APPENDIX 6: SGCN WILDLIFE SPECIES PLANS

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APPENDIX 7: SGCN SALMON PLANS AND STRATEGIES

An Outline For Salmon Recovery Planshttp://wdfw.wa.gov/recovery/recovery_model.htm

Bull Trout and Dolly Varden Management Plan http://wdfw.wa.gov/fish/bulltrt/bulldoly.htm

Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout *(Salvelinus confluentus)* http://pacific.fws.gov/bulltrout/jcs/documents/PugetSdpt1.pdf

Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan (draft) http://www.hccc.cog.wa.us/about.htm

Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (draft) http://www.nwr.noaa.gov/1srd/Recovery/domains/willow/WMU_Plan/WMU_Plan_files.html#vol1

Lower Columbia Salmon Recovery and Watershed Plans http://www.lcfrb.gen.wa.us/December%20Final%20%20Plans/lower_columbia_salmon_recovery_a.htm

Pacific Coastal Salmon Recovery Fund (NOAA) http://www.nwr.noaa.gov/pcsrf/index.htm

Pacific Coastal Salmon Recovery Program (NWIFC) http://www.nwifc.wa.gov/recovery/documents/coastalrecovery.pdf

Pacific Fishery Management Council, Salmon Fishery Management Plan http://www.pcouncil.org/salmon/salfmp.html

Pacific Salmon Commission http://www.psc.org/Index.htm

Puget Sound Action Plan 2005-2007 Puget Sound Conservation and Recovery Plan http://www.psat.wa.gov/Publications/priorities_05/Priorities_05_review.htm

Puget Sound Comprehensive Chinook Management Plan http://wdfw.wa.gov/fish/papers/ps_chinook_management/harvest/index.htm

Puget Sound Salmon Recovery Plan (draft) http://www.sharedsalmonstrategy.org/plan/index.htm

Puget Sound Shared Salmon Strategy http://www.sharedsalmonstrategy.org

Reference Guide to Salmon Habitat Conservation at the Watershed Level. http://www.governor.wa.gov/gsro/publications/watershed/reference.pdf

Regional Fisheries Enhancement Group http://wdfw.wa.gov/volunter/rfeg/rfeg_outcomes.htm

Roadmap for Salmon Habitat Conservation at the Watershed Level http://www.governor.wa.gov/gsro/publications/watershed/roadmap.pdf

Salmon & Steelhead Habitat Inventory & Assessment Project (SSHIAP) http://wdfw.wa.gov/hab/sshiap/

Salmon and Steelhead Stock Inventory (SaSSI) http://wdfw.wa.gov/fish/sassi/sassi.htm

Salmon Recovery Funding Board http://www.iac.wa.gov/srfb/default.asp

Salmon Recovery Plans (2003)
http://wdfw.wa.gov/recovery/salmon_recovery_plan_model_jun03.pdf

Snake River Salmon Recovery Plan for SE Washington (draft)
http://www.snakeriverboard.org/pdf_files/DraftPubSummary06005.pdf

South Puget Sound Salmon Recovery Plan
http://home.comcast.net/%7Esouthsoundsalmon/home.htm

Statewide Strategy to Recover Salmon: Extinction is Not an Option
http://www.governor.wa.gov/gsro/strategy/strategy.htm
The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes (Columbia River Inter-Tribal Fish Commission)
http://www.critfc.org/text/trp.html

Upper Columbia Salmon Recovery Board, A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (2003)
http://www.co.chelan.wa.us/nr/data/biological_strategy_2003.pdf

Upper Columbia Salmon Recovery Plan (draft)
http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm

USFWS Pacific Region: Fisheries Program Strategic Plan 2004-2006
http://pacific.fws.gov/Fisheries/Docs/Pacific%20Region%20Step%20Down%20Plan.pdf

Washington Department of Ecology Watershed Planning
http://www.ecy.wa.gov/watershed/index.html

Watershed (WRIA) Planning for Salmon Habitat http://dnr.metrokc.gov/Wrias/

WDFW Salmon Recovery http://wdfw.wa.gov/recovery.htm

WDFW Watershed Stewardship Team http://wdfw.wa.gov/hab/wst.htm

Yakima Subbasin Salmon Recovery Plan (draft)
http://www.co.yakima.wa.us/yaksubbasin/Library/ExecutiveSummary.pdf

APPENDIX 8: ASSOCIATED HABITATS OF CONSERVATION CONCERN

- Westside Lowlands Conifer-Hardwood Forest
- Westside Oak and Dry Douglas-fir Forest and Woodlands
- Montane Mixed-Conifer Forest
- Eastside (Interior) Mixed Conifer Forest
- Lodgepole Pine Forest and Woodlands
- Ponderosa Pine and Eastside White Oak Forest and Woodlands
- Upland Aspen Forest
- Subalpine Parkland
- Westside Grasslands
- Eastside (Interior) Grasslands
- Shrub-steppe
- Open Water
- Herbaceous Wetlands
- Westside Riparian-Wetlands
- Montane Coniferous Wetlands
- Eastside (Interior) Riparian-Wetlands
- Coastal Dunes and Beaches
- Bays and Estuaries
- Inland Marine Deeper Waters
- Marine Nearshore and Shelf

The following priority habitat descriptions and photos are excerpted from *Wildlife Habitat Relationships in Oregon and Washington*.

Westside Lowlands Conifer-Hardwood Forest

Christopher B. Chappell and Jimmy Kagan

Geographic Distribution. This forest habitat occurs throughout low-elevation western Washington, except on extremely dry or wet sites. 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, 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 in much of northern Washington. 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 west side of the Cascades, 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. 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 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 tall), medium-tall (3.3- 6.6 ft), or tall (6.6-13.1 ft). 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 1 or both are typically present. Most stands are dominated by 1 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 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 much of this habitat. Pacific silver fir (*Abies amabilis*) is largely absent except on the wettest low-elevation 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, 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. Paper birch (*Betula papyrifera*) occurs as a codominant only in Whatcom County, Washington. Grand fir occurs as an occasional co-dominant only in the Puget Lowland. Dominant or co-dominant understory shrub species of more than local importance include salal (*Gaultheria shallon*), dwarf Oregon grape (*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 and rhododendron are particularly associated with low nutrient or relatively 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*), deer fern (*Blechnum spican*t), bracken fern (*Pteridium aquilinum)*, vanilla leaf (*Achlys triphylla*), twinflower (*Linnaea borealis*), false lily-of-the-valley (*Maianthemum dilatatum*), western spring beauty (*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. This habitat is also referred to as Douglas-fir-western hemlock and Sitka spruce-western hemlock forests, spruce-cedar-hemlock forest and cedar-hemlock-Douglas-fir 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 and Cowlitz River zones. A number of other references describe elements of this habitat.

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. 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 condition. 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 forbs and grasses as well as pre-disturbance understory shrubs and herbs that resprout. 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. 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. 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.

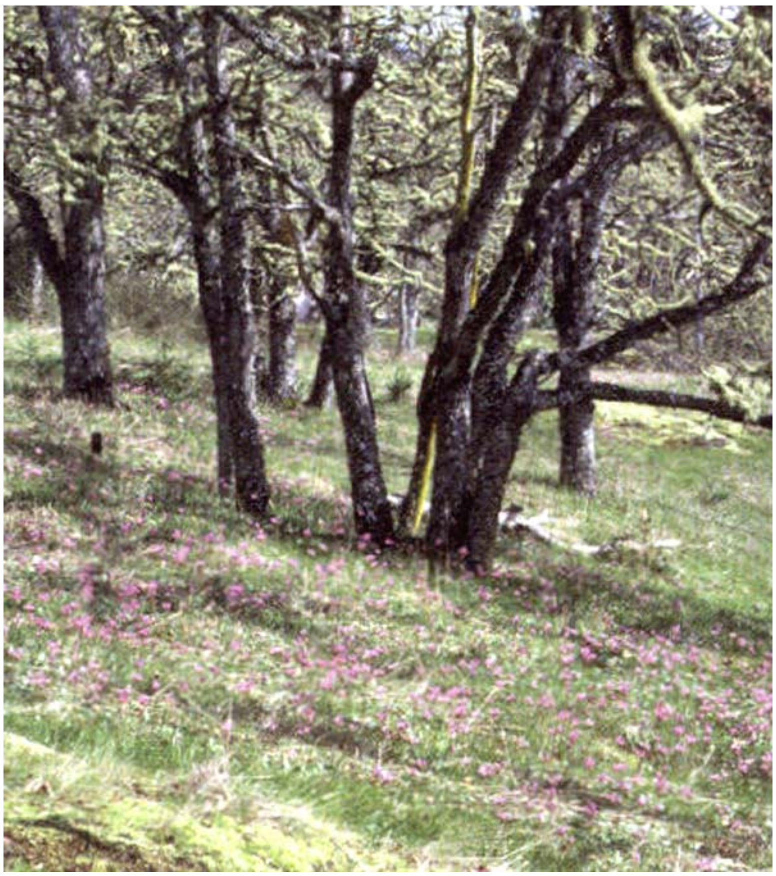
Effects of Management and Anthropogenic Impacts. Red alder is more successful after typical logging disturbance than after fire alone on moist, nutrient-rich sites, perhaps because of the species' ability to establish abundantly on scarified soils. Alder is much more common now because of large-scale logging activities. 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. Salmonberry responds positively to soil disturbance, such as that associated with logging. 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 percent are globally imperiled or critically imperiled.

Westside Oak and Dry Douglas-fir Forest and Woodlands

Christopher B. Chappell and Jimmy Kagan

Geographic Distribution. This habitat is primarily found in the Puget Lowlands ecoregion. It is common in and around the San Juan Islands and in parts of Thurston, Pierce and Mason counties. Minor occurrences can also be found in the northeastern Olympic Mountains and western Cascades. This habitat is composed of several geographic variants: California black oak and ponderosa pine are found in a small area of Pierce County. Shore pine is only important 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 or west Cascades. Pacific madrone and Douglas-fir/Pacific madrone stands without oak are limited to the Puget Lowland foothills.



Physical Setting. This habitat typically occupies dry sites west of the Cascades. Annual mean precipitation ranges from 17 to 60 inches, occasionally higher. Elevation ranges from sea level to about 3,500 in the Olympic Mountains, but is mainly below 1,500 ft. 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. 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, 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 pine (*Pinus contorta* var. *contorta*), or California black oak (*Q. kelloggii*). Grand fir (*Abies grandis*) is occasionally co-dominant with Douglas-fir in the northern Puget Lowlands. 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. 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*), 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 was 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. 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, the Cowlitz River. Other references describe elements of this habitat.

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. 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. Some portions of this habitat in the central Puget Lowlands may have formerly been dominated by shrubs (salal, beaked hazel, and evergreen huckleberry 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 tree sand increasing structural complexity. 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. Animal dissemination of acorns may be important in dispersal of oaks. Shore pine, where present, is an early-seral upper canopy series 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. 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.

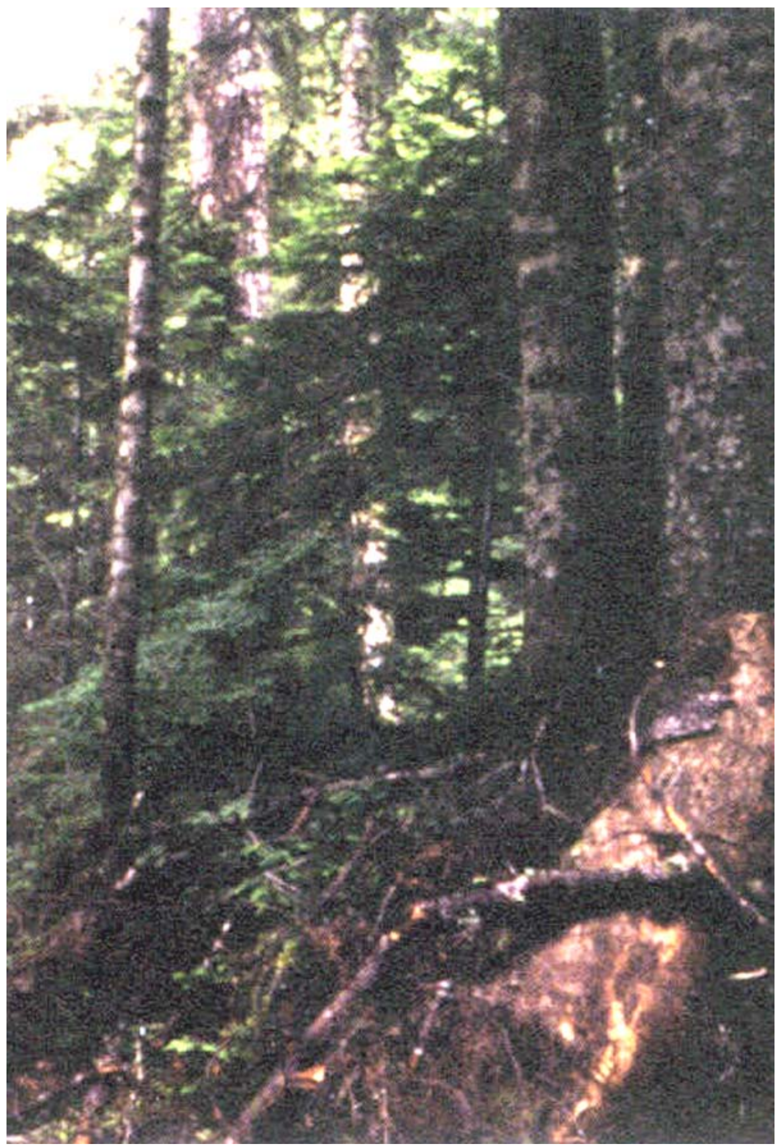
Montane Mixed Conifer Forest

Christopher B. Chappell

Geographic Distribution. These forests occur in mountains throughout Washington, including the Cascade Range, Olympic Mountains, Okanogan Highlands, Coast Range (rarely), and Blue Mountains.

Physical Setting. This habitat is typified by a moderate to deep winter snow pack that persists for 3 to 9 months. The climate is moderately cool and wet to moderately dry and very cold. Mean annual precipitation ranges from about 40 inches to >200 inches. Elevation is mid to upper montane, as low as 2,000 ft in northern Washington. On the west side, it occupies an elevational zone of about 2,500 to 3,000 vertical feet, and on the eastside it occupies a narrower zone of about 1,500 vertical feet. 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.

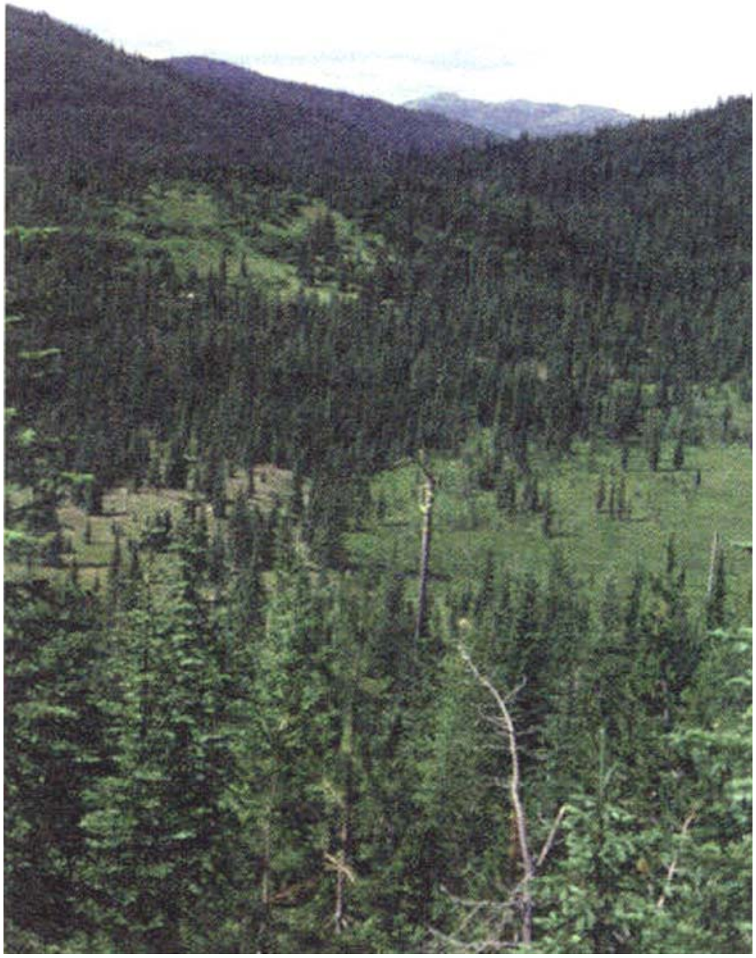
Landscape Setting. This habitat is found adjacent to Westside Lowlands Conifer-Hardwood Forest or Eastside Mixed Conifer Forests to Subalpine Parkland at its upper elevation limits. Inclusions of Montane Forested Wetlands, Westside Riparian Wetlands, and less commonly Open Water or Herbaceous Wetlands 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*), 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*) and western redcedar (*Thuja plicata*). 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 west side and along the Cascade Crest and by subalpine fir in cold, drier eastside zones. Subalpine fir and Engelmann spruce are major species only east of the Cascade Crest in Washington, in the Blue Mountains ecoregion, and in the northeastern Olympic Mountains (spruce is largely absent in the Olympic Mountains). Lodgepole pine is important east of the Cascade Crest. Douglas-fir is important east of the Cascade Crest and at lower elevations on the west side. Pacific silver fir is a major species on the west side. Noble fir, as a native species, is found primarily in the western Cascades in central Washington. 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 west side. Alaska yellow-cedar occurs as a co-dominant west of the Cascade Crest in Washington. 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*), 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*), and beargrass *(Xerophyllum tenax*). Deer fern (*Blechnum spicant*) and western oak fern (*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 unalaschkensis*), twinflower (*Linnaea borealis*), prince's pine (*Chimaphila umbellata*), five-leaved bramble (*Rubus pedatus*), and dwarf bramble (*R. lasiococcus*), avalanche lily (*Erythronium montanum*), Sitka valerian (*Valeriana sitchensis*), and false lily-of-the-valley (*Maianthemum dilatatum*).

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. Portions of this habitat have also been referred to as *A. amabilis-Tsuga heterophylla* forests, *A. magnifica* var. *shastensis* forests, and T*suga mertensiana* forests. It is equivalent to most of the conifer forest in the Silver Fir, Mountain Hemlock, and Subalpine Fir Zones of Washington GAP. Other references describe elements of this habitat.



Natural Disturbance Regime. Fire is the major natural disturbance in this habitat. Fire regimes are primarily of the high-severity type, but also include the moderate-severity regime (moderately frequent and highly variable) for Shasta red fir forests. 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.

Succession and Stand Dynamics. After fire, a typical stand will briefly be occupied by annual and perennial ruderal forbs and grasses, as well as pre-disturbance 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. 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. 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, 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. Planting of Douglas-fir has often failed at higher elevations, even where old Douglas-fir were present in the unmanaged stand. Slash burning often has negative impacts on productivity and regeneration. Management has since shifted away from burning and toward planting noble fir or native species, natural regeneration, and advance regeneration. 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.

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 is considered imperiled.

Eastside (Interior) 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 Washington. Douglas-fir-ponderosa pine forests occur along the eastern slope of the Cascades, the Blue Mountains, and the Okanogan Highlands. Grand fir-Douglas-fir forests and western larch forests are widely distributed throughout the Blue Mountains and, lesser 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, mostly between 3,000 and 5,500 ft. Parent materials for soil development vary. This habitat receives some of the greatest amounts of precipitation in the inland northwest, 30-80 inches/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 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 multi-layered 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 (9) 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 1 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 fools 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), beargrass (*Xerophyllum tenax*), and kinnikinnick (*A. uva-ursi*).Herbaceous broadleaf plants are important indicators of site productivity and disturbance. Species generally indicating productive sites include western oak fern (*Gymnocarpium dryopteris*), vanilla leaf (*Achlys triphylla*), wild ginger (*Asarum caudatum*), queen's cup (*Clintonia uniflora*), goldthread (*Coptis occidentalis*), false bugbane (*Trautvetteria caroliniensis*), windflower (*Anemone oregana, A. piperi, A. lyallii*), Hooker's 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.

Other Classifications and Key References. This habitat includes the moist portions of the *Pseudotsuga menziesii*, *Abies grandis*, and *Tsuga heterophylla* zones of eastern Washington. Other references describe elements of this habitat.
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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. 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. 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 multi-layer 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-intolerant 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 percent more abundant than in historical, native systems. 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. 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. 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.

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 and the Okanogan Highlands. 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. 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.

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. magnifici var. shastensi, 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)* sometimes 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 Oregon grape (*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 2 species may occur with bitterbrush or big sagebrush and other bunchgrass steppe species. Other non-dominant 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 Washington. Quigley and Arbelbide referred to this habitat as Lodgepole pine cover type and as a part of the Dry Forest potential vegetation group. Other references detail forest associations with this habitat.

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. 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.

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.

Status and Trends. Quigley and Arbelbide 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. At a finer scale, these forests have been fragmented by roads, timber harvest, and influenced by periodic livestock grazing and altered fire regimes.

Ponderosa Pine Forest and Woodlands (includes Eastside Oak)

Rex C. Crawford and Jimmy Kagan

Geographic Distribution. This habitat occurs in much of eastern Washington, including the eastern slopes of the Cascades, the Blue Mountains and foothills, and the Okanogan Highlands. 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.

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. Average annual precipitation ranges from about 14 to 30 inches on ponderosa pine sites and often occurs as snow. This habitat can be found at elevations of 100 ft in the Columbia River Gorge to dry, warm areas over 6,000 ft . Timber harvest, livestock grazing, and pockets of urban development are major land uses.

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

Structure. This habitat is typically a woodland or savanna with tree canopy coverage of 10-60 percent, although closed-canopy stands are possible. The tree layer is usually composed of widely spaced large conifer trees. Many stands tend towards a multi-layered 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. Grand fir (Abies grandis) may be frequent in the undergrowth on more productive sites giving stands a multi-layer 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 eastern 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. Short shrubs such as kinnikinnick (*A. uva-ursi*) are found across the range of this habitat. Antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*) and green rabbitbrush (Chrysothamnus viscidiflorus) 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. 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*). 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 Pacific ponderosa pine-Douglas-fir and Pacific ponderosa pine, and Oregon white oak by the Society of American Foresters. Other references describe elements of this habitat.

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. 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. Pre-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, multi-layered canopy. For example, this habitat includes previously natural fire-maintained stands in which grand fir can eventually become the canopy dominant. Fire suppression has lead 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 pre-settlement habitats. In some areas, new woodlands have been created by patchy tree establishment at the forest-steppe boundary.

Status and Trends. 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. 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.

Upland Aspen Forest

Rex C. Crawford and Jimmy Kagan

Geographic Distribution. Quaking aspen groves are the most widespread habitat in North America, but are a minor type throughout eastern Washington. Upland Aspen habitat is found in the northeastern Cascade 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. This habitat is not associated with streams, ponds, or wetlands. This habitat is found from 2,000 to 9,500 ft elevation.

Landscape Setting. Aspen forms a "subalpine belt" above the Western Juniper and Mountain Mahogany Woodland habitat and below Montane Shrubsteppe Habitat on Steens Mountain in southern Oregon. It can occur in seral stands in the lower Eastside Mixed Conifer Forest and Ponderosa Pine Forest and Woodlands habitats. Primary land use is livestock grazing.

Structure. Deciduous trees usually less than 48 feet tall dominate this woodland or forest habitat. The tree layer grows over a forb-, grass-, or low shrub-dominated undergrowth. Relatively simple 2-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.), sweet cicely (*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.

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 Utah 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 multi-clonal 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 five Pacific Northwest upland quaking aspen community types in the National Vegetation Classification is considered imperiled.

Subalpine Parkland

Rex C. Crawford and Christopher B. Chappell

Geographic Distribution. The Subalpine Parkland habitat occurs throughout the high mountain ranges of Washington (e.g., Cascade crest, Olympic Mountains, and Okanogan Highlands).

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 in 6 months and several feet of snow typically accumulate. Whitebark pine sites receive 24-70 inches per year and some sites only rarely accumulate a significant snowpack. Summer soil drought is possible in eastside parklands but rare in west side areas. Elevation varies from 4,500 to 6,000 ft in the western Cascades and Olympic Mountains and from 5,000 to 8,000 ft in the eastern Cascades.

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 percent 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 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 tall, as scattered tall shrubs, as dwarf shrub thickets, or as short herbaceous plants <1.6 ft 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. Alaska yellowcedar (*Chamaecyparis nootkatensis*), Pacific silver fir (*A. amabilis*), and mountain hemlock (*Tsuga mertensiana*) are most common in the Olympics and Cascades. Whitebark pine (*P. albicaulis*) is found primarily in the eastern Cascade 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 (*Phyllodoce empetriformis*), white mountainheather (*Cassiope mertensiana*) and Cascade blueberry (*Vaccinium deliciosum*). Drier areas are more woodland or savanna-like, often with low shrubs, such as common juniper, kinnikinnick (*Arctostaphylos uva-ursi*), low whortleberries or grouseberries (*Vaccinium myrtillus* or *V. scoparium*) or beargrass (*Xerophyllum tenax*) dominating the undergrowth. Wetland shrubs in the Subalpine Parkland habitat include bog-laurel (*Kalmia microphylla*), Booth's willow (*Salix boothii*), undergreen willow (*S. commutata*), and blueberries (*Vaccinium uliginosum or V. deliciosum*). 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, Parkland subzone, meadow-forest mosaic 74, upper subalpine zone, Meadows and Park, and Subalpine Parkland in various references. Other references describe elements of this habitat.

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 reoccurrence 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 sub-irrigation.

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. 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 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 percent of Pacific Northwest subalpine parkland community types listed in the National Vegetation Classification are considered imperiled.

Westside Grasslands

Christopher B. Chappell and Jimmy Kagan

Geographic Distribution. This habitat is restricted primarily to the Puget Lowland ecoregion, with most now occurring in Pierce, Thurston and San Juan counties, Washington. It also occurs in scattered small outliers in the eastern Olympic Mountains and the western Cascades.

Physical Setting. The climate is mild and moderately dry (17-55 inches mean annual precipitation), with moist winters and dry summers. Elevation is mostly low and ranges up to a maximum of about 3,500 feet. Topography varies from flat to mounded or rolling to steep slopes. Most sites are topoedaphically 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.

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 (<1.6 ft) 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. *roemeri*). 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 (*E. 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 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 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. Junegrass is a co-dependent in some montane balds; it occurs less abundantly throughout the area. Lemmon's needlegrass is primarily found on shallow-soiled balds of 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 Dyrness described this habitat as prairie in the Puget Sound area and grassland in the San Juan Islands. The Washington Gap project mapped this habitat as part of nonforested in the Woodland/Prairie Mosaic Zone. Other references describe elements of this habitat.

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. 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. 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. 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 cat's ear (*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 tolls have been used recently to control Scot's broom, Douglas-fir encroachment, and to attempt to mimic historical conditions in some areas.

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. 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 association representing this habitat listed for the National Vegetation Classification are considered imperiled or critically imperiled.

Eastside (Interior) Grasslands

Rex. C. Crawford and Jimmy Kagan

Geographic Distribution. This habitat is found primarily in Washington at mid- to low elevations and on plateaus in the Blue Mountains. Idaho fescue grassland habitats were formerly widespread in the Palouse region of southeastern Washington; 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. Sand dropseed and three-awn needlegrass grassland habitats are restricted to river terraces in the Columbia Basin and Blue Mountains of Washington.

Physical Setting. This habitat develops in hot, dry climates in the Pacific Northwest. Annual precipitation totals 8-20 inches; only 10 percent falls in the hottest months, July through September. Snow accumulation is low (1-6 inches) 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 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 in elevation.

Landscape Setting. Eastside grassland habitat appears well below and in a matrix with lower treeline Ponderosa Pine Forests and Woodlands. It can also be part of the lower elevation forest matrix. Most grassland habitat occurs in 2 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 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.

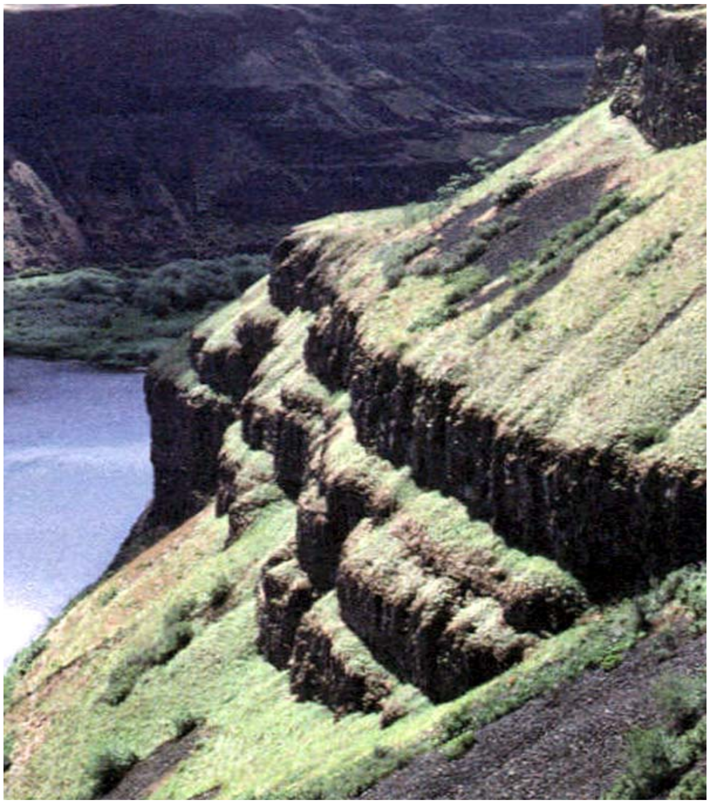
Structure. This habitat is dominated by short to medium-tall grasses (<3.3 ft). Total herbaceous cover can be closed to only sparsely vegetated. In general, this habitat is an open and irregular arrangement of grass clumps rather than a continuous sod cover. These medium-tall grasslands often have scattered and diverse patches of low shrubs, but few or no medium-tall shrubs (<10 percent 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 longiseta*) 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 tumblemustard (*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 prickly pear (*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. Washington GAP types 13, 21, 22, 24, 29-31, 82, and 99 map this habitat. Franklin and Dyrness include this habitat in steppe zones of Washington. Other references describe elements of this habitat.

Natural Disturbance Regime. The fire-return interval for sagebrush and bunchgrass is estimated at 25 years. The native bunchgrass habitat apparently lacked extensive herds of large grazing and browsing animals until the late 1800's. 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. 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 grassland 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. 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. 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 United States, with only one percent 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 percent of the Palouse grasslands have been converted to crop, hay, or pasture lands. Fescue-Bunchgrass and Wheatgrass bunchgrass cover types have significantly decreased in area since pre-1900, while exotic forbs and annual grasses have significantly increased since pre-1900. Fifty percent of the plant associations recognized as components of eastside grassland habitat listed in the National Vegetation Classification are considered imperiled or critically imperiled.

Shrub-steppe

Rex. C. Crawford and Jimmy Kagan

Geographic Distribution. Shrub-steppe habitat is common across the Columbia Plateau of Washington. It extends 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 Washington. Wyoming sagebrush Shrub-steppe is the most widespread habitat in eastern Washington, occurring throughout the Columbia Plateau and the northern Great Basin. Mountain big sagebrush Shrub-steppe habitat occurs throughout the mountains of eastern Washington. Bitterbrush Shrub-steppe habitat appears primarily along the eastern slope of the Cascades, from north-central Washington to the Blue Mountains. Three-tip sagebrush Shrub-steppe occurs mostly along the northern and western Columbia Basin in Washington. Interior shrub dunes and sandy steppe and Shrub-steppe habitat is concentrated at low elevations near the Columbia River and in isolated pockets in the Northern Basin.

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 with most habitat occurring between 2,000 and 6,000 ft). 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 Woodlands, and Western Juniper and Mountain Mahogany Woodlands 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 percent. In an undisturbed condition, shrub cover varies between 10 and 30 percent. Shrubs are generally evergreen, although deciduous shrubs are prominent in many habitats. Shrub height typically is medium tall (1.6-3.3 ft) although some sites support shrubs approaching 9 ft 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 healthy site is better characterized as grassland with shrubs than a shrubland. The bunchgrass layer may contain a variety of forbs. Healthy 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 percent cover, with introduced annual grasses and little or no moss or lichen cover. Moist sites may support tall bunchgrasses (>3.3) 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 co-dominate 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 co-dominant 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. 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. Franklin and Dyrness discussed this habitat in Shrub-steppe zones of Washington and Oregon. Other references describe elements of this habitat.

Natural Disturbance Regime. 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 1800's. 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, post-fire 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. Alteration of fire regimes, fragmentation, livestock grazing, and the addition of >800 exotic plant species have changed the character of Shrub-steppe habitat. 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. Basin Big Sagebrush and Big sagebrush-Warm potential vegetation type's successional pathways have been altered, some pathways of Antelope Bitterbrush have been altered and 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.

Open Water - Lakes, Rivers, and Streams

Eva L. Greda, David H. Johnson, and Tom O’Neil

Lakes, Ponds, and Reservoirs

Geographical Distribution. Lakes in Washington occur statewide and are found from near sea level to about 10,200 ft above sea level. There are 3,887 lakes and reservoirs in western Washington, and they total 176,920 acres. In contrast, there are 4,073 lakes and reservoirs in eastern Washington that total 436,843 acres.

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. Beavers create many ponds and marshes in 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.

Structure. There are 4 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 Wetland's 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.

Natural Disturbance Regime. There are seasonal and decadal variations in the patterns of precipitation. In the Coast Range, there is usually one month of drought per year (usually July or August) and two months of drought once in a decade. The Cascades experience one month with no rain every year and a two-month dry period every third year. Dry years with <33 percent of normal precipitation occur once every 30 years along the coast, and every 30 years in the Cascades. Floods occur in 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 mostly by precipitation 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.

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. 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.

Rivers and Streams

Geographic Distribution. Streams and rivers are distributed statewide in Washington, forming a continuous network connecting high mountain areas to lowlands and the Pacific coast. 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. The Puget Sound Region has 10,217 rivers and streams, which add up to 16,600 miles in length. The rivers and streams range from cold, fast-moving high-elevation streams to warmer lowland valley rivers. In all, there are 13,955 rivers and streams that add up to 24,774 miles. There are many more streams in Washington yet to be catalogued.

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. 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, from 75 to 100 inches in the foothills, and from 100 to >200 inches in the mountains (mostly in the form of snow). The western Cascades in Washington are composed of stable, volcanically derived rocks. They have low sediment-transport rates and stable beds composed largely of cobbles and boulders, which move only during extreme events. Velocities of river flow ranges from as little as 0.2

to 12 mph while large streams have an average annual flow of 10 cubic feet per second or greater. 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.

Landscape setting. This habitat occurs throughout Washington. 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, or Bays and Estuaries habitats.

Other Classifications and Key References. This habitat is called riverine and lacustrine in Anderson *et al.*, Cowardin *et al.*, Washington GAP Analysis Project, Mayer and Laudenslayer, and Wetzel. Other references describe elements of this habitat.

Effects of Management and Anthropogenic Impacts. 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. Incorrectly installed culverts may act as barriers to migrating fish and may contribute to erosion and siltation downstream. 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. 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 have caused a loss of open water habitat that has been detrimental to fish and wildlife production, particularly in the summer. Agricultural, industrial, and sewage runoff such as salts, sediments, fertilizers, pesticides, and bacteria harm aquatic species. 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. Direct loss of habitat and water quality occurs through irrigation. Very large floods 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. 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. Clearcutting and vegetation removal affects the temperatures of streams, increasing them in the summer and decreasing in winter, especially in eastern parts of Washington. Building of roads, especially those of poor quality, can be a major contributor to sedimentation in the streams.

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). 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, Washington state government 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 to removing large federal dams like those on the lower Snake River,

Herbaceous Wetlands

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

Geographic Distribution. Herbaceous wetlands are found throughout the world and are represented in Washington wherever local hydrologic conditions promote their development. This habitat includes all wetlands except bogs and those within Subalpine Parkland and Alpine. 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., Puget Trough, coastal terraces, coastal dunes), but are present in montane and arid climates as well. Hardstem bulrush-cattail-burred marshes occur in wet areas throughout Washington. Sedge meadows and montane meadows are common in the Olympic and Cascade Mountains and Okanogan Highlands.

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 from sea level to 10,000 feet, although infrequently above 6,000 ft.

Landscape Setting. Herbaceous wetlands are found in all terrestrial habitats except Subalpine Parkland, 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 tall or sedge meadows and wetlands <3.3 ft 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 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 star-warts (*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 forb dominated with plants such as arrowleaf groundsel (*Senecio triangularis*) or lady fern (*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*. This habitat occurs in both lotic and lentic systems. National Wetland Inventory (NWI) calls this habitat palustrine shrubland. Other references describe elements of this habitat.

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, semi-permanently 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.

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. Herbaceous wetlands are susceptible to exotic, noxious plant invasions.

Westside Riparian-Wetlands

Christopher B. Chappell and Jimmy Kagan

Geographic Distribution. This habitat is patchily distributed in the lowlands throughout the area west of the Cascade Crest. 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 per year. This habitat is found at elevations mostly below 3,000 ft, but it does extend up to 5,500 ft 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) 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. 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*), and Oregon ash (*Fraxinus latifolia*). Pacific willow (*Salix lucida* ssp. *lasiandra*) can form woodlands on major floodplains or co-dominate with other willows in tall shrublands. 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 (*Salix hookeriana*), Douglas' spirea (*Spiraea douglasii*), red-osier dogwood (*Cornus sericea*), western crabapple (*Malus fusca*), salmonberry (*Rubus spectabilis*), stink currant (*Ribes bracteosum*), devil's club (*Oplopanax horridus*), 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) ecoregion. Sitka spruce communities are mainly found in the Coast Range area and western Olympic Peninsula in areas of coastal fog influence. 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. 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. 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*), lady fern (*Athyrium filix-femina*) oxalis (*Oxalis oregana, O. trillifolia*), stinging nettle (*Urtica dioica*), sword fern (*Polystichum munitum*), great burnet (*Sanguisorba officinalis*), scouring rush (*Equisetum hyemalis*), blue wildrye (*Elymus glaucus*), Pacific golden saxifrage (*Chrysoplenium glechomifolium*), and field horsetail (*Equisetum arvense*). Bogs often have areas dominated by more than one 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. However, drier portions of this habitat in riparian flood plains may not qualify as wetlands according to Cowardin's definition. 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. 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, and Woodland/prairie mosaic. 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. Other references describe this habitat.

Natural Disturbance Regime. The primary natural disturbance is flooding. Flooding frequency and intensity vary greatly with hydrogeomorphic 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, or they occupy a specific time in a successional sequence after a major disturbance. Debris flows/torrents are also an important, typically infrequent, and severe disturbance where topography is mountainous. 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 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. Succession varies greatly depending on the hydrogeomorphic 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. 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 Anthropomorphic 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. Timber harvest can also alter hydrology, most often resulting in post-harvest increases in peak flows. Mass wasting and related disturbances (stream sedimentation, debris torrents) in steep topography increase in frequency with road building and timber harvest. Roads and other water diversion/retention structures change watershed hydrology with wide-ranging and diverse effects, 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 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.

Montane Coniferous Wetlands

Christopher B. Chappell

Geographic Distribution. This habitat occurs in mountains throughout much of Washington. This includes the Cascade Range, Olympic Mountains, Okanogan Highlands and Blue 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. Elevation is mid- to upper montane, as low as 2,000 ft in northern Washington, to as high as 9,500 ft. 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 percent 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*), western hemlock (*T. heterophylla*), or western redcedar (*Thuja plicata*) on the eastside. 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, but are not diagnostic there. 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 quinquiflora*). Some of the most abundant forbs and ferns are lady fern (*Athyrium filix-femina*), western oak fern (*Gymnocarpium dryopteris*), field horsetail (*Equisetum arvense*), arrowleaf groundsel (Senecio triangularis), two-flowered marsh marigold (*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 most of the wet forests in the *Tsuga heterophylla* and *Abies lasiocarpa* zones of eastern Washington. 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. These are primarily palustrine forested wetlands with a seasonally flooded, temporarily flooded, or saturated flooding regime. They occur in both lotic and lentic systems. Other references describe elements of this habitat.

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. 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. 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. 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. 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.

Eastside (Interior) Riparian-Wetlands

Rex C. Crawford and Jimmy Kagan

Geographic Distribution. Riparian and wetland habitats dominated by woody plants are found throughout eastern Washington. Mountain alder-willow riparian shrublands are major habitats in the forested zones of eastern Washington. Eastside lowland willow and other riparian shrublands are the major riparian types throughout eastern Washington at lower elevations. Black cottonwood riparian habitats occur throughout eastern 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, and in western Klickitat and south central Yakima counties, Washington. Quaking aspen wetlands and riparian habitats are widespread but rarely a major component throughout eastern Washington. 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 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 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 multi-layered. 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, 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 exception is 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 spirea (*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, spirea, 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*), lady fern (*Athyrium filix-femina*), field horsetail (*Equisetum arvense*), cow parsnip (*Heracleum maximum*), skunk cabbage (*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*. This habitat occurs in both lotic and lentic systems. Other references describe elements of this habitat.

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 select 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. 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 two percent, they estimated it to have declined to 0.5 percent of the landscape. Approximately 40 percent of riparian shrublands occurred above 3,280 ft in elevation pre-1900; now nearly 80 percent 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. Riparian woodland has always been rare and the change in extent from the past is substantial.

Coastal Dunes and Beaches

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

Geographic Distribution. This habitat occurs primarily along the outer coast of southern 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.

Physical Setting. This habitat occurs primarily in wet, mild outer coastal climates. Precipitation, almost always rain, typically averages >80 inches 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. 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, 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*). 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 Dyrness called this habitat sand dune and strand communities. 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.

Natural Disturbance Regime. Erosion and deposition of sand are the primary natural processes controlling this habitat. Sand is deposited initially on beaches, and the moved into dunes through wind erosion. Wind also maintains Unstabilized dune areas. Major winter storm events may result in blowouts that create holes in existing stabilized or Unstabilized dunes, crating 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 stand to completely stabilized shrub-dominated dunes. 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.

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. 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. 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 areas. Trampling is a potential threat in herbaceous communities.

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 tends 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.

Bays and Estuaries

Mikell O'Mealy and 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. There are 34 principal bays and estuaries in Washington. 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). The greater Puget Sound at times is considered a very large estuary; 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 70°F year-round with little north-south variation. Annual rainfall along the coastal zone averages 80 to 90 inches and is concentrated in winter months, producing correspondingly high river runoff to bays and estuaries. 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 very in specific composition and distribution with variable physical factors.

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) 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. Tidal currents in channels of the principal estuaries typically range from 1 to 5 knots.

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. Inundated by daily tidal flows, tideflats may support eelgrass, various algal species, and invertebrate communities. Eelgrass meadows create protected environments and structured habitats for various wildlife species. Salt marshes form at the upper tidal boundary above tideflats. 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. At the most inland extent of this habitat, transitional marsh forms between salt marshes and bordering upland vegetation dominated by grass or woody vegetation.

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).

Composition. Eelgrass meadows stabilize submerged tideflats and are co-dominated by surfgrass and eelgrass species. Three diagnostic surfgrass species (*Phyllospadix scouleri, P. torreyi, 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. Highly productive macroalgae that dominate estuarine channels include various blue-green algae, green algae (*Enteromorpha* spp.) and rockweed (*Fucus* spp.). Tideflats bordering salt marshes often are co-dominated by pickleweed (*Salicornia virginica*), arrowgrass (*Triglochin maritima*) and three-square rush (Scirpus americanus). 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*). Major components of mid- and high salt marsh areas are alkaligrass (*Puccinellia pumila*) and Canadian sand spurry (*Spergularia canadensis*). 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.

Other Classifications and Key References. Cowardin et al. included marine and estuarine systems of the Columbia Province. Dethier described a classification for marine and estuarine habitat types in Washington. 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. Harper et al. described a shore-zone sensitivity mapping system. Proctor et al. 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 Dethier 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). Downing 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 saltwater wedges up through the system, causing varying degrees of mixing with incoming riverine waters and significant vertical stratification. Riverine discharges and freshwater 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. 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 freshwater discharges at the head of the system.

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. 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. Various exotic species have become naturalized in Washington, including spreading bentgrass and sand spurry introduced from Europe, brass buttons (*Cotula coronopifolia*), introduced from South Africa, and marsh cordgrass (*Spartina alterniflora*) introduced form the Atlantic Coast of North America. 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 lad-use practices have altered significant portions of this habitat and continue to impact remaining areas. The dredging and filling of marshes and tideflats to serve various human needs remove estuarine vegetation. Channel flow, tidal inundation, and freshwater 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.

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. Original diking for crop production and flood control, 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 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.

Inland Marine Deeper Water

David H. Johnson

Geographic Distribution. This habitat is located in the northwestern portion of Washington. 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. 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.

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 70°F year-round, with little north-south variation. Rainfall averages 20 to 80 inches 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 Straight 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. Organics, silt and sand are the primary substrate components of this habitat and vary in specific composition and distribution with fluctuating physical factors. Through deposition of sediments, major river deltas have advanced substantial distances into the deep basins of Puget Sound.

Composition. Marine waters dominate freshwater 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. included this region in the Columbia Province and described a hierarchical classification for wetlands and deepwater habitats in the U.S. Dethier described a classification for marine and estuarine habitat types in Washington. Habitat types were defined by depth, substratum type, energy level, and a few modifiers. Harper et al. described a shore-zone mapping system for use in sensitivity mapping and shoreline countermeasures. Proctor et al. described an ecological characterization of the Pacific Northwest Coastal Region, including physical and chemical environments as well as socioeconomic aspects of watershed units of the region. Schoch and Dethier 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 outcompete 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.

Marine Nearshore

David H. Johnson

Geographic Setting. This habitat reflects marine water areas (high tide line to depth of 66 ft) 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, Straight of Georgia, Strait of Juan de Fuca, and along Washington's outer coastline. In Washington, there are 3,100 miles of this nearshore habitat. 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 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, the effects of coastal streams are generally local and seasonal.

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 nearshore (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

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 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 scouleri*), 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, Z. japonica*) and the red alga (*Gracilaria pacifica*).

Other Classifications and Key References. Dethier provided a detailed classification scheme for the estuary, intertidal, and shallow subtidal areas of Washington. The Cowardin et al. classification scheme has several limitations with regards to adopting it for marine and estuarine systems. Levings and Thom described nine 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. 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 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, has been modified. The Central Puget Sound region, with high human population levels, shows the highest level of modification overall. In Washington there are 26 species of kelp, more than any other area worldwide. Data on floating kelp along the Strait of San Juan de Fuca suggest that while kelp areas are dynamic, the overall extent of kelp has remained stable during 1993-1997.

APPENDIX 12: ECOREGIONAL ASSESSMENTS

This section provides an overview of the ecoregional assessment process as well as provides a more detailed explanation of the conservation utility maps that are included in the Ecoregion Conservation Strategy Chapter VI.

Overview

Limited resources and other social or economic considerations make protection of all wildlife habitat impractical, if not impossible. To be effective, biodiversity conservation must make efficient use of limited resources. This inescapable situation can be addressed two ways. First, we must narrow our immediate attention to the most important places for biodiversity conservation. To do this we need a reliable method for prioritizing potential conservation areas. Second, we should provide organizations, agencies, and landowners with flexibility to pursue other options when particular places are too difficult to protect. Assigning a relative priority to all places in an ecoregion will inform everyone about their options for conservation.

To guide biodiversity conservation and land use planning across Washington State, WDFW and the Washington Department of Natural Resources joined The Nature Conservancy in a partnership to do an ecoregional assessment (EA) for each of Washington's nine ecoregions. An EA attempts to identify and prioritize places for the conservation of all biodiversity in an ecoregion. The relative priority of places is based on such factors as species rarity, species richness, species representation, site suitability, and overall efficiency.

The prioritization of potential conservation areas is an essential element of conservation planning (Margules and Pressey 2000). The need for prioritization is made evident by the extensive research conducted to develop better prioritization techniques (e.g., Margules and Usher 1981, Anselin et al. 1989, Kershaw et al. 1995, Pressey et al. 1996, Freitag and Van Jaarsveld 1997, Benayas et al. 2003). Ecoregional assessments follow an approach developed by The Nature Conservancy (Groves et al. 2000, Groves et al. 2002). In essence, the EA is a data analysis with significant expert input to address data gaps. The analytical tool used in the EA is an optimal site selection algorithm. Since the 1980s considerable research has been conducted on theories, techniques, and applications of optimal site selection algorithms. Over 100 articles on the subject have been published in referred, peer-reviewed journals (Cabeza and Moilanen 2001, Williams et al. 2004). Optimal site selection algorithms select a set of potential conservation areas, also known as assessment units (AUs), which satisfy conservation objectives for the least cost. “Cost” can be expressed as the monetary cost, land area, or suitability of each AU.

The Ecoregional assessment has many steps: (1) choose conservation target (i.e., species, plant communities, ecological systems, and habitat types); (2) assemble occurrence data for the targets; (3) re-organize data and define spatial representation of each target; (4) develop a suitability index and rate assessment units; (5) run site selection algorithm; (6) assemble draft portfolios; (7) refine portfolio through expert review; (9) prioritize the potential conservation sites. All ecological systems and habitat types are targets. Target species must satisfy at least one of the following criteria: federal or state listed, globally imperiled (G1, G2, G3), endemic, disjunct, keystone, vulnerable, or wide-ranging. Usual data sources are WDFW, state natural heritage programs, federal agencies, and regional experts. The suitability index is a surrogate for cost and indicates the relative likelihood of successful conservation at each AU, based on relative human impacts across the ecoregion. Statistical models for suitability are unavailable, and therefore, much of the index is based on expert opinion (Banai-Kashani 1989). To incorporate expert opinion, we use an abbreviated version of the analytic hierarchy process (AHP; Saaty 1980). The analysis utilizes an optimization program known as MARXAN (Ball and Possingham 2000) to find the most efficient set of AUs.

Main Assessment Products

Three principal products emerge from the assessment: a comprehensive compilation of conservation data for the ecoregion, conservation utility maps, and a conservation portfolio map. A number of ancillary products are also produced that should be useful to groups asking specific questions regarding site priorities.

The data used in an assessment have been compiled from a number of other sources and are some of the most sought after products. Agencies and groups who have a stake in the conservation of the ecoregion regularly request these data, especially because it is in a GIS format and has been refined through analysis. One of the uses of the data is to determine how much known biodiversity is located in existing protected areas, a type of gap analysis which can be used to direct conservation actions to elements of biodiversity that are most in need of conservation.
Conservation utility maps are a prioritization of all assessment units (AUs) in an ecoregion based on the relative biological value and relative suitability of AUs. These maps can be used to guide ecoregion-level conservation action and can inform smaller scale conservation decisions as well. Sensitivity analyses of terrestrial conservation utility maps typically show that the ranking of highest ranked AUs is robust to changing assumptions about AU suitability. The conservation utility maps are not based on a particular set of conservation goals. They are a data analysis that is not modified by expert review.

The alternative portfolios are a simplistic illustration of the potential range of policy options for the conservation of biodiversity in an ecoregion. Three alternatives based on three different sets of conservation goals are presented. Goal formulation is not purely scientific; it involves some policy-based decisions that reflect the values of the organization formulating them. For instance, the mid-risk portfolio represents TNC's vision for conservation of the ecoregion's biodiversity. The purpose of the lower and higher risk portfolios is to depict two different visions of what biodiversity conservation could look like. The alternatives are intended to convey a fundamental message – society must make choices about the value of biodiversity and act accordingly.

The conservation portfolio map depicts a set of conservation areas that most efficiently meet a specific set of conservation goals. The goals used in the EA are developed by The Nature Conservancy, Nature Conservancy of Canada and NatureServe, and tailored for each ecoregion by the core team. The goals determine the overall size of the portfolio – lower goals will yield a smaller portfolio. The conservation areas identified in the portfolio are important for a number of reasons. First, some AUs are the only places where one or more species or plant community targets are known to occur. This is particularly true for species and plant communities associated with low-elevation, old growth coniferous forests. Second, some AUs comprise the last large, relatively undisturbed landscapes in the ecoregion. Many of these places are parks or wilderness areas. Large areas are especially important to wide-ranging species. These areas currently make irreplaceable contributions to conserving ecoregional biodiversity and possess significant potential for the maintenance of landscape-scale ecological processes.

Third, wherever possible, the assessment selects AUs that are most promising for successful conservation. The assessment uses a suitability index to map the relative likelihood of successful conservation across the ecoregion. The suitability index is a quantitative expression of several well-accepted principles of conservation biology: (1) large areas of habitat are better than small areas; (2) habitat areas close together are better than areas far apart; and (3) areas with low habitat fragmentation area better than areas with high fragmentation. The suitability index also relies on two reasonable assumptions, first, that existing public land is more suitable for conservation than private land; and second, rural areas are more suitable for conservation than urban areas. Application of these principles and assumptions guide site selection toward existing public lands and away from private land, and toward rural areas with low habitat fragmentation and away from urban areas.

Not every AU in the portfolio is irreplaceable or has exceptionally high value for biodiversity conservation. Some AUs not in the portfolio could be swapped with low value AUs in the portfolio to yield a new portfolio of equal overall value to the original portfolio. The conservation utility maps should be used in conjunction with the portfolio maps to determine which areas in the portfolio are irreplaceable or have exceptionally high value for biodiversity conservation.

As products from the ecoregional assessments become available, they will be posted on the WDFW website http://www.wdfw.wa.gov/ and the ConserveOnline website http://conserveonline.org/.

Ecoregional Assessment Process

Five technical teams of scientists and conservation specialists follow an assessment framework established by Groves et al. (2000, Groves et al. 2002). The teams include a terrestrial ecological systems team, a plant species team, an animal species team, a freshwater team, and a marine team. All the technical teams are coordinated and directed by an oversight group called the core team, made up of technical team leads and other scientists and conservation professionals from British Columbia, Washington, and Oregon. Each technical team contributes to each of the following steps described below and innovates where necessary to address specific data limitations and other challenges.

1. **Choose conservation targets** - Conservation target are the plants, animals, plant communities, and ecological systems included in the analysis. These targets are intended to encompass the full range of biodiversity in the ecoregion and include any elements of special concern.

Robert Jenkins, working for The Nature Conservancy in the 1970s, developed the concept of coarse filter and fine filter conservation targets (Noss 1987). This approach hypothesizes that conservation of multiple, examples of all plant communities and ecological systems (coarse filter targets) will also conserve the majority of species that occupy them. This coarse filter strategy is a way to compensate for the lack of detailed information on the vast number of poorly studied species.

Fine filter targets are those rare or imperiled species that cannot be assumed to be captured by coarse filter targets. Fine filter targets warrant a special effort to ensure they are represented in the conservation assessment. Fine filter targets can also include wide-ranging species that require special analysis, or species that occur in other ecoregions but have genetically important disjunct populations.

2. **Assemble location or "occurrence" data for targets** - location data are assembled from a variety of sources. Although existing agency databases make up the bulk of these data, data gaps are often filled by consulting with experts who work in the ecoregion.

Because ecoregional assessments depend on comprehensive, up-to-date data, step two is especially important.

3. **Re-organize data and define spatial representation of each target** - Data from different agencies and experts must be re-organized into a single standard format. Decisions are made regarding the best way to define a target's occurrences. Standards developed by NatureServe are used to define some target occurrences. Targets may be represented as points, which could show the locations of rare plant populations or bat roosts, or represented as polygons to show the areal extent of a species' habitat or an ecological system. The data are stored in a Geographical Information System (GIS).

4. **Set representation levels for each target** – The analytical tool used for ecoregional assessments requires "goals" for how many occurrences or how much habitat area should be captured in the assessment. Goals are set with the underlying assumption that they will be sufficient to sustain each target over a 50-100 year time period. These "goals" are used to drive the identification and prioritization of potential conservation areas.

It is essential that users of this assessment understand the function of goals in the assessment. The goals cannot be treated as conditions for ensuring long-term survival of species. They are an important device for assembling a portfolio of conservation areas that captures multiple examples of the ecoregion's biodiversity. These goals also provide a metric for gauging the contribution of different portions of the ecoregion to the conservation of its biodiversity and measuring the progress of conservation in the ecoregion over time.

5. **Develop a suitability index and rate assessment units -** Each ecoregion is divided into thousands of assessment units (AUs). AUs have been hexagons in some ecoregions but watersheds in other ecoregions. Within an ecoregion, each AU is compared to other AUs using a set of factors that correspond to an AUs suitability for conservation or the likelihood of conservation success. The factors are those likely to impact habitat quality for native species, such as road density or the proximity to urban areas, as well as factors likely to impact the cost of managing the area for conservation, such as the percent of public versus private lands or the existence of established conservation areas. The factors are brought together in an equation that yields a rating known as a suitability index.

It is important to note that the factors chosen for the suitability index influence the priority of potential conservation areas, i.e., a different set of factors can result in different priorities. Also, some factors in the suitability index require consideration of what are traditionally policy questions. For example, setting the index to favor the selection of public over private land presumes a policy of using existing public lands to conserve biodiversity wherever possible, thereby minimizing the involvement of private or tribal lands. A sensitivity analysis is done to explore how priorities change in response to changes in the suitability index.

6. **Run site selection algorithm** - An ecoregional assessment entails hundreds of different targets existing at thousands of locations. The relative biodiversity value and relative conservation suitability of thousands of assessment units must be evaluated. This complexity precludes simple inspection by experts to arrive at an efficient set of high priority conservation areas. Hence, we used an optimal site selection algorithm known as MARXAN (Ball and Possingham 2000) to assign a conservation priority to every AU. MARXAN is computer software that aids scientists in identifying an efficient set of conservation areas.

To use MARXAN, one must input data describing the biodiversity at and the conservation suitability of the thousands of assessment units in the ecoregion. The number of targets, condition of targets, and rarity of targets present at a particular place determines the biodiversity of the unit. Conservation suitability is input as a suitability index (described above) representing a set of weighted factors chosen to represent the relative likelihood of successful conservation at a unit.

MARXAN strives to minimize an objective function. It begins by selecting a random set of assessment units, i.e., a random conservation portfolio. Next, MARXAN iteratively explores improvements to this random portfolio by randomly adding or removing other units. At each iteration, the new portfolio is compared with the previous portfolio and the better one is accepted. The algorithm uses a method called simulated annealing to reject sub-optimal portfolios, thus greatly increasing the chances of converging on most efficient portfolio. Typically, the algorithm is run for 1 to 2 million iterations.

7. **Assemble conservation utility maps and draft portfolios** - Different types of analyses can be done using MARXAN. One type of analysis calculates relative irreplaceability values for all AUs in the ecoregion. Another type of analysis identifies the most efficient set of AUs that will meet particular conservation goals. The identified set of AUs is called a conservation portfolio. Both of these products are more fully described in the following sections.

8. **Refine the portfolio through expert review** – Expert review and revision are necessary to compensate for gaps in the input data or other limitations of automated selection of assessment units. Experts review the draft portfolio to correct errors of omission or inclusion by the computer-driven process. These experts also assist the teams with refining individual site boundaries. The terrestrial, freshwater, and marine portfolios are then integrated into a single final portfolio. This integrated portfolio is in turn subjected to additional expert refinement to produce the final portfolio.

9. **Prioritize the potential conservation sites** – Ideally, the conservation portfolio would serve as the conservation blueprint to be implemented over time by nongovernmental organizations and government agencies. However, in reality, the entire portfolio cannot be protected immediately and some conservation areas in the portfolio may never be protected (Meir et al. 2004). Limited resources and other social or economic considerations may make protection of the entire portfolio impractical. This inescapable situation can be addressed two ways. First, we should narrow our immediate attention to the most important conservation areas within the portfolio. This can be accomplished by prioritizing conservation areas. Second, we should provide decision makers with the flexibility to pursue other options when portions of the portfolio are too difficult to protect. Assigning a relative priority to all assessment units in the ecoregion will inform decision makers about their options for conservation.

To facilitate prioritization we used MARXAN to generate two different irreplaceability indices for all AUs in an ecoregion. In addition, we created an irreplaceability versus vulnerability scatter plot that was used to further refine priorities.

<u>Irreplaceability</u>

Useful products of an EA are conservation utility maps that depict the conservation priority of all AUs in an ecoregion. *Irreplaceability* has been defined a number of different ways (Pressey et al. 1994, Ferrier et al. 2000, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003). However, the original operational definition was given by Pressey at al. (1994).

They defined irreplaceability of a site as the percentage of alternative reserve systems in which it occurs. Following this definition, Andelman and Willig (2002) and Leslie et al. (2003) each exploited the stochastic nature of simulated annealing algorithm to calculate an irreplaceability index.

MARXAN uses a simulated annealing algorithm that is a controlled random search for the global minimum of an objective function. Since it is random, simulated annealing can arrive at somewhat different answers for a single optimization problem. The algorithm may not converge on the optimal solution, i.e., the global minimum, but it will find local minima that are nearly as good as the global minimum (McDonnell et al. 2002). That is, the objective function value for the local minima will be nearly as small as the global minimum. The random search of simulated annealing enables it to find multiple nearly optimal solutions. An AU may belong to many different nearly optimal solutions. The number of simulated annealing solutions that include a particular AU is a good indication of that AU's irreplaceability. This is the assumption made by Andelman and Willig (2002) and Leslie et al. (2003) for their irreplaceability index. The index of Andelman and Willig (2002) was:

$$I_j = (1/n) \sum_{i=1}^{n} s_i \qquad (1)$$

where I is relative irreplaceability, n is the number of solutions, and s_i is a binary variable that equals 1 when AU_j is selected but 0 otherwise. I_j have values between 0 and 1, and are obtained from a running the simulated annealing algorithm n times at a single representation level.

Irreplaceability is a function of the desired representation or goal level (Pressey et al. 1994, Warman et al. 2004). Changing the representation level for target elements often changes the number of AUs needed for the solution. For instance, low representation levels typically yield a small number of AUs with high irreplaceability and many AUs with zero irreplaceability, but as the representation level increases, some AUs attain higher irreplaceability values. The fact that some AUs go from zero irreplaceability to a positive irreplaceability demonstrates a shortcoming of Willig and Andelman's index – at low representation levels, some AUs are incorrectly shown to have no value for biodiversity conservation. We created an index for relative irreplaceability that addresses this shortcoming. Our global irreplaceability index for AU_j was defined as:

$$G_j = (1/m) \;) \sum_{k=1}^{m} I_{jk} \qquad (2)$$

where I_{jk} are relative irreplaceability values as defined in equation (2) and m is the number of representation levels used in the site selection algorithm. G_j have values between 0 and 1. Each I_{jk} is relative irreplaceability at a particular representation level. We run MARXAN at ten representation levels. At the highest representation level nearly all AUs attained a positive irreplaceability.

Many applications of "irreplaceability" have implicitly subsumed some type of conservation efficiency (e.g., Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003). Efficiency is usually achieved by minimizing the total land area needed to satisfy the representation level. The resulting index we call area-minimized irreplaceability. Efficient conservation is more complex than simply minimizing land area. A more realistic optimization would incorporate other factors that affect the cost of conservation, such as current ownership, current land use, habitat condition, etc. With this in mind, we generated another index we call suitability-maximized irreplaceability. Suitability is an index that reflects the likelihood of successful conservation at each AU (see explanation below). Efficiency is achieved by maximizing the total suitability of AUs selected to satisfy the representation level.

<u>Interpreting Irreplaceability Values</u>

Irreplaceability is a complicated metric. The relative irreplaceability of places is based on such factors as species rarity, species representation, species richness, site suitability, and overall efficiency. The optimal site selection algorithm integrates all of these factors when selecting AUs. Knowing which factor or factors lead to the irreplaceability value of a particular AU is often difficult to determine, but some generalizations do help with interpreting irreplaceability values.

AUs obtain high irreplaceability values for a number of reasons. First, some highly rated AUs are the only places where one or more species or plant communities are known to occur. This is particularly true for species and plant communities associated with rare or imperiled habitat types such as low-elevation, old growth coniferous forests, prairies, oak woodland, and balds. Second, some highly rated AUs have high target richness and/or high target representation. High target richness means that an AU contains a high number of different target elements. High target representation means that an AU contains a large proportion of the ecoregion's total occurrences of a target species or total area of a target habitat type. High target representation is usually more important than high target richness. Third, for SMI, some highly rated AUs present the best opportunities for conservation action. These AUs contain target elements and should also be places where conservation is more likely to succeed as indicated by the suitability index.

AMI and SMI are different ways to prioritize places for conservation. AMI has been the most commonly used index (e.g., Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Stewart et al. 2003), and it assumes that land area is the sole consideration for efficient conservation. SMI incorporates other factors that can effect efficient conservation such as land management and current condition. Not surprisingly, many AUs attained values of 100 for both AMI and SMI. If an AU is the only place where a species is known to occur, then it attains a value of 100. Typically, for AUs with irreplaceability values at or near 100, suitability has little influence on priority; occurrence data drive the prioritization.

AMI and SMI values can be quite different for many individual AUs at the middle and low end of the irreplaceability value range. This is useful information for prioritization. AUs at the low end of irreplaceability typically are unremarkable in terms of biodiversity value. They contribute habitat or target occurrences, but they are interchangeable with other AUs. For these AUs, prioritizing on the basis of suitability rather than biodiversity value makes most sense. That is, if an AU can be distinguished from other AUs because conservation there will be cheaper or more successful, then that AU should be a higher priority for action. In other words, SMI values should be used for their prioritization.

Irreplaceability is just one way of looking at the prioritization of AUs. Irreplaceability, both AMI and SMI, incorporates some notion of efficiency, but efficiency may not be relevant to some questions regarding biodiversity. For such questions, data from EAs can be used to prioritize AUs according to other well known metrics such as maximum rarity, average rarity, richness, maximum representation, average representation, rarity weighted richness, representation weighted richness, and rarity weighted representation. By comparing irreplaceability and these other, more conventional, metrics, managers and decision-makers can make well informed decisions for allocating limited resources to biodiversity conservation.

Conservation Portfolios

A conservation portfolio is another useful way of establishing conservation priorities. A portfolio is the most efficient set of AUs that will meet particular conservation goals. A critical difference between a portfolio and an conservation utility map is conservation goals. A portfolio is based on a particular set of goals; the conservation utility maps are based on a wide range of goals, called representation levels. The size of a portfolio, i.e., the amount of land encompassed by it, is strongly determined by goals – larger goals typically result in a larger portfolio. Another important difference is that the portfolio compensates for data gaps and anomalies by incorporating expert review of modeled data.

One challenging aspect of creating a portfolio is that there is no scientific consensus regarding what percent of habitat to protect when conserving biodiversity, or even on what fraction of biodiversity we can expect to lose with each loss of habitat. Unless assessment teams have specific biological information, they typically set as a goal protection of 30% of historical habitat (e.g., Marshall et al. 2000, Neely et al. 2001, Rumsey et al. 2003, Floberg et al. 2003). This is among the range of goals published in the literature or used by agencies and institutions. It is above average, but not the highest advocated. The sense in selecting this 30% figure is that it is risk averse, but not so high as to be untenable (which 100% might be, for example). Assessment teams believe it is unproductive to fixate on the particular number, and think a better use of scientific thinking is to design monitoring and tracking programs that will tell how well our conservation targets are faring so that conservation approaches can be modified if needed in future iterations of ecoregional assessments.

In addition, current assessments in Washington State and the Pacific Northwest have adopted a new approach, based on differing risk factors, to address this lack of scientific consensus. Currently, we create 3 different scenarios, identified as higher, mid or lower risk and representing protection of roughly 20%, 30% and 40% of historical habitat, respectively. Where we lack historic information, like in many marine regions, we set similar percentages but base them on current distributions. Both of these approaches allow all users to see the effect that varying the goal (and thus the risk level one is willing to accept) has on the selection of priority sites.

Species survival is not deterministic; it is probabilistic. A portfolio cannot ensure the long-term survival of species; it can only provide some level of assurance that species will survive. In other words, every portfolio has some level of risk that species will not survive. A goal setting process should ask the question: “what level of risk is tolerable?” Society – citizens, stakeholders, and elected officials – may ultimately make this choice, but it should be informed by the best available science and expert opinion.

Because of the uncertainty about conservation goals, not all the agencies and organizations that participate in the portfolio-building process endorse a particular portfolio. However, the mid-risk portfolio could be viewed as an acceptable starting place for establishing a conservation vision that helps coordinate conservation actions among a wide variety of partners.

Suitability

Both types of analyses – conservation utility maps and conservation portfolios – use a suitability index to help select AUs. This section explains the suitability index.

The optimization algorithm searches for the lowest cost set of AUs that will meet representation or goal levels for all target elements. "Cost" corresponds to the resources necessary to successfully maintain the targets present in each AU. The actual cost of conservation encompasses many complicated factors: acquisition or easement costs, management costs, restoration costs, and the intrinsic cost of failing to maintain a species at a site. Because determining the monetary cost of conservation for every assessment unit would be an extremely demanding task, we used a surrogate measure for cost called a *suitability index*. A place with a low "cost" for maintaining biodiversity has high suitability. Suitability indicates the relative likelihood of successful conservation at each assessment unit.

Land use suitability is a well-established concept amongst land use planners (see Hopkins 1977, Collins et al. 2001 for reviews), and there are many different methods for constructing an index (Banai-Kashini 1989, Carver 1991, Miller et al. 1998, Stoms et al. 2002). Suitability indices have been used to locate the best places for a wide range of land uses – from farms to nuclear waste sites. Suitability indices are also used to rate the quality of wildlife habitats (USFWS 1981). We used a suitability index in an optimization algorithm that will find the best places for biodiversity conservation.

Our index is based on the analytic hierarchy process (AHP; Saaty 1980, Banai-Kashini 1989). AHP generates an equation that is a linear combination of things thought to affect suitability. Each thing is represented by a separate term in the equation, and each term is multiplied by a weighting factor. AHP is unique because the weighting factors are obtained through a technique known as pair-wise comparisons through which experts are asked for the relative importance of each term in the equation. AHP has been used in other conservation assessments where expert judgments are needed in lieu of empirical data (Store and Kangas 2001, Clevenger et al. 2002, and Bojorquez-Tapia 2003).

The suitability index was based on one simple assumption: existing public land is more suitable for conservation than private land; and on three well-accepted principles of conservation biology (Diamond 1975, Forman 1995):

1) areas with low habitat fragmentation are better than areas with high fragmentation.
2) large areas of habitat are better than small areas;
3) areas close together are better than areas far apart.

The assumption was based on the work of the Gap Analysis Program (Cassidy et al. 1997, Kagan et al. 1999). Both the Oregon and Washington GAP projects rated nearly all public lands as better managed for biodiversity than most private lands. Furthermore, eminent conservation biologists have noted that existing public lands are the logical starting point for habitat protection programs (Dwyer et al. 1995). We reasoned that by focusing conservation on lands already set aside for public purposes the overall cost of conservation would be less than if public and private lands were treated equally. Therefore, existing public lands could form the core of large multiple-use landscapes where biodiversity is a major management goal.

The management of various public land managers was rated according to how it impacted biodiversity. These rating were modified from Cassidy et al. (1997) and Kagan et al. (1999). Road density and the proportion of an AU converted to intensive land uses (i.e., urban and agricultural) were typically used as surrogates for habitat fragmentation. In some ecoregions fire condition class was used as a measure of habitat quality.

The suitability index is a quantitative, spatially explicit expression of the assumptions and principles that form its conceptual basis. Using this index, the optimal site selection algorithm will prefer: (1) AUs in and near public lands over AUs far from public lands, and (2) AUs with less fragmented habitat. The first preference is based on both science and policy. Successful conservation of many targets will depend on large areas and existing public lands are the most practical places upon which to build large areas. The science is well founded, but the policy is debatable. That is, other organizations or stakeholders may contend that biodiversity conservation on private lands is just as feasible as conservation on public lands. Certainly, there are situations where this contention is true. However, we believe that public lands are the most sensible starting point for biodiversity conservation. The second preference accounts for only current habitat conditions. It does not consider restoration potential of an AU. Finally, we readily admit that the index cannot account for the many complex local situations that influence successful conservation, but we believe that some reasonable generalities are still quite useful for establishing priorities and assessing conservation opportunities across an entire ecoregion.

Uses for the Assessments

The ecoregional assessment is prepared to support effective long-term conservation of the ecoregion's biodiversity. It provides information for decisions and activities that occur at an ecoregional scale: establishing regional priorities for conservation action, coordinating programs for species or habitats that cross political boundaries, and evaluating the regional importance of biodiversity for any particular place. The conservation data sets, the prioritized AUs, and the conservation portfolio are each suitable for particular applications. Some of the ancillary products developed during the assessment process also can be used for conservation applications. Every effort is taken to insure that these products are catalogued and maintained for later use.

Datasets compiled for the assessment have broad utility to everyone who wants to know about specific aspects of biodiversity in the ecoregion. In addition, they are accessible for subsequent analysis to ask different conservation-related questions. The datasets are organized in GIS data layers and in easy to use formats such as spreadsheets that enhance their utility. They also have undergone broad reviews to make them more consistent with one another and to correct data errors.

The Nature Conservancy and Nature Conservancy of Canada have committed to using the "mid-risk" conservation portfolio to drive their priorities for site-based work and for identifying priority investments in "multi-site" strategies that conserve portfolio sites through policy, education, research, and other approaches. Likewise, local land trusts and public agencies can use the portfolio to gain an ecoregional perspective on local biological resource values and to quickly obtain detailed information on the biological value and conservation suitability of local portfolio sites. "On-the-ground" conservation activities will require more site-specific analysis and planning. A useful framework for site-scale conservation planning developed by The Nature Conservancy is "The Enhanced 5-S Project Management Process" and is available at http://www.conserveonline.org/2004/03/a/Enhanced_5S_Resources.

The conservation utility maps are most useful for prioritizing habitat protection and informing land use policies. Government agencies and NGOs that fund conservation projects or provide financial incentives for habitat protection could use the conservation utility maps as they consider priorities. Conservation projects occurring within high priority AUs should receive special consideration, and projects that can have siting flexibility should be located within high priority AUs whenever possible. The Washington Department of Fish and Wildlife will use the conservation utility maps to guide their development of a state Comprehensive Wildlife Conservation Strategy (CWCS) in coordination with other governmental and non-governmental organizations.

The following are some examples of how an ecoregional assessment could be used by local planners:

Urban Growth Area (UGA) expansion. A county must expand its UGA to accommodate future growth and has narrowed its options to two areas, each of which produce similar economic results. EAs provide a regional context for choosing the option most beneficial to regional biodiversity conservation.
Land Use Zoning. A county is trying to determine where to maintain natural resource zones in order to retain agriculture and forestry industries. EAs can tell them where continuation of forestry or agriculture will provide the most benefit to regional biodiversity.
Land Acquisition. A timber company is selling a block of land for residential development but the land was identified by an EA as important for biodiversity conservation. The county government could use information in the EA to write a convincing grant proposal for funding land acquisition.
Tax Incentives. Numerous landowners want property tax relief because they maintain wildlife habitats on their property. The county code has a provision regarding property tax relief, but it cannot afford to grant relief to all landowners. The county government could use EAs to help rate the biodiversity conservation value of land and grant tax relief based on this rating.

<u>Caveats for Using the Assessments</u>

- The assessment is conducted at an ecoregional scale. It provides information for decisions and activities that occur at an ecoregional scale, such as establishing regional priorities for conservation action, coordinating programs for species or habitats that cross state, county, or other political boundaries, judging the regional importance of any particular site in the ecoregion, and measuring progress in protecting the full biodiversity of the ecoregion.

- The assessment is designed to inform ongoing ecoregional conservation efforts. The assessments identify and prioritize areas that contribute the most towards conservation of existing biodiversity. At the same time, it is important to recognize what this assessment is not intended to provide, and identify several important limitations on this work. In addition to those already described, users should be mindful of the following:

- The assessment has no regulatory authority. It is simply a guide to help inform conservation decision-making across the ecoregion. The portfolio is intrinsically flexible. The sites described are approximate, and often large and complex enough to require a wide range of resource management approaches. Ultimately, the exact siting and management of any potential conservation area will be based on the policies, values, and decisions of the affected landowners, governments, and other community members.

- The assessment should be treated as a first approximation. It is more complete for some species or ecological systems than for others, reflecting the variable state of knowledge of the natural world. Generally speaking, terrestrial biodiversity is more adequately represented than that of freshwater and marine systems. The hexagons or watersheds used as assessment units should be used only as a rough starting point for the detailed site-level planning necessary to support local land-use decisions.

- Many high priority conservation areas described in EAs may accommodate multiple uses and are not intended to become parks or nature reserves set aside from economic activity. While some areas may warrant such protection, others will accommodate various activities as determined by landowners, local communities and appropriate agencies.

- The assessment is one of many science-based tools that will assist conservation efforts by government agencies, non-governmental organizations, and individuals. It cannot replace, for example, recovery plans for endangered species, or the detailed planning required in designing a local conservation project. It does not address all of the special considerations of salmon or game management, and so, for example, cannot be used to ensure adequate populations for harvest.

- The assessment does not describe all the important natural places in the ecoregion. Many places outside of the ecoregional conservation portfolio are important for natural beauty, environmental education, ecological services, and conservation of local biodiversity. These include many small wetlands, small patches of natural habitat, and other important features of our natural landscape. They should be managed to support their own special values.

- Many high priority areas will contain lower-quality habitats in need of restoration and this restoration could greatly enhance the viability of the conservation targets they contain. However, the assessment's results should not be used as the sole guide for siting restoration projects. A reliable assessment of restoration priorities would require a different approach than the one we have presented. AUs and portfolio sites were selected for the habitats and species that exist there now, not for their restoration potential.

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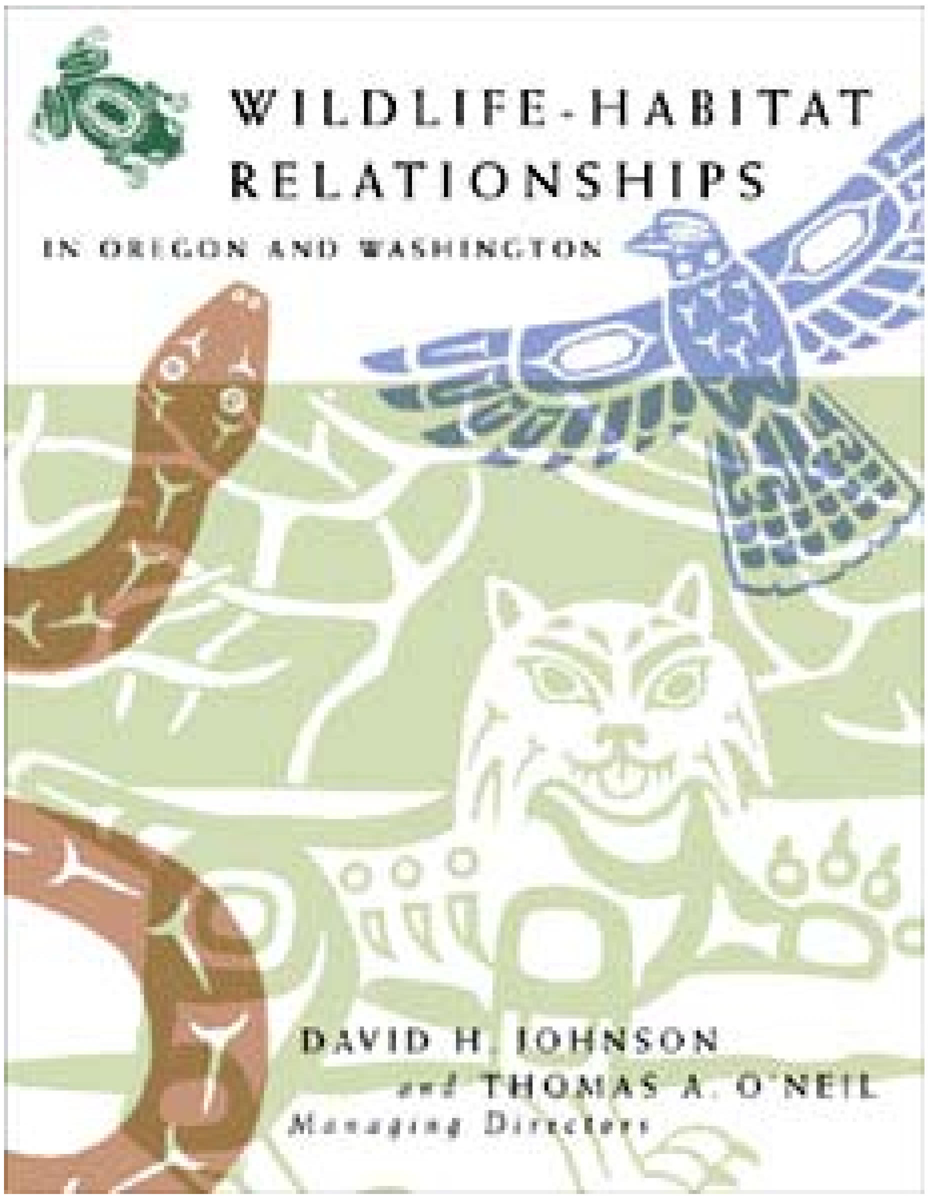
APPENDIX 13: WILDLIFE-HABITAT RELATIONSHIPS IN OREGON AND WASHINGTON

A copy of the book will accompany each copy of the Washington Comprehensive Wildlife Conservation Strategy. This page is merely a place marker.



APPENDIX 14: HABITAT CLASSIFICATION CROSSWALK

* From Ecological Systems of the United States (NatureServe, 2003)

Courtesy of Rex Crawford, Washington National Heritage Program

Ecological System-based Land Cover Types*	WHROW Habitat Classifications	WDFW Priority Habitats 1	WDFW Priority Habitats 2
Agriculture	Agriculture, Pasture and Mixed Environs		
Cultivated Crops	Agriculture, Pasture and Mixed Environs		
Invasive Annual Grassland	Agriculture, Pasture and Mixed Environs		
Invasive Forbland	Agriculture, Pasture and Mixed Environs		
Invasive Perennial Grassland	Agriculture, Pasture and Mixed Environs		
Pasture/Hay	Agriculture, Pasture and Mixed Environs		
CES204.099 North Pacific Alpine and Subalpine Dry Grassland	Alpine Grassland and Shrublands		
CES204.862 North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow	Alpine Grassland and Shrublands		
CES306.806 Northern Rocky Mountain Subalpine Dry Grassland	Alpine Grassland and Shrublands		
CES306.810 Rocky Mountain Alpine Dwarf-Shrubland	Alpine Grassland and Shrublands		
CES306.811 Rocky Mountain Alpine Fell-Field	Alpine Grassland and Shrublands		
CES306.816 Rocky Mountain Dry Tundra	Alpine Grassland and Shrublands		
CES306.829 Rocky Mountain Subalpine Mesic Meadow	Alpine Grassland and Shrublands		
CES200.091 Temperate Pacific Tidal Salt and Brackish Marsh	Bays and Estuaries		
CES200.882 North Pacific Maritime Eelgrass Bed	Bays and Estuaries	Vegetated Marine/Estuarine	
CES204.875 North Pacific Intertidal Freshwater Wetland	Bays and Estuaries	Estuary	
CES204.879 Temperate Pacific Intertidal Mudflat	Bays and Estuaries		
CES200.881 North Pacific Maritime Coastal Sand Dune	Coastal Dunes and Beaches		
CES204.088 North Pacific Hypermaritime Shrub and Herbaceous Headland	Coastal Headlands and Islets		
CES204.094 North Pacific Coastal Cliff and Bluff	Coastal Headlands and Islets	Cliffs	Talus
CES304.780 Inter-Mountain Basins Greasewood Flat	Desert Playa and Salt Scrub Shrublands		
CES304.784 Inter-Mountain Basins Mixed Salt Desert Scrub	Desert Playa and Salt Scrub Shrublands		
CES304.786 Inter-Mountain Basins Playa	Desert Playa and Salt Scrub Shrublands		
CES304.080 Columbia Plateau Low Sagebrush Steppe	Dwarf Shrub-steppe		
CES304.770 Columbia Plateau Scabland Shrubland	Dwarf Shrub-steppe		
CES306.994 Northern Rocky Mountain Lower Montane Mesic Deciduous Shrubland	Eastside (Interior) Canyon Shrublands		
CES304.083 Columbia Plateau Steppe and Grassland	Eastside (Interior) Grasslands	Prairies and Steppe	
CES304.787 Inter-Mountain Basins Semi-Desert Grassland	Eastside (Interior) Grasslands	Prairies and Steppe	

Ecological System-based Land Cover Types*	**WHROW Habitat Classifications**	**WDFW Priority Habitats 1**	**WDFW Priority Habitats 2**
CES304.792 Columbia Basin Palouse Prairie	Eastside (Interior) Grasslands	Prairies and Steppe	
CES304.993 Columbia Basin Foothill and Canyon Dry Grassland	Eastside (Interior) Grasslands	Prairies and Steppe	
CES306.040 Northern Rocky Mountain Plateau and Valley Grassland	Eastside (Interior) Grasslands	Prairies and Steppe	
CES306.836 Northern Rocky Mountain Montane Grassland	Eastside (Interior) Grasslands	Prairies and Steppe	
CES204.086 East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	Eastside (Interior) Mixed Conifer Forest	Old-growth/mature forests	
CES306.802 Northern Rocky Mountain Western Hemlock-Western Red-cedar Forest	Eastside (Interior) Mixed Conifer Forest	Old-growth/mature forests	
CES306.805 Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Eastside (Interior) Mixed Conifer Forest	Old-growth/mature forests	
CES306.837 Northern Rocky Mountain Western Larch Woodland	Eastside (Interior) Mixed Conifer Forest	Old-growth/mature forests	
CES360.xxx Northern Interior Spruce-Fir Woodland and Forest	Eastside (Interior) Mixed Conifer Forest	Old-growth/mature forests	
CES304.768 Columbia Basin Foothill Riparian Woodland and Shrubland	Eastside (Interior) Riparian-Wetlands	Riparian	
CES306.804 Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	Eastside (Interior) Riparian-Wetlands	Riparian	
CES306.832 Rocky Mountain Subalpine-Montane Riparian Shrubland	Eastside (Interior) Riparian-Wetlands	Riparian	
CES306.833 Rocky Mountain Subalpine-Montane Riparian Woodland	Eastside (Interior) Riparian-Wetlands	Riparian	
Invasive Riparian Woodland and Shrubland	Eastside (Interior) Riparian-Wetlands		
Artificial Wetland	Herbaceous Wetlands		
CES200.876 Temperate Pacific Freshwater Aquatic Bed	Herbaceous Wetlands	Instream	
CES200.877 Temperate Pacific Freshwater Emergent Marsh	Herbaceous Wetlands	Freshwater wetlands & Freshwater deepwater	
CES200.878 Temperate Pacific Freshwater Mudflat	Herbaceous Wetlands	Instream	
CES200.998 Temperate Pacific Subalpine-Montane Wet Meadow	Herbaceous Wetlands		
CES204.874 Willamette Valley Wet Prairie	Herbaceous Wetlands		
CES300.729 North American Arid West Emergent Marsh	Herbaceous Wetlands		
CES304.058 Northern Columbia Plateau Basalt Pothole Ponds [Provisional]	Herbaceous Wetlands	Freshwater wetlands & Freshwater deepwater	
CES306.812 Rocky Mountain Alpine-Montane Wet Meadow	Herbaceous Wetlands	Riparian	
CES306.831 Rocky Mountain Subalpine-Montane Fen	Herbaceous Wetlands	Riparian	
Open Water this is in Aquatic and Marine Ecological Systems	Inland Marine Deeper Water (Puget Sound)		
CES306.820 Rocky Mountain Lodgepole Pine Forest	Lodgepole Pine Forest and Woodlands		
Unconsolidated Shore - this is in Aquatic and Marine Ecological Systems	Marine Nearshore	Marine/Esturine shorelines	
CES204.063 North Pacific Bog and Fen	Montane Coniferous Wetlands		
CES204.090 North Pacific Hardwood-Conifer Swamp	Montane Coniferous Wetlands		
CES306.803 Northern Rocky Mountain Conifer Swamp	Montane Coniferous Wetlands		

Ecological System-based Land Cover Types*	WHROW Habitat Classifications	WDFW Priority Habitats 1	WDFW Priority Habitats 2
CES204.087 North Pacific Montane Shrubland	Montane Mixed Conifer Forest		
CES204.097 North Pacific Mesic Western Hemlock-Silver Fir Forest	Montane Mixed Conifer Forest	Old-growth/mature forests	
CES204.098 North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest	Montane Mixed Conifer Forest	Old-growth/mature forests	
CES204.838 North Pacific Mountain Hemlock Forest	Montane Mixed Conifer Forest	Old-growth/mature forests	
CES204.883 North Pacific Wooded Lava Flow	Montane Mixed Conifer Forest		
CES306.828 Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	Montane Mixed Conifer Forest	Old-growth/mature forests	
CES306.830 Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	Montane Mixed Conifer Forest	Old-growth/mature forests	
CES204.092 North Pacific Volcanic Rock and Cinder Land	none	Cliffs	Talus
CES204.093 North Pacific Montane Massive Bedrock, Cliff and Talus	none	Cliffs	Talus
CES204.095 North Pacific Serpentine Barren	none		Talus
CES204.853 North Pacific Alpine and Subalpine Bedrock and Scree	none	Cliffs	Talus
CES300.728 North American Alpine Ice Field	none		
CES304.779 Inter-Mountain Basins Cliff and Canyon	none	Cliffs	Talus
CES306.809 Rocky Mountain Alpine Bedrock and Scree	none	Cliffs	Talus
CES306.815 Rocky Mountain Cliff, Canyon and Massive Bedrock	none	Cliffs	Talus
Sparsely Vegetated	none		
CES204.859 North Pacific Hardpan Vernal Pool	not explictly in any		
CES204.996 Modoc Basalt Flow Vernal Pool	not explictly in any		
CES304.057 Northern Columbia Plateau Vernal Pool	not explictly in any		
CES306.801 Northern Rocky Mountain Avalanche Chute Shrubland	not explictly in any		
CES204.085 East Cascades Oak-Pine Forest and Woodland	Ponderosa Pine Forest and Woodlands (includes EastsideOak Woodlands)	Oregon white Oak woodlands	
CES306.030 Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Ponderosa Pine Forest and Woodlands (includes EastsideOak Woodlands)	Old-growth/mature forests	
CES304.775 Inter-Mountain Basins Active and Stabilized Dune	Shrub-steppe		
CES304.777 Inter-Mountain Basins Big Sagebrush Shrubland	Shrub-steppe	Shrub-steppe	
CES304.778 Inter-Mountain Basins Big Sagebrush Steppe	Shrub-steppe	Shrub-steppe	
CES304.785 Inter-Mountain Basins Montane Sagebrush Steppe	Shrub-steppe	Shrub-steppe	
CES304.788 Inter-Mountain Basins Semi-Desert Shrub-Steppe	Shrub-steppe	Shrub-steppe	
CES204.837 North Pacific Maritime Mesic Subalpine Parkland	Subalpine Parkland		
CES306.807 Northern Rocky Mountain Subalpine Dry Parkland	Subalpine Parkland		
CES306.808 Northern Rocky Mountain Subalpine Larch Woodland	Subalpine Parkland		

Ecological System-based Land Cover Types*	**WHROW Habitat Classifications**	**WDFW Priority Habitats 1**	**WDFW Priority Habitats 2**
CES306.813 Rocky Mountain Aspen Forest and Woodland	Upland Aspen Forest	Aspen Stands	
Developed	Urban and Mixed Environs		
Developed, High Intensity	Urban and Mixed Environs		
Developed, Low Intensity	Urban and Mixed Environs		
Developed, Medium Intensity -	Urban and Mixed Environs		
Developed, Open Space (Parks, Golf Courses, Open Space)	Urban and Mixed Environs		
CES304.082 Columbia Plateau Western Juniper Woodland and Savanna	Western Juniper and Mountain Mahogany Woodlands	Juniper Savannah	
CES204.089 North Pacific Herbaceous Bald and Bluff	Westside Grasslands	Prairies and Steppe	
CES204.858 Willamette Valley Upland Prairie and Savanna	Westside Grasslands	Prairies and Steppe	
CES204.846 North Pacific Broadleaf Landslide Forest and Shrubland	Westside Lowland Conifer-Hardwood (Mature) Forest		
CES204.001 North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	Westside Lowland Conifer-Hardwood Forest	Old-growth/mature forests	
CES204.002 North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest	Westside Lowland Conifer-Hardwood Forest	Old-growth/mature forests	
CES204.841 North Pacific Hypermaritime Sitka Spruce Forest	Westside Lowland Conifer-Hardwood Forest	Old-growth/mature forests	
CES204.842 North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest	Westside Lowland Conifer-Hardwood Forest	Old-growth/mature forests	
CES204.845 North Pacific Dry Douglas-fir Forest and Woodland	Westside Oak and Dry Douglas-fir Forest and Woodlands	Old-growth/mature forests	
CES204.852 North Pacific Oak Woodland	Westside Oak and Dry Douglas-fir Forest and Woodlands	Oregon white Oak woodlands	
CES204.854 North Pacific Avalanche Chute Shrubland	Westside Riparian-Wetlands		
CES204.865 North Pacific Shrub Swamp	Westside Riparian-Wetlands	Riparian	
CES204.866 North Pacific Montane Riparian Woodland and Shrubland	Westside Riparian-Wetlands	Riparian	
CES204.869 North Pacific Lowland Riparian Forest and Shrubland	Westside Riparian-Wetlands	Riparian	
Subterranean System		Caves	