Appendix 3. Defining the Willamette Valley–Puget Trough–Georgia Basin Ecoregion

Ecoregions define areas of general similarity in ecosystems and in the type, quantity, and quality of environmental resources (Pater et al. 1998) (see Map 1.2 "Ecoregions of Western North America"). They serve as a useful spatial framework for research, assessment, management, and monitoring of ecosystems and ecosystem components (Bryce et al. 1999). Ecoregion boundaries are established using knowledge of regional-scaled patterns in climate, physiography, and biotic communities. Given the integrative character of ecoregions, defining their boundaries is interpretive science, and several interpretations exist for North American ecoregions (Bailey 1994, Omernik 1995).

In 1996, TNC adopted the U.S. Department of Agriculture Forest Service Province scale units, derived from Bailey (1994), to define ecoregions that TNC could use to develop a series of detailed conservation assessments in the United States. The Pacific Lowland Mixed Forest Province (Unit 242) defined, generally, the U.S. portion of the ecoregion assessed in this document.

Subsequent to Bailey's work, a joint effort of the U.S. Environmental Protection Agency, the Natural Resource Conservation Service, the U.S. Forest Service, the Washington Department of Ecology and Department of Natural Resources, and The Nature Conservancy produced *Ecoregions of Western Washington and Oregon* (Pater et al. 1998). The map has a similar conceptual basis to Bailey's, but represents a significant improvement in the level of detail for defining landscape units and was very similar to the units defined by Omernik (1987). Within the U.S. portion of the Willamette Valley-Puget Trough-Georgia Basin (WPG) ecoregion, it was decided to adopt Omernik's boundary because it was consistent with local knowledge of the ecoregion and because the boundary also proved more consistent with ecoregional boundaries most often utilized in British Columbia.

The northern portion of the ecoregion, the Georgia Basin, was defined using slightly modified boundaries of the Georgia Depression "ecoprovince," of Demarchi (1996). These boundaries coincide with the Eastern Vancouver Island, Georgia-Puget Basin, and Lower Mainland ecoregional units that were defined as part of *A National Ecological Framework for Canada* (Ecological Stratification Working Group 1995).

The WPG ecoregion is further split up into four sections (Table 1.1, Map 1.3). A description of each of these sections and what sets each apart from the other sections in the ecoregion is discussed below.

Table 1.1. Ecoregion and Section Area Measures

Section	Hectares (Acres)	% of Ecoregion
Willamette Valley	1,047,600 (2,588,575)	19
Lower Columbia	642, 200(1,586, 927)	12
Puget Trough	1,918,700 (4,741,137)	35
Georgia Basin	1,942,100 (4,798,942)	35
TOTAL	5,550,600 (13,715,581)	100

Willamette Valley Section

The Willamette Valley Section is characterized by pre-European dominance in the landscape of prairies, oak savanna, and open woodlands. The climate is moderate in terms of precipitation and is warmer, especially in summer, than the other sections. Fluvial terrace and floodplain landforms of relatively recent origin predominate in the relatively flat valley bottom. Residual soils predominate on the foothills that surround the valley bottom. Historic vegetation was mostly a mosaic of dry and wet prairies, riparian floodplain forests, oak savannas, woodlands dominated by tall shrubs with scattered oaks and Douglas fir

(shrub barrens ecological system), and dry evergreen forest and woodland. This mosaic was controlled and maintained by indigenous burning practices, with fire frequency presumably controlling vegetation type. The Douglas-fir western hemlock-western redcedar forest system that dominates the three sections to the north is only common around the perimeter of the section where precipitation and elevation is somewhat greater. The large Willamette River flows through the valley bottom for the length of the section. The boundary between this section and the Lower Columbia section is the line at which the historic landscape pattern changed from forest-dominated to prairie/savanna/woodland-dominated.

Lower Columbia Section

The Lower Columbia Section is characterized by extensive pre-European conifer forest on old, well-weathered soils and more recent alluvial deposits associated with Pleistocene floods. This section includes ancient residual soils and ancient glacial drift in the north where landforms are flat to very hilly, and Pleistocene era fluvial deposits, the result of the Ice Age Floods, in the Portland Basin area of the south where landforms tend to be less hilly. Most of the soils are relatively fine-textured. While the historic landscape was dominated by forest, it also had significant well-distributed areas of wet and dry prairie, oak woodland, and abundant wetlands however bogs and fens become relatively rare this far south). Dry evergreen forest and woodland is rare to uncommon in the northern portion of the section and common in the Portland Basin. A short section of the massive Columbia River flows through the Portland Basin. The climate is relatively moderate by ecoregion-wide standards, except that the Portland Basin is frequently affected by hot or cold winds blowing out of the Columbia River Plateau to the east. This section was distinguished from the Puget Trough section by the southern limit of recent (Vashon stade) continental glaciation and associated outwash deposits.

Puget Trough Section

The Puget Trough Section is characterized by rolling to level plains of glacial drift deposited by recent continental glaciation. Most of the soils are relatively coarse-textured. Steep slopes (often with finer-textured soils) are found around Puget Sound marine shorelines and where streams and rivers dissect the glacial plain. This section has a moderate to relatively wet climate for this ecoregion. The vegetation is typified by the Douglas fir-western hemlock-western redcedar forest ecological system, with relatively small patches of dry evergreen forest and woodland mainly associated with localized prairie landscapes. Prairies and oak woodlands were historically common in a local areas with of coarse outwash around southern Puget Sound, and relatively rare to uncommon elsewhere. Wetlands (including bogs and fens) and lakes are very frequent because of the glacial landscape. The northeastern portion of this section has several extensive riverine bottomlands that are now prime agricultural land. Extensive marine shorelines tend to have better development of intertidal marshes and other estuarine communities than the Georgia Basin section. Annual precipitation primarily, and landforms secondarily, were used to distinguish between this section and the Georgia Basin.

Georgia Basin Section

The Georgia Basin Section is characterized by a dry, rainshadow climate and surficial geology that contains extensive areas of bedrock that was overrun by glaciers. Many of the soils are relatively shallow. This combination of climate and geology supports relatively dry-site vegetation and so there are relatively large amounts of dry evergreen forest and woodland, as well as many herbaceous balds and bluffs in this section. Oak woodlands were historically common (now less so) as small patches and prairies were once present in some areas though are now functionally extirpated. The landforms are more varied, hilly, and steep here than in the more southern sections and a few small hill tops extend up to montane elevations. Glacial drift deposits are also prominent in many some areas. Riverine floodplains tend to be relatively narrow and rivers not as large as in other sections. Extensive marine shorelines are included in this section. Intertidal marshes are relatively uncommon in this section in comparison to the Puget Trough section and rocky shorelines are more common.

Characteristics of the Ecoregion

Ecoregion boundaries are established using knowledge of regional-scaled patterns in climate, physiography (geology and soils), and biotic communities. Each of these components is described below.

Climate

The ecoregion has a Mediterranean-like warm maritime climate, with warm, dry summers followed by wet winters. Precipitation throughout the ecoregion is variably effected by the rain shadow produced by coastal mountain ranges. Overall, this is the driest ecoregion west of the Cascade Crest and north of southern Oregon, a larger region that is known for its abundant precipitation.

The mean annual temperature for this ecoregion varies between 11.8 ^{o}C in Eugene, Oregon to 9.8 ^{o}C in Vancouver, British Columbia (Table 1.2) though is undoubtedly lower at more northerly locations like Campbell River, B.C. and at higher elevations. The growing season lasts 140-240 days. Precipitation primarily occurs as rain between October and June, ranging from a low of about 50 cm annually in the extreme rainshadow of the Olympic Mountains to a high of about 230 cm in southwestern Mason County, Washington. Average annual precipitation from the major cities (91-111 cm) is fairly typical of much of the ecoregion.

Table 1.2. Climate Data Depicting Average Weather Conditions Along the North-South Axis of the Ecoregion.

City	Average Temp C (F)	Average Max Temp C (F)	Average Min Temp C (F)	Average Total Precipitation cm (in)	Average Total Snowfall cm (in)
Vancouver	9.8 (49.6)	13.6 (56.5)	6 (42.8)	110.7 (43.6)	47 (18.5)
Seattle	11.1 (52.0)	15.2 (59.3)	6.7 (44.1)	97.2 (38.27)	29.7 (11.7)
Portland	11.7 (53.1)	16.8 (62.3)	6.9 (44.5)	94.4 (37.16)	16.8 (6.6)
Eugene	11.8 (53.3)	17.7 (63.8)	5.0 (42.0)	91.3 (35.96)	14.7 (5.8)

Physiography: Geology and Soils

The northern two thirds of the ecoregion was glaciated, with rolling topography of glacial till and outwash overlying bedrock at depths up to 2,000 ft. (610 m). Sharp crests and narrow valleys are common along the margins of the ecoregion, especially on Vancouver Island. The San Juan and Gulf islands were scoured by glaciers, leaving exposed sedimentary rocks at the surface. Throughout the ecoregion, marine deposits of Tertiary age are exposed at the surface. The Willamette Valley floor is a series of floodplain terraces and low rolling hills, many resulting from the Pleistocene or Holocene (i.e., Ice Age) flood events. In some areas throughout the ecoregion, flood-derived silts reach a depth of 100 ft. (30m). Productive soils and temperate climate have made this ecoregion important for agriculture, especially in the Willamette Valley. Soils vary from coarse-textured gravelly sands that are excessively drained to moderately well drained with underlying clays. There are also extensive fine-textured and poorly drained clays and silts. South of glaciated areas, well-weathered soils have developed on old erosional surfaces.

Biotic Communities

Biotic communities include terrestrial ecological systems as well as wetland, freshwater, and marine ecological systems. Each is briefly described below.

Terrestrial Ecological Systems

Over the past several thousand years, uplands throughout the northern ¾ of the ecoregion have been dominated by conifer forests; with oak woodlands, savanna, and grassland becoming dominant to the south. Douglas-fir (*Pseudotsuga menziesii*) dominates the vast majority of conifer forests except in wetlands, and is often mixed with western hemlock (*Tsuga heterophylla)*, western red cedar (*Thuja plicata)*, or grand fir

(*Abies grandis)*, especially on less dry sites or climatic areas. Deciduous forests of big-leaf maple (*Acer macrophylla)* and red alder (*Alnus rubra)*, and are found in more disturbance-prone, moist sites. Herbaceous "balds" are common on exposed bedrock outcrops with thin soils and sunny exposures. Oregon white oak *(Quercus garryana)*, along with madrone (*Arbutus menziesii*), is common on dry sites from southern Vancouver Island south. Oak becomes more widespread in the Willamette Valley where it occupies more moist sites as well. Floristically diverse grasslands with Roemer's fescue (Festuca roemeri) and California oatgrass (Danthonia californica) were historically dominant on open plains where wildfire passed frequently. Native American use of fire likely maintained or augmented historic grassland extent (Cooper 1994, Norton 1979).

A number of terrestrial animal species have shown significant declines in the ecoregion over the past 100 years, presumably related to increased human development. They include amphibians endemic to the northwest such as the tailed frog (*Ascaphus truei*) and Cope's giant salamander (*Dicamptodon copei*), birds like marbled murrelets (*Brachyramphus marmorata*) and northern goshawks (*Accipiter gentilis),* invertebrates including Edith's checkerspot butterfly (*Euphydrayas editha taylori*) and the Oregon giant earthworm (*Driloleirus macelfreshi)*, mammals like the western gray squirrel (*Sciurus griseus*) and reptiles such as the northwestern pond turtle (*Clemmys Marmorata marmorata*). Though populations of declining animals may still persist in many areas, their long-term viability is called into question as these populations become more isolated from each other by continued development.

Wetland, Freshwater and Marine Ecological Systems

Diverse depressional wetlands support conifer forest, broadleaf forest and shrubland, fens and bogs, marshes and vernal pools. River floodplains support forest and shrubland of ash, cottonwood, willow, red alder, and maple. Extensive inter-tidal salt marsh characterizes major river deltas. Tidally influenced freshwater wetlands occur along the Columbia River and on the lower portions of some smaller rivers entering Puget Sound. Extensive wet prairies were historically characteristic of the Willamette Valley on moderate-poorly drained soils. They were likely maintained both by water table fluctuation and wildfire. Freshwater aquatic ecosystems primarily occur as rivers of variable size and gradient. Most rivers within the ecoregion are moderate to large, being located low in the watersheds that drain surrounding mountain ranges.

The marine waters of the WPG consist of three natural basins that formed nearly 150 million years ago as colliding continental plates formed the Georgia Depression, or Georgia Basin. To the north lies the long (220 km), broad (25-55 km), and deep Strait of Georgia. To the south, the Puget Sound. The sound is shorter, not as deep, and subdivided into numerous channels and bays. Connecting these two basins with the Pacific Ocean to the west is the open Strait of Juan de Fuca, whose western end connects with the Pacific Ocean. These basins contain a wide variety of habitats include coastal lagoons, kelp and sea-grass beds, rocky shores, sand beaches and spits, and salt marsh.

Characterized as an inland sea, the Georgia Basin is an estuary of global significance. Here the marine waters from the Pacific are diluted by thousands of rivers, large and small. These rivers originate high in the surrounding glaciated mountain ranges of the Cascades, Olympics, and Vancouver Island. About ¾ of the freshwater entering the Georgia Basin comes from the Fraser River in southern British Columbia and the Skagit River in northwest Washington.

Land Use and Population

An influential man-made feature of the WPG ecoregion is Interstate Highway 5 that extends from the southern portion of the Willamette Valley through the Puget Sound region of Washington to the Canadian Border. As I-5 crosses into British Columbia it becomes Route 99 and proceeds northward through Vancouver. This major transportation corridor has facilitated the conversion of landscapes from rural land uses, i.e., forestry and agriculture, to urban and suburban land uses, i.e., residential and commercial. Currently 60 % of lands in the ecoregion are considered in some type of natural land cover (e.g. forest), 25 % is in agriculture production, and 15 % is in residential or urban development (Table 1.3).

Table 1.3. Land Cover Summary for the Willamette Valley-Puget Trough-Georgia Basin Ecoregion.

Hectares					
Section	**Water**	**Natural**	**Urban**	**Agriculture**	**Sum**
Georgia Basin	1,179,392	602,111	106,069	51,680	1,939,251
Puget Trough	355,380	995,589	334,933	232,799	1,918,701
Willamette Valley	12,522	409,569	47,479	578,014	1,047,584
Lower Columbia	23,608	345,576	82,525	190,511	642,219
Total	1,570,902	2,352,845	571,006	1,053,003	5,547,755
Acres					
Section	**Water**	**Natural**	**Urban**	**Agriculture**	**Sum**
Georgia Basin	2,914,336	1,487,845	262,102	127,703	4,791,987
Puget Trough	878,162	2,460,151	827,636	575,257	4,741,206
Willamette Valley	30,943	1,012,065	117,323	1,428,302	2,588,632
Lower Columbia	58,336	853,935	203,923	470,762	1,586,956
Total	3,881,777	5,813,997	1,410,983	2,602,023	13,708,780

A more telling statistic and one that specifically begins to characterize the current condition of the ecoregion is the change in the population that has occurred over the past century. Oregon had a total population of just over 400,000 at the turn of the century. Today Oregon's population has increased over 800% to over 3.4 million. Sixty-seven percent of Oregon's population resides within the Willamette Valley portion of the ecoregion (Risser et al. 2000).

Washington's population was approximately 520,000 in the year 1900. In 2000, the population increased to 5.9 million, more than an 1100% increase. The Washington portion of the ecoregion contains 74.2 % of the states overall population (US Census Bureau 2000).

British Columbia has seen the most significant increase in total population. At the turn of the century British Colombia had significantly less people than both Washington and Oregon. A 2300% increase in population has seen the province grow from 178,000 to 4.1 million people. Nearly 73% of the people residing in British Colombia reside within the WPG Ecoregion (StatCan 2002).

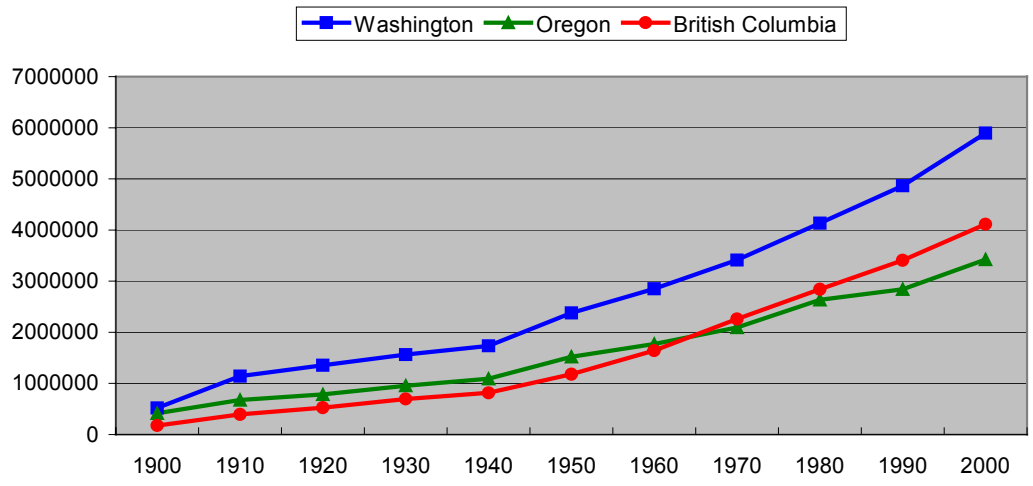

Figure 1.1. Population trends in Oregon, Washington, and British Columbia.

Ecosystems are dynamic and change at varying rates, with short-term cycles and long-term trajectories. In many places, however, Euro-American land use has abruptly altered the cycles and trajectories and has had

an obvious impact on native biodiversity. This is most evident in the Willamette Valley-Puget Trough-Georgia Basin with regard to fire regimes and the removal of relatively frequent, often human-ignited (Native American) fires from the landscape.

Ownership for the ecoregion is shown in Maps 1.4a and 1.4b.

Protected Status Classifications

Planning for conservation at a regional or large landscape scale requires comparing how much protection different land use jurisdictions provide for their species and natural processes. Biodiversity Management Status Categories (BMSC) or GAP codes were developed by the United States Geological Survey and have been used by governmental and non-governmental organizations to provide broad geographic information on the current protected status of a given land use jurisdiction. The BMSC are also called Gap Codes because they are used to identify gaps between land areas that are rich in biodiversity and areas that are managed for conservation. Gap code definitions are found in Table 1.4 and the area in hectares for GAP code classifications is shown in Table 1.5. Map 1.5 shows distribution of GAP code classifications in the ecoregion.

Table 1.4. Gap Analysis Program (GAP) Code Definitions

Code	Definition
Gap 1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management. Examples: National Parks, Nature Preserves, Wilderness Areas.
Gap 2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance. Example: State Parks, National Wildlife Refuges, National Recreation Areas.
Gap 3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area. Examples: National Forests, most Bureau of Land Management Land, Wildlife Management Areas.
Gap 4	There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.
Gap 5	This is not a standard status category. This code is used to classify open bodies of water (e.g., lakes, ponds, reservoirs) for which protection is "unknown."[1]

[1] (Cassidy et al. 1997, Kagan et al. 1999)
[2] From http://www.y2y.net/landuse/codes.asp

The following show Gap Codes for all the sections in the ecoregion.

Table 1.5. GAP Code Areas for Sections of Willamette Valley-Puget Trough-Georgia Basin Ecoregion

(in hectares)	Lower Columbia	Willamette Valley	Puget Trough	Georgia Basin	TOTAL
Gap 1	710	1,430	14,770	38,140	55,070
Gap 2	11,620	9,940	25,460	16,710	63,730
Gap 3	10,990	39,980	167,090	51,050	269,110
Gap 4	618,900	996,220	1,472,520	678,510	3,766,150
Gap 5?	0	0	238,860	1,157,700	1,396,550
TOTAL	642,210	1,047,580	1,918,710	1,942,100	**5,550,600**

[1] From http://www.y2y.net/landuse/codes.asp