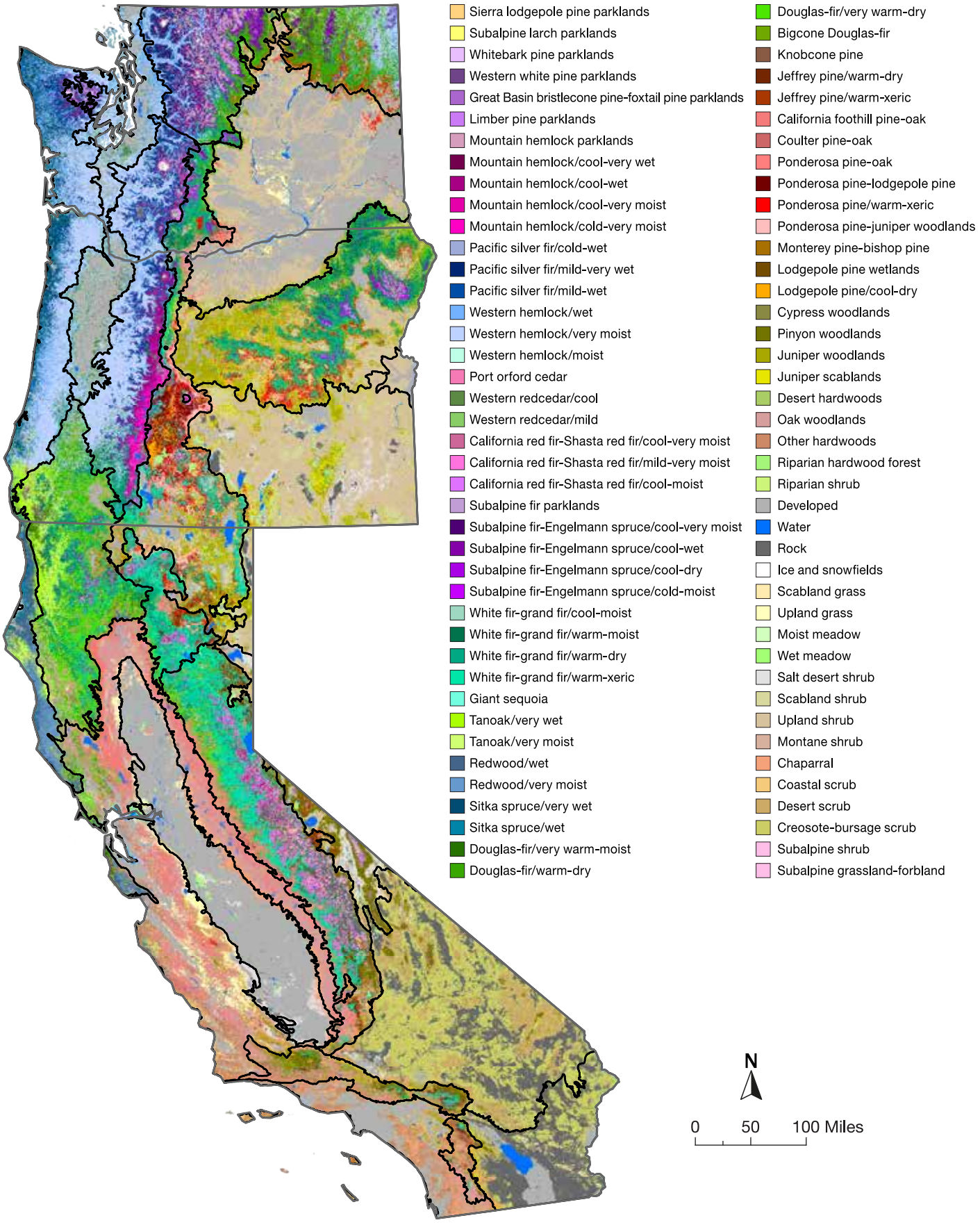
Zobel, D.B. 1974. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades. II. Stomatal reaction to moisture stress. Botanical Gazette. 135(3): 200–210. https://doi.org/10.1086/336753.

Zobel, D.B. 1975. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades. III. Timing of growth and stomatal characteristics in relation to environment. Botanical Gazette. 136(1): 63–71. https://doi.org/10.1086/336783.

Zobel, D.B.; Roth, L.F.; Hawk, G.M. 1985. Ecology, pathology, and management of Port-Orford-cedar (*Chamaecyparis lawsoniana*). Gen. Tech. Rep. PNW-184. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 161 p.

Appendix 12: Subzone Map

Subzone distribution across the Potential Natural Vegetation Map project area.



Appendix 13: Vegzone Error Matrix

We assessed the accuracies of potential natural vegetation map vegzones by exploring local-scale accuracy in plot-level classifications both across the entire project area and within different modeling regions. The worksheet "READ ME" is a key to help interpret the error matrix data. The worksheet "Vegzone_crosswalk" is the same as table A10.1 in app. 10; it provides vegzone names and corresponding numbers. The worksheet "Vegzone_error_matrix" is the matrix. The worksheet "Vegzone_fuzzy_matches" is the same as table A7.1. It is a confusion matrix based on "fuzzy" classifications. We constructed lists for each vegzone of other types sufficiently similar in their environmental relationships and floristic composition that interpretation of the map would not significantly suffer if the assignments were swapped. See the "Methods" section for more details on the process.

Download appendix 13 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 14: Subzone Error Matrix

We assessed the accuracies of potential natural vegetation map subzones by exploring local-scale accuracy in plot-level classifications both across the entire project area and within different modeling regions. The worksheet "READ ME" is a key to help interpret the error matrix data. The worksheet "Subzone_crosswalk" is the same as table A10.2 in app. 10; it provides subzone names and corresponding numbers. The worksheet "Subzone_error_matrix" is the matrix. The worksheet "Subzone_fuzzy_matches" is the same table A8.1. See "Methods" for more details on the process.

Download appendix 14 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 15: Vegzone Error Matrices by Gradient Nearest Neighbor Modeling Region

We also assessed the accuracies of potential natural vegetation map vegzones by comparing region-level estimates of vegzone areas using only plots (design-based) and the potential natural vegetation map (model-based and error-adjusted). The worksheet "READ ME" is a key to help interpret the error matrix data. The worksheet "Vegzone_crosswalk" is the same as table A10.1 in app. 10; it provides vegzone names and corresponding numbers. The other worksheets (e.g., "MR221_Vegzone_errmat") are the error matrices for each modeling region. See table 7 and figure 7 for modeling regions.

Download appendix 15 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 16: Subzone Error Matrices by Gradient Nearest Neighbor Modeling Region

We also assessed the accuracies of potential natural vegetation map subzones by comparing region-level estimates of vegzone areas using only plots (design based) and the potential natural vegetation map (model based and error adjusted). The worksheet "READ ME" is a key to help interpret the error matrix data. The worksheet "Subzone_crosswalk" is the same as table A10.2 in app. 10; it provides subzone names and corresponding numbers. The other worksheets (e.g., "MR221_Subzone_errmat") are the error matrices for each modeling region. See table 7 and figure 7 for modeling regions.

Download appendix 16 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 17: Area-Based Regional Accuracy Assessment

These tables provide predicted Gradient Nearest Neighbor (GNN) model-based and U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) design-based stratification vegzone and subzone data. The spreadsheet in the supplemental materials provides the regional accuracy data for vegzones and subzones. We used the data in this spreadsheet to generate figures 15 and 16 comparing GNN-predicted area versus FIA area for vegzones and subzones. For GNN area estimates, we summed pixels in our potential natural vegetation map. For FIA stratification area estimates, we used species composition data from plot locations and applied expansion factors. Figures show comparisons in area (in acres) for projected GNN versus FIA poststratification vegzone and subzone data. Whiskers on the FIA area estimate bars denote the 95-percent confidence interval of the area estimate for each vegzone/subzone.

Download appendix 17 (an Excel workbook file) here: https://doi.org/10.2737/pnw-gtr-1041.

Appendix 18: Gradient Nearest Neighbor Publications

The following references are Gradient Nearest Neighbor publications prepared by the Landscape Ecology, Modeling, Mapping and Analysis team, a collaborative research group of the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station and Oregon State University.

Battles, J.J.; Bell, D.M.; Kennedy, R.E. [et al.]. 2018. Innovations in measuring and managing forest carbon stocks in California: a report for California's Fourth Climate Change Assessment. CCCA4-CNRA-2018-014. 45 p. + apps. https://www.energy.ca.gov/sites/default/files/2019-12/Forests_CCCA4-CNRA-2018-014_ada.pdf. (May 1, 2025).

Bell, D.M.; Acker, S.A.; Gregory, M.J. [et al.]. 2020. Quantifying regional trends in large live tree and snag availability in support of forest management. Forest Ecology and Management. 479: 118554. https://doi.org/10.1016/j.foreco.2020.118554.

Bell, D.M.; Gregory, M.J.; Kane, V. [et al.]. 2018. Multiscale divergence between Landsat- and lidar-based biomass mapping is related to regional variation in canopy cover and composition. Carbon Balance and Management. 13: 15. https://doi.org/10.1186/s13021-018-0104-6.

Bell, D.M.; Gregory, M.J.; Ohmann, J.L. 2015. Imputed forest structure uncertainty varies across elevational and longitudinal gradients in the western Cascade Mountains, Oregon, USA. Forest Ecology and Management. 358: 154–164. https://doi.org/10.1016/j.foreco.2015.09.007.

Bell, D.M.; Gregory M.J.; Roberts, H.M. [et al.]. 2015. How sampling and scale limit accuracy assessment of vegetation maps: a comment on Loehle et al. (2015). Forest Ecology and Management. 358: 361–364. https://doi.org/10.1016/j.foreco.2015.07.017.

Brown, M. 2010. Getting in the game: out on the landscape without leaving your desk with GNNViz. Fire Science Brief. 94 (February 2010). https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1113&context=jfspbriefs. (May 1, 2025).

Davis, R.J.; Ohmann, J.L.; Kennedy, R.E. [et al.]. 2015. Northwest Forest Plan—the first 20 years (1994–2013): status and trends of late-successional and old-growth forests. PNW-GTR-911. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. https://doi.org/10.2737/PNW-GTR-911.

Grossmann, E.B.; Kagan, J.; Ohmann, J.L. [et al.]. 2008. Final report on land cover mapping methods, map zones 2 and 7, Pacific Northwest ReGAP. Corvallis, OR: Oregon State University, Institute for Natural Resources.

Grossmann, E.B.; Ohmann, J.L.; Gregory, M.J.; May, H.K. 2009. Nationwide forest imputation study (NaFIS)—western team final report. 48 p. https://lemma.forestry.oregonstate.edu/export/pubs/grossmann_etal_2009_nafis_report.pdf. (May 1, 2025).

Grossmann, E.; Ohmann, J.; Kagen, J. [et al.]. 2010. Mapping ecological systems with a random forest model: tradeoffs between errors and bias. Gap Analysis Bulletin. 17: 16–22. https://www.fs.usda.gov/pnw/pubs/journals/pnw_2010_grossman001.pdf. (May 1, 2025).

Hemstrom, M.A.; Merzenich, J.; Burcsu, T. [et al.]. 2006. Integrating natural disturbances and management activities to examine risks and opportunities in the central Oregon landscape analysis. In: Pye, J.M.; Rauscher, H.M.; Sands, Y., tech. eds. Advances in threat assessment and their application to forest and rangeland management. Gen. Tech. Rep. PNW-GTR-802. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest and Southern Research Stations: 93–109. https://www.fs.usda.gov/pnw/pubs/gtr802/Vol1/pnw_gtr802vol2.pdf.

Henderson, E.B.; Bell, D.M.; Gregory, M.J. 2019. Vegetation mapping to support greater sage-grouse habitat monitoring and management: multi-or univariate approach? Ecosphere. 10(8): e02838. https://doi.org/10.1002/ecs2.2838.

Henderson, E.B.; Ohmann, J.L.; Gregory, M.J. [et al.]. 2014. Species distribution modelling for plant communities: stacked single species or multivariate modelling approaches? Applied Vegetation Science. 17: 516–527. https://doi.org/10.1111/avsc.12085.

Holt, T.M.; Gregory, M.J.; Ohmann, J.L. 2007. GNNViz user guide. Appendix 1 of the Joint Fire Science Program final report; project 05-4-1-12. 19 p. https://lemma.forestry.oregonstate.edu/export/gnnviz/gnnviz_user_guide.pdf. (May 1, 2025).

Kagan, J.; Ohmann, J.L.; Gregory, M.J.; Tobalske, C. 2008. Land cover map for map zones 8 and 9 developed from SAGEMAP, GNN, and SWReGAP: a pilot for NWGAP. Gap Analysis Bulletin. 15: 15–19. https://www.fs.usda.gov/pnw/pubs/journals/pnw_2008_kagan001.pdf. (May 1, 2025).

Kagan, J.S.; Ohmann, J.L.; Gregory, M.J. [et al.]. 2006. Final report on land cover mapping methods, map zones 8 and 9, Pacific Northwest ReGAP. Corvallis, OR: Oregon State University, Institute for Natural Resources. 118 p. + apps. https://lemma.forestry.oregonstate.edu/export/pubs/kagan_etal_2006_gap89_final_report.pdf.

Kennedy, R.E.; Ohmann, J.L.; Gregory, M.J. [et al.]. 2018. An empirical, integrated forest biomass monitoring system. Environmental Research Letters. 13: 025004. https://doi.org/10.1088/1748-9326/aa9d9e.

Lesmeister, D.B.; Sovern, S.G.; Davis, R.J. [et al.]. 2019. Mixed-severity wildfire and habitat of an old-forest obligate. Ecosphere. 10(4): e02696. https://doi.org/10.1002/ecs2.2696.

Moeur, M.; Ohmann, J.L.; Hemstrom, M. [et al.]. 2009. Projecting watershed condition with Interagency Mapping and Assessment Project (IMAP) vegetation data and landscape models. In: Bayer, J.M.; Schei, J.L., eds. PNAMP special publication: remote sensing applications for aquatic resource monitoring. Cook, Washington: Pacific Northwest Aquatic Monitoring Partnership: 83–90. Chapter 11.

Moeur, M.; Ohmann, J.L.; Kennedy, R.E. [et al.]. 2011. Northwest Forest Plan—status and trends of late-successional and old-growth forests from 1994 to 2008. PNW-GTR-853. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p. https://doi.org/10.2737/PNW-GTR-853.

Myroniuk, V.; Bell, D.M.; Gregory, M.J. [et al.]. 2022. Uncovering forest dynamics using historical forest inventory data and Landsat time series. Forest Ecology and Management. 513: 120184. https://doi.org/10.1016/j.foreco.2022.120184.

Ohmann, J.L.; Gregory, M.J. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, USA. Canadian Journal of Forest Research. 32(4): 725–741. https://doi.org/10.1139/x02-011.

Ohmann, J.L.; Gregory, M.J.; Henderson, E.B.; Roberts, H.M. 2011. Mapping gradients of community composition with nearest-neighbor imputation: extending plot data for landscape analysis. Journal of Vegetation Science. 22(4): 660–676. https://doi.org/10.1111/j.1654-1103.2010.01244.x.

Ohmann, J.L.; Gregory, M.J.; Holt, T.M. 2007. Innovative, 3-D, interactive, and immersive techniques for visualizing, querying, and understanding regional maps of forest vegetation, fuels, and fire risk. Final report to the Governing Board, Joint Fire Science Program; project 05-4-1-12. 33 p. https://lemma.forestry.oregonstate.edu/export/gnnviz/gnnviz_final_report.pdf. (May 1, 2025).

Ohmann, J.L.; Gregory, M.J.; Roberts, H.M. 2014. Scale considerations for integrating forest inventory plot data and satellite image data for regional forest mapping. Remote Sensing of Environment. 151: 3–15. https://doi.org/10.1016/j.rse.2013.08.048.

Ohmann, J.L.; Gregory, M.J.; Roberts, H.M. [et al.]. 2012. Mapping change of older forest with nearest-neighbor imputation and Landsat time-series. Forest Ecology and Management. 272: 13–25. https://doi.org/10.1016/j.foreco.2011.09.021.

Ohmann, J.L.; Gregory, M.J.; Spies, T.A. 2007. Influence of environment, disturbance, and ownership on forest vegetation of coastal Oregon. Ecological Applications. 17(1): 18–33. https://doi.org/10.1890/1051-0761(2007)017[0018:IOEDAO]2.0.CO;2.

Ohmann, J.L.; Spies, T.A. 1998. Regional gradient analysis and spatial pattern of woody plant communities of Oregon forests. Ecological Monographs. 68(2): 151–182. https://doi.org/10.1890/0012-9615(1998)068[0151:RGAASP]2.0.CO;2.

Ohmann, J.L.; Wimberly, M.C.; Fried, J.S. [et al.]. 2005. A novel approach to regional fuel mapping: linking inventory plots with satellite imagery and GIS databases using the Gradient Nearest Neighbor method. Final report to the Governing Board, Joint Fire Science Program; project 01-1-4-09. 17 p. + apps. https://lemma.forestry.oregonstate.edu/export/pubs/final_report_01-1-4-09_29sep05.pdf. (May 1, 2025).

Pierce, K.B., Jr.; Brewer, C.K.; Ohmann, J.L. 2006. Moderate-resolution data and Gradient Nearest Neighbor imputation for regional-national risk assessment. In: Pye, J.M.; Rauscher, H.M.; Sands, Y., tech. eds. Advances in threat assessment and their application to forest and rangeland management. Gen. Tech. Rep. PNW-GTR-802. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest and Southern Research Stations: 111–122. https://www.fs.usda.gov/pnw/pubs/gtr802/Vol1/pnw_gtr802vol1_pierce.pdf. (May 1, 2025).

Pierce, K.B., Jr.; Ohmann, J.L. 2005. Gradient Nearest Neighbor imputation for mapping forest attributes and variability. In: Marsden, M.; Downing, M.; Riffe, M., comp. Workshop proceedings: quantitative techniques for deriving national-scale data. Pub. FHTET-2005-12. Fort Collins, CO: U.S. Department of Agriculture, Forest Heath Technology Enterprise Team: 145–172.

Pierce, K.B., Jr.; Ohmann, J.L.; Wimberly, M.C. [et al.]. 2009. Mapping wildland fuels and forest structure for land management: a comparison of nearest-neighbor imputation and other methods. Canadian Journal of Forest Research. 39(10): 1901–1916. https://doi.org/10.1139/X09-102.

Spies, T.A.; Johnson, K.N.; Burnett, K.M [et al.]. 2007. Cumulative ecological and socioeconomic effects of forest policies in coastal Oregon. Ecological Applications. 17(1): 5–17. https://doi.org/10.1890/1051-0761(2007)017[0005:CEASEO]2.0.CO;2.

Strunk, J.L.; Bell, D.M.; Gregory, M.J. 2022. Pushbroom photogrammetric heights enhance state-level forest attribute mapping with Landsat and environmental gradients. Remote Sensing. 14(14): 3433. https://doi.org/10.3390/rs14143433.

Wimberly, M.C.; Ohmann, J.L. 2004. A multi-scale assessment of human and environmental constraints on forest land cover change on the Oregon (USA) coast range. Landscape Ecology. 19(6): 631–646. https://doi.org/10.1023/B:LAND.0000042904.42355.f3.

Wimberly, M.C.; Ohmann, J.L.; Pierce Jr., K.B. [et al.]. 2003. A multivariate approach to mapping forest vegetation and fuels using GIS databases, satellite imagery, and forest inventory plots. In: Proceedings of the second International Wildland Fire Ecology and Fire Management Congress. American Meteorological Society.

Zald, H.S.J.; Ohmann, J.L.; Roberts, H.M. [et al.]. 2014. Influence of lidar, Landsat imagery, disturbance history, plot location accuracy, and plot size on accuracy of imputation maps of forest composition and structure. Remote Sensing of Environment. 143: 26–38. https://doi.org/10.1016/j.rse.2013.12.013.

Appendix 19: Gradient Nearest Neighbor Project Descriptions

This appendix describes current and past projects of the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) team, a collaborative research group of the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station and Oregon State University.

Forest Biomass Mapping in California and Western Oregon (CA-Biomass)

Ongoing

In this project, we are continuing the development of an integrated system for monitoring forest carbon and biomass dynamics (see CMONster below) in California and western Oregon. This system leverages U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) data and fitted Landsat imagery based on theLandTrendr algorithms. In particular, this project incorporated satellite imagery from multiple Landsat missions (Landsat 5, 7, and 8) and 16 years of FIA plot data to understand the patterns, causes, and consequences of biomass stock status and change, especially as it related to forest disturbances (e.g., drought-induced mortality, wildfire, etc.). Additionally, this work aimed to better understand uncertainties in resulting forest biomass maps to inform their use by land managers, policymakers, and scientists.

Northwest Forest Plan (NWFP) Effectiveness Monitoring

Ongoing

This project involves developing detailed maps of forest vegetation for multiple dates across the NWFP area in Washington, Oregon, and California. The maps are used in effectiveness monitoring for the NWFP to assess changes in late-successional and old-growth forest, and habitat for the northern spotted owl, marbled murrelet, and aquatic species. Maps developed for the 15-year report (completed in 2010) were for two dates: 1996 and 2006 in Oregon and Washington, and 1994 and 2007 in California. The current map dates, used in the 20-year report, are for 1993 and 2012 across the entire NWFP area. Whereas all maps were developed using Gradient Nearest Neighbor (GNN) imputation based on Landsat time-series (LandTrendr) data, the current maps incorporate new plot data and several improvements to modeling techniques.

Carbon Monitoring for Wooded Ecosystems (CMONster)

Ongoing

In this project, we are building an integrated system to monitor carbon dynamics for all forests and woodlands of Washington, Oregon, and California from 1985 to present. The system will improve understanding of the patterns, causes, and carbon consequences of forest dynamics over areas large enough to (1) directly address fundamental science questions, and (2) evaluate the actual history of forest management across a range of ownerships, forest types, and climatic conditions. The system will be designed to accommodate new or improved tools, algorithms, and data as they become available, and will explicitly provide estimates of uncertainty in carbon pools and fluxes to independently evaluate the significance of trends across space and time. GNN maps will be based on the most current available Landsat thematic mapper imagery, processed using theLandTrendr algorithms.

LiDAR Integration with GNN (LiGNN)

Completed 2014

The purpose of this project was to assess the benefits of incorporating light detection and ranging (LiDAR) data and disturbance history derived from multitemporal Landsat imagery (LandTrendr) into regional predictive mapping of vegetation using GNN. GNN maps developed using regional inventory plots and Landsat data are appropriately used to inform regional or “mid-scale” land management planning, policy formulation, and monitoring, but are not expected to be sufficiently accurate to support stand-level management decisions. This project investigated whether incorporating vegetation metrics derived from LiDAR point clouds and disturbance history derived from multitemporal Landsat imagery as spatial predictors in GNN can yield vegetation maps that are sufficiently accurate for use in local-scale management. Additionally, this project evaluated the effects of (1) more precise Global Positioning System (GPS) georeferencing of inventory plot locations, and (2) use of inventory plots versus subplots, on GNN map accuracy. This project was conducted on the Deschutes National Forest in central Oregon.

Nationwide Forest Imputation Study (NaFIS)

Completed 2009

The goal of the NaFIS was to evaluate methods that could be used to produce nationwide data products using nearest neighbor methods. Primary needs for national maps are to provide spatially explicit and statistically valid large- and small-area estimates of forest attributes measured by the Forest Service’s FIA program, and to provide detailed data needed for national risk mapping of multiple forest threats. The project used forest inventory data, satellite imagery and ancillary data, and nearest neighbor techniques to construct moderate- (30-m-) resolution datasets of forest attributes to satisfy three strategic objectives: (1) to support spatial applications, such as risk estimation, natural resource planning, and landscape scenario analyses; (2) to construct forest attribute maps; and (3) to distribute forest inventory data within spatial contexts. We produced pilot random forest nearest neighbor map products corresponding to U.S. Geological Survey (USGS) mapzones 7 (Oregon), 19 (Montana/Idaho), and 28 (Colorado) for 2000 Landsat thematic mapper imagery.

Interagency Mapping and Assessment Project (IMAP)

Completed 2008

The IMAP used a variety of modeling tools and data needed by policymakers, land managers, and others to evaluate alternative land management approaches. The IMAP aimed to provide tools and data that were easy to use and understand, economical to apply, and that provided a reasonable representation of the implications of vegetative succession, management, and natural disturbances. Mid-scale assessments and plans are needed by many state and federal agencies, organizations, and others. Key issues for analysis and planning efforts included integrating fire risk, fuel conditions, wildlife habitats, old forests, forest products, rangeland conditions, potential biomass supplies, carbon sequestration, and others. LEMMA's contribution to this project was to provide the initial GNN vegetation model (based on 2000 Landsat thematic mapper imagery), which was integrated into IMAP's Vegetation Dynamics Development Tool modeling approach. In addition, LEMMA produced a GNN model for a pilot project called the Central Oregon Landscape Assessment project in 2004.

Ecological Systems Mapping (PNWReGAP)

Completed 2008

As part of the Northwest Regional Gap Analysis Program, land cover maps were generated for USGS mapzones 2, 7, 8 and 9, covering Oregon, eastern Washington, and parts of Idaho, Nevada, and California. The project goal was to develop land cover maps and databases that provided information on the status of the vegetation and habitats, taking advantage of existing information but applying some new techniques. This was done as two separate but related projects. For mapzones 8 and 9, the map of ecological systems was derived from two primary components: Sagebrush And Grassland Ecosystem Map Assessment Project (SAGEMAP) and Southwest Regional Gap Analysis Project (SWReGAP) for nonforest areas, and GNN for forested areas. The nonforest and forest components were integrated to create the final maps. For mapzones 2 and 7, spatial modeling of ecological systems was done by building two random forest models: one for forested ecological systems and one for nonforested ecological systems. We then applied a variety of ancillary spatial data to map those ecological systems that we could not model well.

Interactive Visualization of GNN Models (GNNViz)

Completed 2007

In this project, we developed innovative ways to visualize and interact with broad-scale mapped information on fuels and vegetation, to improve communication between researchers and managers, as well as to enhance delivery and use of our own and similar research products. As part of this project, we created 3-D interactive and immersive tours of our threeGNNFire project study areas using state-of-the-art computer gaming technology and detailed data from existing GNN vegetation and fuels maps. In addition, we coupled these visualization tools to the underlying geographic information system (GIS) data and provided users with on-screen and real-time displays of GNN attributes based on user location within the visualization environment. The methodology for creating this visualization environment was generalized to be extendable to other locations and mapping methods.

Forest Fuels and Vegetation Mapping (GNNFire)

Completed 2005

The GNNFire project examined the utility of the GNN method to predict fuel patterns in three prototype landscapes in coastal Oregon, northeastern Washington, and the California Sierra Nevada, which encompassed vegetation from dense forests to rangelands in a mosaic of natural and human-dominated environments. We developed a methodology for using multivariate statistical models and imputation to simultaneously map fuel characteristics, species composition, and forest structure as continuous variables across environmentally heterogeneous, multiownership landscapes using inventory plot data, remote-sensing imagery, and environmental GIS data layers. We applied this methodology to generate vegetation and fuel maps for pilot landscapes located in three distinctive ecoregion divisions in the Western United States. We produced GNN map products corresponding to 2000 Landsat thematic mapper imagery in Washington and California and 1996 Landsat thematic mapper imagery in Oregon.

Coastal Landscape Analysis and Modeling Study (CLAMS)

Completed 2002

The CLAMS was a multidisciplinary research effort with the main goal to develop and evaluate concepts and tools to understand pattern and dynamics of provincial ecosystems, such as the Oregon Coast Range, and to analyze the aggregate ecological and socioeconomic consequences of different forest policies and strategies across multiple ownerships of the province. LEMMA's contribution to this project was to provide the initial GNN forest vegetation model (based on 1996 Landsat thematic mapper imagery) from which alternative forest management policies could be evaluated.

Appendix 20: Ecological Departure Assessments

This appendix includes six tables with summaries of tree species composition (tables A20.1, A20.2), trees per acre and basal area (tables A20.3, A20.4), and size class (tables A20.3, A20.4) by selected vegzones and indicator species group using historical General Land Office (GLO) data and recent U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) data for the Deschutes National Forest area. It also includes two tables comparing size class and species composition by selected subzones for the two datasets (tables A20.3, A20.4).

Table A20.1—Tree species composition based on historical reference trees from General Land Office surveys for all section and quarter-section corners on the Deschutes National Forest poststratified by vegzone and indicator species group, 1865–1899

					Tree species								
Vegzone	Indicator species group	Corners	Trees	Nontree	JUOC	PICO	PIPO	CADE27	LAOC	White pine[a]	Fir[b]	PIEN	TSME
		NUMBER		PERCENT									
JUOC	WaXe	68	96	73	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PICO	ClMe	174	293	11	N/a	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	WaXe	649	1,178	18	4	0	95	N/a	0	N/a	N/a	N/a	N/a
	WaDr + WaMe	1,410	2,846	12	N/a	0	99	0	0	0	1	N/a	N/a
	ClMe	2,629	6,401	6	N/a	70	30	N/a	N/a	N/a	N/a	N/a	N/a
PSME	WaDr + WaMe	262	563	3	1	0	77	6	2	1	14	0	0
ABGRC	WaDr	386	725	9	N/a	2	82	1	0	N/a	6	N/a	N/a
	WaMe	893	1,960	5	0	5	71	1	3	0	14	5	N/a
	WaWM	164	392	3	N/a	23	46	2	7	1	17	3	2
	ClMe	499	1,038	4	N/a	64	28	N/a	0	0	7	0	1
ABMAS	ClMe + WaMe	44	110	4	N/a	74	16	N/a	N/a	N/a	6	5	N/a
TSME	ClMe	644	1,849	2	N/a	49	2	N/a	1	7	18	7	16
	WaMe	675	1,865	2	N/a	38	3	N/a	4	9	23	9	14
	WaWM	160	396	4	N/a	39	4	N/a	5	10	25	5	11
Parkland	CdWM	105	236	2	N/a	48	N/a	N/a	N/a	4	21	5	23

Pinyon-juniper-cypress (JUOC), Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Tree species and vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

N/a = not applicable.

[a] White pine includes sugar pine (PILA), western white pine (PIMO3), and whitebark pine (PIAL).

[b] Fir includes Douglas-fir (PSME), grand fir (ABGR) and/or white fir (ABCO), Shasta red fir (ABMAS), Pacific silver fir (ABAM), and subalpine fir (ABLA).

Table A20.2—Tree composition based on Forest Inventory and Analysis annual plot data by species and category for white pines and firs, 2007–2016

				Tree species								
Vegzone	Indicator species group	Plots	Trees	JUOC	PICO	PIPO	CADE27	LAOC	White pine[a]	Fir[b]	PIEN	TSME
		NUMBER		PERCENT								
JUOC	WaXe	75	562	100	N/a	0	N/a	N/a	N/a	N/a	N/a	N/a
PICO	ClMe	22	539	N/a	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	WaXe	63	847	5	N/a	95	N/a	N/a	N/a	N/a	N/a	N/a
	WaDr + WaMe	79	1,423	1	18	80	1	N/a	0	N/a	N/a	N/a
	ClMe	106	2,656	N/a	71	29	N/a	N/a	0	N/a	N/a	N/a
PSME	WaDr + WaMe	8	197	2	N/a	39	3	N/a	0	55	N/a	N/a
ABGRC	WaDr	27	571	N/a	1	69	2	N/a	N/a	29	N/a	N/a
	WaMe	36	1,072	N/a	19	20	N/a	1	3	54	3	N/a
	WaWM	4	135	N/a	50	1	1	N/a	11	38	N/a	N/a
	ClMe	34	1,000	N/a	49	15	N/a	N/a	1	35	N/a	N/a
ABMAS	ClMe + WaMe	4	108	N/a	65	22	N/a	N/a	2	11	N/a	1
TSME	ClMe	32	1,238	N/a	19	0	N/a	N/a	1	13	1	66
	WaMe	16	569	N/a	43	0	N/a	N/a	1	28	3	24
	WaWM	15	644	N/a	31	0	N/a	N/a	12	18	1	39
Parkland	CdWM	13	386	N/a	68	N/a	N/a	N/a	19	2	N/a	11

Data for the Pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. The intensified grid plots were not added to this analysis. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Tree species and vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

N/a = not applicable.

[a] White pine includes sugar pine (PILA), western white pine (PIMO3), and whitebark pine (PIAL).

[b] Fir includes Douglas-fir (PSME), grand fir (ABGR) and/or white fir (ABCO), Shasta red fir (ABMAS), Pacific silver fir (ABAM), and subalpine fir (ABLA).

Table A20.3—Tree species composition based on U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis annual plot data by species, 2007–2016

				Tree species														
									White pine			Fir						
Vegzone	Indicator species group	Plots	Trees	JUOC	PICO	PIPO	CADE27	LAOC	PILA	PIMO3	PIAL	PSME	ABGR, ABCO	ABMAS	ABAM	ABLA	PIEN	TSME
		NUMBER		PERCENT														
JUOC	WaXe	75	562	100	N/a	0	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PICO	ClMe	22	539	N/a	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	WaXe	63	847	5	N/a	95	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
	WaDr + WaMe	79	1423	1	18	80	1	N/a	0	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
	ClMe	106	2656	N/a	71	29	N/a	N/a	N/a	N/a	0	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PSME	WaDr + WaMe	8	197	2	N/a	39	3	N/a	0	N/a	N/a	54	1	N/a	N/a	N/a	N/a	N/a
ABGRC	WaDr	27	571	N/a	1	69	2	N/a	N/a	N/a	N/a	5	24	N/a	N/a	N/a	N/a	N/a
	WaMe	36	1072	N/a	19	20	N/a	1	3	0	N/a	6	46	1	N/a	1	3	N/a
	WaWM	4	135	N/a	50	1	1	N/a	N/a	8	3	3	31	4	N/a	N/a	N/a	N/a
	ClMe	34	1000	N/a	49	15	N/a	N/a	0	0	N/a	2	32	0	N/a	N/a	N/a	N/a
ABMAS	ClMe + WaMe	4	108	N/a	65	22	N/a	N/a	N/a	2	N/a	N/a	N/a	11	N/a	N/a	N/a	1
TSME	ClMe	32	1238	N/a	19	0	N/a	N/a	N/a	1	0	N/a	N/a	1	6	5	1	66
	WaMe	16	569	N/a	43	0	N/a	N/a	N/a	1	0	2	11	7	1	6	3	24
	WaWM	15	644	N/a	31	0	N/a	N/a	N/a	5	7	1	2	6	9	0	1	39
Parkland	CdWM	13	386	N/a	68	N/a	N/a	N/a	N/a	5	15	N/a	N/a	0	N/a	2	N/a	11

Data for the Pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. The intensified grid plots were not added to this analysis. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Tree species and vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

N/a = not applicable.

Table A20.4—Trees per acre (TPA) and basal area per acre (BA) based on historical reference trees from General Land Office surveys for all section and quarter-section corners for the Deschutes National Forest, poststratified by vegzone and indicator species group, 1865–1899

Vegzone	Indicator species group	Corners	Trees	Average distance	$n^{2/3}$	R	Nonparametric TPA	TPA 95 percent CI	Low TPA	High TPA	BA	BA 95 percent CI	Low BA	High BA
		NUMBER		FEET			TREES PER ACRE				SQUARE FEET PER ACRE			
JUOC	WaXe	68	96	56.7	16.2	24.4	5.2	2.5	2.7	7.7	6.9	3.4	3.6	10.3
PICO	ClMe	174	293	32.8	30.1	8.6	31.4	11.2	20.2	42.6	14.9	5.3	9.6	20.2
PIPO	WaXe	649	1,178	36.0	71.8	7.9	24.2	5.6	18.6	29.8	54.8	12.7	42.1	67.4
	WaDr + WaMe	1,410	2,846	31.7	119.8	5.9	33.6	6.0	27.6	39.6	70.8	15.7	55.1	86.5
	ClMe	2,629	6,401	25.6	180.7	4.6	44.8	6.5	38.3	51.3	68.9	10.0	58.8	78.9
PSME	WaDr + WaMe	262	563	29.4	39.5	7.9	32.6	10.2	22.4	42.8	84.1	16.6	58.1	110.8
ABGRC	WaDr	386	725	28.1	51.0	7.3	33.7	9.2	24.4	42.9	57.3	15.7	41.6	73.0
	WaMe	893	1,960	22.9	88.6	4.6	64.3	13.4	50.9	77.7	132.4	27.6	104.9	160.0
	WaWM	164	392	24.9	29.0	6.6	54.3	19.8	34.5	74.0	106.0	38.6	67.4	144.6
	ClMe	499	1,038	22.4	60.4	4.6	77.9	19.7	58.3	97.6	105.1	26.5	78.6	131.6
ABMAS	ClMe + WaMe	44	110	22.0	12.2	6.6	80.7	45.4	35.3	126.0	79.5	44.7	34.8	124.2
TSME	ClMe	644	1,849	15.7	71.4	4.0	94.8	22.0	72.8	116.7	120.1	27.8	92.2	147.9
	WaMe	675	1,865	16.2	73.7	3.3	137.1	31.3	105.8	168.4	172.0	39.3	132.7	211.3
	WaWM	160	396	18.8	28.5	5.3	84.8	31.1	53.7	116.0	108.2	39.7	68.4	147.9
Parkland	CdWM	105	236	21.6	21.6	5.9	78.1	32.9	45.1	111.0	92.7	39.1	53.6	131.8

Pinyon-juniper-cypress (JUOC), Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes in those zones. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions. The nonparametric estimate of density (TPA) is based on Mitchell (2007: formula 36 and example C.1). The density formula in Mitchell (2007) is based on a paper by Patil et al. (1982). The basal area estimate is based on the sum of (percentages of total reference trees in each 2-inch diameter at breast height [DBH] class by subzone × nonparametric TPA estimate by subzone × DBH^2 by DBH class by subzone × 0.005454).

CI = confidence interval.

Table A20.5—Trees per acre (TPA) and basal area per acre (BA) based on Forest Inventory and Analysis annual plot data, 2007–2016

Vegzone	Indicator species group	Plots	Trees	z or t score	Sum of TPA	Average TPA	Standard deviation TPA	TPA 95 percent CI	Average BA	Standard deviation BA	BA 95 percent CI
		NUMBER			TREES PER ACRE				SQUARE FEET PER ACRE		
JUOC	WaXe	75	562	1.96	3112.5	41.5	34.2	7.7	28.1	26.9	6.1
PICO	ClMe	22	539	2.08	4344.7	197.5	135.2	60.0	53.9	28.2	12.5
PIPO	WaXe	63	847	1.96	4922.0	78.1	73.4	18.1	63.0	35.6	8.8
	WaDr + WaMe	79	1,423	1.96	8972.2	113.6	90.1	19.9	69.5	35.7	7.9
	ClMe	106	2,656	1.96	19476.6	183.7	139.7	26.6	69.9	34.4	6.5
PSME	WaDr + WaMe	8	197	2.37	1062.6	132.8	105.3	88.0	104.2	76.8	64.2
ABGRC	WaDr	27	571	2.06	3302.5	122.3	77.1	30.5	89.7	41.9	16.6
	WaMe	36	1,072	1.96	6379.5	177.2	105.4	34.4	127.6	63.8	20.8
	WaWM	4	135	3.18	1023.0	255.7	168.9	268.7	113.3	90.1	143.3
	ClMe	34	1,000	1.96	6898.5	202.9	138.0	46.4	103.4	59.5	20.0
ABMAS	ClMe + WaMe	4	108	3.18	1015.1	253.8	50.7	80.6	75.6	8.1	12.9
TSME	ClMe	32	1,238	1.96	7715.2	241.1	152.4	52.8	155.2	89.7	31.1
	WaMe	16	569	2.13	3303.1	206.4	95.0	50.6	148.9	81.1	43.2
	WaWM	15	644	2.15	4440.7	296.0	152.6	84.5	156.1	98.2	54.4
Parkland	CdWM	13	386	2.18	2944.3	226.5	151.0	91.3	90.1	58.4	35.3

Data for the pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes in those zones. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. The intensified grid plots were not added to this analysis. To facilitate direct comparison with the General Land Office (GLO) data, all sample trees <4-inch diameter at breast height (DBH) were excluded from TPA and BA calculations because only one tree <4-inch DBH was used as a reference tree in the GLO sample. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

CI = confidence interval.

Table A20.6—Size class distributions based on historical reference trees from General Land Office surveys for all section and quarter-section corners on the Deschutes National Forest poststratified by vegzone and indicator species group, 1865–1899

			Size class[a]						
Vegzone	Indicator species group	Trees	Grass/forb/ shrub	Seedling/ sapling	Pole	Small	Medium	Large	X-large
		NUMBER	PERCENT						
JUOC	WaXe	96	73	1	7	12	3	3	2
PICO	ClMe	293	12	8	43	34	3	—	—
PIPO	WaXe	1178	19	2	18	16	13	18	14
	WaDr + WaMe	2846	13	2	18	17	14	23	14
	ClMe	6401	6	6	35	23	11	10	10
PSME	WaDr + WaMe	562	3	1	8	20	12	43	11
ABGRC	WaDr	725	9	2	23	28	12	17	9
	WaMe	1960	5	2	17	27	14	24	11
	WaWM	392	3	2	21	30	15	19	10
	ClMe	1038	4	4	31	33	11	11	7
ABMAS	ClMe + WaMe	110	5	11	25	39	10	11	—
TSME	ClMe	1849	2	1	29	38	12	12	5
	WaMe	1865	2	2	28	36	14	13	5
	WaWM	396	4	2	23	38	16	13	5
Parkland	CdWM	236	2	5	32	35	10	12	4

Pinyon-juniper-cypress (JUOC), Douglas-fir (PSME), and California red fir-Shasta red fir (AMBAS) vegzones are summarized at the vegzone grain because of small sample sizes in those zones. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

– = no data.

[a] Size classes: grass/forb/shrub (<10 percent tree cover), seedling/sapling (1- to 5-inch diameter at breast height [DBH]), pole (5- to 10-inch DBH), small (10- to 15-inch DBH), medium (15- to 20-inch DBH), large (20- to 30-inch DBH), X-large (>30-inch DBH).

Table A20.7—Size class distributions based on Forest Inventory and Analysis annual plot data, 2007–2016

				Size class[a]					
Vegzone	Indicator species group	Number of plots	Number of trees	Seedling/ sapling	Pole	Small	Medium	Large	X-large
		NUMBER		PERCENT					
JUOC	WaXe	75	562	5	57	24	9	4	1
PICO	ClMe	22	539	28	63	9	1	0	—
PIPO	WaXe	63	847	15	40	25	12	7	1
	WaDr + WaMe	79	1423	16	46	26	8	4	1
	ClMe	106	2656	25	60	12	2	1	0
PSME	WaDr + WaMe	8	197	14	46	23	10	6	2
ABGRC	WaDr	27	571	14	49	22	10	5	1
	WaMe	36	1072	22	46	16	8	6	2
	WaWM	4	135	29	49	16	4	2	0
	ClMe	34	1000	26	52	14	4	3	1
ABMAS	ClMe + WaMe	4	108	44	46	8	1	1	0
TSME	ClMe	32	1238	17	49	19	8	5	1
	WaMe	16	569	14	52	17	9	7	1
	WaWM	15	644	24	50	17	6	3	1
Parkland	CdWM	13	386	31	54	10	2	2	0

Data for the pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. The intensified grid plots were not added to this analysis. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes in those zones. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. To facilitate direct comparison with the GLO data, all sample trees <4-inch diameter at breast height [DBH] were excluded because only one tree <4-inch DBH was used as a reference tree in the GLO sample. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[a] Size classes: seedling/sapling (1- to 5-inch DBH), pole (5- to 10-inch DBH), small (10- to 15-inch DBH), medium (15- to 20-inch DBH), large (20- to 30-inch DBH), X-large (>30-inch DBH).

Table A20.8—Size class distributions based on historical reference trees from General Land Office (GLO) surveys for all section and quarter-section corners on the Deschutes National Forest poststratified by vegzone and indicator species group, 1865–1899 and Forest Inventory and Analysis (FIA) annual plot data, 2007–2016

					Size class					
Vegzone	Indicator species group	Subzone number	Dataset	Trees	Seedling/ sapling	Pole	Small	Medium	Large	X-large
				NUMBER	PERCENT					
JUOC	WaXe	22	GLO	96	1	7	12	3	3	2
JUOC	WaXe	22	FIA	562	5	57	24	9	4	1
PICO	WaDr	25	GLO	293	8	43	34	3	0	0
PICO	WaDr	25	FIA	539	28	63	9	1	0	0
PIPO	WaXe	30	GLO	1178	2	18	16	13	18	14
PIPO	WaXe	30	FIA	847	15	40	25	12	7	1
PIPO	WaDr + WaMe	31	GLO	2846	2	18	17	14	23	14
PIPO	WaDr + WaMe	31	FIA	1423	16	46	26	8	4	1
PIPO	ClMe	33	GLO	6401	6	35	23	11	10	10
PIPO	ClMe	33	FIA	2656	25	60	12	2	1	0
PSME	WaDr + WaMe	41	GLO	562	1	8	20	12	43	11
PSME	WaDr + WaMe	41	FIA	197	14	46	23	10	6	2
ABGRC	WaDr	56	GLO	725	2	23	28	12	17	9
ABGRC	WaDr	56	FIA	571	14	49	22	10	5	1
ABGRC	WaMe	57	GLO	1960	2	17	27	14	24	11
ABGRC	WaMe	57	FIA	1072	22	46	16	8	6	2
ABGRC	WaWM	58	GLO	392	2	21	30	15	19	10
ABGRC	WaWM	58	FIA	135	29	49	16	4	2	0
ABGRC	ClMe	59	GLO	1038	4	31	33	11	11	7
ABGRC	ClMe	59	FIA	1000	26	52	14	4	3	1
ABMAS	ClMe + WaMe	71	GLO	110	11	25	39	10	11	0
ABMAS	ClMe + WaMe	71	FIA	108	44	46	8	1	1	0
TSME	ClMe	91	GLO	1849	1	29	38	12	12	5
TSME	ClMe	91	FIA	1238	17	49	19	8	5	1
TSME	WaMe	92	GLO	1865	2	28	36	14	13	5
TSME	WaMe	92	FIA	569	14	52	17	9	7	1
TSME	ClWM + WaWM	93	GLO	396	2	23	38	16	13	5
TSME	ClWM + WaWM	93	FIA	644	24	50	17	6	3	1
Parkland	CdMe	99	GLO	236	5	32	35	10	12	4
Parkland	CdMe	99	FIA	386	31	54	10	2	2	0

Data for the pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. The intensified grid plots were not added to this analysis. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes in those zones. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. To facilitate direct comparison with the GLO data, all sample trees <4-inch diameter at breast height (DBH) were excluded because only one tree <4-inch DBH was used as a reference tree in the GLO sample. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

[a] Size classes: seedling/sapling (1- to 5-inch DBH), pole (5- to 10-inch DBH), small (10- to 15-inch DBH), medium (15- to 20-inch DBH), large (20- to 30-inch DBH), X-large (>30-inch DBH).

Table A20.9—Tree species composition based on historical reference trees from General Land Office (GLO) surveys for all section and quarter-section corners on the Deschutes National Forest poststratified by vegzone and indicator species group, 1865–1899, and Forest Inventory and Analysis (FIA) annual plot data, 2007–2016

Vegzone	Indicator species group	Subzone number	Dataset	Corners	Trees	JUOC	PICO	PIPO	CADE27	LAOC	White pine[a]	Fir[b]	PIEN	Hemlock
				NUMBER		PERCENT								
JUOC	WaXe	22	GLO	68	96	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
JUOC	WaXe	22	FIA	75	562	100	N/a	0	N/a	N/a	N/a	N/a	N/a	N/a
PICO	WaDr	25	GLO	174	293	N/a	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PICO	WaDr	25	FIA	22	539	N/a	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	WaXe	30	GLO	649	1178	4	0	95	N/a	0	N/a	N/a	N/a	N/a
PIPO	WaXe	30	FIA	63	847	5	N/a	95	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	WaDr + WaMe	31	GLO	1410	2846	N/a	0	99	0	0	0	1	N/a	N/a
PIPO	WaDr + WaMe	31	FIA	79	1423	1	18	80	1	N/a	0	N/a	N/a	N/a
PIPO	ClMe	33	GLO	2629	6401	N/a	70	30	N/a	N/a	N/a	N/a	N/a	N/a
PIPO	ClMe	33	FIA	106	2656	N/a	71	29	N/a	N/a	0	N/a	N/a	N/a
PSME	WaDr + WaMe	41	GLO	262	563	1	0	77	6	2	1	14	0	0
PSME	WaDr + WaMe	41	FIA	8	197	2	N/a	39	3	N/a	0	55	N/a	N/a
ABGRC	WaDr	56	GLO	386	725	N/a	2	82	1	0	N/a	6	N/a	N/a
ABGRC	WaDr	56	FIA	27	571	N/a	1	69	2	N/a	N/a	29	N/a	N/a
ABGRC	WaMe	57	GLO	893	1960	0	5	71	1	3	0	14	5	N/a
ABGRC	WaMe	57	FIA	36	1072	N/a	19	20	N/a	1	3	54	3	N/a
ABGRC	WaWM	58	GLO	164	392	N/a	23	46	2	7	1	17	3	2
ABGRC	WaWM	58	FIA	4	135	N/a	50	1	1	N/a	11	38	N/a	N/a
ABGRC	ClMe	59	GLO	499	1038	N/a	64	28	N/a	0	0	7	0	1
ABGRC	ClMe	59	FIA	34	1000	N/a	49	15	N/a	N/a	1	35	N/a	N/a
ABMAS	ClMe + WaMe	71	GLO	44	110	N/a	74	16	N/a	N/a	N/a	6	5	N/a
ABMAS	ClMe + WaMe	71	FIA	4	108	N/a	65	22	N/a	N/a	2	11	N/a	1
TSME	ClMe	91	GLO	644	1849	N/a	49	2	N/a	1	7	18	7	16
TSME	ClMe	91	FIA	32	1238	N/a	19	0	N/a	N/a	1	13	1	66
TSME	WaMe	92	GLO	675	1865	N/a	38	3	N/a	4	9	23	9	14
TSME	WaMe	92	FIA	16	569	N/a	43	0	N/a	N/a	1	28	3	24

Table A20.9—Tree species composition based on historical reference trees from General Land Office (GLO) surveys for all section and quarter-section corners on the Deschutes National Forest poststratified by vegzone and indicator species group, 1865–1899, and Forest Inventory and Analysis (FIA) annual plot data, 2007–2016 (continued)

Vegzone	Indicator species group	Subzone number	Dataset	Corners	Trees	JUOC	PICO	PIPO	CADE27	LAOC	White pine[a]	Fir[b]	PIEN	Hemlock
				NUMBER		PERCENT								
TSME	ClWM + WaWM	93	GLO	160	396	N/a	39	4	N/a	5	10	25	5	11
TSME	ClWM + WaWM	93	FIA	15	644	N/a	31	0	N/a	N/a	12	18	1	39
Parkland	CdMe	99	GLO	105	236	N/a	48	N/a	N/a	N/a	4	21	5	23
Parkland	CdMe	99	FIA	13	386	N/a	68	N/a	N/a	N/a	19	2	N/a	11

Data for the Pinyon-juniper-cypress (JUOC) vegzone includes all juniper vegzone plots in Deschutes, Jefferson, and Klamath Counties. All other vegzones use only plots from within the Deschutes National Forest. The intensified grid plots were not added to this analysis. Pinyon-juniper-cypress, Douglas-fir (PSME), and California red fir-Shasta red fir (ABMAS) vegzones are summarized at the vegzone grain because of small sample sizes. Note that more than one species group (e.g., WaDr + WaMe) indicates that current subzone mapping includes both groups. See table 3 for species group code definitions and appendix 6 for a list of key indicator species for each group. Tree species and vegzone names include USDA PLANTS Database species symbols (USDA NRCS, n.d.) or combinations thereof; see appendix 5 for symbol definitions.

N/a = not applicable.

[a] White pine includes sugar pine (PILA), western white pine (PIMO3), and whitebark pine (PIAL).

[b] Fir includes Douglas-fir (PSME), grand fir (ABGR) and/or white fir (ABCO), Shasta red fir (ABMAS), Pacific silver fir (ABAM), and subalpine fir (ABLA).

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