APPENDIX E

The City's Natural Environment

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The City's Environmental Setting

General Characteristics

Portland is situated at 20 feet above sea level, near the confluence of the Columbia and Willamette rivers, about 65 miles inland from the Pacific Ocean. It lies midway between the lower Coast Range to the west and the high Cascades Range to the east, each about 30 miles distant. Portland's varied topography includes steep hills, isolated volcanic cones, low rolling hills and extensive flat areas. The area is composed primarily of alluvial deposits and Columbia River basalts. Much of the city is located in the Willamette Valley Plains ecoregion, although steeper portions of the Tualatin Hills on the west side are characteristic of Willamette Valley Hills and Coastal Mountains ecoregions (Clarke and others 1991).

Portland has a mild marine climate that is heavily influenced by the mountain ranges east and west of the city. The Coast Range protects the Portland area from Pacific storms, while the Cascades prevent colder continental air masses from invading western Oregon. In winter, the average temperature is 40°F and the average minimum temperature is 34°F. In summer the average temperature is 65°F with an average daily maximum of 74 to 78°F (Rockey 2002).

The Cascades also lift moisture-laden westerly winds from the Pacific, driving local rainfall patterns. Average annual rainfall in the Portland area is approximately 37 inches. Nearly 90 percent of the annual rainfall occurs from October through May. Only 9 percent of the annual rainfall occurs between June and September, with 3 percent in July and August. Precipitation falls predominantly as rain, with an average of only five days per year recording measurable snow.

The City of Portland's estimated 2000 population was nearly 530,000, and the City's population is expected to be approximately 589,000 by 2017. Land uses in the Portland area include industrial, commercial, low- and high-density residential and open space.

Portland's Watersheds and Waterways and Their Current Conditions

A number of tributaries to the Willamette River pass through the City of Portland, including Johnson Creek, Tryon Creek, Fanno Creek (via the Tualatin River), and a series of small tributaries draining the Tualatin Hills and Forest Park. In addition, the Columbia and Willamette River confluence area (including the Columbia Slough) lies within the City. A general overview of existing conditions within these watersheds is provided below. Detailed watershed characterizations were completed as part of the watershed management process (watershed characterizations are described in Chapter 3 of the *Framework*). The City's watersheds are depicted in Figure E-1 and described in the following sections. Additional information on Portland's watersheds can be found at http://www.portlandonline.com/bes.

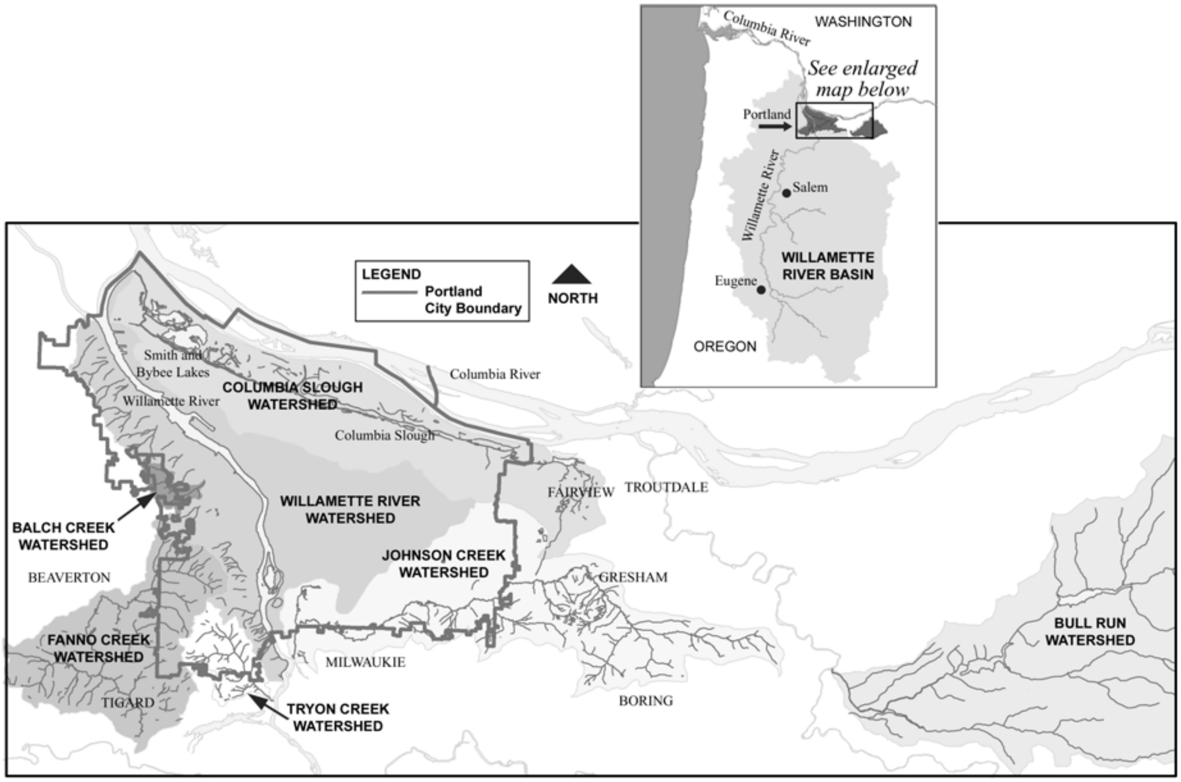

FIGURE E-1
City of Portland Watersheds

Lower Columbia River

The Columbia River is the second largest river in the contiguous United States in terms of stream flow. Land uses within the lower Columbia River watershed are urban/industrial, residential and rural/agricultural. Many of the region's heaviest industrial users are present in the lower Columbia watershed. Land uses in the basin upstream of Portland include timber production, grazing, irrigated and dryland agricultural and urban areas. The lower Columbia watershed has been heavily urbanized and industrialized in the vicinity of Portland for decades and has had many point source and nonpoint source pollution problems. The south bank of the Columbia River in this area of Portland is moderately urbanized. The banks are a mixture of steep natural cobble and sandbanks and riprap; riparian vegetation is generally sparse to absent and consists mostly of invasive plants and shrubs. The south bank of the Columbia River between North Portland Road on the west and the Sandy River on the east acts as a primary levee for flood control. The levee, located under and adjacent to NE Marine Drive, is managed by the Multnomah County Drainage District.

The lower Columbia watershed is degraded relative to historical conditions. River flow in the project area has been significantly altered from historical conditions as a result of the upstream storage reservoir releases and hydropower operations. The channel and broader floodplain has been diked and dredged, and steep, riprapped shorelines along the river have reduced growth of riparian areas and recruitment of large wood (that is, wood deposited through natural processes). Most of the historical off-channel habitats (side channels, oxbow lakes and marshes) have long since been cut off from the channel and filled. Silt and sand dominate the river substrate.

Water quality in the lower Columbia River is fair to poor in summer. Mainstem temperatures often exceed 20°C (68°F), and maximum temperatures can reach 26°C (79°F). The Oregon Department of Environmental Quality (DEQ) has listed the lower Columbia River, from the Willamette to the Bonneville Dam, as water quality limited for total dissolved gases and arsenic under the 303(d) process. This reach was also listed as water quality limited for temperature (summer), pH (spring) and toxics (tissue PCB and DDE, DDT).

The current biological conditions in the lower Columbia River have been degraded as a result of extensive changes in flow, habitat and water quality. Many nonnative fish species have been introduced into the Columbia Basin. This has resulted in increased competition and extirpation (that is, local extinction) of some native species and reduction of the biotic integrity of the system.

Lower Willamette River

The Willamette River is a tributary to the Columbia River at approximately river kilometer (Rkm) 164 (river mile [RM] 102). It is the 10th largest river in the contiguous United States in terms of streamflow. The Willamette Basin is 11,460 square miles in size and constitutes 12 percent of the land area of Oregon (Willamette Restoration Initiative 1999). In 1990, about 70 percent of Oregon's population lived in the Willamette Basin. The Willamette Basin is divided into 12 subbasins. The lower reach of the Willamette—the subbasin that includes the City of Portland—extends from the mouth upstream to the Willamette Falls at Oregon City (RM 26.5, Rkm 42 of the Willamette River).

Land uses within the lower Willamette River watershed in the vicinity of Portland and its suburbs are urban/industrial, residential and rural/agricultural. Many of the state's heaviest industrial users are present in the lower Willamette watershed. Land uses in the basin upstream of Portland include timber production, grazing, irrigated and dryland agricultural and urban areas.

The lower Willamette watershed has been heavily urbanized and industrialized for decades. Within the Portland downtown and harbor areas, the river's banks are typically steep and are primarily composed of bank stabilization and fill materials such as sheet pile, riprap, seawall and concrete fill. Riparian vegetation is generally sparse to absent and frequently consists of nonnative plants and shrubs.

The lower Willamette watershed is heavily degraded relative to historical conditions. Historically, the Willamette River in the Portland area comprised an extensive and interconnected system of river channels, open slack waters, emergent wetlands, riparian forest and adjacent upland forests on hill slopes and Missoula Flood terraces. Connectivity of habitat was high both longitudinally along the river and laterally from the vegetated riverbanks to the upland forests.

Gradually, habitats along the Willamette River have been destroyed, degraded or disconnected through construction of dams throughout the Willamette and Columbia rivers and from fill and development along the Willamette River shoreline and floodplain areas. Large expanses of black cottonwood/Pacific willow forest and spirea/willow wetland have been filled and developed, leaving small strips of riparian forest, wetland and associated upland forests. These remnants are few or entirely lacking for large reaches through the downtown and industrial segments of the river. Most of the historical off-channel habitats (such as side channels, oxbow lakes and marshes) have long since been cut off from the channel and filled. Connectivity and maintenance of these habitats have been reduced or eliminated as a result of marked alteration of the seasonal hydrograph[1], particularly dramatic reduction of peak flows during wet weather months. Connection of many tributary habitats to the mainstem is eliminated or reduced by culverts.

The channel has been diked and dredged throughout the Portland Harbor. The channelized characteristics of the Portland Harbor and surrounding area have adversely modified the habitat types and the localized flow regime. The urban setting minimizes the presence of riparian vegetation and the input of new large wood from riparian areas.

A few small areas of higher quality habitat remain within the highly urbanized reaches of the Willamette. Remnant habitats of high quality—or with the potential to provide important ecological functions if reconnected or restored—include Powers Marine Park, Ross Island, lower Stephens Creek, Tryon Creek, Oaks Bottom, Willamette Park, Kelley Point Park, the Forest Park watersheds and Smith and Bybee wetlands. In addition, natural areas along the Willamette River shoreline provide opportunities to restore lost floodplain and riparian wetland habitats.

Water quality in the lower Willamette River is fair to poor. In 2000, the Portland Harbor was placed on the National Priorities List ("Superfund") for elevated levels of DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and heavy metals. The Lower Willamette River is listed on the 303(d) list for temperature, bacteria, biological criteria (fish skeletal deformities) and toxics (mercury; arsenic and pentachlorophenol near the McCormick and Baxter site). DEQ also identified lead and copper as potential water quality concerns in a 1997 analysis (Oregon Department of Environmental Quality 1997). These parameters are being investigated further to evaluate whether they should be included on the 303(d) list, using ultra-clean sampling and analysis methods and improved detection limits.

The aquatic biota of the lower Willamette River has changed significantly from historical conditions. Extirpations of sensitive species have occurred, and introductions of nonnative species have resulted in increased competition for food and habitat for native species. The existing fish community in the lower Willamette River consists of warm-water, cool-water and cold-water fish. There are several listed salmonid evolutionarily significant units (ESUs) that use the lower Willamette River. At least 33 other native and introduced species of both warm-water and cool-water fish inhabit the river (Oregon Department of Fish and Wildlife 1994).

Johnson Creek

Johnson Creek originates in the hills east of Portland and flows westward approximately 25 miles to its confluence with the Willamette River. The stream receives water from several major tributaries, including Crystal Springs Creek, Kelley Creek, Mitchell Creek, Butler Creek, Hogan Creek, Sunshine Creek and Badger Creek. Land use in the 34,560-acre Johnson Creek watershed ranges from heavily developed urban areas (the cities of Portland, Milwaukie and Gresham) to rural farm and nursery lands (headwaters).

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[1] A hydrograph is the annual and seasonal trend in flow in a stream or river.

Flow monitoring indicates that low-flow conditions in Johnson Creek may adversely impact aquatic life. The Oregon Department of Fish and Wildlife (ODFW) has set minimum flow targets to protect salmonids in Johnson Creek (Meross 2000). Flows in the middle and upper watershed frequently do not meet those minimum flows, particularly in spring and summer months. Below Crystal Springs, which provides consistent and abundant groundwater flows, minimum instream flows are typically met.

There is also evidence of adverse impacts from excessive peak flows. The Sycamore gage provides the longest period of record with which to evaluate changes in flow over time that result from human activities.[2] Statistical evaluation of flow since 1940 indicates some increase in the flashiness of peak flows over the period of record (Clark 1999). Significant impacts on peak flows in Johnson Creek also appear to be affected by alterations in the stream channel and floodplain that change the way floods flow through Johnson Creek, as described below.

Johnson Creek has been substantially altered from its historical configuration. Diking, channelization and other alterations of the natural floodplain have eliminated many of the areas that once absorbed and conveyed floods through the watershed. One of the most significant alterations occurred in the 1930s when the Works Progress Administration widened, deepened, rock-lined and channelized 15 miles of the 25-mile stream in an attempt to control flooding. These alterations have had long-lasting and marked effects on the habitat and hydrology of the watershed. Most significantly, the historical floodplain of Johnson Creek is disconnected or minimally connected through much of the stream's length. The lack of floodplain connection means that flood flows cannot spread out and attenuate on the floodplain. Instead they are directed and concentrated into the main channel, where they increase scour and degrade instream habitat.

ODFW conducted habitat surveys throughout Johnson Creek (Oregon Department of Fish and Wildlife 2000). The department's findings indicate that Johnson Creek has extremely low wood volumes, a high percentage of hardened banks, lack of refugia through many reaches, channel incision and high levels of fine sediment. Riparian vegetation is minimal or lacking throughout much of the watershed. Interestingly, riparian vegetation is as lacking in the upper watershed as it is in the lower watershed.

Fish access to tributary habitat is impaired by culverts throughout the watershed. Although there are no culverts on the mainstem until high in the watershed, they are present on nearly all the tributaries to Johnson Creek. Crystal Springs, an area used by resident and migratory Willamette Basin salmonids, has a series of partially impassable culverts along its length, and some of the least developed tributaries along the southern side of the middle watershed also have culverts along their confluences with the mainstem.

Water quality in Johnson Creek is rated as fair to poor. Johnson Creek was placed on the 303(d) list by DEQ for bacteria, summer temperature and toxics (DDT and dieldrin). The 303(d) listing includes the entire stream, from the mouth to headwaters. The numerous investigations of temperature in Johnson Creek over the years have consistently indicated that elevated temperatures are a problem throughout the watershed.

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[2] The Sycamore gage is above the City of Portland and so does not reflect the impacts from the most intensely urbanized portion of the watershed. However, it does reflect impacts from Gresham and other changes within the middle and upper watershed since the 1940s.

The fish community in Johnson Creek is dominated by native redside shiners, reticulate sculpin and speckled dace (Johnson Creek Corridor Committee 1995). Largescale suckers are abundant in the lower reaches. Adult salmonids that have been observed in the stream include coho salmon, Chinook salmon, cutthroat trout and steelhead (ODFW unpublished data, as cited in Ellis 1994; C. Smith, City of Portland, personal communication, 2005).

Tryon Creek

Tryon Creek is a seven-mile free-flowing stream located in a 4,237-acre watershed. The stream flows in a southeasterly direction from the West Hills of Portland to the Willamette River near Lake Oswego. It is primarily a low gradient stream with steep hillslopes. The upper watershed has undergone common impacts associated with urban development, including increased stream velocities and stream bank erosion (City of Portland Bureau of Environmental Services 1997). The increased impervious surface in the upper watershed has resulted in higher volume peak flows during wet weather months, and low summer base flows.

Channel condition is typical of a moderate-gradient Cascade stream with steep slopes. Approximately 60 to 75 percent of the slopes within the watershed exceed a 30 percent grade (City of Portland Bureau of Environmental Services 1997). This results in a high frequency of mass wasting and erosion. In addition, soils in the watershed are from a silt loam series (Cascade) that are underlain by a fragipan[3] that impedes water infiltration and root penetration. This results in a high incidence of wind throw, mass wasting, channel incision and bank erosion.

Historically, Tryon Creek provided habitat for sea-run cutthroat, steelhead, and coho salmon. However, development activities, particularly culvert and road crossings, have resulted in degraded habitat and migration barriers. Habitat in Tryon Creek has been evaluated in ODFW stream surveys (Oregon Department of Fish and Wildlife 2000) and a City of Portland corridor assessment (City of Portland Bureau of Environmental Services 1997). Instream habitat ranged from marginal to optimal in a few areas, with most of the marginal habitat within the more heavily urbanized upper watershed. Highest quality habitats were located within Tryon Creek State Natural Area and Oregon State Parks, which had wide and relatively undisturbed riparian, floodplain and upland buffers. Even within this protected area, however, wood volume was low and channel incision was evident. Above the park the stream becomes highly segmented by road crossings and their associated culverts, and it is affected by intensive urban development.

Arnold Creek, one of the larger tributaries to Tryon, has good instream habitat within the lower section, with suboptimal percentages of fines, bank erosion and incision being the primary forms of degradation within the lower reaches. However, Arnold Creek is highly segmented by culverts from road and driveway crossings. In addition, invasions of nonnative plants are evident even within the higher quality areas of Arnold Creek and Tryon Creek State Park. Falling Creek, another major tributary to Tryon, has poor to marginal instream habitat, with a lack of instream cover, poor bank and riparian structure and excessive fine sediments.

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[3] A soil layer, often composed of clays, that can act to slow or impede infiltration of water.

Water quality in Tryon Creek is good to fair. Tryon Creek is on the DEQ 303(d) list for summer temperature. An examination of the data indicates that with the exception of temperature and bacteria, water quality generally meets water quality standards.

Impairment of fish access to habitat by culverts is a significant issue throughout the Tryon Creek watershed. A large culvert is present at the mouth of Tryon Creek just above its confluence with the Willamette River (at RM 19.9). Although baffles are present within this culvert, it is likely that the culvert impairs salmonid movements into and out of the watershed. An impassable culvert is present at Boones Ferry Road. Above this, there are many additional impassable culverts on Tryon and Arnold creeks that limit movements of resident fish through the watershed. A series of waterfalls and rapids at Marshall Park (at RM 2.7) would have naturally limited anadromous fish access prior to the presence of culverts, except during high flows.

Fanno Creek

Fanno Creek is a tributary to the Tualatin River Basin, which drains about 20,500 acres (City of Portland Bureau of Environmental Services 1997). Land use in Fanno Creek is dominated by residential and commercial activities. Impervious areas, which are connected to a stormwater drainage system, make up 28 percent of the watershed, and 12 percent of the watershed consists of impervious areas that are not connected to the storm drain system.

Instream habitat quality in Fanno Creek and in two tributaries—Vermont and Woods creeks—was rated as extremely impaired or threatened, primarily as a result of adverse effects from excessive amounts of fine sediment (City of Portland Bureau of Environmental Services 1997). High channel erosion is present through much of the watershed within the city as a result of lack of bank vegetation, large wood and rock. These factors result in limited habitat complexity and instream cover. Channel morphology is generally poor and dominated by pools or glides with very few riffle areas. Isolated areas with comparably higher habitat values are present in some reaches in relatively undeveloped areas, headwater reaches, and at tributary confluence areas.

As a tributary to the Tualatin River, Fanno Creek has total maximum daily loads (TMDLs) for temperature, total phosphorus, dissolved oxygen and bacteria. Urban and suburban development within the watershed has contributed to these water quality problems as a result of reduced riparian vegetation and increased nutrient loading and stream temperatures.

Most of Fanno Creek within the City of Portland is currently inaccessible to anadromous fish because of impassable culverts downstream of City limits. However, anadromous steelhead and coho salmon likely historically used upper Fanno Creek for spawning and rearing, and could potentially in the future with fish passage improvements through mainstem habitats. The City of Portland sampled fish populations in 1993 and found reticulate sculpin, redshide shiner, cutthroat trout and peamouth present in the upper reaches.

Forest Park Streams (Balch Creek, Miller Creek and Other Tributaries)

The Forest Park streams contain a number of small watersheds such as Balch and Miller creeks. Land use within these subbasins is largely open space, although there are also residential, industrial and transportation uses.

Because of the extensive protection provided by Forest Park, the Forest Park watersheds are probably among the least altered watersheds within Portland when compared with their historical conditions. The exception to this is in the lower reaches, where each stream must pass under Highway 30 and through the heavily industrialized port and industrial areas along the banks of the Willamette. The streams typically pass through pipes for considerable lengths through this section and receive stormwater and combined sewer overflow discharges before discharging to the Willamette.

The hydrographs in these small watersheds are probably reasonably comparable to historical conditions because of the low overall percentages of imperviousness and small amounts of stormwater drainage to them. Channel conditions range from mature forested stands with good bank stability in the middle and upper sections to underground pipes that carry the streamflow through industrial areas and then out to the Willamette River via a pipe outlet in the lower sections.

Limited water quality data are available for these streams. Based on our knowledge of these streams, water quality is probably generally good, except in the lower sections, which receive stormwater and CSO discharges. Excessive amounts of fine sediment may occur in sections of these streams near residential or industrial development. Summer temperatures may be unsuitable in certain areas, as a result of reduced and unvegetated riparian areas. Toxic contamination may be an issue in reaches receiving CSO and stormwater discharges.

The biota of the Forest Park streams are likely altered relative to historical conditions. The piping of streams and installation of culverts have blocked habitat access for anadromous fish; this has resulted in the extirpation of native anadromous fish species. Resident cutthroat trout are still present in many of these watersheds.

Columbia Slough

The Columbia Slough extends 18 miles from Fairview Lake on the east to the Willamette River at Kelley Point Park on the west. The slough drains 51 square miles, or 33,000 acres, of residential neighborhoods, commercial and industrial areas, open space and transportation corridors. The Columbia Slough is the remnant system of marshes, wetlands, lakes and side channels that historically formed the floodplain of the Columbia River between the mouths of the Willamette and Sandy rivers. However, the Columbia Slough has been severely altered from this historical condition. About half of the waterway is now a highly managed water conveyance system with dikes and pumps that provide watershed drainage and flood control and maintain a highly artificial hydrograph. Over the years extensive urban, agricultural and industrial development have profoundly altered the watershed and have resulted in a contaminated watershed that has lost a vast percentage of its upland, wetland and aquatic habitat.

The slough's channel configuration and flow regime have been altered significantly from historical conditions. Large amounts of open water areas and wetlands have been eliminated as a result of urban development, and the hydrologic connectivity of the entire system has been greatly reduced. The creation of the levee on which Marine Drive is located has blocked the direct connection between the Columbia Slough and the Columbia River system. A levee and pump station at NE 18th Avenue blocks passage of fish into the upper parts of the slough.

Consequently, juvenile salmonids from the lower Willamette River that are seeking out rearing habitats have access only to the lower section of the slough and Smith and Bybee wetlands.

Water quality in the Columbia Slough watershed is highly degraded. DEQ has placed the Columbia Slough on the 303(d) list for 10 parameters (four toxics, bacteria, nutrients, pH, dissolved oxygen, chlorophyll *a* and temperature).

The biological communities in the Columbia Slough are degraded as a result of the extensive degradation of flow, habitat and water quality conditions. Though heavily altered, these habitats continue to provide stopover, wintering and nesting habitat for over 200 bird species, including nesting bald eagles, great blue heron rookeries, and a number of other sensitive species. Fish communities are dominated by nonnative warm-water fish species such as common carp and bluegill although the Lower Columbia Slough and Smith and Bybee wetlands continue to provide important rearing and refuge habitat for juvenile steelhead, coho and Chinook salmon. All three native freshwater mussel species (*Anadonta* sp.) have been documented in the Columbia Slough and Smith and Bybee wetlands. Benthic macroinvertebrate communities are extremely sparse.

Biological Communities and Habitats in the City

Three broad classes of habitat are present in the Portland area that support fish and wildlife: aquatic, riparian and upland. A fourth habitat type—wetland—can occur in any of these, and therefore is also presented. The type, distribution and quantity of these habitats in Portland's watersheds and waterways are highly variable as a result of the diversity of environmental factors (topography, soils, geomorphology, climate, vegetation, etc.) and human-related factors (land use activities, habitat disturbance, etc.).

Habitat attributes can be used as valuable indicators of the composition and condition of the biological community. For example, the composition of biological communities can be tied in very predictable fashion to their preferred habitat associations. The health of biological communities is directly affected by the types and condition of specific habitat features. For example, salmonids prefer not only cold, clean and clear water but also specific physical habitat features, such as a diversity of depths, velocities and substrates.

Aquatic Habitats

Aquatic habitats can be broadly classified as running-water or slack-water systems. In the mainstem Columbia and Willamette rivers running-water habitats and the processes that form them differ substantially from running-water habitats in the much smaller tributaries. More than size and flow volume distinguish large, low-gradient streams from small tributaries. Elements such as flood frequency, channel characteristics, disturbance regimes and productivity all vary, creating unique habitats.

Floods are a driving force in large rivers such as the Columbia and Willamette. In these rivers, floods are often slow to rise, extensive and can last for several months, but they generally occur during predictable seasons. Plants and animals found in the floodplain environment have responded to this regime of predictable flooding by developing adaptations suited to the wetter location. In contrast, smaller tributaries tend to have irregular flood patterns that are strongly influenced by local precipitation events.

Tributary streams generally have smaller channels and narrower floodplains. The channel and the floodplain, when there is one, consist of larger rocks and boulders and poorly sorted gravels (Gurnell 1995). Pools, riffles and glides are common habitat features. Wood may be large enough to span the channel and is not easily dislodged in headwater streams. Where tributaries are wide enough and have flow volume that allows the downstream movement of logs and stumps, logs can accumulate in jams spaced several channel-widths apart. In large, low-gradient streams, sediments are sorted by size and generally include abundant fine particles of silt and clay. The pool, riffle and glide sequence common in the tributary streams is no longer the dominant feature of the habitat. Instead, channel roughness, shallow-water areas and deep pools define aquatic habitats. Logjams are scattered along the shoreline near the high-water line, at the end of islands and bars and submerged in the channel.

Disturbance regimes also can differ. In tributary streams, the more direct contact between the river and adjacent hillsides results in more frequent landslides, debris flows, dam-break floods and bank erosion. In turn, channel form is more likely to be influenced by mass wasting and alluvial processes (Naiman and others 1992). However, mass wasting is less common along large rivers because the river's terraces and floodplains generally insulate adjacent hillsides from the river's erosive forces. However, floods, tree falls and bank erosion are common forms of disturbance along large rivers.

Tributary streams typically have narrow tree canopy openings, which reduce the amount sunlight reaching the stream. In headwater streams as little as 1 to 3 percent of the total available solar radiation reaches the stream. This reduced sunlight helps maintain relatively cool and stable daily temperatures (Naiman and others 1992). As stream size increases, solar input increases. For large rivers, most of the solar input reaches the river, although penetration can be limited by river depth.

The amount of sunlight reaching large river waters supports the production of phytoplankton, periphyton and rooted vascular plants that are dominant in large river food webs. Fine particulate matter from upstream and from floodplains also plays a critical role in supporting the tropic structure of large river aquatic communities. Zooplankton and benthic detritivores are considered important invertebrate consumers. However, floodplain inundation is critical to providing the organic inputs necessary to support productivity. In smaller tributary streams primary production is lower. Invertebrates consume algae or organic material derived from riparian vegetation.

Riparian Habitats

Riparian areas are the environments adjacent to streams and rivers, a zone of direct interaction between terrestrial and aquatic ecosystems. An intact riparian area serves a multitude of functions vital to aquatic ecosystem health. More specifically, a healthy riparian and aquatic ecosystem provides the functions discussed below.

Organic Materials. Riparian vegetation influences adjacent aquatic systems by providing important components of the food web (Hachmoller and others 1991, Forest Ecosystem Management Assessment Team 1993), and it plays a significant role in the structure of aquatic communities. Litterfall, such as leaves, twigs, bark and needles, can fall to the ground or directly into the stream, providing an important food source for insects and invertebrates.

Channel Dynamics. Stream channels are dynamic systems. Water velocities and levels fluctuate, submerging and exposing the riparian zone and floodplain (Swanson and others 1982) through time. Meanders can slowly shift downstream or across the floodplain as erosion wears at stream banks, or they can migrate suddenly when a flood cuts a new channel that captures the bulk of a stream's flow. Wood entering the stream channel from the riparian area influences channel dynamics by diverting flow, creating channel roughness and stabilizing banks (Forest Ecosystem Management Assessment Team 1993, May and others 1997, Gregory and others 1991, Sedell and others 1988). Such processes help create a variety of habitats in the floodplain and maintain channel complexity. Annual flooding allows for the interchange of organic material and nutrients (in the form of wood, leaf litter and invertebrates) between the riparian and aquatic environments.

Water Quality. The roots, wood and soils in the riparian area contribute to water quality (Forest Ecosystem Management Assessment Team 1993). Roots and wood help limit sediments entering the stream by moderating the erosive power of floodwaters and holding soils in place (Budd and others 1987). Riparian vegetation acts as a barrier that reduces sediment and debris transport (Swanson and others 1982, Gregory and others 1991), slows surface flows and encourages infiltration (Budd and others 1987, Knutson and Naef 1997). Riparian areas also filter (from groundwater and surface flows) sediments (Forest Ecosystem Management Assessment Team 1993), pollutants (Knutson and Naef 1997), metals and excess nutrients (Castelle and others 1994). Riparian vegetation absorbs and stores nutrients and other dissolved materials as they are transported through the riparian zone (Spence and others 1996).

Water Quantity. In a watershed, a variety of characteristics, such as climate, topography, geology, geomorphology and vegetation, all interact to determine the amount and velocity of water flowing in a stream (Spence and others 1996). In riparian areas, and throughout a watershed, water can be stored and transported in the atmosphere, vegetation, stream channel, floodplain, soil and shallow or deep groundwater aquifers. Riparian features and functions are a critical part of this storage and transport system.

Riparian plants intercept, store and transpire water. Water stored in the atmosphere can be intercepted by vegetation or other structures. The leaves, needles and branches in the canopy and on the ground can absorb precipitation and prevent it from reaching the ground, or they slow its progress, thus reducing the amount of erosion and runoff (Black 1990).

Microclimate. The diverse structure and composition of the riparian zone create microclimates, multi-layered canopies and off-channel areas that provide fish and wildlife habitat. Riparian vegetation creates a microclimate that influences both the riparian area and stream environment by affecting soil moisture and temperature, air temperature, water temperature, wind speed and relative humidity (Forest Ecosystem Management Assessment Team 1993).

Wildlife Habitat. Budd and others (1987) claims that, regarding riparian habitat, "there is no other habitat type upon which wildlife is more dependent." This statement is supported by Kauffman and others (2001), who report that although riparian zones cover only an estimated one to two percent of the landscape, 53 percent (319 out of 593) of wildlife species that occur in Oregon and Washington use these areas. The Forest Ecosystem Management Assessment Team (1993) reports that most vertebrates regularly use the riparian zone for some part of their activity and that the zone also provides wet micro-sites, seeps and springs that are important for maintaining arthropods, mollusks, bryophytes, vascular plants and riparian-associated amphibians. Riparian vegetation also is known to influence benthic communities (Erman and others 1977), birds and mammals (Castelle and others 1994, Kauffman and others 2001) and herpetofauna (Kauffman and others 2001).

Intact riparian areas are important to fish and wildlife because they do the following:

- Have a high diversity of vegetation species and structure
- Often have unique vegetation assemblages relative to the upland area
- Exhibit high edge-to-area ratios because of their linear nature
- Influence the environment-microclimate, chemistry, structure
- Provide corridors and migration routes
- Provide habitat features necessary for the survival of many species, including water, forage, nesting and breeding habitat, resting areas and cover (Kauffman and others 2001)

Upland Habitats

Upland habitat refers to all areas that are not riparian, wetland or open water habitats. (It should be noted, however, that wetlands may be found within upland areas). Although most wildlife species associated with upland habitats also use riparian areas, they are dependent on upland areas for key aspects of their life history such as breeding, food or shelter. Habitat types found in upland areas include grassland or meadow, shrubs, coniferous or deciduous forests and rocky slopes.

Johnson and O'Neil (2001) describe five upland habitat types present in significant amounts in the Portland area. These include Westside Lowlands Conifer-Hardwood Forest, Westside Oak and Dry Douglas-fir Forest and Woodlands, Westside Grasslands, Agriculture Pasture and Mixed Environs, and Urban and Mixed Environs. These five make up the majority of upland habitats available to native wildlife in this region. Eighty-nine percent of all terrestrial species in the Portland area are associated with upland habitats, with at least 28 percent depending on these habitats to meet their life history requirements.

Westside Lowlands Conifer-Hardwood Forest

This habitat is widespread and prevalent in the Portland area. Historically and currently the most extensive of all natural habitats west of the Cascade Mountains, it often forms the matrix within which other habitats occur as patches and is very important to wildlife in this region. This habitat may be dominated by conifers, deciduous trees or both and tends to have structurally diverse understories. In nutrient-poor soil conditions evergreen shrubs dominate the understory, while nutrient-rich or moist sites contain more deciduous shrubs, ferns and grasslike plants. Mosses are a major ground cover component, and older stands are rich with lichens.

Several wildlife species dependent on this habitat are at risk at the state and/or federal level. This includes one amphibian, the Northern red-legged frog. At-risk bird species dependent on this habitat include band-tailed pigeon, Northern pygmy-owl and olive-sided flycatcher. Mammals include two bat species (long-legged myotis and silver-haired bat) and a tree-dwelling rodent, the red tree vole.

Westside Oak and Dry Douglas-Fir Forest and Woodlands

This habitat is limited in area and declining in extent and condition in the Willamette Valley. Conifers, deciduous trees or some combination of the two may dominate these typically dry woodlands. Canopy and understory structures are variable, ranging from single- to multi-storied, with large conifers sometimes emerging above deciduous trees in mixed stands. This habitat is too dry for western hemlock and western red cedar; lack of shade-tolerant tree regeneration, along with understory indicators such as tall Oregon grape, help distinguish oak woodlands from Westside Lowlands Coniferous-Hardwood forests. Large woody debris and snags are less abundant than in other westside forested habitats. Sweet cherry (*Prunus avium*) and English hawthorn (*Crataegus monogyna*) have invaded and sometimes dominate this habitat's subcanopy in the Metro region.

Several wildlife species dependent on this habitat are considered at risk at state and/or federal levels. These include band-tailed pigeon, Lewis' woodpecker (extirpated as a breeding species), acorn woodpecker and Western bluebird. At-risk mammals include Western gray squirrel and red tree vole.

Westside Grasslands

Once widespread in the Willamette Valley, Westside Grasslands are now rare and declining because of fire suppression, conversion to agriculture and urban habitats and invasion by nonnative species. In the Metro region, this habitat has virtually disappeared.

Agriculture, Pasture and Mixed Environs

Occurring within a matrix of other habitat types, agricultural lands often dominate the landscape in flat or gently rolling terrain, on well-developed soils and in areas with access to irrigation water. This habitat can be diverse, ranging from hayfields and grazed lands to multiple crop types, including low-stature annual grasses to row crops to mature orchards. Hedges, windbreaks, irrigation ditches and fencerows provide especially important habitat for wildlife (Demers and others 1995). The U.S. Department of Agriculture (USDA) Conservation Reserve Program lands are included in this category and may provide valuable wildlife habitat. Agricultural lands are subject to exposed soils and harvesting at various times during the year and receive regular inputs of fertilizer and pesticides, thus influencing the quality of water-associated habitats.

The greatest conversion of native habitats to agricultural production occurred between 1950 and 1985, primarily as a function of U.S. agricultural policy (Gerard 1995). Since the 1985 Farm Bill and the economic downturn of the early to mid 1980s, the amount of land in agricultural habitat has stabilized and begun to decline (National Research Council 1989). The 1985 and subsequent farm bills contained conservation provisions encouraging farmers to convert agricultural land to native habitats (Gerard 1995, McKenzie and Riley 1995). Clean farming practices and single-product farms have become prevalent since the 1960s, resulting in larger farms and widespread removal of fencerows, field borders, roadsides and shelterbelts (National Research Council 1989, Gerard 1995, McKenzie and Riley 1995). In Oregon, land-use planning laws adopted in 1973 prevent or slow urban encroachment and subdivisions into areas zoned as agriculture.

Twenty-nine percent of birds and 25 percent of mammals native to Oregon use croplands and pasturelands to meet their habitat needs (Puchy and Marshall 1993). Agricultural fields left fallow for the winter often provide wintering habitat for migratory birds (Puchy and Marshall 1993). Many of the species that use this habitat require the nearby associated aquatic habitats to meet their needs. Bird species at risk that depend on this habitat include Oregon vesper sparrow and Western meadowlark. One mammal, the Camas pocket gopher, is at risk at the federal level.

Urban and Mixed Environs

These areas are widely distributed but patchy. Urbanization encompasses all habitats with impervious surfaces covering at least 10 percent of the land's surface (less than 10 percent is considered rural). Characterized by buildings and other structures, impervious surfaces and plantings of nonnative species, urban environments provide habitat to some species requiring structures such as cavities, caves, cliffs and rocky outcrops and ledges. Nonetheless, neighborhood and street trees and vegetation is important for migratory birds and other native animals. This habitat is subdivided into low-density (10 to 29 percent impervious surfaces), medium-density (30 to 59 percent impervious) and high-density (60+ percent impervious) areas, described in detail in Johnson and O'Neil (2001). Many human-induced changes in urban areas are essentially irreversible; for example, building a house requires removing vegetation, scraping and leveling topsoil, building driveways and roads and running sewers and utilities both above and underground. Canopy cover is reduced in these habitats, and structural features present in historical vegetation, such as snags and dead wood, are rare.

Frequent human disturbance is normal in urban habitats, and species that are disturbance-sensitive tend to be absent or reduced in numbers (Marzluff and others 1998). Historical natural disturbance patterns are largely absent in urban habitats, although flooding, ice, wind or fire still occur. Flooding and pollution are more frequent and more severe in areas with significant impervious surface cover and/or modified stream systems. Temperatures are elevated, background lighting is increased and wind velocities are altered by the urban landscape (often they are reduced, except around the tallest structures downtown, where high-velocity winds are funneled around the skyscrapers). Urban development often occurs in areas with little or no slope and frequently includes wetland habitats. The urban and mixed environs habitat type is expected to increase at an accelerating pace locally and nationally (Parlange 1998).

Studies in the Pacific Northwest document declining wildlife diversity with increasing urbanization (Penland 1984, Puchy and Marshall 1993). Nonnative species and generalists are most common in urban habitats. Few sensitive species are associated with this habitat, because sensitive species are often habitat specialists that are quickly out-competed by nonnatives and generalists. The only closely associated mammal of concern is big brown bat (*Eptesicus fuscus*), also known by the common name "house bat." This nonmigratory species often lives in a variety of artificial structures, eating termites and beetles (Csuti and others 1997).

Artificial structures provide key habitat for some wildlife species in the urban area (Puchy and Marshall 1993). For example, bridges provide important bat habitat. Fences, power lines and poles provide perches from which hawks and falcons search for prey. Ledges of several tall buildings in the urban area provide perching sites for wintering peregrines, from which they can chase prey (Puchy, personal communication, 2001). Nest boxes and bird feeders provide valuable resources, as the continuing recovery of western bluebirds within the Metro area demonstrates. Chapman Elementary School in Portland is renowned for the annual roosting of thousands of Vaux's swifts in the furnace chimney, and the school community is working to conserve these long-distance migrants (Robertson 1999). Since 1993 peregrine falcons have chosen the Fremont Bridge, the St. Johns Bridge and other structures in the Portland area as a nesting place, as these structures have characteristics similar to the high cliffs that would be attractive in the wild (Sallinger 2000; Puchy, personal communication, 2001). The bridges provide two important functions for the peregrine falcons: a high nesting spot inaccessible to humans and proximity to a constant food supply, in the form of nonnative pigeons, starlings and other birds.

There are no species at risk dependent upon this habitat, although the purple martin population in Portland appears to be dependent on artificial nest boxes along Marine Drive (Puchy, personal communication, 2004).

Wetland Habitats

Wetlands can occur in aquatic, riparian and upland areas, and play important roles in watershed health. Key wetland functions are described below.

Streamflow, water storage and watershed hydrology. Wetlands are of major importance to watershed hydrology. Riparian wetlands intercept surface and subsurface (groundwater) runoff from the upland regions of the watershed, and thus function as buffers for the river systems. Riparian wetlands found in low-lying areas adjacent to rivers and streams are periodically subject to overbank flooding and can provide important seasonal storage and flood control functions (Debusk, 1999; Adamus et al., 2002). Wetlands function like sponges, storing floodwater, surface water or groundwater, and slowly releasing it (Arkansas Multi-Agency Wetland Planning Team, 2001). How riparian wetlands interact with groundwater and floodwaters, can vary considerably depending on their geomorphology, e.g., located in headwater areas, riparian slopes, floodplains, etc. (Cole et al., 1997). Upland wetlands formed by depressions in the landscape my be isolated from stream and rivers and can have a lesser role in the surface hydrology of the watershed (DeBusk, 1999). However, isolated wetlands commonly are integral parts of extensive groundwater flow systems, and isolated wetlands can spill over their surface water divides into adjacent surface water bodies during periods of abundant precipitation and high water levels (Winter, T. and LaBaugh, J.W., 2003).

Bank stabilization and sediment, pollution and nutrient control. Wetlands play an important role in maintaining water quality. When wetlands reduce flows and velocity of floodwaters, they reduce erosion and allow floodwaters to drop their sediment (CA Dept. of Water Resources 2000). Chemicals and nutrients can enter a wetland through surface water and sediment, or through groundwater. Riparian wetlands have been shown to be highly effective in the reduction of non-point source (NPS) loading of nutrients and sediments to rivers and streams. The physical and biogeochemical processes that occur in wetlands provide a natural filtering mechanism in the watershed to maintain or enhance downstream water quality (Debusk 1999). Nutrients such as nitrogen and phosphorus are transferred from water to sediment, wetland plants or atmosphere (Arkansas Multi-Agency Wetland Planning Team 2001). Wetlands can also help to decompose organic waste materials and heavy metals. Of particular significance to downstream water quality are riparian wetlands associated with low-order (smaller) streams, because of the large hydrologic throughput in these wetlands relative to the flow in the river or stream. These wetlands generally occur in the upper reaches of watersheds (DeBusk, 1999).

Channel dynamics. Wetlands help contribute to channel dynamics by moderating flood flows that can cause scour or channel down-cutting. Wetlands also help stabilize the banks of drainageways, creeks and small streams, and seeps and springs, reducing erosion and sedimentation in adjacent waters. Wetlands protect banks from erosion by absorbing and dissipating the impact of waves and fast flowing, running water (Metro 1998). Floodplain and riparian wetlands can also contribute to channel complexity and provide fish and wildlife access to off-channel habitats (Adamus et al., 2002).

Organic inputs, food web, and nutrient cycling. The production, accumulation, dispersal, and decay of plant material in appropriate amounts and at appropriate times of the year are essential to maintaining healthy aquatic food webs. Because of their high productivity, wetlands provide essential food chain support (Mannix and Morlan for the Woodland Fish and Wildlife Project, 1994). Floodplain wetlands are often productive because nutrients are regularly cycled through the system by floodwaters, discharging groundwater, and extensive ecotones between oxic and anoxic sediments (Adamus et al., 2002).

Microclimate. Wetlands help maintain the local microclimate. Evapotranspiration from wetlands maintains local humidity and rainfall levels. Vegetation in and surrounding wetlands can help maintain the microclimate at the wetland edge, a factor particularly important in small wetlands (British Columbia Ministry of Forest Research Program 2000). Vegetation removal in or around a wetland can result in changes to local microclimate (Mannix, R. and Morlan, J. for the Woodland Fish and Wildlife Project, 1994).

Habitat. Wetlands provide food in abundance, water, refuge from summer heat, shelter from winter cold, hiding cover, late summer green forage when upland areas are dry, and critical breeding and rearing habitats (Mannix and Morlan for the Woodland Fish and Wildlife Project, 1994). Wetlands provide important habitat for a variety of species, including resident and migratory birds (e.g., swallows, flycatchers, waterfowl and shorebirds); mammals (e.g., bats, ungulates, and beavers); amphibians (e.g., salamanders and frogs); as well as important plant species such as cattails, sedges, rushes, pond lilies and willows (Missoula County, 1999).

Salmonid Use of the Lower Willamette River Basin and Portland's Waterways

Adult Chinook, coho and steelhead migrate through the lower Willamette River to reach spawning areas in the Clackamas River and the middle and upper reaches of the Willamette River Basin. In addition, fry, subyearling and yearling salmon rear and reside in available habitats of the lower Willamette River. Because the lower Willamette River is the only migratory route for adult and juvenile salmonids, habitat quantity and quality (and environmental condition) through the lower river prominently affects pre-spawn survival, spawning success; juvenile growth and survival; and ultimately potential population productivity of Willamette Basin salmonids.

Below is a brief description of Willamette River Basin salmon and their use of the lower Willamette River basin, including mainstem and tributary use.

Chinook Salmon (*Onchorynchus tshawytscha*)

Juvenile Migration. Recent studies through the lower, middle and upper Willamette Basin show that juvenile Chinook express complex life history traits (Cramer 1996; ODFW 2005; Schroeder et al. 2003). For example, ODFW staff biologists (Schroeder et al. 2003) have documented three distinct migration patterns in McKenzie River spring Chinook: 1) age-0 fry that migrate in late winter through early spring, 2) age-0 subyearlings that migrate in late winter through early spring, and 3) yearling smolts that migrate in early spring. These documented life history traits are similar to those observed in the 1950's and 1960's (Mattson 1962, Mattson 1963, Craig and Townsend 1946).

Four consecutive years of fish monitoring and research (below Willamette Falls) confirm the presence of large numbers of subyearling Chinook salmon using mainstem habitats for a greater portion of the year (ODFW 2005), particularly from November through June and July. Data likewise show that yearling Chinook travel quickly through the lower river (median migration rate = 12.4 km/day and residence time = 2.4 days), coincident with increasing river flows and increasing body size (or forklength). Baker and Miranda (2003) note that subyearling Chinook enter Multnomah Channel and the lower Columbia Slough from January through June, with peaks in February, and Portland General Electric staff observe Chinook fry and juveniles passing the Willamette Falls (Sullivan Plan) during high flow events (Reed 2004). In addition to mainstem use, juvenile Chinook have been documented in lower tributary reaches of Johnson Creek and Crystal Springs Creek (Ellis 1994, Reed and Smith 2000) and have been documented in the lower Columbia Slough and Smith and Bybee Lakes (Fishman Environmental Services 1987). The combination of these studies confirms the Independent Scientific Group's (2000) belief that juveniles move from upriver tributary sites into mainstem habitats to rear and over winter before migrating to the ocean (Healey 1991).

Juvenile Feeding and Growth. Salmonid diet studies in large, low gradient rivers, such as the lower Willamette River are scarce. In the early 1960's, Mattson analyzed scales of returning adult Chinook salmon to evaluate relative growth patterns during freshwater rearing. Mattson (1962) concluded that growth rates of fry and subyearling Chinook that reared in the lower Willamette River (near Lake Oswego) exceeded freshwater growth rates of yearling migrants that remained in the upper Willamette tributaries such as the McKenzie, Middle Fork Willamette and Santiam rivers. Mattson (1962) further concluded that the small number of yearling spring migrants experienced superior freshwater growth in the lower Willamette River. Howell et al. (1985) found similar results, noting that juveniles rearing in the lower mainstem Willamette had an accelerated growth pattern and emigrated seaward up to two months earlier than juveniles emigrating from upper Willamette Basin tributaries.

Recent studies completed by ODFW suggest similar findings. From 2000 through 2004, ODFW (2005) analyzed the diet and growth rate of juvenile Chinook in the lower Willamette River, specifically from Willamette Falls to the confluence with the Columbia River. They found that migrating yearling Chinook extensively feed in the lower Willamette River. Baker and Miranda (2003) likewise documented subyearling growth during residence in the lower Columbia Slough, Smith and Bybee Lakes and in several locations of Multnomah Channel from January through June. Diet analysis show that daphnia are a dominant food item (comprising 91% of the food items in the samples collected) and comprise a significant proportion of dietary intake (43% of the weight) throughout most of the year. The compilation of recent studies confirms what Mattson (1963), Howell (1988) and others concluded nearly 50 years before – the lower Willamette River is valuable rearing habitat.

Adult Migration. Willamette Basin spring Chinook are an early-run population and are believed to be relatively isolated from other Columbia Basin spring Chinook salmon. As early as 1903, Oregon state fish biologists noted that Willamette River salmon were an early-run fish that enter the Columbia River basin early in the season in order to navigate above Willamette Falls and get up into remote areas of the upper Willamette River (and its tributaries) (Department of Fisheries 1905). The majority of Willamette River spring Chinook historically matured in their fourth and fifth year, with five year olds comprising the largest portion of the run. Today, spring Chinook enter the Willamette at age three to five from April through June.

Adult migrations generally coincided with periods of high rainfall or snowmelt and with warmer temperatures. This relationship between flow and run-timing of Willamette Basin Chinook has long been recognized by fishery biologists. Adult spring Chinook enter the lower Columbia and Willamette Rivers beginning in February and ascend Willamette Falls in April and May (with peak migrations from mid to late May) (Myers 2003, Wilkes 1845). Depending on weather patterns and the river state, migration timing may vary. In recent past, spring Chinook have ascended the falls beginning in March, with peak passage in May, and the majority of adults passing in April and May (Firman et al. 2005).

Although a large portion of the spring run passed and occupied reaches above the falls, historic records show that a run of spring Chinook entered the Clackamas subbasin in March, prior to the upper Willamette fish run. The upper Clackamas basin was historically very productive for spring Chinook salmon. Oregon Department of Fisheries (1903) reported that, "the Clackamas River is, as has always been conceded, the greatest salmon breeding stream of the water that our state affords". Important areas included the upper mainstem river and the Collawash River, particularly the Big Bottom area. The Clackamas River run historically entered the river in March and April, and sometimes as early as February (Barin 1886). Today, adults enter the upper Clackamas basin from May through July, with peak spawning in October.

Adult Spawning. Adult spring Chinook migrate slowly upstream, holding in deep pools (0.10-m to 10-m) through the summer (Chapman, 1943; and Briggs, 1953), then spawn in mid- to upper river reaches in late summer and fall (between August and November). Spawning generally begins in late August or early September (but sometimes as early as late July in the Clackamas and Molalla rivers (Dimick and Merryfield 1945)) and continues through mid-October, with peak spawning in September. Dimick and Merryfield (1945), and Mattson (1963) observed that spawning generally coincided with a slight drop in water temperature following the first few cool nights. Today, Willamette River spring Chinook continue to spawn from late August through October, with peak spawning in September (Schroeder et al. 2003, Olsen et. al. 1992).

Most, if not all fall Chinook native to the Willamette Basin populated reaches below Willamette Falls, most notably the lower Clackamas River, Johnson Creek, Abernathy Creek and Scappoose Creek (Hutchinson and Aney 1964, Willis et al. 1960, Myers 2003). Today, a late-run population of Chinook salmon continues to spawn and rear in the lower Clackamas River; however, it is unknown whether these fish are of fall Chinook origin or are the later part of the spring-run. Adults enter freshwater at an advanced stage of maturity and spawn shortly after reaching their spawning grounds (from mid-September through early October). Both Stone (1878) and Barin (1886) observed Chinook salmon returning to the lower Clackamas River (just upstream of

Clear Creek) beginning in early September, with "ripe" spawning salmon observed just two weeks later in mid-September. Due to managed flows in the Willamette, and fish passage improvements at Willamette Falls (beginning in the 1880's) fall Chinook ascend Willamette Falls and spawn and rear in middle reaches of the Willamette subbasin; the McKenzie River is believed to be the only basin above the Falls to sustain significant natural production (Myers 2003).

Both spring and fall run Chinook historically and presently spawn in areas below Willamette Falls, most prominently the Clackamas River, Johnson Creek (and Crystal Springs Creek), Milton Creek, and Scappoose Creek (Hutchinson and Aney 1964, Willis et al. 1960). Today, there has been little documentation of the extended presence of adult Chinook in Johnson Creek and Crystal Springs.

Coho (*Onchorynchus kisutch*)

Historically, the lower Willamette River basin provided the third most important spawning grounds for coho salmon throughout the entire Columbia River basin (Fulton 1970). Coho are believed to be native only to subbasins below Willamette Falls, notably the Clackamas River, Johnson Creek (Fulton 1970), Tyron Creek, and tributaries of Multnomah Channel (Willis 1960). This population, now classified as the Lower Columbia River coho population (or Evolutionarily Significant Unit) is listed "endangered" under the State ESA (July 1999) and were recently listed "threatened" under the federal ESA (June 2005). Critical habitat has not yet been identified by NOAA Fisheries, however, based on historic and present fish use, the lower Willamette River (and its tributaries) up to Willamette Falls includes critical spawning and rearing habitat for this ESU.

Life history of this population is based upon native populations in the Lower Willamette River, most notably the early-run Clackamas River population. Native lower Willamette basin coho return as three-year age adults and two-year age jacks. They are an early run population, reaching Willamette Falls from late August through early November, with peak migrations occuring from middle to late September, following periods of considerable rainfall. Peak spawning generally occurs soon afterwards from September through December. Coho commonly use tributaries to lower river reaches, and spawn in small, low-gradient areas; however, they will spawn in mainstem reaches. Generally, they prefer fast-flowing waters with small to large gravel substrates (1.3 to 10.2 cm). After fertilization, eggs incubate for 80-150 days, depending on stream temperatures. Fry emerge from mid-January through April, yielding a four-month emergence period. During this period they seek shallow water areas, before dispersing downstream into deeper habitats. While a small proportion of fry emigrate during the first year, most fingerling smolts emigrate during the second spring, beginning in March and extending through mid-July. Those that remain in their natal streams will migrate upstream or downstream, seeking slack water habitats often found in side channels, backwater pools, and beaver ponds. These habitats are especially important during overwintering months because they harbor insects and provide a continual source of food for coho. Yearling juvenile coho emigrate seaward in early spring, with peak migrations in April and May. Generally, coho will rear for two additional years in the ocean and return to their natal streams as three- and four-year age adults in the fall.

Steelhead (*Onchorynchus mykiss*)

Anadromous and resident steelhead (or rainbow trout) inhabit eastside and westside tributaries of the Willamette River Basin (Dimick and Merryfield 1945). Populations below Willamette Falls are part of the larger Lower Columbia River Evolutionarily Significant Unit (ESU), listed as "threatened" under the federal Endangered Species Act in March 1998 and reaffirmed in January 2006. Critical spawning and rearing habitat was described and adopted by NOAA Fisheries in January 2006, and includes all streams and tributaries in the lower Willamette River, below Willamette Falls. Tualatin River steelhead are part of the larger Upper Willamette River ESU, which were listed in March 1998 and reaffirmed in January 2006. Critical habitat designations for these populations were adopted in January 2006; and include all of the Willamette River in Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River.

The life history of lower Willamette River populations (most prominently the Clackamas River) is generally a late returning population, taking advantage of high river flows (and cool stream temperatures) to move upstream and navigate natural falls and high gradient stream reaches. The lower Willamette populations return to spawn during their fifth and sixth year. Native, late-run winter steelhead enter the Willamette River from October through May (Dimmick and Merryfield 1945). Spawning begins as early as March; however, peak spawning is believed to be greatest in April in westside tributaries and May in eastside tributaries. Steelhead spawn in cool, clear, and well-oxygenated streams with small to large gravel (1.3 to 11.4 cm) and suitable flow (0.76 meters/second) (USFWS 1983). These conditions are found in riffle-type habitats and are typical of habitat found in the upper tributary reaches. Most steelhead die after spawning, however, some will re-enter the ocean, returning to their natal stream for a second time to spawn again. Adults exhibiting this life history characteristic are called "kelts".

Eggs hatch and fry emerge in winter or early spring, depending on habitat, water temperature, and spawning season. After emergence, fry continue to rear in riffle-type habitats through the summer, then move into pools in the winter. Steelhead generally become inactive in winter months, often burrowing into stream-bottom substrates and other available instream cover. Steelhead, like Chinook, rely on an abundance of instream structure for cover during overwintering months.

Juvenile steelhead generally spend two years in freshwater before smolting, with peak juvenile emigration beginning early April and extending through early June, and larger steelhead emigrating earlier than smaller ones (ODFW 2000). Smoltification is initiated by a combination of environmental factors including photoperiod, water temperature, and water chemistry. Larger steelhead generally emigrate sooner than their smaller cohorts (ODFW 2000). Marine survival is correlated with smolt size, with the critical minimum size ranging from 14 to 16 cm upon saltwater entry. Steelhead rear in the ocean for one to four years before returning to their natal streams.

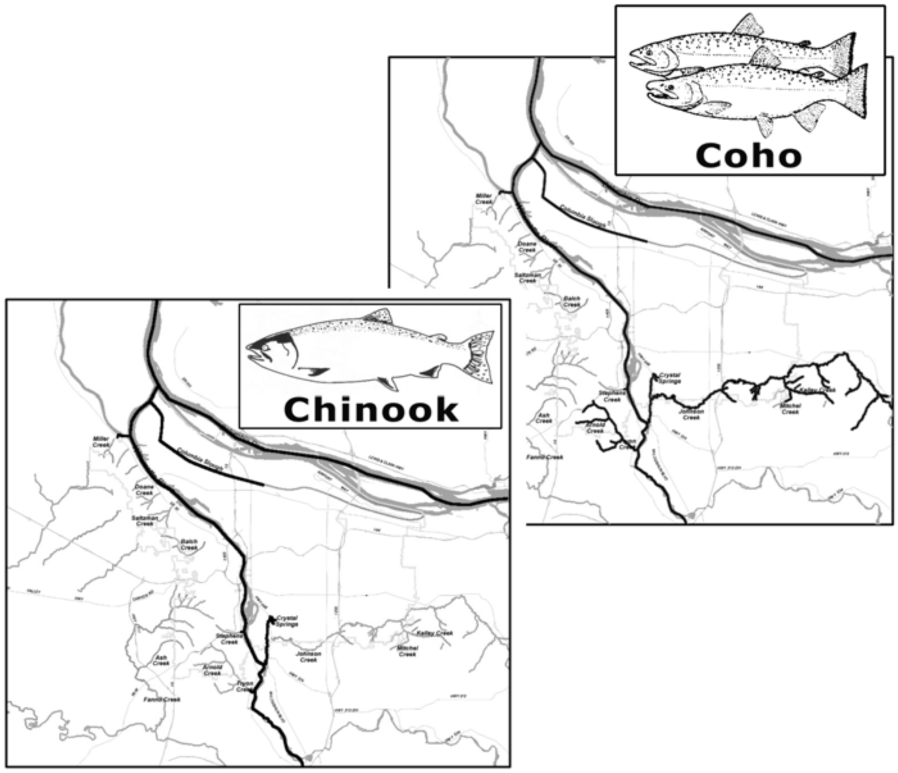

FIGURE E-2
Distribution of Chinook and Coho Salmon In Portland's Waterways

Cutthroat (*Onchorynchus clarki)*

Coastal cutthroat had the greatest overall distribution of any of the salmonids in the Willamette River Basin, and were known to populate most streams in the basin (Hutchinson and Aney 1964). Dimick and Merryfield (1945) reported "few tributaries of the Willamette system is without cutthroat trout unless blocked by natural barriers. Two life-history phases of cutthroat trout resided in Portland area streams: migratory and non-migratory. Non-migratory, or resident, cutthroat historically did not migrate far from upper tributary reaches (Hutchison and Aney 1964), remaining in fresh water for their entire lifespan. Migratory, or sea-run, cutthroat were believed to drop down into the mainstem Willamette River in the spring, rear throughout the summer, then migrate to the ocean in the fall or early winter. Notably, they did not use the mainstem reaches for spawning; rather, they used them for spring, summer, fall, and early winter rearing. Sea-run cutthroat were noted to reside predominantly near tributary confluence regions of mainstem Willamette River. The U.S. Fish and Wildlife Service previously considered Southwest Washington/Columbia River coastal cutthroat trout a "candidate" species for federal ESA listing. However, in June 2002, that agency determined that the population did not warrant protection under the ESA, based on trends in population abundance and recently enacted fish and habitat protections (that included protections by the City of Portland).

In 1945, Dimick and Merryfield noted that no morphological differences between resident and sea-run cutthroat, except for differences in the size of adults. One distinct difference they did note was related to spawn timing; sea-run cutthroat spawned in January, February, and March (much like native winter steelhead), while resident cutthroat spawned in May, June, and July. Notably, in Oregon and Washington, sea-run cutthroat return to their natal stream anytime from mid-summer through spring of the following year, with peak movement occurring from September thru October. Generally, they migrate to upper mainstem and tributary stream reaches (above favorable coho and steelhead spawning habitat), but will spawn and rear along-side other resident fish (notably, resident cutthroat and rainbow trout). Selection of these upper reaches spatially segregates them from other co-occurring salmonids and avoids competition for rearing and spawning areas. Cutthroat spawn in small- to moderate-size gravel, often in pool tail-outs. They are repeat spawners; if they survive post-spawning, they overwinter in fresh water and emigrate downstream the following spring. Adult migrations generally precede emigration of juvenile cutthroat heading seaward. Note, some female cutthroat do not spawn in the first winter after returning to freshwater (Johnston 1982). Rather, they overwinter in freshwater, then return to the ocean the following spring.

Eggs incubate for four to six weeks in the gravel. Upon emergence, fry seek shallow stream margins, with low-velocity flows. During early life history rearing cutthroat are opportunistic feeders, feeding predominately on aquatic invertebrates suspended in the water column. If other salmonids are present, fry can be easily displaced; their distribution and habitat use is therefore highly dependent on interspecific competition with other native fishes. Notably, juvenile (and adult) cutthroat generally prefer deep pools and low-velocity instream habitats, but will move either upstream and downstream to seek food, avoid competition and find better rearing habitats. Cutthroat smolt from age one to four (and sometimes later), but generally at age three or four, when they reach a size of 200 to 250 mm (fork length). Downstream migrations generally occur from March to June, peaking in mid-May. A unique characteristic that cutthroat exhibit (different from other salmonids) is that they form schools before salt-water entry and remain schooled throughout their saltwater migrations and rearing. In the ocean, cutthroat remain close to the Pacific shoreline, rearing in shallow waters. Although salt-water residence time varies among populations, cutthroat tend to re-enter freshwater in the same year they migrated to sea; hence return to their natal stream during the subsequent fall season.

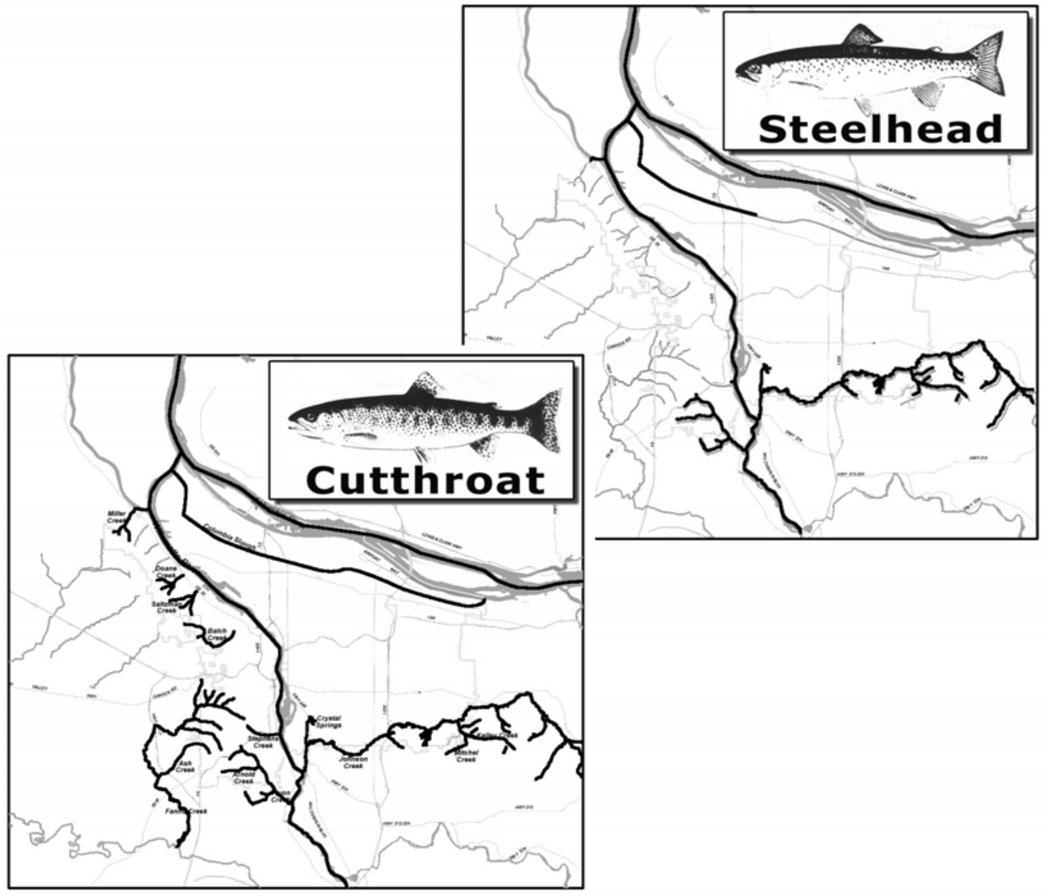

FIGURE E-3
Distribution of Steelhead and Cutthroat Trout in Portland's Waterways

Wildlife in Portland's Watersheds

The Portland metro area is fortunate to have retained some important natural areas such as Forest Park, the East Buttes, Cooper Mountain, Smith and Bybee wetlands, Big Four Corners, and other habitat that is essential for maintaining a diversity of wildlife species within the urban area. While some wildlife species that once inhabited our region are no longer found, remaining natural areas still provide habitat for many wildlife species, as well as recreational opportunities for humans (Houck and Cody 2000).

Metro's Regional Urban Growth Goals and Objectives (RUGGOs), adopted in 1995 state that "a region-wide system of linked significant wildlife habitats should be developed. This system should be preserved, restored where appropriate, and managed to maintain the region's biodiversity." Also in 1995, citizens of the Portland metro area passed a $135.6 million bond measure to acquire natural areas within the Portland metropolitan region. Metro has since acquired more than 8,000 acres of key habitat. The Metro Council will consider putting a Regional Greenspaces Bond Measure before voters in 2006. If passed, this measure would provide funds for additional land purchases as well as fish and wildlife habitat-related projects.

Amphibians

There are sixteen extant native amphibian species in the Portland metro area, including twelve salamanders and five frogs (see Metro's species list in Appendix 1 of Metro's *Technical Report for Goal 5*, revised draft dated January 2002; see http://www.metro.dst.or.us/metro/habitat/habitat_fish_docs.html). An additional species, the bullfrog, is introduced and places considerable pressure on native species. Amphibians and birds are the two groups in the area most dependent on aquatic and riparian habitats. In the Portland area, 69 percent of native amphibian species (salamanders, toads and frogs) rely exclusively on stream- or wetland-related riparian habitat for foraging, cover, reproduction sites and habitat for aquatic larvae. Another 25 percent use these habitats during their life cycle. Six Portland-area amphibian species are state-listed species at risk; four species are considered at risk at the federal level (see Metro's species list).

Because amphibians require both aquatic and terrestrial habitats to complete their life cycle, changes to either ecosystem may interfere with amphibians' success (Schueler 1995). Small non-fish-bearing streams and beaver ponds may be important because they are free from competition and predation by fish (Gomez 1998, Metts and others 2001). As with salmonids, amphibians have specific habitat requirements and are sensitive to environmental change. Clean, relatively sediment-free water, rocky stream beds and woody debris are important to amphibians in western Oregon (Bury and others 1991, Welsh and Lind 1991, Butts and McComb 2000).

Reptiles

Thirteen native reptile species inhabit the Portland area, including two turtle, four lizard and seven snake species (see Metro's species list). This is the least riparian-associated group; even so, 23 percent of native reptile species depend on water-related habitats and another 46 percent use water-related habitats during their lives. Although most lizards and snakes are associated with upland habitats, many species use riparian areas extensively for foraging because of the high density of prey species and vegetation. Both of the native turtle species — the Northwestern pond turtle and the Western painted turtle — are riparian/wetland obligates and rely on large wood in streams, wetlands and lakes for basking (Kauffman and others 2001). These two turtles are state and/or federal species at risk. Several nonnative turtle species have established breeding populations in Portland, and they compete with native turtle species.

Birds

Birds represent the majority of vertebrate diversity in this region, and 209 native bird species occur in the Portland area (see Metro's species list). An additional four nonnative species have established breeding populations in the area. In the Portland area, about half (49 percent) of native bird species depend on riparian habitats for their daily needs, and 94 percent of all native bird species use riparian habitats at various times during their lives. Twenty-two bird species are state or federal species at risk (see Metro's species list). Nineteen of these are riparian obligates or regularly use water-based habitats. An additional riparian obligate, the yellow-billed cuckoo, is extirpated in the Portland area.

Bird abundance, species richness and diversity are typically higher in riparian habitats compared to other habitat types (Stauffer and Best 1980, LaRoe and others 1995, Kauffman and others 2001). This reflects greater plant volume and structural diversity (birds are highly threedimensional in their habitat use) and food, water and habitat resources associated with riparian vegetation (LaRoe and others 1995).

Mammals

Mammals are another diverse group of species in the Portland area, with 54 native species (see Metro's species list). This is the terrestrial group with the highest number of nonnative species (eight species, or 15 percent of total species; most are rodents). Of native species, 28 percent are closely associated with water-based habitats, with another 64 percent using these habitats at various points during their lives. Six out of nine bat species are state or federal species at risk. Three native rodent species are similarly listed.

Riparian resources are important to mammals for many of the same reasons they are important to amphibians and birds (i.e., diverse habitat structure, abundant coarse woody debris, good connectivity, access to water and a wealth of food resources) (Butts and McComb 2000, Kauffman and others 2001). In Pacific Northwest forests, multispecies canopies, coarse woody debris and well-developed understories (dominated by herbs, deciduous shrubs and shade-tolerant seedlings) are important to small mammal biodiversity across a broad spatial scale (Carey and Johnson 1995). Other Pacific Northwest studies have shown increased small mammal abundance and/or diversity with increasing coarse woody debris (McComb and others 1993, Butts and McComb 2000, Wilson and Carey 2000). Riparian forests contain high amounts of coarse woody debris, and this may be why some studies document higher small mammal abundance in riparian habitats than in uplands (Doyle 1990, Menzel and others 1999, Bellows and Mitchell 2000).

Mammals can profoundly influence habitat conditions for other animals, including fish. Beaver, a keystone species in riparian areas, play a critical role in the creation and maintenance of wetlands and stream complexity and may have broad effects on physical, chemical and biological characteristics within a watershed (Cirmo and Driscoll 1993, Snodgrass 1997, Schlosser and Kallemeyn 2000). Historically, beavers were nearly extirpated from the Willamette Valley as a result of trapping, but populations have rebounded (Oregon Department of Fish and Wildlife 2001). Large herbivores such as deer browse on herbs and shrubs, which can promote vigorous growth (Kauffman and others 2001). Medium-sized carnivores keep rodent and small predator populations in check, with important implications for bird nest success. Bats help regulate insect populations and may contribute to nutrient cycling, particularly in riparian areas (LaRoe and others 1995).

Priority Wildlife Habitat Types and Wildlife Species

In 2005, the Oregon Natural Heritage Information Center developed preliminary lists of priority wildlife habitats and species that should be considered for future conservation actions in Portland[4]. Those lists have been augmented by City staff, and will be refined over time. At this

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[4] There are several classification systems that are useful in understanding the biological communities and habitats in the Portland area. In addition to the "Habitat Types" developed by Johnson and O'Neil (2001), presented earlier in this appendix, there are "Ecological Systems" and "Wildlife Habitat" classifications. Ecological systems and wildlife habitat classifications are similar. The distinction is that ecological systems are biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes (such as fire or flooding). They are vegetation-based classifications. Wildlife habitat classifications are similar, but include tree size classes and structural components that may be important to wildlife species. Because the ecological systems and wildlife habitats classifications are similar, only the priority habitats and species are presented in Tables E-1 and E-2. The Oregon Natural Heritage Information Center developed a "cross-walk" matrix showing the relationships between the various classification systems.

time, invertebrates and plants are not included.   In the future, City staff also will determine wildlife species-habitat associations, associations with aquatic species and habitats, and develop objectives, measures and actions to achieve the Physical Habitat and Biological Communities goals.

Priority Wildlife Habitat Types in Portland

The following wildlife habitat types are considered important for possible future conservation and/or restoration for the reasons listed.

TABLE E-1
Priority Wildlife Habitats in Portland and Reasons for High Importance

PRIORITY WILDLIFE HABITATS	REASONS FOR HIGH IMPORTANCE
Marsh	Diminished habitat extent; importance for water quality and fish protection.
Large Mixed Conifer-Deciduous	Diminished habitat extent. There are opportunities in the City of Portland for development of legacy old-growth stands and control of exotics.
Oak	Diminished habitat and rare or at-risk species associated with oak woodlands and savannah.
Westside Grasslands	Important statewide for diminished habitat extent and rare species associated with them. Exotic species are of concern.
Westside Riparian	Important for water quality and fish protection. Most occurrences are fragmented and of low quality because of buffer widths, lack of tree overstory and abundant exotic species. There are many restoration opportunities in the City of Portland to improve buffer widths and riparian vegetation, remove barriers, and daylight culverted stream reaches.
Medium Mixed Conifer-Deciduous	Diminished habitat extent. There are opportunities in the City of Portland for development of legacy old-growth stands and control of exotics.
Medium West Side Douglas-fir Mixed Conifer	Diminished habitat extent. There are opportunities in the City of Portland for develop of legacy old-growth stands and control of exotics.

Priority Wildlife Species in Portland

The amphibians, reptiles, birds and mammals potentially having high priority for conservation with the City of Portland, along with reasons for their importance are listed in Table E-2. Species considered priorities are those that:

- are known to be showing population declines, either regionally or more broadly, and for which conservation or restoration efforts by the City of Portland may be particularly beneficial;
- have been listed as priorities by the Oregon Watershed Enhancement Board in its process of identifying land acquisition priorities;

- have been designated with some federal or state status (e.g., federally-listed under the Endangered Species Act, classified by the Oregon Fish and Wildlife Commission as a Sensitive Species[5]) and/or
- have been identified as "focal species" by Partners In Flight (PIF)[6] in the "Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington" or "Conservation Strategy for Landbirds in Coniferous Forests of Western Oregon and Washington".

TABLE E-2
Priority Wildlife Species in Portland and Reasons for High Importance

PRIORITY SPECIES[7]	REASONS FOR HIGH IMPORTANCE
Amphibians	
Northern red-legged frog	USFWS Species of Concern; ODFW Sensitive Species (Vulnerable); OWEB priority; general pattern of extirpation continues where introduced warm water fishes and bullfrogs have invaded (recruitment is very low in these areas)*
Reptiles	
Western painted turtle	ODFW Sensitive Species (Critical); OWEB priority; continuing habitat loss and high predation of nests by raccoons and of juveniles by non-native warm water fishes and bullfrogs*
Northwestern pond turtle	USFWS Species of Concern; ODFW Sensitive Species (Critical); OWEB priority; continues to decline from lack of recruitment, urbanization, predation, and agricultural practices*
Birds	
American bittern	OWEB priority; lack of high-quality, large freshwater wetlands
Great blue heron	OWEB priority; declining regional populations; sensitive to expanding disturbances
Hooded merganser	OWEB priority; nest in tree cavities, not always adjacent to a body of water
Bald eagle	USFWS Threatened; ODFW Threatened
Northern harrier	PIF focal species; loss/fragmentation of large wetland/upland prairie complexes

5 Sensitive Species are those naturally-reproducing native animals which may become threatened or endangered throughout all or any significant portion of their range in Oregon (OAR 635-100-140). There are four sub-categories of Sensitive Species—Critical, Vulnerable, Peripheral or Naturally Rare, and Undetermined Status.

6 Partners In Flight is an international effort aimed at ensuring healthy populations of native landbirds. The Bird Conservation Plan was developed by American Bird Conservancy, in cooperation with numerous individuals, agencies and organizations within the Oregon-Washington chapter of Partners In Flight.

7 Species generally are listed in phylogenetic order, not necessarily in order or importance.

* Also identified as a "Strategy Species" in the Oregon Department of Fish and Wildlife's Draft Comprehensive Wildlife Conservation Strategy for Oregon (2005) for the Willamette Valley Ecoregion. "Strategy Species" are those closely associated with "Strategy Habitats" or are declining for a variety of reasons. It should be noted that small parts of Portland are within two other ecoregions—the Coast Range and West Cascades. There may be additional species that could be considered "Strategy Species".

American kestrel	OWEB priority; PIF focal species; highly significant declining trend; loss of old oak savannah trees with cavities for nesting
(American) Peregrine falcon	ODFW Endangered
Dunlin	OWEB priority; wetlands and flooded fields important for non-breeding season foraging
Band-tailed pigeon	USFWS Species of Concern; OWEB priority; highly significant declining trend; needs closed canopy coniferous forests for nesting and open canopy coniferous forests for foraging
Short-eared owl	OWEB priority; loss/fragmentation of large wetland/upland prairie complexes*
Vaux's swift	PIF focal species; loss of late-stage seral forests with snags for nest and roost sites; significantly declining population trends at regional and western Oregon and Washington levels
Downy woodpecker	PIF focal species; needs deciduous riparian snags; competition with European starlings for nest cavities
Pileated woodpecker	ODFW Sensitive Species (Vulnerable); PIF focal species; needs mature, large trees and snags for nesting, roosting and foraging; needs dense canopy to provide cover from predators
Olive-sided flycatcher	USFWS Species of Concern; ODFW Sensitive Species (Vulnerable); OWEB priority; PIF focal species; significantly declining population trends at regional and western Oregon and Washington levels
Western wood-pewee	PIF focal species; highly significant declining trend; loss/degradation of riparian gallery forest and oak woodland openings and edges
Willow flycatcher	ODFW Sensitive Species (Vulnerable); OWEB priority; PIF focal species; highly significant declining trends at regional and western Oregon levels; needs dense riparian shrub habitat*
Pacific-slope flycatcher	OWEB priority; PIF focal species; needs mature/young deciduous canopy trees; significantly declining population trends at regional, western Oregon and Washington levels
Red-eyed vireo	PIF focal species; fragmented riparian gallery forest (especially cottonwood) along the Columbia River and tributaries
Streaked horned lark	USFWS Candidate Species; ODFW Sensitive Species (Critical); OWEB priority; PIF focal species; small and local populations lack protection; needs short grass with areas of bare ground for nesting; significantly impacted by land management (e.g., mowing, tilling)*
Purple martin	USFWS Species of Concern; ODFW Sensitive Species (Critical); OWEB priority; PIF focal species; loss of large snags with cavities in open forest and adjacent large bodies of water*
White-breasted nuthatch	OWEB priority; PIF focal species; highly significant declining trends; loss/degradation of large patches of oak woodlands and savannah, especially with old trees*
Swainson's thrush	PIF focal species; needs dense understory riparian shrub habitat
Yellow warbler	OWEB priority; PIF focal species; significant declining population trend; loss/fragmentation of structurally diverse riparian woodlands and thickets dominated by willow and cottonwood

Yellow-breasted chat	ODFW Sensitive Species (Critical in the Willamette Valley Ecoregion); long-term declining trend; needs riparian shrub habitat*
Chipping sparrow	OWEB priority; PIF focal species; highly significant declining trend; loss/degradation of oak woodlands with an open, herbaceous understory*
Oregon vesper sparrow	USFWS Species of Concern (*affinis* subspecies); ODFW Sensitive Species (Critical); OWEB priority; PIF focal species; vulnerable small and local populations lack protection; needs grassland with scattered shrubs and/or bunchgrass; significantly impacted by land management such as mowing and grazing*
Tri-colored blackbird	USFWS Species of Concern; ODFW Sensitive Species (Peripheral or Naturally Rare); loss of wetland habitats for breeding
Western meadowlark	ODFW Sensitive Species (Critical in the Willamette Valley ecoregion); OWEB priority; PIF focal species; highly significant declining trends; requires large patches of grassland habitat; loss/degradation of grassland/prairie and oak savannah habitat; significantly impacted by land management (e.g., mowing, grazing)*
Bullock's oriole	OWEB priority; PIF focal species; highly significant declining trends at regional and western Oregon levels; fragmented riparian gallery forest (especially cottonwood) along the Columbia River and tributaries
Mammals	
California myotis (bat)	ODFW Sensitive Species (Vulnerable)*
Yuma myotis (bat)	USFWS Species of Concern
Long-legged myotis (bat)	USFWS Species of Concern; ODFW Sensitive Species (Undetermined)
Fringed myotis (bat)	USFWS Species of Concern; ODFW Sensitive Species (Vulnerable)
Long-eared myotis (bat)	USFWS Species of Concern; ODFW Sensitive Species (Undetermined)
Silver-haired bat	USFWS Species of Concern; ODFW Sensitive Species (Undetermined)
Pacific western big-eared bat	USFWS Species of Concern; ODFW Sensitive Species (Critical)*
Western gray squirrel	ODFW Sensitive Species (Undetermined)*