

Appendix D: Information on Focal Habitats from IBIS

No. 5. Interior Mixed Conifer Forest

Author: Rex C. Crawford

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

Douglas-fir-ponderosa pine forests occur along the eastern slope of the Oregon and Washington Cascades, the Blue Mountains, and the Okanogan Highlands of Washington. Grand fir-Douglas-fir forests and western larch forests are widely distributed throughout the Blue Mountains and, 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 (305-2,137 m), mostly between 3,000 and 5,500 ft (914-1,676 m). Parent materials for soil development vary. This habitat receives some of the greatest amounts of precipitation in the inland northwest, 30-80 inches (76-203 cm)/year. Elevation of this habitat varies geographically, with generally higher elevations to the east.

Landscape Setting: This habitat makes up most of the continuous montane forests of the inland Pacific Northwest. It is located between the subalpine portions of the Montane Mixed Conifer Forest habitat in eastern Oregon and Washington and lower tree line Ponderosa Pine and Forest and Woodlands.

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

Composition: This habitat contains a wide array of tree species (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 Oregongrape (*Mahonia nervosa* in the east Cascades and *M. repens* elsewhere), tobacco brush (*Ceanothus velutinus*), an increaser with fire, Oregon boxwood (*Paxistima myrsinites*) generally at mid- to lower elevations, beargrass (*Xerophyllum tenax*), pinemat manzanita (*Arctostaphylos nevadensis*) and kinnikinnick (*A. uva-ursi*).

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

Graminoids are common in this forest habitat. Columbia brome (*Bromus vulgaris*), oniongrass (*Melica bulbosa*), northwestern sedge (*Carex concinnoides*) and western fescue (*Festuca occidentalis*) are found mostly in mesic forests with shrubs or mixed with forb species. Bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue

(*Festuca idahoensis*), and junegrass (*Koeleria macrantha*) are found in drier more open forests or woodlands. Pinegrass (*Calamagrostis rubescens*) and Geyer's sedge (*C. geyeri*) can form a dense layer under Douglas-fir or grand fir trees.

Other Classifications and Key References: This habitat includes the moist portions of the *Pseudotsuga menziesii*, the *Abies grandis*, and the *Tsuga heterophylla* zones of eastern Oregon and Washington⁸⁸. This habitat is called Douglas-fir (No. 12), Cedar-Hemlock-Pine (No. 13), and Grand fir-Douglas-fir (No. 14) forests in Kuchler¹³⁶. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are the eastside Douglas-fir dominant-mixed conifer forest, ponderosa pine dominant mixed conifer forest, and the northeast Oregon mixed conifer forest. Quigley and Arbelbide¹⁸¹ referred to this habitat as Grand fir/White fir, the Interior Douglas-fir, Western larch, Western redcedar/Western hemlock, and Western white pine cover types and the Moist Forest potential vegetation group. Other references detail forest associations for this habitat^{45, 59, 117, 118, 123, 122, 144, 148, 208, 209, 212, 221, 228}.

Natural Disturbance Regime: Fires were probably of moderate frequency (30-100 years) in presettlement times. Inland Pacific Northwest Douglas-fir and western larch forests have a mean fire interval of 52 years²². 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 red cedar 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 regime²²⁸. Generally, early seral forests of shade-intolerant trees (western larch, western white pine, ponderosa pine, Douglas-fir) or tolerant trees (grand fir, western redcedar, western hemlock) develop some 50 years following disturbance. This stage is preceded by forb- or shrub- dominated communities. These early stage mosaics are maintained on ridges and drier topographic positions by frequent fires. Early seral forest develops into mid-seral habitat of large trees during the next 50-100 years. Stand replacing fires recycle this stage back to early seral stages over most of the landscape. Without high-severity fires, a late-seral condition develops either single-layer or multilayer structure during the next 100-200 years. These structures are typical of cool bottomlands that usually only experience low-intensity fires.

Effects of Management and Anthropogenic Impacts: This habitat has been most affected by timber harvesting and fire suppression. Timber harvesting has focused on large shade-intolerant species in mid- and late-seral forests, leaving shade-tolerant species. Fire suppression enforces those logging priorities by promoting less fire-resistant, shade-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% more abundant than in historical, native systems

¹⁸¹. Late-seral forests of shade-intolerant species are now essentially absent. Early-seral forest abundance is similar to that found historically but lacks snags and other legacy features.

Status and Trends: Quigley and Arbelbide ¹⁸¹ concluded that the Interior Douglas-fir, Grand fir, and Western redcedar/Western hemlock cover types are more abundant now than before 1900, whereas the Western larch and Western white pine types are significantly less abundant. Twenty percent of Pacific Northwest Douglas-fir, grand fir, western redcedar, western hemlock, and western white pine associations listed in the National Vegetation Classification are considered imperiled or critically imperiled ¹⁰. Roads, timber harvest, periodic grazing, and altered fire regimes have compromised these forests. Even though this habitat is more extensive than pre-1900, natural processes and functions have been modified enough to alter its natural status as functional habitat for many species.

No. 7. Ponderosa Pine Forest and Woodlands

Authors: Rex C. Crawford and Jimmy Kagan

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

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

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

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

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

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

Undergrowth is generally dominated by herbaceous species, especially graminoids. Within a forest matrix, these woodland habitats have an open to closed sodgrass undergrowth dominated by pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*C. rossii*), long-stolon sedge (*C. inops*), or blue wildrye (*Elymus*

glaucus). Drier savanna and woodland undergrowth typically contains bunchgrass steppe species, such as Idaho fescue (*Festuca idahoensis*), rough fescue (*F. campestris*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass (*Oryzopsis hymenoides*), or needlegrasses (*Stipa comata*, *S. occidentalis*). Common exotic grasses that may appear in abundance are cheatgrass (*Bromus tectorum*), and bulbous bluegrass (*Poa bulbosa*). Forbs are common associates in this habitat and are too numerous to be listed.

Other Classifications and Key References: This habitat is referred to as Merriam's Arid Transition Zone, Western ponderosa forest (*Pinus*), and Oregon Oak wood (*Quercus*) in Kuchler¹³⁶, and as Pacific ponderosa pine-Douglas-fir and Pacific ponderosa pine, and Oregon white oak by the Society of American Foresters. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are ponderosa pine forest and woodland, ponderosa pine-white oak forest and woodland, and ponderosa pine-lodgepole pine on pumice. Other references describe elements of this habitat^{45, 62, 88, 117, 118, 121, 122, 123, 144, 148, 209, 212, 221, 222}.

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

Succession and Stand Dynamics.: This habitat is climax on sites near the dry limits of each of the dominant conifer species and is more seral as the environment becomes more favorable for tree growth. Open seral stands are gradually replaced by more closed shade-tolerant climax stands. Oregon white oak can reproduce under its own shade but is intolerant of overtopping by conifers. Oregon white oak woodlands are considered fire climax and are seral to conifers. In drier conditions, unfavorable to conifers, oak is climax. Oregon white oak sprouts from the trunk and root crown following cutting or burning and form clonal patches of trees.

Effects of Management and Anthropogenic Impacts: 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, multilayered canopy. For example, this habitat includes previously natural fire-maintained stands in which grand fir can eventually become the canopy dominant. Fire suppression has led to a buildup of fuels that in turn increase the likelihood of stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover and tends to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support cloning of oak and invasion by conifers. Large late-seral ponderosa pine, Douglas-fir, and Oregon white oak are harvested in much of this habitat. Under most management regimes, typical tree size decreases and tree density increases in this habitat. Ponderosa pine-Oregon white oak habitat is now denser than in the past and

may contain more shrubs than in presettlement habitats. In some areas, new woodlands have been created by patchy tree establishment at the forest-steppe boundary.

Status and Trends: Quigley and Arbelbide¹⁸¹ concluded that the Interior Ponderosa Pine cover type is significantly less in extent than pre-1900 and that the Oregon White Oak cover type is greater in extent than pre-1900. They included much of this habitat in their Dry Forest potential vegetation group¹⁸¹, which they concluded has departed from natural succession and disturbance conditions. The greatest structural change in this habitat is the reduced extent of the late-seral, single-layer condition. This habitat is generally degraded because of increased exotic plants and decreased native bunchgrasses. One third of Pacific Northwest Oregon white oak, ponderosa pine, and dry Douglas-fir or grand fir community types listed in the National Vegetation Classification are considered imperiled or critically imperiled¹⁰.

No. 8. Upland Aspen Forest

Authors: 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 and Oregon. Upland Aspen habitat is found in isolated mountain ranges of Southeastern Oregon, e.g. Steens Mountains, and in the northeastern Cascades of Washington. Aspen stands are much more common in the Rocky Mountain states.

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

Landscape Setting: Aspen forms a "subalpine belt" above the Western Juniper and Mountain Mahogany Woodland habitat and below Montane Shrub-steppe Habitat 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 <48 ft (15 m) tall dominate this woodland or forest habitat. The tree layer grows over a forb-, grass-, or low-shrub-dominated undergrowth. Relatively simple 2-tiered stands characterize the typical vertical structure of woody plants in this habitat. This habitat is composed of 1 to many clones of trees with larger trees toward the center of each clone. Conifers invade and create mixed evergreen-deciduous woodland or forest habitats.

Composition: Quaking aspen (*Populus tremuloides*) is the characteristic and dominant tree in this habitat. It is the sole dominant in many stands although scattered ponderosa pine (*Pinus ponderosa*) or Douglas-fir (*Pseudotsuga menziesii*) may be present.

Snowberry (*Symphoricarpos oreophilus* and less frequently, *S. albus*) is the most common dominant shrub. Tall shrubs, Scouler's willow (*Salix scouleriana*) and serviceberry (*Amelanchier alnifolia*) may be abundant. On mountain or canyon slopes, antelope bitterbrush (*Purshia tridentata*), mountain big sagebrush (*Artemisia tridentata ssp. vaseyana*), low sagebrush (*A. arbuscula*), and curl-leaf mountain mahogany (*Cercocarpus ledifolius*) often occur in and adjacent to this woodland habitat.

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

Other Classifications and Key References: This habitat is called "Aspen" by the Society of American Foresters and "Aspen woodland" by the Society of Range Management. The Oregon Gap II Project ¹²⁶ and Oregon Vegetation Landscape-Level Cover Type 127 that would represent this type is aspen groves. Other references describe this habitat ^{2, 88, 119, 161, 222}.

Natural Disturbance Regime: Fire plays an important role in maintenance of this habitat. Quaking aspen will colonize sites after fire or other stand disturbances through root sprouting. Research on fire scars in aspen stands in central Utah ¹¹⁹ indicated that most fires occurred before 1885, and concluded that the natural fire return interval was 7-10 years. Ungulate browsing plays a variable role in aspen habitat; ungulates may slow tree regeneration by consuming aspen sprouts on some sites, and may have little influence in other stands.

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

Effects of Management and Anthropogenic Impacts: Domestic sheep reportedly consume 4 times more aspen sprouts than do cattle. Heavy livestock browsing can adversely impact aspen growth and regeneration. With fire suppression and alteration of fine fuels, fire rejuvenation of aspen habitat has been greatly reduced since about 1900. Conifers now dominate many seral aspen stands and extensive stands of young aspen are uncommon.

Status and Trends: With fire suppression and change in fire regimes, the Aspen Forest habitat is less common than before 1900. None of the 5 Pacific Northwest upland

quaking aspen community types in the National Vegetation Classification is considered imperiled¹⁰.

No. 13. Western Juniper and Mountain Mahogany Woodlands

Authors: Rex. C. Crawford and Jimmy Kagan

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

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

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

Landscape Setting: This habitat reflects a transition between Ponderosa Pine Forest and Woodlands and Shrub-steppe, Eastside Grasslands, and rarely Desert Playa and Salt Desert Scrub habitats. Western juniper generally occurs on higher topography, whereas the shrub communities are more common in depressions or steep slopes with bunchgrass undergrowth. In the Great Basin, mountain mahogany may form a distinct belt on mountain slopes and ridgetops above pinyon-juniper woodland. Mountain-mahogany can occur in isolated, pure patches that are often very dense. The primary land use is livestock grazing.

Structure: This habitat is made up of savannas, woodlands, or open forests with 10-60% canopy cover. The tallest layer is composed of short (6.6-40 ft [2-12 m] tall) evergreen trees. Dominant plants may assume a tall-shrub growth form on some sites. The short trees appear in a mosaic pattern with areas of low or medium-tall (usually evergreen)

shrubs alternating with areas of tree layers and widely spaced low or medium-tall shrubs. The herbaceous layer is usually composed of short or medium tall bunchgrass or, rarely, a rhizomatous grass-forb undergrowth. These vegetated areas can be interspersed with rimrock or scree. A well-developed cryptogam layer often covers the ground, although bare rock can make up much of the ground cover.

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

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

Part of this woodland habitat lacks a shrub layer. Various native bunchgrasses dominate different aspects of this habitat. Sandberg bluegrass (*Poa sandbergii*), a short bunchgrass, is the dominant and most common grass throughout many juniper sites. Medium-tall bunchgrasses such as Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needlegrasses (*Stipa occidentalis*, *S. thurberiana*, *S. lemmonii*), bottlebrush squirreltail (*Elymus elymoides*) can dominate undergrowth. Threadleaf sedge (*Carex filifolia*) and basin wildrye (*Leymus cinereus*) are found in lowlands and Geyer's and Ross' sedge (*Carex geyeri*, *C. rossii*), pinegrass (*Calamagrostis rubescens*), and blue wildrye (*E. glaucus*) appear on mountain foothills. Sandy sites typically have needle-and-thread (*Stipa comata*) and Indian ricegrass (*Oryzopsis hymenoides*). Cheatgrass (*Bromus tectorum*) or bulbous bluegrass (*Poa bulbosa*) often dominate overgrazed or disturbed sites. In good condition this habitat may have mosses growing under the trees.

Other Classifications and Key References: This habitat is also called Juniper Steppe Woodland¹³⁶. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are ponderosa pine-western juniper woodland, western juniper woodland, and mountain mahogany shrubland. Other references describe this habitat^{64, 79, 122, 207}.

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

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

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

Status and Trends: This habitat is dominated by fire-sensitive species, and therefore, the range of western juniper and mountain mahogany has expanded because of an interaction of livestock grazing and fire suppression. Quigley and Arbelbide¹⁸¹ concluded that in the Inland Pacific Northwest, Juniper/Sagebrush, Juniper Woodlands, and Mountain Mahogany cover types now are significantly greater in extent than before 1900. Although it covers more area, this habitat is generally in degraded condition because of increased exotic plants and decreased native bunchgrasses. One third of Pacific Northwest juniper and mountain mahogany community types listed in the National Vegetation Classification are considered imperiled or critically imperiled¹⁰.

No. 15. Interior Grasslands

Authors: Rex. C. Crawford and Jimmy Kagan

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

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

Physical Setting: This habitat develops in hot, dry climates in the Pacific Northwest. Annual precipitation totals 8-20 inches (20-51 cm); only 10% falls in the hottest months, July through September. Snow accumulation is low (1-6 inches [3-15 cm]) and occurs only in January and February in eastern portions of its range and November through March in the west. More snow accumulates in grasslands within the forest matrix. Soils are variable: (1) highly productive loess soils up to 51 inches (130 cm) deep, (2) rocky flats, (3) steep slopes, and (4) sandy, gravel or cobble soils. An important variant of this habitat occurs on sandy, gravelly, or silty river terraces or seasonally exposed river gravel or Spokane flood deposits. The grassland habitat is typically upland vegetation but it may also include riparian bottomlands dominated by non-native grasses. This habitat is found from 500 to 6,000 ft (152-1,830 m) in elevation.

Landscape Setting: Eastside grassland habitats appear well below and in a matrix with lower treeline Ponderosa Pine Forests and Woodlands or Western Juniper and Mountain Mahogany Woodlands. It can also be part of the lower elevation forest matrix. Most grassland habitat occurs in 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 (650 m) deep below the plateau. The plateau above is composed of gentle slopes with deep silty loess soils in an expansive rolling dune-like landscape. Grasslands may occur in a patchwork with shallow soil scablands or within biscuit scablands or mounded topography. Naturally occurring grasslands are beyond the range of bitterbrush and sagebrush species. This habitat exists

today in the shrub-steppe landscape where grasslands are created by brush removal, chaining or spraying, or by fire. Agricultural uses and introduced perennial plants on abandoned or planted fields are common throughout the current distribution of eastside grassland habitats.

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

Composition: Bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*) are the characteristic native bunchgrasses of this habitat and either or both can be dominant. Idaho fescue is common in more moist areas and bluebunch wheatgrass more abundant in drier areas. Rough fescue (*F. campestris*) is a characteristic dominant on moist sites in northeastern Washington. Sand dropseed (*Sporobolus cryptandrus*) or three-awn (*Aristida 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 tumbled mustard (*Sisymbrium altissimum*), and Russian thistle (*Salsola kali*).

Smooth sumac (*Rhus glabra*) is a deciduous shrub locally found in combination with these grassland species. Rabbitbrushes (*Chrysothamnus nauseosus*, *C. viscidiflorus*) can occur in this habitat in small amounts, especially where grazed by livestock. In moist Palouse regions, common snowberry (*Symphoricarpos albus*) or Nootka rose (*Rosa nutkana*) may be present, but is shorter than the bunchgrasses. Dry sites contain low succulent pricklypear (*Opuntia polyacantha*). Big sagebrush (*Artemisia tridentata*) is occasional and may be increasing in grasslands on former shrub-steppe sites. Black

hawthorn (*Crataegus douglasii*) and other tall shrubs can form dense thickets near Idaho fescue grasslands. Rarely, ponderosa pine (*Pinus ponderosa*) or western juniper (*Juniperus occidentalis*) can occur as isolated trees.

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

Natural Disturbance Regime: The fire-return interval for sagebrush and bunchgrass is estimated at 25 years²². 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 cropland¹⁵⁹. 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 grasslands²⁰⁷. Evidently, these drier native bunchgrass grasslands changed irreversibly to persistent annual grass and forblands. Some annual grassland, native bunchgrass, and shrub-steppe habitats were converted to intermediate wheatgrass, or more commonly, crested wheatgrass (*Agropyron cristatum*)-dominated areas. Apparently, these form persistent grasslands and are included as modified grasslands in the Agriculture habitat. With intense livestock use, some riparian bottomlands become dominated by non-native grasses. Many native dropseed grasslands have been submerged by dam reservoirs.

Status and Trends: Most of the Palouse prairie of southeastern Washington and adjacent Idaho and Oregon has been converted to agriculture. Remnants still occur in the foothills of the Blue Mountains and in isolated, moist Columbia Basin sites. The Palouse is one of

the most endangered ecosystems in the U.S. ¹⁶⁶ with only 1% of the original habitat remaining; it is highly fragmented with most sites <10 acres. All these areas are subject to weed invasions and drift of aerial biocides. Since 1900, 94% of the Palouse grasslands have been converted to crop, hay, or pasture lands. Quigley and Arbelbide ¹⁸¹ concluded that 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 ¹⁰.

No. 16. Shrub-steppe

Authors: Rex. C. Crawford and Jimmy Kagan

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

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

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

Composition: Characteristic and dominant mid-tall shrubs in the shrub-steppe habitat include all 3 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 2 shorter sagebrushes, silver (*A. cana*) and three-tip (*A. tripartita*). Each of these species can be the only shrub or appear in complex seral conditions with other shrubs. Common shrub complexes are bitterbrush and Wyoming big sagebrush, bitterbrush and three-tip sagebrush, Wyoming big sagebrush and three-tip sagebrush, and mountain big sagebrush and silver sagebrush. Wyoming and mountain big sagebrush can codominate areas with tobacco brush (*Ceanothus velutinus*). Rabbitbrush (*Chrysothamnus viscidiflorus*) and short-spine horsebrush (*Tetradymia spinosa*) are common associates and often dominate sites after disturbance. Big sagebrush occurs with the shorter stiff sagebrush (*A. rigida*) or low sagebrush (*A. arbuscula*) on shallow soils or high elevation sites. Many sandy areas are shrub-free or are open to patchy shrublands of bitterbrush and/or rabbitbrush. Silver sagebrush is the dominant and characteristic shrub along the edges of stream courses, moist meadows, and ponds. Silver sagebrush and rabbitbrush are associates in disturbed areas.

When this habitat is in good or better ecological condition a bunchgrass steppe layer is characteristic. Diagnostic native bunchgrasses that often dominate different shrub-steppe habitats are (1) mid-grasses: bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Elymus elymoides*), and Thurber needlegrass (*Stipa thurberiana*); (2) short grasses: threadleaf sedge (*Carex filifolia*) and Sandberg bluegrass (*Poa sandbergii*); and (3) the tall grass, basin wildrye (*Leymus cinereus*). Idaho fescue is characteristic of the most productive shrub-steppe vegetation.

Bluebunch wheatgrass is codominant at xeric locations, whereas western needlegrass (*Stipa occidentalis*), long-stolon (*Carex inops*) or Geyer's sedge (*C. geyeri*) increase in abundance in higher elevation shrub-steppe habitats. Needle-and-thread (*Stipa comata*) is the characteristic native bunchgrass on stabilized sandy soils. Indian ricegrass (*Oryzopsis hymenoides*) characterizes dunes. Grass layers on montane sites contain slender wheatgrass (*Elymus trachycaulus*), mountain fescue (*F. brachyphylla*), green fescue (*F. viridula*), Geyer's sedge, or tall bluegrasses (*Poa spp.*). Bottlebrush squirreltail can be locally important in the Columbia Basin, sand dropseed (*Sporobolus cryptandrus*) is important in the Basin and Range and basin wildrye is common in the more alkaline areas. Nevada bluegrass (*Poa secunda*), Richardson muhly (*Muhlenbergia richardsonis*), or alkali grass (*Puccinella spp.*) can dominate silver sagebrush flats. Many sites support non-native plants, primarily cheatgrass (*Bromus tectorum*) or crested wheatgrass (*Agropyron cristatum*) with or without native grasses. Shrub-steppe habitat, depending on site potential and disturbance history, can be rich in forbs or have little forb cover. Trees may be present in some shrub-steppe habitats, usually as isolated individuals from adjacent forest or woodland habitats.

Other Classifications and Key References.: This habitat is called Sagebrush steppe and Great Basin sagebrush by Kuchler¹³⁶. The Oregon Gap II Project¹²⁶ and Oregon Vegetation Landscape-Level Cover Types¹²⁷ that would represent this type are big sagebrush shrubland, sagebrush steppe, and bitterbrush-big sagebrush shrubland. Franklin and Dyrness⁸⁸ discussed this habitat in shrub-steppe zones of Washington and Oregon. Other references describe this habitat^{60, 116, 122, 123, 212, 224, 225}.

Natural Disturbance Regime: Barrett et al.²² concluded that the fire-return interval for this habitat is 25 years. The native shrub-steppe habitat apparently lacked extensive herds of large grazing and browsing animals until the late 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, postfire moisture, and plant competition. Three-tip sagebrush is a climax species that reestablishes (from seeds or commonly from sprouts) within 5-10 years following a disturbance. Certain disturbance regimes promote three-tip sagebrush and it can out-compete herbaceous species. Bitterbrush is a climax species that plays a seral role colonizing by seed onto rocky and/or pumice soils. Bitterbrush may be declining and may be replaced by woodlands in the absence of fire. Silver sagebrush is a climax species that establishes during early seral stages and coexists with later arriving species. Big sagebrush, rabbitbrush, and short-spine horsebrush invade and can form dense stands after fire or livestock grazing. Frequent or high-intensity fire can create a patchy shrub cover or can eliminate shrub cover and create Eastside Grasslands habitat.

Effects of Management and Anthropogenic Impacts: Shrub density and annual cover increase, whereas bunchgrass density decreases with livestock use. Repeated or intense

disturbance, particularly on drier sites, leads to cheatgrass dominance and replacement of native bunchgrasses. Dry and sandy soils are sensitive to grazing, with needle-and-thread replaced by cheatgrass at most sites. These disturbed sites can be converted to modified grasslands in the Agriculture habitat.

Status and Trends: Shrub-steppe habitat still dominates most of southeastern Oregon although half of its original distribution in the Columbia Basin has been converted to agriculture. Alteration of fire regimes, fragmentation, livestock grazing, and the addition of >800 exotic plant species have changed the character of shrub-steppe habitat. Quigley and Arbelbide¹⁸¹ concluded that Big Sagebrush and Mountain Sagebrush cover types are significantly smaller in area than before 1900, and that Bitterbrush/Bluebunch Wheatgrass cover type is similar to the pre-1900 extent. They concluded that Basin Big Sagebrush and Big sagebrush-Warm potential vegetation type's successional pathways are altered, that some pathways of Antelope Bitterbrush are altered and that most pathways for Big Sagebrush-Cool are unaltered. Overall this habitat has seen an increase in exotic plant importance and a decrease in native bunchgrasses. More than half of the Pacific Northwest shrub-steppe habitat community types listed in the National Vegetation Classification are considered imperiled or critically imperiled¹⁰.

No. 22. Herbaceous Wetlands

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

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

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

Physical Setting: This habitat is found on permanently flooded sites that are usually associated with oxbow lakes, dune lakes, or potholes. Seasonally to semi-permanently flooded wetlands are found where standing freshwater is present through part of the growing season and the soils stay saturated throughout the season. Some sites are temporarily to seasonally flooded meadows and generally occur on clay, pluvial, or alluvial deposits within montane meadows, or along stream channels in shrubland or woodland riparian vegetation. In general, this habitat is flat, usually with stream or river

channels or open water present. Elevation varies between sea level to 10,000 ft (3,048 m), although infrequently above 6,000 ft (1,830 m).

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

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

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

Aquatic beds are part of this habitat and support a number of rooted aquatic plants, such as, yellow pond lily (*Nuphar lutea*) and unrooted, floating plants such as pondweeds (*Potamogeton spp.*), duckweed (*Lemna minor*), or water-meals (*Wolffia spp.*). Emergent herbaceous broadleaf plants, such as Pacific water parsley (*Oenanthe sarmentosa*),

buckbean (*Menyanthes trifoliata*), water 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 ladyfern (*Athyrium filix-femina*). Climbing nightshade (*Solanum dulcamara*), purple loosestrife (*Lythrum salicaria*), and poison hemlock (*Conium maculatum*) are common non-native forbs in wetland habitats.

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

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

Natural Disturbance Regime: This habitat is maintained through a variety of hydrologic regimes that limit or exclude invasion by large woody plants. Habitats are permanently flooded, 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; e.g., Willamette Valley wet prairies are invaded by Oregon ash (*Fraxinus latifolia*) with fire suppression.

Effects of Management and Anthropogenic Impacts: Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. If the alteration is long term, wetland systems may reestablish to reflect new hydrology, e.g., cattail is an aggressive invader in roadside ditches. Severe livestock grazing and trampling decreases aquatic sedge, Northwest Territory sedge (*Carex utriculata*), bluejoint reedgrass, and tufted hairgrass. Native species, however, such as

Nebraska sedge, Baltic and jointed rush (*Juncus nodosus*), marsh cinquefoil (*Comarum palustris*), and introduced species dandelion (*Taraxacum officinale*), Kentucky bluegrass, spreading bentgrass (*Agrostis stolonifera*), and fowl bluegrass (*Poa palustris*) generally increase with grazing.

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

No. 25. Interior Riparian-Wetlands

Authors: Rex C. Crawford and Jimmy Kagan

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

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

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

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

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

Composition: Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), quaking aspen (*P. tremuloides*), white alder (*Alnus rhombifolia*), peachleaf willow (*Salix amygdaloides*) and, in northeast Washington, paper birch (*Betula papyrifera*) are dominant and characteristic tall deciduous trees. Water birch (*B. occidentalis*), shining willow (*Salix lucida* ssp. *caudata*) and, rarely, mountain alder (*Alnus incana*) are co-dominant to dominant mid-size deciduous trees. Each can be the sole dominant in stands. Conifers can occur in this habitat, rarely in abundance, more often as individual trees. The 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 spiraea (*Spiraea douglasii*) can occur in wetter stands. Red-osier dogwood and common snowberry are shade-tolerant and dominate stand interiors, while these and other shrubs occur along forest or woodland edges and openings. Mountain alder is frequently a prominent shrub, especially at middle elevations. Tall shrubs (or small trees) often growing under or with white alder include chokecherry (*Prunus virginiana*), water birch, shining willow, and netleaf hackberry (*Celtis reticulata*).

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

codominant to dominant. Shorter shrubs, Woods rose, spiraea, snowberry and gooseberry are usually present in the undergrowth.

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

Other Classifications and Key References: This habitat is called Palustrine scrub-shrub and forest in Cowardin et al. ⁵³. Other references describe this habitat ^{44, 57, 60, 131, 132, 147, 156}. This habitat occurs in both lotic and lentic systems. The Oregon Gap II Project ¹²⁶ and Oregon Vegetation Landscape-Level Cover Types ¹²⁷ that would represent this type are eastside cottonwood riparian gallery, palustrine forest, palustrine shrubland, and National Wetland Inventory (NWI) palustrine emergent.

Natural Disturbance Regime: This habitat is tightly associated with stream dynamics and hydrology. Flood cycles occur within 20-30 years in most riparian shrublands although flood regimes vary among stream types. Fires recur typically every 25-50 years but fire can be nearly absent in colder regions or on topographically protected streams. Rafted ice and logs in freshets may cause considerable damage to tree boles in mountain habitats. Beavers crop younger cottonwood and willows and frequently dam side channels in these stands. These forests and woodlands require various flooding regimes and specific substrate conditions for reestablishment. Grazing and trampling is a major influence in altering structure, composition, and function of this habitat; some portions are very sensitive to heavy grazing.

Succession and Stand Dynamics: Riparian vegetation undergoes "typical" stand development that is strongly controlled by the site's initial conditions following flooding and shifts in hydrology. The initial condition of any hydrogeomorphic surface is a sum of the plants that survived the disturbance, plants that can get to the site, and the amount of unoccupied habitat available for invasions. Subsequent or repeated floods or other influences on the initial vegetation selects species that can survive or grow in particular life forms. A typical woody riparian habitat dynamic is the invasion of woody and herbaceous plants onto a new alluvial bar away from the main channel. If the bar is not scoured in 20 years, a tall shrub and small deciduous tree stand will develop.

Approximately 30 years without disturbance or change in hydrology will allow trees to overtop shrubs and form woodland. Another 50 years without disturbance will allow conifers to invade and in another 50 years a mixed hardwood-conifer stand will develop. Many deciduous tall shrubs and trees cannot be invaded by conifers. Each stage can be reinitiated, held in place, or shunted into different vegetation by changes in stream or wetland hydrology, fire, grazing, or an interaction of those factors.

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

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

References Cited:

1. Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, D.C. 493 pp.
2. _____. 1994. Fire and weather disturbances in terrestrial ecosystems of the eastern Cascades. U.S. Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-320. 52 pp.
3. _____, and L. Smith. 1984. Subalpine tree establishment after fire in the Olympic Mountains, Washington. *Ecology* 65:810-819.
4. Ahlenslager, K. E. 1987. *Pinus albicaulis*. In W.C. Fischer, compiler. The Fire Effects Information System (Data base). Missoula, Montana. U.S. Forest service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.
<http://www.fs.fed.us/database/feis/plants/tree/pinalb>.
- 4a. Airola, T. M., and K. Buchholz. 1984. Species structure and soil characteristics of five urban sites along the New Jersey Palisades. *Urban Ecology* 8: 149-164.

5. Akins, G. J., and C. A. Jefferson. 1973. Coastal wetlands of Oregon. Oregon Conservation and Development Commission, Portland, OR. 159 pp.
6. Albright, R., R. Hirschi, R. Vanbianchi, and C. Vita. 1980. Pages 449-887 in Coastal zone atlas of Washington, land cover/land use narratives, Volume 2. Washington State Department of Ecology, Olympia, WA.
7. Aldrich, F. T. 1972. A chorological analysis of the grass balds in the Oregon Coast Range. Ph.D. Dissertation. Oregon State University, Corvallis, OR.
8. Alpert, P. 1984. Inventory and analysis of Oregon coastal dunes. Unpublished Manuscript prepared for the Oregon Natural Heritage Program, Portland, OR.
9. American Forest. 1998. Study documents dramatic tree loss in Puget Sound area. American Forest Press Release July 14, 1998. 2 pp.
10. Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A. S. Weakley. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types. The Nature Conservancy, Arlington, Virginia.
11. Arno, S. F. 1970. Ecology of alpine larch (*Larix lyallii* Parl.) in the Pacific Northwest. Ph.D. Dissertation. University of Montana, Missoula. 264 pp.
12. Associated Press. 1991. Census: cities takeover U.S., Statesman Journal, December 18, 1991.
13. Atzet, T., and L. A. McCrimmon. 1990. Preliminary plant associations of the southern Oregon Cascade Mountain Province. U.S. Forest Service, PNW Region, Siskiyou National Forest, Grants Pass, OR. 330 pp.
14. _____, and D. L. Wheeler. 1982. Historical and ecological perspectives on fire activity in the Klamath Geological Province of the Rogue River and Siskiyou National Forests. : U.S. Forest Service, Pacific Northwest Region, Portland, OR. 16 pp.
15. _____, and _____. 1984. Preliminary plant associations of the Siskiyou Mountains Province, Siskiyou National Forest. U.S. Forest Service, Pacific Northwest Region, Portland, OR.
16. _____, _____, G. Riegel, and others. 1984. The mountain hemlock and Shasta red fir series of the Siskiyou Region of southwest Oregon. FIR Report 6(1): 4-7.

17. _____, D.E. White, L.A. McCrimmon, P.A. Martinez, P.R. Fong, and V.D. Randall. 1996. Field guide to the forested plant associations of southwestern Oregon. U.S. Forest Service, Pacific Northwest Research Paper R6-NR-ECOL-TP-17-96.
18. Bakun, A. 1973. Coastal upwelling indices, west coast of North America, 1946-71. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
19. Barber, W. H., Jr. 1976. An autecological study of salmonberry (*Rubus spectabilis*, Pursh) in western Washington. M.S. Thesis. University of Washington, Seattle, WA. 154 pp.
20. Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York, NY.
21. Barnes, C. A., A. C. Duxbury, and B. A. Morse. 1972. Circulation and selected properties of the Columbia River effluent at sea. Pages 41-80 in A. T. Pruter and D. L. Alverson, editors. The Columbia River Estuary and adjacent ocean waters, bioenvironmental studies. University of Washington Press, Seattle, WA.
22. Barrett, S. W., S. F. Arno, and J. P. Menakis. 1997. Fire episodes in the inland Northwest (1540-1940) based on fire history data. U.S. Forest Service, Intermountain Research Station. General Technical Report INT-GTR-370. 17 pp.
23. Bastasch, R. 1998. Waters of Oregon. A source book on Oregon's water and water management. Oregon State University Press, Corvallis, OR.
- 23b. Beisiinger, S. R. and D. R. Osborne. 1982. Effects of urbanization on avian community organization. Condor 84: 75-83.
24. Beschta, R. L., R. E. Bilby, G. W. Brown, L. B. Holtby, and T. J. D. Hofstra. 1987. Pages 191-232 in E. O. Salo and T. W. Cundy, editors. Streamside management: forestry and fishery interactions. College of Forest Resources, University of Washington, Seattle, WA.
25. Bigley, R., and S. Hull. 1992. Siouxan guide to site interpretation and forest management. Washington Department of Natural Resources, Olympia, WA. 215 pp.
26. _____, and _____. 1995. Draft guide to plant associations on the Olympic Experimental Forest. Washington Department of Natural Resources, Olympia WA. 50 pp.
27. Bilby, R. E., and J. W. Ward. 1991. Large woody debris characteristics and function in streams draining old growth, clear-cut, and second-growth forests in southwestern Washington. Canadian Journal of Fisheries and Aquatic Sciences 48:2499-2508.

28. Black, A. E., J. M. Scott, E. Strand, R.G. Wright, P. Morgan, and C. Watson. 1998. Biodiversity and land-use history of the Palouse Region: pre-European to present. Chapter 10 in Perspectives on the land use history of North America: a context for understanding our changing environment. USDI/USGS. Biological Resources Division, Biological Science Report USGS/BRD-1998-003.
29. Blackburn, W. H., P. T. Tueller, and R. E. Eckert Jr. 1969. Vegetation and soils of the Coils Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-48. Reno, Nevada. 81 pp.
30. _____, _____, and _____. 1969. Vegetation and soils of the Cow Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-49. Reno, Nevada. 80 pp.
- 30a. Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6: 506-519.
31. Bottom, D. K., K. K. Jones, J. D. Rodgers, and R. F. Brown. 1989. Management of living marine resources: a research plan for the Washington and Oregon continental margin. National Coastal Resources Research and Development Institute, Publication No. NCRI-T-89-004. 80 pp.
32. _____, _____, _____, and _____. 1993. Research and management in the Northern California Current ecosystem. Pages 259-271 in K. Sherman, L. M. Alexander, and B. D. Gold, editors. Large marine ecosystems: stress, mitigation, and sustainability. AAAS Press, Washington D.C.
33. _____, J. A. Lichatowich, and C. A. Frissell. 1998. Variability of Pacific Northwest marine ecosystems and relation to salmon production. Pages 181-252 in B. R. McMurray and R. J. Bailey, editors. Change in Pacific coastal ecosystems. National Oceanic and Atmospheric Administration Coastal Ocean Program Decision Analysis Series No. 11. NOAA Coastal Ocean Office, Silver Spring, Maryland.
34. Brady, R. F., T. Tobius, P. F. J. Eagles, R. Ohrner, J. Micak, B. Veale, and R. S. Dorney. 1979. A typology for the urban ecosystem and its relationship to large biogeographical landscape units. Urban Ecology. 4:11-28.
35. Broadhurst, G. 1998. Puget Sound nearshore habitat regulatory perspective: a review of issues and obstacles. Puget Sound Water Quality Action Team. Olympia, WA.
36. Brockway, D. G., C. Topik, M. A. Hemstrom, and W. H. Emmingham. 1983. Plant association and management guide for the Pacific silver fir zone, Gifford Pinchot National Forest. U.S. Forest Service. R6-Ecol-130a. 121 pp.
37. Cassidy, K. M. 1997. Land cover of Washington state: description and management. Volume 1 in K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, editors.

Washington State Gap Analysis Project Final Report. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA.

38. Chappell, C. B. 1991. Fire ecology and seedling establishment in Shasta red fir forests of Crater Lake National Park, Oregon. M.S. Theses. University of Washington, Seattle, WA. 133 pp.
39. _____, and J. K. Agee. 1996. Fire severity and tree seedling establishment in *Abies magnifica* forests, southern Cascades, Oregon. *Ecological Applications* 6:628-640.
40. _____, R. Bigley, R. Crawford, and D. F. Giglio. In prep. Field guide to terrestrial plant associations of the Puget Lowland, Washington. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.
41. _____, and R. C. Crawford. 1997. Native vegetation of the South Puget Sound prairie landscape. Pages 107-122 in P. Dunn and K. Ewing, editors. *Ecology and conservation of the South Puget Sound prairie landscape*. The Nature Conservancy of Washington, Seattle WA. 289 pp.
42. Christy, J.A., J. S. Kagan, and A. M. Wiedemann. 1998. Plant associations of the Oregon Dunes National Recreation Area, Siuslaw National Forest, Oregon. Technical Paper R6-NR-ECOL-TP-09-98. U.S. Forest Service, Pacific Northwest Region, Portland, Oregon. 170 pp.
43. _____, and J. A. Putera. 1993. Lower Columbia River natural area inventory, 1992. Unpublished Report to the Washington Field Office of The Nature Conservancy, Seattle, Washington. Oregon Natural Heritage Program, Portland, Oregon. 74 pp.
44. _____, and J. H. Titus. 1996. Draft, wetland plant communities of Oregon. Unpublished Manuscript, Oregon Natural Heritage Program, Portland, Oregon. 87 pp.
45. Clausnitzer, R. R., and B. A. Zamora. 1987. Forest habitat types of the Colville Indian Reservation. Unpublished Report prepared for the Department of Forest and Range Management, Washington State University, Pullman, WA.
46. Clemens, J., C. Bradley, and O. L. Gilbert. 1984. Early development of vegetation on urban demolition sites in Sheffield, England. *Urban Ecology*. 8:139-148.
47. Cochran, P. H. 1985. Soils and productivity of lodgepole pine. in D. M. Baumgartner, R. G. Krebill, J. T. Arnott, and G. F. Gordon, editors. *Lodgepole pine: the species and its management: symposium proceedings*, Washington State University, Cooperative Extension, Pullman, WA.
48. Cole, D. N. 1977. Man's impact on wilderness vegetation: an example from Eagle Cap Wilderness, NE Oregon. Ph.D. Dissertation. University of Oregon, Eugene, OR.

49. _____. 1982. Vegetation of two drainages in Eagle Cap Wilderness, Wallowa Mountains, Oregon. U.S. Forest Service Research Paper INT-288.
50. Conard, S. G., A. E. Jaramillo, K. Cromack, Jr., and S. Rose, compilers. 1985. The role of the genus *Ceanothus* in western forest ecosystems. General Technical Report PNW-182. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR. 72 pp.
51. _____, and S. R. Radosevich. 1981. Photosynthesis, xylem pressure potential, and leaf conductance of three montane chaparral species in California. *Forest Science* 27(4):627-639.
52. Copeland, W. N. 1979. Harney Lake RNA Guidebook, Supplement No. 9. U.S. Forest Service Experiment Station, Portland, OR.
53. Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79.31.
54. Crawford, R. C., and H. Hall. 1997. Changes in the South Puget Sound prairie landscape. Pages 11-15 in P. Dunn and K. Ewing, editors. Ecology and conservation of the South Puget Sound prairie landscape. The Nature Conservancy of Washington, Seattle, WA. 289 pp.
55. Crook, C. S. 1979. An introduction to beach and dune physical and biological processes. In K. B. Fitzpatrick, editor. Articles of the Oregon Coastal Zone Management Association, Inc., Newport, OR.
56. _____. 1979. A system of classifying and identifying Oregon's coastal beaches and dunes. In K. B. Fitzpatrick, editor. Articles of the Oregon Coastal Zone Management Association, Inc., Newport, OR.
57. Crowe, E. A., and R. R. Clausnitzer. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla and Wallowa-Whitman National Forests. U.S., PNW Technical Paper, R6-NR-ECOL-TP-22-97. 299 pages.
58. Csuti, B., A. J. Kimerling, T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, and M. M. P. Huso. 1997. Atlas of Oregon wildlife. Oregon State University Press, Corvallis, OR. 492 pp.
59. Daniels, J. D. 1969. Variation and integration in the grand fir-white fir complex. Ph.D. Dissertation, University of Idaho, Moscow. 235 pp.
60. Daubenmire, R. F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin No. 62. 131 pp.

61. _____. 1981. Subalpine parks associated with snow transfer in the mountains of Idaho and eastern Washington. *Northwest Science* 55(2):124-135.
62. _____, and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Technical Bulletin 60. Washington Agricultural Experiment Station, College of Agriculture, Washington State University, Pullman, WA. 104 pp.
63. Davidson, E. D. 1967. Synecological features of a natural headland prairie on the Oregon coast. M.S. Thesis. Oregon State University, Corvallis, OR. 78 pp.
64. Dealy, J. E. 1971. Habitat characteristics of the Silver Lake mule deer range. U.S. Forest Service Research Paper PNW-125. 99 pp.
65. del Moral, R. 1979. High elevation vegetation of the Enchantment Lakes Basin, Washington. *Canadian Journal of Botany* 57(10):1111-1130.
66. _____, and J. N. Long. 1977. Classification of montane forest community types in the Cedar River drainage of western Washington, U.S.A. *Canadian Journal of Forest Research* 7(2):217-225.
67. Dethier, M. N. 1988. A survey of intertidal communities of the Pacific coastal area of Olympic National Park, Washington. Prepared for the National Park Service and cooperating agencies.
68. _____. 1990. A marine and estuarine habitat classification system for Washington State. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA. 56 pp.
69. Detling, L. E. 1961. The chaparral formation of southwestern Oregon, with considerations of its postglacial history. *Ecology* 42:348-357.
70. Detwyler, T. R. 1972. Urbanization and environment. Duxbury Press, Belmont, CA.
71. Diaz, N. M., and T. K. Mellen. 1996. Riparian ecological types, Gifford Pinchot and Mt. Hood National Forests, Columbia River Gorge National Scenic Area. U.S. Forest Service, Pacific Northwest Region, R6-NR-TP-10-96. 203 pp.
72. Dickman, A., and S. Cook. 1989. Fire and fungus in a mountain hemlock forest. *Canadian Journal of Botany* 67(7):2005-2016.
73. Dodimead, A. J., F. Favorite, and T. Hirano. 1963. Salmon of the North Pacific Ocean-- Part II. Review of oceanography of the subarctic Pacific region. International Commission Bulletin No. 13. 195 pp.
74. Douglas, G. W. 1970. A vegetation study in the subalpine zone of the western North Cascades, Washington. M.S. Thesis, University of Washington, Seattle, WA. 293 pp.

75. _____, and L. C. Bliss. 1977. Alpine and high subalpine plant communities of the North Cascades Range, Washington and British Columbia. *Ecological Monographs* 47:113-150.
76. Downing, J. P. 1983. *The coast of Puget Sound: its process and development*. Washington Sea Grant Publication, University of Washington. Seattle, WA. 126 pp.
77. Druehl, L. D. 1969. The northeast Pacific rim distribution of the Laminariales. *Proceedings of the International Seaweed Symposium* 6:161-170.
78. Dunn, P. V., and K. Ewing, editors. 1997. *Ecology and conservation of the South Puget Sound Prairie Landscape*. The Nature Conservancy, Seattle, WA.
79. Eddleman, L. E. 1984. Ecological studies on western juniper in central Oregon. In *Proceedings western juniper management short course, 1984 October 15-16*. Oregon State University, Extension Service and Department of Rangeland Resources, Corvallis, OR.
80. Edwards, O. M. 1980. *The alpine vegetation of Mount Rainier National Park: structure, development, and constraints*. Ph.D. Dissertation. University of Washington, Seattle, WA. 280 pp.
- 80a. Emlen, J. T. 1974. An urban bird community of Tucson, Arizona: derivation, structure, regulation. *The Condor* 76: 184-197.
81. Everest, F. H. 1987. Salmonids of western forested watersheds. Pages 3-38 in E. O. Salo and T. W. Cundy, editors. *Streamside management: forestry and fishery interactions*. College of Forest Resources, University of Washington, Seattle, WA.
82. _____, R. L. Beschta, J. C. Scrivener, K. V. Koski, J. R. Sedell, and C. J. Cederholm. 1987. Fine sediments and salmonid production: a paradox. Pages 98-142 in E. O. Salo and T. W. Cundy, editors. *Streamside management: forestry and fishery interactions*. College of Forest Resources, University of Washington, Seattle.
- 82a. Falk, J. H. 1976. Energetics of a suburban lawn ecosystem. *Ecology* 57: 141-150.
83. Favorite, F., A. J. Dodimead, and K. Nasu. 1976. Oceanography of the subarctic Pacific region, 1960-71. *International North Pacific Fisheries Commission Bulletin* No. 33. 187 pp.
84. Florence, M. 1987. Plant succession on prescribed burn sites in chamise chaparral. *Rangelands* 9(3):119-122.

85. Fonda, R. W. 1974. Forest succession in relation to river terrace development in Olympic National Park, Washington. *Ecology* 55:927-942.
86. _____, and J. A. Bernardi. 1976. Vegetation of Sucia Island in Puget Sound, Washington. *Bulletin of the Torrey Botanical Club* 103(3):99-109.
87. Franklin, J. F. 1988. Pacific Northwest forests. Pages 104-130 in M. G. Barbour and W. D. Billings, editors. *North American terrestrial vegetation*. Cambridge University Press, New York, NY. 434 pp.
88. _____, and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. Pacific Northwest Forest and Range Experiment Station, General Technical Report. PNW-8, Portland, OR. 417 pp.
89. _____, K. Cromack, Jr., W. Denison, A. McKee, C. Maser, J. Sedell, F. Swanson, and G. Juday. 1981. Ecological characteristics of old-growth Douglas-fir forests. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-118. Portland, OR. 48 pp.
90. _____, W. H. Moir, M. A. Hemstrom, S. E. Greene, and B. G. Smith. 1988. The forest communities of Mount Rainier National Park. U.S. National Park Service, Scientific Monograph Series 19, Washington, D.C. 194pp.
91. Frenkel, R. E., and E. F. Hieinitz. 1987. Composition and structure of Oregon ash (*Fraxinus latifolia*) forest in William L. Finley National Wildlife Refuge, Oregon. *Northwest Science* 61:203-212.
92. Frey, D. G., editor. 1966. *Limnology in North America*. The University of Wisconsin Press, Madison, Wisconsin.
93. Furniss, M. J., T. D. Roelogs, and C. S. Yee. 1991. Road construction and maintenance. Pages 297-323 in W. R. Meehan, editor. *Influences of forest and rangeland management on salmonid fishes and their habitats*. American Fisheries Society Special Publication No. 19, Bethesda, Maryland.
94. Ganskopp, D. C. 1979. Plant communities and habitat types of the Meadow Creek Experimental Watershed. M.S. Thesis. Oregon State University, Corvallis, OR. 162 pp.
95. Gaumer, T. F., S. L. Benson, L. W. Brewer, L. Osis, D. G. Skeesick, R. M. Starr, and J. F. Watson. 1985. Estuaries. In E. R. Brown, editor. *Management of wildlife and fish habitats in forests of western Oregon and Washington*. U.S. Forest Service, Pacific Northwest Region, Portland, OR.
96. Gerard, P. W. 1995. Agricultural practices, farm policy, and the conservation of biological diversity. USDI, National Biological Service, Biological Science Report 4. 28 pp.

97. Gordon, D. T. 1970. Natural regeneration of white and red fir: influence of several factors. U.S. Forest Service, Research Paper PSW-90.
- 97a. Green, R. J. 1984. Native and exotic birds in a suburban habitat. *Australian Wildlife Research* 11: 181-190.
98. Greenlee, J. M., and J. H. Langenheim. 1990. Historic fire regimes and their relation to vegetation patterns in the Monterey Bay area of California. *American Midland Naturalist* 124(2):239-253.
99. Habeck, J. R. 1961. Original vegetation of the mid-Willamette Valley, Oregon. *Northwest Science* 35:65-77.
100. Haeussler, S., and D. Coates. 1986. Autecological characteristics of selected species that compete with conifers in British Columbia: a literature review. Land Management Report No. 33. Ministry of Forests, Information Services Branch, Victoria, British Columbia, Canada. 180 pp.
101. Hall, F. C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. U.S. Forest Service , R-6, Area Guide 3-1. 62 pp.
102. Halpern, C. B. 1989. Early successional patterns of forest species: interactions of life history traits and disturbance. *Ecology* 70:704-720.
103. Halverson, N. M., and W. H. Emmingham. 1982. Reforestation in the Cascades Pacific silver fir zone: a survey of sites and management experiences on the Gifford Pinchot, Mt. Hood and Willamette National Forests. U.S. Forest Service. R6-ECOL-091-1982. 37 pp.
104. _____, C. Topik, and R. van Vickle. 1986. Plant associations and management guide for the western hemlock zone, Mt. Hood National Forest. U.S. Forest Service, R6-ECOL-232A-1986. 111 pp.
105. Hamann, M. J. 1972. Vegetation of alpine and subalpine meadows of Mount Rainier National Park, Washington. M.S. Thesis. Washington State University, Pullman. 120 pp.
106. Harper, J. R., D. E. Howes, and P. D. Reimer. 1991. Shore-zone mapping system for use in sensitivity mapping and shoreline countermeasures. Proceedings of the 14 th Arctic and Marine Oil spill Program (AMOP), Environment Canada.
107. Harr, R. D., and B. A. Coffin. 1992. Influence of timber harvest on rain-on-snow runoff: a mechanism for cumulative watershed effects. Pages 455-469 in M. E. Jones and A. Laemon, editors. *Interdisciplinary approaches in hydrology and hydrogeology*. American Institute of Hydrology. Minneapolis. 618 pp.

108. Hemstrom, M. A., W. H. Emmingham, N. M. Halverson, S. E. Logan, and C. Topik. 1982. Plant association and management guide for the Pacific silver fir zone, Mt. Hood and Willamette National Forests. U.S. Forest Service R6-Ecol 100-1982a. 104 pp.
109. _____, and J. F. Franklin. 1982. Fire and other disturbances of the forests in Mount Rainier National Park. *Quaternary Research* 18:32-51.
110. _____, and S.E. Logan. 1986. Plant association and management guide, Siuslaw National Forest. U.S. Forest Service Report R6-Ecol 220-1986a. Portland, OR. 121 pp.
111. _____, _____, and W. Pavlat. 1987. Plant association and management guide, Willamette National Forest. U.S. Forest Service. R6-ECOL 257-B-86. 312 pp.
112. Henderson, J. A. 1973. Composition, distribution, and succession of subalpine meadows in Mount Rainier National Park, Washington. Ph.D. Dissertation. Oregon State University, Corvallis, OR. 150 pp.
113. _____. 1978. Plant succession on the *Alnus rubra/Rubus spectabilis* habitat type in western Oregon. *Northwest Science* 52(3):156-167.
114. _____, D. A. Peter, and R. Leshner. 1992. Field guide to the Forested Plant Associations of the Mt. Baker-Snoqualmie National Forest. U.S. Forest Service Technical Paper R6-ECOL 028-91. 196 pp.
115. _____, _____, _____, and D.C. Shaw. 1989. Forested Plant Associations of the Olympic National Forest. U.S. Forest Service Publication R6-ECOL-TP 001-88. 502 pp.
116. Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. *Forestry, Wildlife, and Range Experiment Station Bulletin No. 15*, University of Idaho, Moscow. 44 pp.
- 116a. Hobbs, E. 1988. Using ordination to analyze the composition and structure of urban forest islands. *Forest Ecology and Management* 23: 139-158.
117. Hopkins, W. E. 1979. Plant associations of the Fremont National Forest. U.S. Forest Service Publication R6-ECOL-79-004. 106 pp.
118. _____. 1979. Plant associations of South Chiloquin and Klamath Ranger Districts--Winema National Forest. U.S. Forest Service Publication R6-ECOL-79-005. 96 pp.
119. Howard, J. L. 1996. *Populus tremuloides*. In D. G. Simmerman, compiler. The Fire Effects Information System [Data base]. U.S. Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Missoula, Montana.
<http://www.fs.fed.us/database/feis/plants/tree/poptre>.

- 119a. Ingold, D. J. 1996. Delayed nesting decreased reproductive success in northern flickers: implications for competition with European starlings. *Journal of Field Ornithology* 67: 321-326.
- 119b. Ingold, D. J. and R. J. Densmore. 1992. Competition between European starlings and native woodpeckers for nest cavities in Ohio. *Sialia* 14: 43-48.
120. Jefferson, C. A. 1975. Plant communities and succession in Oregon coastal salt marshes. Ph.D. Dissertation. Oregon State University, Corvallis, OR. 192 pp.
121. John, T., and D. Tart. 1986. Forested plant associations of the Yakima Drainage within the Yakima Indian Reservation. Review copy prepared for the Yakima Indian Nation-- Bureau of Indian Affairs-Soil Conservation Service.
122. Johnson, C. G., and R. R. Clausnitzer. 1992. Plant associations of the Blue and Ochoco mountains. U.S. Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest R6-ERW-TP-036-92. 163 pp.
123. _____, and S.A. Simon. 1987. Plant associations of the Wallowa-Snake Province. U.S. Forest Service R6-ECOL-TP-255A-86. 400 pp.
124. Keeley, J. E. 1975. Longevity of nonsprouting *Ceanothus*. *American Midland Naturalist* 93(2):504-507.
125. _____, and S. C. Keeley. 1988. Chaparral. Pages 165-208 in M. G. Barbour and W. D. Billings, editors. *North American terrestrial vegetation*. Cambridge University Press, New York, NY.
126. Kiilsgaard, C. 1999. Oregon vegetation: mapping and classification of landscape level cover types. Final Report. U.S. Geological Survey-Biological Resources Division: Gap Analysis Program. Moscow, Idaho. 22pp.
127. _____, and C. Barrett. 1998. Oregon vegetation landscape-level cover types 127. Northwest Habitat Institute, Corvallis, OR.
128. Kilgore, B. M. 1973. The ecological role of fire in Sierran conifer forests--its application to National Park management. *Quaternary Research* 3:496-513.
129. King County Park, Planning and Resource Department. 1987. Wildlife habitat profile-- King County Open Space Program, Seattle, WA. 111 pp.
130. Knutson, K. L., and V. L. Naef. 1997. Priority habitat management recommendations: riparian. Washington Department of Fish and Wildlife, Olympia, WA.
131. Kovalchik, B. L. 1987. Riparian zone associations--Deschutes, Ochoco, Fremont, and Winema national forests. U.S. Forest Service R6 ECOL TP-279-87. 171 pp.

132. _____. 1993. Riparian plant associations of the National Forests of eastern Washington. A partial draft version 1. U.S. Forest Service, Colville National Forest. 203 pp.
133. Kozloff, E. N. 1973. Seashore life of Puget Sound, the Straight of Georgia, and the San Juan Archipelago. University of Washington Press, Seattle, WA.
134. Krajina, V. J. 1965. Bioclimatic zones and classification of British Columbia. Pages 1-17 in V. J. Krajina, editor. Ecology of western North America. Volume 1. University of British Columbia, Vancouver, British Columbia, Canada.
135. Kruckeberg, A. R. 1996. Gardening with native plants of the Pacific Northwest: an illustrated guide. University of Washington Press, Seattle. ISBN 0-295-97476-1. 288 pp.
136. Kuchler, A.W. 1964. Manual to accompany the map: potential natural vegetation of the conterminous United States. Special Publication. 36, American Geographic Society, New York, NY.
137. Kumler, M. L. 1969. Plant succession on the sand dunes of the Oregon coast. *Ecology* 50(4):695-704.
138. Kunze, L. M. 1994. Preliminary classification of native, low elevation, freshwater wetland vegetation in western Washington. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA. 120 pp.
139. Kuramoto, R. T., and L. C. Bliss. 1970. Ecology of subalpine meadows in the Olympic Mountains, Washington. *Ecological Monograph* 40:317-347.
140. Laacke, R. J., and J. N. Fiske. 1983. Red fir and white fir. Pages 41-43 in R. M. Burns, compiler. *Silvicultural systems for the major forest types of the United States*. U.S. Forest Service Agriculture Handbook No. 44. Washington, D.C.
141. Landry, M. R., and B. M. Hickey, editors. 1989. *Coastal oceanography of Washington and Oregon*. Elsevier Science Publishing Company, New York, NY.
142. Lang, F. A. 1961. A study of vegetation change on the gravelly prairies of Pierce and Thurston counties, western Washington. M.S. Thesis. University of Washington, Seattle, WA.
143. Levings, C. D., and R. M. Thom. 1994. Habitat changes in Georgia Basin: implications for resource management and restoration. Pages 330-351 in R. C. H. Wilson, R. J. Beamish, F. Aitkins, and J. Bell, editors. *Review of the marine environment and biota of Strait of Georgia, Puget Sound and Juan de Fuca Strait*. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1948.

144. Lillybridge, T. R., B. L. Kovalchik, C. K. Williams, and B. G. Smith. 1995. Field guide for forested plant association of the Wenatchee National Forest. U.S. Forest Service General Technical Report PNW-GTR-359, Portland, OR. 336 pp.
145. Little, C., and J. A. Kitching. 1996. The biology of rocky shores. Oxford University Press, New York, NY.
146. Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran. 1998. Status and trends of the nation's biological resources. Volume 1. U.S. Department of the Interior, U. S. Geological Survey, Reston, Virginia. 436 pp.
147. Manning, M. E., and W. G. Padgett. 1992. Riparian community type classification for the Humboldt and Toiyabe national forests, Nevada and eastern California. Unpublished Draft Report prepared for U.S. Forest Service, Intermountain Region Ecology and Classification Program, Ogden, Utah. 490 pp.
148. Marsh, F., R. Helliwell, and J. Rodgers. 1987. Plant association guide for the commercial forest of the Warm Springs Indian Reservation. Confederated Tribes of the Warm Springs Indians, Warm Springs, OR.
- 148a. Marzluff, J. M. 1997. Effects of urbanization and recreation on songbirds. Pages 89-102 in W. M. Block, and D. M. Finch, editors. Songbird ecology in southwestern ponderosa pine forests: a literature review. U.S. Forest Service General Technical Report RM-292, Fort Collins, Colorado.
149. Marzluff, J. M., F. R. Gehlbach, and D. A. Manuwal. 1998. Urban environments: influences on avifauna and challenges for the avian conservationist. Pages 283-299 in J. M. Marzluff and R. Sallabanks, editors. Avian conservation, research, and management. Island Press, Washington D.C.
150. Mayer, K. E., and W. F. Laudenslayer, Jr., editors. 1988. A guide to wildlife habitats of California. State of California, the Resources Agency, Department of Fish and Game, Wildlife Management Division, CWHR Program, Sacramento, CA. 166 pp.
151. McBride, J. R., and C. Reid. 1988. Urban. Pages 142-144 in K. E. Mayer and W. F. Laudenslayer, Jr., editors. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA.
152. McDonald, P. M., and J.C. Tappeiner, II. 1987. Silviculture, ecology, and management of tanoak in northern California. Pages 64-70 in T. R. Plumb and N. H. Pillsbury, technical coordinators. Proceedings of the symposium on multiple-use management of California's hardwood resources; 12-14 November 1986; San Luis Obispo, California. U.S. Forest Service General Technical Report PSW-100.

153. McKenzie, D. F., and T. Z. Riley, editors. 1995. How much is enough? A regional wildlife habitat needs assessment for the 1995 Farm Bill. Wildlife Management Institute, Washington, D.C. 30 pp.
154. McNeil, R. C., and D. B. Zobel. 1980. Vegetation and fire history of a ponderosa pine-white fir forest in Crater Lake National Park. *Northwest Science* 54(1):30-46.
155. Merriam, C. H. 1898. Life zones and crop zones of the United States. U.S. Department of Agriculture, Division of Biological Survey, Bulletin 10.
156. Miller, T. B. 1976. Ecology of riparian communities dominated by white alder in western Idaho. M.S. Thesis. University of Idaho, Moscow. 154 pages.
157. Minnich, R. A. 1983. Fire mosaics in southern California and north Baja California. *Science* 219:1287-1294.
158. Mitchell, R., and W. Moir. 1976. Vegetation of the Abbott Creek Research Natural Area, Oregon. *Northwest Science* 50:42-57.
159. Morgan, P., S. C. Bunting, A. E. Black, T. Merrill, and S. Barrett. 1996. Fire regimes in the interior Columbia River Basin: past and present. Final Report RJVA-INT-94913. U.S. Forest Service, Intermountain Research Station, Intermountain Fire Sciences Lab, Missoula, Montana.
160. Morrison, P., and F. J. Swanson. 1990. Fire history and pattern in a Cascade Range landscape. U.S. Forest Service General Technical Report PNW-GTR-254.
161. Mueggler, W. F. 1988. Aspen community types of the Intermountain Region. U.S. Forest Service, General Technical Report INT-250. Intermountain Research Station, Ogden, Utah. 32 pp.
162. Naiman, R. J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications* 3:209-212.
163. National Oceanic and Atmospheric Administration. 1993. Olympic Coast National Marine Sanctuary, Final Environmental Impact Statement/Management Plan, November 1993. NOAA, Sanctuaries and Reservoirs Division, Washington D.C.
164. National Research Council. 1989. Alternative agriculture. National Academy Press, Washington, D.C. 448 pp.
165. Norton, H. H. 1979. The association between anthropogenic prairies and important food plants in western Washington. *Northwest Anthropological Research Notes* 13:199-219.

166. Noss, R. F., E. T. LaRoe, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. U.S. National Biological Service, Biological Report 28.
167. Nowak, D. J. 1994. Understanding of the structure of urban forests. *Journal of Forestry* October: 42-46.
168. Oliver, C. D. 1981. Forest development in North America following major disturbances. *Forest Ecology and Management* 3:153-168.
169. Oregon Department of Forestry. 1994. Water protection rules: purpose, goals, classification, and riparian management. OAR No.629-635-200-Water classification. Oregon Department of Forestry, Salem, OR.
170. Oregon State University. 1971. Oceanography of the nearshore coastal waters of the Pacific Northwest relating to possible pollution. Volume 1. Corvallis, OR. 615 pp.
171. Parsons, D. J., and S. H. DeBenedetti. 1979. Impact of fire suppression on a mixed-conifer forest. *Forest Ecology and Management* 2:21-33.
172. Pettinger, A. 1996. Native plants in the coastal garden: a guide for gardeners in British Columbia and the Pacific Northwest. Whitecap Books 1-55110-405-9. Vancouver, British Columbia. 170 pp.
173. Phillips, R. C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. U. S. Fish and Wildlife Service, FWS/OBS-84/24. 85 pp.
174. Phinney, L. A., and P. Bucknell. 1975. A catalog of Washington streams and salmon utilization. Washington Department of Fisheries. Volume 2: coastal region.
175. Poulton, C. E. 1955. Ecology of the non-forested vegetation in Umatilla and Morrow counties, Oregon. Ph.D. Dissertation. State College of Washington, Pullman, WA. 166 pp.
176. Proctor, C. M., J. C. Garcia, D. V. Galvin, G. B. Lewis, L. C. Loehr, and A. M. Massa. 1980. An ecological characterization of the Pacific Northwest coastal region. Volume 2. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-79/14.
177. _____, _____, _____, _____, _____, and _____. 1980. An ecological characterization of the Pacific Northwest coastal region. Volume 3. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-79/14.

178. _____, _____, _____, _____, _____, and _____. 1980. An ecological characterization of the Pacific Northwest coastal region. Volume 4. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-79/14.
179. Pruter, A. T., and D. L. Alverson, editors. 1972. The Columbia River estuary and adjacent waters: bioenvironmental studies. University of Washington Press, Seattle. 868 pp.
180. Puget Sound Water Quality Authority. 1997. 1997 Puget Sound update. Seventh annual report of the Puget Sound Ambient Monitoring Program. Puget Sound Water Quality Authority, Olympia, Washington.
181. Quigley, T. M., and S. J. Arbelbide, technical editors. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Volume 2. U.S. Forest Service General Technical Report PNW-GTR-405.
182. Quinn, T. 1997. Coyote (*Canis latrans*) food habits in three urban habitat types of western Washington. Northwest Science 71(1):1-5.
183. Ripley, J. D. 1983. Description of the plant communities and succession of the Oregon coast grasslands. M.S. Thesis. Oregon State University, Corvallis, OR.
184. Roberts, K., L. Bischoff, K. Brodersen, G. Green, D. Gritten, S. Hamilton, J. Kierstead, M. Benham, E. Perkins, T. Pogson, S. Reed, and D.E. Kerley. 1976. A preliminary ecology survey of the Alvord Basin, Oregon. Unpublished, Final Technical Report, Eastern Oregon State College, La Grande. NSF Grant 76-08175.
185. Rowntree, R. A. 1986. Ecology of the urban forest--introduction to part II. Urban Ecology 9(3/4):229-243.
- 185a. Rudnický, J. L., and M. J. McDonnell. 1989. Forty-eight years of canopy change in a hardwood-hemlock forest in New York City. Bulletin of the Torrey Botanical Club 116: 52-64.
186. Ruth, R. H. 1974. Regeneration and growth of west-side mixed conifers. In O. P. Camer, editor. Environmental effects of forest residues in the Pacific Northwest: a state-of-knowledge compendium. U.S. Forest Service General Technical Report PNW-24.
187. Sampson, A. W., and B. S. Jespersen. 1963. California range brushlands and browse plants. University of California, Division of Agricultural Sciences, California Agricultural Experiment Station, Extension Service, Berkeley, CA. 162 pp.
188. Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. Native Plant Society of California, Sacramento, CA. 471 pp.

189. Schoch, G. C., and M. N. Dethier. 1997. Analysis of shoreline classification and biophysical data for Carr Inlet. Washington State Department of Natural Resources. Olympia, WA.
190. Shipman, H. 1997. Shoreline armoring on Puget Sound. In T. Ransom, editor. Puget Sound Notes No. 40. Puget Sound Water Quality Action Team, Olympia, WA.
191. Shreffler, D. K., R. M. Thom, and K. B. MacDonald. 1995. Shoreline armoring effects on biological resources and coastal ecology in Puget Sound. In E. Robichaud, editor. Puget Sound Research 1995: Proceedings. Puget Sound Water Quality Action Team, Olympia, WA.
192. Simenstad, C. A. 1983. The ecology of estuarine channels of the Pacific Northwest coast: a community profile. U.S. Fish and Wildlife Services. FWS/OBS-83/05. 181 pp.
193. Spies, T. A., J. F. Franklin, and T. B. Thomas. 1988. Coarse woody debris in Douglas-fir forests of western Oregon and Washington. *Ecology* 69:1689-1702.
194. Strickland, R., and D. J. Chasan. 1989. Coastal Washington, a synthesis of information. Washington State and Offshore Oil and Gas, Washington Sea Grant, University of Washington, Seattle, WA.
195. Strickler, G. S. 1961. Vegetation and soil condition changes on a subalpine grassland in eastern Oregon. U.S. Forest Service Research Paper PNW-40, Portland, OR. 46 pp.
196. _____, and W. B. Hall. 1980. The Standley allotment: a history of range recovery. U.S. Forest Service, Forest and Range Experiment Station Research Paper, PNW-278. 35 pp.
197. Sullivan, K., T. E. Lidle, C. A. Dolloff, G. E. Grant, and L. M. Reid. 1987. Stream Channels: the link between forest and fishes. Pages 39-97 in E. O. Salo and T. W. Cundy, editors. Streamside management: forestry and fishery interactions. College of Forest Resources. University of Washington, Seattle, WA.
198. Swanson, F. J., L. E. Benda, S. H. Duncan, G. E. Grant, W. F. Megaham, L. M. Reid, and R. R. Zeimer. 1987. Mass failures and other processes of sediment production in Pacific Northwest forest landscapes. Pages 9-38 in E. O. Salo and T. W. Cundy, editors. Streamside management: forestry and fisheries interactions. College of Forest Resources Contribution No. 57, University of Washington, Seattle, WA.
199. _____, and C. T. Dyrness. 1975. Impact of clearcutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. *Geology* 3:393-396.
200. _____, R. L. Fredriksen, and F. M. McCorison. 1982. Material transfer in a western Oregon forested watershed. Pages 223-266 in R. L. Edmonds, editor. Analysis of

coniferous forest ecosystems in the western United States. Hutchinson Ross, Stroudsburg, Pennsylvania.

201. The University of Oregon's Atlas of Oregon. 1976.

202. Thilenius, J. F. 1968. The *Quercus garryana* forests of the Willamette Valley, Oregon. Ecology 49:1124-1133.

203. Thomson, R. E. 1981. Oceanography of the British Columbia coast. Canadian Special Publication, Fisheries and Aquatic Sciences 56:1-292.

204. Thompson, K., and D. Snow. 1974. Fish and Wildlife Resources: Oregon coastal zone. Oregon Coastal Conservation and Development Commission, Portland, OR. 114 pp.

205. Tiner, R. W. 1984. Wetlands of the United States: current status and recent trends. National Wetlands Inventory. U.S. Fish and Wildlife Service. 59 pp.

206. Tisdale, E. W. 1983. Grasslands of western North America: the Pacific Northwest bunchgrass type. Pages 223-245 in A. C. Nicholson, A. McLean and T. E. Baker, editors. Grassland ecology and classification symposium proceedings. British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

207. _____. 1986. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. Bulletin No. 40. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID. 42 pp.

208. Topik, C. 1989. Plant association and management guide for the Grand Fir Zone, Gifford Pinchot National Forest. U.S. Forest Service, R6-ECOL-006-88.. 110 pp.

209. _____, N. M. Halverson, and T. High. 1988. Plant association and management guide for the Ponderosa Pine, Douglas-fir, and Grand Fir Zones, Mount Hood National Forest. U.S. Forest Service, R6-ECOL-TP-004-88. 136 pp.

210. _____, _____, and D. G. Brockway. 1986. Plant association and management guide for the Western Hemlock Zone, Gifford Pinchot National Forest. U.S. Forest Service. R6-ECOL-230A-1986. 132 pp.

211. Turner, R. B. 1969. Vegetation changes of communities containing medusahead (*Taeniatherum asperum* [Sim.] Nevski) following herbicide, grazing and mowing treatments. Ph.D. Dissertation. Oregon State University, Corvallis, OR.

212. Volland, L. A. 1976. Plant communities of the central Oregon pumice zone. U.S. Forest Service R-6 Area Guide 4-2. Pacific Northwest Region, Portland, OR. 113 pp.

- 212a. Walcott, C. F. 1974. Changes in bird life in Cambridge, Massachusetts from 1960 to 1964. *The Auk* 91: 151-160.
213. Ware, D. M., and G. A. McFarlane. 1989. Fisheries production domains in the Northeast Pacific Ocean. Pages 359-379 in R. J. Beamish and G. A. McFarlane, editors. *Effects of ocean variability on recruitment and evaluation of parameters used in stock assessment models*. Canadian Special Publication, Fisheries and Aquatic Sciences 108.
214. Washington Department of Ecology. 1994. Inventory of dams. Washington Department of Ecology, Water Resources Program, Dam Safety Section. Publication No.9
215. Washington Department of Natural Resources. 1998. Our changing nature--natural resource trends in Washington State. Washington Department of Natural Resources, Olympia, WA. 75 pp.
216. West, J. E. 1997. Protection and restoration of marine life in the inland waters of Washington State. Puget Sound/Georgia Basin Environmental Report Series: No. 6. Puget Sound Water Quality Action Team, Olympia, WA. 144 pp.
217. Wetzel, R. G. 1983. *Limnology*. Saunders College Publishing. New York, NY.
218. Whittier, T. R., R. M. Hughes, and D. P. Larsen. 1988. Correspondence between ecoregions and spatial patterns in stream ecosystems in Oregon. *Canadian Journal of Fisheries and Aquatic Sciences* 45:1264-1278.
219. Wiedemann, A. M. 1966. Contributions to the plant ecology of the Oregon Coastal Sand Dunes. Ph.D. Dissertation. Oregon State University, Corvallis, OR. 255 pp.
220. _____. 1984. The ecology of Pacific Northwest coastal sand dunes: a community profile. U.S. Fish and Wildlife Service, FWS/OBS-84/04. 130 pp.
221. Williams, C. K., B. F. Kelley, B. G. Smith, and T. R. Lillybridge. 1995. Forested plant associations of the Colville National Forest. U.S. Forest Service General Technical Report PNW-GTR-360. Portland, OR. 140 pp.
222. _____, and T.R. Lillybridge. 1983. Forested plant association of the Okanogan National Forest. U.S. Forest Service, R6-Ecol-132b. Portland, OR. 140 pp.
223. Williams, R. W., R. M. Laramie, and J. J. Ames. 1975. A catalog of Washington streams and salmon utilization. Washington Department of Fisheries. Volume 1: Puget Sound Region.
224. Winward, A. H. 1970. Taxonomic and ecological relationships of the big sagebrush complex in Idaho. Ph.D. Dissertation. University of Idaho, Moscow. 90 pp.

225. _____. 1980. Taxonomy and ecology of sagebrush in Oregon. Oregon State University Agricultural Experiment Station Bulletin 642:1-15.
226. Wolcott, E. E. 1973. Lakes of Washington. Water Supply. State of Washington, Department of Conservation, Bulletin No. 14. Volume 1: Western Washington. Olympia, WA.
227. _____. 1973. Lakes of Washington. Water Supply. State of Washington, Department of Conservation, Bulletin No. 14. Volume 2: Eastern Washington. Olympia, WA.
228. Zack, A. C., and P. Morgan. 1994. Early succession on hemlock habitat types in northern Idaho. Pages 71-84 in D. M. Baumgartner, J. E. Lotan, and J. R. Tonn, editors. Interior cedar-hemlock-white pine forests: ecology and management. Cooperative Extension Program, Washington State University, Seattle, WA.
229. Ziemer, R. R. 1981. Roots and the stability of forested slopes. Pages 343-361 in Proceedings of a symposium on erosion and sediment transport in Pacific Rim steeplands. Publication 132. International Association of Hydrological Scientists. Washington, D.C.
230. Zobel, D. B., L. F. Roth, and G. L. Hawk. 1985. Ecology, pathology and management of Port-Orford cedar (*Chamaecyparis lawsoniana*). U.S. Forest Service.

The crested ibis (*Nipponia nippon*), also known as the Japanese crested ibis, Asian crested ibis or Toki (㇏㇏), variously written in kanji as ㇏㇏, ㇏㇏, ㇏㇏, or ㇏㇏, and written in hanzi as ㇏㇏ or ㇏㇏, is a large (up to 78.5 cm (30.9 in) long), white-plumaged ibis of pine forests. Its head is partially bare, showing red skin, and it has a dense crest of white plumes on the nape. This species is the only member of the genus *Nipponia*.