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Wildlife Habitats: Descriptions, Status, Trends, and System Dynamics

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Introduction

In the previous chapter, the authors described the process by which the 32 wildlife-habitat types of Oregon and Washington (Table 1, Frontispiece) were defined. In this chapter, we offer detailed descriptions of each wildlife-habitat type to support a common understanding for their delineation, inventory, and management across the region.

Each wildlife habitat below is described as to its geographic distribution, physical setting, landscape setting, structure, and composition. Additionally, we include other information that might help managers, researchers, and others gain further insight into each habitat, such as listing other classification systems and key references, natural disturbance regimes, succession and stand dynamics, effects of management and anthropogenic impacts, and status and trends. We have also included photographs of each wildlife-habitat type to give the reader an idea of what each habitat type looks like. Multiple photographs are offered for most habitats in order to depict some of the variability that exists within each type. Each of the habitats below is numbered (Table 1); the descriptions in this chapter reflect the same numbering sequence.

The following are definitions of each category used to characterize the wildlife-habitat types:

Geographic Distribution. Describes the broad geographic range within which the habitat is located, both within Oregon and Washington and elsewhere. Major variations in dominance type are noted either here or under Composition.

Physical Setting. Describes physical features of the environment on sites where the habitat is found in Oregon and Washington. These typically include climate, elevation, soils, hydrology, geology, and topography.

Landscape Setting. Describes the landscape pattern and distribution of the habitat in relation to other habitats. Primary land use is also noted.

Structure. Describes the physical structure of the habitat, both its typical aspect and the range of variation in structure present within the habitat. Aspects of physical structure include some description of cover or density

(horizontal dimension) of vegetation; layering (vertical dimension) of vegetation; dominant growth forms, leaf phenologies (evergreen or deciduous), leaf characters (conifer or broadleaf), and vegetation persistence (annual or perennial) represented in different structural layers; and significant structural components of dead and decaying vegetation. Growth forms include trees, shrubs (>1.6 ft [0.5 m] tall), dwarf-shrubs (<1.6 ft [0.5 m] tall), graminoids (grasses, sedges, rushes), forbs, ferns, mosses, lichens, and algae. Vegetation cover categories frequently referred to include forest (>60% cover of trees), woodland (25-60% cover of trees), shrubland (>25% cover of shrubs), dwarf-shrubland (>25% cover of dwarf-shrubs), and grassland (graminoids dominant). Water-dominated habitats (e.g., marine and open water) may be described in terms of the physical aspects of the water column and the bottom substrate of the habitat.

Composition. Describes the species composition of the vegetation that creates structure. Composition is described as dominant, co-dominant (shares dominance with •1 species), or important indicator species by structural layer. English names for all vertebrates are used in the text and corresponding standard names are in Appendix I. The geographic distribution or physical setting is noted for those dominant species that occur only in particular physical settings or specific geographic areas of the overall habitat's range of occurrence.

Other Classifications and Key References. Notes other names that have been applied to this habitat by other classifications or major summary publications, and important references that describe the habitat or parts of the habitat in greater detail.

Natural Disturbance Regime. Describes the major natural disturbances that are important in the habitat. The regime includes the disturbance type, severity, frequency, extent, and range of variation in these characteristics.

Succession and Stand Dynamics. Describes the way in which structure and composition change over time in relation to natural disturbances.

Table 1. The 32 wildlife habitats and their total acreage in Oregon and Washington. The marine waters extend out to the 200-mile Exclusive Economic Zone.

Wildlife Habitat	Oregon Total Acreage	Washington Total Acreage	Page Number
1. Westside Lowlands Conifer-Hardwood Forest	9,349,756	9,064,128	24
2. Westside Oak and Dry Douglas-fir Forest and Woodlands	433,132	425,038	26
3. Southwest Oregon Mixed Conifer-Hardwood Forest	4,020,320	Does Not Occur	28
4. Montane Mixed Conifer Forest	2,949,586	4,653,306	30
5. Eastside (Interior) Mixed Conifer Forest	4,126,957	4,662,101	31
6. Lodgepole Pine Forest and Woodlands	532,587	119,201	33
7. Ponderosa Pine Forest and Woodlands (includes Eastside Oak)	6,226,351	1,927,176	35
8. Upland Aspen Forest	19,685	100,621	36
9. Subalpine Parkland	84,240	327,442	37
10. Alpine Grassland and Shrublands	291,494	1,591,115	39
11. Westside Grasslands	133 ¹	22,491	40
12. Ceanothus-Manzanita Shrublands	52,104	Does Not Occur	42
13. Western Juniper and Mountain Mahogany Woodlands	4,037,221	Does Not Occur	43
14. Eastside (Interior) Canyon Shrublands	358,250	Not Mapped ³	44
15. Eastside (Interior) Grasslands	1,935,794	1,002,076	46
16. Shrub-steppe	17,420,753	7,144,697 ³	47
17. Dwarf Shrub-steppe	514,066	Not Mapped ³	49
18. Desert Playa and Salt Scrub Shrublands	719,503	Not Mapped ³	50
19. Agriculture, Pasture and Mixed Environs	6,197,887	9,251,107	52
20. Urban and Mixed Environs	575,087	1,204,680	53
21. Open Water - Lakes, Rivers, Streams	780,901	761,360	56
22. Herbaceous Wetlands	1,031,343	210,451	58
23. Westside Riparian-Wetlands	168,872	347,653	90
24. Montane Coniferous Wetlands	56,099	241,450	92
25. Eastside (Interior) Riparian-Wetlands	31,121	100,763	93
26. Coastal Dunes and Beaches	52,451	Not Mapped ²	95
27. Coastal Headlands and Islets	9,137	7,776	96
28. Bays and Estuaries	172,748	226,336	97
29. Inland Marine Deeper Water	Does Not Occur	1,855,780	99
30. Marine Nearshore	223,371	750,329	100
31. Marine Shelf	3,905,164	4,780,625	101
32. Oceanic	33,987,189	19,845,660	102
Totals	100,263,303	70,532,093	

¹Because of difficulty in classifying this type using remote sensing (i.e., discerning native grasslands from pasture lands) native westside grasslands have inadvertently been classified within the agriculture habitat type. Nonetheless, there are few areas known to be native westside grasslands in Oregon.

²This type was not part of the vegetation classification when the Washington Gap Project mapped the state of Washington. Thus, no wildlife habitat area was determined.

³In Washington, Eastside Canyon Shrublands, Dwarf Shrub-steppe, and Desert Playa and Salt Scrub Shrublands were mapped as part of Shrub-steppe for the Washington GAP Project. Thus, no wildlife habitat area was determined.

Effects of Management and Anthropogenic Impacts.

Describes typical changes in structure and composition observed after typical management activities (human disturbances) and widespread changes in the habitat that have occurred since Euro-American settlement. Disturbances addressed include land uses that do not necessarily convert the habitat to urban or agriculture, but have a significant influence on structure or composition, e.g., hydrologic alterations, logging, and grazing. Exotic species that have become abundant in the habitat are noted.

Status and Trends. Describes the general extent of the type in Oregon and Washington, its current ecological condition, and historical and current trends in extent and condition. Ecological condition refers primarily to how similar the current structure, composition, and disturbance regime is to natural or presettlement conditions. The total number of plant associations recognized in the habitat and the number of those that are considered globally imperiled provide some idea of the degree of loss, degradation, and threat that is associated with the habitat.

1. Westside Lowlands Conifer-Hardwood Forest

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This forest habitat occurs throughout low-elevation western Washington, except on extremely dry or wet sites. In Oregon it occurs on the western slopes of the Cascades, around the margins of the Willamette Valley, in the Coast Range, and along the outer coast. The global distribution extends from southeastern Alaska south to southwestern Oregon.

Physical Setting. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 35-100 inches (90-254 cm), but can vary locally. Snowfall ranges from rare to regular, but is transitory. Summers are relatively dry. Summer fog is a major factor on the outer coast in the Sitka spruce zone. Elevation ranges from sea level to a maximum of about 2,000 ft (610 m) in much of northern Washington and 3,500 ft (1,067 m) in central Oregon. Soils and geology are very diverse. Topography ranges from relatively flat glacial till plains to steep mountainous terrain.

Landscape Setting. This is the most extensive habitat in the lowlands on the westside of the Cascades, except in southwestern Oregon, and forms the matrix within which other habitats occur as patches, especially Westside Riparian-Wetlands and less commonly Herbaceous Wetlands or Open Water. It also occurs adjacent to or in a mosaic with Urban and Mixed Environs (hereafter Urban) or Agriculture, Pasture and Mixed Environs (hereafter Agriculture) habitats. In the driest areas, it occurs adjacent to or in a mosaic with Westside Oak and Dry Douglas-fir Forest and Woodlands. Bordering this habitat at upper elevations is Montane Mixed Conifer Forest. Along the coastline, it often occurs adjacent to Coastal Dunes and Beaches. In southwestern Oregon, it may border Southwest Oregon Mixed Conifer-Hardwood Forest. The primary land use for this habitat is forestry.

Structure. This habitat is forest, or rarely woodland, dominated by evergreen conifers, deciduous broadleaf trees, or both. Late seral stands typically have an abundance of large (>164 ft [50 m] tall) coniferous trees, a multi-layered canopy structure, large snags, and many

large logs on the ground. Early seral stands typically have smaller trees, single-storied canopies, and may be dominated by conifers, broadleaf trees, or both. Coarse woody debris is abundant in early seral stands after natural disturbances but much less so after clearcutting. Forest understories are structurally diverse: evergreen shrubs tend to dominate on nutrient-poor or drier sites; deciduous shrubs, ferns, and/or forbs tend to dominate on relatively nutrient-rich or moist sites. Shrubs may be low (1.6 ft [0.5 m] tall), medium-tall (3.3-6.6 ft [1-2 m]), or tall (6.6-13.1 ft [2-4 m]). Almost all structural stages are represented in the successional sequence within this habitat. Mosses are often a major ground cover. Lichens are abundant in the canopy of old stands.

Composition. Western hemlock (*Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziesii*) are the most characteristic species and one or both are typically present. Most stands are dominated by one or more of the following: Douglas-fir, western hemlock, western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), red alder (*Alnus rubra*), or bigleaf maple (*Acer macrophyllum*). Trees of local importance that may be dominant include Port-Orford cedar (*Chamaecyparis lawsoniana*) in the south, shore pine (*Pinus contorta* var. *contorta*) on stabilized dunes, and grand fir (*Abies grandis*) in drier climates. Western white pine (*Pinus monticola*) is frequent but subordinate in importance through portions of this habitat. Pacific silver fir (*Abies amabilis*) is largely absent except on the wettest portion of the western Olympic Peninsula, where it is common and sometimes co-dominant. Common small subcanopy trees are cascara buckthorn (*Rhamnus purshiana*) in more moist climates and Pacific yew (*Taxus brevifolia*) in somewhat drier climates or sites.

Sitka spruce is found as a major species only in the outer coastal area at low elevations where summer fog is a significant factor. Bigleaf maple is most abundant in the Puget Lowland, around the Willamette Valley, and in the central Oregon Cascades, but occurs elsewhere also. Douglas-fir is absent to uncommon as a native species in the very wet maritime outer coastal area of Washington, including the coastal plain on the west side of the Olympic Peninsula. However, it has been extensively planted in that area. Port-Orford cedar occurs only in southern Oregon. Paper birch (*Betula papyrifera*) occurs as a co-dominant only in Whatcom County, Washington. Grand fir occurs as an occasional co-dominant only in the Puget Lowland and Willamette Valley.

Dominant or co-dominant understory shrub species of more than local importance include salal (*Gaultheria shallon*), dwarf Oregongrape (*Mahonia nervosa*), vine maple (*Acer circinatum*), Pacific rhododendron (*Rhododendron macrophyllum*), salmonberry (*Rubus spectabilis*), trailing blackberry (*R. ursinus*), red elderberry (*Sambucus racemosa*), fools huckleberry (*Menziesia ferruginea*), beargrass (*Xerophyllum tenax*), oval-leaf huckleberry (*Vaccinium ovalifolium*), evergreen huckleberry (*V. ovatum*), and red huckleberry (*V. parvifolium*). Salal, rhododendron, and beargrass are particularly associated with low nutrient or dry sites.

Swordfern (*Polystichum munitum*) is the most common herbaceous species and is often dominant on nitrogen-rich or moist sites. Other forbs and ferns that frequently dominate the understory are Oregon oxalis (*Oxalis oregana*), deerfern (*Blechnum spicant*), bracken fern (*Pteridium aquilinum*), vanillaleaf (*Achlys triphylla*), twinflower (*Linnaea borealis*), false lily-of-the-valley (*Maianthemum dilatatum*), western springbeauty (*Claytonia siberica*), foamflower (*Tiarella trifoliata*), inside-out flower (*Vancouveria hexandra*), and common whipplea (*Whipplea modesta*).

Other Classifications and Key References. This habitat includes most of the forests and their successional seres within the *Tsuga heterophylla* and *Picea sitchensis* zones.⁸⁸ This habitat is also referred to as Douglas-fir-western hemlock and Sitka spruce-western hemlock forests,⁸⁷ spruce-cedar-hemlock forest (*Picea-Thuja-Tsuga*, No. 1) and cedar-hemlock-Douglas-fir forest (*Thuja-Tsuga-Pseudotsuga*, No. 2).¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ would crosswalk with Sitka spruce-western hemlock maritime forest, Douglas-fir-western hemlock-redcedar forest, red alder forest, red alder-bigleaf maple forest, mixed conifer/mixed deciduous forest, south coast mixed-deciduous forest, and coastal lodgepole forest. The Washington Gap Vegetation map includes this vegetation as conifer forest, mixed hardwood/conifer forest, and hardwood forest in the Sitka spruce, western hemlock, Olympic Douglas-fir, Puget Sound Douglas-fir, Cowlitz River and Willamette Valley zones.³⁷ A number of other references describe elements of this habitat.^{13, 25, 26, 40, 42, 66, 90, 104, 110, 111, 114, 115, 210}

Natural Disturbance Regime. Fire is the major natural disturbance in all but the wettest climatic area (Sitka spruce zone), where wind becomes the major source of natural disturbance. Natural fire-return intervals generally range from about 100 years or less in the driest areas to several hundred years.^{1, 115, 160} Mean fire-return interval for the western hemlock zone as a whole is 250 years, but may vary greatly. Major natural fires are associated with occasional extreme weather conditions.¹ Fires are typically high-severity, with few trees surviving. However, low- and moderate-severity fires that leave partial to complete live canopies are not uncommon, especially in drier climatic areas. Occasional major windstorms hit outer coastal forests most intensely, where fires are rare. Severity of wind disturbance varies greatly, with minor events being extremely frequent and major events occurring once every few decades. Bark beetles and fungi are significant causes of mortality that typically operate on a small scale. Landslides are another natural disturbance that occur in some areas.

Succession and Stand Dynamics. After a severe fire or blowdown, a typical stand will be briefly occupied by annual and perennial ruderal forbs and grasses as well as predisturbance understory shrubs and herbs that resprout.¹⁰² Herbaceous species generally give way to dominance by shrubs or a mixture of shrubs and young trees within a few years. If shrubs are dense and trees did

not establish early, the site may remain as a shrubland for an indeterminate period. Early seral tree species can be any of the potential dominants for the habitat, depending on environment, type of disturbance, and seed source. All of these species except the short-lived red alder are capable of persisting for at least a few hundred years. Douglas-fir is the most common dominant after fire, but is uncommon in the wettest zones. It is also the most fire resistant of the trees in this habitat and survives moderate-severity fires well. After the tree canopy closes, the understory may become sparse, corresponding with the stem-exclusion stage.¹⁶⁸ Eventually tree density will decrease and the understory will begin to flourish again, typically at stand age 60-100 years. As trees grow larger and a new generation of shade-tolerant understory trees (usually western hemlock, less commonly western redcedar) grows up, a multi-layered canopy will gradually develop and be well expressed by stand age 200-400 years.⁸⁹ Another fire is likely to return before the loss of shade-intolerant Douglas-fir from the canopy at stand age 800-1,000 years, unless the stand is located in the wet maritime zone. Throughout this habitat, western hemlock tends to increase in importance as stand development proceeds. Coarse woody debris peaks in abundance in the first 50 years after a fire and is least abundant at about stand age 100-200 years.¹⁹³

Effects of Management and Anthropogenic Impacts. Red alder is more successful after typical logging disturbance than after fire alone on moist, nutrient-rich sites, perhaps because of the species' ability to establish abundantly on scarified soils.¹⁰⁰ Alder is much more common now because of large-scale logging activities.⁸⁷ Alder grows more quickly in height early in succession than the conifers, thereby prompting many forest managers to apply herbicides for alder control. If alder is allowed to grow and dominate early successional stands, it will decline in importance after about 70 years and die out completely by age 100. Often there are suppressed conifers in the subcanopy that potentially can respond to the death of the alder canopy. However, salmonberry sometimes forms a dense shrub layer under the alder, which can exclude conifer regeneration.⁸⁸ Salmonberry responds positively to soil disturbance, such as that associated with logging.¹⁹ Bigleaf maple sprouts readily after logging and is therefore well adapted to increase after disturbance as well. Clearcut logging and plantation forestry have resulted in less diverse tree canopies, and have focused mainly on Douglas-fir, with reductions in coarse woody debris over natural levels, a shortened stand initiation phase, and succession truncated well before late-seral characteristics are expressed. Douglas-fir has been almost universally planted, even in wet coastal areas of Washington, where it is rare in natural stands.

Status and Trends. Extremely large areas of this habitat remain. Some loss has occurred, primarily to development in the Puget Lowland. Condition of what remains has been degraded by industrial forest practices at both the stand and landscape scale. Most of the habitat is probably now

in Douglas-fir plantations. Only a fraction of the original old-growth forest remains, mostly in national forests in the Cascade and Olympic mountains. Areal extent continues to be reduced gradually, especially in the Puget Lowland. An increase in alternative silviculture practices may be improving structural and species diversity in some areas. However, intensive logging of natural-origin mature and young stands and even small areas of old growth continues. Of the 62 plant associations representing this habitat listed in the National Vegetation Classification, 27 % are globally imperiled or critically imperiled.¹⁰

2. Westside Oak and Dry Douglas-fir Forest and Woodlands

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This habitat is primarily found in the Willamette Valley, Puget Lowlands, and Klamath Mountains ecoregions. In the Puget Lowlands, it is common in and around the San Juan Islands and in parts of Thurston, Pierce, and Mason counties. In southwestern Oregon, it is now restricted mainly to the valleys of the Rogue and Umpqua rivers. Minor occurrences can also be found in the northeastern Olympic Mountains and western Cascades.

This habitat is comprised of several geographic variants: California black oak and ponderosa pine are important only in southwestern Oregon and the southern Willamette Valley. The latter is also found in a small area of Pierce County, Washington. Shore (lodgepole) pine is only important in the Puget Lowland, mainly in San Juan and Mason counties. Dry Douglas-fir forests (without oak or madrone) are mainly in the Puget Lowland and rarely in the Olympic Mountains, west Cascades, and Willamette Valley. Pacific madrone and Douglas-fir/Pacific madrone stands without oak are limited to the Puget Lowland and the southern Willamette Valley foothills. Mixed oak-madrone stands occur primarily in Oregon, especially southwestern Oregon.

Physical Setting. This habitat typically occupies dry sites west of the Cascades. Annual mean precipitation ranges from 17 to 60 inches (43 to 152 cm), occasionally higher. Elevation ranges from sea level to about 3,500 ft (1,069 m)

in the Olympic Mountains, but is mainly below 1,500 ft (457 m). Topography ranges from nearly level to very steep slopes, where aspect tends to be southern or western. Soils on dry sites are typically shallow over bedrock, very stony, or very deep and excessively drained. Willamette Valley soils are typically much older and have more moderate drainage and water availability. Parent materials include various types of bedrock, shallow or very coarse glacial till, alluvium, and glacial outwash.

Landscape Setting. This habitat is found in a mosaic with, or adjacent to, Westside Grasslands, Westside Lowlands Conifer-Hardwood Forest, Westside Riparian-Wetlands, Southwest Oregon Mixed Conifer-Hardwood Forest, Urban, and Agriculture. Inclusions of Open Water or Herbaceous Wetlands sometimes occur. In the Puget Lowland, this habitat is sometimes found adjacent to Puget Sound (Nearshore Marine). Land use of this habitat includes forestry (generally small scale), livestock grazing, and low-density rural residential.

Structure. This is a forest or woodland dominated by evergreen conifers, deciduous broadleaf trees, evergreen broadleaf trees, or some mixture of conifers and broadleaf trees. Canopy structure varies from single- to multi-storied. Large conifers, when present, typically emerge above broadleaf trees in mixed canopy stands. Large snags and logs are less abundant than in other westside forest habitats, but can be prominent, especially in unlogged old stands. Understories vary in structure: grasses, shrubs, ferns, or some combination will typically dominate. Deciduous broadleaf shrubs are perhaps most typical as understory dominants in the existing landscape. Early successional stand structure varies depending on understory species present and if initiated following logging or fire.

Composition. The canopy is typically dominated by one or more of the following species: Douglas-fir (*Pseudotsuga menziesii*), Oregon white oak (*Quercus garryana*), Pacific madrone (*Arbutus menziesii*), shore (lodgepole) pine (*Pinus contorta* var. *contorta*), or California black oak (*Q. kelloggii*). Ponderosa pine (*Pinus ponderosa*) is important in southwestern Oregon and the southern Willamette Valley as a subordinate or co-dominant with oak. Grand fir (*Abies grandis*) is occasionally co-dominant with Douglas-fir in the northern Puget Lowland or in the Willamette Valley. Oregon ash (*Fraxinus latifolia*) is occasionally co-dominant with white oak in riparian oak stands. Several other tree species may be present, but western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) generally cannot regenerate successfully because of dry conditions. This lack of shade-tolerant tree regeneration, along with understory indicators like tall Oregon grape (*Mahonia aquifolium*), and blue wildrye (*Elymus glaucus*), help distinguish dry Douglas-fir forests from mid-seral Douglas-fir stands on more mesic sites, which are part of the Westside Lowlands Conifer-Hardwood Forest. Tree regeneration, when present, is typically Douglas-fir, less commonly grand fir. Sweet cherry (*Prunus avium*) and/or English hawthorn (*Crataegus monogyna*) have invaded and

now dominate a subcanopy layer in many oak forests of the Willamette Valley.

Deciduous shrubs that commonly dominate or co-dominate the understory are oceanspray (*Holodiscus discolor*), baldhip rose (*Rosa gymnocarpa*), poison-oak (*Toxicodendron diversiloba*), serviceberry (*Amelanchier alnifolia*), beaked hazel (*Corylus cornuta*), trailing blackberry (*Rubus ursinus*), Indian plum (*Oemleria cerasiformis*), snowberries (*Symphoricarpos albus* and *S. mollis*), wedge-leaf ceanothus (*Ceanothus cuneatus*), and oval-leaf viburnum (*Viburnum ellipticum*). Evergreen shrubs or vines that sometimes are dominant where conifers are important in the canopy include salal (*Gaultheria shallon*), dwarf Oregon grape (*Mahonia nervosa*), Pacific rhododendron (*Rhododendron macrophyllum*), hairy honeysuckle (*Lonicera hispidula*), evergreen huckleberry (*Vaccinium ovatum*), and Piper's barberry (*Mahonia piperiana*).

Native graminoids that commonly dominate or co-dominate the understory are western fescue (*Festuca occidentalis*), Alaska oniongrass (*Melica subulata*), blue wildrye, and long-stolon sedge (*Carex inops*). Kentucky bluegrass (*Poa pratensis*) is a major non-native dominant in oak woodland understories. Swordfern (*Polystichum munitum*) or, less commonly, bracken fern (*Pteridium aquilinum*) sometimes co-dominates the understory, especially on sites that formerly supported grasslands and savannas. Forbs, many of which are characteristic of these dry sites, are often abundant and diverse, but typically do not dominate. Common camas (*Camassia quamash*), cleavers (*Galium aparine*), or other forbs are occasionally co-dominant with graminoids.

Other Classifications and Key References. This habitat has been described as oak groves and dry site Douglas-fir forest in the *Tsuga heterophylla* zone of western Washington and northwestern Oregon as well as oak woodland in the interior valleys of western Oregon.⁸⁸ It is also referred to as Oregon oakwoods No. 22 and a minor part of Cedar-hemlock-Douglas-fir forest No. 2;¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are Oregon white oak forest and Douglas-fir/white oak forest. The Washington Gap Project represents this habitat as part of hardwood forest, mixed hardwood/conifer forest, and conifer forest in the Woodland/Prairie Mosaic, Puget Sound Douglas-fir, and, to a minor degree, Cowlitz River, and Willamette Valley zones of Washington.³⁷ Other references also describe elements of this habitat.^{13, 17, 40, 41, 86, 111, 115, 202, 210}

Natural Disturbance Regime. Fire is the major natural disturbance in this habitat. In presettlement times, fire frequency probably ranged from frequent (every few years) to moderately frequent (once every 50-100 years), and reflected low-severity and moderate-severity fire regimes.¹ Fire frequency has been much lower in the last 100 years. Windstorms are an occasional disturbance, most important in the San Juan Islands and vicinity. Understories are sometimes browsed heavily by deer in the San Juan Islands, thus preventing dominance by deciduous shrubs and favoring grasses and forbs.

Succession and Stand Dynamics. Many of these forests and woodlands were formerly either grasslands or savannas that probably burned frequently, thus preventing dominance by trees.^{41, 54} Some portions of this habitat in the central Puget Lowlands may have formerly been dominated by shrubs (salal, beaked hazel, evergreen huckleberry, hairy manzanita [*Arctostaphylos columbiana*]) for lengthy periods, probably also because of the particular combination of fire frequency and intensity. Other areas were woodlands to semi-open forests that burned moderately frequently, as evidenced by the relict stands of old-growth Douglas-fir. The dominant trees in this habitat establish most abundantly after fire. Moderate-severity fires kill many trees but also leave many alive, creating opportunities for establishment of new cohorts of trees and increasing structural complexity.¹ Oaks and madrone resprout after fire if they are top-killed. Without periodic fire, most oak-dominated stands will eventually convert to Douglas-fir forests.¹ Animal dissemination of acorns may be important in dispersal of oaks. Shore pine, where present, is an early-seral upper canopy species that grows quickly and dies out after about 100-150 years, yielding to a mature Douglas-fir stand unless another fire intervenes before the death of the pine.

Effects of Management and Anthropogenic Impacts. Clearcut or similar logging reduces canopy structural complexity and abundance of large woody debris. Dry Douglas-fir stands are well suited to alternative silvicultural practices, such as uneven-aged management or maintaining two-storied stands. Oaks and madrone will typically resprout after logging and thus can increase in importance relative to conifers in mixed canopy stands. Selective logging of Douglas-fir in oak stands can prevent long-term loss of oak dominance. With fire exclusion, stands have probably increased in tree density and grassy understories have been replaced by deciduous shrubs.⁴¹ Moderate to heavy grazing or other significant ground disturbance, especially in grassy understories, leads to increases in non-native invader species, many of which are now abundant in stands with grassy or formerly grassy understories. Scot's broom (*Cytisus scoparius*) is an exotic shrub particularly invasive and persistent in oak woodlands. Exotic herbaceous invaders include colonial bentgrass (*Agrostis capillaris*), common velvetgrass (*Holcus lanatus*), Kentucky bluegrass, tall oatgrass (*Arrhenatherum elatius*), rigid brome (*Bromus rigidus*), orchardgrass (*Dactylis glomerata*), hedgehog dogtail (*Cynosurus echinatus*), tall fescue (*Festuca arundinacea*), and common St. Johnswort (*Hypericum perforatum*).

Status and Trends. This habitat is relatively limited in area and is currently declining in extent and condition. With the cessation of regular burning 100-130 years ago, many grasslands and savannas were invaded by a greater density of trees and thus converted to a different habitat. Conversely, large areas of this habitat have been converted to Urban or Agriculture habitats. Most of what remains has been considerably degraded by invasion of exotic species or by logging and consequent loss of structural

diversity. Ongoing threats include residential development, increase and spread of exotic species, and fire suppression effects (the latter especially in oak-dominated stands). Thirteen of 27 plant associations listed in the National Vegetation Classification are considered globally imperiled or critically imperiled.¹⁰

3. Southwest Oregon Mixed Conifer-Hardwood Forest

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Geographic Distribution. This upland forest and woodland habitat occurs in southwestern Oregon, northwestern California, and the Sierra Nevada. In southern Oregon, it is found at low and middle elevations in the Klamath Mountains, Cascades, Coast Range, and Eastern Cascade Slopes and Foothills ecoregions. Portions of Curry, Josephine, Jackson, Douglas, Lane, and Klamath counties are included in the range of this habitat.

Physical Setting. The climate varies from relatively dry and very warm to moderately moist and cool to slightly warm and very moist. Mean annual precipitation ranges from 20 to 140 inches (51 to 356 cm). Snow is uncommon except at the highest elevations, where a winter snow pack occurs for a few months. Summers are hot and dry. Elevation ranges from near sea level to 6,000 ft (1,829 m). Topography is mostly mountainous but also includes two fairly large valleys, and a corresponding variety of terrain. Soils are diverse as is the bedrock geology. Serpentine soils are common in portions of the Siskiyou Mountains, where they have a major effect on vegetation.

Landscape Setting. This habitat is typically bounded at its upper elevation limits by Montane Mixed Conifer Forest and at its lower limits, along the coast, by Westside Lowlands Conifer-Hardwood Forest. At lower elevations in the Rogue and Umpqua valleys it can be found in a mosaic with Westside Oak and Dry Douglas-fir Forest and Woodland, Ceanothus-Manzanita Shrublands, Urban, and Agriculture. Small inclusions of Open Water, Herbaceous Wetlands, Westside Riparian-Wetlands, and Ceanothus-Manzanita Shrublands occur scattered throughout this habitat. The predominant land use is forestry. Low-density residential is prominent in the Rogue and Umpqua valleys.

Grazing occurs on some areas, especially at lower elevations.

Structure. Conifer trees typically dominate this forest or woodland habitat. In some generally more coastal areas, a well developed subcanopy layer of smaller evergreen broadleaf trees is present. Occasionally, deciduous broadleaf trees are co-dominant. Complex multi-layered canopies are typical, though single-layered canopies also occur, especially in areas of intensive forest management. Dominant canopy trees vary from 60 to >300 ft (18 to >91 m) tall at maturity. Large woody debris (snags and logs) is typically common, although variable. Understories are mostly dominated by shrubs, but can be dominated by forbs, graminoids, or may be largely depauperate.

Composition. The tree canopy is often diverse. Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), ponderosa pine (*P. ponderosa*), or incense cedar (*Calocedrus decurrens*) are typically dominant or co-dominant. Port-Orford cedar (*Chamaecyparis lawsoniana*), tanoak (*Lithocarpus densiflorus*), canyon live oak (*Quercus chrysolepis*), and Pacific madrone (*Arbutus menziesii*) are locally important. Jeffrey pine (*Pinus jeffreyi*) is dominant on serpentine parent materials in the Siskiyou Mountains, and to a lesser degree in the southwestern Cascades.

Douglas-fir is found in almost every area; ponderosa pine is also found in most stands, although it has been declining with fire suppression. White fir, incense cedar, and sugar pine are common in mixed stands in the Cascades and central and eastern Siskiyou on all but the driest sites. White fir dominates the canopy in only the moist, cool sites at higher elevations, although it is the major tree regeneration in most areas. Jeffrey pine and knobcone pine (*Pinus attenuata*) are limited primarily to serpentine soils, which they dominate. Port-Orford cedar dominates some more moist sites near the coast and riparian and wetland habitats inland. Brewer's spruce (*Picea breweri*) is an uncommon dominant at high elevations in the Siskiyou. The broadleaf subcanopy is most prominent on the western sides of the Coast Range and Siskiyou, where tanoak is most abundant, with Pacific madrone, golden chinquapin (*Castanopsis chrysophylla*), or canyon live oak also sometimes dominating the subcanopy. Coast redwood (*Sequoia sempervirens*) occurs only in a very small area near the coast in far southern Oregon.

Dominant or co-dominant evergreen shrubs include pinemat manzanita (*Arctostaphylos nevadensis*), green-leaf manzanita (*A. patula*), white-leaf manzanita (*A. viscida*), kinnikinnick (*A. uva-ursi*), Piper's barberry (*Mahonia piperiana*), dwarf Oregon grape (*M. nervosa*), tobacco brush (*Ceanothus velutinus*), squawcarpet (*C. prostratus*), salal (*Gaultheria shallon*), deer oak (*Quercus sadleriana*), huckleberry oak (*Q. vacciniifolia*), snow bramble (*Rubus nivalis*), Pacific rhododendron (*Rhododendron macrophyllum*), and evergreen huckleberry (*Vaccinium ovatum*). Major deciduous shrubs are serviceberry (*Amelanchier alnifolia*), sticky currant (*Ribes viscosissimum*),

oceanspray (*Holodiscus discolor*), creeping snowberry (*Symphoricarpos mollis*), baldhip rose (*Rosa gymnocarpa*), beaked hazel (*Corylus cornuta*), Rocky Mountain maple (*Acer glabrum*), vine maple (*A. circinatum*), poison-oak (*Toxicodendron diversiloba*), big huckleberry (*Vaccinium membranaceum*), deerbrush (*Ceanothus integerrimus*), and trailing blackberry (*Rubus ursinus*). Early seral shrublands, part of this habitat, can be difficult to distinguish from *Ceanothus*-*Manzanita* Shrublands. They are best separated by their different species composition, especially the predominance in this habitat of *Ceanothus velutinus*, *Arctostaphylos patula*, and *A. nevadensis*.

Graminoids that are most prominent are long-stolon sedge (*Carex inops*), Idaho fescue (*Festuca idahoensis*), and California fescue (*F. californica*). Forbs that are indicative of site conditions or dominate understories include common whippiea (*Whippiea modesta*), twinflower (*Linnaea borealis*), sidebells (*Orthilia secunda*), rattlesnake plantain (*Goodyera oblongifolia*), vanillaleaf (*Achlys triphylla*), beargrass (*Xerophyllum tenax*), and starry false solomonseal (*Maianthemum stellata*).

Other Classifications and Key References. This habitat includes the conifer-dominated forests and their successional seres within the Interior Valley, Mixed-Conifer, Mixed-Evergreen, and *Abies* concolor zones of southwestern Oregon, plus Redwood forests in the *Picea sitchensis* Zone.⁸⁸ It is also referred to as Klamath Mountains mixed evergreen forests and Sierran-type mixed conifer forests,⁸⁷ *Pseudotsuga menziesii*/hardwood forests and *Abies concolor* forests,¹ Mixed conifer forest No. 5, Redwood forest No. 6, California mixed evergreen forest No. 29, and Montane chaparral No. 34.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are the southwestern portion of the Douglas-fir dominant-mixed conifer forest, Jeffrey pine forest and woodland, serpentine conifer woodland, Douglas-fir-Port Orford cedar forest, Douglas-fir mixed deciduous forest, Douglas-fir-white fir/tanoak-madrone mixed forest, and Siskiyou Mountains mixed deciduous forest. Other references also describe this habitat.^{13, 15, 17, 111, 117}

Natural Disturbance Regime. Fire is the predominant natural disturbance. Fire regime varies depending on environmental conditions. Drier, hotter sites within this area have a low-severity fire regime. Cooler and/or moister sites typically have a moderate-severity fire regime. Presettlement mean fire return intervals vary from 10 years to about 80 years.^{1, 98, 154} Lightning ignitions are more frequent here than anywhere else in the region and Native Americans probably burned some areas intentionally.¹ Wind is a somewhat important disturbance at higher elevations. Root rot fungi and insects are other important disturbances in some forests, mostly operating at small-scales.

Succession and Stand Dynamics. Most evergreen broadleaf trees, when present, are top-killed by moderate-severity fires but resprout vigorously to dominate or co-dominate after most fires.^{14, 152} Mature Oregon white oak

and canyon live oak can survive fairly hot fires if the fuels do not extend into the canopy. Conifers are at a disadvantage in regeneration following stand replacement fires because of dependence on local seed-fall. Many conifers of this habitat are able to survive moderate-severity fire well, including, in decreasing order of fire resistance, Ponderosa pine, Jeffrey pine, Douglas-fir, sugar pine, coast redwood, incense cedar, and Port-Orford cedar. These species are fairly well represented throughout the successional sequence, unless a high-severity fire was closely followed by another, in which case the subcanopy broadleaf species are likely to dominate.¹ Development of complex multi-layered canopies of conifers and broadleaf evergreens are typical under a moderate-severity fire regime.

Where hardwoods are absent and white fir is prominent, succession differs from that described above. Under a low-severity fire regime with frequent fires, white fir is relatively unimportant and fire-resistant conifers, especially Douglas-fir and ponderosa pine, dominate. White fir increases in the absence of fire.¹⁷¹ With a moderate-severity fire regime, i.e., less frequent fires, white fir can dominate or co-dominate, especially on cooler sites.¹ Small gaps created by moderate-severity fires, blowdown, or disease afford opportunities for regeneration of less shade-tolerant tree species, thus maintaining a diverse tree canopy for lengthy periods. Evergreen shrubs, especially tobacco brush, often dominate after high-severity fire and may persist as a cover type for decades, especially if they are reburned.^{51, 88} On the driest, hottest sites in this habitat, white fir does not grow and tree regeneration is limited to Douglas-fir and ponderosa pine, with the former tending to increase in the absence of fire.

Effects of Management and Anthropogenic Impacts. Clearcut logging where hardwoods are present favors post-disturbance dominance of tanoak or madrone. Control of this competing vegetation has been a major focus of timber management in this habitat. Fire control over the last 100 years has decreased fire frequencies and altered stand structure through increases in small tree density and heavy fuels, especially where low-severity fire regimes were prevalent. As a result, most of these areas are more susceptible to stand-replacement fires. White fir has increased dramatically on drier sites where it occurs, creating dense subcanopy thickets.^{1, 128} Evergreen shrubs often dominate after clearcut logging and in some cases hinder the establishment of conifers.¹⁴⁰ Clearcut logging tends to decrease tree species diversity, coarse woody debris loads, and structural diversity. The non-native species white pine blister rust (*Cronartium ribicola*) and *Phytophthora lateralis*, a root rot disease, have had significant negative impacts on the abundance of sugar pine and Port-Orford cedar, respectively.

Status and Trends. This habitat covers most of southwestern Oregon and has declined little in areal extent. Conditions of most communities and stands have been degraded by forestry practices and by fire suppression. The low-elevation, driest communities have

been altered by grazing and invasion of exotic species. Port-Orford cedar has declined dramatically in extent from logging and *Phytophthora lateralis*.²³⁰ Effects of fire suppression and logging-related impacts continue to be threats. Twenty-one % of 68 plant associations representing this habitat listed in the National Vegetation Classification are listed as globally imperiled.¹⁰

4. Montane Mixed Conifer Forest

Christopher B. Chappell



Geographic Distribution. These forests occur in mountains throughout Washington and Oregon, excepting the Basin and Range of southeastern Oregon. These include the Cascade Range, Olympic Mountains, Okanogan Highlands, Coast Range (rarely), Blue and Wallowa mountains, and Siskiyou Mountains.

Physical Setting. This habitat is typified by a moderate to deep winter snow pack that persists for three to nine months. The climate is moderately cool and wet to moderately dry and very cold. Mean annual precipitation ranges from about 40 inches (102 cm) to >200 inches (508 cm). Elevation is mid- to upper montane, as low as 2,000 ft (610 m) in northern Washington, to as high as 7,500 ft (2,287 m) in southern Oregon. On the westside, it occupies an elevational zone of about 2,500 to 3,000 vertical feet (762 to 914 m), and on the eastside it occupies a narrower zone of about 1,500 vertical feet (457 m). Topography is generally mountainous. Soils are typically not well developed, but varied in their parent material: glacial till, volcanic ash, residuum, or colluvium. Spodosols are common.

Landscape Setting. This habitat is found adjacent to Westside Lowlands Conifer-Hardwood Forest, Eastside Mixed Conifer Forest, or Southwest Oregon Mixed Conifer-Hardwood Forest at its lower elevation limits and to Subalpine Parkland at its upper elevation limits. Inclusions of Montane Forested Wetlands, Westside Riparian-Wetlands, and less commonly Open Water or Herbaceous Wetlands occur within the matrix of montane forest habitat. The typical land use is forestry or recreation. Most of this type is found on public lands managed for

timber values and much of it has been harvested in a dispersed-patch pattern.

Structure. This is a forest, or rarely woodland, dominated by evergreen conifers. Canopy structure varies from single- to multi-storied. Tree size also varies from small to very large. Large snags and logs vary from abundant to uncommon. Understories vary in structure: shrubs, forbs, ferns, graminoids or some combination of these usually dominate, but they can be depauperate as well. Deciduous broadleaf shrubs are most typical as understory dominants. Early successional structure after logging or fire varies depending on understory species present. Mosses are a major ground cover and epiphytic lichens are typically abundant in the canopy.

Composition. This forest habitat is recognized by the dominance or prominence of one of the following species: Pacific silver fir (*Abies amabilis*), mountain hemlock (*Tsuga mertensiana*), subalpine fir (*A. lasiocarpa*), Shasta red fir (*A. magnifica* var. *shastensis*), Engelmann spruce (*Picea engelmannii*), noble fir (*A. procera*), or Alaska yellow-cedar (*Chamaecyparis nootkatensis*). Several other trees may co-dominate: Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), or white fir (*A. concolor*). Tree regeneration is typically dominated by Pacific silver fir in moist westside middle-elevation zones; by mountain hemlock, sometimes with silver fir, in cool, very snowy zones on the westside and along the Cascade Crest; by subalpine fir in cold, drier eastside zones; and by Shasta red fir in the snowy mid- to upper-elevation zone of southwestern and south-central Oregon.

Subalpine fir and Engelmann spruce are major species only east of the Cascade Crest in Washington, in the Blue and Wallowa mountains, and in the northeastern Olympic Mountains (spruce is largely absent in the Olympic Mountains). Lodgepole pine is important east of the Cascade Crest throughout and in central and southern Oregon. Douglas-fir is important east of the Cascade Crest and at lower elevations on the westside. Pacific silver fir is a major species on the westside as far south as central Oregon. Noble fir, as a native species, is found primarily in the western Cascades from central Washington to central Oregon. Mountain hemlock is a common dominant at higher elevations along the Cascade Crest and to the west. Western hemlock, and to a lesser degree western redcedar, occur as dominants primarily with silver fir at lower elevations on the westside. Alaska yellow-cedar occurs as a co-dominant west of the Cascade Crest in Washington, rarely in northern Oregon. Shasta red fir and white fir occur only from central Oregon south, the latter mainly at lower elevations.

Deciduous shrubs that commonly dominate or co-dominate the understory are oval-leaf huckleberry (*Vaccinium ovalifolium*), big huckleberry (*V. membranaceum*), grouseberry (*V. scoparium*), dwarf huckleberry (*V. cespitosum*), fools huckleberry (*Menziesia ferruginea*), Cascade azalea (*Rhododendron albiflorum*), copperbush (*Elliottia pyroliflorus*), devil's-club (*Oplopanax horridus*), and,

in the far south only, baldhip rose (*Rosa gymnocarpa*), currants (*Ribes* spp.), and creeping snowberry (*Symphoricarpos mollis*). Important evergreen shrubs include salal (*Gaultheria shallon*), dwarf Oregon grape (*Mahonia nervosa*), Pacific rhododendron (*Rhododendron macrophyllum*), deer oak (*Quercus sadleriana*), pinemat manzanita (*Arctostaphylos nevadensis*), beargrass (*Xerophyllum tenax*), and Oregon boxwood (*Paxistima myrsinites*).

Graminoid dominants are found primarily just along the Cascade Crest and to the east and include pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), smooth woodrush (*Luzula glabrata* var. *hitchcockii*), and long-stolon sedge (*Carex inops*). Deerfern (*Blechnum spicant*) and western oakfern (*Gymnocarpium dryopteris*) are commonly co-dominant. The most abundant forbs include Oregon oxalis (*Oxalis oregana*), single-leaf foamflower (*Tiarella trifoliata* var. *unifoliata*), rosy twisted-stalk (*Streptopus roseus*), queen's cup (*Clintonia uniflora*), western bunchberry (*Cornus unalaschensis*), twinflower (*Linnaea borealis*), prince's pine (*Chimaphila umbellata*), five-leaved bramble (*Rubus pedatus*), dwarf bramble (*R. lasiococcus*), sidebells (*Orthilia secunda*), avalanche lily (*Erythronium montanum*), Sitka valerian (*Valeriana sitchensis*), false lily-of-the-valley (*Maianthemum dilatatum*), and Idaho goldthread (*Coptis occidentalis*).

Other Classifications and Key References. This habitat includes most of the upland forests and their successional stages, except lodgepole pine dominated forests, in the *Tsuga mertensiana*, *Abies amabilis*, *A. magnifica* var. *shastensis*, *A. lasiocarpa* zones of Franklin and Dyrness.⁸⁸ Portions of this habitat have also been referred to as *A. amabilis*-*Tsuga heterophylla* forests, *A. magnifica* var. *shastensis* forests, and *Tsuga mertensiana* forests.⁸⁷ It is equivalent to Silver fir-Douglas-fir forest No. 3, closed portion of Fir-hemlock forest No. 4, Red fir forest No. 7, and closed portion of Western spruce-fir forest No. 15.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are mountain hemlock montane forest, true fir-hemlock montane forest, montane mixed conifer forest, Shasta red fir-mountain hemlock forest, and subalpine fir-lodgepole pine montane conifer; also most of the conifer forest in the Silver Fir, Mountain Hemlock, and Subalpine Fir Zones of Washington Gap.³⁷ A number of other references describe this habitat.^{13, 15, 17, 25, 26, 36, 38, 90, 108, 111, 114, 115, 118, 144, 148, 158, 212, 221}

Natural Disturbance Regime. Fire is the major natural disturbance in this habitat. Fire regimes are primarily of the high-severity type,¹ but also include the moderate-severity regime (moderately frequent and highly variable) for Shasta red fir forests.³⁹ Mean fire-return intervals vary greatly, from •800 years for some mountain hemlock-silver fir forests to about 40 years for red fir forests. Windstorms are a common small-scale disturbance and occasionally result in stand replacement. Insects and fungi are often important small-scale disturbances. However, they may affect larger areas also, for example, laminated root rot (*Phellinus weirii*) is a major natural disturbance, affecting

large areas of mountain hemlock forests in the Oregon Cascades.⁷²

Succession and Stand Dynamics. After fire, a typical stand will briefly be occupied by annual and perennial ruderal forbs and grasses, as well as predisturbance understory shrubs and herbs that resprout. Stand initiation can take a long time, especially at higher elevations, resulting in shrub/herb dominance (with or without a scattered tree layer) for extended periods.^{3, 109} Early seral tree species can be any of the potential dominants for the habitat, or lodgepole pine, depending on the environment, type of disturbance, and seed source. Fires tend to favor early seral dominance of lodgepole pine, Douglas-fir, noble fir, or Shasta red fir, if their seeds are present.¹ In some areas, large stand-replacement fires will result in conversion of this habitat to the Lodgepole Pine Forest and Woodland habitat, distinguished by dominance of lodgepole. After the tree canopy closes, the understory typically becomes sparse for a time. Eventually tree density will decrease and the understory will begin to flourish again, but this process takes longer than in lower elevation forests, generally at least 100 years after the disturbance, sometimes much longer.¹ As stand development proceeds, relatively shade-intolerant trees (lodgepole pine, Douglas-fir, western hemlock, noble fir, Engelmann spruce) typically decrease in importance and more shade-tolerant species (Pacific silver fir, subalpine fir, Shasta red fir, mountain hemlock) increase. Complex multi-layered canopies with large trees will typically take at least 300 years to develop, often much longer, and on some sites may never develop. Tree growth rates, and therefore the potential to develop these structural features, tend to decrease with increasing elevation.

Effects of Management and Anthropogenic Impacts. Forest management practices, such as clearcutting and plantations, have in many cases resulted in less diverse tree canopies with an emphasis on Douglas-fir. They also reduce coarse woody debris compared to natural levels, and truncate succession well before late-seral characteristics are expressed. Post-harvest regeneration of trees has been a perpetual problem for forest managers in much of this habitat.^{16, 97} Planting of Douglas-fir has often failed at higher elevations, even where old Douglas-fir were present in the unmanaged stand.¹¹⁵ Slash burning often has negative impacts on productivity and regeneration.¹⁸⁶ Management has since shifted away from burning and toward planting noble fir or native species, natural regeneration, and advance regeneration.^{16, 103} Noble fir plantations are now fairly common in managed landscapes, even outside the natural range of the species. Advance regeneration management tends to simulate wind disturbance but without the abundant downed wood component. Shelterwood cuts are a common management strategy in Engelmann spruce or subalpine fir stands.²²¹

Status and Trends. This habitat occupies large areas of the region. There has probably been little or no decline in the extent of this type over time. Large areas of this habitat

are relatively undisturbed by human impacts and include significant old-growth stands. Other areas have been extensively affected by logging, especially dispersed patch clearcuts. The habitat is stable in area, but is probably still declining in condition because of continued logging. This habitat is one of the best protected, with large areas represented in national parks and wilderness areas. The only threat is continued road building and clearcutting in unprotected areas. None of the 81 plant associations representing this habitat listed in the National Vegetation Classification are considered imperiled.¹⁰

5. Eastside Mixed Conifer Forest

Rex C. Crawford



Geographic Distribution. The Eastside Mixed Conifer Forest habitat appears primarily in the Blue Mountains, East Cascades, and Okanogan Highland Ecoregions of Oregon, Washington, adjacent Idaho, and western Montana. It also extends north into British Columbia.

Douglas-fir-ponderosa pine forests occur along the eastern slope of the Oregon and Washington Cascades, the Blue Mountains, and the Okanogan Highlands of Washington. Grand fir-Douglas-fir forests and western larch forests are widely distributed throughout the Blue Mountains and, less so, along the east slope of the Cascades south of Lake Chelan and in the eastern Okanogan Highlands. Western hemlock-western redcedar-Douglas-fir forests are found in the Selkirk Mountains of eastern Washington, and on the east slope of the Cascades south of Lake Chelan to the Columbia River Gorge.

Physical Setting. The Eastside Mixed Conifer Forest habitat is primarily mid-montane with an elevation range of between 1,000 and 7,000 ft (305-2,137 m), mostly between 3,000 and 5,500 ft (914-1,676 m). Parent materials for soil development vary. This habitat receives some of the greatest amounts of precipitation in the inland northwest, 30-80 inches (76-203 cm)/year. Elevation of this habitat varies geographically, with generally higher elevations to the east.

Landscape Setting. This habitat makes up most of the continuous montane forests of the inland Pacific

Northwest. It is located between the subalpine portions of the Montane Mixed Conifer Forest habitat in eastern Oregon and Washington and lower tree line Ponderosa Pine and Forest and Woodlands.

Structure. Eastside Mixed Conifer habitats are montane forests and woodlands. Stand canopy structure is generally diverse, although single-layer forest canopies are currently more common than multilayered forests with snags and large woody debris. The tree layer varies from closed forests to more open-canopy forests or woodlands. This habitat may include very open stands. The undergrowth is complex and diverse. Tall shrubs, low shrubs, forbs or any combination may dominate stands. Deciduous shrubs typify shrub layers. Prolonged canopy closure may lead to development of a sparsely vegetated undergrowth.

Composition. This habitat contains a wide array of tree species (nine) and stand dominance patterns. Douglas-fir (*Pseudotsuga menziesii*) is the most common tree species in this habitat. It is almost always present and dominates or co-dominates most overstories. Lower elevations or drier sites may have ponderosa pine (*Pinus ponderosa*) as a co-dominant with Douglas-fir in the overstory and often have other shade-tolerant tree species growing in the undergrowth. On moist sites, grand fir (*Abies grandis*), western redcedar (*Thuja plicata*) and/or western hemlock (*Tsuga heterophylla*) are dominant or co-dominant with Douglas-fir. Other conifers include western larch (*Larix occidentalis*) and western white pine (*Pinus monticola*) on mesic sites, Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), and subalpine fir (*Abies lasiocarpa*) on colder sites. Rarely, Pacific yew (*Taxus brevifolia*) may be an abundant undergrowth tree or tall shrub.

Undergrowth vegetation varies from open to nearly closed shrub thickets with one to many layers. Throughout the eastside conifer habitat, tall deciduous shrubs include vine maple (*Acer circinatum*) in the Cascades, Rocky Mountain maple (*A. glabrum*), serviceberry (*Amelanchier alnifolia*), oceanspray (*Holodiscus discolor*), mallowleaf ninebark (*Physocarpus malvaceus*), and Scouler's willow (*Salix scouleriana*) at mid- to lower elevations. Medium-tall deciduous shrubs at higher elevations include foos huckleberry (*Menziesia ferruginea*), Cascade azalea (*Rhododendron albiflorum*), and big huckleberry (*Vaccinium membranaceum*). Widely distributed, generally drier site mid-height to short deciduous shrubs include baldhip rose (*Rosa gymnocarpa*), shiny-leaf spirea (*Spiraea betulifolia*), and snowberry (*Symphoricarpos albus*, *S. mollis*, and *S. oreophilus*). Low shrubs of higher elevations include low huckleberries (*Vaccinium cespitosum*, and *V. scoparium*) and five-leaved bramble (*Rubus pedatus*). Evergreen shrubs represented in this habitat are chinquapin (*Castanopsis chrysophylla*), a tall shrub in southeastern Cascades, low to mid-height dwarf Oregon grape (*Mahonia nervosa* in the east Cascades and *M. repens* elsewhere), tobacco brush (*Ceanothus velutinus*), an increaser with fire, Oregon boxwood (*Paxistima myrsinites*) generally at mid- to lower

elevations, beargrass (*Xerophyllum tenax*), pinemat manzanita (*Arctostaphylos nevadensis*) and kinnikinnick (*A. uva-ursi*).

Herbaceous broadleaf plants are important indicators of site productivity and disturbance. Species generally indicating productive sites include western oakfern (*Gymnocarpium dryopteris*), vanillaleaf (*Achlys triphylla*), wild sarsparilla (*Aralia nudicaulis*), wild ginger (*Asarum caudatum*), queen's cup (*Clintonia uniflora*), goldthread (*Coptis occidentalis*), false bugbane (*Trautvetteria caroliniensis*), windflower (*Anemone oregana*, *A. piperi*, *A. lyallii*), fairybells (*Disporum hookeri*), Sitka valerian (*Valeriana sitchensis*), and pioneer violet (*Viola glabella*). Other indicator forbs are dogbane (*Apocynum androsaemifolium*), false solomonseal (*Maianthemum stellata*), heartleaf arnica (*Arnica cordifolia*), several lupines (*Lupinus caudatus*, *L. latifolius*, *L. argenteus* ssp. *argenteus* var. *laxiflorus*), western meadowrue (*Thalictrum occidentale*), rattlesnake plantain (*Goodyera oblongifolia*), skunkleaf polemonium (*Polemonium pulcherrimum*), trailplant (*Adenocaulon bicolor*), twinflower (*Linnaea borealis*), western starflower (*Trientalis latifolia*), and several wintergreens (*Pyrola asarifolia*, *P. picta*, *Orthilia secunda*).

Graminoids are common in this forest habitat. Columbia brome (*Bromus vulgaris*), oniongrass (*Melica bulbosa*), northwestern sedge (*Carex concinnoides*) and western fescue (*Festuca occidentalis*) are found mostly in mesic forests with shrubs or mixed with forb species. Bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), and junegrass (*Koeleria macrantha*) are found in drier more open forests or woodlands. Pinegrass (*Calamagrostis rubescens*) and Geyer's sedge (*C. geyeri*) can form a dense layer under Douglas-fir or grand fir trees.

Other Classifications and Key References. This habitat includes the moist portions of the *Pseudotsuga menziesii*, the *Abies grandis*, and the *Tsuga heterophylla* zones of eastern Oregon and Washington.⁸⁸ This habitat is called Douglas-fir (No. 12), Cedar-Hemlock-Pine (No. 13), and Grand fir-Douglas-fir (No. 14) forests in Kuchler.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are the eastside Douglas-fir dominant-mixed conifer forest, ponderosa pine dominant mixed conifer forest, and the northeast Oregon mixed conifer forest. Quigley and Arbelbide¹⁸¹ referred to this habitat as Grand fir/White fir, the Interior Douglas-fir, Western larch, Western redcedar/Western hemlock, and Western white pine cover types and the Moist Forest potential vegetation group. Other references detail forest associations for this habitat.^{45, 59, 117, 118, 123, 122, 144, 148, 208, 209, 212, 221, 228}

Natural Disturbance Regime. Fires were probably of moderate frequency (30-100 years) in presettlement times. Inland Pacific Northwest Douglas-fir and western larch forests have a mean fire interval of 52 years.²² Typically, stand-replacement fire-return intervals are 150-500 years with moderate severity-fire intervals of 50-100 years. Specific fire influences vary with site characteristics.

Generally, wetter sites burn less frequently and stands are older with more western hemlock and western redcedar than drier sites. Many sites dominated by Douglas-fir and ponderosa pine, which were formerly maintained by wildfire, may now be dominated by grand fir (a fire sensitive, shade-tolerant species).

Succession and Stand Dynamics. Successional relationships of this type reflect complex interrelationships between site potential, plant species characteristics, and disturbance regime.²²⁸ Generally, early seral forests of shade-intolerant trees (western larch, western white pine, ponderosa pine, Douglas-fir) or tolerant trees (grand fir, western redcedar, western hemlock) develop some 50 years following disturbance. This stage is preceded by forb- or shrub- dominated communities. These early stage mosaics are maintained on ridges and drier topographic positions by frequent fires. Early seral forest develops into mid-seral habitat of large trees during the next 50-100 years. Stand replacing fires recycle this stage back to early seral stages over most of the landscape. Without high-severity fires, a late-seral condition develops either single-layer or multilayer structure during the next 100-200 years. These structures are typical of cool bottomlands that usually only experience low-intensity fires.

Effects of Management and Anthropogenic Impacts. This habitat has been most affected by timber harvesting and fire suppression. Timber harvesting has focused on large shade-intolerant species in mid- and late-seral forests, leaving shade-tolerant species. Fire suppression enforces those logging priorities by promoting less fire-resistant, shade-tolerant trees. The resultant stands at all seral stages tend to lack snags, have high tree density, and are composed of smaller and more shade-tolerant trees. Mid-seral forest structure is currently 70% more abundant than in historical, native systems.¹⁸¹ Late-seral forests of shade-intolerant species are now essentially absent. Early-seral forest abundance is similar to that found historically but lacks snags and other legacy features.

Status and Trends. Quigley and Arbelbide¹⁸¹ concluded that the Interior Douglas-fir, Grand fir, and Western redcedar/Western hemlock cover types are more abundant now than before 1900, whereas the Western larch and Western white pine types are significantly less abundant. Twenty percent of Pacific Northwest Douglas-fir, grand fir, western redcedar, western hemlock, and western white pine associations listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰ Roads, timber harvest, periodic grazing, and altered fire regimes have compromised these forests. Even though this habitat is more extensive than pre-1900, natural processes and functions have been modified enough to alter its natural status as functional habitat for many species.

6. Lodgepole Pine Forest and Woodlands

Rex C. Crawford



Geographic Distribution. This habitat is found along the eastside of the Cascade Range, in the Blue Mountains, the Okanogan Highlands and ranges north into British Columbia and south to Colorado and California.

With grassy undergrowth, this habitat appears primarily along the eastern slope of the Cascade Range and occasionally in the Blue Mountains and Okanogan Highlands. Subalpine lodgepole pine habitat occurs on the broad plateau areas along the crest of the Cascade Range and the Blue Mountains, and in the higher elevations in the Okanogan Highlands. On pumice soils this habitat is confined to the eastern slope of the Cascade Range from near Mt. Jefferson south to the vicinity of Crater Lake.

Physical Setting. This habitat is located mostly at mid- to higher elevations (3,000-9,000 ft [914-2,743 m]). These environments can be cold and relatively dry, usually with persistent winter snowpack. A few of these forests occur in low-lying frost pockets, wet areas, or under edaphic control (usually pumice) and are relatively long-lasting features of the landscape. Lodgepole pine is maintained as a dominant by the well-drained, deep Mazama pumice in eastern Oregon.

Landscape Setting. This habitat appears within Montane Mixed Conifer Forest east of the Cascade crest and the cooler Eastside Mixed Conifer Forest habitats. Most pumice soil lodgepole pine habitat is intermixed with Ponderosa Pine Forest and Woodland habitats and is located between Eastside Mixed Conifer Forest habitat and either Western Juniper Woodland or Shrub-steppe habitat.

Structure. The lodgepole pine habitat is composed of open to closed evergreen conifer tree canopies. Vertical structure is typically a single tree layer. Reproduction of other more shade-tolerant conifers can be abundant in the undergrowth. Several distinct undergrowth types develop under the tree layer: evergreen or deciduous medium-tall shrubs, evergreen low shrub, or graminoids with few shrubs. On pumice soils, a sparsely developed shrub and

graminoid undergrowth appears with open to closed tree canopies.

Composition. The tree layer of this habitat is dominated by lodgepole pine (*Pinus contorta* var. *latifolia* and *P. c.* var. *murrayana*), but it is usually associated with other montane conifers (*Abies concolor*, *A. grandis*, *A. magnifica* var. *shastensis*, *Larix occidentalis*, *Calocedrus decurrens*, *Pinus lambertiana*, *P. monticola*, *P. ponderosa*, *Pseudotsuga menziesii*). Subalpine fir (*Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*), Engelmann spruce (*Picea engelmannii*), and whitebark pine (*Pinus albicaulis*), indicators of subalpine environments, are present in colder or higher sites. Quaking aspen (*Populus tremuloides*) may occur in small numbers.

Shrubs can dominate the undergrowth. Tall deciduous shrubs include Rocky Mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), oceanspray (*Holodiscus discolor*), or Scouler's willow (*Salix scouleriana*). These tall shrubs often occur over a layer of mid-height deciduous shrubs such as baldhip rose (*Rosa gymnocarpa*), russet buffaloberry (*Shepherdia canadensis*), shiny-leaf spirea (*Spiraea betulifolia*), and snowberry (*Symphoricarpos albus* and/or *S. mollis*). At higher elevations, big huckleberry (*Vaccinium membranaceum*) can be locally important, particularly following fire. Mid-tall evergreen shrubs can be abundant in some stands, for example, creeping Oregongrape (*Mahonia repens*), tobacco brush (*Ceanothus velutinus*), and Oregon boxwood (*Paxistima myrsinites*). Colder and drier sites support low-growing evergreen shrubs, such as kinnikinnick (*Arctostaphylos uva-ursi*) or pinemat manzanita (*A. nevadensis*). Grouseberry (*V. scoparium*) and beargrass (*Xerophyllum tenax*) are consistent evergreen low shrub dominants in the subalpine part of this habitat. Manzanita (*Arctostaphylos patula*), kinnikinnick, tobacco brush, antelope bitterbrush (*Purshia tridentata*), and wax current (*Ribes cereum*) are part of this habitat on pumice soil.

Some undergrowth is dominated by graminoids with few shrubs. Pinegrass (*Calamagrostis rubescens*) and/or Geyer's sedge (*Carex geyeri*) can appear with grouseberry in the subalpine zone. Pumice soils support grassy undergrowth of long-stolon sedge (*C. inops*), Idaho fescue (*Festuca idahoensis*) or western needlegrass (*Stipa occidentalis*). The latter two species may occur with bitterbrush or big sagebrush and other bunchgrass steppe species. Other nondominant indicator graminoids frequently encountered in this habitat are California oatgrass (*Danthonia californica*), blue wildrye (*Elymus glaucus*), Columbia brome (*Bromus vulgaris*) and oniongrass (*Melica bulbosa*). Kentucky bluegrass (*Poa pratensis*), and bottlebrush squirreltail (*Elymus elymoides*) can be locally abundant where livestock grazing has persisted.

The forb component of this habitat is diverse and varies with environmental conditions. A partial forb list includes goldthread (*Coptis occidentalis*), false solomonseal (*Maianthemum stellata*), heartleaf arnica (*Arnica cordifolia*), several lupines (*Lupinus caudatus*, *L. latifolius*, *L. argenteus* ssp. *argenteus* var. *laxiflorus*), meadowrue (*Thalictrum*

occidentale), queen's cup (*Clintonia uniflora*), rattlesnake plantain (*Goodyera oblongifolia*), skunkleaf polemonium (*Polemonium pulcherrimum*), trailplant (*Adenocaulon bicolor*), twinflower (*Linnaea borealis*), Sitka valerian (*Valeriana sitchensis*), western starflower (*Trientalis latifolia*), and several wintergreens (*Pyrola asarifolia*, *P. picta*, *Orthilia secunda*).

Other Classifications and Key References. The Lodgepole Pine Forest and Woodland habitat includes the *Pinus contorta* zone of eastern Oregon and Washington.⁸⁸ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is lodgepole pine forest and woodlands. Quigley and Arbelbide¹⁸¹ referred to this habitat as Lodgepole pine cover type and as a part of the Dry Forest potential vegetation group. Other references detail plant associations with this habitat.^{117, 118, 122, 123, 144, 212, 221}

Natural Disturbance Regime. This habitat typically reflects early successional forest vegetation that originated with fires. Inland Pacific Northwest lodgepole pine has a mean fire interval of 112 years.²² Summer drought areas generally have low to medium-intensity ground fires occurring at intervals of 25-50 years, whereas areas with more moisture have a sparse undergrowth and slow fuel build-up that results in less frequent, more intense fire. With time, lodgepole pine stands increase in fuel loads. Woody fuels accumulate on the forest floor from insect (mountain pine beetle) and disease outbreaks and residual wood from past fires. Mountain pine beetle outbreaks thin stands that add fuel and create a drier environment for fire or open canopies and create gaps for other conifer regeneration. High-severity crown fires are likely in young stands, when the tree crowns are near deadwood on the ground. After the stand opens up, shade-tolerant trees increase in number.

Succession and Stand Dynamics. Most Lodgepole Pine Forest and Woodlands are early- to mid seral stages initiated by fire. Typically, lodgepole pine establishes within 10-20 years after fire. This can be a gap phase process where seed sources are scarce. Lodgepole stands break up after 100-200 years. Without fires and insects, stands become more closed-canopy forest with sparse undergrowth. Because lodgepole pine cannot reproduce under its own canopy, old unburned stands are replaced by shade-tolerant conifers. Lodgepole pine on pumice soils is not seral to other tree species; these extensive stands, if not burned, thin naturally, with lodgepole pine regenerating in patches. On poorly drained pumice soils, quaking aspen sometimes plays a mid-seral role and is displaced by lodgepole when aspen clones die. Serotinous cones (cones releasing seeds after fire) are uncommon in eastern Oregon lodgepole pine (*P. c.* var. *murrayana*). On the Colville National Forest in Washington, only 10% of lodgepole pine (*P. c.* var. *latifolia*) trees in low-elevation Douglas-fir habitats had serotinous cones, whereas 82% of cones in high-elevation subalpine fir habitats were serotinous.⁴

Effects of Management and Anthropogenic Impacts. Fire suppression has left many single-canopy lodgepole pine habitats unburned to develop into more multilayered stands. Thinning of serotinous lodgepole pine forests with fire intervals <20 years can reduce their importance over time. In pumice-soil lodgepole stands, lack of natural regeneration in harvest units has led to creation of "pumice deserts" within otherwise forested habitats.⁴⁷

Status and Trends. Quigley and Arbelbide¹⁸¹ concluded that the extent of the lodgepole pine cover type in Oregon and Washington is the same as before 1900 and in regions may exceed its historical extent. Five percent of Pacific Northwest lodgepole pine associations listed in the National Vegetation Classification are considered imperiled.¹⁰ At a finer scale, these forests have been fragmented by roads, timber harvest, and influenced by periodic livestock grazing and altered fire regimes.

7. Ponderosa Pine Forest and Woodlands (includes Eastside Oak)

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. This habitat occurs in much of eastern Washington and eastern Oregon, including the eastern slopes of the Cascades, the Blue Mountains and foothills, and the Okanogan Highlands. Variants of it also occur in the Rocky Mountains, the eastern Sierra Nevada, and mountains within the Great Basin. It extends into south-central British Columbia as well.

In the Pacific Northwest, ponderosa pine-Douglas-fir woodland habitats occur along the eastern slope of the Cascades, the Okanogan Highlands, and in the Blue Mountains. Ponderosa pine woodland and savanna habitats occur in the foothills of the Blue Mountains, along the eastern base of the Cascade Range, the Okanogan Highlands, and in the Columbia Basin in northeastern Washington. Ponderosa pine is widespread in the pumice zone of south-central Oregon between Bend and Crater Lake east of the Cascade Crest. Ponderosa pine-Oregon white oak habitat appears east of the Cascades in the vicinity of Mt. Hood near the Columbia River Gorge north to the Yakama Nation and south to the Warm Springs Nation. Oak-dominated woodlands follow a similar

distribution as Ponderosa Pine-White Oak but are more restricted and less common.

Physical Setting. This habitat generally occurs on the driest sites supporting conifers in the Pacific Northwest. It is widespread and variable, appearing on moderate to steep slopes in canyons, foothills, and on plateaus or plains near mountains. In Oregon, this habitat can be maintained by the dry pumice soils, and in Washington it can be associated with serpentine soils. Average annual precipitation ranges from about 14 to 30 inches (36 to 76 cm) on ponderosa pine sites in Oregon and Washington, and often as snow. This habitat can be found at elevations of 100 ft (30m) in the Columbia River Gorge to dry, warm areas over 6,000 ft (1,829 m). Timber harvest, livestock grazing, and pockets of urban development are major land uses.

Landscape Setting. This woodland habitat typifies the lower tree line zone forming transitions with Eastside Mixed Conifer Forest and Western Juniper and Mountain Mahogany Woodland, Shrub-steppe, Eastside Grasslands, or Agriculture habitats. Douglas-fir-ponderosa pine woodlands are found near or within the Eastside Mixed Conifer Forest habitat. Oak woodlands appear in the driest, most restricted, landscapes in transition to Eastside Grasslands or Shrub-steppe.

Structure. This habitat is typically a woodland or savanna with tree canopy coverage of 10-60%, although closed-canopy stands are possible. The tree layer is usually composed of widely spaced large conifer trees. Many stands tend towards a multilayered condition with encroaching conifer regeneration. Isolated taller conifers above broadleaf deciduous trees characterize part of this habitat. Deciduous woodlands or forests are an important part of the structural variety of this habitat. Clonal deciduous trees can create dense patches across a grassy landscape rather than scattered individual trees. The undergrowth may include dense stands of shrubs or, more often, be dominated by grasses, sedges, or forbs. Shrub-steppe shrubs may be prominent in some stands and create a distinct tree-shrub-sparse-grassland habitat.

Composition. Ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) are the most common evergreen trees in this habitat. The deciduous conifer, western larch (*Larix occidentalis*), can be a co-dominant with the evergreen conifers in the Blue Mountains of Oregon, but seldom as a canopy dominant. Grand fir (*Abies grandis*) may be frequent in the undergrowth on more productive sites, giving stands a multilayer structure. In rare instances, grand fir can be co-dominant in the upper canopy. Tall ponderosa pine over Oregon white oak (*Quercus garryana*) trees form stands along part of the east Cascades. These stands usually have younger cohorts of pines. Oregon white oak dominates open woodlands or savannas in limited areas.

The undergrowth can include dense stands of shrubs or, more often, be dominated by grasses, sedges, and/or forbs. Some Douglas-fir and ponderosa pine stands have

a tall to medium-tall deciduous shrub layer of mallowleaf ninebark (*Physocarpus malvaceus*) or common snowberry (*Symphoricarpos albus*). Grand fir seedlings or saplings may be present in the undergrowth. Pumice soils support a shrub layer represented by green-leaf or white-leaf manzanita (*Arctostaphylos patula* or *A. viscida*). Short shrubs, pinemat manzanita (*Arctostaphylos nevadensis*) and kinnikinnick (*A. uva-ursi*) are found across the range of this habitat. Antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and in southern Oregon, curl-leaf mountain mahogany (*Cercocarpus ledifolius*) often grow with Douglas-fir, ponderosa pine and/or Oregon white oak, which typically have a bunchgrass and shrub-steppe ground cover.

Undergrowth is generally dominated by herbaceous species, especially graminoids. Within a forest matrix, these woodland habitats have an open to closed sodgrass undergrowth dominated by pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*C. rossii*), long-stolon sedge (*C. inops*), or blue wildrye (*Elymus glaucus*). Drier savanna and woodland undergrowth typically contains bunchgrass steppe species, such as Idaho fescue (*Festuca idahoensis*), rough fescue (*F. campestris*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass (*Oryzopsis hymenoides*), or needlegrasses (*Stipa comata*, *S. occidentalis*). Common exotic grasses that may appear in abundance are cheatgrass (*Bromus tectorum*), and bulbous bluegrass (*Poa bulbosa*). Forbs are common associates in this habitat and are too numerous to be listed.

Other Classifications and Key References. This habitat is referred to as Merriam's Arid Transition Zone, Western ponderosa forest (*Pinus*), and Oregon Oak wood (*Quercus*) in Kuchler,¹³⁶ and as Pacific ponderosa pine-Douglas-fir, Pacific ponderosa pine, and Oregon white oak by the Society of American Foresters. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are ponderosa pine forest and woodland, ponderosa pine-white oak forest and woodland, and ponderosa pine-lodgepole pine on pumice. Other references describe elements of this habitat.^{45, 62, 88, 117, 118, 121, 122, 123, 144, 148, 209, 212, 221, 222}

Natural Disturbance Regime. Fire plays an important role in creating vegetation structure and composition in this habitat. Most of the habitat has experienced frequent low-severity fires that maintained woodland or savanna conditions. A mean fire interval of 20 years for ponderosa pine is the shortest of the vegetation types listed by Barrett et al.²² Soil drought plays a role in maintaining an open tree canopy in part of this dry woodland habitat.

Succession and Stand Dynamics. This habitat is climax on sites near the dry limits of each of the dominant conifer species and is more seral as the environment becomes more favorable for tree growth. Open seral stands are gradually replaced by more closed shade-tolerant climax stands. Oregon white oak can reproduce under its own shade but is intolerant of overtopping by conifers. Oregon

white oak woodlands are considered fire climax and are seral to conifers. In drier conditions, unfavorable to conifers, oak is climax. Oregon white oak sprouts from the trunk and root crown following cutting or burning and form clonal patches of trees.

Effects of Management and Anthropogenic Impacts. Before 1900, this habitat was mostly open and park like with relatively few undergrowth trees. Currently, much of this habitat has a younger tree cohort of more shade-tolerant species that gives the habitat a more closed, multilayered canopy. For example, this habitat includes previously natural fire-maintained stands in which grand fir can eventually become the canopy dominant. Fire suppression has led to a buildup of fuels that in turn increase the likelihood of stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover and tends to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support cloning of oak and invasion by conifers. Large late-seral ponderosa pine, Douglas-fir, and Oregon white oak are harvested in much of this habitat. Under most management regimes, typical tree size decreases and tree density increases in this habitat. Ponderosa pine-Oregon white oak habitat is now denser than in the past and may contain more shrubs than in presettlement habitats. In some areas, new woodlands have been created by patchy tree establishment at the forest-steppe boundary.

Status and Trends. Quigley and Arbelbide¹⁸¹ concluded that the Interior Ponderosa Pine cover type is significantly less in extent than pre-1900 and that the Oregon White Oak cover type is greater in extent than pre-1900. They included much of this habitat in their Dry Forest potential vegetation group,¹⁸¹ which they concluded has departed from natural succession and disturbance conditions. The greatest structural change in this habitat is the reduced extent of the late-seral, single-layer condition. This habitat is generally degraded because of increased exotic plants and decreased native bunchgrasses. One third of Pacific Northwest Oregon white oak, ponderosa pine, and dry Douglas-fir or grand fir community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

8. Upland Aspen Forest

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. Quaking aspen groves are the most widespread habitat in North America, but are a minor type throughout eastern Washington and Oregon. Upland Aspen habitat is found in the isolated mountain ranges of southeastern Oregon, e.g., Steens Mountain, and in the northeastern Cascades of Washington. Aspen stands are much more common in the Rocky Mountain states.

Physical Setting. This habitat generally occurs on well-drained mountain slopes or canyon walls that have some moisture. Rockfalls, talus, or stony north slopes are often typical sites. It may occur in steppe on moist microsites, but is not associated with streams, ponds, or wetlands. This habitat is found from 2,000 to 9,500 ft (610 to 2,896 m) elevation.

Landscape Setting. Aspen forms a “subalpine belt” above the Western Juniper and Mountain Mahogany Woodland habitat and below montane Shrub-steppe Habitat and Alpine Grasslands on Steens Mountain in southern Oregon. It can occur in seral stands in the lower Eastside Mixed Conifer Forest and Ponderosa Pine Forest and Woodland habitats. Primary land use is livestock grazing.

Structure. Deciduous trees usually <48 ft (15 m) tall dominate this woodland or forest habitat. The tree layer grows over a forb-, grass-, or low-shrub-dominated undergrowth. Relatively simple two-tiered stands characterize the typical vertical structure of woody plants in this habitat. This habitat is composed of one to many clones of trees with larger trees toward the center of each clone. Conifers invade and create mixed evergreen-deciduous woodland or forest habitats.

Composition. Quaking aspen (*Populus tremuloides*) is the characteristic and dominant tree in this habitat. It is the sole dominant in many stands although scattered ponderosa pine (*Pinus ponderosa*) or Douglas-fir (*Pseudotsuga menziesii*) may be present. Snowberry (*Symphoricarpos oreophilus* and less frequently *S. albus*) is the most common dominant shrub. Tall shrubs, Scouler’s willow (*Salix scouleriana*) and serviceberry (*Amelanchier alnifolia*) may be abundant. On mountain or canyon slopes, antelope bitterbrush (*Purshia tridentata*), mountain big

sagebrush (*Artemisia tridentata* ssp. *vaseyana*), low sagebrush (*A. arbuscula*), and curl-leaf mountain mahogany (*Cercocarpus ledifolius*) often occur in and adjacent to this woodland habitat.

In some stands, pinegrass (*Calamagrostis rubescens*) may dominate the ground cover without shrubs. Other common grasses are Idaho fescue (*Festuca idahoensis*), California brome (*Bromus carinatus*), or blue wildrye (*Elymus glaucus*). Characteristic tall forbs include horsemint (*Agastache* spp.), aster (*Aster* spp.), senecio (*Senecio* spp.), coneflower (*Rudbeckia* spp.). Low forbs include meadowrue (*Thalictrum* spp.), bedstraw (*Galium* spp.), sweetcicely (*Osmorhiza* spp.), and valerian (*Valeriana* spp.).

Other Classifications and Key References. This habitat is called “Aspen” by the Society of American Foresters and “Aspen woodland” by the Society of Range Management. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is aspen groves. Other references describe this habitat^{2, 88, 119, 161, 222}.

Natural Disturbance Regime. Fire plays an important role in maintenance of this habitat. Quaking aspen will colonize sites after fire or other stand disturbances through root sprouting. Research on fire scars in aspen stands in central Utah¹¹⁹ indicated that most fires occurred before 1885, and concluded that the natural fire return interval was 7-10 years. Ungulate browsing plays a variable role in aspen habitat; ungulates may slow tree regeneration by consuming aspen sprouts on some sites, and may have little influence in other stands.

Succession and Stand Dynamics. There is no generalized successional pattern across the range of this habitat. Aspen sprouts after fire and spreads vegetatively into large clonal or multiclinal stands. Because aspen is shade intolerant and cannot reproduce under its own canopy, conifers can invade most aspen habitat. In central Utah, quaking aspen was invaded by conifers in 75-140 years. Apparently, some aspen habitat is not invaded by conifers, but eventually clones deteriorate and succeed to shrubs, grasses, and/or forbs. This transition to grasses and forbs occurs more likely on dry sites.

Effects of Management and Anthropogenic Impacts. Domestic sheep reportedly consume four times more aspen sprouts than do cattle. Heavy livestock browsing can adversely impact aspen growth and regeneration. With fire suppression and alteration of fine fuels, fire rejuvenation of aspen habitat has been greatly reduced since about 1900. Conifers now dominate many seral aspen stands and extensive stands of young aspen are uncommon.

Status and Trends. With fire suppression and change in fire regimes, the Aspen Forest habitat is less common than before 1900. None of the 5 Pacific Northwest upland quaking aspen community types in the National Vegetation Classification are considered imperiled.¹⁰

9. Subalpine Parkland

Rex C. Crawford & Christopher B. Chappell



Geographic Distribution. The Subalpine Parkland habitat occurs throughout the high mountain ranges of Washington and Oregon (e.g., Cascade crest, Olympic Mountains, Wallowa and Blue mountains, and Okanogan Highlands), extends into mountains of Canada and Alaska, and to the Sierra Nevadas and Rocky Mountains.

Physical Setting. Climate is characterized by cool summers and cold winters with deep snowpack, although much variation exists among specific vegetation types. Mountain hemlock sites receive an average precipitation of >50 inches (127 cm) in 6 months and several feet of snow often accumulates. Whitebark pine sites receive 24-70 inches (61-178 cm) per year and some sites only rarely accumulate a significant snowpack. Summer soil drought is possible in eastside parklands but rare in westside areas. Elevation varies from 4,500 to 6,000 ft (1,371 to 1,829 m) in the western Cascades and Olympic Mountains and from 5,000 to 8,000 ft (1,524 to 2,438 m) in the eastern Cascades and Wallowa mountains.

Landscape Setting. The Subalpine Parkland habitat lies above the Mixed Montane Conifer Forest or Lodgepole Pine Forest habitat and below the Alpine Grassland and Shrubland habitat. Associated wetlands in subalpine parklands extend up a short distance into the alpine zone. Primary land use is recreation, watershed protection, and grazing.

Structure. Subalpine Parkland habitat has a tree layer typically between 10 and 30% canopy cover. Openings among trees are highly variable. The habitat appears either as parkland, that is, a mosaic of treeless openings and small patches of trees often with closed canopies, or as woodlands or savanna-like stands of scattered trees. The ground layer can be composed of (1) low to matted dwarf-shrubs (<1 ft [0.3 m] tall) that are evergreen or deciduous and often small-leaved; (2) sod grasses, bunchgrasses, or sedges; (3) forbs; or (4) moss- or lichen-covered soils. Herb or shrub-dominated wetlands appear within the parkland areas and are considered part of this habitat; wetlands can occur as deciduous shrub thickets up to 6.6 ft (2 m) tall, as scattered tall shrubs, as dwarf shrub thickets, or as short

herbaceous plants <1.6 ft (0.5 m) tall. In general, western Cascades and Olympic areas are mostly parklands composed of a mosaic of patches of trees interspersed with heather shrublands or wetlands, whereas, eastern Cascades and Rocky mountain areas are parklands and woodlands typically dominated by grasses or sedges, with fewer heathers.

Composition. Species composition in this habitat varies with geography or local site conditions. The tree layer can be composed of one or several tree species. Subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*) are found throughout the Pacific Northwest, whereas limber pine (*P. flexilis*) is restricted to southeastern Oregon. Alaska yellowcedar (*Chamaecyparis nootkatensis*), Pacific silver fir (*A. amabilis*), and mountain hemlock (*Tsuga mertensiana*) are most common in the Olympics and western Cascades. Whitebark pine (*P. albicaulis*) is found primarily in the eastern Cascades mountains, Okanogan Highlands, and Blue Mountains. Subalpine larch (*Larix lyallii*) occurs only in the northern Cascade Mountains, primarily east of the crest.

West Cascades and Olympic areas generally are parklands. Tree islands often have big huckleberry (*Vaccinium membranaceum*) in the undergrowth interspersed with heather shrublands between. Openings are composed of pink mountain-heather (*Phylodoce empetriformis*), and white mountain-heather (*Cassiope mertensiana*) and Cascade blueberry (*Vaccinium deliciosum*). Drier areas are more woodland or savanna-like, often with low shrubs, such as common juniper (*Juniperus communis*), kinnikinnick (*Arctostaphylos uva-ursi*), low whortleberries or grouseberries (*Vaccinium myrtillus* or *V. scoparium*) or beargrass (*Xerophyllum tenax*) dominating the ground cover. Wetland shrubs in the Subalpine Parkland habitat include bog-laurel (*Kalmia microphylla*), Booth's willow (*Salix boothii*), undergreen willow (*S. commutata*), Sierran willow (*S. eastwoodiae*), and blueberries (*Vaccinium uliginosum* or *V. deliciosum*).

Undergrowth in drier areas may be dominated by pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*C. rossii*), smooth woodrush (*Luzula glabrata* var. *hitchcockii*), Drummond's rush (*Juncus drummondii*), or short fescues (*Festuca viridula*, *F. brachyphylla*, *F. saximontana*). Various sedges are characteristic of wetland graminoid-dominated habitats: black (*Carex nigricans*), Holm's Rocky Mountain (*C. scopulorum*), Sitka (*C. aquatilis* var. *dives*) and Northwest Territory (*C. utriculata*) sedges. Tufted hairgrass (*Deschampsia caespitosa*) is characteristic of subalpine wetlands.

The remaining flora of this habitat is diverse and complex. The following herbaceous broadleaf plants are important indicators of differences in the habitat: American bistort (*Polygonum bistortoides*), American false hellebore (*Veratrum viride*), fringe leaf cinquefoil (*Potentilla flabellifolia*), marsh marigolds (*Caltha leptosepala*), avalanche lily (*Erythronium montanum*), partridgefoot (*Luetkea pectinata*), Sitka valerian (*Valeriana sitchensis*), subalpine

lupine (*Lupinus arcticus* ssp. *subalpinus*), and alpine aster (*Aster alpigenus*). Showy sedge (*Carex spectabilis*) is also locally abundant.

Other Classifications and Key References. This habitat is called the Hudsonian Zone,¹⁵⁵ Parkland subzone,¹³⁴ meadow-forest mosaic,⁷⁴ upper subalpine zone,⁸⁸ Meadows and Park, and Subalpine Parkland.²⁰ Quigley and Arbelbide¹⁸¹ called this habitat Whitebark pine and Whitebark pine-Subalpine larch cover types. Kuchler¹³⁶ included this within the subalpine fir-mountain hemlock forest. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are whitebark-lodgepole pine montane forest and subalpine parkland. Additional references describe this habitat.^{11, 49, 75, 105, 112, 114, 115, 139, 144, 221}

Natural Disturbance Regime. Although fire is rare to infrequent in this habitat, it plays an important role, particularly in drier environments. Whitebark pine woodland fire intervals varied from 50 to 300 years before 1900. Mountain hemlock parkland fire recurrence is 400-800 years. Wind blasting by ice and snow crystals is a critical factor in these woodlands and establishes the higher limits of the habitat. Periodic shifts in climatic factors, such as drought, snowpack depth, or snow duration either allow tree invasions into meadows and shrublands or eliminate or retard tree growth. Volcanic activity plays a long-term role in establishing this habitat. Wetlands are usually seasonally or perennially flooded by snowmelt and springs, or by subirrigation.

Succession and Stand Dynamics. Succession in this habitat occurs through a complex set of relationships between vegetation response to climatic shifts and catastrophic disturbance, and plant species interactions and site modification that create microsites. A typical succession of subalpine trees into meadows or shrublands begins with the invasion of a single tree, subalpine fir and mountain hemlock in the wetter climates and whitebark pine and subalpine larch in drier climates. If the environment allows, tree density slowly increases (over decades to centuries) through seedlings or branch layering by subalpine fir. The tree patches or individual trees change the local environment and create microsites for shade-tolerant trees, Pacific silver fir in wetter areas, and subalpine fir and Engelmann spruce in drier areas. Whitebark pine, an early invading tree, is dispersed long distances by Clark's nutcrackers and shorter distances by mammals. Most other tree species are wind dispersed.

Effects of Management and Anthropogenic Impacts. Fire suppression has contributed to change in habitat structure and functions. For example, the current "average" whitebark pine stand will burn every 3,000 years or longer because of fire suppression. Blister rust, an introduced pathogen, is increasing whitebark pine mortality in these woodlands.⁴ Even limited logging can have prolonged effects because of slow invasion rates of trees. This is particularly important on drier sites and in subalpine larch stands. During wet cycles, fire suppression can lead to

tree islands coalescing and the conversion of parklands into a more closed forest habitat. Parkland conditions can displace alpine conditions through tree invasions. Livestock use and heavy horse or foot traffic can lead to trampling and soil compaction. Slow growth in this habitat prevents rapid recovery.

Status and Trends. This habitat is generally stable with local changes to particular tree variants. Whitebark pine is maybe declining because of the effects of blister rust or fire suppression that leads to conversion of parklands to more closed forest. Global climate warming will likely have an amplified effect throughout this habitat. Less than 10% of Pacific Northwest subalpine parkland community types listed in the National Vegetation Classification are considered imperiled.¹⁰

10. Alpine Grasslands and Shrublands

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This habitat occurs in high mountains throughout the region, including the Cascades, Olympic Mountains, Okanogan Highlands, Wallowa Mountains, Blue Mountains, Steens Mountain in southeastern Oregon, and, rarely, the Siskiyou. It is most extensive in the Cascades from Mount Rainier north and in the Wallowa Mountains. Similar habitats occur throughout mountains of northwestern North America.

Physical Setting. The climate is the coldest of any habitat in the region. Winters are characterized by moderate to deep snow accumulations, very cold temperatures, and high winds. Summers are relatively cool. Growing seasons are short because of persistent snow pack or frost. Blowing snow and ice crystals on top of the snow pack at and above treeline prevent vegetation such as trees from growing above the depth of the snow pack. Snow pack protects vegetation from the effects of this winter wind-related disturbance and from excessive frost heaving. Community composition is much influenced by relative duration of snow burial and exposure to wind and frost heaving.⁷⁵ Elevation ranges from a minimum of 5,000 ft (1,524 m) in parts of the Olympics to •10,000 ft (3,048 m). The topography varies from gently sloping broad ridgetops, to glacial cirque basins, to steep slopes of all aspects. Soils

are generally poorly developed and shallow, though in subalpine grasslands they may be somewhat deeper or better developed. Geologic parent material varies with local geologic history.

Landscape Setting. This habitat always occurs above upper treeline in the mountains or a short distance below it (grasslands in the subalpine parkland zone). Typically, it occurs adjacent to, or in a mosaic with, Subalpine Parkland. Occasionally, it may grade quickly from this habitat down into Montane Mixed Conifer Forest without intervening Subalpine Parkland. In southeastern Oregon, this habitat occurs adjacent to and above Upland Aspen Forest and Shrub-steppe habitats. Small areas of Open Water, Herbaceous Wetlands, and Subalpine Parkland habitats sometimes occur within a matrix of this habitat. Cliffs, talus, and other barren areas are common features within or adjacent to this habitat. Land use is primarily recreation, but in some areas east of the Cascade Crest, it is grazing, especially by sheep.

Structure. This habitat is dominated by grassland, dwarf-shrubland (mostly evergreen microphyllous), or forbs. Cover of the various life forms is extremely variable, and total cover of vascular plants can range from sparse to complete. Patches of krummholz (coniferous tree species maintained in shrub form by extreme environmental conditions) are a common component of this habitat, especially just above upper treeline. In subalpine grasslands, which are considered part of this habitat, widely scattered coniferous trees sometimes occur. Five major structural types can be distinguished: (1) subalpine and alpine bunchgrass grasslands, (2) alpine sedge turf, (3) alpine heath or dwarf-shrubland, (4) fellfield and boulderfield, and (5) snowbed forb community. Fellfields have a large amount of bare ground or rocks with a diverse and variable open layer of forbs, graminoids, and less commonly dwarf-shrubs. Snowbed forb communities have relatively sparse cover of few species of mainly forbs. In the alpine zone, these types often occur in a complex fine-scale mosaic with each other.

Composition. Most subalpine or alpine bunchgrass grasslands are dominated by Idaho fescue (*Festuca idahoensis*), alpine fescue (*F. brachyphylla*), green fescue (*F. viridula*), Rocky Mountain fescue (*F. saximontana*), or timber oatgrass (*Danthonia intermedia*), and to a lesser degree, purple reedgrass (*Calamagrostis purpurascens*), downy oatgrass (*Trisetum spicatum*) or muttongrass (*Poa fendleriana*). Forbs are diverse and sometimes abundant in the grasslands. Alpine sedge turfs may be moist or dry and are dominated by showy sedge (*Carex spectabilis*), black alpine sedge (*C. nigricans*), Brewer's sedge (*C. breweri*), capitate sedge (*C. capitata*), nard sedge (*C. nardina*), dunhead sedge (*C. phaeocephala*), or western single-spike sedge (*C. pseudoscirpoidea*).

One or more of the following species dominates alpine heaths: pink mountain-heather (*Phyllodoce empetriformis*), green mountain-heather (*P. glanduliflora*), white mountain-heather (*Cassiope mertensiana*), or black crowberry (*Empetrum nigrum*). Other less extensive dwarf-shrublands

may be dominated by the evergreen coniferous common juniper (*Juniperus communis*), the evergreen broadleaf kinnikinnick (*Arctostaphylos uva-ursi*), the deciduous shrubby cinquefoil (*Pentaphylloides floribunda*) or willows (*Salix cascadenis* and *S. reticulata* ssp. *nivalis*). Tree species occurring as shrubby krummholz in the alpine are subalpine fir (*Abies lasiocarpa*), whitebark pine (*Pinus albicaulis*), mountain hemlock (*Tsuga mertensiana*), Engelmann spruce (*Picea engelmannii*), and subalpine larch (*Larix lyallii*).

Fellfields and similar communities are typified by variable species assemblages and co-dominance of multiple species, including any of the previously mentioned species, especially the sedges, as well as golden fleabane (*Erigeron aureus*), Lobb's lupine (*Lupinus sellulus* var. *lobbii*), spreading phlox (*Phlox diffusa*), eight-petal mountain-avens (*Dryas octopetala*), louseworts (*Pedicularis contorta*, *P. ornithorhyncha*) and many others. Snowbed forb communities are dominated by Tolmie's saxifrage (*Saxifraga tolmiei*), Shasta buckwheat (*Eriogonum pyrolifolium*), or Piper's woodrush (*Luzula piperi*).

Other Classifications and Key References. This habitat is equivalent to the alpine communities and the subalpine *Festuca* communities of Franklin and Dyrness.⁸⁸ It is also referred to as Alpine meadows and barren No. 52.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are subalpine grassland and alpine fell-snowfields; represented by nonforest in the alpine/parkland zone of Washington Gap.³⁷ Other references describe this habitat.^{61, 65, 75, 80, 94, 105, 112, 123, 139, 195, 207}

Natural Disturbance Regime. Most natural disturbances seem to be small scale in their effects or very infrequent. Herbivory and associated trampling disturbance by elk, mountain goats, and occasionally bighorn sheep seems to be an important disturbance in some areas, creating patches of open ground, though the current distribution and abundance of these ungulates is in part a result of introductions. Small mammals can also have significant effects on vegetation: e.g., the heather vole occasionally overgrazes heather communities.⁸⁰ Frost heaving is a climatically related small-scale disturbance that is extremely important in structuring the vegetation.⁸⁰ Extreme variation from the norm in snow pack depth and duration can act as a disturbance, exposing plants to winter dessication,⁸⁰ shortening the growing season, or facilitating summer drought. Subalpine grasslands probably burn on occasion and can be formed or expanded in area by fires in subalpine parkland.¹³⁹

Succession and Stand Dynamics. Little is known about vegetation changes in these communities, in part because changes are relatively slow. Tree invasion rates into subalpine grasslands are relatively slow compared to other subalpine communities.¹³⁹ Seedling establishment for many plant species in the alpine zone is poor. Heath communities take about 200 years to mature after initial establishment and may occupy the same site for thousands of years.¹³⁹

Effects of Management and Anthropogenic Impacts. The major human impacts on this habitat are trampling and associated recreational impacts, e.g., tent sites. Resistance and resilience of vegetation to impacts varies by life form.⁴⁸ Sedge turfs are perhaps most resilient to trampling and heaths are least resilient. Trampling to the point of significantly opening an alpine heath canopy will initiate a degradation and erosion phase that results in continuous bare ground, largely unsuitable for vascular plant growth.⁸⁰ Bare ground in the alpine zone left alone after recreational disturbance will typically not revegetate in a time frame that humans can appreciate. Introduction of exotic ungulates can have noticeable impacts (e.g., mountain goats in the Olympic Mountains). Domestic sheep grazing has also had dramatic impacts,¹⁹⁶ especially in the bunchgrass habitats east of the Cascades.

Status and Trends. This habitat is naturally very limited in extent in the region. There has been little to no change in abundance over the last 150 years. Most of this habitat is still in good condition and dominated by native species. Some areas east of the Cascade Crest have been degraded by livestock use. Recreational impacts are noticeable in some national parks and wilderness areas. Current trends seem to be largely stable, though there may be some slow loss of subalpine grassland to recent tree invasion. Threats include increasing recreational pressures, continued grazing at some sites, and, possibly, global climate change resulting in expansion of trees into this habitat. Only 1 out of 40 plant associations listed in the National Vegetation Classification is considered imperiled.¹⁰

11. Westside Grasslands

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This habitat is restricted primarily to the Puget Lowland and Willamette Valley ecoregions, with most now occurring in Pierce, Thurston, and San Juan counties, Washington. It also occurs in scattered small outliers in the Coast Range of Oregon, the eastern Olympic Mountains and the Western Cascades of southern Washington and Oregon, and in adjacent southwestern British Columbia.

Physical Setting. The climate is mild and moderately dry (17-55 inches [43-140 cm] mean annual precipitation), with

moist winters and dry summers. Elevation is mostly low and ranges up to a maximum of about 3,500 ft (1,067 m). Topography varies from flat, to mounded or rolling, to steep slopes. Most sites are topographically dry and experience extreme soil drought in the summer. Much of what currently remains of this habitat is found on the South Puget prairies, which are underlain by very deep gravelly/sandy glacial outwash that is excessively well drained. Many other small sites, often called “balds”, have shallow soils overlying bedrock and typically are on south- or west-facing slopes. The habitat also occurs rarely in Oregon on deeper soils that are not excessively drained.

Landscape Setting. This habitat occurs adjacent to or in a mosaic with Westside Riparian-Wetlands, Westside Oak and Dry Douglas-fir Forests and Woodlands, Agriculture, or Urban habitats. Westside grassland habitat occurs less commonly in a matrix of Westside Lowland Conifer-Hardwood Forest. In the San Juan Islands, the habitat sometimes occurs on bluffs or slopes adjacent to marine habitats. Currently this habitat is used for grazing, recreation, and, in the southern Puget Sound area, for military training.

Structure. This habitat is grassland or, less commonly, savanna, with <30% tree or shrub cover. Bunchgrasses predominate in native-dominated sites, with space between the vascular plants typically covered by mosses, fruticose lichens, or native forbs. Montane balds are sometimes dominated in part by short forbs (<1.6ft. [0.6 m]) or dwarf shrubs. Degraded sites are dominated by rhizomatous exotic grasses with some native herbaceous component still present. Scattered trees are either evergreen conifers or deciduous broadleaves. Shrubs may be absent, scattered, or very prominent, and include evergreen and deciduous broadleaf physiognomy.

Composition. The major native dominant bunchgrass is Roemer’s fescue (*Festuca idahoensis* var. *roemerii*). Red fescue (*F. rubra*) and California oatgrass (*Danthonia californica*) are frequently dominant or co-dominant on a local basis. Long-stolon sedge (*Carex inops*) is occasionally co-dominant, especially in savannas and in the Columbia Gorge. Slender wheatgrass (*Elymus trachycaulus*), blue wildrye (*Elymus glaucus*), prairie junegrass (*Koeleria macrantha*), and Lemmon’s needlegrass (*Stipa lemmonii*) can be important locally. Major exotic dominant species are colonial bentgrass (*Agrostis capillaris*), sweet vernalgrass (*Anthoxanthum odoratum*), Kentucky bluegrass (*Poa pratensis*), tall oatgrass (*Arrhenatherum elatius*), medusahead (*Taeniatherum caput-medusae*), tall fescue (*F. arundinacea*), and soft brome (*Bromus mollis*). Common camas (*Camassia quamash*) is probably the most important forb in terms of cover, but it rarely dominates. The bracken fern (*Pteridium aquilinum*) is sometimes co-dominant. A rich diversity of native forbs is typical of sites in good condition.

Roemer’s fescue is distributed throughout the Puget Lowland and the Willamette Valley and in montane balds of the eastern and northeastern Olympics. Native red fescue is a major component near saltwater in the northern

Puget Lowland and in montane balds of the Oregon Coast Range and the Columbia Gorge. Non-native varieties of red fescue can occur throughout the area, especially in degraded habitats. California oatgrass communities are found in the San Juan Islands and in the Willamette Valley. Junegrass is a co-dominant in some montane balds and the Willamette Valley prairies; it occurs less abundantly throughout the area. Lemmon’s needlegrass is primarily found on shallow-soiled balds of Willamette Valley fringes and the San Juan Islands.

The most common savanna tree is Douglas-fir (*Pseudotsuga menziesii*). Oregon white oak (*Quercus garryana*) formerly was part of extensive savannas, but is now rare in that structural condition. Ponderosa pine (*Pinus ponderosa*) is very local. The most common shrub is the exotic species Scot’s broom (*Cytisus scoparius*), which frequently forms open stands over the grass. Common snowberry (*Symphoricarpos albus*), Nootka rose (*Rosa nutkana*), poison-oak (*Toxicodendron diversilobum*), and serviceberry (*Amelanchier alnifolia*) are other common shrubs. The dwarf shrubs kinnikinnick (*Arctostaphylos uva-ursi*) and common juniper (*Juniperus communis*) sometimes dominate small areas in montane balds, and the former sometimes on South Puget prairies. *Racomitrium canescens* is the most common ground moss.

Other Classifications and Key References. Portions of this habitat have been referred to as prairies by many authors. Franklin and Dyrness⁸⁸ described this habitat as prairie in the Puget Sound area, grassland in the San Juan Islands and Interior Valley zone of Oregon, and grass balds in the Oregon Coast Range. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ effort did not map this type; it was inadvertently aggregated with the agriculture classification. The Washington Gap project mapped this habitat as part of nonforested in the Woodland/Prairie Mosaic Zone. Other references describe elements of this habitat.^{7, 40, 41, 54, 99, 142, 211}

Natural Disturbance Regime. Historically, fire was a major component of this habitat. In addition to occasional lightning strikes, fires were intentionally set by indigenous inhabitants to maintain food staples such as camas and bracken fern.¹⁶⁵ Although there is no definitive fire history information, evidence suggests that many, if not most, of these grasslands burned every few years. Annual soil drought naturally eliminated or thinned invading trees and promoted higher frequency fire regimes in the past.

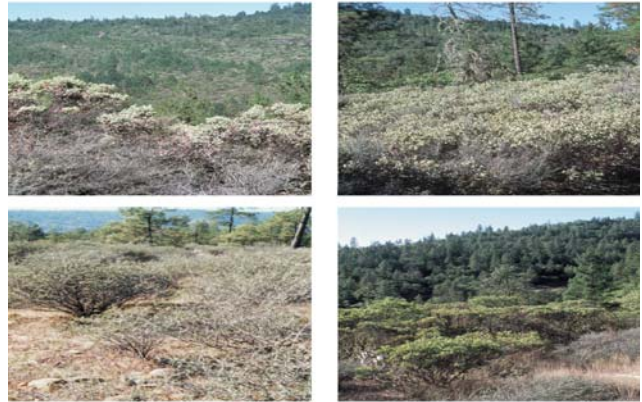
Succession and Stand Dynamics. Historically, regular fires or extreme environmental conditions on the most xeric sites prevented the establishment and continued growth of most woody vegetation, thereby maintaining the grasslands and oak savannas. In some patches, scattered oaks or even Douglas-fir survived long enough to obtain some fire resistance and the frequent light fires then helped to maintain savannas.^{1,41} Oaks were also able to resprout if the above-ground stem was killed. High fire frequencies combined with digging of roots by Native Americans could have favored the abundance of forbs over that of grasses in many areas of the pre-European landscape.

Effects of Management and Anthropogenic Impacts. The exclusion of fire from most of this habitat over the last 100+ years has resulted in profound changes. Oak savanna has, for all practical purposes, disappeared from the landscape.⁴¹ Douglas-fir encroachment, in the absence of fire, is a “natural” process that occurs eventually on the vast majority of westside grasslands, except perhaps on the very driest sites. This encroachment leads to the conversion of grasslands to forests. Fire exclusion has also resulted in increases in shrub cover and the conversion of some grasslands to shrublands. Exotic species are prominent in this habitat and generally increase after ground-disturbing activities like grazing or off-road vehicle use. Scot’s broom, tall oatgrass, colonial bentgrass, sweet vernalgrass, tall fescue, common velvetgrass (*Holcus lanatus*), Kentucky bluegrass, soft brome, common St. Johnswort (*Hypericum perforatum*), and hairy catsear (*Hypochaeris radicata*) are among the most troublesome species. The dominant native grass, Roemer’s fescue, can be eliminated with heavy grazing. Prescribed fire and other management tools have been used recently to control Scot’s broom, Douglas-fir encroachment, and to attempt to mimic historical conditions in some areas.⁷⁸

Status and Trends. This habitat is very rare and limited in areal extent. In the southern Puget Sound area, only about 10% of the original area of the habitat is extant, and only 3% is dominated by native species.⁵⁴ Overall decline is significantly greater than these figures suggest because the habitat is even more decimated and degraded elsewhere. Causes of the decline are fire suppression, conversion to agriculture and urban, and invasion of exotic species. Most of what remains is dominated or co-dominated by exotic species. Current trends are continued decline both in area and condition. Ongoing threats include urban conversion, increase of exotic species, ground disturbance via tracked vehicle use for military training, and effects of fire suppression. Eleven out of 12 native plant associations representing this habitat listed for the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

12. *Ceanothus-Manzanita* Shrublands

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This habitat ranges from southwestern Oregon south through much of California. Within Oregon, it is primarily located in the Rogue and Illinois valleys in Curry, Josephine, and Jackson counties; it is also found scattered in the Siskiyou Mountains of the same counties, in Douglas County, and in the southern Cascades of Jackson and western Klamath counties.

Physical Setting. Climate is mostly very warm and relatively dry (about 17-30 inches [43-76 cm] mean annual precipitation), but extends less commonly on serpentine or extremely dry sites into somewhat cooler and moister climates (up to 50 inches [127 cm] annual precipitation). Summers are very dry; winters are only slightly cool, much warmer than shrublands on the eastside. Primary elevation range is about 1,000-2,000 ft (305-610 m), but extends up to a maximum of 5,000 ft (1,524 m). Topography is typified by mainly lower valley slopes and foothills, but extends to nearly flat valley bottoms (where before European settlement this habitat was a major type) and sporadically onto mountain slopes. This habitat tends to occur on southern aspects when it does occur outside of low valleys. Soils are typically shallow to bedrock or are derived from coarse alluvial deposits. Ultramafic bedrock is a major parent material in the western Siskiyou Mountains, whereas the eastern Siskiyou Mountains and adjacent valleys are largely volcanic.

Landscape Setting. This habitat occurs adjacent to or in a mosaic with Southwest Oregon Mixed Conifer-Hardwood Forest, Westside Oak and Dry Douglas-fir Forest and Woodlands, Agriculture, and rarely, Westside Grassland. Urban is also adjacent in a few areas. Westside Riparian-Wetlands habitat occurs as small inclusions within this habitat. This habitat covers large areas only in lower elevation valleys or on extensive areas of serpentine soils. At moderate to high elevations it is mainly small patches within a forest mosaic. Major land use of this habitat is grazing and low-density residential development.

Structure. This habitat consists mainly of shrubland dominated by sclerophyllous evergreen broadleaf shrubs, but can also include grasslands with scattered tall shrubs.

Deciduous broadleaf shrubs are less important, but are in some cases dominant. The shrubs are mostly 3.3–13 ft (1–4 m) high. Shrub canopy ranges from very open to completely closed. Herbaceous cover varies inversely with shrub canopy cover. Perennial bunchgrasses are the dominant understory at sites in good condition, whereas annual grasses dominate at sites in poorer condition. If shrubs are not too dense, forbs are abundant. Historically, many of these shrublands were probably grasslands with scattered shrubs. Occasional conifers or broadleaf trees are sometimes scattered in the habitat.

Composition. Sclerophyllous and hemi-sclerophyllous shrubs that dominate are, most commonly, wedge-leaf ceanothus (*Ceanothus cuneatus*) and white-leaf manzanita (*Arctostaphylos viscida*), and less commonly, chaparral whitethorn (*Ceanothus leucodermis*), blueblossom (*C. thrysiflorus*), deerbrush (*C. integerrimus*), and deer oak (*Quercus sadleriana*). Wedge-leaf ceanothus is the most abundant species at low elevations in the major valleys and is the shrub most tolerant of xeric conditions. Other common, but not typically dominant shrubs include hairy manzanita (*Arctostaphylos columbiana*), pinemat manzanita (*A. nevadensis*), birchleaf mountain-mahogany (*Cercocarpus montanus* var. *glaber*), Klamath plum (*Prunus subcordata*), bitter cherry (*P. emarginata*), chokecherry (*P. virginiana*), Brewer's oak (*Quercus garryana* var. *breweriana*), huckleberry oak (*Q. vacciniifolia*), California yerba-santa (*Eriodictyon californicum*), and bearbrush (*Garrya fremontii*).

The native bunchgrasses are Idaho fescue (*Festuca idahoensis*), California fescue (*F. californica*), California oatgrass (*Danthonia californica*), Lemmon's needlegrass (*Stipa lemmonii*), western needlegrass (*S. occidentalis*), and bluegrass (*Poa secunda*). Forb diversity is often high and common genera include *Lilium*, *Calochortus*, *Fritillaria*, *Microseris*, *Monardella*, and *Erigeron*. One of several species of oak (*Quercus*) or pine (*Pinus*), Douglas-fir (*Pseudotsuga menziesii*), or incense cedar (*Calocedrus decurrens*) are sometimes present as scattered individuals, especially on less xeric sites.

Other Classifications and Key References. Franklin and Dyrness⁸⁸ referred to this habitat as sclerophyllous shrub communities in the interior valleys of Oregon. It is also called chaparral.^{125, 130, 141} The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is Siskiyou Mountain serpentine shrubland. Other references include describe aspects of this habitat.^{69, 188}

Natural Disturbance Regime. Fire is the major natural disturbance. Fire regimes have not been studied in Oregon, but in central California the fire-return interval has been estimated at 30–60 years.⁸⁴ Fire frequency may have been greater during historic times based on chaparral fire regimes in southern California.¹⁵⁷ High-severity fires are typical, with most shrubs being top-killed.

Succession and Stand Dynamics. Wedge-leaf ceanothus and white-leaf manzanita are killed by fire. Some less common shrubs sprout after fire. The dominant shrub

species regenerate abundantly after fire from a long-lived seedbank that is scarified by fire.¹⁸⁷ Many seedlings die in the first 3 years after fire.⁵⁰ Wedge-leaf ceanothus can maintain prominence for >100 years.¹²⁴ Shrub canopy cover generally increases up to 30 years or so after the last fire, and in the absence of another fire, the herbaceous understory can be reduced under dense late-successional shrub canopies. Wedge-leaf ceanothus is considered a climax, or late-successional, dominant species on low-elevation dry sites in the Rogue Valley and on some serpentine sites.^{14, 69} On many other sites, this habitat seems to be maintained by occasional fires, and trees, especially oaks and ponderosa pine, will gradually increase in the absence of fire.

Effects of Management and Anthropogenic Impacts. Fire suppression has probably increased the predominance of dense, tall shrub stands versus a more open, patchy structure. It also seems to reduce the cover of bunchgrasses and forbs as stands become old. Grazing reduces native bunchgrasses in favor of exotics and/or the native rhizomatous California brome (*Bromus carinatus*). Exotic species that have successfully invaded the understory of this habitat are soft brome (*Bromus mollis*), medusahead (*Taeniatherum caput-medusae*), hedgehog dogtail (*Cynosurus echinatus*), and yellow star-thistle (*Centaurea solstitialis*).

Status and Trends. This habitat occupies a small area within this region; it has declined considerably because of conversion to agriculture, residential development, and fire suppression. Most of this habitat has been degraded by fire suppression, grazing, and exotic species invasions. This habitat is still declining in extent from development pressures. One out of 7 Oregon plant associations listed in the National Vegetation Classification is considered imperiled globally,¹⁰ but this type of vegetation has been poorly studied in Oregon and there may be other associations.

13. Western Juniper and Mountain Mahogany Woodlands

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. This habitat is distributed from the Pacific Northwest south into southern California and east to western Montana and Utah, where it often occurs with pinyon-juniper habitat. In Oregon and Washington, this dry woodland habitat appears primarily in the Owyhee Uplands, High Lava Plains, and northern Basin and Range ecoregions. Secondarily, it develops in the foothills of the Blue Mountains and East Cascades ecoregions, and seems to be expanding into the southern Columbia Basin ecoregion, where it was naturally found in outlier stands.

Western juniper woodlands with shrub-steppe species appear throughout the range of the habitat primarily in central and southern Oregon. Many isolated mahogany communities occur throughout canyons and mountains of eastern Oregon. Juniper-mountain mahogany communities are found in the Ochoco and Blue Mountains.

Physical Setting. This habitat is widespread and variable, occurring in basins and canyons, and on slopes and valley margins in the southern Columbia Plateau, and on fire-protected sites in the northern Basin and Range province. It may be found on benches and foothills. Western juniper and/or mountain mahogany woodlands are often found on shallow soils, on flats at mid- to high elevations, usually on basalts. Other sites range from deep, loess soils and sandy slopes to very stony canyon slopes. At lower elevations, or in areas outside of shrub-steppe, this habitat occurs on slopes and in areas with shallow soils. Mountain mahogany can occur on steep rimrock slopes, usually in areas of shallow soils or protected slopes. This habitat can be found at elevations of 1,500- 8,000 ft (457-2,438 m), mostly between 4,000-6,000 ft (1,220-1,830 m). Average annual precipitation ranges from approximately 10 to 13 inches (25 to 33 cm), with most occurring as winter snow.

Landscape Setting. This habitat reflects a transition between Ponderosa Pine Forest and Woodlands and Shrub-steppe, Eastside Grasslands, and rarely Desert Playa and Salt Desert Scrub habitats. Western juniper generally occurs on higher topography, whereas the shrub

communities are more common in depressions or steep slopes with bunchgrass undergrowth. In the Great Basin, mountain mahogany may form a distinct belt on mountain slopes and ridgetops above pinyon-juniper woodland. Mountain mahogany can occur in isolated, pure patches that are often very dense. The primary land use is livestock grazing.

Structure. This habitat is made up of savannas, woodlands, or open forests with 10-60% canopy cover. The tallest layer is composed of short (6.6-40 ft [2-12 m] tall) evergreen trees. Dominant plants may assume a tall-shrub growth form on some sites. The short trees appear in a mosaic pattern with areas of low or medium-tall (usually evergreen) shrubs alternating with areas of tree layers and widely spaced low or medium-tall shrubs. The herbaceous layer is usually composed of short or medium tall bunchgrass or, rarely, a rhizomatous grass-forb undergrowth. These vegetated areas can be interspersed with rimrock or scree. A well-developed cryptogam layer often covers the ground, although bare rock can make up much of the ground cover.

Composition. Western juniper and/or mountain mahogany dominate these woodlands either with bunchgrass or shrub-steppe undergrowth. Western juniper (*Juniperus occidentalis*) is the most common dominant tree in these woodlands. Part of this habitat will have curl-leaf mountain mahogany (*Cercocarpus ledifolius*) as the only dominant tall shrub or small tree. Mahogany may be co-dominant with western juniper. Ponderosa pine (*Pinus ponderosa*) can grow in this habitat and in some rare instances may be an important part of the canopy.

The most common shrubs in this habitat are basin, Wyoming, or mountain big sagebrush (*Artemisia tridentata* ssp. *tridentata*, ssp. *wyomingensis*, and ssp. *vaseyana*) and/or bitterbrush (*Purshia tridentata*). They usually provide significant cover in juniper stands. Low or stiff sagebrush (*Artemisia arbuscula* or *A. rigida*) are dominant dwarf shrubs in some juniper stands. Mountain big sagebrush appears most commonly with mountain mahogany and mountain mahogany mixed with juniper. Snowbank shrubland patches in mountain mahogany woodlands are composed of mountain big sagebrush with bitter cherry (*Prunus emarginata*), quaking aspen (*Populus tremuloides*), and serviceberry (*Amelanchier alnifolia*). Shorter shrubs such as mountain snowberry (*Symphoricarpos oreophilus*) or creeping Oregongrape (*Mahonia repens*) can be dominant in the undergrowth. Rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*) will increase with grazing.

Part of this woodland habitat lacks a shrub layer. Various native bunchgrasses dominate different aspects of this habitat. Sandberg bluegrass (*Poa sandbergii*), a short bunchgrass, is the dominant and most common grass throughout many juniper sites. Medium-tall bunchgrasses such as Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needlegrasses (*Stipa occidentalis*, *S. thurberiana*, *S. lemmonii*), bottlebrush squirreltail (*Elymus elymoides*) can dominate undergrowth.

Threadleaf sedge (*Carex filifolia*) and basin wildrye (*Leymus cinereus*) are found in lowlands and Geyer's and Ross' sedge (*Carex geyeri*, *C. rossii*), pinegrass (*Calamagrostis rubescens*), and blue wildrye (*E. glaucus*) appear on mountain foothills. Sandy sites typically have needle-and-thread (*Stipa comata*) and Indian ricegrass (*Oryzopsis hymenoides*). Cheatgrass (*Bromus tectorum*) or bulbous bluegrass (*Poa bulbosa*) often dominate overgrazed or disturbed sites. In good condition this habitat may have mosses growing under the trees.

Other Classifications and Key References. This habitat is also called Juniper Steppe Woodland.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are ponderosa pine-western juniper woodland, western juniper woodland, and mountain mahogany shrubland. Other references describe this habitat.^{64, 79, 122, 207}

Natural Disturbance Regime. Both mountain mahogany and western juniper are fire intolerant. Under natural high-frequency fire regimes both species formed savannas or occurred as isolated patches on fire-resistant sites in shrub-steppe or steppe habitat. Western juniper is considered a topoedaphic climax tree in a number of sagebrush-grassland, shrub-steppe, and drier conifer sites. It is an increaser in many earlier seral communities in these zones and invades without fires. Most trees >13 ft (4 m) tall can survive low-intensity fires. The historic fire regime of mountain mahogany communities varies with community type and structure. The fire-return interval for mountain mahogany (along the Salmon River in Idaho) was 13-22 years until the early 1900's and has increased ever since. Mountain mahogany can live to 1,350 years in western and central Nevada. Some old-growth mountain mahogany stands avoid fire by growing on extremely rocky sites.

Succession and Stand Dynamics. Juniper invades shrub-steppe and steppe and reduces undergrowth productivity. Although slow seed dispersal delays recovery time, western juniper can regain dominance in 30-50 years following fire. A fire-return interval of 30-50 years typically arrests juniper invasion. The successional role of curl-leaf mountain mahogany varies with community type. Mountain brush communities where curl-leaf mountain mahogany is either dominant or co-dominant are generally stable and successional rates are slow.

Effects of Management and Anthropogenic Impacts. Over the past 150 years, with fire suppression, overgrazing, and changing climatic factors, western juniper has increased its range into adjacent shrub-steppe, grasslands, and savannas. Increased density of juniper and reduced fine fuels from an interaction of grazing and shading result in high severity fires that eliminate woody plants and promote herbaceous cover, primarily annual grasses. Diverse mosses and lichens occur on the ground in this type if it has not been too disturbed by grazing. Excessive grazing will decrease bunchgrasses and increase exotic annual grasses plus various native and exotic forbs.

Animals seeking shade under trees decrease or eliminate bunchgrasses and contribute to increasing cheatgrass cover.

Status and Trends. This habitat is dominated by fire-sensitive species, and therefore, the range of western juniper and mountain mahogany has expanded because of an interaction of livestock grazing and fire suppression. Quigley and Arbelbide¹⁸¹ concluded that in the Inland Pacific Northwest, Juniper/Sagebrush, Juniper Woodlands, and Mountain Mahogany cover types now are significantly greater in extent than before 1900. Although it covers more area, this habitat is generally in degraded condition because of increased exotic plants and decreased native bunchgrasses. One third of Pacific Northwest juniper and mountain mahogany community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

14 Eastside Canyon Shrublands

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. This habitat occurs primarily on steep canyon slopes in the Blue Mountains and the margins of the Columbia Basin in Idaho, Oregon, and Washington. This habitat also appears as isolated patches across Washington's Columbia Basin.

Physical Setting. This habitat develops in hot dry climates in the Pacific Northwest. Annual precipitation totals 12-20 inches (31-51 cm); only 10% falls in the hottest months, July through September. Snow accumulation is low (1-6 inches [3-15 cm]), persisting only a few weeks. Sites are generally steep (>60%) on all aspects but most common on northerly aspects in deep, dry canyons. Columbia River basalt is the major geologic substrate although many sites are underlain with loess deposits mixed with colluvium. Steep northerly aspects in the Palouse Hills can also support this habitat. This habitat is found from 500 to 5,000 ft (152 to 1,524 m) in elevation.

Landscape Setting. This habitat is generally found in steep canyons surrounded by the Eastside Grassland Habitat and below or in a mosaic with the Ponderosa Pine Forest and Woodland habitat. This habitat can develop near talus

slopes, at the heads of dry drainages, and toe slopes in moist shrub-steppe and steppe zones. At lower elevation sites, these are more often in a mix with bluebunch wheatgrass, dry rocky grasslands, and low-elevation riparian habitats. The primary surrounding land use is livestock grazing.

Structure. The Eastside Canyon Shrubland habitat is generally a mix of tall (5 ft [1.5 m]) to medium (1.6 ft [0.5 m]) deciduous shrublands in a mosaic with bunchgrass or annual grasslands. Shrub canopies are almost always closed (>60% cover), forming a thicket of interwoven stems and branches. Shrub layers can be one or two-tiered but often are so dense they restrict the herbaceous layer to shade-tolerant rhizomatous species.

Composition. Mallowleaf ninebark (*Physocarpus malvaceus*), a major dominant, bitter cherry (*Prunus emarginata*), chokecherry (*Prunus virginiana*), oceanspray (*Holodiscus discolor*) or Rocky Mountain maple (*Acer glabrum*) are the most common tall shrubs in this habitat. In moist areas, black hawthorn (*Crataegus douglasii*) may appear and can dominate some sites as a tall shrub or small tree. Other tall shrubs such as syringa (*Philadelphus lewisii*) or serviceberry (*Amelanchier alnifolia*) often dominate sites associated with talus. Common medium-tall shrubs are common snowberry (*Symphoricarpos albus*), rose (*Rosa nutkana*, *R. woodsii*), smooth sumac (*Rhus glabra*), and currants (*Ribes* spp.). Basin or Wyoming big sagebrush (*Artemisia tridentata* ssp. *tridentata* or *A. t.* ssp. *wyomingensis*), along with rabbitbrush (*Chrysothamnus* spp.), may be important members of these thickets in weedy sites, dry areas, or transitions with grasslands. Scattered ponderosa pine (*Pinus ponderosa*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and rarely Douglas-fir (*Pseudotsuga menziesii*) trees may be found in and adjacent to this habitat.

Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Thurber's needlegrass (*Stipa thurberiana*), and Sandberg's bluegrass (*Poa sandbergii*) found in the surrounding steppe or shrub-steppe are common but never abundant in these thickets. Basin wildrye (*Leymus cinereus*) can be locally important. Kentucky bluegrass (*Poa pratensis*) is a common introduced grass and, where grazed by livestock, is a dominant undergrowth species. Annual grasses (*Bromus tectorum*, *B. briziformis*) can be abundant especially on disturbed dry sites. Cleavers (*Galium aparine*) is a frequent member of the herbaceous component of this habitat. Other common forbs include red avens (*Geum triflorum*), horsemint (*Agastache urticifolia*), sticky cinquefoil (*Potentilla gracilis*), balsamroots (*Balsamorhiza* spp.), and fleabanes (*Erigeron* spp.).

Other Classifications and Key References. This habitat is called shrub garland⁸⁸ or talus thickets. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is eastside big sagebrush shrubland. Other references describe this habitat.^{60, 122, 123, 207}

Natural Disturbance Regime. This habitat is within the sagebrush and bunchgrass vegetation type of Barrett et al.²² who concluded it had a fire-return interval of 25 years. Canyon shrublands associated with talus burn less frequently but are subject to talus movement. Similar shrubfields are associated with forest landscapes and are early seral stages of the Eastside Mixed Conifer Forest Habitat.

Succession and Stand Dynamics. Many of the major shrubs sprout following fire and will be maintained with moderate fire frequency. Most thickets will increase in size without fire. This habitat has increased primarily in moist steppe and shrub-steppe habitat with fire suppression and restricted grazing. Prolonged fire suppression may lead to invasions by tree species. Apparently some representatives of this habitat could potentially support Douglas-fir or ponderosa pine woodlands after a long fire-free period.

Effects of Management and Anthropogenic Impacts. Livestock grazing in adjacent grassland or shrub-steppe habitat changes the surrounding fine-fuel matrix for fire. That, combined with fire suppression, leads to a change in habitat patch size, structure, and composition. In response to fire suppression, shrub thickets on northerly aspects near lower treeline tend to increase in patch size and height and are invaded by tree species. With heavy livestock grazing, shrubs are browsed, broken, and trampled, which eventually creates a more open shrubland with a more abundant herbaceous layer.

Status and Trends. The Eastside Canyon Shrubland habitat is restricted in range and probably has increased locally in area. Johnson and Simon¹²³ reported increases in common snowberry-rose communities as a response to fire suppression and heavy grazing that depleted bunchgrass cover. One of the three Eastside Canyon Shrubland community types in the National Vegetation Classification is considered imperiled.¹⁰

15. Eastside Grasslands

Rex.C. Crawford & Jimmy Kagan



Geographic Distribution. This habitat is found primarily in the Columbia Basin of Idaho, Oregon, and Washington, at mid- to low elevations and on plateaus in the Blue Mountains, usually within the ponderosa pine zone in Oregon.

Idaho fescue grassland habitats were formerly widespread in the Palouse region of southeastern Washington and adjacent Idaho; most of this habitat has been converted to agriculture. Idaho fescue grasslands still occur in isolated, moist sites near lower treeline in the foothills of the Blue Mountains, the Northern Rockies, and east Cascades near the Columbia River Gorge. Bluebunch wheatgrass grassland habitats are common throughout the Columbia Basin, both as modified native grasslands in deep canyons and the dry Palouse and as fire-induced representatives in the shrub-steppe. Similar grasslands appear on the High Lava Plains ecoregion, where they occur in a matrix with big sagebrush or juniper woodlands. In Oregon they are also found in burned shrub-steppe and canyons in the Basin and Range and Owyhee Uplands. Sand dropseed and three-awn needlegrass grassland habitats are restricted to river terraces in the Columbia Basin, Blue Mountains, and Owyhee Uplands of Oregon and Washington. Primary location of this habitat extends along the Snake River from Lewiston south to the Owyhee River.

Physical Setting. This habitat develops in hot, dry climates in the Pacific Northwest. Annual precipitation totals 8-20 inches (20-51 cm); only 10% falls in the hottest months, July through September. Snow accumulation is low (1-6 inches [3-15 cm]) and occurs only in January and February in eastern portions of its range and November through March in the west. More snow accumulates in grasslands within the forest matrix. Soils are variable: (1) highly productive loess soils up to 51 inches (130 cm) deep, (2) rocky flats, (3) steep slopes, and (4) sandy, gravel or cobble soils. An important variant of this habitat occurs on sandy, gravelly, or silty river terraces or seasonally exposed river gravel or Spokane flood deposits. The grassland habitat is typically upland vegetation but it may also include

riparian bottomlands dominated by non-native grasses. This habitat is found from 500 to 6,000 ft (152-1,830 m) in elevation.

Landscape Setting. Eastside grassland habitats appear well below and in a matrix with lower treeline Ponderosa Pine Forest and Woodlands or Western Juniper and Mountain Mahogany Woodlands. It can also be part of the lower elevation forest matrix. Most grassland habitat occurs in two distinct large landscapes: plateau and canyon grasslands. Several rivers flow through narrow basalt canyons below plateaus supporting prairies or shrub-steppe. The canyons can be some 2,132 ft (650 m) deep below the plateau. The plateau above is composed of gentle slopes with deep silty loess soils in an expansive rolling dune-like landscape. Grasslands may occur in a patchwork with shallow soil scablands or within biscuit scablands or mounded topography. Naturally occurring grasslands are beyond the range of bitterbrush and sagebrush species. This habitat exists today in the shrub-steppe landscape where grasslands are created by brush removal, chaining or spraying, or by fire. Agricultural uses and introduced perennial plants on abandoned or planted fields are common throughout the current distribution of eastside grassland habitats.

Structure. This habitat is dominated by short to medium-tall grasses (<3.3 ft [1 m]). Total herbaceous cover can be closed to only sparsely vegetated. In general, this habitat is an open and irregular arrangement of grass clumps rather than a continuous sod cover. These medium-tall grasslands often have scattered and diverse patches of low shrubs, but few or no medium-tall shrubs (<10% cover of shrubs are taller than the grass layer). Native forbs may contribute significant cover or they may be absent. Grasslands in canyons are dominated by bunchgrasses growing in lower densities than on deep-soil prairie sites. The soil surface between perennial plants can be covered with a diverse cryptogamic or microbiotic layer of mosses, lichens, and various soil bacteria and algae. Moister environments can support a dense sod of rhizomatous perennial grasses. Annual plants are a common spring and early summer feature of this habitat.

Composition. Bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*) are the characteristic native bunchgrasses of this habitat and either or both can be dominant. Idaho fescue is common in more moist areas and bluebunch wheatgrass more abundant in drier areas. Rough fescue (*F. campestris*) is a characteristic dominant on moist sites in northeastern Washington. Sand dropseed (*Sporobolus cryptandrus*) or three-awn (*Aristida longisetata*) are native dominant grasses on hot dry sites in deep canyons. Sandberg bluegrass (*Poa sandbergii*) is usually present, and occasionally codominant in drier areas. Bottlebrush squirreltail (*Elymus elymoides*) and Thurber needlegrass (*Stipa thurberiana*) can be locally dominant. Annual grasses are usually present; cheatgrass (*Bromus tectorum*) is the most widespread. In addition, medusahead (*Taeniatherum caput-medusae*), and other

annual bromes (*Bromus commutatus*, *B. mollis*, *B. japonicus*) may be present to co-dominant. Moist environments, including riparian bottomlands, are often co-dominated by Kentucky bluegrass (*Poa pratensis*).

A dense and diverse forb layer can be present or entirely absent; >40 species of native forbs can grow in this habitat including balsamroots (*Balsamorhiza* spp.), biscuitroots (*Lomatium* spp.), buckwheat (*Eriogonum* spp.), fleabane (*Erigeron* spp.), lupines (*Lupinus* spp.), and milkvetches (*Astragalus* spp.). Common exotic forbs that can grow in this habitat are knapweeds (*Centaurea solstitialis*, *C. diffusa*, *C. maculosa*), tall tumbled mustard (*Sisymbrium altissimum*), and Russian thistle (*Salsola kali*).

Smooth sumac (*Rhus glabra*) is a deciduous shrub locally found in combination with these grassland species. Rabbitbrushes (*Chrysothamnus nauseosus*, *C. viscidiflorus*) can occur in this habitat in small amounts, especially where grazed by livestock. In moist Palouse regions, common snowberry (*Symphoricarpos albus*) or Nootka rose (*Rosa nutkana*) may be present, but is shorter than the bunchgrasses. Dry sites contain low succulent pricklypear (*Opuntia polyacantha*). Big sagebrush (*Artemisia tridentata*) is occasional and may be increasing in grasslands on former shrub-steppe sites. Black hawthorn (*Crataegus douglasii*) and other tall shrubs can form dense thickets near Idaho fescue grasslands. Rarely, ponderosa pine (*Pinus ponderosa*) or western juniper (*Juniperus occidentalis*) can occur as isolated trees.

Other Classifications and Key References. This habitat is called Palouse Prairie, Pacific Northwest grassland, steppe vegetation, or bunchgrass prairie in general ecological literature. Quigley and Arbelbide¹⁸¹ called this habitat Fescue-Bunchgrass and Wheatgrass Bunchgrass and the dry Grass cover type. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are northeast Oregon canyon grassland, forest-grassland mosaic, and modified grassland; Washington Gap³⁷ types 13, 21, 22, 24, 29-31, 82, and 99 map this habitat. Kuchler¹³⁶ includes this within Fescue-wheatgrass and wheatgrass-bluegrass. Franklin and Dyrness⁸⁸ include this habitat in steppe zones of Washington and Oregon. Other references describe this habitat.^{1, 28, 60, 159, 166, 206, 207}

Natural Disturbance Regime. The fire-return interval for sagebrush and bunchgrass is estimated at 25 years.²² The native bunchgrass habitat apparently lacked extensive herds of large grazing and browsing animals until the late 1800s. Burrowing animals and their predators likely played important roles in creating small-scale patch patterns.

Succession and Stand Dynamics. Currently fires burn less frequently in the Palouse grasslands than historically because of fire suppression, roads, and conversions to cropland.¹⁵⁹ Without fire, black hawthorn shrubland patches expand on slopes along with common snowberry and rose. Fires covering large areas of Shrub-steppe habitat can eliminate shrubs and their seed sources and create Eastside Grasslands habitat. Fires that follow heavy

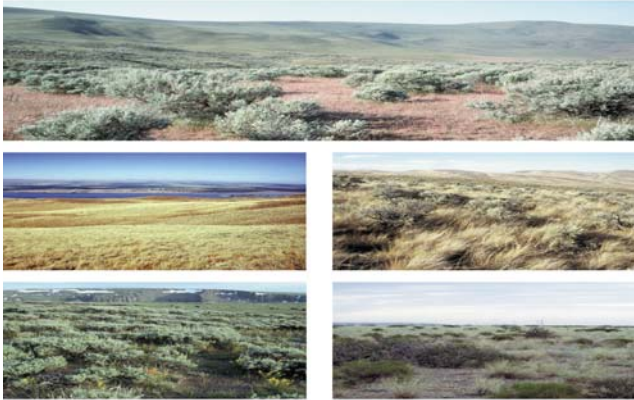
grazing or repeated early season fires can result in annual grasslands of cheatgrass, medusahead, knapweed, or yellow star-thistle. Annual exotic grasslands are common in dry grasslands and are included in modified grasslands as part of the Agriculture habitat.

Effects of Management and Anthropogenic Impacts. Large expanses of grasslands are currently used for livestock ranching. Deep soil Palouse sites are mostly converted to agriculture. Drier grasslands and canyon grasslands, those with shallower soils, steeper topography, or hotter, drier environments, were more intensively grazed and for longer periods than were deep-soil grasslands.²⁰⁷ Evidently, these drier native bunchgrass grasslands changed irreversibly to persistent annual grass and forblands. Some annual grassland, native bunchgrass, and shrub-steppe habitats were converted to intermediate wheatgrass, or more commonly, crested wheatgrass (*Agropyron cristatum*)-dominated areas. Apparently, these form persistent grasslands and are included as modified grasslands in the Agriculture habitat. With intense livestock use, some riparian bottomlands become dominated by non-native grasses. Many native dropseed grasslands have been submerged by dam reservoirs.

Status and Trends. Most of the Palouse prairie of southeastern Washington and adjacent Idaho and Oregon has been converted to agriculture. Remnants still occur in the foothills of the Blue Mountains and in isolated, moist Columbia Basin sites. The Palouse is one of the most endangered ecosystems in the U.S.¹⁶⁶ with only 1% of the original habitat remaining; it is highly fragmented with most sites <10 acres. All these areas are subject to weed invasions and drift of aerial biocides. Since 1900, 94% of the Palouse grasslands have been converted to crop, hay, or pasture lands. Quigley and Arbelbide¹⁸¹ concluded that Fescue-Bunchgrass and Wheatgrass bunchgrass cover types have significantly decreased in area since before 1900, while exotic forbs and annual grasses have significantly increased since pre-1900. Fifty percent of the plant associations recognized as components of Eastside Grasslands habitat listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

16. Shrub-steppe

Rex.C. Crawford & Jimmy Kagan



Geographic Distribution. Shrub-steppe habitats are common across the Columbia Plateau of Washington, Oregon, Idaho, and adjacent Wyoming, Utah, and Nevada. They extend up into the cold, dry environments of surrounding mountains.

Basin big sagebrush shrub-steppe occurs along stream channels, in valley bottoms and flats throughout eastern Oregon and Washington. Wyoming sagebrush shrub-steppe is the most widespread habitat in eastern Oregon and Washington, occurring throughout the Columbia Plateau and the northern Great Basin. Mountain big sagebrush shrub-steppe occurs throughout the mountains of the eastern Oregon and Washington. Bitterbrush shrub-steppe appears primarily along the eastern slope of the Cascades, from north-central Washington to California and occasionally in the Blue Mountains. Three-tip sagebrush shrub-steppe occurs mostly along the northern and western Columbia Basin in Washington and occasionally appears in the lower valleys of the Blue Mountains and in the Owyhee Upland ecoregions of Oregon. Interior shrub dunes and sandy steppe and shrub-steppe is concentrated at low elevations near the Columbia River and in isolated pockets in the Northern Basin and Range and Owyhee Uplands. Bolander silver sagebrush shrub-steppe is common in southeastern Oregon. Mountain silver sagebrush is more prevalent in the Oregon East Cascades and in montane meadows in the southern Ochoco and Blue Mountains.

Physical Setting. Generally, this habitat is associated with dry, hot environments in the Pacific Northwest although variants are in cool, moist areas with some snow accumulation in climatically dry mountains. Elevation range is wide (300-9,000 ft [91-2,743 m]) with most habitat occurring between 2,000 and 6,000 ft (610-1,830 m). Habitat occurs on deep alluvial, loess, silty or sandy-silty soils, stony flats, ridges, mountain slopes, and slopes of lake beds with ash or pumice soils.

Landscape Setting. Shrub-steppe habitat defines a biogeographic region and is the major vegetation on average sites in the Columbia Plateau, usually below Ponderosa Pine Forest and Woodland, and Western

Juniper and Mountain Mahogany Woodland habitats. It forms mosaic landscapes with these woodland habitats and Eastside Grasslands, Dwarf Shrub-steppe, and Desert Playa and Salt Scrub habitats. Mountain sagebrush shrub-steppe occurs at high elevations occasionally within the dry Eastside Mixed Conifer Forest and Montane Mixed Conifer Forest habitats. Shrub-steppe habitat can appear in large landscape patches. Livestock grazing is the primary land use in the shrub-steppe although much has been converted to irrigation or dry land agriculture. Large areas occur in military training areas and wildlife refuges.

Structure. This habitat is a shrub savanna or shrubland with shrub coverage of 10-60%. In an undisturbed condition, shrub cover varies between 10 and 30%. Shrubs are generally evergreen although deciduous shrubs are prominent in many habitats. Shrub height typically is medium-tall (1.6-3.3 ft [0.5-1.0 m]) although some sites support shrubs approaching 9 ft (2.7 m) tall. Vegetation structure in this habitat is characteristically an open shrub layer over a moderately open to closed bunchgrass layer. The more northern or productive sites generally have a denser grass layer and sparser shrub layer than southern or more xeric sites. In fact, the rare good-condition site is better characterized as grassland with shrubs than a shrubland. The bunchgrass layer may contain a variety of forbs. Good-condition habitat has very little exposed bare ground, and has mosses and lichens carpeting the area between taller plants. However, heavily grazed sites have dense shrubs making up >40% cover, with introduced annual grasses and little or no moss or lichen cover. Moist sites may support tall bunchgrasses (>3.3 ft [1 m]) or rhizomatous grasses. More southern shrub-steppe may have native low shrubs dominating with bunchgrasses.

Composition. Characteristic and dominant mid-tall shrubs in the shrub-steppe habitat include all three subspecies of big sagebrush, basin (*Artemisia tridentata* ssp. *tridentata*), Wyoming (*A. t.* ssp. *wyomingensis*) or mountain (*A. t.* ssp. *vaseyana*), antelope bitterbrush (*Purshia tridentata*), and two shorter sagebrushes, silver (*A. cana*) and three-tip (*A. tripartita*). Each of these species can be the only shrub or appear in complex seral conditions with other shrubs. Common shrub complexes are bitterbrush and Wyoming big sagebrush, bitterbrush and three-tip sagebrush, Wyoming big sagebrush and three-tip sagebrush, and mountain big sagebrush and silver sagebrush. Wyoming and mountain big sagebrush can codominate areas with tobacco brush (*Ceanothus velutinus*). Rabbitbrush (*Chrysothamnus viscidiflorus*) and short-spine horsebrush (*Tetradymia spinosa*) are common associates and often dominate sites after disturbance. Big sagebrush occurs with the shorter stiff sagebrush (*A. rigida*) or low sagebrush (*A. arbuscula*) on shallow soils or high elevation sites. Many sandy areas are shrub-free or are open to patchy shrublands of bitterbrush and/or rabbitbrush. Silver sagebrush is the dominant and characteristic shrub along the edges of stream courses, moist meadows, and ponds. Silver sagebrush and rabbitbrush are associates in disturbed areas.

When this habitat is in good or better ecological condition a bunchgrass steppe layer is characteristic. Diagnostic native bunchgrasses that often dominate different shrub-steppe habitats are (1) mid-grasses: bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Elymus elymoides*), and Thurber needlegrass (*Stipa thurberiana*); (2) short grasses: threadleaf sedge (*Carex filifolia*) and Sandberg bluegrass (*Poa sandbergii*); and (3) the tall grass, basin wildrye (*Leymus cinereus*). Idaho fescue is characteristic of the most productive shrub-steppe vegetation. Bluebunch wheatgrass is codominant at xeric locations, whereas western needlegrass (*Stipa occidentalis*), long-stolon (*Carex inops*) or Geyer's sedge (*C. geyeri*) increase in abundance in higher elevation shrub-steppe habitats. Needle-and-thread (*Stipa comata*) is the characteristic native bunchgrass on stabilized sandy soils. Indian ricegrass (*Oryzopsis hymenoides*) characterizes dunes. Grass layers on montane sites contain slender wheatgrass (*Elymus trachycaulus*), mountain fescue (*F. brachyphylla*), green fescue (*F. viridula*), Geyer's sedge, or tall bluegrasses (*Poa* spp.). Bottlebrush squirreltail can be locally important in the Columbia Basin, sand dropseed (*Sporobolus cryptandrus*) is important in the Basin and Range and basin wildrye is common in the more alkaline areas. Nevada bluegrass (*Poa secunda*), Richardson muhly (*Muhlenbergia richardsonis*), or alkali grass (*Puccinella* spp.) can dominate silver sagebrush flats. Many sites support non-native plants, primarily cheatgrass (*Bromus tectorum*) or crested wheatgrass (*Agropyron cristatum*) with or without native grasses. Shrub-steppe habitat, depending on site potential and disturbance history, can be rich in forbs or have little forb cover. Trees may be present in some shrub-steppe habitats, usually as isolated individuals from adjacent forest or woodland habitats.

Other Classifications and Key References. This habitat is called Sagebrush steppe and Great Basin sagebrush by Kuchler.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are big sagebrush shrubland, sagebrush steppe, and bitterbrush-big sagebrush shrubland. Franklin and Dyrness⁸⁸ discussed this habitat in shrub-steppe zones of Washington and Oregon. Other references describe this habitat.^{60, 116, 122, 123, 212, 224, 225}

Natural Disturbance Regime. Barrett et al.²² concluded that the fire-return interval for this habitat is 25 years. The native shrub-steppe habitat apparently lacked extensive herds of large grazing and browsing animals until the late 1800s. Burrowing animals and their predators likely played important roles in creating small-scale patch patterns.

Succession and Stand Dynamics. With disturbance, mature stands of big sagebrush are reinvaded through soil-stored or windborne seeds. Invasion can be slow because sagebrush is not disseminated over long distances. Site dominance by big sagebrush usually takes a decade or more depending on fire severity and season, seed rain,

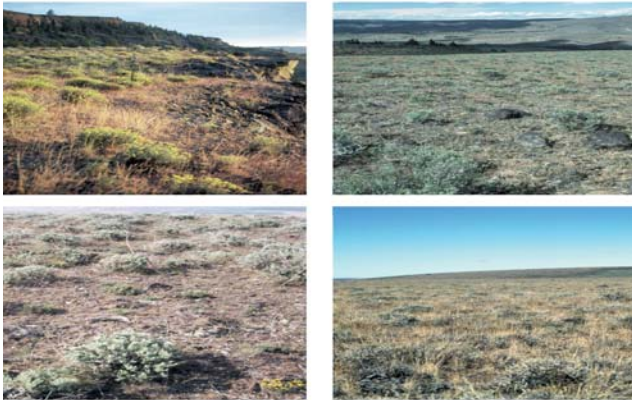
postfire moisture, and plant competition. Three-tip sagebrush is a climax species that reestablishes (from seeds or commonly from sprouts) within 5-10 years following a disturbance. Certain disturbance regimes promote three-tip sagebrush and it can out-compete herbaceous species. Bitterbrush is a climax species that plays a seral role colonizing by seed onto rocky and/or pumice soils. Bitterbrush may be declining and may be replaced by woodlands in the absence of fire. Silver sagebrush is a climax species that establishes during early seral stages and coexists with later arriving species. Big sagebrush, rabbitbrush, and short-spine horsebrush invade and can form dense stands after fire or livestock grazing. Frequent or high-intensity fire can create a patchy shrub cover or can eliminate shrub cover and create Eastside Grasslands habitat.

Effects of Management and Anthropogenic Impacts. Shrub density and annual cover increase, whereas bunchgrass density decreases, with livestock use. Repeated or intense disturbance, particularly on drier sites, leads to cheatgrass dominance and replacement of native bunchgrasses. Dry and sandy soils are sensitive to grazing, with needle-and-thread replaced by cheatgrass at most sites. These disturbed sites can be converted to modified grasslands in the Agriculture habitat.

Status and Trends. Shrub-steppe habitat still dominates most of southeastern Oregon although half of its original distribution in the Columbia Basin has been converted to agriculture. Alteration of fire regimes, fragmentation, livestock grazing, and the addition of >800 exotic plant species have changed the character of shrub-steppe habitat. Quigley and Arbelbide¹⁸¹ concluded that Big Sagebrush and Mountain Sagebrush cover types are significantly smaller in area than before 1900, and that Bitterbrush/Bluebunch Wheatgrass cover type is similar to the pre-1900 extent. They concluded that Basin Big Sagebrush and Big Sagebrush-Warm potential vegetation type's successional pathways are altered, that some pathways of Antelope Bitterbrush are altered and that most pathways for Big Sagebrush-Cool are unaltered. Overall this habitat has seen an increase in exotic plant importance and a decrease in native bunchgrasses. More than half of the Pacific Northwest shrub-steppe habitat community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

17. Dwarf Shrub-steppe

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. Dwarf-shrub and related scabland habitats are located throughout the Columbia Plateau and in adjacent woodland and forest habitats. They are more common in southern Oregon than in Washington.

Low sagebrush steppe is common in the Basin and Range and the Owyhee Uplands in eastern Lake, Harney, and Malheur counties and is a minor type in eastern Washington and northeastern Oregon. It usually occurs on low, scabby plateaus above lake basins. Stiff sagebrush/Sandberg bluegrass is a major type widely distributed in the Columbia Basin, particularly associated with the channeled scablands, High Lava Plains, and in isolated spots throughout the Blue Mountains and the Palouse. Black sagebrush steppe is not found in Washington and is rare in Oregon, occurring along the Nevada border in southern Lake, Harney, and Malheur counties, in the southern Basin and Range and Owyhee Uplands Physiographic Province.

Physical Setting. This habitat appears on sites with little soil development that often have extensive areas of exposed rock, gravel, or compacted soil. The habitat is characteristically associated with flats, plateaus, or gentle slopes although steep slopes with rock outcrops are common. Scabland types within the shrub-steppe area occur on barren, usually fairly young basalts or shallow loam over basalt <12 inches (30 cm) deep. In woodland or forest mosaics, scabland soils are deeper (still <26 inches [65 cm]) but too droughty or extreme soils for tree growth. Topoedaphic drought is the major process influencing these communities on ridge tops and gentle slopes around ridgetops. Spring flooding is characteristic of scablands in concave topographic positions. This habitat is found across a wide range of elevations from 500 to 7,000 ft (152 to 2,134 m).

Landscape Setting. These scabland habitats form a mosaic with Shrub-steppe habitat, Eastside Grasslands habitat, and with Western Juniper and Mountain Mahogany Woodland or Ponderosa Pine Forest and Woodland habitats. Low sagebrush stands are often extensive and

occasionally occur in a mosaic with big sagebrush, stiff sagebrush, or black sagebrush steppe or within lower treeline woodlands. Stiff sagebrush stands may also be extensive, but usually occur in a mosaic with grassland, big sagebrush or occasionally in juniper (*Juniperus occidentalis*) or Ponderosa pine (*Pinus ponderosa*) woodlands. Black sagebrush stands are extensive and may occur in a mosaic with low sagebrush or mountain or Wyoming big sagebrush.

Structure. These low shrub (<1.6 ft [0.5 m] high) communities have an undergrowth of short grasses and forbs with extensive exposed rock and cryptogamic crusts. More productive sites have an open, native medium-tall bunchgrass layer with scattered low shrubs. Some scablands in the Columbia Basin have few to no dwarf shrubs and the habitat is entirely dominated by grasses and forbs. Total vegetation cover is open to sparse. Individual trees can appear among the low shrubs when this habitat appears in the forest matrix.

Composition. Several dwarf-shrub species characterize this habitat: low sagebrush (*Artemisia arbuscula*), black sagebrush (*A. nova*), stiff sagebrush (*A. rigida*), or several shrubby buckwheat species (*Eriogonum douglasii*, *E. sphaerocephalum*, *E. strictum*, *E. thymoides*, *E. niveum*, *E. compositum*). These dwarf-shrub species can be found as the sole shrub species or in combination with these or other low shrubs. Purple sage (*Salvia dorrii*) can dominate scablands on steep sites with rock outcrops.

Sandberg bluegrass (*Poa sandbergii*) is the characteristic and sometimes the dominant grass making up most of this habitat's sparse vegetative cover. Taller bluebunch wheatgrass (*Pseudoroegneria spicata*) or Idaho fescue (*Festuca idahoensis*) grasses may occur on the most productive sites with Sandberg bluegrass. Bottlebrush squirreltail (*Elymus elymoides*) and Thurber needlegrass (*Stipa thurberiana*) are typically found in low cover areas, although they can dominate some sites. One-spine oatgrass (*Danthonia unispicata*), prairie junegrass (*Koeleria macrantha*), and Henderson ricegrass (*Achnatherum hendersonii*) are occasionally important. Exotic annual grasses, commonly cheatgrass (*Bromus tectorum*), increase with heavy disturbance and can be locally abundant. Common forbs include serrate balsamroot (*Balsamorhiza serrata*), Oregon twinpod (*Physaria oregana*), Oregon bitterroot (*Lewisia rediviva*), big-head clover (*Trifolium macrocephalum*), and Rainier violet (*Viola trinervata*). Several other forbs (*Arenaria*, *Collomia*, *Erigeron*, *Lomatium*, and *Phlox* spp.) are characteristic, early blooming species. A diverse lichen and moss layer is a prominent component of these communities.

Medium-tall shrubs, such as big sagebrush (*Artemisia tridentata*), Silver sagebrush (*A. cana*), antelope bitterbrush (*Purshia tridentata*), and rabbitbrush (*Chrysothamnus* spp.) occasionally appear in these scablands.

Other Classifications and Key References. This habitat is called scabland, biscuit-swale topography, lithosolic steppe, or low shrub-steppe. Quigley and Arbelbide¹⁸¹ called this habitat low sagebrush cover type and "Low

Sagebrush-Xeric” and “Low Sagebrush-Mesic” potential vegetation groups. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is low-dwarf sagebrush. Kuchler¹³⁶ did not distinguish this habitat but included it within Sagebrush Steppe. Franklin and Dyrness⁸⁸ discussed this habitat as lithosolic sites in steppe and shrub-steppe zones of Washington and as plant associations in steppe and shrub-steppe zones of central and southern Oregon. Other references describe this habitat.^{60, 64, 122, 123, 207}

Natural Disturbance Regime. Scabland habitats often do not have enough vegetation cover to support wildfires. Bunchgrass sites with black or low sagebrush may burn enough to damage shrubs and decrease shrub cover with repetitive burns. Many scabland sites have poorly drained soil and because of shallow soil are prone to winter flooding. Freezing of saturated soil results in “frost-heaving” that churns the soil and is a major disturbance factor in vegetation patterns. Stiff sagebrush is a preferred browse for elk as well as livestock. Native ungulates use scablands in early spring and contribute to churning of the soil surface.

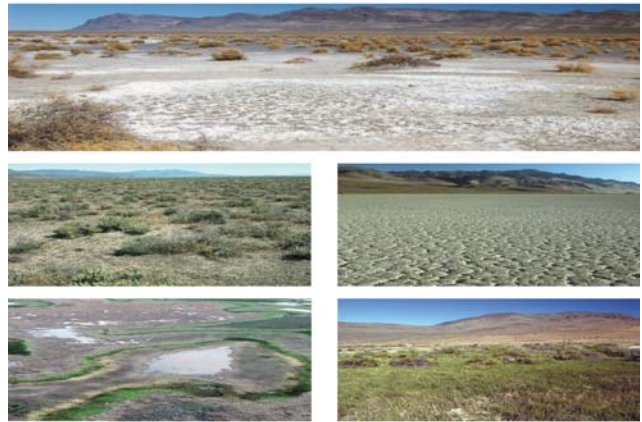
Succession and Stand Dynamics. Grazing reduces the cover of bunchgrasses and increases the abundance of common yarrow (*Achillea millefolium*), phlox species, bighead clover, serrate balsamroot, bottlebrush squirreltail and annual bromes on dwarf shrublands. Increased ground disturbing activities increases exotic plant abundance, particularly on deeper soil sites. All dwarf-shrub species are intolerant of fire and do not sprout. Consequently, redevelopment of dwarf shrub-steppe habitat is slow following fire or any disturbance that removes shrubs.

Effects of Management and Anthropogenic Impacts. Scabland habitats provide little forage and consequently are used only as a final resort by livestock. Heavy use by livestock or vehicles disrupts the moss/lichen layer and increases exposed rock and bare ground that create habitat for exotic plant invasion. Exotic annual bromes have become part of these habitats with natural soil churning disturbance.

Status and Trends. Quigley and Arbelbide¹⁸¹ concluded that the low sagebrush cover type is as abundant as it was before 1900. They concluded that “Low Sagebrush-Xeric” successional pathways have experienced a high level of change from exotic invasions and that some pathways of “Low Sagebrush-Mesic” are unaltered. Twenty percent of Pacific Northwest dwarf shrub-steppe community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

18. Desert Playa and Salt Scrub Shrublands

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. The desert playa and salt scrub habitat centers on the Great Basin of Nevada and Utah. In the Pacific Northwest, it is most common and abundant in the larger, alkaline lake basins in southeastern Oregon, although it is represented throughout the Columbia Plateau, Basin and Range, and Owyhee Provinces.

Shadscale salt desert shrub and mixed salt desert shrub range from southeastern Oregon south into Utah and Nevada. Black greasewood salt desert scrub and alkaline/saline bottomland grasslands and wetlands appear throughout the Columbia Plateau of Washington and Oregon.

Physical Setting. This habitat typically occupies the lowest elevations in hydrologic basins in the driest regions of the Pacific Northwest. Elevation range is highly variable, from 3,000 to 7,500 ft (914 to 2,286 m) in southeastern Oregon to 500 to 5,500 ft (152-1,676 m) in central Washington. Structural and compositional variation in this habitat are related to changes in salinity and fluctuations in the water table. Areas with little or no vegetative cover have highly alkaline and saline soils and are poorly drained or irregularly flooded. Other arid soil types include desert pavement and barren ash. The wettest variants of the habitat are usually found at the mouth of stream drainages or in areas with some freshwater input into a playa. These have finer, deeper alluvial soils that occur in low alkaline dunes, around playas, on slopes above alkaline basins or in small, poorly drained basins in sagebrush steppe. Topographically, this habitat occurs on playas or desert pavement, or on low benches above playas with occasional low alkaline dune ridges.

Landscape Setting. This habitat is typically surrounded by shrub-steppe habitat. It forms a habitat mosaic of playas, salt grass meadows, salt desert shrublands and sagebrush shrublands. This habitat may be associated with Herbaceous Wetland habitat. Local land use can result in juxtaposition with Agriculture or Eastside Grasslands habitat. Most of this habitat provides rangeland for

livestock, particularly as winter range. Portions of this habitat associated with water are most attractive to livestock. Other portions of this type are designated wildlife refuges.

Structure. This habitat is structurally diverse, ranging from dense shrublands to sparse grasslands to unvegetated flats. Generally, low to medium-tall alkali or saline tolerant shrubs form an open layer over a grass and annual, often succulent, forb undergrowth. Deciduous shrubs, when present, usually create <50% cover but occasionally can exceed 70% on previously disturbed ground. Ground cover between shrubs is variable, ranging from widely spaced tall, medium-tall, or short bunchgrasses to dense, short rhizomatous grasses. Other areas have no shrubs and support a fairly continuous cover of graminoids, occasionally with widely spaced bunchgrasses. Sites can have extensive bare ground, usually gravelly flats, ash, desert pavement, or low alkaline dune ridges. Typically, this habitat is a mosaic of open medium-tall to low shrubland communities, patchy grasslands or herb lands, and sparsely to unvegetated areas.

Composition. Characteristic medium-tall shrubs that dominate well-drained sites are shadscale (*Atriplex confertifolia*), bud sagebrush (*Artemisia spinescens*), and hopsage (*Grayia spinosa*). Characteristic low shrubs are greenmolly (*Kochia americana*), saltbush (*Atriplex gardneri* or *A. nuttallii*), and winter fat (*Krascheninnikovia lanata*). Other medium-tall shrubs, big sagebrush (*Artemisia tridentata*), horsebrush (*Tetradymia nuttallii* or *T. glabrata*), Mormon tea (*Ephedra viridis*), or rabbitbrush (*Chrysothamnus nauseosus* or *C. viscidiflorus*) can be co-dominant. The medium-tall shrub black greasewood (*Sarcobatus vermiculatus*) or low shrubs, iodinebush (*Allenrolfea occidentalis*) or Mojave seablite (*Suaeda moquinii*) can be dominant or co-dominant on less well drained, generally more saline parts of this habitat.

Herbaceous indicators of salt desert habitats appear in various habitats. On densely vegetated sites, native bunchgrasses, basin wildrye (*Leymus cinereus*), curly bluegrass (*Poa secunda*), and needle-and-threadgrass (*Stipa comata*) are important, usually with shrubs in this habitat. Basin wildrye is also a common and diagnostic grass in sites with less alkaline, deeper soils and some movement of water. Indian ricegrass (*Oryzopsis hymenoides*) and bottlebrush squirreltail (*Elymus elymoides*) are dominant grasses on the alkaline dunes. Introduced plants, particularly cheatgrass (*Bromus tectorum*) or halogeton (*Halogeton glomeratus*), often dominate overgrazed sites. Saltgrass (*Distichlis spicata*) is a common, diagnostic native sod-forming grass on more saline sites that often dominates large areas with and without shrubs. Pickleweed (*Salicornia virginica*) is found in wetter saline areas. Alkaline sites have mat muhly (*Muhlenbergia richardsonis*), alkali bluegrass (*Poa secunda* ssp. *juncifolia*), beardless wildrye (*Leymus triticoides*), and Lemmon's alkaligrass (*Puccinella lemmonii*). Common reedgrass (*Phragmites australis*), bulrush (*Scirpus americanus*, *S.*

maritimus), and creeping spikerush (*Eleocharis palustris*) are diagnostic of the wettest parts of this habitat.

Other Classifications and Key References. Popular literature refers to this habitat as shadscale, salt desert scrub, and saltflat desert. This habitat encompasses the “Desert or Salt Desert Shrub” and “*Distichlis stricta* Associations on Saline-Alkali Soils” in Franklin and Dyrness⁸⁸ and Saltbush-greasewood in Kuchler.¹³⁶ The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are salt desert scrub shrubland and alkali playa. Other references describe this habitat.^{29, 30, 52, 60, 123, 131, 147, 175, 184}

Natural Disturbance Regime. Fire plays a minor role over much of the distribution of the type because of sparse vegetation and lack of fuel. Many of these areas are prone to irregular flooding and prolonged droughts; both factors lead to a redistribution of component species and creation of sparsely or unvegetated areas.

Succession and Stand Dynamics. Many of the dominant shrub species sprout following fire, herbicide treatments, or heavy grazing.⁴ The characteristic shrubs of this habitat increase with grazing and can invade adjacent big sagebrush communities with intense grazing.

Effects of Management and Anthropogenic Impacts. Several exotic species invade this habitat with grazing. Halogeton, a toxic exotic plant, is found most commonly in this habitat. Other noxious but nontoxic exotics that increase with grazing are Russian thistle (*Salsola kali*), tall tumbledustard (*Sisymbrium altissimum*), and cheatgrass. These can replace native grasses and change the structure of the native habitat.

Status and Trends. Agricultural development is generally not feasible; consequently, little of this habitat is converted to other uses. Most of this habitat is used for livestock grazing, which overall has increased shrub and annual cover and decreased bunchgrass cover. Quigley and Arbelbide¹⁸¹ concluded that the Salt Desert Shrub cover type is less abundant now than before 1900. They further noted that the cover type has undergone a moderate level of change, so that some successional pathways have been unaltered. Approximately one third of Pacific Northwest salt desert and related community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

19. Agriculture, Pastures, and Mixed Environments

W. Daniel Edge, Rex C. Crawford, & David H. Johnson



Geographic Distribution. Agricultural habitat is widely distributed at low to mid-elevations (<6,000 ft [1,830 m]) throughout both states. This habitat is most abundant in broad river valleys throughout both states and on gentle rolling terrain east of the Cascades.

Physical Setting. This habitat is maintained across a range of climatic conditions typical of both states. Climate constrains agricultural production at upper elevations where there are <90 frost-free days. Agricultural habitat in arid regions east of the Cascades with <10 inches (25 cm) of rainfall require supplemental irrigation or fallow fields for 1-2 years to accumulate sufficient soil moisture. Soils types are variable, but usually have a well developed A horizon. This habitat is found from 0 to 6,000 ft (0 to 1,830 m) elevation.

Landscape Setting. Agricultural habitat occurs within a matrix of other habitat types at low to mid-elevations, including Eastside grasslands, Shrub-steppe, Westside Lowlands Conifer-Deciduous Forest and other low- to mid-elevation forest and woodland habitats. This habitat often dominates the landscape in flat or gently rolling terrain, on well-developed soils, broad river valleys, and areas with access to abundant irrigation water. Unlike other habitat types, agricultural habitat is often characterized by regular landscape patterns (squares, rectangles, and circles) and straight borders because of ownership boundaries and multiple crops within a region. Edges can be abrupt along the habitat borders within agricultural habitat and with other adjacent habitats.

Structure. This habitat is structurally diverse because it includes several cover types ranging from low-stature annual grasses and row crops (<3.3 ft [1 m]) to mature orchards (>66 ft [20 m]). However, within any cover type, structural diversity is typically low because usually only one to a few species of similar height are cultivated. Depending on management intensity or cultivation method, agricultural habitat may vary substantially in structure annually; cultivated cropland and modified

grasslands are typified by periods of bare soil and harvest whereas pastures are mowed, hayed, or grazed one or more times during the growing season. Structural diversity of agricultural habitat is increased at local scales by the presence of noncultivated or less intensively managed vegetation such as fencerows, roadsides, field borders, and shelterbelts.

Composition. Agricultural habitat varies substantially in composition among the cover types it includes. Cultivated cropland includes >50 species of annual and perennial plants in Oregon and Washington, and hundreds of varieties ranging from vegetables such as carrots, onions, and peas to annual grains such as wheat, oats, barley, and rye. Row crops of vegetables and herbs are characterized by bare soil, plants, and plant debris along bottomland areas of streams and rivers and areas having sufficient water for irrigation. Annual grains, such as barley, oats, and wheat are typically produced in almost continuous stands of vegetation on upland and rolling hill terrain without irrigation.

The orchard/vineyard/nursery cover type is composed of fruit and nut (apples, peaches, pears, and hazelnuts) trees, vineyards (grapes, Kiwi), berries (strawberries, blueberries, blackberries, and raspberries), Christmas trees, and nursery operations (ornamental container and greenhouses). This cover type is generally located on upland sites with access to abundant irrigation. Cultivation for most orchards, vineyards and Christmas tree farms includes an undergrowth of short-stature perennial grasses between the rows of trees, vines, or bushes. Christmas trees are typically produced without irrigation on upland sites with poorer soils.

Improved pastures are used to produce perennial herbaceous plants for grass seed and hay. Alfalfa and several species of fescue (*Festuca* spp.) and bluegrass (*Poa* spp.), orchardgrass (*Dactylis glomerata*), and timothy (*Phleum pratensis*) are commonly seeded in improved pastures. Grass seed fields are single-species stands, whereas pastures maintained for haying are typically composed of two to several species. The improved pasture cover type is one of the most common agricultural uses in both states and produced with and without irrigation.

Unimproved pastures are predominately grassland sites, often abandoned fields that have little or no active management such as irrigation, fertilization, or herbicide applications. These sites may or may not be grazed by livestock. Unimproved pastures include rangelands planted to exotic grasses that are found on private land, state wildlife areas, federal wildlife refuges and U.S. Department of Agriculture Conservation Reserve Program (CRP) sites. Grasses commonly planted on CRP sites are crested wheatgrass (*Agropyron cristatum*), tall fescue (*F. arundinacea*), perennial bromes (*Bromus* spp.) and wheatgrasses (*Elytrigia* spp.). Intensively grazed rangelands, which have been seeded to intermediate wheatgrass (*Elytrigia intermedia*), crested wheatgrass, or are dominated by increaser exotics such as Kentucky wheatgrass (*Poa pratensis*) or tall oatgrass (*Arrhenatherum elatius*) are unimproved pastures. Other unimproved

pastures have been cleared and intensively farmed in the past, but are allowed to convert to other vegetation. These sites may be composed of uncut hay, litter from previous seasons, standing dead grass and herbaceous material, invasive exotic plants (tansy ragwort [*Senecio jacobea*], thistle [*Cirsium* spp.], Himalaya blackberry [*Rubus discolor*], and Scot's broom [*Cytisus scoparius*]) with patches of native black hawthorn (*Crataegus douglasii*), snowberry (*Symphoricarpos* spp.), spirea (*Spirea* spp.), poison oak (*Toxicodendron diversilobum*), and encroachment of various tree species, depending on seed source and environment.

Modified grasslands are generally overgrazed habitats that formerly were native eastside grasslands or shrub-steppe but are now dominated by annual plants with only remnant individual plants of the native vegetation. Cheatgrass (*Bromus tectorum*), other annual bromes, medusahead (*Taeniatherum caput-medusae*), bulbous bluegrass (*Poa bulbosa*), and knapweeds (*Centaurea* spp.) are common increasers that form modified grasslands. Fire, following heavy grazing or repeated early season fires can create modified grassland monocultures of cheatgrass.

Agricultural habitat also contains scattered dwellings and outbuildings such as barns and silos, rural cemeteries, ditchbanks, windbreaks, and small inclusions of remnant native vegetation. These sites typically have a discontinuous tree layer or one to a few trees over a ground cover similar to improved or unimproved pastures.

Other Classifications and Key References. Quigley and Arbelbide¹⁸¹ referred to this as agricultural and exotic forbs-annual grasses cover types. Csuti et al.⁵⁸ referred to this habitat as agricultural. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is agriculture. U.S. Department of Agriculture Conservation Reserve Program lands are included in this habitat.

Natural Disturbance Regime. Natural fires are almost totally suppressed in this habitat, except for unimproved pastures and modified grasslands, where fire-return intervals can resemble those of native grassland habitats. Fires are generally less frequent today than in the past, primarily because of fire suppression, construction of roads, and conversion of grass and forests to cropland.¹⁵⁹ Bottomland areas along streams and rivers are subject to periodic floods, which may remove or deposit large amounts of soil.

Succession and Stand Dynamics. Management practices disrupt natural succession and stand dynamics in most of the agricultural habitats. Abandoned eastside agricultural habitats may convert to other habitats, mostly grassland and shrub habitats from the surrounding native habitats. Some agricultural habitats that occur on highly erodible soils, especially east of the Cascades, have been enrolled in the U.S. Department of Agriculture Conservation Reserve Program. In the absence of fire or mowing, westside unimproved pastures have increasing amounts of hawthorn, snowberry, rose (*Rosa* spp.), Himalaya blackberry, spirea, Scot's broom, and poison

oak. Douglas-fir or other trees can be primary invaders in some environments.

Effects of Management and Anthropogenic Impacts. The dominant characteristic of agricultural habitat is a regular pattern of management and vegetation disturbance. With the exception of the unimproved pasture cover type, most areas classified as agricultural habitat receive regular inputs of fertilizer and pesticides and have some form of vegetation harvest and manipulation. Management practices in cultivated cropland include different tillage systems, resulting in vegetation residues during the non-growing season that range from bare soil to 100% litter. Cultivation of some crops, especially in the arid eastern portions of both states, may require the land to remain fallow for 1-2 growing seasons in order to store sufficient soil moisture to grow another crop. Harvest in cultivated cropland, Christmas tree plantations, and nurseries, and mowing or haying in improved pasture cover types substantially change the structure of vegetation. Harvest in orchards and vineyards is typically less intrusive, but these crops as well as Christmas trees and some ornamental nurseries are regularly pruned. Improved pastures are often grazed after haying or during the nongrowing season. Livestock grazing is the dominant use of unimproved pastures. All of these practices prevent agricultural areas from reverting to native vegetation. Excessive grazing in unimproved pastures may increase the prevalence of weedy or exotic species.

Status and Trends. Agricultural habitat has steadily increased in amount and size in both states since Eurasian settlement of the region. Conversion to agricultural habitat threatens several native habitat types.¹⁶⁶ The greatest conversion of native habitats to agricultural production occurred between 1950 and 1985, primarily as a function of U.S. agricultural policy.⁹⁶ Since the 1985 Farm Bill and the economic downturn of the early to mid 1980s, the amount of land in agricultural habitat has stabilized and begun to decline.¹⁶⁴ The 1985 and subsequent Farm Bills contained conservation provisions encouraging farmers to convert agricultural land to native habitats.^{96, 153} Clean farming practices and single-product farms have become prevalent since the 1960s, resulting in larger farms and widespread removal of fencerows, field borders, roadsides, and shelterbelts.^{96, 153, 164} In Oregon, land-use planning laws prevent or slow urban encroachment and subdivisions into areas zoned as agriculture. Washington's growth management is currently controlled by counties and agricultural land conversion to urban development is much less regulated.

20. Urban and Mixed Environs

Howard L. Ferguson



Geographic Distribution. Urban habitat occurs throughout Oregon and Washington. Most urban development is located west of the Cascades of both Oregon and Washington, with the exception of Spokane, Washington. However, urban growth is being felt in almost every small town throughout the Pacific Northwest.

Physical Setting. Urban development occurs in a variety of sites in the Pacific Northwest. It creates a physical setting unique to itself: temperatures are elevated and background lighting is increased; wind velocities are altered by the urban landscape, often reduced except around the tallest structures downtown, where high-velocity winds are funneled around the skyscrapers. Urban development often occurs in areas with little or no slope and frequently includes wetland habitats. Many of these wetlands have been filled in and eliminated. Today, ironically, many artificial “wetland” impoundments are being created for stormwater management, whose function is the same as the original wetland that was destroyed.

Landscape Setting. Urban development occurs within or adjacent to nearly every habitat type in Oregon and Washington, and often replaces habitats that are valuable for wildlife. The highest urban densities normally occur in lower elevations along natural or human-made transportation corridors, such as rivers, railroad lines, coastlines, or interstate highways. These areas often contain good soils with little or no slope and lush vegetation. Once level areas become crowded, growth continues along rivers or shores of lakes or oceans, and eventually up elevated sites with steep slopes or rocky outcrops. Because early settlers often modified the original landscape for agricultural purposes, many of our urban areas are surrounded by agricultural and grazing lands.

Structure. The original habitat is drastically altered in urban environments and is replaced by buildings, impermeable surfaces, bridges, dams, and planting of non-native species. Some human-made structures provide habitats similar to those of cavities, caves, fissures, cliffs, and ledges. With the onset of urban development, total crown cover and tree density are reduced to make way

for the construction of buildings and associated infrastructure. Many structural features typical of the historical vegetation, such as snags, dead and downed wood, and brush piles, are often completely removed from the landscape. Understory vegetation may be completely absent, or if present, is diminutive and single-layered. Typically, three zones are characteristic of urban habitat.

High-density Zone

The high-density zone is the downtown area of the inner city. It also encompasses the heavy industrial and large commercial interests of the city in addition to high-density housing areas such as apartment buildings or high-rise condominiums. This zone has >60% of its total surface area covered by impervious surfaces. This zone has the smallest lot size, the tallest buildings, the least amount of total tree canopy cover, the lowest tree density, the highest percentage of exotics, the poorest understory and subcanopy, and the poorest vegetative structure.^{4a, 116a, 185a} Human structures have replaced almost all vegetation.^{23b, 148a} Road density is the highest of all zones. An example of road density can be seen from Washington’s Growth Management Plan requiring Master Comprehensive Plans to set aside 20% of the identified urban growth area for roads and road rights-of-way. For example, Spokane’s urban growth area is approximately 57,000 acres (23,077 ha); therefore >11,000 acres (4,453 ha) were set aside for road surfaces.

In the high-density zone, land-use practices have removed most of the native vegetation. Patch sizes of remaining natural areas often are so small that native interior species cannot be supported. Not only are remaining patches of native vegetation typically disconnected, but also they are frequently missing the full complement of vertical strata.¹⁴⁹ Stream corridors become heavily impacted and discontinuous. Most, if not all, wetlands have been filled or removed. Large buildings dominate the landscape and determine the placement of vegetation in this zone.^{30a} This zone has the most street tree strips or sidewalk trees, most of which are exotics. There is virtually no natural tree replacement, and new trees are planted only when old ones die or are removed. Replacement trees are chosen for their small root systems and are generally short in stature with small diameters. Ground cover in this zone, if not synthetic or impervious, is typically exotic grasses or exotic annuals, most of which are rarely allowed to go to seed. Snags, woody debris, rock piles, and any other natural structures are essentially nonexistent. There are few tree cavities because of cosmetic pruning, cavity filling, snag removal, and tree thinning.¹⁴⁹

Medium-density Zone

This zone, continuing out from the center of the continuum, is composed of light industry mixed with high-density residential areas. Housing density of 3-6 single-family homes per acre (7-15 per ha) is typical. Compared with the high-density zone, this zone has more potential wildlife habitat. With 30-59% impervious soil cover, this zone has 41-70% of the ground available for plants. Road density is less than the high-density zone.

Vegetation in this mid-zone is typically composed of non-native plant species. Native plants, when present, represent only a limited range of the natural diversity for the area. The shrub layer is typically clipped or minimal, even in heavily vegetated areas. Characteristic of this zone are manicured lawns, trimmed hedges, and topped trees. Lawns can be highly productive.^{82a, 97a} Tree canopy is still discontinuous and consists of 1-2 levels, if present at all. Consequently, vertical vegetative diversity and total amount of understory are still low. Coarse and fine woody debris is minimal or absent; most snags and diseased live trees are still removed as hazards in this zone.^{119a, 119b}

Isolated wetlands, stream corridors, open spaces, and greenbelts are more frequently retained in this zone than in the high-density zone. However, remnant wetland and upland areas are often widely separated by urban development.

Low-density Zone

The low-density zone is the outer zone of the urban-rural continuum. This zone contains only 10-29% impervious ground cover and normally contains only single-family homes. It has more natural ground cover than artificial surfaces. Vegetation is denser and more abundant than in the previous two zones. Typical housing densities are 0.4-1.6 single-family homes per acre (1-4 per ha). Road density is lowest of all three zones and consists of many secondary and tertiary roads. Although this zone may have large areas of native vegetation and is generally the least impacted of all three zones; it still has been significantly altered by human activities and associated disturbances.

Roads, fences, livestock paddocks, and pets are more abundant than in neighboring rural areas. With many animals and limited acreage, pasture conditions may be more overgrazed in this zone than in the rural zone; overgrazing can significantly affect shrub layers as well. Areas around home sites are often cleared for fire protection. Dogs are more likely to be loose and allowed to run free, increasing disturbance levels and wildlife harassment in this zone. Vegetable and flower gardens are widespread; fencing is prevalent.

Many wetlands remain and are less impacted. Water levels are more stable and peak flows are more typical of historical flows. Watertables are less impacted and vernal wetlands are more frequent; stream corridors are less impacted and more continuous.

This zone has the most vertical and horizontal structure and diversity of any of the three urban zones.^{30a, 80a, 140a, 187a} In forested areas, tree conditions are semi-natural, although stand characteristics vary from parcel to parcel. The tree canopy is more continuous and may include multiple levels. Patch sizes are large enough to support native interior species. Large blocks of native vegetation may still be found, and some of these may be connected to large areas of native undeveloped land.^{220a} In this zone, snags, diseased trees, coarse and fine woody debris, brush piles, and rock piles are widespread. Structural diversity approaches historical levels. Non-native hedges are nearly nonexistent and the native shrub layer, except for small

areas around houses, is relatively intact. Lawns are fewer and native ground covers are more common than in the previous two zones.

Composition. Remnant isolated blocks of native vegetation may be found scattered throughout a town or city mixed with a multitude of introduced exotic vegetation. As urban development increases, these remnant native stands become fragmented and isolated. The dominant species in an urban setting may be exotic or native; for example, in Seattle, the dominant species in one area may be Douglas-fir (*Pseudotsuga menziesii*), whereas a few blocks away it may be the exotic silver maple (*Acer saccharinum*). Dominant species will not only vary from city to city but also within each city and within each of the three urban zones. Nowack¹⁶⁷ found that in the high-density urban zone, species richness is low, and in one case, four species made up almost 50% of the cover. In the same study, exotics made up 69% of the total species.

In urban and suburban areas, species richness is often increased because of the introduction of exotics. The juxtaposition of exotics interspersed with native vegetation produces a diverse mosaic with areas of extensive edge. Also, because of irrigation and the addition of fertilizers, the biomass in the urban communities is often increased.¹⁴⁹ Interest in the use of native plants for landscaping is rapidly expanding,^{135, 172} particularly in the more arid sites where drought-resistant natives are the only plants able to survive without water.

Across the U.S., urban tree cover ranges from 1 to 55%.¹⁶⁷ As expected, tree cover tends to be highest in cities developed in naturally forested areas with an average of 32% cover in forested areas, 28% in grasslands, and 10% in arid areas. Yakima, Washington, has an overall city tree cover of 18%, ranging from 10% to 12% in the industrial/commercial area to 23% in the low-density residential zone.¹⁶⁷ Remnant blocks of native vegetation or native trees left standing in yards and parks will compositionally be related to whatever native habitat was on site prior to development. In the Puget Sound and Willamette Valley areas, Douglas-fir is a major constituent, whereas the Spokane area has a lot of ponderosa pine (*Pinus ponderosa*).

Other Classifications and Key References. Many attempts have been made to classify or describe the complex urban environment. The Washington GAP Analysis³⁷ classified urban environments as “developed” land cover using the same three zones as described above: (1) high density (>60% impervious surface); (2) medium density (30-60% impervious surface); and (3) low density (10-30% impervious surface). The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ represented this type as an urban class. Several other relevant studies characterizing the urban environment have been reported.^{182, 129, 34, 70, 151}

Natural Disturbance Regime. In many instances, natural disturbances are modified or prevented from occurring by humans over the landscape and this is particularly true of urban areas. However, disturbances such as ice, wind,

or firestorms still occur. The severity of these intermittent disturbances varies greatly in magnitude and their impact on the landscape varies accordingly. One of the differences between urban and nonurban landscapes is the lengthening of the disturbance cycles. Another is found in the aftermath of these disturbances. In urban areas, damaged trees are often entirely removed and if they are replaced, a shorter, smaller tree, often non-native, is selected. The natural fire disturbance interval is highly modified in the urban environment. Fire (mostly accidental or arson) still occurs, and is quickly suppressed. Another natural disturbance in many of our Pacific Northwest towns is flooding, which historically altered and rerouted many of our rivers and streams, and still scarifies fields and deposits soil on flood plains and potentially recharges local aquifers. Floods now are more frequent and more violent than in the past because of the many modifications made to our watersheds. Attempts to lessen flooding in urban areas often lead to channelization, paving, or diking of our waterways, most of which fail in their attempt to stem the flooding and usually result in increased flooding for the communities farther downstream.

Succession and Stand Dynamics. Due to anthropogenic influences found in the urban environment, succession differs in the urban area from that expected for a native stand. Rowntree¹⁸⁵ emphasized that urbanization is not in the same category as natural disturbance in affecting succession. He points out that urbanization is anthropogenic and acts to remove complete vegetation associations and creates new ones made of mixes of native residual vegetation and introduced vegetation. Much human effort in the city goes toward either completely removing native vegetation or sustaining or maintaining a specific vegetative type, e.g., lawns or hedges. Much of the vegetative community remains static. Understory and ground covers are constantly pruned or removed, seedlings are pulled and lawns are planted, fertilized, mowed, and meticulously maintained. Trees may be protected to maturity or even senescence, yet communities are so fragmented or modified that a genuine old-growth community never exists. However, a type of “urban succession” occurs across the urban landscape. The older neighborhoods with their mature stands are at a later seral stage than new developments; species diversity is characteristically higher in older neighborhoods as well. An oddity of the urban environment is the absence of typical structure generally found within the various seral stages. For example, the understory is often removed in a typical mid-seral stand to give it a “park-like” look. Or if the understory is allowed to remain, it is kept pruned to a consistent height. Lawns are the ever-present substitute for native ground covers. Multilayered habitat is often reduced to one or two heights. Vertical and horizontal structural diversity is drastically reduced.

Effects of Management and Anthropogenic Impacts. These additional, often irreversible, impacts include more impervious surfaces, more and larger human-made

structures, large-scale storm and wastewater management, large-scale sewage treatment, water and air pollution, toxic chemicals, toxic chemical use on urban lawns and gardens, removal of species considered to be pests, predation and disturbance by pets and feral cats and dogs, and the extensive and continual removal of habitat due to expanding urbanization, and in some cases, uncontrolled development. Another significant impact is the introduction and cultivation of exotics in urban areas. Native vegetation is often completely replaced by exotics, leaving little trace of the native vegetative cover.

Status and Trends. From 1970 to 1990, >30,000 mile² (77,700 km²) of rural lands in the U.S. became urban, as classified by the U.S. Census Bureau. That amount of land equals about one third of Oregon’s total land area.¹² From 1940 to 1970, the population of the Portland urban region doubled and the amount of land occupied by that population quadrupled.²⁰¹ More than 300 new residents arrive in Washington each day, and each day, Washington loses 100 acres (41 ha) of forest to development.²¹⁵ Using satellite photos and GIS software, American Forests⁹ discovered that nearly one third of Puget Sound’s most heavily timbered land has disappeared since the early 1970s. The amount of land with few or no trees more than doubled, from 25% to 57%, an increase of >1 million acres (404,858 ha). Development and associated urban growth was blamed as the single biggest factor affecting the area’s environment. This urban growth is predicted to continue to increase at an accelerated pace, at the expense of native habitat.

21. Open Water— Lakes, Rivers, and Streams

Eva L. Greda, David H. Johnson, & Thomas A. O’Neil



Lakes, Ponds, and Reservoirs

Geographic Distribution. Lakes in Oregon and Washington occur statewide and are found from near sea level to about 10,200 ft (3,110 m) above sea level. There are 3,887 lakes and reservoirs in western Washington and

Text continues on page 91

Westside Lowlands Conifer-Hardwood Forest



1. Goodman Creek, Oregon



2. H.J. Andrews Experimental Forest, Oregon



3. Deception Pass State Park, Island County, Washington



4. Capitol Forest, Thurston County, Washington



5. Dungeness River Valley, Clallam County, Washington



6. Lake Quinalt, Grays Harbor County, Washington

Westside Oak and Dry Douglas-fir Forest and Woodlands



1. Orcas Island, San Juan County, Washington



2. James Island, San Juan County, Washington



3. San Juan Island, San Juan County, Washington



4. Fort Lewis, Pierce County, Washington

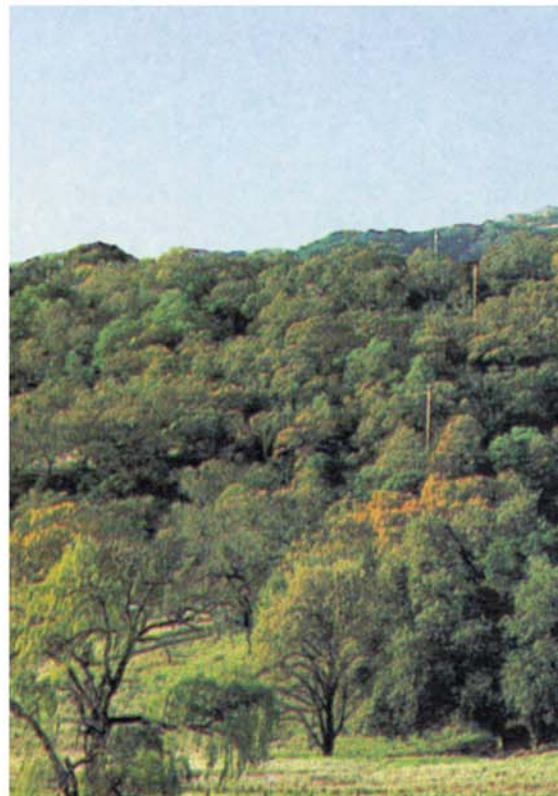
Southwest Oregon Mixed Conifer-Hardwood Forest



1. Southwestern Oregon



2. Jackson County, Oregon



3. Ruch, Oregon

Montane Mixed Conifer Forest



1. Mt. Pilchuck Conservation Area, Snohomish Co., WA



2. Pend Oreille County, Washington



3. Mt. Pilchuck Conservation Area, Snohomish County, Washington



4. Arlecho Creek, Whatcom County, Washington

Eastside (Interior) Mixed Conifer Forest



1. Wenatchee Mountains, Kittitas County, Washington



2. Alice Mae Mountain, Stevens County, Washington



2. Alice Mae Mountain, Stevens County, Washington



4. Rainbow Creek Research Natural Area, Blue Mountains, Washington

Lodgepole Pine Forest and Woodlands



1. Loomis State Forest, Okanogan County, Washington



2. Loomis State Forest, Okanogan County, Washington



3. Loomis State Forest, Okanogan County, Washington



4. Loomis State Forest, Okanogan County, Washington



5. Loomis State Forest, Okanogan County, Washington

Ponderosa Pine Forest and Woodlands (includes Eastside Oak)



1. Barker Mountain, Okanogan County, Washington



2 Near Sisters, Oregon



3. Turnbull National Wildlife Refuge, Spokane County, Washington



4. Indian Ford, north of Sisters, Oregon



5. Briske Canyon, Washington



6. Badger Gulch Natural Area Preserve, Klickitat County, Washington

Upland Aspen Forest



1. Winthrop, Okanogan County, Washington



2. Hart Mountain National Wildlife Refuge, Oregon



3. Hart Mountain Mountain National Wildlife Refuge, Oregon



4. Steens Mountain, Oregon

Subalpine Parkland



1. Mt. Rainier National Park, Washington



4. Eagle Cap Wilderness Area, Wallowa Mts., Oregon



2. Strawberry Mountain, Oregon



5. Goat Rocks Wilderness Area, Lewis County, Washington



3. Mt. Pilchuck Conservation Area, Snohomish County, Washington

Alpine Grasslands and Shrublands



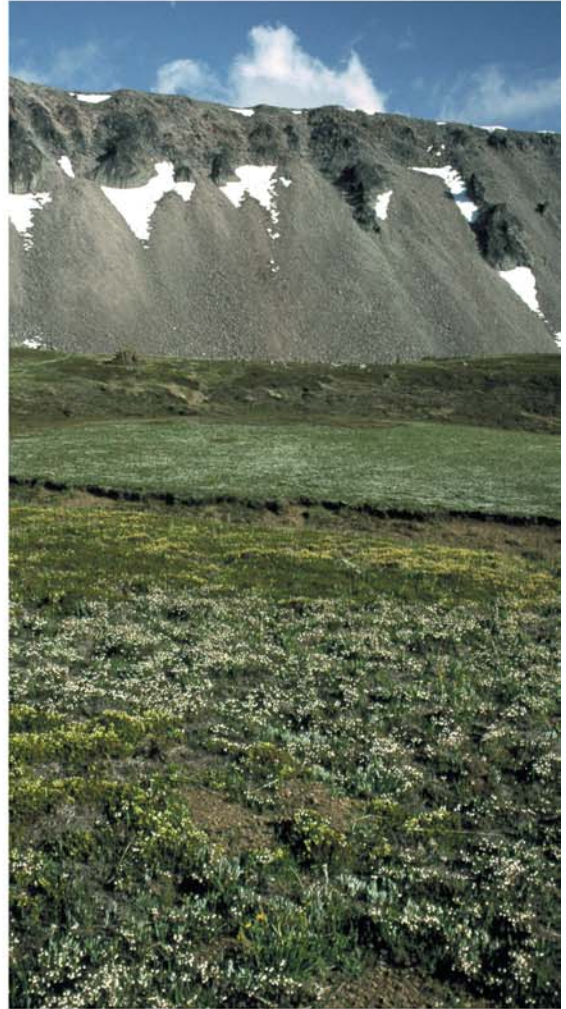
1. Mt. Rainier National Park, Washington



2. Steens Mountain, Oregon



3. Buckhorn Wilderness Area, Clallam County, Washington



4. Mt. Rainier National Park, Washington

Westside Grasslands



1. Scatter Creek Wildlife Area, Thurston County, Washington



2. Lane County, Oregon



3. Near Stayton, Linn County, Oregon



4. Burrows Island, Skagit County, Washington



5. Mima Mounds Natural Area Preserve, Thurston County, Washington

Ceanothus – Manzanita Shrublands



1. Southwestern Oregon



2. South of Shady Cove, Oregon



3. Southwestern Oregon



4. South of Shady Cove, Oregon

Western Juniper and Mountain Mahogany Woodlands



1. Sheldon National Wildlife Refuge, Nevada



2. Sheldon National Wildlife Refuge, Nevada



3. Jefferson County, Oregon



4. Klamath County, Oregon

Eastside (Interior) Canyon Shrublands



1. Campus Prairie Biological Study Area, Whitman County, Washington



2. Douglas Creek, Douglas County, Washington



3. Asotin County, Washington



4. Kramer Palouse Biological Study Area, Whitman County, Washington



5. Grand Ronde River, Asotin County, Washington

Eastside (Interior) Grasslands



1. Gibraltar Mountain, Ferry County, Washington



2. Palouse River, Franklin County, Washington



3. Columbia Hills Natural Area Preserve, Klickitat County, Washington



4. Arid Lands Ecology Reserve, Hanford, Washington

Shrub-Steppe



1. Horse Heaven Hills, Benton County, Washington



2. Yakima Firing Range, Washington



3. Yakima Firing Range, Washington



3. Steens Mountain, Oregon



4. Vernita, Grant County, Washington

Dwarf Shrub-Steppe



1. Castle Rock, Grand Coulee, Washington



2. Umtanum Ridge, Kittitas County, Washington



3. Saddle Mountains, Hanford, Washington



4. Sheldon National Wildlife Refuge, Nevada

Desert Playa and Salt Scrub Shrublands



1. Alvord Desert, Oregon



2. Alvord Desert, Oregon



3. Alvord Desert, Oregon



4. Harney Basin, Oregon



5. Alvord Desert, Oregon

Agriculture, Pasture, and Mixed Environs



1. Near Samish Bay, Skagit County, Washington



2. Sinlahekin Valley, Okanogan County, Washington



3. Ellensburg area, Kittitas County, Washington



4. Southeast Washington (wheat field)



5. Benton County, Oregon

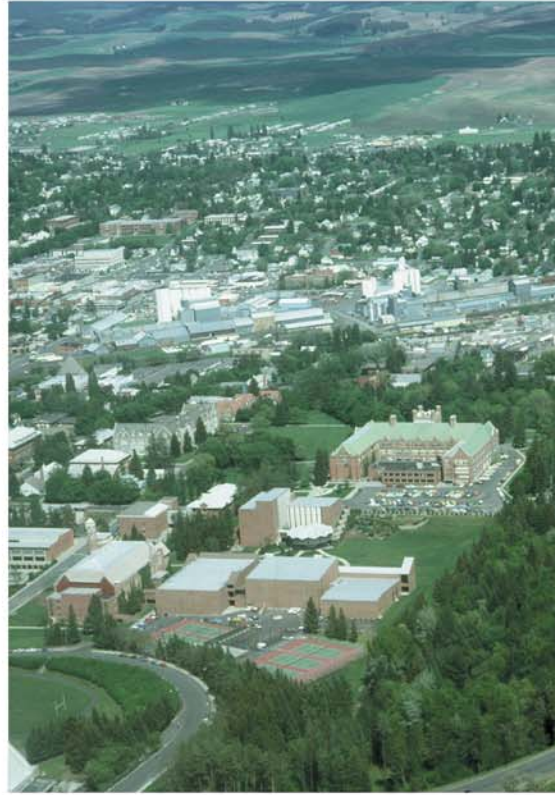


6. Scotch Creek Wildlife Area, Okanogan County, Washington

Urban and Mixed Environs



1. Example of high density urban, Seattle, Washington



2. Example of medium density urban, Washington



3. Example of low density urban, Benton County, Oregon



4. Example of low density urban, Wenatchee, Washington

Open Water–Lakes, Rivers, Streams



1. Lake Ozette, Washington



2. Lower Soleduck River, Washington



3. Grant County, Washington



4. Snake River, Washington



5. Willamette River, Linn County, Oregon

Herbaceous Wetlands



1. Okanogan County, Washington



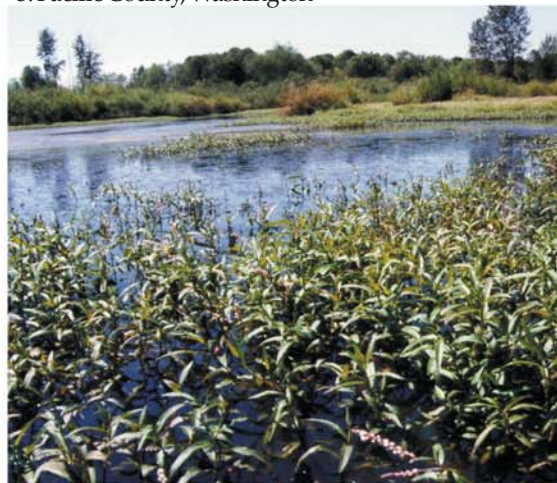
2. Methow Valley, Okanogan County, Washington



3. Pacific County, Washington



4. Lincoln County, Washington



5. Linn County, Oregon

Westside Riparian - Wetlands



1. Stequaleho Creek, Jefferson County, Washington



2. Cranberry Creek, Grays Harbor County, Washington



3. Maxfield Creek, Clallam County, Washington



4. Cranberry Creek, Grays Harbor, Washington



5. Quinalt River, Grays Harbor County, Washington

Montane Coniferous Wetlands



1. Arlecho Creek, Whatcom County, Washington



2. Roger Lake, Okanogan County, Washington



3. Mt. Rainier National Park, Washington



4. Mt. Pilchuck Conservation Area, Snohomish County, Washington

Eastside (Interior) Riparian-Wetlands



1. Northrup Canyon, Grant County, Washington



2. Little Pend Oreille River, Stevens County, Washington



3. Douglas Creek, Douglas County, Washington



4. Myers Creek, Okanogan County, Washington



5. Eastern Klickitat County, Washington



6. Crimm's Creek, Washington

Coastal Dunes and Beaches



1. Florence, Oregon



2. Whidbey Island, Washington



3. Ocean Shores, Grays Harbor County, Washington



4. Whidbey Island, Washington



5. Whidbey Island, Washington

Coastal Headlands and Islets



1. Near Cape Perpetua, Oregon



2. Heceta Head, Oregon



3. Near Yaquina Head, Oregon



4. Near Cape Perpetua, Oregon



5. Coastline near Quinalt River, Grays Harbor County, Washington

Bays and Estuaries



1. Estuary, Washington



2. Dogfish Point, Skagit County, Washington



3. Niawiakum River Natural Area Preserve, Willapa Bay, Washington



4. Nisqually Delta, Thurston County, Washington



5. Niawiakum River, Willapa Bay, Washington



6. Newport, Oregon

Marine Nearshore



1. Ben Ure Island, Island County, Washington



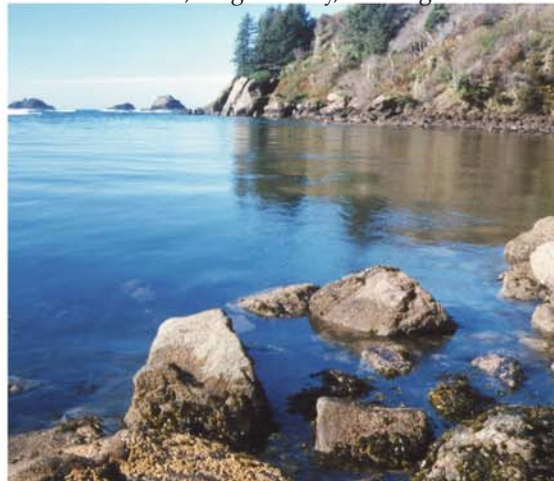
2. Cypress Island, Skagit County, Washington



3. Guemes Island, Skagit County, Washington



4. Near Biz Point, Skagit County, Washington



5. Near Cascade Head, Lincoln County, Oregon

Inland Marine Deeper Water

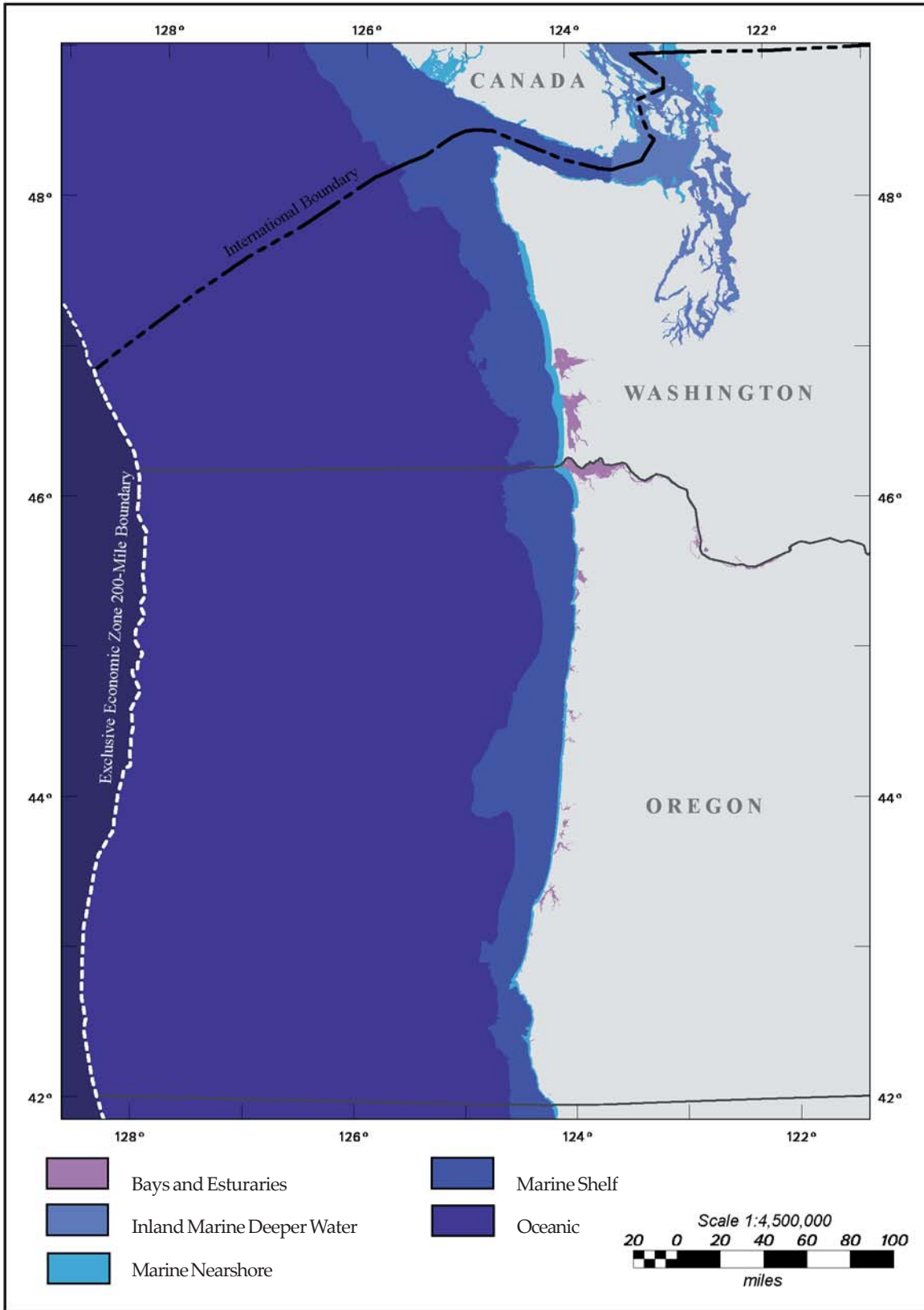


1. Squaxin Island, South Puget Sound, Washington



2. San Juan Islands, Washington

Marine Habitats



they total 176,920 acres (71,628 ha)²²⁶. In contrast, there are 4,073 lakes and reservoirs in eastern Washington that total 436,843 acres (176,860 ha).²²⁷ There are 6,000 lakes, ponds, and reservoirs in Oregon including almost 1,800 named lakes and over 3,800 named reservoirs, all amounting to 270,641 acres (109,571 ha). Oregon has the deepest lake in the nation, Crater Lake, at 1,932 ft (589 m).²³

Physical Setting. Continental glaciers melted and left depressions, where water accumulated and formed many lakes in the region. These kinds of lakes are predominantly found in Lower Puget Sound. Landslides that blocked natural valleys also allowed water to fill in behind them to form lakes, like Crescent Lake, Washington. The lakes in the Cascades and Olympic ranges were formed through glaciation and range in elevation from 2,500 to 5,000 ft (762 to 1,524 m). Beavers create many ponds and marshes in Oregon and Washington. Craters created by extinct volcanoes, like Battleground Lake, Washington, also formed lakes. Human-made reservoirs created by dams impound water that creates lakes behind them, like Bonneville Dam on the main stem of the Columbia River. In the lower Columbia Basin, many lakes formed in depressions and rocky coulees through the process of seepage from irrigation waters.²²⁶

Structure. There are four distinct zones within this aquatic system: (1) the littoral zone at the edge of lakes is the most productive with diverse aquatic beds and emergent wetlands (part of Herbaceous Wetlands habitat); (2) the limnetic zone is deep open water, dominated by phytoplankton and freshwater fish, and extends down to the limits of light penetration; (3) the profundal zone below the limnetic zone, devoid of plant life and dominated with detritivores; (4) and the benthic zone reflecting bottom soil and sediments. Nutrients from the profundal zone are recycled back to upper layers by the spring and fall turnover of the water. Water in temperate climates stratifies because of the changes in water density. The uppermost layer, the epilimnion, is where water is warmer (less dense). Next, the metalimnion or thermocline, is a narrow layer that prevents the mixing of the upper and lowermost layers. The lowest layer is the hypolimnion, with colder and most dense waters. During the fall turnover, the cooled upper layers are mixed with other layers through wind action.

Rivers and Streams

Geographic Distribution. Streams and rivers are distributed statewide in Oregon and Washington, forming a continuous network connecting high mountain areas to lowlands and the Pacific coast. There are >12,000 named rivers and streams in Oregon, totalling 112,640 miles (181,238 km) in length. Oregon's longest stretch of river is the Columbia (309 miles [497 km]) that borders Oregon and Washington. The longest river in Oregon is the John Day (284 miles [457 km]) and the shortest river is the D River (440 ft [134 m]) that is the world's second shortest

river. Washington has more streams than any other state except Alaska. In Washington, the coastal region has 3,783 rivers and streams totaling 8,176 miles (13,155 km)¹⁷⁴. The Puget Sound Region has 10,217 rivers and streams, which add to 16,600 miles (26,709 km) in length.²²³ The rivers and streams range from cold, fast-moving high-elevation streams to warmer lowland valley rivers.²²³ In all, there are 13,955 rivers and streams that add up to 24,774 miles (39,861 km).¹⁷⁴ There are many more streams in Washington yet to be catalogued.¹⁷⁴ Streams reflect flowing water •6 feet (2 m) wide; narrower water bodies are considered within their respective habitats.

Physical Setting. Climate of the area's coastal region is very wet. The northern region in Washington is volcanic and bordered to the east by the Olympic Mountain Range, on the north by the Strait of Juan de Fuca, and on the west by the Pacific Ocean. In contrast, the southern portion in Washington is characterized by low-lying, rolling hills.¹⁷⁴ The Puget Sound Region has a wet climate. Most of the streams entering Puget Sound have originated in glacier fields high in the mountains. Water from melting snowpacks and glaciers provide flow during the spring and winter. Annual rainfall in the lowlands ranges from 35 to 50 inches (89-127 cm), from 75 to 100 inches (191 to 254 cm) in the foothills, and from 100 to >200 inches (254 to 508 cm) in the mountains (mostly in the form of snow).¹⁷⁴

Rivers and streams in southwestern Oregon are fed by rain and are located in an area composed of sheared bedrock and thus an unstable terrain. Streams in that area have high suspended-sediment loads. Beds composed of gravel and sand are easily transported during floods. The western Cascades in Washington and Oregon are composed of volcanically derived rocks and are more stable. They have low sediment-transport rates and stable beds composed largely of cobbles and boulders, which move only during extreme events.⁸¹ Velocities of river flow ranges from as little as 0.2 to 12 mph (0.3 to 19.3 km/hr) while large streams have an average annual flow of 10 cubic feet (0.3 m³) per second or greater.^{23, 169} Rivers and streams in the Willamette Valley are warm, productive, turbid, and have high ionic strength. They are characterized by deep pools, and highly embedded stream bottoms with claypan and muddy substrates, and the greatest fish species diversity. High desert streams of the interior are similar to those of the Willamette Valley but are shallower, with fewer pools, and more runs, glides, cobbles, boulders, and sand. The Cascades and Blue mountains are similar in that they have more runs and glides and fewer pools, similar fish assemblages, and similar water quality.²¹⁸

Lakes, Rivers and Streams

Landscape setting. This habitat occurs throughout Washington and Oregon. Ponds, lakes, and reservoirs are typically adjacent to Herbaceous Wetlands, while rivers and streams typically adjoin the Westside Riparian-Wetlands, Eastside Riparian-Wetlands, Herbaceous Wetlands, and Bays and Estuaries habitats.

Other Classifications and Key References. This habitat is called riverine and lacustrine in Anderson et al.,¹⁰ Cowardin et al.,⁵³ Washington Gap Analysis Project,³⁷ Mayer and Laudenslayer,¹⁵⁰ and Wetzel.²¹⁷ However, this habitat is referred to as Open Water in the Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types.¹²⁷

Natural Disturbance Regime. There are seasonal and decadal variations in the patterns of precipitation. In the Coast Range, there is usually 1 month of drought per year (usually July or August) and 2 months of drought once in a decade. The Willamette Valley and the Cascades experience 1 month with no rain every year and a 2-month dry period every third year. In eastern Oregon, dry periods last 2 or 3 months every year, with dry spells as long as 4–6 months occurring once every 4 years. Dry years, with <33% of normal precipitation, occur once every 30 years along the coast, every 20 years in the Willamette Valley, every 30 years in the Cascades, and every 15 years in most of eastern Oregon.²³

Floods occur in Oregon and Washington every year. Flooding season west of the Cascades occurs from October through April, with more than half of the floods occurring during December and January. Floods are the result of precipitation and snow melts. Floods west of the Cascades are influenced by precipitation mostly and thus are short-lived, while east of the Cascades floods are caused by melting snow, and the amount of flooding depends on how fast the snow melts. High water levels frequently last up to 60 days. In 1984, heavy precipitation flooded Malheur and Harney lakes to the point where the two lakes were joined together for several years. The worst floods have resulted from cloudbursts caused by thunderstorms, like Heppner, Oregon's 1903 flood. Other "flash floods" in the region were among the largest floods in the U.S. and occurred in the John Day Basin's Meyers Canyon in 1956 and the Umatilla Basin's Lane Canyon in 1965.²³

Effects of Management and Anthropogenic Impacts. Sewage effluents caused eutrophication of Lake Washington in Seattle, where plants increased in biomass and caused decreased light transmission. The situation was corrected, however, before it became serious as a result of a campaign of public education, and timely cleanup of the lake.¹⁴⁶ Irrigation projects aimed at watering drier portions of the landscape may pose flooding dangers, as was the case with Soap Lake and Lake Leonore in eastern Washington. Finally, natural salinity of lakes can decrease as a result of irrigation withdrawal and can change the biota associated with them.⁹²

Removal of gravel results in reduction of spawning areas for anadromous fish. Overgrazing, and loss of vegetation caused by logging produces increased water temperatures and excessive siltation, harming the invertebrate communities such as that reported in the John Day River Basin, Oregon.¹⁴⁶ Incorrectly installed culverts may act as barriers to migrating fish and may contribute to erosion and siltation downstream.¹⁷⁴ Construction of dams is associated with changes in water quality, fish

passage, competition between species, loss of spawning areas because of flooding, and declines in native fish populations.¹⁴⁶ Historically, the region's rivers contained more braided multi-channels. Flood control measures such as channel straightening, diking, or removal of streambed material along with urban and agriculture development have all contributed to a loss of oxbows, river meanders, and flood plains. Unauthorized or over-appropriated withdrawals of water from the natural drainages also has caused a loss of open water habitat that has been detrimental to fish and wildlife production, particularly in the summer.¹⁷⁴

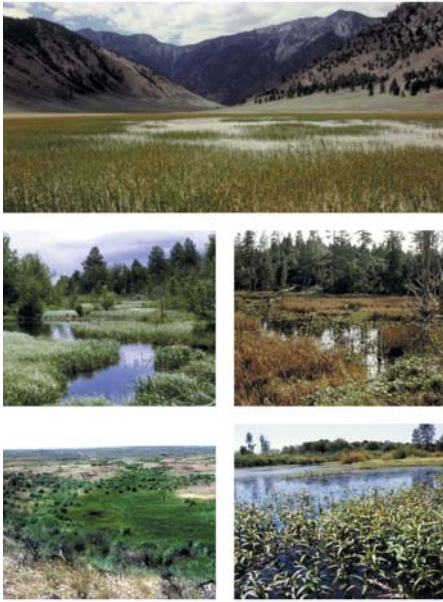
Agricultural, industrial, and sewage runoff such as salts, sediments, fertilizers, pesticides, and bacteria harm aquatic species.¹⁴⁶ Sludge and heavy waste buildup in estuaries is harmful to fish and shellfish. Unregulated aerial spraying of pesticides over agricultural areas also poses a threat to aquatic and terrestrial life.¹⁷⁴ Direct loss of habitat and water quality occurs through irrigation.¹³⁰ The Oregon Department of Environmental Quality, after a study of water quality of the Willamette River, determined that up to 80% of water pollution enters the river from nonpoint sources and especially agricultural activity.²³ Very large floods (e.g., Oregon Flood of 1964) may change the channels permanently through the settling of large amounts of sediments from hillslopes, through debris flow, and through movement of large boulders, particularly in the montane areas. The width of the channel along the main middle fork of the Willamette increased over a period of 8 years. Clearcutting creates excessive intermittent runoff conditions and increases erosion and siltation of streams as well as diminishes shade, and therefore causes higher water temperatures, fewer terrestrial and aquatic food organisms, and increased predation. Landslides, which contributed to the widening of the channel, were a direct result of clearcutting. Clearcut logging can alter snow accumulation and increase the size of peak flows during times of snowmelt.¹⁹⁷ Clearcutting and vegetation removal affects the temperatures of streams, increasing them in the summer and decreasing in winter, especially in eastern parts of the Oregon and Washington.²⁴ Building of roads, especially those of poor quality, can be a major contributor to sedimentation in the streams.⁸²

Status and Trends. The principal trend has been in relationship to dam building or channelization for hydroelectric power, flood control, or irrigation purposes. As an example, in 1994, there were >900 dams in Washington alone. The dams vary according to size, primary purpose, and ownership (state, federal, private, local).²¹⁴ The first dam and reservoir in Washington was the Monroe Street Dam and Reservoir, built in 1890 at Spokane Falls. Since then the engineering and equipment necessary for dam building developed substantially, culminating in such projects as the Grand Coulee Dam on the Columbia River.²¹⁴ In response to the damaging effects of dams on the indigenous biota and alteration and destruction of freshwater aquatic habitats, Oregon and Washington state governments questioned the benefits of

dams, especially in light of the federal listing of several salmon species. There are now talks of possibly removing small dams, like the Savage Rapids Dam in Oregon, to removing large federal dams like those on the lower Snake River.²³

22. Herbaceous Wetlands

Rex C. Crawford, Jimmy Kagan, and Christopher B. Chappell



Geographic Distribution. Herbaceous wetlands are found throughout the world and are represented in Oregon and Washington wherever local hydrologic conditions promote their development. This habitat includes all those except bogs and those within Subalpine Parkland and Alpine habitats.

Freshwater aquatic bed habitats are found throughout the Pacific Northwest, usually in isolated sites. They are more widespread in valley bottoms and high rainfall areas (e.g., Willamette Valley, Puget Trough, coastal terraces, coastal dunes), but are present in montane and arid climates as well. Hardstem bulrush-cattail-burreed marshes occur in wet areas throughout Oregon and Washington. Large marshes are common in the lake basins of Klamath, Lake, and Harney counties, Oregon. Sedge meadows and montane meadows are common in the Blue and Ochoco mountains of central and northeastern Oregon, and in the valleys of the Olympic and Cascade mountains and Okanogan Highlands. Extensive wet meadow habitats occur in Klamath, Deschutes, and western Lake counties in Oregon.

Physical Setting. This habitat is found on permanently flooded sites that are usually associated with oxbow lakes, dune lakes, or potholes. Seasonally to semi-permanently flooded wetlands are found where standing freshwater is present through part of the growing season and the soils stay saturated throughout the season. Some sites are

temporarily to seasonally flooded meadows and generally occur on clay, pluvial, or alluvial deposits within montane meadows, or along stream channels in shrubland or woodland riparian vegetation. In general, this habitat is flat, usually with stream or river channels or open water present. Elevation varies between sea level to 10,000 ft (3,048 m), although infrequently above 6,000 ft (1,830 m).

Landscape Setting. Herbaceous wetlands are found in all terrestrial habitats except Subalpine Parkland and Alpine Grasslands and Shrublands habitats. Herbaceous wetlands commonly form a pattern with Westside and Eastside Riparian-Wetlands and Montane Coniferous Wetlands habitats along stream corridors. These marshes and wetlands also occur in closed basins in a mosaic with open water by lakeshores or ponds. Extensive deflation plain wetlands have developed between Coastal Dunes and Beaches habitat and the Pacific Ocean. Herbaceous wetlands are found in a mosaic with alkali grasslands in the Desert Playa and Salt Scrub habitat.

Structure. The herbaceous wetland habitat is generally a mix of emergent herbaceous plants with a grass-like life form (graminoids). These meadows often occur with deep or shallow water habitats with floating or rooting aquatic forbs. Various wetland communities are found in mosaics or in nearly pure stands of single species. Herbaceous cover is open to dense. The habitat can be comprised of tule marshes >6.6 ft (2 m) tall or sedge meadows and wetlands <3.3 ft (1 m) tall. It can be a dense, rhizomatous sward or a tufted graminoid wetland. Graminoid wetland vegetation generally lacks many forbs, although the open extreme of this type contains a diverse forb component between widely spaced tall tufted grasses.

Composition. Various grasses or grass-like plants dominate or co-dominate these habitats. Cattails (*Typha latifolia*) occur widely, sometimes adjacent to open water with aquatic bed plants. Several bulrush species (*Scirpus acutus*, *S. tabernaemontani*, *S. maritimus*, *S. americanus*, *S. nevadensis*) occur in nearly pure stands or in mosaics with cattails or sedges (*Carex* spp.). Burreed (*Sparganium angustifolium*, *S. eurycarpum*) are the most important graminoids in areas with up to 3.3 ft (1m) of deep standing water. A variety of sedges characterize this habitat. Some sedges (*Carex aquatilis*, *C. lasiocarpa*, *C. scopulorum*, *C. simulata*, *C. utriculata*, *C. vesicaria*) tend to occur in cold to cool environments. Other sedges (*C. aquatilis* var. *dives*, *C. angustata*, *C. interior*, *C. microptera*, *C. nebrascensis*) tend to be at lower elevations in milder or warmer environments. Slough sedge (*C. obnupta*), and several rush species (*Juncus falcatus*, *J. effusus*, *J. balticus*) are characteristic of coastal dune wetlands that are included in this habitat. Several spike rush species (*Eleocharis* spp.) and rush species can be important. Common grasses that can be local dominants and indicators of this habitat are American sloughgrass (*Beckmannia syzigachne*), bluejoint reedgrass (*Calamagrostis canadensis*), mannagrass (*Glyceria* spp.), and tufted hairgrass (*Deschampsia caespitosa*). Important introduced grasses that increase and can dominate with

disturbance in this wetland habitat include reed canary grass (*Phalaris arundinacea*), tall fescue (*Festuca arundinacea*) and Kentucky bluegrass (*Poa pratensis*).

Aquatic beds are part of this habitat and support a number of rooted aquatic plants, such as yellow pond lily (*Nuphar lutea*) and unrooted, floating plants such as pondweeds (*Potamogeton* spp.), duckweed (*Lemna minor*), or water-meals (*Wolffia* spp.). Emergent herbaceous broadleaf plants, such as Pacific water parsley (*Oenanthe sarmentosa*), buckbean (*Menyanthes trifoliata*), water starwarts (*Callitriche* spp.), or bladderworts (*Utricularia* spp.) grow in permanent and semi-permanent standing water. Pacific silverweed (*Argentina egedii*) is common in coastal dune wetlands. Montane meadows occasionally are forbdominated with plants such as arrowleaf groundsel (*Senecio triangularis*) or ladyfern (*Athyrium filix-femina*). Climbing nightshade (*Solanum dulcamara*), purple loosestrife (*Lythrum salicaria*), and poison hemlock (*Conium maculatum*) are common non-native forbs in wetland habitats.

Shrubs or trees are not a common part of this herbaceous habitat although willow (*Salix* spp.) or other woody plants occasionally occur along margins, in patches or along streams running through these meadows.

Other Classifications and Key References. This habitat is called Palustrine emergent wetlands in Cowardin et al.⁵³ Other references describe this habitat.^{43, 44, 57, 71, 131, 132, 138, 147, 219} This habitat occurs in both lotic and lentic systems. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are wet meadow, palustrine emergent, and National Wetland Inventory (NWI) palustrine shrubland.

Natural Disturbance Regime. This habitat is maintained through a variety of hydrologic regimes that limit or exclude invasion by large woody plants. Habitats are permanently flooded, semipermanently flooded, or flooded seasonally and may remain saturated through most of the growing season. Most wetlands are resistant to fire and those that are dry enough to burn usually burn in the fall. Most plants are sprouting species and recover quickly. Beavers play an important role in creating ponds and other impoundments in this habitat. Trampling and grazing by large native mammals is a natural process that creates habitat patches and influences tree invasion and success.

Succession and Stand Dynamics. Herbaceous wetlands are often in a mosaic with shrub- or tree-dominated wetland habitat. Woody species can successfully invade emergent wetlands when this herbaceous habitat dries. Emergent wetland plants invade open-water habitat as soil substrate is exposed; e.g., aquatic sedge and Northwest Territory sedge (*Carex utriculata*) are pioneers following beaver dam breaks. As habitats flood, woody species decrease to patches on higher substrate (soil, organic matter, large woody debris) and emergent plants increase unless the flooding is permanent. Fire suppression can lead to woody species invasion in drier herbaceous wetland habitats; e.g., Willamette Valley wet prairies are

invaded by Oregon ash (*Fraxinus latifolia*) with fire suppression.

Effects of Management and Anthropogenic Impacts. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. If the alteration is long term, wetland systems may reestablish to reflect new hydrology, e.g., cattail is an aggressive invader in roadside ditches. Severe livestock grazing and trampling decreases aquatic sedge, Northwest Territory sedge (*Carex utriculata*), bluejoint reedgrass, and tufted hairgrass. Native species, however, such as Nebraska sedge, Baltic and jointed rush (*Juncus nodosus*), marsh cinquefoil (*Comarum palustris*), and introduced species dandelion (*Taraxacum officinale*), Kentucky bluegrass, spreading bentgrass (*Agrostis stolonifera*), and fowl bluegrass (*Poa palustris*) generally increase with grazing.

Status and Trends. Nationally, herbaceous wetlands have declined and the Pacific Northwest is no exception. These wetlands receive regulatory protection at the national, state, and county level; still, herbaceous wetlands have been filled, drained, grazed, and farmed extensively in the lowlands of Oregon and Washington. Montane wetland habitats are less altered than lowland habitats even though they have undergone modification as well. A keystone species, the beaver, has been trapped to near extirpation in parts of the Pacific Northwest and its population has been regulated in others. Herbaceous wetlands have decreased along with the diminished influence of beavers on the landscape. Quigley and Arbelbide¹⁸¹ concluded that herbaceous wetlands are susceptible to exotic, noxious plant invasions.

23. Westside Riparian-Wetlands

Christopher B. Chappell & Jimmy Kagan

Geographic Distribution. This habitat is patchily distributed in the lowlands throughout the area west of the Cascade Crest south into northwestern California and north into British Columbia. It also occurs less extensively at mid- to higher elevations in the Cascade and Olympic

mountains, where it is limited to more specific environments.

Physical Setting. This habitat is characterized by wetland hydrology or soils, periodic riverine flooding, or perennial flowing freshwater. The climate varies from very wet to moderately dry and from mild to cold. Mean annual precipitation ranges from 20 to >150 inches (51 to >381 cm) per year. This habitat is found at elevations mostly below 3,000 ft (914 m), but it does extend up to 5,500 ft (1,676 m) in Washington and 6,500 ft (1,981 m) in Oregon in the form of Sitka alder communities. Wetlands above these elevations are generally considered part of the Subalpine Parkland habitat and are not included here. Topography is typically flat to gently sloping or undulating, but can include moderate to steep slopes in the mountains. Geology is extremely variable. Gleyed or mottled mineral soils, organic soils, or alluvial soils are typical. Flooding regimes include permanently flooded (aquatic portions of small streams), seasonally flooded, saturated, and temporarily flooded. Nutrient-poor acidic bogs, except those high in the mountains, are considered part of this habitat.

Landscape Setting. This habitat typically occupies patches or linear strips within a matrix of forest or regrowing forest. The most frequent matrix habitat is Westside Lowlands Conifer-Hardwood Forest. If not forest, the matrix can be Agriculture, Urban, or Coastal Dunes and Beaches habitats, or rarely Westside Grasslands or Ceanothus-Manzanita Shrublands. This habitat also forms mosaics with or includes small patches of Herbaceous Wetlands. Open Water habitat is often adjacent to Westside Riparian-Wetlands. The major land use of the forested portions of this habitat is timber harvest. Livestock grazing occurs in some areas. Peat mining occurs in some bogs.

Structure. Most often this habitat is either a tall (6-30 ft [2-9 m]) deciduous broadleaf shrubland, woodland or forest, or some mosaic of these. Short to medium-tall evergreen shrubs or graminoids and mosses dominate portions of bogs. Trees are evergreen conifers or deciduous broadleaf or a mixture of both. Conifer-dominated wetlands in the lowlands are included here, whereas mid-elevation conifer sites are part of Montane Coniferous Wetlands habitat. Height of the dominant vegetation can be >200 ft (62 m). Canopy height and structure vary greatly. Typical understories are composed of shrubs, forbs, and/or graminoids. Water is sometimes present on the surface for a portion of the year. Large woody debris is abundant in late seral forests and adjacent stream channels. Small stream channels and small backwater channels on larger streams are included in this habitat.

Composition. Red alder (*Alnus rubra*) is the most widespread tree species, but is absent from sphagnum bogs. Other deciduous broadleaf trees that commonly dominate or co-dominate include black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), bigleaf maple (*Acer macrophyllum*), Oregon ash (*Fraxinus latifolia*), and, locally, white alder (*Alnus rhombifolia*). Pacific willow (*Salix lucida*

ssp. *lasiandra*) can form woodlands on major floodplains or co-dominate with other willows in tall shrublands. Oregon white oak (*Quercus garryana*) and California black oak (*Q. kelloggii*) can be important in the interior valleys of western Oregon. Conifers that frequently dominate or co-dominate include western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and Sitka spruce (*Picea sitchensis*). Grand fir (*Abies grandis*) sometimes co-dominates, especially in drier climates and riverine flood plains. Douglas-fir (*Pseudotsuga menziesii*) is relatively uncommon. Shore pine (*Pinus contorta* var. *contorta*) is common in bogs and in deflation plain wetlands along the outer coast. Dominant species in tall shrublands include Sitka willow (*Salix sitchensis*), Hooker's willow (*S. hookeriana*), Douglas' spirea (*Spirea douglasii*), red-osier dogwood (*Cornus sericea*), western crabapple (*Malus fusca*), salmonberry (*Rubus spectabilis*), stink currant (*Ribes bracteosum*), devil's-club (*Oplopanax horridum*), and sweet gale (*Myrica gale*). Labrador-tea (*Ledum groenlandicum*, L. *glandulosum*), western swamp-laurel (*Kalmia microphylla*), sweet gale, and salal (*Gaultheria shallon*) often dominate sphagnum bogs. Vine maple (*Acer circinatum*) or Sitka alder (*Alnus viridis* ssp. *sinuata*) dominate tall shrublands in the mountains that are located on moist talus or in snow avalanche tracks.

Forests and willow, spirea, and dogwood shrublands within this habitat are limited to the area west of the Cascade Crest. Oregon ash communities occur primarily in the southern Puget Lowland (King County south), Willamette Valley, and Klamath Mountains ecoregions. White alder occurs only in the Willamette Valley and southwestern Oregon. Sitka spruce communities are mainly found in the Coast Range area and western Olympic Peninsula in areas of coastal fog influence. Western hemlock and western redcedar riparian and wetland habitats are largely absent from the southern Oregon Cascades and the Klamath Mountains. Sitka alder and vine maple communities are located in the mountains, mainly in western Washington but to a lesser degree on the east slope of the Cascades and in the Oregon Cascades. Sweet gale communities are found primarily at low elevations on the western Olympic Peninsula. Lodgepole pine-dominated communities are found as bogs in western Washington and along the outer coast of Oregon. Most sphagnum bogs are found in low elevation western Washington.

Shrubs that commonly dominate underneath a tree layer include salmonberry, salal, vine maple, red-osier dogwood, stink currant, Labrador-tea, devil's-club, thimbleberry (*Rubus parviflorus*), common snowberry (*Symphoricarpos albus*), beaked hazel (*Corylus cornuta*), and Pacific ninebark (*Physocarpus capitatus*). Understory dominant herbs include slough sedge (*Carex obnupta*), Dewey sedge (*C. deweyana*), Sitka sedge (*C. aquatilis* var. *dives*), skunk-cabbage (*Lysichiton americanus*), coltsfoot (*Petasites frigidus*), great hedge-nettle (*Stachys ciliata*), youth-on-age (*Tolmiea menziesii*), ladyfern (*Athyrium filix-femina*), oxalis (*Oxalis oregana*, *O. trillifolia*), stinging nettle (*Urtica dioica*), swordfern (*Polystichum munitum*), great

burnet (*Sanguisorba officinalis*), scouring-rush (*Equisetum hyemale*), blue wildrye (*Elymus glaucus*), Pacific golden-saxifrage (*Chrysosplenium glechomifolium*), and field horsetail (*Equisetum arvense*). Bogs often have areas dominated by 1 species of sedge (*Carex* spp.) or beakrush (*Rhynchospora alba*) and sphagnum moss (*Sphagnum* spp.) that are included within this habitat, despite their lack of woody vegetation. Sphagnum moss is a major ground cover in most bogs.

Other Classifications and Key References. This habitat includes all palustrine, forested wetlands and scrub-shrub wetlands at lower elevations on the westside as well as a small subset of persistent emergent wetlands, those within sphagnum bogs.⁵³ However, drier portions of this habitat in riparian flood plains may not qualify as wetlands according to Cowardin's definition.⁵³ They are associated with both lentic and lotic systems. Much of this habitat is probably not mapped as distinct types by the Gap projects because of its relatively small scale on the landscape and the difficulty of distinguishing forested wetlands. A portion of this habitat is mapped as the Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ westside cottonwood riparian gallery, palustrine forest, palustrine shrubland, NWI (National Wetland Inventory) palustrine emergent, NWI estuarine emergent, and alder/cottonwood riparian gallery. In the Washington Gap project, this habitat occupies portions of open water/wetlands (especially riparian), hardwood forest, and mixed hardwood/conifer forest, and to a minor degree, conifer forest in the following zones: Western hemlock, Sitka spruce, Olympic Douglas-fir, Puget Sound Douglas-fir, Cowlitz River, Willamette Valley, and Woodland/prairie mosaic.³⁷ This habitat also occupies much of hardwood forest in the Silver fir, Mountain hemlock, portions of Subalpine fir, Interior western hemlock/redcedar, and Grand fir zones.³⁷ Other references describe this habitat.^{41, 71, 85, 88, 90, 91, 104, 113, 114, 115, 138, 210, 220}

Natural Disturbance Regime. The primary natural disturbance is flooding. Flooding frequency and intensity vary greatly with hydro-geomorphic setting. Floods can create new surfaces for primary succession, erode existing streambank communities, deposit sediment and nutrients on existing communities, and selectively kill species not adapted to a particular duration or intensity of flood. Most plant communities are more or less adapted to a particular flooding regime,¹³⁸ or they occupy a specific time in a successional sequence after a major disturbance.⁸⁵ Debris flows/torrents are also an important, typically infrequent, and severe disturbance where topography is mountainous.²⁰⁰ Fires were probably infrequent or absent because of the combination of landscape position and site moisture, although fires within the watershed would usually have effects on the habitat through impacts on flooding, sedimentation, and large woody debris inputs. Windthrow of trees can also be significant, especially near the outer coast or on saturated soils. Beavers act as important disturbances by changing the hydrology of a stream system through dams. Grazing by native

ungulates, e.g., elk, can have a major effect on vegetation.

Succession and Stand Dynamics. Riparian, i.e., streamside, habitats are extremely dynamic.¹⁶² Succession varies greatly depending on the hydro-geomorphic environment. A typical sequence on a riparian terrace on a large stream involves early dominance by Sitka willow, mid-seral dominance by red alder or cottonwood, with a gradual increase in conifers, and eventual late-seral dominance of spruce, redcedar, and/or hemlock. Such a sequence corresponds with increasing terrace height above the bankfull stream stage.⁸⁵ Some communities in bogs or depressional wetlands, as opposed to riverine, seem to be relatively stable given a particular flooding regime and environment. Successional sequences are not completely understood and can be complex. Beaver dams or other alterations of flood regime often result in vegetation changes.

Effects of Management and Anthropogenic Impacts. Intense logging disturbance in conifer or mixed riparian or wetland forests, except bogs, often results in establishment of red alder, and its ensuing long-term dominance. Salmonberry responds similarly to this disturbance and tends to dominate the understory. Logging activities reduce amounts of large woody debris in streams and remove sources of that debris.²⁷ Timber harvest can also alter hydrology, most often resulting in post-harvest increases in peak flows.¹⁰⁷ Mass wasting and related disturbances (stream sedimentation, debris torrents) in steep topography increase in frequency with road building and timber harvest.¹⁹⁸ Roads and other water diversion/retention structures change watershed hydrology with wide-ranging and diverse effects,⁹³ including major vegetation changes. The most significant of these are the major flood controlling dams, which have greatly altered the frequency and intensity of bottomland flooding. Increases in nutrients and pollutants are other common anthropogenic impacts, the former with particularly acute effects in bogs. Reed canarygrass (*Phalaris arundinacea*) is an abundant non-native species in low-elevation, disturbed settings dominated by shrubs or deciduous trees. Many other exotic species also occur.

Status and Trends. This habitat occupies relatively small areas and has declined greatly in extent with conversion to urban development and agriculture. What remains is mostly in poor condition, having experienced any of various anthropogenic impacts that have degraded the functionality of these ecosystems: channeling, diking, dams, logging, road-building, invasion of exotic species, changes in hydrology and nutrients, and livestock grazing. Current threats include all of the above as well as development. Some protection has been afforded to this habitat through government regulations that vary in their scope and enforcement with jurisdiction. Of the 77 plant associations representing this habitat in the National Vegetation Classification, almost half are considered imperiled or critically imperiled.¹⁰

24. Montane Coniferous Wetlands

Christopher B. Chappell & Jimmy Kagan



Geographic Distribution. This habitat occurs in mountains throughout much of Washington and Oregon, except the Basin and Range of southeastern Oregon, the Klamath Mountains of southwestern Oregon, and the Coast Range of Oregon. This includes the Cascade Range, Olympic Mountains, Okanogan Highlands, Blue and Willowa mountains.

Physical Setting. This habitat is typified as forested wetlands or floodplains with a persistent winter snow pack, ranging from moderately to very deep. The climate varies from moderately cool and wet to moderately dry and very cold. Mean annual precipitation ranges from about 35 to >200 inches (89 to >508 cm). Elevation is mid- to upper montane, as low as 2,000 ft (610 m) in northern Washington, to as high as 9,500 ft (2,896 m) in eastern Oregon. Topography is generally mountainous and includes everything from steep mountain slopes to nearly flat valley bottoms. Gleyed or mottled mineral soils, organic soils, or alluvial soils are typical. Subsurface water flow within the rooting zone is common on slopes with impermeable soil layers. Flooding regimes include saturated, seasonally flooded, and temporarily flooded. Seeps and springs are common in this habitat.

Landscape Setting. This habitat occurs along stream courses or as patches, typically small, within a matrix of Montane Mixed Conifer Forest, or less commonly, Eastside Mixed Conifer Forest or Lodgepole Pine Forest and Woodlands. It also can occur adjacent to other wetland habitats: Eastside Riparian-Wetlands, Westside Riparian-Wetlands, or Herbaceous Wetlands. The primary land uses are forestry and watershed protection.

Structure. This is a forest or woodland (>30% tree canopy cover) dominated by evergreen conifer trees. Deciduous broadleaf trees are occasionally co-dominant. The understory is dominated by shrubs (most often deciduous and relatively tall), forbs, or graminoids. The forb layer is usually well developed even where a shrub layer is dominant. Canopy structure includes single-storied canopies and complex multi-layered ones. Typical tree sizes range from small to very large. Large woody debris

is often a prominent feature, although it can be lacking on less productive sites.

Composition. Indicator tree species for this habitat, any of which can be dominant or co-dominant, are Pacific silver fir (*Abies amabilis*), mountain hemlock (*Tsuga mertensiana*), and Alaska yellow-cedar (*Chamaecyparis nootkatensis*) on the westside, and Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), western hemlock (*T. heterophylla*), or western redcedar (*Thuja plicata*) on the eastside. Lodgepole pine is prevalent only in wetlands of eastern Oregon. Western hemlock and redcedar are common associates with silver fir on the westside. They are diagnostic of this habitat on the east slope of the central Washington Cascades, and in the Okanogan Highlands. Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) are sometimes prominent on the eastside. Quaking aspen (*Populus tremuloides*) and black cottonwood (*P. balsamifera* ssp. *trichocarpa*) are in certain instances important to co-dominant, mainly on the eastside.

Dominant or co-dominant shrubs include devil's-club (*Oplopanax horridus*), stink currant (*Ribes bracteosum*), black currant (*R. hudsonianum*), swamp gooseberry (*R. lacustre*), salmonberry (*Rubus spectabilis*), red-osier dogwood (*Cornus sericea*), Douglas' spirea (*Spirea douglasii*), common snowberry (*Symphoricarpos albus*), mountain alder (*Alnus incana*), Sitka alder (*Alnus viridis* ssp. *sinuata*), Cascade azalea (*Rhododendron albiflorum*), and glandular Labrador-tea (*Ledum glandulosum*). The dwarf shrub bog blueberry (*Vaccinium uliginosum*) is an occasional understory dominant. Shrubs more typical of adjacent uplands are sometimes co-dominant, especially big huckleberry (*V. membranaceum*), oval-leaf huckleberry (*V. ovalifolium*), grouseberry (*V. scoparium*), and fools huckleberry (*Menziesia ferruginea*).

Graminoids that may dominate the understory include bluejoint reedgrass (*Calamagrostis canadensis*), Holm's Rocky Mountain sedge (*Carex scopulorum*), widefruit sedge (*C. angustata*), and fewflower spikerush (*Eleocharis quinqueflora*). Some of the most abundant forbs and ferns are ladyfern (*Athyrium filix-femina*), western oakfern (*Gymnocarpium dryopteris*), field horsetail (*Equisetum arvense*), arrowleaf groundsel (*Senecio triangularis*), two-flowered marshmarigold (*Caltha leptosepala* ssp. *howellii*), false bugbane (*Trautvetteria carolinensis*), skunk-cabbage (*Lysichiton americanus*), twinflower (*Linnaea borealis*), western bunchberry (*Cornus unalaschkensis*), clasping-leaved twisted-stalk (*Streptopus amplexifolius*), singleleaf foamflower (*Tiarella trifoliata* var. *unifoliata*), and five-leaved bramble (*Rubus pedatus*).

Other Classifications and Key References. This habitat includes nearly all of the wettest forests within the *Abies amabilis* and *Tsuga mertensiana* zones of western Washington and northwestern Oregon and most of the wet forests in the *Tsuga heterophylla* and *Abies lasiocarpa* zones of eastern Oregon and Washington.⁸⁸ On the eastside, they may extend down into the *Abies grandis* zone also. This habitat is not well represented by the Gap

projects because of its relatively limited acreage and the difficulty of identification from satellite images. But in the Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ the vegetation types that include this type would be higher elevation palustrine forest, palustrine shrubland, and NWI palustrine emergent. These are primarily palustrine forested wetlands with a seasonally flooded, temporarily flooded, or saturated flooding regime.⁵⁴ They occur in both lotic and lentic systems. Other references describe this habitat.^{36, 57, 90, 101, 108, 111, 114, 115, 118, 123, 132, 221}

Natural Disturbance Regime. Flooding, debris flow, fire, and wind are the major natural disturbances. Many of these sites are seasonally or temporarily flooded. Floods vary greatly in frequency depending on fluvial position. Floods can deposit new sediments or create new surfaces for primary succession. Debris flows/torrents are major scouring events that reshape stream channels and riparian surfaces, and create opportunities for primary succession and redistribution of woody debris. Fire is more prevalent east of the Cascade Crest. Fires are typically high in severity and can replace entire stands, as these tree species have low fire resistance. Although fires have not been studied specifically in these wetlands, fire frequency is probably low. These wetland areas are less likely to burn than surrounding uplands, and so may sometimes escape extensive burns as old forest refugia.¹ Shallow rooting and wet soils are conducive to windthrow, which is a common small-scale disturbance that influences forest patterns. Snow avalanches probably disturb portions of this habitat in the northwestern Cascades and Olympic mountains. Fungal pathogens and insects also act as important small-scale natural disturbances.

Succession and Stand Dynamics. Succession has not been well studied in this habitat. Following disturbance, tall shrubs may dominate for some time, especially mountain alder, stink currant, salmonberry, willows (*Salix* spp.), or Sitka alder. Quaking aspen and black cottonwood in these habitats probably regenerate primarily after floods or fires, and decrease in importance as succession progresses. Lodgepole pine is often associated with post-fire conditions in eastern Oregon,¹³¹ although in some wetlands it can be an edaphic climax species. Pacific silver fir, subalpine fir, or Engelmann spruce would be expected to increase in importance with time since the last major disturbance. Western hemlock, western redcedar, and Alaska yellow-cedar typically maintain co-dominance as stand development progresses because of the frequency of small-scale disturbances and the longevity of these species. Tree size, large woody debris, and canopy layer complexity all increase for at least a few hundred years after fire or other major disturbance.

Effects of Management and Anthropogenic Impacts. Roads and clearcut logging practices can increase the frequency of landslides and resultant debris flows/torrents, as well as sediment loads in streams.^{198, 199, 229} This in turn alters hydrologic patterns and the composition and structure of montane riparian habitats. Logging typically

reduces large woody debris and canopy structural complexity. Timber harvest on some sites can cause the water table to rise and subsequently prevent trees from establishing.²²¹ Wind disturbance can be greatly increased by timber harvest in or adjacent to this habitat.

Status and Trends. This habitat is naturally limited in its extent and has probably declined little in area over time. Portions of this habitat have been degraded by the effects of logging, either directly on site or through geohydrologic modifications. This type is probably relatively stable in extent and condition, although it may be locally declining in condition because of logging and road building. Five of 32 plant associations representing this habitat listed in the National Vegetation Classification are considered imperiled or critically imperiled.¹⁰

25. Eastside Riparian-Wetlands

Rex C. Crawford & Jimmy Kagan



Geographic Distribution. Riparian and wetland habitats dominated by woody plants are found throughout eastern Oregon and eastern Washington.

Mountain alder-willow riparian shrublands are major habitats in the forested zones of eastern Oregon and eastern Washington. Eastside lowland willow and other riparian shrublands are the major riparian types throughout eastern Oregon and Washington at lower elevations. Black cottonwood riparian habitats occur throughout eastern Oregon and Washington, at low to middle elevations. White alder riparian habitats are restricted to perennial streams at low elevations, in drier climatic zones in Hells Canyon at the border of Oregon, Washington, and Idaho, in the Malheur River drainage and in western Klickitat and southcentral Yakima counties, Washington. Quaking aspen wetlands and riparian habitats are widespread but rarely a major component throughout eastern Washington and Oregon. Ponderosa pine-Douglas-fir riparian habitat occurs only around the periphery of the Columbia Basin in Washington and up into lower montane forests.

Physical Setting. Riparian habitats appear along perennial and intermittent rivers and streams. This habitat also appears in impounded wetlands and along lakes and

ponds. Their associated streams flow along low to high gradients. The riparian and wetland forests are usually in fairly narrow bands along the moving water that follows a corridor along montane or valley streams. The most typical stand is limited to 100-200 ft (31-61 m) from streams. Riparian forests also appear on sites subject to temporary flooding during spring runoff. Irrigation of streamsides and toeslopes provides more water than precipitation and is important in the development of this habitat, particularly in drier climatic regions. Hydrogeomorphic surfaces along streams supporting this habitat have seasonally- to temporarily-flooded hydrologic regimes. Eastside riparian and wetland habitats are found from 100- 9,500 ft (31-2,896 m) in elevation.

Landscape Setting. Eastside riparian habitats occur along streams, seeps, and lakes within the Eastside Mixed Conifer Forest, Ponderosa Pine Forest and Woodlands, Western Juniper and Mountain Mahogany Woodlands, and part of the Shrub-steppe habitat. This habitat may be described as occupying warm montane and adjacent valley and plain riparian environments.

Structure. The Eastside riparian and wetland habitat contains shrublands, woodlands, and forest communities. Stands are closed to open canopies and often multilayered. A typical riparian habitat would be a mosaic of forest, woodland, and shrubland patches along a stream course. The tree layer can be dominated by broadleaf, conifer, or mixed canopies. Tall shrub layers, with and without trees, are deciduous and often nearly completely closed thickets. These woody riparian habitats have an undergrowth of low shrubs or dense patches of grasses, sedges, or forbs. Tall shrub communities (20-98 ft [6-30 m], occasionally tall enough to be considered woodlands or forests) can be interspersed with sedge meadows or moist, forb-rich grasslands. Intermittently flooded riparian habitat has ground cover composed of steppe grasses and forbs. Rocks and boulders may be a prominent feature in this habitat.

Composition. Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), quaking aspen (*P. tremuloides*), white alder (*Alnus rhombifolia*), peachleaf willow (*Salix amygdaloides*), and, in northeast Washington, paper birch (*Betula papyrifera*) are dominant and characteristic tall deciduous trees. Water birch (*B. occidentalis*), shining willow (*Salix lucida* ssp. *caudata*), and, rarely, mountain alder (*Alnus incana*) are co-dominant to dominant mid-size deciduous trees. Each can be the sole dominant in stands. Conifers can occur in this habitat, rarely in abundance, more often as individual trees. The exceptions are ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) that characterize a conifer-riparian habitat in portions of the shrub-steppe zones.

A wide variety of shrubs are found in association with forest/woodland versions of this habitat. Red-osier dogwood (*Cornus sericea*), mountain alder, gooseberry (*Ribes* spp.), rose (*Rosa* spp.), common snowberry (*Symphoricarpos albus*) and Drummonds willow (*Salix drummondii*) are important shrubs in this habitat. Bog birch

(*B. nana*) and Douglas spiraea (*Spiraea douglasii*) can occur in wetter stands. Red-osier dogwood and common snowberry are shade-tolerant and dominate stand interiors, while these and other shrubs occur along forest or woodland edges and openings. Mountain alder is frequently a prominent shrub, especially at middle elevations. Tall shrubs (or small trees) often growing under or with white alder include chokecherry (*Prunus virginiana*), water birch, shining willow, and netleaf hackberry (*Celtis reticulata*).

Shrub-dominated communities contain most of the species associated with tree communities. Willow species (*Salix bebbiana*, *S. boothii*, *S. exigua*, *S. geyeriana*, or *S. lemmonii*) dominate many sites. Mountain alder can be dominant and is at least codominant at many sites. Chokecherry, water birch, serviceberry (*Amelanchier alnifolia*), black hawthorn (*Crataegus douglasii*), and red-osier dogwood can also be codominant to dominant. Shorter shrubs, Woods rose, spiraea, snowberry and gooseberry are usually present in the undergrowth.

The herb layer is highly variable and is composed of an assortment of graminoids and broadleaf herbs. Native grasses (*Calamagrostis canadensis*, *Elymus glaucus*, *Glyceria* spp., and *Agrostis* spp.) and sedges (*Carex aquatilis*, *C. angustata*, *C. lanuginosa*, *C. lasiocarpa*, *C. nebrascensis*, *C. microptera*, and *C. utriculata*) are significant in many habitats. Kentucky bluegrass (*Poa pratensis*) can be abundant where heavily grazed in the past. Other weedy grasses, such as orchard grass (*Dactylis glomerata*), reed canarygrass (*Phalaris arundinacea*), timothy (*Phleum pratense*), bluegrass (*Poa bulbosa*, *P. compressa*), and tall fescue (*Festuca arundinacea*) often dominate disturbed areas. A short list of the great variety of forbs that grow in this habitat includes Columbian monkshood (*Aconitum columbianum*), alpine leafybract aster (*Aster foliaceus*), ladyfern (*Athyrium filix-femina*), field horsetail (*Equisetum arvense*), cow parsnip (*Heracleum maximum*), skunkcabbage (*Lysichiton americanus*), arrowleaf groundsel (*Senecio triangularis*), stinging nettle (*Urtica dioica*), California false hellebore (*Veratrum californicum*), American speedwell (*Veronica americana*), and pioneer violet (*Viola glabella*).

Other Classifications and Key References. This habitat is called Palustrine scrub-shrub and forest in Cowardin et al.⁵³ Other references describe this habitat.^{44, 57, 60, 131, 132, 147, 156} This habitat occurs in both lotic and lentic systems. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are eastside cottonwood riparian gallery, palustrine forest, palustrine shrubland, and National Wetland Inventory (NWI) palustrine emergent.

Natural Disturbance Regime. This habitat is tightly associated with stream dynamics and hydrology. Flood cycles occur within 20-30 years in most riparian shrublands although flood regimes vary among stream types. Fires recur typically every 25-50 years but fire can be nearly absent in colder regions or on topographically protected streams. Rafted ice and logs in freshets may cause considerable damage to tree boles in mountain

habitats. Beavers crop younger cottonwood and willows and frequently dam side channels in these stands. These forests and woodlands require various flooding regimes and specific substrate conditions for reestablishment. Grazing and trampling is a major influence in altering structure, composition, and function of this habitat; some portions are very sensitive to heavy grazing.

Succession and Stand Dynamics. Riparian vegetation undergoes “typical” stand development that is strongly controlled by the site’s initial conditions following flooding and shifts in hydrology. The initial condition of any hydrogeomorphic surface is a sum of the plants that survived the disturbance, plants that can get to the site, and the amount of unoccupied habitat available for invasions. Subsequent or repeated floods or other influences on the initial vegetation selects species that can survive or grow in particular life forms. A typical woody riparian habitat dynamic is the invasion of woody and herbaceous plants onto a new alluvial bar away from the main channel. If the bar is not scoured in 20 years, a tall shrub and small deciduous tree stand will develop. Approximately 30 years without disturbance or change in hydrology will allow trees to overtop shrubs and form woodland. Another 50 years without disturbance will allow conifers to invade and in another 50 years a mixed hardwood-conifer stand will develop. Many deciduous tall shrubs and trees cannot be invaded by conifers. Each stage can be reinitiated, held in place, or shunted into different vegetation by changes in stream or wetland hydrology, fire, grazing, or an interaction of those factors.

Effects of Management and Anthropogenic Impacts. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. In general, excessive livestock or native ungulate use leads to less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Undesirable forb species, such as stinging nettle and horsetail, increase with livestock use.

Status and Trends. Quigley and Arbelbide¹⁸¹ concluded that the Cottonwood-Willow cover type covers significantly less in area now than before 1900 in the Inland Pacific Northwest. The authors concluded that although riparian shrubland was a minor part of the landscape, occupying 2%, they estimated it to have declined to 0.5% of the landscape. Approximately 40% of riparian shrublands occurred above 3,280 ft (1,000 m) in elevation before 1900; now nearly 80% is found above that elevation. This change reflects losses to agricultural development, roading, dams and other flood-control activities. The current riparian shrublands contain many exotic plant species and generally are less productive than historically. Quigley and Arbelbide¹⁸¹ found that riparian woodland was always rare and the change in extent from the past is substantial.

26. Coastal Dunes and Beaches

Christopher B. Chappell, David H. Johnson, & Jimmy Kagan



Geographic Distribution. This habitat occurs primarily along the outer coast from southern Washington (Grays Harbor County) south to northern California. It occurs in all coastal Oregon counties, most abundantly in Tillamook County and between Florence and Reedsport. In Washington it occurs mainly in Grays Harbor and Pacific counties, and sporadically along the inland marine waters of Clallam, San Juan, Skagit, Jefferson, Whatcom, King, Pierce, Kitsap, Snohomish, and Island counties. It also occurs in British Columbia.

Physical Setting. This habitat occurs primarily in wet, mild outer coastal climates. Precipitation, almost always rain, typically averages >80 inches (203 cm) annually. Summers are relatively dry, but fog is common. Elevation is at and very near sea level, only extending as high as the highest dunes. Topography is mildly to strongly undulating in the form of mostly north-south trending dune ridges and troughs. Soils, when present, are always sandy and are underlain by deep deposits of sand, thereby creating edaphically dry sites. Soils are also very poor in nutrients and organic matter. These dunes, spits, and berms are derived from sand carried by longshore drift and wind erosion. Dunes consist of several types that differ in their physical form, including foredunes, transverse dunes, parabola dunes, and retention ridges.²²⁰ Outlier examples away from the outer coast in the Puget Trough are small in extent, occur in a drier climate, and mainly occur in the form of sand spits and berms as opposed to dunes.

Landscape Setting. This habitat occurs in a natural mosaic with Westside Lowland Conifer-Hardwood Forest, Westside Riparian-Wetlands, and Herbaceous Wetlands. Forests adjacent to this habitat are found on stabilized dunes and are dominated by shore pine (*Pinus contorta* var. *contorta*) and Sitka spruce (*Picea sitchensis*). Wooded, shrubby, and herbaceous wetlands occur in seasonally flooded deflation plains or dune troughs. Hooker’s willow (*Salix hookeriana*) and slough sedge (*Carex obnupta*) are the two most characteristic species in these wetlands. This habitat is in a mosaic with the Urban habitat, as coastal

areas have been developed extensively for tourism and low-density residential uses. Recreation is a major land use and includes the use of off-road vehicles. In southern Washington and northern Oregon, the wetlands are often converted to agriculture for cranberries.

Structure. This habitat consists of a variable mosaic of structures ranging from open sand with sparse herbaceous vegetation to dense shrublands. Trees are typically absent but may be scattered. Unstabilized sand may have very little vegetation or open short grasslands or forb-dominated communities, though these are now relatively uncommon and local. Medium-tall grasslands, typically closed, are a major component in the current landscape. Tall broadleaf evergreen shrubs, typically dense, are also a significant component of the mosaic.

Composition. Where they are vegetated, unstabilized dunes or strand are typically dominated or co-dominated by American dunegrass (*Leymus mollis*), dune bluegrass (*Poa macrantha*), or Chinook lupine (*Lupinus littoralis*). Red fescue (*Festuca rubra*) was once a major dominant on more stabilized dunes but has been largely replaced by European beachgrass (*Ammophila arenaria*), an introduced species that is now the most common dune grass. Many forb species are largely confined to herb-dominated dunes or strand and may take on local importance.

Tall shrublands are dominated primarily by salal (*Gaultheria shallon*) and evergreen huckleberry (*Vaccinium ovatum*), but may also have prominent amounts of hairy manzanita (*Arctostaphylos columbiana*), kinnikinnick (*Arctostaphylos uva-ursi*), bush lupine (*Lupinus arboreus*), or California wax-myrtle (*Myrica californica*). Coyotebrush (*Baccharis pilularis*) is abundant in southern Oregon. Both Scot's broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*) are exotic shrubs that dominate disturbed areas. Scattered trees are mainly shore pine (*Pinus contorta* var. *contorta*), or, less commonly, Sitka spruce (*Picea sitchensis*).

Other Classifications and Key References. Franklin and Dryness⁸⁸ called this habitat sand dune and strand communities. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ would crosswalk with coastal dunes habitat. This habitat is not well represented by the Washington Gap project: it takes up small percentages of several types in the Sitka spruce zone, including conifer forest, hardwood forests, and coastline, sandy beaches, and rocky islands. Other references describe this habitat.^{8, 42, 137, 219, 220}

Natural Disturbance Regime. Erosion and deposition of sand are the primary natural processes controlling this habitat. Sand is deposited initially on beaches, and then moved into dunes through wind erosion.²²⁰ Wind also maintains unstabilized dune areas. Major winter storm events may result in blowouts that create holes in existing stabilized or unstabilized dunes, creating new areas of sand deposition.

Succession and Stand Dynamics. The different structural variants of the mosaic within this habitat are primarily stages in succession from freshly deposited sand to

completely stabilized shrub-dominated dunes.²²⁰ Unstabilized sand, such as foredunes with little European beachgrass, has the most open and herbaceous vegetation. Closing of the vegetation typically results in stabilization of the sand. Recently stabilized dunes are now primarily dominated by European beachgrass. Given more time without a major disturbance, shrubs and/or trees colonize the grasslands. Shrublands are sometimes an intermediate stage in succession toward forests. Pine woodlands are another very common intermediate stage. Eventually, pine woodlands are colonized by Sitka spruce or Douglas-fir and become mixed pine-spruce or pine-Douglas-fir forests. Any one of these stages can be set back to sand by a blowout or reburial by dunes, and a cyclic successional sequence is common in many areas.⁴²

Effects of Management and Anthropogenic Impacts.

European beachgrass has been extensively planted for stabilization purposes and has also spread widely on its own. Unstabilized sand is now a relatively rare condition primarily because of the introduction of this species. The physical forms of dunes also have been altered by beachgrass.^{55, 56} Forests are probably forming at a greater rate than they did in the past because of increased stabilization. Exotic species, especially sweet vernalgrass (*Anthoxanthum odoratum*) and common velvetgrass (*Holcus lanatus*), are now a nearly ubiquitous component of herb-dominated communities. The spread of such species may be related to past livestock grazing in many areas.⁴² Scot's broom and gorse are aggressive exotic shrub invaders that were planted for stabilization and have spread widely. Since both are legumes, they result in major nitrogen increases where they establish. Off-road vehicle use has resulted in complete destruction of native herbaceous communities in some areas²²⁰ Trampling is a potential threat in herbaceous communities.^{42, 220}

Status and Trends. This habitat covers a relatively limited area and major expanses of it have been converted to other uses. The vast majority of herbaceous vegetation that remains is in poor condition, being dominated by exotic species. Current trends are probably decreasing in both extent and condition because of continued development in coastal areas and continuing expansion of exotic species into the few remaining native-dominated areas. Six of 11 plant associations currently listed in the National Vegetation Classification representing this habitat are considered imperiled or critically imperiled.¹⁰

27. Coastal Headlands and Islets

Christopher B. Chappell & David H. Johnson



Geographic Distribution. This shrubland, grassland, and nearshore rocky island habitat occurs along slopes and exposed headlands along the outer coast, from Cape Flattery, Clallam County, Washington, southward to (and beyond) California. On small islands it also extends into the Strait of Juan de Fuca and the inland marine waters of Puget Sound and Hood Canal, Washington. Sporadic along the Washington coast (absent between Point Grenville and Cape Disappointment), this habitat becomes most extensive on the southern Oregon coast.

Physical Setting. Wind is extreme in this environment and, in combination with abundant salt-spray, limits tree growth. Fog is common in the summer. Climate is generally mild and moist to wet, with mean annual precipitation ranging from about 70 to 120 inches (178 to 305 cm). Elevation is sea level to about 500 ft (152 m). This habitat occurs mainly on coastal headlands, bluffs, and islands with steep slopes or cliffs. Soils are typically shallow to bedrock or consist of exposed glacial deposits on steep erodable bluffs. Slopes range from gentle to very steep. In some areas, seeps create moist to wet microsites.

Landscape Setting. This habitat is always located adjacent to, or in the case of the rock islets (“sea stacks”), within the Marine Nearshore habitat. It is found mainly along the outer coastline where it typically occupies small areas between the Marine Nearshore and Westside Lowland Conifer-Hardwood Forest or on small islands. Cliffs are a common feature. In far southern Oregon (Curry County), it occupies continuous ocean-facing slopes for many miles. Land use is recreation or low-density residential.

Structure. This habitat is a shrubland, grassland, forbland, rocky island, or often a mosaic of these. The dominant shrubs may be tall or short and composed of evergreen or deciduous broadleaf shrubs. Native grasses can be short or up to 5 ft (1.5 m) in height and rhizomatous or cespitose. Forbs or ferns dominate some patches. Coniferous trees are sometimes scattered, occur in small clumps, or form dominant patches of short wind-blasted individuals.

Composition. Shrublands are dominated by salal (*Gaultheria shallon*), evergreen huckleberry (*Vaccinium ovatum*), salmonberry (*Rubus spectabilis*), black twinberry (*Lonicera involucrata*), California wax-myrtle (*Myrica californica*), thimbleberry (*Rubus parviflorus*), or the dwarf shrub, crowberry (*Empetrum nigrum*). Deer brush (*Ceanothus integerrimus*), and hairy manzanita (*Arctostaphylos columbiana*) become important on the southern Oregon coast, as does the non-native gorse (*Ulex europaeus*). Sitka spruce (*Picea sitchensis*) is the most common tree, although western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), or red alder (*Alnus rubra*) also may occur. Native dominant grasses are red fescue (*Festuca rubra*) or Nootka reedgrass (*Calamagrostis nutkaensis*). Blue wildrye (*Elymus glaucus*), California danthonia (*Danthonia californica*), and Sitka brome (*Bromus sitchensis*) can also be important. A diversity of forbs occurs, with some of the most prominent being Canada goldenrod (*Solidago canadensis*), Martindale’s lomatium (*Lomatium martindalei*), giant vetch (*Vicia gigantea*), giant horsetail (*Equisetum telmateia*), and coastal wormwood (*Artemisia suksdorfii*). Bracken (*Pteridium aquilinum*) is a fern that often co-dominates. Southern Oregon has a number of unique herbaceous species.

Other Classifications and Key References. Franklin and Dyrness⁸⁸ described portions of this habitat as oceanfront communities on northern Oregon headlands and the southern Oregon coast. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Type¹²⁷ that would represent this type is coastal strand. The Washington Gap project mapped parts of this habitat as coastline, sandy beaches, and rocky islands. Other important references describe elements of the habitat.^{7, 63, 177, 183}

Natural Disturbance Regime. Wind may topple trees if they do attain upright stature. Charcoal in the soil at some sites in Oregon suggests that this habitat may have had occasional fires in the past.¹⁸³

Succession and Stand Dynamics. Little is known about the dynamics of this habitat. Trees slowly invade some areas of this habitat. As they do so, herbaceous or shrub-dominated vegetation declines. Fires would favor maintenance of grasslands or forblands.

Effects of Management and Anthropogenic Impacts. Livestock grazing of the grasslands results in decreasing importance of native grasses, especially bunchgrasses, and increasing importance of exotic species. Sweet vernalgrass (*Anthoxanthum odoratum*), common velvetgrass (*Holcus lanatus*), and orchardgrass (*Dactylus glomerata*) are major exotic grass species that dominate significant areas. Gorse has invaded large areas on the southern Oregon coast.

Status and Trends. This habitat occupies a very small area relative to other habitats in the Pacific Northwest. Condition of the grasslands is generally poor, with an abundance of non-native species. Grasslands continue to decline in condition and extent over time. Shrublands are probably more stable. Three of 5 plant associations listed

in the National Vegetation Classification are considered imperiled,¹⁰ but portions of this habitat have not been described at the association level.

28. Bays and Estuaries

Mikell O'Mealy & David H. Johnson



Geographic Distribution. This habitat reflects areas with significant mixing of salt and freshwater, including lower reaches of rivers, intertidal sand and mud flats, saltwater and brackish marshes, and open-water portions of associated bays. The habitat is distributed along the marine coast and shoreline of Washington and Oregon. There are some 21 principal bays and estuaries on the Oregon coast, and 34 in Washington.^{5,95,178} Willapa Bay and Grays Harbor (both in Washington) are expansive and have the largest and second largest intertidal areas of the two states. The Columbia River Estuary is the largest estuary in the Pacific Northwest. This habitat does not include open water areas of Puget Sound (see Inland Marine Deeper Waters). Similar bay and estuarine habitats exist on the coasts of California and British Columbia.

The greater Puget Sound at times is considered a very large estuary;¹⁸⁰ for purposes of this project Puget Sound is comprised of three wildlife habitats: Bays and Estuaries, Marine Nearshore, and Inland Marine Deeper Waters.

Physical Setting. Climate is moderated by the Pacific Ocean and is usually mild. Mean temperatures at coastal stations generally range from 40 to 70½F (4-21½C) year-round with little north-south variation within Washington and Oregon. Annual rainfall along the coastal zone averages 80-90 inches (203-229 cm) and is concentrated in winter months, producing correspondingly high river runoff to bays and estuaries.^{173,176} Elevation is at sea level to a few feet above. Coastal zone topography is characterized by long stretches of sandy beaches broken by steep rocky cliffs, rocky headlands, and the mouths of bays and estuaries. Organics, silt, and sand are the primary substrate components of this habitat and vary in specific composition and distribution with variable physical factors.¹²⁰

Landscape Setting. This habitat is adjacent to Westside Riparian-Wetlands, Coastal Dunes and Beaches, Westside Lowland Conifer-Hardwood Forest, Coastal Headlands

and Islets, Marine Nearshore, and Inland Marine Deeper Waters habitats. Major uses of bays and estuaries are recreation, tourism, the shellfish industry, and navigation. The terrestrial interface portions of this habitat have been extensively converted for agricultural crop production, livestock grazing, and residential and commercial development. Water channels of many areas have been dredged for ship navigation.

Structure. At the most seaward extent (e.g., river mouths), water depths are shallow (mostly <20 ft [6 m]) except for dredged channels. This habitat is strongly influenced by the daily tides and currents. Depending on location, mean higher high water to mean lower low water ranges from 6.1 to 10.2 ft (1.9 to 3.1 m). Tidal currents in channels of the principal estuaries typically range from 1 to 5 knots (0.5 to 2.6 m/sec) 176.

Diverse habitats result from riverine discharges and tidal fluxes, salinity, mixing, sedimentation, discharge, and insolation. Unconsolidated or consolidated tideflats are composed of rocks, gravel, sand, silt and clay as well as abundant organic material.^{68,204} Inundated by daily tidal flows, tideflats may support eelgrass, various algal species, and invertebrate communities.⁵ Eelgrass meadows create protected environments and structured habitats for various wildlife species.¹⁷³ Salt marshes form at the upper tidal boundary above tideflats.¹²⁰ Salt marshes are usually open to closed graminoid or forb communities. Highly branched estuarine channels drain across salt marshes and tideflats, creating a diverse mix of structures.¹⁹² At the most inland extent of this habitat, transitional marsh forms between salt marshes and bordering upland vegetation dominated by grass or woody vegetation.⁶

The Columbia River estuary is characterized as a partially mixed estuary and can be divided into three sections along the salinity gradient: from the mouth to about river mile 7 it is basically marine; from river mile 7 to mile 23 it is transitional (mixing); and above river mile 23 it is fluvial (fresh water). Pruter and Alverson¹⁷⁹ compiled available physical and biological studies at the interface between riverine and marine waters in the nearshore aspects of the Columbia River estuary and adjacent waters.

Composition. Eelgrass meadows stabilize submerged tideflats and are co-dominated by surfgrass and eelgrass species. Three diagnostic surfgrass species (*Phyllospadix scouleri*, *P. torreyi*, and *P. serrulatus*) occur on rocky substrates in exposed waters, whereas two species of eelgrasses (*Zostera marina*, *Z. japonica*) are characteristic of mud or mixed mud-sand substrates in areas sheltered from turbulent waters.^{68,173} Highly productive macroalgae that dominate estuarine channels include various blue-green algae, green algae (*Enteromorpha* spp.) and rockweed (*Fucus* spp.).¹⁹² Tideflats bordering salt marshes often are co-dominated by pickleweed (*Salicornia virginica*), arrowgrass (*Triglochin maritima*) and three-square rush (*Scirpus americanus*).⁵ The transition to higher areas of the low-marsh zone is indicated by the dominance of jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), and Lyngby's

sedge (*Carex lyngbyei*).⁶⁸ Major components of mid and high salt marsh areas are alkaligrass (*Puccinellia pumila*) and Canadian sand spurry (*Spergularia canadensis*).¹²⁰ Salt rush (*Juncus lesueurii*), tufted hairgrass (*Deschampsia caespitosa*), Pacific silverweed (*Argentina egedii*) and spreading bentgrass (*Agrostis stolonifera*) are salt-tolerant upland species diagnostic of high salt marshes that experience freshwater runoff or riverine discharge.⁶

Other Classifications and Key References. Cowardin et al.⁵³ included marine and estuarine systems of the Columbian Province. Dethier⁶⁸ described a classification for marine and estuarine habitat types in Washington State. Habitat types are defined by depth, substratum type, energy level, and a few modifiers. Species (plants and animals) are described for combinations of these physical variables. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are exposed tidal flats and estuarine emergent. Harper et al.¹⁰⁶ described a shore-zone sensitivity mapping system. Proctor et al.¹⁷⁶ described an ecological characterization of the Pacific Northwest Coastal Region, including physical and chemical environments as well as socioeconomic aspects of watersheds of the region. Schoch and Dethier¹⁸⁹ provided high-resolution data on the physical features and associated biota of Puget Sound's shorelines using the SCALE model (Shoreline Classification and Landscape Extrapolation). Downing⁷⁶ offered a detailed review of the geological and broad ecological development of Puget Sound.

Natural Disturbance Regime. Natural disturbance perpetuates the dynamic, transitional nature of this habitat. Tides, seasonal riverine discharges, winds, storm events, erosion, and accretion are the primary natural processes that shape this habitat. Tides are mixed, characterized by two unequal high and low tides daily, with varying intrusion into estuaries and bays at different locations along the coast. Tides and winds push salt-water wedges up through the system, causing varying degrees of mixing with incoming riverine waters and significant vertical stratification.⁵ Riverine discharges and fresh-water runoff vary seasonally with precipitation and freshet regimes. Generally, a large range in annual discharge exists with high volumes of fresh water entering the system in winter and significantly reduced flows in summer.¹⁹² Short-term storm events produce dramatic variations in physical habitat conditions. Sudden erosion or accretion may result from strong oceanic currents at the mouth of the system or from increased fresh water discharges at the head of the system. For a detailed conceptual model of disturbance regimes in estuary zones, see Proctor et al.¹⁷⁶

Succession and Stand Dynamics. General successional stages reflect unconsolidated barren tideflats to stabilized high salt marshes and salt meadows. Unvegetated tideflats are colonized by pioneer plants, commonly eelgrass, that are tolerant of extended tidal inundation and vary depending on sediment type.¹⁷³ Initial colonization causes

sediment accretion and gradual rise in land elevation, changes that shift environmental conditions and permit other plants to establish. Arrowgrass, pickleweed, sand spurry, and spike rush can invade the emerging marsh, further increasing and stabilizing substrates. Saltgrass and sedge establish on higher areas of the marsh. When initial colonizers die back, tufted hairgrass and salt rush may establish.⁵ Various exotic species have become naturalized in Oregon and Washington, including spreading bentgrass (*Agrostis stolonifera*) and sand spurry (*Spergularia marina*) introduced from Europe, brass buttons (*Cotula coronopifolia*) introduced from South Africa, and marsh cordgrass (*Spartina alterniflora*) introduced from the Atlantic Coast of North America.^{6, 120} These successional stages can be disrupted by riverine or tidal scouring and succession can be reinitiated at any point.

Effects of Management and Anthropogenic Impacts. Management, water quality, contaminants, and land-use practices have altered significant portions of this habitat and continue to impact remaining areas.²¹⁶ The dredging and filling of marshes and tideflats to serve various human needs remove estuarine vegetation. Channel flow, tidal inundation, and fresh water discharges are disrupted by construction of seawalls, jetties, dikes, and dams. The physical and chemical conditions of these habitats are degraded by the discharge of municipal, industrial, and agricultural effluents. Functional plant and animal communities are altered by domestic and agricultural runoff of pesticides, herbicides, and fertilizers. Invasions of exotic plants (e.g., *Spartina*) and invertebrates (e.g., green crabs) pose significant, long-term ecological and economic threats to this habitat. Large tracts of habitat have been lost and converted for coastal development. Additionally, upland activities occurring throughout the watershed, including logging, mining, and hydroelectric power development, can have destructive impacts downstream in estuarine and bay environments.^{192, 205}

Status and Trends. Significant quantitative and qualitative alterations of this habitat have occurred with Euro-American settlement. Although natural erosion and accretion processes continue, most habitat modification can be attributed to anthropogenic impacts.¹⁹² Because of original diking for crop production and flood control, almost no areas of natural high marsh remain in Oregon.¹²⁰ These dikes, and other more recent barriers, prevent natural recovery and re-establishment of this habitat. Remaining examples of the bay and estuarine habitat exist in various conditions, from the more natural areas, areas undergoing active restoration, to the more prevalent polluted, degraded, or overused areas throughout Oregon and Washington. With increasing population pressures in coastal areas and the corresponding threats of habitat use and conversion, future trends will likely be continued degradation and reduction of remaining bay and estuarine areas.

29. Inland Marine Deeper Water

David H. Johnson



Geographic Distribution. This habitat is located in the northwestern portion of Washington and adjacent areas of southwest British Columbia. It includes the open waters of the Strait of Georgia, Puget Sound, Hood Canal, and the Strait of Juan de Fuca. More specifically, this habitat reflects waters >66 ft (20 m) deep, found inland from a line between the Elwha River (just west of Port Angeles) on the Washington side of the Strait of Juan de Fuca, northward to Race Rocks on the southeastern tip of Vancouver Island, British Columbia. This line was independently determined based on (1) kelp distribution, (2) marine bird distribution, and (3) fish species and abundance data. With the exception of Marine Nearshore areas, waters west of this line are considered Marine Shelf. The Inland Marine Deeper Water habitat is not found in Oregon.

Physical Setting. This habitat lies largely within the Puget Lowland and northward in Georgia Strait on the east side of Vancouver Island, British Columbia. Mean air temperatures generally range between 40 and 70½F (4-21½C) year round, with little north-south variation. Rainfall averages 20 to 80 inches (50 to 200 cm) annually and is concentrated in winter months, producing correspondingly high river runoff to bays, estuaries, and inland marine waters.

Landscape Setting. This habitat is commonly adjacent to Bays and Estuaries, Coastal Headlands and Islets, and Marine Nearshore habitats and merges with the Marine Shelf habitat in the Strait of Juan de Fuca. Inland marine waters are used extensively for navigation, commercial transport of goods, recreation, tourism, and fishery operations.

Structure. A diversity of underwater structures are created as swift tidal currents circulate waters of the Pacific Ocean through the reaches of Strait of Georgia, Puget Sound, Hood Canal and the Strait of Juan de Fuca. Aspects of geology are particularly important in understanding the structure and dynamics of this habitat. Glacial ice initially excavated several long, narrow valleys that today form

Lake Washington, Lake Sammamish, Hood Canal, and the major basins of Puget Sound. The arrangement of the present shorelines was established 13,000 years ago when glacial ice retreated from the Puget Lowland.⁷⁶ Organics, silt, and sand are the primary substrate components of this habitat and vary in specific composition and distribution with fluctuating physical factors.¹²⁰ Through deposition of sediments, major river deltas have advanced substantial distances into the deep basins of Puget Sound.⁷⁶

Composition. Marine waters dominate fresh water influences in areas away from riverine discharges or from the shoreline. Because of the water depths involved, sunlight is diffused, and few if any plants attached to the benthic substrates are capable of growing.

Other Classifications and Key References. Cowardin et al.⁵³ included this region in the Columbia Province and described a hierarchical classification for wetlands and deepwater habitats in the U.S. Dethier⁶⁸ described a classification for marine and estuarine habitat types in Washington State. Habitat types were defined by depth, substratum type, energy level, and a few modifiers. Harper et al.¹⁰⁶ described a shore-zone mapping system for use in sensitivity mapping and shoreline countermeasures. Proctor et al.¹⁷⁶ described an ecological characterization of the Pacific Northwest Coastal Region, including physical and chemical environments as well as socioeconomic aspects of watershed units and of the region. Schoch and Dethier¹⁸⁹ provided high-resolution data on the physical features and associated biota of Puget Sound's shorelines using the SCALE model (Shoreline Classification and Landscape Extrapolation).

Natural Disturbance Regime. Seasonal and larger, periodically occurring disturbances shape this habitat. Seasonal variation in tidal regimes, precipitation and riverine discharges (winter highs), as well as periodic storm events cause changes in temperature, salinity, energy level, and gradual or sudden erosion and accretion in localized areas.

Successional and Community Dynamics. Diverse plant and invertebrate communities compete for a variety of habitats in this region. Succession occurs in each habitat area as disturbances create temporary vacancies, allowing opportunistic species to become established.

Effects of Management and Anthropogenic Impacts. Land conversion, use, and management have altered significant portions of this habitat. The physical, chemical, and biological condition of some habitats are degraded by both point and nonpoint discharges from municipal and industrial effluents. Functional plant and animal communities are altered by domestic and agricultural runoff of pesticides, herbicides, and fertilizers. Large portions of shoreline have been converted for residential, commercial, and port development, affecting inputs into the adjacent deeper waters. Benthic communities are significantly impacted by maintenance dredging done to support navigation and commerce. The transport of oil and chemical substances creates the potential for harmful

spills that can affect these areas for extended periods of time. Passage of vessels from other regions increases the introduction rate of exotic species which, once established, can effectively out-compete native species.

Status and Trends. With the important exceptions of locally increased sedimentation rates and contaminant deposition/retention, the status and trends in the physical and biological aspects of this habitat are poorly known.

30. Marine Nearshore

David H. Johnson



Geographic Setting. This habitat reflects marine water areas (high tide line to depth of 66 ft [20 m]) along shorelines not significantly affected by freshwater inputs (i.e., excludes Bays and Estuaries). This includes all marine shorelines of Puget Sound, Hood Canal, San Juan Islands, Strait of Georgia, Strait of Juan de Fuca, and along the outer coastlines of Washington and Oregon. In Washington, there are 3,100 miles (4,990 km) of this nearshore habitat⁸⁵ (H. D. Berry, Department of Natural Resources, Aquatic Resources Division, Olympia, pers. comm.); in Oregon, there are 377 miles (607 km) of this nearshore habitat (C. Barrett, Northwest Habitat Institute, Corvallis, Oregon, pers. comm.). For mapping and classification purposes, this habitat does not extend into, or overlap with, shallow or intertidal areas found within Bays and Estuaries.

Physical Setting. The outer coastline of Washington and Oregon can be characterized as a series of sandy beaches interspersed with rocky headlands. This coastline is oriented in a north-south direction and is subjected to long-fetch, high-energy waves. Nearshore areas within Puget Sound, Hood Canal, and elsewhere landward from the Strait of Juan de Fuca, are more protected. With the exception of the far-reaching Columbia River plume,¹⁹⁴ the effects of coastal streams are generally local and seasonal.¹⁷⁰

Landscape Setting. This habitat is adjacent to the Marine Shelf, Inland Marine Deeper Water, Bays and Estuaries, and a number of terrestrial-based habitats (e.g., Coastal Dunes and Beaches, Westside Lowland Conifer-

Hardwood Forest, and Urban). It occurs in a mosaic with Coastal Headlands and Islets.

Structure. Fresh waters drain from lands surrounding these inland marine waters to create estuarine environments nearshore¹³³ (see Bays and Estuaries habitat). Nearshore subtidal habitats are diversified by degree of wave and current action, availability of sunlight, and presence of vegetation. Submerged unvegetated habitats cover a greater area than do vegetated nearshore habitats, such as salt marshes and eelgrass beds. Various combinations of water depth, character of substrates, and exposure to tidal action create a wide range of benthic habitats. Sand, cobble, boulders, and hardpan are commonly found in areas of moderate to strong currents, whereas silt and clay settle out in protected inlets and bays.^{67, 145}

Composition. This habitat supports marine organisms capable of withstanding short-term exposure to air. Bottom substrates in exposed areas are generally rock or sand, but can include cobble or gravel. The subtidal photic zone includes the region from mean low low water (MLLW or the 0 ft depth) to about -50 ft (-15 m) where water is deep enough to prevent sufficient light penetration to the marine floor for primary productivity of kelp and other marine plants. The rocky-bottom intertidal habitats support kelps (*Laminaria* spp., *Lessoniopsis* spp., *Hedophyllum sessile*), brown rockweed (*Pelvetiopsis limitata*), red algae (*Iridaea* spp.), and surfgrass (*Phyllospadix scouleri*), as well as an abundance and variety of sessile benthic invertebrates. The larger kelps, such as *Macrocystis integrifolia* and *Nereocystis leutkeana*, are found in the rocky-bottom subtidal areas. Because of constant wave action, the sandy-bottom areas of the intertidal and subtidal zones support few or no plants. The moderate to low energy intertidal and subtidal areas where sand, mud, and gravel accumulate support eelgrass (*Zostera marina* and *Z. japonica*), and the red alga (*Gracilaria pacifica*).

Other Classifications and Key References. Dethier⁶⁸ provided a detailed classification scheme for the estuary, intertidal, and shallow subtidal areas of Washington. The Cowardin et al.⁵³ classification scheme has several limitations with regards to adopting it for marine and estuarine systems. Levings and Thom¹⁴³ described 9 categories of nearshore habitat in Puget Sound and Georgia Basin.

Natural Disturbance Regimes. This habitat is strongly influenced by tidal rhythms, wave action, storm events, light penetration, and bottom substrate. Because of these factors, this habitat is characterized by a high degree of patchiness; this patchiness leads to differences in its faunal makeup and use. Herbivory by marine invertebrates also causes significant disturbance in plant communities, as evidenced by the direct control of kelp beds by urchin populations.

Succession and Stand Dynamics. The primary natural processes that shape the nearshore habitats include tides, erosion, accretion, and storm events. The rocky surf zone

of the outer coast of the Olympic Peninsula includes some of the most complex and diverse shores in the United States.⁶⁷ Here, high wave energy provides space for habitation for species as materials are eroded away, and by increasing the capacity of algae to acquire nutrients and use sunlight. Examples of succession can be found on rocky intertidal shores where wave energy periodically disturbs established communities, or in kelp forests where herbivory or the scouring action of swift tidal currents removes vegetation.

Effects of Management and Anthropogenic Impacts. This habitat reflects the interface between land and sea, and is the site of intense commercial and navigational activities, such as seaports, marinas, ferry docks, and log booms. A significant concern identified by Broadhurst³⁵ is the site-by-site consideration of projects with no ability to account for and assess the cumulative environmental effects of various development activities (from small residential projects to large commercial and industrial development projects). Without the ability to measure or understand cumulative effects, managers are permitting individual activities that may result in dramatic resource losses over time. Making high-quality nearshore vegetation and shoreline characteristics inventory mapping available to land-use planners, natural resource scientists, and the public will increase opportunities to protect this habitat.

Status and Trends. Shoreline modification such as bulkheading, filling, and dredging can lead to direct habitat loss. Indirectly, it can lead to changes in the sediment and wave energy on a beach and in adjacent subtidal areas. One third of Puget Sound's shorelines, approximately 800 miles (1,287 km), has been modified.^{180, 190, 191} The Central Puget Sound region, with high human population levels, shows the highest level of modification overall (52%).¹⁸⁰ In Washington there are 26 species of kelp, more than any other area worldwide.⁷⁷ Data on floating kelp along the Strait of Juan de Fuca suggest that while kelp areas are dynamic, the overall extent of kelp has remained stable during 1993-1997.¹⁸⁰

31. Marine Shelf

David H. Johnson

Geographic Setting. This habitat consists of marine waters along the outer coast of Washington and Oregon that are 66-656 ft (20-200 m) deep. This also includes the western portion of the Strait of Juan de Fuca (excluding the Marine Nearshore areas), west of a line from the Elwha River on the Washington side of the Strait of Juan de Fuca to Race Rocks on the southeastern tip of Vancouver Island.

Physical Setting. Along the coasts of Oregon and Washington, the Marine Shelf (also called the Continental Shelf) habitat exists as a relatively shallow, flat, submerged area, which varies from about 9 to 40 miles (14 to 64 km) in width. At about the 656-ft (200-m) isobath, roughly the edge of the marine shelf, the bottom drops off more steeply to the continental slope, which is indented by several major

submarine canyons. Beyond the shelf and slope are deep abyssal oceanic waters.

Landscape Setting. This habitat is located between the Nearshore Marine and Oceanic habitats; at about one third of the way into the Strait of Juan de Fuca, this habitat adjoins the Inland Marine Deeper Water habitat.

Structure. The marine shelf extends seaward from the 60-ft (20 m) to the 656-ft (200 m) isobath. It is occasionally divided into the inner (0-328 ft [100 m] deep) and outer (328-656 ft [100-200 m] deep) shelf areas, reflective of differing oceanographic influences. The bottom substrate of the shelf is mostly sand, giving way to silt on the outer edges, and is described as smooth as a result of sediment accumulation. Currents over the shelf tend to follow the seasonal pattern of the oceanic currents (i.e., northward during winter [Davidson current]). The mean surface temperatures in summer were $>5\frac{1}{2}^{\circ}\text{C}$ lower, and mean salinities were 0.1-0.3% higher in upwelling areas than farther offshore. These conditions reflect an active upwelling process.⁸³ The shelf areas off Oregon and Washington are known for their heavy surface waves; extremes of wave heights ranging from 49 to 95 ft (15 to 29 m) have been recorded. More typical are waves of 20 to 33 ft (6 to 10 m) during storm events.

Composition. The Marine Shelf, as with other deep-water regions, does not support rooted plant life. Strickland and Chasan¹⁹⁴ offered a synthesis of phytoplankton; the Washington shelf has been ranked in the highest productivity category of U.S. continental shelves.

Other Classifications and Key References. Strickland and Chasan¹⁹⁴ offered a synthesis of information on Coastal Washington, as related to understanding impacts of offshore oil and gas exploration. The National Oceanic and Atmospheric Administration¹⁶³ reflects the Final Environmental Impact Statement/Management Plan for the Olympic Coast National Marine Sanctuary. Bottom et al.,³³ Dodimead et al.,⁷³ Favorite et al.,⁸³ Thomson,²⁰³ and Ware and McFarlane²¹³ offered classification schemes and terminology for understanding the oceanic systems in the Northeastern Pacific.

Natural Disturbance Regimes. Currents over the shelf tend to follow the seasonal pattern of the oceanic currents, but also are strongly influenced by local winds, bottom and shoreline configuration, and freshwater input. On average, water flows southward in the upper 328 ft (100 m) during summer, and northward below that. Water over the shelf flows generally northward at all depths during the winter.¹⁹⁴ In addition to ocean currents, this habitat is heavily influenced by freshwater infusion from the Columbia River, the largest river on the Pacific west coast. The Columbia River effluent amounts to approximately 60% of the freshwater entering the Pacific Ocean between San Francisco and the Strait of Juan de Fuca in winter, and $>90\%$ the rest of the year.²¹ Furthermore, the 12- to 16-mile (20 to 25 km)-wide Strait of Juan de Fuca, separating Vancouver Island from mainland Washington, is a glacially excavated channel that is the primary avenue for vigorous

estuarine exchange between the shelf and the inland marine waters of Washington and British Columbia.

Effects of Management and Anthropogenic Impacts. The chief human influence on the ecology of Oregon and Washington marine waters is fishing, especially bottom and mid-water trawl fishing in shelf waters for flatfish and Pacific hake. Other significant fisheries include salmon (inner shelf), shrimp (outer shelf), and albacore (slope). The effects of overfishing have been documented. Other risks to the shelf environment include pollution, contaminants, and oil spills.

Status and Trends. Until the early 1990s, the Minerals Management Service of the U.S. Department of the Interior had planned to conduct Lease Sales for offshore oil and gas exploration in federal waters on the outer marine shelf of Oregon and Washington.¹⁹⁴ A moratorium on these leases is now in place. Designated in 1994, the Olympic Coast National Marine Sanctuary covers 2.11 million acres (854,251 ha) and is managed to protect its natural resources while encouraging compatible commercial and recreational uses.

32. Oceanic

David H. Johnson & Greg Green

Geographic Setting. Deep water (>656 ft [200 m] deep), open areas of the northeast Pacific Ocean extending seaward from the 656-ft (200-m) isobath along the outer coast of Washington and Oregon.

Physical Setting. This habitat includes the continental slope, which is generally found at depths between the 656- and 6,560-ft (200- and 2,000-m) isobath. In general, the 656-ft (200-m) isobath follows a north-south line.

Landscape Setting. The Oceanic habitat adjoins the shallower marine waters of the Marine Shelf habitat.

Structure. The oceanic area off Oregon and Washington includes marine waters >656 ft (200 m) deep. This region can be divided into two general habitats reflecting geomorphic features and water depth.

The continental shelf along Oregon is characterized by a series of oceanic banks including Daisy, Stonewall, Perpetua, Heceta, and Silcoos banks, and a major promontory, Cape Blanco. In contrast, the Washington shelf is furrowed by Nitinat, Juan de Fuca, Quinalt, Grays, Guide, Willapa, and Astoria submarine canyons, remnants of the last glacial period.

The continental slope is usually defined as depths between 656 and 6,560 ft (200 and 2,000 m) deep. Beyond the slope is a more gradual sloping area known as the continental rise. The rise eventually terminates at the abyssal sea floor (approximately 13,120 ft [4,000 m] deep). Boundaries between the rise and abyssal plain are not clearly distinct. Both the rise and abyssal sea floor are composed largely of mud.

Marine currents define important aspects of this habitat, as wind-driven equatorward surface flow in the spring

and summer results in episodic upwelling of cold nutrient-rich water; the poleward surface flow in the autumn and winter is when the downwelling prevails. The transition from poleward to equatorward flow occurs abruptly in the spring and the reverse transition occurs somewhat less abruptly in the autumn.

Other Classifications and Key References. A number of oceanographic studies have attempted to identify distinct features or parameters to define the geographical extent of the Subarctic and Subtropical Pacific waters. These studies were based mostly on temperature-salinity properties and oxygen-salinity curves.^{73,213} Favorite et al.⁸³ and Thomson²⁰³ discussed new information and terminology for the oceanic systems in the Northeast Pacific. A recent review by Bottom et al.³³ synthesized existing information on the characteristics of the ocean environment and the influence of ocean variability on the capacity of the Northeast Pacific to produce salmon. Bottom et al.^{31,32} provided information on classifications of subsystems of the Coastal Upwelling Domain.

Natural Disturbance Regime. This deeper water habitat is influenced by seasonal water temperatures, winds, currents, and upwelling. The shelf slope essentially defines the pathway of the large-scale California Current, which transports water eastward from mid-ocean, then southward to California. The current is essentially driven by seasonal northwesterly winds. The relatively wide shelf off Oregon and Washington tends to isolate the California Current and its infusion of nutrients from nearshore flow. It is pushed farther offshore during the winter when southeasterly winds generate the seasonal northern flow of the more coastal Davidson Current.¹⁴¹

In addition to driving currents, seasonal winds also promote upwelling of colder, nutrient-rich waters. Coastal upwelling occurs most frequently in summer and fall, promoted by northerly and northwesterly winds. The upwelling season runs from April to October, with maximum intensity in July and August.¹⁸ Upwelling intensity is typically greatest along the southern Oregon coast (Cape Blanco upwelling zone) and diminishes northward. However, it can occur anywhere along the Oregon-Washington coast under favorable winds. Shelf promontories such as Heceta Bank, the submarine canyons off Washington, and the shelf edge and slope create biologically productive mixing zones influenced both by large-scale currents and upwelling. Sporadic events causing large-scale changes in both nearshore and offshore habitats include extreme La Niña (cold water) and El Niño (warm water) events, and toxic red tide blooms.

Effects of Management and Anthropogenic Impacts. The main activities in this habitat are fishing and commercial transport; other than regulations to support these actions, little active management for biological resources takes place in this habitat.

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