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Exhibit A
Resolution 02-3177A

Contents:

- Metro's Riparian Corridor and Wildlife Habitat Inventories (preliminary draft, August 8, 2002)
- Memo dated July 29, 2002 entitled "Revisions to Metro's January 2002 Technical Report for Goal 5"
- Memo dated July 23, 2002 entitled "City of Hillsboro's Technical Review (Fishman report): Wildlife portion"
- Metro's Technical Report for Goal 5 plus appendices (includes revisions referred to in July 29, 2002 memo)

PRELIMINARY DRAFT

Metro's Riparian Corridor and Wildlife Habitat Inventories

AUGUST 8, 2002

AUGUST 8, 2002 PRELIMINARY DRAFT

METRO'S RIPARIAN CORRIDOR AND

WILDLIFE HABITAT INVENTORIES

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Introduction

Metro has completed its Goal 5 inventory, following the Goal 5 rule, for riparian corridors and wildlife habitat within its jurisdiction. The Goal 5 rule defines an ***inventory*** as "a survey, map, or description of one or more resource sites...that includes information about the resource values and features associated with such sites." The Goal 5 rule provides specific guidance on the inventory process for local governments to follow. The rule describes a standard inventory process, which involves four steps, and specific rules for each of the fifteen Goal 5 resource categories addressed in the rule. An optional inventory approach, known as a "safe harbor," satisfies certain requirements under the standard process (OAR 660-23-020 (1)). The Goal 5 rule allows for the inventory process to be conducted for a "single site, for sites in a particular geographical area, or for the entire jurisdiction or urban growth boundary (UGB), and a single inventory process may be followed for multiple resource categories that are being considered simultaneously" (OAR 660-23-030 (1)).

The Goal 5 rule includes guidance for Metro in addressing the Goal 5 rule on a regional basis. The rule allows Metro to identify regional resources, defined as "...a site containing a significant Goal 5 resource, including but not limited to a riparian corridor, wetland, or open space area, which is identified as a regional resource on a map identified by Metro ordinance" (OAR 660-23-080 (1)(b)). Goal 5 identifies "riparian corridors" and "wildlife habitat" as two resources among many. Local governments are required to address all Goal 5 resources, but Metro may address those that the Metro Council determines to be regionally significant. The Metro Council concluded that riparian corridors and wildlife habitat are the corresponding resources that constitute regional fish and wildlife habitat consistent with Title 3. Metro has pursued identification of both riparian corridors and wildlife habitat – but separately – in order to ensure that there is independent verification of each resource type.

A regional approach to inventorying natural resources requires a consistent level of data and analysis across the entire Metro region. Metro's Goal 5 inventory is based on the best available information that can be applied consistently at a regional scale. In this document we include: a discussion of Metro's inventory methodology and how it complies with the Goal 5 rule; an analysis of existing riparian corridors and wildlife habitats by resource site; a description of the adequacy of Metro's inventories in terms of location, quantity and quality; and a discussion of Metro's significance and regional resource recommendations.

Goal 5 inventory process

Metro used the standard Goal 5 process, modified by specific requirements in the rule, to inventory riparian corridors (see *Definition of Riparian Corridor* section) and wildlife habitat (see *Definition of Wildlife Habitat* section) within its jurisdiction. The standard inventory process involves four steps:

1. *Collect information about Goal 5 resource sites.* The rule specifically notes that "existing and available information" is what drives the inventory process (OAR 660-023-030(2)). Therefore, information that could be obtainable though expensive field studies is not required (OAR 660-23-090 (4).

2. *Determine the adequacy of the information.* The inventory is deemed adequate if it provides location, quality, and quantity of the resource in question (OAR 660-023-030(3)). The inventory includes a map of resource areas, information about relative value of sites compared to others, and relative abundance or scarcity. A "site" is a particular area where resources are located. Local governments may divide the riparian corridor into a series of stream segments or reaches and regard these as individual sites (OAR 660-023-090(3)).

3. *Determine the significance of resource sites.* Once the adequacy of the information is determined, a significance determination must be made based on: (1) the location, quality, and quantity of the resource; (2) special significance criteria; and (3) additional criteria adopted by a local government (OAR 660-023-0030(4)(a), (b), & (c)). Scientific knowledge of the functions and values of riparian areas and upland wildlife habitat plays a critical role in determining resource significance. All sites that are deemed significant by local governments are included on a list of significant Goal 5 resources referred to as a "resource list" or "adopted inventory." All resources included in the adopted inventory are subject to the remaining steps of the process.

4. *Determine regional resources.* The Goal 5 rule gives Metro the authority to complete the Goal 5 process for "regional resources." A regional resource, as defined by the Goal 5 rule, is a "site containing a significant Goal 5 resource, including, but not limited to a riparian corridor, wetland, or open space area...." (OAR 660-023-080(1)(b)).

Riparian corridors and wildlife habitats identified as regional resources then proceed through the remaining Goal 5 process. These steps include an analysis of the economic, social, environmental, and energy (ESEE) consequences of protecting or not protecting a resource, and development of a Goal 5 protection program. Title 3, Section 5 of Metro's Urban Growth Management Functional Plan contains additional steps.

This chapter describes how Metro addressed the four steps in the Goal 5 inventory process for riparian and wildlife habitat resources.

Metro's advisory committees

Metro Advisory Committees play an ongoing and vital role in Metro's Goal 5 process. Citizens – that is, members of the public that are not representing a particular organization – are members of each committee; the number of citizens on each committee described below are indicated in brackets. Metro has more than a dozen committees that advise the Metro Council, Executive Officer, Auditor and staff on various matters of Metro's responsibility. Membership on these committees is varied, based on the purpose of each committee.

The Goal 5 Technical Advisory Committee (Goal 5 TAC) is composed of more than 20 representatives from local jurisdictions, natural resource agencies such as ODFW, USFWS DEQ and NMFS, consulting firms, and private citizens. The committee was formed at the inception of Metro's Goal 5 efforts in 1999 to provide technical support and review of the process. Many of the same members have been on the committee throughout the process, adding an invaluable level of detailed knowledge and consistency that would not otherwise be possible. This committee has provided substantial input into Metro's Goal 5 inventory process and will continue to do so through subsequent phases of the Goal 5 process. [1 citizen member]

A new Goal 5 advisory committee was formed in spring 2002 to address the economic issues involved with weighing the consequences of development of sites within the riparian corridors and wildlife habitat inventories. This committee, called the Goal 5 ETAC (Economic Technical Advisory Committee), will work with Metro's staff and consultant to provide information and advice on the Environmental, Social, Economic and Energy (ESEE) consequences of allowing, limiting, or prohibiting development. The Goal 5 ETAC is composed of 22 members.

Other committees that provide feedback or recommendations relating to Metro's Goal 5 inventory process include:

- Metro Policy Advisory Committee (MPAC) – charter-mandated committee of local government representatives and citizens who consult on policy issues, especially those related to services provided by local governments, and advise Metro Council on the Regional Framework Plan and other Metro services. [three citizen members]
- Metro Technical Advisory Committee (MTAC) – committee of planners, citizens and business representatives that provide detailed technical support to MPAC for shaping land use policies. [three citizen members]
- Water Resources Policy Advisory Committee (WRPAC) - committee of water and sewer district representatives, environmental groups, federal and state natural resources agencies, business and residents advising the Metro Council on water resource matters. [four citizen members]
- Metro Committee for Citizen Involvement – 27-member citizen committee assisting in the development, implementation and evaluation of Metro's citizen involvement activities. Metro's home-rule charter mandates this committee. [27 citizen members]

Metro's public participation process

Public involvement has been a key element in Metro's efforts to conserve, protect and restore riparian corridors and wildlife habitat as resources of regional significance (i.e., Goal 5), described below.

Spring 1999 — Two series of workshops and a set of public open houses were conducted. The project team identified the following key stakeholder groups as critical to the process: citizens/neighborhood activists; watershed organizations; business/development representatives; local government officials; state/federal/tribal government officials; and environmental/non-profit organizations. These stakeholders were contacted and encouraged to distribute information to their mailing lists and participate in the public workshops. Media advisories and press releases were sent to local and regional print media, with articles and pre-event notices appearing in The Oregonian, The Beaverton Times, The Clackamas Review, The Daily Journal of Commerce, and smaller community newspapers. Metro's technical advisory committee members were also encouraged to promote the events. A more detailed description of this outreach process is available in Metro's Streamside CPR handbook (Metro 1999).

February 2000 144,000 inserts were mailed to the public via utility billings. Approximately 45,000 notices were mailed to landowners whose properties fell partially or wholly within the initial inventory.

February 2000 Meetings with the region's 27 local governments (councils and planning commissions) to explain the draft inventory program were held, as well as a series of open houses around the region.

Public comments from this outreach resulted in a revised Goal 5 inventory process, undertaken in early 2001, to identify existing ecological functions on a more site-specific basis rather than a generalized buffer width program, ultimately yielding the current inventory. The public outreach component of the current effort includes the following:

2001 Several opinion surveys were conducted in 2001, including a May 2001 Davis and Hibbits phone survey commissioned by Metro, an October 2001 Moore Information survey sponsored by KGW-TV and the Portland Tribune, and an informal "SurveyPoint" poll available by phone and on Metro's website. Results from all three studies demonstrated that Metro residents place great value on protecting natural resources and maintaining the region's quality of life. Results of these surveys are available from Metro by request.

Early 2001 A preliminary inventory map was reviewed by local governments and the public.

2001-2002 Metro's "Coffee Talks" were a series of 93 public outreach forums held in various locales throughout the urban region during non-business hours, to promote accessibility to the general public. Coffee Talks were held from September 2001 through January 2002. The public was notified through a variety of means similar to the earlier outreach efforts – approximately 1,000 brochures were mailed to businesses and business leaders, neighborhood associations, citizen participatory organizations, civic and community groups, chambers of commerce, local jurisdictions, and advocacy groups. Overall, approximately 90,000 citizens received the October 2001 "Let's Talk" brochure, including contacts for the regional conference described below. The Coffee Talks were also advertised via local radio, television, and newspapers. An important component of these talks involved whether the public thought it was important to protect fish and wildlife habitat in the urban region and if so, how this should be accomplished. This public feedback was distributed to Metro staff and Councilors for consideration in the planning process. The executive summary from these talks is in Appendix 1. One important outcome of this process was indication of strong public support for Metro's efforts to maintain and enhance natural habitat areas.

March 2002 Metro held a regional conference and series of localized workshops to garner public opinion and participation entitled "Let's Talk" (Appendix 1). The conference was held during the week and the workshops on the following weekend. Metro undertook a major notification process to encourage attendance to these activities, including more than 90,000 mailings to property owners and interested parties; press releases to major and local newspapers; partnership with KGW, a major local television station; and follow-up calls to encourage to neighborhood associations, business interests and many other parties to encourage participation (also part of the Coffee Talk outreach, above). Scholarships were offered to parties that could not afford conference registration fees, which covered part of Metro's cost for the conference. About 2,400 people attended the conference and workshops. Partial results were tabulated and immediately distributed to Metro staff and Council so that public opinion could help guide the current process. The final conference report has just been completed and is included in Appendix 1. Once again, the results confirmed the importance of natural resource protection to the area's citizens, and interest in several strategies for natural resource protection emerged – perhaps most notably, financial incentives for protection as well as dis-incentives for failing to protect these resources.

June 2002	Nearly 20,000 notices were mailed to property owners whose land fell partially or wholly within the current riparian corridor or wildlife habitat, who had not previously been notified because of the revised mapping or new wildlife habitat inventory information. The letter invited interested citizens and property owners to speak with Metro staff and make comments at upcoming meetings of the Metro Natural Resource Committee and Council.

Review information about Metro's Goal 5 inventory process on Metro's website: http://www.metro-region.org/habitat/habitat_home.html.

Collection of information about riparian resource sites

Metro, following the Goal 5 rule's standard inventory process, collected information about streams, water areas, wetlands, riparian areas, and fish habitat to assist in delineating and mapping the region's riparian corridors.

The Goal 5 inventory process began in 1999 as part of the draft Streamside CPR (Conservation, Protection and Restoration) Report (Metro 1999). The Water Quality and Flood Management map, adopted as part of Metro's Urban Growth Management Functional Plan (Title 3) served as the starting point, or base map, for the Goal 5 inventory (Title 3 Functional Plan Map). The map included water features such as primary and secondary water features[1] including streams, rivers, lakes, and wetlands. Also mapped were the 100-year FEMA floodplain, areas flooded in 1996 (the 1996 area of inundation), and steep slopes (over 25 percent) adjacent to water features. This base map was compiled using Metro's extensive Geographic Information System (GIS) database layers and was edited through local jurisdiction review and public input. Appendix 2 is a data dictionary, including variable descriptions and resource site/watershed summary data (raw data table).

Metro incorporated a classification scheme for organizing streams into groups that share key characteristics, known as Channel Habitat Types (CHT) (GWEB 1999). The classification scheme used stream confinement[2] and stream gradient[3] to determine CHT. Eleven channel habitat types were originally identified within the region, as described in Table 1. Based on the comments of technical reviewers, these eleven channel habitat types were combined into three main categories: headwater streams (high), mid-section streams (middle), and floodplain and rivers (low). The benefit of incorporating such a classification system is that it can serve as the foundation for a more detailed inventory of stream and watershed conditions.

Table 1. Channel Habitat Types within the Metro region.

Channel type code	Name	Channel type category
FP1	Low gradient large floodplain channel	Low
FP2	Low gradient medium floodplain channel	Low
LUS	Low gradient unconfined	Low
AF	Alluvial fan channel	Low
MH/MC	Moderate gradient confined headwater channel	Middle
MH/MV/BC	Moderate gradient headwater channel, moderately steep narrow valley channel, bedrock canyon channel	Middle
LC	Low gradient confined channel	Middle
LM	Low gradient moderately confined channel	Middle
MM	Moderate gradient moderately confined channel	Middle
VH	Very steep headwater	High
SV/BC/MV	Steep narrow valley channel, bedrock canyon channel, moderately steep narrow valley channel	High

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[1] Primary water features include Title 3 wetlands; rivers, streams, and drainages downstream from the point at which 100 acres or more are drained to that water feature (regardless of whether it carries year-round flow); and streams carrying year-round flow; springs which feed streams and wetlands and have year-round flow; and natural lakes. Secondary water features include intermittent streams and seeps downstream of the point at which 50 acres are drained and upstream of the point at which 100 acres are drained to that water feature.

[2] Confinement is a characterization of a channel's cross-sectional profile. It represents a stream's potential interactions with its floodplain. The GWEB protocol defines confinement classes according to the ratio of floodplain width to channel (bankfull width).

[3] Gradient refers to the angle, or slope, at which the stream runs downhill.

Additional improvements to the Goal 5 inventory base map were made during 2000 and the early part of 2001 to improve the accuracy and consistency of regional information on streams and land cover. For example, Metro converted its stream GIS data layer to a stream routing database (streamroute), which more accurately represents stream location, supports the use of advanced GIS operations, and allows data sharing with state and federal organizations. Current wetland information obtained from local jurisdictions was used to update and augment the National Wetlands Inventory GIS coverage (Appendix 3). Another improvement to the Goal 5 inventory of resource features was the delineation of forest canopy along streams, rivers and other water features, as well as upland forest patches. A companion piece to the forest cover – the delineation of woody vegetation, low structure vegetation and undeveloped soils within 300 feet of streams – was completed in the spring of 2001.

An abbreviated sequence of events leading to the current riparian corridors inventory is summarized below:

- In February 2001, maps displaying the location of resource features such as flood areas, lakes, wetlands, streams, steep ravines, and forest canopy were made available to local governments and the general public for review and comment. Metro requested information to improve the accuracy of the features represented on the maps. The maps were made available as hard copies and as downloadable files on the internet via Metro's file transfer protocol (FTP) server.
- In June 2001, staff presented draft criteria for mapping riparian corridors and three pilot area maps. These criteria and pilot maps were reviewed by the WRPAC, Goal 5 TAC, MTAC and other Metro advisory committees. MTAC and WRPAC and the Metro Natural Resource Committee recommended that the criteria were adequate to warrant region-wide mapping for further review of the criteria.
- In the summer of 2001, Metro Council Natural Resource Committee directed staff to prepare a set of riparian corridor maps for the entire region.
- In the fall of 2001, staff presented a draft map of riparian corridors based on the criteria for WRPAC and other Metro advisory committee review.
- In November 2001, WRPAC recommended that all areas on the draft riparian corridors map (areas identified as providing both primary and secondary ecological functions) be deemed both significant and regionally significant resources.
- On November 21, 2001 Metro's Natural Resource Committee directed that changes to the criteria be made including showing developed floodplains as secondary, not primary function for streamflow moderation and water storage and not at all for large wood and channel dynamics and revising the organic material function adding undisturbed soils within 50 feet.
- On November 28, 2001, MTAC considered the draft riparian corridor maps. MTAC recommended that Metro allow a basin approach where a coordinated, intergovernmental basin-wide effort was made to address all resources identified by Metro as being significant and regional.
- In late November 2001, Metro received a critique of its draft technical report for Goal 5 from the City of Hillsboro; Metro responded to all criticisms by December 12, 2001 (Appendix 4). The critique did not result in alteration of any of the riparian functional criteria, but did result in several corrections in the technical report.
- On December 12, 2001, MPAC recommended that the Metro Council:
  (a) Revise the criteria for identifying riparian corridors as recommended by the Metro Natural Resource Committee,
  (b) Designate all areas identified through the revised criteria as regionally significant, and
  (c) Explore the basin approach.
- On December 13, 2001, the Metro Council considered all recommendations, including MPAC's recommendation, and approved Resolution No. 01-3141C (Appendix 5). This resolution accepted the riparian corridor criteria, concluded that several mapping changes (developed floodplains, organic materials) should be made, directed that a basin approach should be explored and that all riparian resources meeting the criteria should be considered as both significant and regionally significant, consistent with State Goal 5.

- On May 16, 2002, the Metro Council approved Resolution No. 02-3195 (Appendix 5), authorizing the Executive Officer to sign an intergovernmental agreement with the Tualatin Basin Natural Resource Coordinating Committee concerning a basin approach with the Tualatin River basin.
- The current riparian corridor maps have been revised as directed in Resolution No. 01-3141C (Appendix 5) for developed floodplains (Appendix 3) and organic materials. In addition:
  (a) Extensive map corrections have been made;
  (b) The map geographic extent has been increased to include areas one mile outside the Metro jurisdictional boundary and all Urban Growth Boundary Alternative Analysis sites. (This data is provided for analytical purposes, as Metro has no jurisdiction in these areas unless annexed to Metro.)
- In June 2002, MTAC, WRPAC, MPAC, the Goal 5 TAC, and Metro Natural Resources Committee considered a recommendation concerning the draft riparian corridor inventory and voted to support proposed Resolution No. 02-3176 (Appendix 5), for the purpose of adopting a draft map of regionally significant fish habitat (riparian corridors) pursuant to Resolution No. 01-3141C (Appendix 5). The Metro Council is scheduled to consider riparian corridors under proposed Resolution No. 02-3176 in late July 2002.

Metro received and reviewed numerous map corrections from local jurisdictions, property owners and other interested parties. Included in these changes was incorporation of local wetlands inventory information (see Appendix 3). Metro staff applied a consistent set of map change protocols to these requests. Some of the proposed corrections were represented on the February 2001 maps, and additional corrections were received as a result of public review of the maps in the spring of 2001. When documentation was adequate, Metro corrected its GIS data layers depicting resource features. Other proposed corrections that lacked adequate documentation will be considered in on-going updates of Metro's GIS data layers. Metro is continuing to accept map change requests and is making every attempt to see that Goal 5 maps are as accurate and complete as possible.

In fall 2001 Metro conducted U.S. Fish and Wildlife Service-funded fieldwork to assess the riparian corridor inventory's ability to identify valuable riparian resources. Processing the data for this research is time-consuming and the results are not yet complete; however, the conceptual underpinnings for this fieldwork are described in the section below entitled "Fieldwork to assess mapping criteria."

Table 2 below describes the Goal 5 inventory resource features that were used the construction of regional criteria for delineation of riparian corridors. GIS metadata (descriptions of collection methodologies for each data layer) or their locations are included in Appendix 6.

Table 2. Goal 5 riparian corridor inventory resource features.

Resource Features	Description
Flood Areas (FEMA/1996)*	Areas covered by the 100-year floodplain mapped for the Federal Emergency Management Administration and/or areas mapped as inundated during the 1996 flood event by the Army Corps of Engineers, excluding ponded areas as noted by local governments.
Forest Canopy*	Land covered by forest canopy in patches generally larger than one acre in size. Delineated at a scale of 1:4800 using 2000 aerial photos and generalized criteria by the Metro Data Resource Center.
Steep Slopes*	Slopes greater than 25 percent occurring within 200 horizontal feet of the stream centerline or bank where mapped using the slope calculation method within the Arc-Info software program and using the 7½-minute USGS topographic map data.
Wetlands*	Wetlands mapped by the National Wetland Inventory and later updated as a part of the Title 3 water quality process. Additionally modified to incorporate information from local government review and local wetland inventories (see Appendix 3). Wetlands are considered hydrologically connected if the wetland boundary begins within ¼ mile of a riparian corridor.

Resource Features	Description
Open Water*	Open water surface areas of lakes, ponds, and some rivers from the USGS 7½-minute quadrangle map data, from Metro stream modeling data of topography and as modified by review by cities and counties in the region.
Stream Centerlines*	Central channels or central braids of streams included on Metro's stream network. The network is composed of streams appearing on USGS digital line graph data, supplemented by stream model and edited for accuracy using air photos by Data Resource Center. The network includes minor edits to incorporate local information received through the Title 3 map review process and subsequent public reviews.
Stream Links*	Portions of streams that are non-surface, historic, or inferred and determined by examination of aerial photographs and comments from cities and counties in the region. Help to associate fragmented surface streams and drainage basins with downstream areas.
Culverts*	Stream crossings by roads and other transportation facilities but excluding stream links. Prepared by Metro Transportation Department, 2000 using road network, stream network and field inspections.
Proposed Stream Corrections*	Stream segments identified for removal, addition or relocation by local agencies.
Other Proposed Corrections*	Flood areas, wetlands, slopes, forest canopies or water bodies proposed for removal, addition or relocation by local agencies.
Woody vegetation and open space	Woody vegetation, or low structure vegetation/undeveloped soils mapped within 300 feet of streams and wetlands. Delineated at a scale of 1:4800 using 2000 aerial photos and generalized criteria by the Metro Data Resource Center.
Riparian Values Layers**	Represents resource features receiving values for one or more of the five ecological functions appearing in the riparian scoring matrix. The matrix is included in Metro's Resolution No. 01-3087A (Appendix 5). These layers were derived using the Goal 5 inventory features and the riparian scoring matrix. There is a layer for each individual function and a layer depicting cumulative score for all features.
Satellite land cover	Satellite derived land cover data. Data at 25 x 25 meter (80 x 80 feet) pixels for 17 land cover classifications.

Source: Metro 2001. See Appendix 6 for GIS metadata for each data layer.
*Goal 5 inventory features that were subject of a formal local government and general public review from February to April 2001.
**See Definition of Riparian Corridor section for more detail on the riparian values layers.

Metro has incorporated the best available information in its GIS database to accurately depict, at a regional scale, the location and quantity of Goal 5 resource features. The addition of the vegetation data layer adds information about the quality of mapped Goal 5 resource features (*see Adequacy of Information section*).

Consultations

At a minimum, the Goal 5 rule requires that local governments consult with the following sources:

(a) Oregon Department of Forestry stream classification maps;
(b) United States Geological Service (USGS) 7.5 minute quadrangle maps;
(c) National Wetlands Inventory maps;
(d) Oregon Department of Fish and Wildlife (ODFW) maps indicating fish habitat;
(e) Federal Emergency Management Agency (FEMA) flood maps; and

(f) Aerial photographs (OAR 660-23-090 (4))

Table 3 below describes these consultations and others undertaken by Metro in the inventory process.

Table 3. Agency consultations and information sources for riparian corridor inventory.

Agency	Information Type
Clean Water Services (Tualatin Basin)	• Rapid Stream Assessment point data (450 sampling sites) • Benthic Index of Biological Integrity sampling sites and data • Reports on watersheds, water quality status and trends, fish distribution and fish habitat • Stream location information
Ecotrust	• Landsat TM landcover type information
Federal Emergency Management Agency	• 100-year flood maps
Independent Multidisciplinary Science Team (IMST)	• Provided peer-review and comments on Metro's Technical Report for Goal 5.
Local governments	• Local plan Goal 5 inventories, review of Metro GIS base feature layers for accuracy and completeness • Members of several local jurisdictions on Goal 5 Technical Advisory Committee and other advisory committees
National Marine Fisheries Service	• Critical habitat for listed salmon species • Reports on salmon and trout ecology • Member on Goal 5 Technical Advisory Committee
Natural Resources Conservation Service	• Oregon Hydrology Group working to identify watersheds by USGW Hydrologic Unit Code system • U.S. Department of Agriculture and NRCS certified soil surveys
Oregon Department of Environmental Quality	• Water quality model code and handbook • 303(d) listed streams and lakes • Water quality index sampling points and data • Benthic index of biological integrity protocol and data • Total Maximum Daily Loads (TMDLs) for Tualatin Basin • Reports on environmental site cleanup information, Portland Harbor, brownfield sites, underground tanks, wastewater permits • Member on Goal 5 Technical Advisory Committee
Oregon Department of Fish and Wildlife	• Anadromous and other fish species distribution at 1:100,000 scale (statewide data) • ODFW Aquatic Inventories Project, habitat and reach data coverage • ODFW Natural Resources Information Management Program fish habitat distribution data at 1:24,000 scale • Threatened, endangered, and sensitive wildlife species habitat information • Fish and wildlife species status information • Willamette Valley vegetation, 1:24,000 scale • Willamette Valley dams and barriers • Fish Passage Program data re: road culverts with fish passage problems on state and county roads • Big game winter range • Members on Goal 5 Technical Advisory Committee
Oregon Department of Forestry	• DOF stream classification maps • DOF fish presence and distribution • DOF sensitive bird site inventories
Oregon Natural Heritage Program	• record files of rare, threatened, and endangered plant and animal species within metro study area

Agency	Information Type
Oregon Progress Board	• Water quality data used in the Oregon State of the Environment Report
Pacific Northwest Ecosystem Research Consortium	• procedures and data bases for evaluating Willamette Valley habitats for wildlife species • 1850 historic vegetation • land use/land cover projected at 10 year increments through 2050 • demographic, hydrologic, physiographic, base grids and land use/land cover spatial data for Willamette Valley
Port of Portland	• Wetland location on Port properties; floodplain information
Spencer B. Gross, Inc.	• Aerial photos, natural color ortho-rectified digital imagery with a pixel size of 2, 4, 10 and 20 feet. Metro area covered in 726 section tiles.
U. S. Fish and Wildlife Service	• National Wetlands Inventory maps • Threatened, endangered, and sensitive wildlife species habitat information • Fish and wildlife species status information • Oregon Endangered Species Consultation Handbook • Federally listed and proposed endangered and threatened species, candidate species, and species of concern
U.S. Environmental Protection Agency	• Terrestrial vertebrate species of the Willamette River basin, species-habitat relationships matrix • Pacific States Marine Fisheries Commission/EPA Streamnet data for anadromous fish distribution • Streamnet Pacific NW water quality sampling data for streams and lakes • Toxic Release Inventory (1985-1999) • Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) for environmental information, watershed and water quality planning
United States Geological Service	• 7.5 quadrangle maps • USGS 1:24,000 10 meter digital elevation data (terrain model) • USGS Hydrologic Unit Code system • USGS reports and GIS data on water quality, toxins, habitat, hydrology, and groundwater for the Willamette Basin
Watershed Councils	• Watershed assessments and plans
Xerces Society	• Invertebrate species in the metro area • Benthic Index of Biological Integrity report for Lower Clackamas, Sandy rivers

Definition of riparian corridor

The previous section described how potential Goal 5 resources were inventoried and mapped. This section describes the methodology Metro used to identify riparian corridors. The Goal 5 rule defines a riparian corridor as a "Goal 5 resource that includes the water areas, fish habitat, adjacent riparian areas, and wetlands within the riparian area boundary." The rule does not provide guidance on how to identify the width of the riparian corridor. It only states that the riparian corridor boundary is an "imaginary line that is a certain distance upland from the top of bank" (660-23-090(1)). The Goal 5 rule allows a jurisdiction flexibility in defining the riparian corridor, the area for which a significance determination must be made.

Methodology for mapping riparian corridors

Metro has taken an ecological functions approach to define the riparian corridor based on its extensive scientific literature review (Metro 2002). This approach, described below, combines GIS mapping technology, scientific recommendations, and fieldwork for an inventory that encompasses the entire Metro region. It is intended to inform policymakers and the public about resource features in the landscape that provide some service or function to the riparian ecosystem. The methodology assigns values to resource features that allows comparison of their cumulative importance to riparian health.

As described in Metro's Technical Report for Goal 5 (science review), the riparian area refers to the land and vegetation adjacent to waterbodies such as streams, rivers, wetlands and lakes that are influenced by perennial or intermittent water. The spatial extent or width of the riparian area is difficult to delineate. Naiman and Decamps (1997) describe the riparian area as encompassing

> "The stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the upland where vegetation may be influenced by elevated water tables or flooding and the ability of the soils to hold water."

Gregory et al. (1991) further describes riparian areas as "three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems," the boundaries of which "extend outward to the limits of flooding and upward into the canopy of streamside vegetation."

Kauffman et al (2001) encourage a functional approach to defining the "riparian zone," stating that "from an ecosystem perspective, riparian zones are defined in terms of their multiple functional roles as the interface between aquatic and terrestrial environments." According to Kauffman et al (2001), "interactions between terrestrial and aquatic ecosystems include modifications of microclimate (e.g., light, temperature, and humidity), alteration of nutrient inputs from hill slopes, contribution of organic matter to streams and floodplains, and retention of inputs."

According to the scientific literature reviewed, riparian corridors provide important ecological benefits for fish and wildlife including:

1. Microclimate and shade
2. Streamflow moderation and water storage
3. Bank stabilization, sediment and pollution control
4. Large wood and channel dynamics
5. Organic matter input
6. Riparian wildlife habitat and connectivity[4]

The biological integrity of the riparian corridor depends, in part, on the width and condition of the riparian area, helps dictate stream functions and ultimately the type of species that can live in and around streams. Several recent literature reviews have addressed the effectiveness of various widths for maintaining specific riparian functions for both protecting water quality and preserving the biologic integrity of the riparian corridor. Metro's Technical Report for Goal 5 lists a range of recommended minimum riparian area widths for fish and wildlife habitat (Table 7 in Metro's Technical Report for Goal 5, January 2002 version).

The ecological functions listed above provide the basis for Metro's delineation of riparian corridors. In the spring of 2001, Metro launched an effort to map the ecological functions of riparian corridors and the specific resource features that are associated with these functions.

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[4] Wildlife habitat is excluded from the riparian corridor inventory, and is addressed under the inventory for wildlife habitat under OAR 660-23-110.

Features include stands of trees, woody vegetation, meadows, wetlands, steep slopes, and flood areas that are located along the region's stream and rivers. The recommended riparian corridor widths from Metro's science review were used to help develop a set of mapping criteria and are summarized in Table 4. The full matrix for mapping riparian corridors is in Appendix 7.

In December 12, 2001, the Metro Policy Advisory Committee (MPAC) recommended that the Metro Council revise the riparian corridor criteria for identifying riparian corridors as identified by the Metro Natural Resource Committee and designate all identified through the revised criteria as regionally significant. On December 13, 2001, the Metro Council considered all recommendations, including MPAC's recommendation, and approved Resolution 01-3141C (Appendix 5). This resolution accepted the riparian corridor criteria, concluded that several mapping changes (developed floodplains, organic materials) should be made, and that all riparian resources meeting the criteria should be considered as both significant and regionally significant, consistent with State Goal 5. Metro subsequently created and implemented a methodology for identifying developed floodplains (Appendix 8); the current riparian corridor maps have been revised as directed in resolution 01-3141C for developed floodplains and organic materials. In addition, extensive map corrections have been made and the map geographic extent has been increased to include areas one mile outside the Metro jurisdictional boundary and all UGB Alternative Analysis sites (this data is provided for analytical purposes as Metro has no jurisdiction in these areas unless annexed to Metro).

Table 4. Riparian corridors ecological functions and criteria for receiving a primary score.

Ecological function	Criteria for receiving a primary score	Criteria for receiving a secondary score
Microclimate and shade	Forest or woody vegetation within **100 feet** of a stream; a wetland[1]; or a flood area[2].	Forest or woody vegetation that is contiguous to the primary area (which is **100** feet) and extends outward to **780** feet.
Streamflow moderation and water storage	A wetland or other water body[3] with a hydrologic connection to a stream; or a flood area.	Forest, woody vegetation, or low structure vegetation/undeveloped soils within **300 feet**[4] of a stream; or forest that is contiguous to the riparian corridor (starts within **300 feet**[5] but extends beyond); or developed floodplains.
Bank stabilization, sediment and pollution control	A 50-foot band is included within the riparian corridor as a default to maintain basic functions. All sites within **50 feet** of a surface stream receive a primary score. Forest, woody vegetation, or low structure vegetation/undeveloped soils within **100 feet**[6] of a stream or a wetland; or forest, woody vegetation, or low structure vegetation/ undeveloped soils[8] within a flood area. Forest, woody vegetation, or low structure vegetation/undeveloped soils within **100-200 feet** of a stream if the slope is greater than 25%.	Forest, woody vegetation, or low structure vegetation/undeveloped soils located on a slope greater than 25%, that starts within **175** feet[7] of a stream and runs to the first effective break in slope.
Large wood and channel dynamics	Forest within **150 feet** of a stream or wetland; or within a flood area. The channel migration zone is basically defined by the floodplain, but where there is no mapped floodplain a default of **50 feet** was selected to allow for the channel migration zone[9].	Forest within **150 to 262 feet** of a stream; or developed floodplains.
Organic material sources	Forest or woody vegetation within **100 feet** of a stream or wetland; or within a flood area.	Forest or woody vegetation within **100 to 170** feet of a stream.

Source: Metro 2001.
[1]Here we refer to "hydrologically-connected wetlands," which are located partially or wholly within ¼ mile of a surface stream or flood area.
[2]Developed floodplains are not included as a regional resource since they do not receive a primary ecological function score.
[3]"Other water body" could include lakes, ponds, reservoirs, or manmade water feature that is not a water quality facility or farm pond.
[4]All upland forests, vegetation, and undeveloped soils help to moderate streamflow and store water. Staff used 300 feet here because some data layers for landcover types do not extend past 300 feet from a stream.
[5]Forest landcover is the only type that extends beyond 300 feet in the Metro database and thus excludes other types.
[6]Metro's science paper indicates 100 feet as a suitable average distance for vegetation contributing to filtering.
[7]175 feet was chosen due to the method used for mapping riverine slopes.
[8]The woody vegetation and low structure vegetation/undeveloped soils are mapped to 300 feet, the forest is mapped to the edge of the floodplain.
[9]Application of the default to maintain basic functions will be limited to low and moderate gradient channel types.

An example of Metro's mapping technique can be illustrated by examining the ecological function of microclimate and shade. Trees and other vegetation along streams provide a microclimate that is uniquely different from upland areas because of its proximity to water. This unique microclimate influences soil moisture, temperature and relative humidity, which allows for an increase in plant diversity and a variety of food and cover opportunities for fish and wildlife. Trees and other vegetation along streams also provide shade, which moderates the amount of light reaching the stream and helps to regulate water temperature.

According to the scientific literature, the minimum riparian area width needed to provide for microclimate ranges from 75 feet to 787 feet, and from 33 feet to 250 feet for shade (on each side of the stream). Based on the scientific literature, Metro used 100 feet as the area (on each side of the stream) where trees and other woody vegetation make a significant contribution to riparian function (microclimate and shade). Using GIS mapping technology, forest and woody vegetation within 100 feet of a surface stream, a hydrologically connected wetland, or an area subject to flooding were mapped. However, forest and woody vegetation beyond 100 feet also provide riparian function, according to the scientific literature, but to a lesser degree. These areas were also mapped to the outer range of the widths recommended by the literature, in this case 780 feet.

Metro devised a scoring system to rate the landscape features according to their contribution to riparian function. Based on distances recommended in the scientific literature, landscape features were considered either primary or secondary for ecological function. For example, trees and other woody vegetation contributing to riparian function within the first 100 feet are considered primary features and given six points. Trees and other woody vegetation beyond 100 feet and up to 780 feet still provide some ecological function according to the scientific literature, and are considered secondary features and assigned one point to reflect the reduced, but still valuable, ecological functions provided. Each of the other functions listed above (streamflow moderation, organic input, etc.) went through a similar process that linked land features with the ecological function they support, based on primary and secondary functions.

The scores are additive for any given landscape feature and reflect relative ecological function at any given point on the map. For example, a point on a map could contribute significantly to all five functions listed above and receive a score of 30 (five primary functions times six points each). Another point on the map may receive primary scores for three functions (three primary functions times six points) plus secondary functions for up to two other functions (18 points for primary functions, plus two points for secondary functions). Still another point on the map may receive only a single point for one secondary function. Table 4 and Appendix 7 describe the criteria used to evaluate each ecological function, the contributing land features, and the criteria for mapping those features.

Metro's methodology for mapping ecological functions has undergone extensive public review. The methodology was first applied to three nine square mile study areas: Bronson Creek, Johnson Creek, and Wilsonville. These study area maps were presented to Metro's Natural Resources Committee in May 2001. After a period of extensive public review, Metro Council adopted the methodology as part of Resolution 01-3087A (Appendix 5) and directed staff to produce maps applying the methodology on a regional basis.[5]

The resulting regional maps were presented to Metro's Natural Resources Committee in September 2001 and show areas with primary functions in gradations of green, with the darkest green providing the most function, the lightest green providing the least. Secondary functions are shown in gradations of fuchsia. This mapping methodology provides a valuable tool for defining riparian corridors, for identifying significant resource and regional resources, and for focusing the area of analysis (for quality data) within resource sites. It will also provide valuable information for locating potential restoration sites.

[5] Review included the Goal 5 Technical Advisory Committee, Metro Technical Advisory Committee, Water Resources Policy Advisory Committee, and Metro Policy Advisory Committee.

Collection of information about wildlife habitat resource sites

In public hearings before Metro Council Natural Resources Committee and in recommendations from the Metro Policy Advisory Committee (MPAC), Metro Technical Advisory Committee (MTAC), Metro Goal 5 Technical Advisory Committee (Goal 5 TAC) and the Water Resources Policy Advisory Committee (WRPAC), Metro Council was urged to complete the analysis of potential regionally significant wildlife habitat and combine that information with the mapping of regionally significant riparian corridors

Metro, following the Goal 5 rule's standard inventory process, collected information about forested areas, low-structure vegetation, streams, water areas and wetlands to assist in delineating and mapping the region's important wildlife habitats.

The current Goal 5 wildlife habitat inventory process began in 2001. In February 2001, pilot maps were made available on Metro's ftp website for review by interested parties. In July 2001, Metro Council adopted Resolution No. 01-3087A (Appendix 5) directing staff to apply functional science-based criteria to determine Goal 5 fish and Wildlife habitat areas. The criteria and mapping methodology are described in the section below, entitled "Mapping Technology for Wildlife Habitats."

An abbreviated sequence of events leading to the current wildlife habitat inventory is summarized below:

- In early 2001, pilot maps were made available on Metro's ftp site for review by interested parties.
- In fall 2001, in public hearings before Metro Council Natural Resources Committee (NRC) and in recommendations from the Metro Policy Advisory Committee (MPAC), Metro Technical Advisory Committee (MTAC), Metro Goal 5 Technical Advisory Committee (Goal 5 TAC) and the Water Resources Policy Advisory Committee (WRPAC), Metro Council was urged to complete the analysis of potential regionally significant wildlife habitat and combine that information with the mapping of regionally significant riparian corridors.
- In fall 2001, Metro conducted U.S. Fish and Wildlife Service-funded fieldwork to assess the original model's ability to appropriately assign value to habitat patches. The results of this fieldwork, described in the section entitled "Fieldwork to assess mapping criteria" below, provided guidance for adjusting the model to more accurately reflect the region's wildlife habitat values. These changes included redefining patches based on substantially closed canopy forest plus all vegetation within 300' of waterways and omitting the species richness criterion from the model.
- In December 2001, Council adopted Resolution No. 01-3141C (Appendix 5) directing staff to complete additional work necessary to inventory and map regional wildlife habitat and present that information to Metro Council in early 2002.
- In response, staff produced the following products:
  - An analysis of existing Goal 5 data, reports and regulations from cities and counties
  - A methodology and criteria for identifying wildlife habitat and maps applying those criteria to the region
  - A map identifying Goal 5 resource sites and Goal "wildlife habitat" within those sites to serve as the basis for identifying regionally significant wildlife habitats
  - An inventory narrative (this document) including information on the location, quantity and quality of the potential resources sites identified on the map
  - A map of potentially significant wildlife habitat
  - A summary of recommended criteria for identifying and defining regionally significant wildlife habitat (see Table 7 and Appendix 7)
  - A map depicting wildlife habitat that could be adopted as "regional resources" under the Goal 5 administrative rule

- In February 2002, staff presented draft criteria to the Metro Council Natural Resource Committee for identifying Goal 5 wildlife habitat based on information contained in "Metro's Technical Report for Goal 5" (formerly entitled "Metro's Scientific Literature Review for Goal 5")
- In a subsequent step to the wildlife habitat mapping process, Metro requested information on species and habitats of concern through several advisory committees and by contacting local experts knowledgeable in the region's wildlife habitats (see Table 7; section below entitled "Species and Habitats of Concern").
- In May 2002, the inventory was revised to reflect a larger study area, habitats of concern, and several relatively minor alterations to refine the inventory. These maps were made available via Metro's FTP server.
- In summer 2002, MPAC, MTAC, and the Goal 5 TAC recommended identifying all wildlife habitats on the map as significant and recommended Option 2 (see Table 7 and Appendix 7) for regional significance. However, WRPAC recommended identifying all wildlife habitats on the map as significant but recommended Option 1 for regional significance. Also during this period a series of public hearings were held to provide information to interested parties and obtain public opinion.

The map of regionally significant riparian corridors and wildlife habitat that staff produced is a draft map which will provide the basis for conducting subsequent steps in the Goal 5 process including the economic, social, environmental and energy consequences analysis and the Program to Achieve Goal 5. Metro Council reserves the opportunity to minimally or substantially alter the draft map prior to adoption of a final map of regionally significant fish and wildlife habitat areas and Program to Achieve Goal 5, after public comment and review.

Table 5 below describes the Goal 5 inventory resource features that were used the construction of regional criteria for delineation of wildlife habitats. Appendix 7 shows the full criteria matrix used to map wildlife habitats on Metro's GIS system.

Table 5. Goal 5 wildlife habitat inventory resource features.

Resource Features	Description
Forest Canopy*	Land covered by forest canopy in patches generally larger than one acre in size. Delineated at a scale of 1:4800 using 2000 aerial photos and generalized criteria by the Metro Data Resource Center.
Wetlands*	Wetlands mapped by the National Wetland Inventory and later updated as a part of the Title 3 water quality process. Additionally modified to incorporate information from local government review and local wetland inventories (see Appendix 3).
Stream Centerlines*	Central channels or central braids of streams included on Metro's stream network. The network is composed of streams appearing on USGS digital line graph data, supplemented by stream model and edited for accuracy using air photos by Data Resource Center. The network includes minor edits to incorporate local information received through the Title 3 map review process and subsequent public reviews.
Stream Links*	Portions of streams that are non-surface, historic, or inferred and determined by examination of aerial photographs and comments from cities and counties in the region. Help to associate fragmented surface streams and drainage basins with downstream areas.
Proposed Stream Corrections*	Stream segments identified for removal, addition or relocation by local agencies.
Other Proposed Corrections*	Flood areas, wetlands, slopes, forest canopies or water bodies proposed for removal, addition or relocation by local agencies.
Woody vegetation and open space	Woody vegetation, or low structure vegetation/undeveloped soils mapped within 300 feet of streams and wetlands. Delineated at a scale of 1:4800 using 2000 aerial photos and generalized criteria by the Metro Data Resource Center.
Wildlife Habitat Values Layers	Represents resource features receiving values for one or more of the four criteria identified in the Goal 5 Technical Report. These layers were derived

	using the Goal 5 inventory features and the wildlife habitat scoring matrix. There is a layer for each individual criterion and a layer depicting cumulative score for all features.
Habitats of Concern Layer	Site-specific information collected from a variety of knowledgeable sources and digitized in a separate GIS layer (see Table 7 and section below entitled "Species and Habitats of Concern").
Species of Concern Layer	Species of concern sightings for species listed under the federal or state Endangered Species Act or identified by the Oregon Natural Heritage Program as at-risk (see Table 7 and section below entitled "Species and Habitats of Concern").

Source: Metro 2001. See Appendix 6 for GIS metadata for each data layer.
*Goal 5 inventory features that were subject of a formal local government and general public review from February to April 2001.

Metro has incorporated the best available information in its GIS database to accurately depict, at a regional scale, the location and quantity of Goal 5 resource features. The addition of the species of concern and habitats of concern data layers, combined with field studies, add information about the quality of mapped Goal 5 resource features (*see Adequacy of Information section*).

Consultations

At a minimum, the Goal 5 rule requires that local governments shall obtain current habitat inventory information from the Oregon Department of Fish and Wildlife (ODFW) and other state and federal agencies. These inventories shall include at least the following:

(a) Threatened, endangered, and sensitive wildlife species habitat information;
(b) Sensitive bird site inventories;
(c) Wildlife species of concern and/or habitats of concern identified and mapped by ODFW (e.g., big game winter range and migration corridors, golden eagle and prairie falcon next sites, and pigeon springs (OAR 660-23-110 (1))

Table 6 below describes these consultations and others undertaken by Metro in the inventory process.

Table 6. Agency consultations and information sources for wildlife habitat inventory.

Agency	Information Type
Army Corps of Engineers	• 1978 "Regional Urban Wildlife Habitat Maps" to supplement Habitats of Concern information
Audubon Society of Portland / Coalition for a Livable Future	• Mike Houck is a member of the Goal 5 Technical Advisory Committee and is Chair of the Natural Resources Working Group; comments on all aspects of program, including model criteria and scoring. • Species of Concern and Habitats of Concern information
Bob Altman, American Bird Conservancy	• Sensitive species and sensitive species habitat information (also linked with Partners in Flight, Oregon/Washington chapter)
Charlotte Corkran, local herptile expert/consultant	• Sensitive species location information • Vertebrate species list in Tualatin Basin
Clean Water Services (Tualatin Basin)	• Reports on watersheds, fish distribution and fish habitat
Defenders of Wildlife (in cooperation with ODFW)	• Information on restoration and enhancement practices for rare habitats in the Willamette Valley

Agency	Information Type
Ecotrust	• Landsat TM landcover type information
Independent Multidisciplinary Science Team (IMST)	• Provided peer-review and comments on Metro's Technical Report for Goal 5.
Local governments	• Local plan Goal 5 inventories, review of Metro GIS base feature layers for accuracy and completeness • Members of various governments on Goal 5 Technical Advisory Committee (including cities of Beaverton, Portland, Troutdale, Lake Oswego, Tualatin; and Clackamas, Washington, and Multnomah counties) and other advisory committees • Input on Habitats of Concern, Species of Concern, model formulation and refinement, scoring system
Members of GTAC (Greenspaces Technical Advisory Committee) and G5TAC (Goal 5 Technical Advisory Committee)	• Habitats of Concern request for information
Metro Parks and Greenspaces Department	• Metro Greenspaces Master Plan, including corridor information; Habitats of Concern; Species of Concern information
National Marine Fisheries Service	• Member of Goal 5 Technical Advisory Committee (Marc Liverman)
Numerous regional wildlife experts, including the fish and wildlife agencies, PSU, OSU, consultants	• Development of Vertebrate Species List
Oregon Cooperative Fish and Wildlife Unit, Oregon State University	• Sensitive species surveys (obtained via ODFW)
Oregon Department of Environmental Quality	• Member of Goal 5 Technical Advisory Committee (Don Yon)
Oregon Department of Fish and Wildlife	• Wildlife species status information; threatened, endangered, and sensitive wildlife species occurrence and habitat requirement information • Information on at-risk wildlife habitat types in the Willamette Valley • Information on restoration and enhancement of at-risk wildlife habitat types in the Willamette Valley • Wildlife Diversity Plan • Willamette Valley vegetation, 1:24,000 scale • Big game winter range • 2 Members on Goal 5 Technical Advisory Committee
Oregon Department of Forestry	• DOF stream classification maps
Oregon Natural Heritage Program	• Record files of rare, threatened, and endangered plant and animal species within metro study area • ONHP species status rankings for species list • Consultation regarding Habitats of Concern
Pacific Northwest Ecosystem Research Consortium	• Procedures and data bases for evaluating Willamette Valley habitats for wildlife species • 1850 historic vegetation • Land use/land cover projected at 10 year increments through 2050 • Demographic, hydrologic, physiographic, base grids and land use/land cover spatial data for Willamette Valley
Partners in Flight	• Status and conservation of state sensitive grassland bird species • Conservation strategy for landbirds in coniferous forests and lowlands and valleys of western Oregon and Washington

Agency	Information Type
Port of Portland	• Site-specific information regarding Habitats of Concern
Spencer B. Gross, Inc.	• Aerial photos, natural color ortho-rectified digital imagery with a pixel size of 2, 4, 10 and 20 feet. Metro area covered in 726 section tiles.
Tualatin Hills Parks and Recreation District	• Information on Habitats of Concern and comments on model scoring criteria
U.S. Environmental Protection Agency	• Terrestrial vertebrate species of the Willamette River basin, species-habitat relationships matrix
U.S. Fish and Wildlife Service	• National Wetlands Inventory maps • Federally listed and proposed endangered and threatened species, candidate species, and species of concern • Threatened, endangered, and sensitive wildlife species habitat and sighting location information • Oregon Endangered Species Consultation Handbook • Member on Goal 5 Technical Advisory Committee
United States Geological Service	• 7.5 quadrangle maps • USGS 1:24,000 10 meter digital elevation data (terrain model) • Breeding Bird Survey information
URS Corporation (Lynn Sharp, local wildlife habitat expert)	• Information on Habitats of Concern
Watershed Councils	• Watershed assessments and plans
Wetlands Conservancy	• Habitats of Concern request for information
Xerces Society	• Invertebrate species in the metro area

Definition of wildlife habitat

The previous section described how potential Goal 5 resources were inventoried and mapped. This section describes the methodology Metro used to identify wildlife habitats. The Goal 5 rule defines wildlife habitat as "an area upon which wildlife depend in order to meet their requirements for food, water, shelter, and reproduction. Examples include wildlife migration corridors, big game winter range, and nesting and roosting sites" (OAR 660-023-0110(1)(b)). The rule does not provide specific guidance on how to identify significant wildlife habitats other than referring to the standard inventory process (OAR 660-23-030) and minimum consultation requirements outlined in OAR 660-23-110. The Goal 5 rule allows a jurisdiction flexibility in defining the area for which a significance determination must be made.

Mapping methodology for wildlife habitats

As the agency responsible for identifying regionally significant wildlife habitat, it is not feasible to visit each potential site during the inventory process. Field surveys are encouraged but not required by the Goal 5 rule. Therefore, Metro has taken a multi-tiered approach to identify the region's important wildlife habitats based on a combination of (1) best available scientific literature; (2) GIS modeling; (3) field studies to address the Goal 5 rule to determine the location, quantity and quality of potential resource sites, as well as the adequacy of that information; and (4) local expertise to identify locations of sensitive species and habitats. This approach, described in Table 7, combines GIS mapping technology, scientific recommendations, and fieldwork for an inventory that encompasses the entire Metro region. It is intended to inform policymakers and the public about resource features in the landscape that provide habitat to meet wildlife requirements for food, water, shelter and reproduction. The methodology assigns values to resource features that allows comparison of their cumulative importance to the regional wildlife habitat network.

According to the scientific literature reviewed, important ecological characteristics of wildlife habitat include the following:

1. Terrestrial habitat is important for many wildlife species. Important guidelines in developing a conservation plan for wildlife habitat are:
   - large patches are better than smaller patches
   - interior habitat is more important to at-risk species than edge habitat
   - connectivity to other patches is important
   - connectivity and/or proximity to water is important
   - unique or at-risk habitats deserves special consideration
2. Native vegetation plays a critical role in a watershed, particularly the longitudinal and lateral connectivity of the riparian corridor. In general, native wildlife species prefer native plants.
3. Downed wood and snags (or large woody debris), frequently found in natural ecosystems but often lacking in disturbed environments, are crucial in providing high quality habitat in both aquatic and terrestrial ecosystems.
4. Habitat fragmentation is a critical issue; buffers and surrounding land use play an important role in maintaining the functions of remaining habitat.

The ecological characteristics listed above provide the basis for Metro's delineation of wildlife habitat. In early 2001, Metro launched an effort to map wildlife habitat based on specific resource features that are associated with these characteristics. Features include stands of trees, woody vegetation, meadows, and wetlands located within the region. The recommended wildlife habitat criteria from Metro's science review were used to help develop a set of mapping criteria and these are summarized in Table 7 (see also Appendix 7).

A GIS model developed through Metro's Parks and Greenspaces Department served as the starting point, or base map, for the Goal 5 inventory (original model). Vegetation data for the original model was derived from satellite imagery (24-m rasters). The original model was based on four criteria: habitat patch size (minimum patch size of 2 acres unless considered a Habitat of Concern, described below), proximity to water sources, proximity to other natural areas, and an Oregon Natural Heritage Program-derived species richness criterion. After reviewing the scientific literature and available local research a fifth criterion measuring forest interior, derived from Metro-region field data, was incorporated into the model. The original inventory map, which included habitat patches composed of natural land cover such as forest, shrub and grassy areas, as well as water features including streams and wetlands, was compiled using Metro's extensive Geographic Information System (GIS) database layers. Each habitat patch was ranked within the universe of habitat patches and assigned a score for each of the four model criteria, relative to other habitat patches. Sites were subsequently separated into three quality classes, of up to three possible points, for each criterion (see Table 7 footnotes for more information).

Table 7. Wildlife habitat characteristics and criteria for GIS model scoring.

Habitat characteristic	Criteria for scoring
Habitat patch size	The size value for a patch is calculated by: 1. Calculating the area in acres for all type 1 patches[6] using a GIS system. Assigning all type 1 patches a value of 1 to 3 based on their distribution within three classes derived by finding natural breaks using a GIS system[7].
Habitat interior (minimizes edge habitat)	The interior value for a patch is calculated by: 1. Defining an interior zone for all type 1 patches by using a GIS system to draw internal buffers of 200 feet for each. 2. Calculating the interior zone area (if any) in acres for all type 1 patches using a GIS system. Assigning all type 1 patches an interior value of 1 to 3 based on their distribution within three classes derived by finding natural breaks using a GIS system.
Connectivity and proximity to water resources	The connectivity to water value for a patch is calculated by: 1. Calculating the area of all type 1 and 2 patches that is less than 300 feet from of a source of water[8] using a GIS system. 2. Deriving the "connectivity to water" ratio of each type 1 patch. This is done by dividing the patch area inside 300 feet by the patch area greater than 300 feet away from a stream. (Inside 300 / outside 300 = "connectivity to water" ratio) 3. Deriving the "adjusted connectivity to water" ratio of each type 2 patch. The area inside 300 feet is divided by two to create an adjusted total. The adjusted amount is divided by the patch area greater than 300 feet away from a stream. ((Inside 300 / 2) / outside 300 = "adjusted connectivity to water" ratio) Assigning all type 1 and 2 patches a connectivity to water value of 1 to 3 based on the distribution of their ratios within three classes derived by finding natural breaks using a GIS system.
Connectivity and proximity to other patches	The Connectivity/Proximity value for a patch is calculated as follows: 1. Perform a nearest neighbor operation GIS operation that measures the average distance from each type 1 and 2 patch to other patches within ¼ mile of their perimeters.* 2. Assigning all type 1 and 2 patches a connectivity/proximity value of 1 to 3 based on their distribution within three classes derived by finding natural breaks using a GIS system. *General fragmentation also affects the overall score to a lesser degree. The more fragmented a patch the lower the score.
Habitats of concern and habitats for unique and sensitive species	A habitat of concern is a unique or unusually important wildlife habitat area. They are identified based on site-specific information provided by local wildlife or habitat experts. Habitats of concern can be smaller than 2 acres, and will be included in the inventory if falling into one or more of the following categories: Any patch specifically identified as a Priority Conservation Habitat by ODFW, USFWS, or other agencies or local wildlife experts. Priority conservation habitats are Oregon white oak savannas and woodlands, native prairie grasslands, wetlands, and bottomland hardwood forests. Any patch of natural land cover identified by ODFW, USFWS, or other agencies or local wildlife experts as a riverine island or delta important to wildlife.

[6] Type 1 patches are defined as any forest landcover, forested wetland, or nonforested wetland with a total combined size greater than 2 acres. Where different cover types are contiguous they are considered to be part of a single larger patch. Type 2 patches are defined as any shrubland/scrubland or grassland/open soils landcover in a tract greater than 2 acres, within 300 feet off a surface stream.

[7] The Jenkins method for finding natural breaks was used. This method creates classes based on natural groupings of data values. Features are divided into classes whose boundaries are set where there are relatively big jumps in the data values.

[8] A source of water is defined as any surface river or stream, wetland, or other water body.

Habitat characteristic	Criteria for scoring
	Specifically delineated habitat areas that provide life-history requirements of sensitive, threatened or endangered wildlife species or Great Blue Heron rookeries (for example, nesting habitat for an existing population of native turtles); habitats that support at-risk plants; or habitats that provide unusually important wildlife functions, such as major wildlife crossings/pathways or a key migratory pathway, such as an elk migratory corridor.

The scoring range within each criterion was determined by natural breaks in the data, as identified by the Jenkins method; this method creates classes based on natural groupings of data values. Field data confirmed that the breaks were logical, justifiable, and provided a means of differentiating sites from one another based on model criteria and ecological value.

The scores are additive for any given habitat patch and reflect relative wildlife habitat value for each of the habitat patches identified on the map. A habitat patch may receive a score from 1-3 for each of the four model criteria, for a maximum of 12 possible points (four criteria times three points; see Appendix 7). However, in reality the highest score was ten and the low score was two due to the interactions of the criteria (for example, very large patches tend not to have as high a rating for water availability per unit area). Scores were adjusted downward one point to allow for an easily understandable point range of 1-9.

An example of Metro's mapping technique can be illustrated by examining the ecological function of interior habitats (see Metro's Technical Report for Goal 5, Metro 2002). Edge effects are the detrimental effects associated with the edge of a habitat patch, including human disturbance, non-native species invasion, reduced food resources, increased wildlife mortality and decreased bird nest success. Interior habitat is the part of a habitat patch that is sufficiently distant from the edge such that negative edge effects are reduced or eliminated.

The scientific literature indicates a wide range of edge effect distances, depending on such factors as what species or what effect is being examined and geographic location. Edge effects may be stronger in urban areas because of the high contrast between natural and human-associated environments. In the Portland metro region, research shows that non-native bird and plant species are substantially reduced beyond 200 ft from the edge of a habitat patch. Based on this data, Metro used GIS mapping technology to construct a 200-ft buffer to the interior of forest and forest/wetland habitat patches. The acreage of interior habitat was calculated for each patch; many long, linear patches contained no interior habitat and fell within the lowest point category. Interior-containing patches of the same size but different shapes may receive 2 or 3 points, depending on how much interior habitat is in the patch.

Metro's methodology for mapping wildlife habitats has undergone extensive public review. The methodology was first applied to three nine square mile study areas: Bronson Creek, Johnson Creek, and Wilsonville. These study area maps were presented to Metro's Natural Resources Committee in May 2001. After a period of extensive public review, Metro Council adopted the methodology as part of Resolution 01-3087A (Appendix 5) and directed staff to produce maps applying the methodology on a regional basis.[9]

[9] Review included the Goal 5 Technical Advisory Committee, Metro Technical Advisory Committee and Metro Policy Advisory Committee.

Species and Habitats of Concern

To identify wildlife habitat in a biologically meaningful way, habitat must be linked to wildlife use. In 2001 Metro created a species list of all vertebrates typically occurring in the region on a yearly basis (Appendix 9). The species list is based on the opinion of more than two dozen local wildlife experts, and links species to habitat types via species-habitat associations based on Johnson and O'Neil's (2001) scheme. The purpose of Metro's Species List is threefold:

1. To identify fish and wildlife species that occur in the Metro region.
2. To identify the relative importance of various types of habitat to fish and wildlife species.
3. To describe the biodiversity of the Metro region.

There are 294 known native vertebrate species in the Metro region. Ninety-three percent use riparian areas, with 45 percent dependent on those areas to meet life history requirements. Eighty-nine percent of all terrestrial species in the Metro region use upland habitats, with 28 percent depending on these habitats.

In the Metro region several species of wildlife species are listed as threatened under the federal and state Endangered Species Acts. There are also numerous species that are identified as at risk both by the state and federal agencies. However, in this region we still have substantial wildlife habitat worth protecting and restoring for the purpose of retaining existing species and preventing future ESA listings.

The Goal 5 rule states that the wildlife habitat inventory process shall contain, at a minimum, threatened, endangered, and sensitive wildlife species habitat information; sensitive bird site inventories; and wildlife species of concern and/or habitats of concern identified and mapped by ODFW. For each resource site Metro has gathered existing and new data on sensitive species sighting locations, sensitive bird sites, and wildlife species and habitats of concern; linked sensitive wildlife species to their habitat needs; and estimated the amount of potential habitat available. These procedures are described in the following section.

Species of Concern: data sources, limitations and applications. Metro has gathered information from a variety of knowledgeable sources including ODFW, ORNHP, Metro Parks and Greenspaces, Audubon Society of Portland, local wildlife experts, and our own fieldwork that documents known sensitive species sightings, sensitive bird site inventories, and wildlife species of concern (hereafter termed "Species of Concern"). The current Species of Concern inventory includes a total of 344 sightings, including 43 sensitive plant locations included at the request of USFWS. About a quarter of these sightings are from our own data, a third each from ODFW and ORNHP, and the remainder from a variety of local experts. Note that many of these sightings fall outside of designated resource sites, reflecting the importance of the natural lands surrounding the urban region. These sightings were mapped as a GIS coverage that can be overlaid on the existing wildlife habitat inventory. When possible, species sightings were linked directly to a wildlife habitat patch in the current inventory, but in many cases this was not possible due to lack of data precision. For this and other reasons described below, there are limitations to the data and its availability. Thus in this Goal 5 inventory we present Species of Concern data in a non-specific manner by resource site, listing what is known to have been sighted within the watershed(s). We also estimate the amount of existing habitat for sensitive species. This is consistent with the Goal 5 rule, which requires sensitive wildlife species *habitat* information. Where sufficient information was available, we also mapped specific areas known to provide critical habitat to a sensitive species, and these are included as one type of "Habitats of Concern" (described below).

Sensitive species data for the metro region is sparse and has not been systematically collected for all species by any entity. There are good reasons for the lack of data; first, it would be prohibitively expensive to scientifically conduct biologically valid surveys for the region and would take more resources than any one agency has at this time. It would also be very time-consuming, probably taking years to accomplish even with adequate financial resources. In fact, although our data sources extended back as far as the 1800s, we included only species sightings since the inception of the Goal 5 rule in the early 1970's. Second, sensitive species are rare and difficult to detect by nature, making such surveys even more difficult. The most appropriate types of surveys would measure reproductive success and species-habitat associations, and these are very intensive types of studies in which researchers are typically only able to consider one or a few species at a time. Third, habitat patches not preserved as parks or open spaces typically contain multiple tax lot owners. Permission would need to be gained in advance to inventory each patch, and not all landowners would be willing to give such permission. As a result, sensitive species sightings would be biased towards public lands, but public lands are already protected to varying degrees thus are not as vulnerable to loss compared to unprotected lands. Fourth, such surveys may be limited to one or two seasons of the year, depending on the suite of species. For example, ODFW has identified the entire group of Neotropical migratory songbirds as a sensitive group in the Willamette Valley (Goggans and Boulay 1999), but these species only breed here, migrating south of the US border to overwinter. Adding further difficulty, some sensitive species information may not be generally released to the public due to potential harm to sensitive wildlife species, thus greatly complicating protection schemes.

Although these drawbacks limit the existing data's appropriateness in judging the relative value of different habitat patches, such data can provide useful information for sensitive species management within each resource site by linking sensitive species' habitat needs to the amount of available habitat.

Metro's Vertebrate Species List (Appendix 9) includes state, federal, and Oregon Natural Heritage Program (ORNHP) sensitive species status information, as well as species-habitat relationship information for each sensitive species based on Johnson and O'Neil's (2001) information. The section below entitled "Sensitive species accounts" provides a brief species account for each sensitive species. The steps for including Species of Concern sightings in the inventory were as follow:

1. Use Metro's Vertebrate Species List to identify Species of Concern known to occur in the region, and the habitat(s) with which each species is closely associated.
2. Gather sensitive species data from knowledgeable sources, including: ODFW, USFWS, Oregon Natural Heritage Program, and other sources of field data.
3. Map Species of Concern sightings using GIS. Use a 3-tiered coding system to indicate how certain we are that the species was actually detected in a particular habitat patch. In the inventory narrative, indicate which Species of Concern have occurred in each resource site since 1972 (the 1972 cut-off was selected by consensus

of the Goal 5 Technical Advisory Committee; this time frame generally matches the inception of the Goal 5 rule).

4. Crosswalk habitat patches contained in the Wildlife Habitat inventory with Johnson and O'Neil's (2001) habitat classification scheme to obtain a generalized estimate of the amount of each habitat type available within each resource site.

Of the 48 extant (still existing in the metro region; seven more are extirpated) non-fish species on the Species of Concern list, 73 percent are habitat specialists (most often riparian, oak or grassland). Specialization on a habitat type is indicated by a double XX in the Habitat Type column of Appendix 9. Of those sensitive species that are not considered habitat specialists, most depend on large wood or snags, resources that tend to decline in small habitat patches and in urban areas (Cline and Phillips 1983; Booth et al. 1997; May et al. 1997; Maser et al. 1988).

Evidence links sensitive species declines to sensitive habitat declines in our region. For example, native grasslands have virtually disappeared from the metro region, and birds depending on this habitat show substantial declines over the past several decades (Table 8). However, although long-term (since 1966) population trends for bird species are available through Breeding Bird Surveys (Sauer et al. 2001), many sensitive species in the metro region now occur in numbers too low to estimate trends through this source. Nonetheless, changes over time can be detected for species still occurring in sufficient abundance to allow estimation, and trends for the Portland-area route may be compared with statewide trends, as shown in Table 8. Note that these population trend changes are *per year* – some of these declines over the long term are quite precipitous; for example, California Quail Breeding Bird Survey detections are declining at an average rate of nearly eleven percent per year. These trends can be viewed on the following USGS website:

http://www.mbr-pwrc.usgs.gov/bbs/bbs.html

The route for the Portland metro region is ORE-002, Tualatin. It cuts a 24-mile swath through the central/south-central Portland metro region; birds are surveyed each year at the same points, every half mile.

Table 8. Long-term Breeding Bird Survey trends for grassland specialists occurring in the metro region. Trends represent percent change per year.

Species	Portland region trend (% decline per year)	Statewide trend (% change per year)
California Quail	-10.6	No significant change
Common Yellowthroat	-3.5	+ 3.6
Vesper Sparrow	Numbers too low to estimate	No significant change
Savannah Sparrow	-6.3	No significant change
Western Meadowlark	Numbers too low to estimate	No significant change
Ring-necked Pheasant*	-8.0	-2.0

* Breeding Bird Survey trends from 1966 through 2000 (statewide trends through 1999).
** Non-native species included to illustrate effects of habitat loss.

Species trends in the Portland area compared to statewide trends confirm that as a group, grassland-dependent bird species are faring poorly in the metro region, both in their own right and compared to statewide trends. Vesper Sparrows were last detected during Breeding Bird Surveys in 1988, and Western Meadowlarks, Oregon's state bird, were last detected in 1968. These birds were formerly relatively common breeders here. Agricultural lands are typically where grassland-dependent species may presently be found in our region, adding to the importance of retaining low-structure vegetation within 300' of waterways in the regional wildlife habitat system.

Sensitive Species Accounts

Below is a brief account of the habitat needs and reason(s) for sensitive status for each sensitive species on our list, synthesized with permission from ODFW, USFWS, The Nature Conservancy, and NatureServe Explorer (featuring data derived from state Natural Heritage Program conservation data centers). Species' scientific names are given in Metro's Vertebrate Species List (Appendix 9). At the time of this writing a new "Birds of Oregon" book is being compiled by David Marshall, and a partial draft list of Oregon species accounts is available online at http://www.osu.orst.edu/pubs/birds/bogr/accounts.htm. Further wildlife information may be obtained via Johnson and O'Neil (2001).

Cope's Giant Salamanders need streams and seepages in moist conifer forests. Restricted distribution and habitat destruction, as well as potential demand by collectors because of rare status, are listed as reasons for sensitive status (ODFW 1996). Habitat specialist: riparian wetlands.

Cascade and Columbia Torrent ("Seep") salamanders need cold clear springs and small headwater streams (especially those associated with old-growth forests). Very sensitive to microclimate conditions, and die if they dry out. ODFW cites lack of adequate protection for headwater streams and spring habitats as a reason for sensitive status, commenting that this may result in extinctions. Effective conservation of this species should include headwater riparian buffers (ODFW 1996). Habitat specialist: riparian wetlands.

Clouded Salamanders occur in forests and forest openings, especially those created by fire. They occur under loose bark in decayed snags and logs, and ODFW cites loss of snags and large woody debris and older forest structures as a reason for their decline (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Oregon Slender Salamanders are most common in mature and old-growth forest, but also occur in second growth. These salamanders are associated with dead and decaying wood; they also occur on talus areas. Loss of snags and large woody debris and habitat fragmentation are cited as reasons for sensitive status (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Western Toads occur in humid areas with dense cover, and rely on damp woody debris or burrows during dry weather. They breed in springs, ponds, shallow areas of lakes, and slow moving streams. Possible causes for decline include increases in UV-B radiation or pathogenic funguses, according to ODFW. Given their life history requirements, it is also likely that loss of large woody debris and microclimate changes associated with loss of riparian forests negatively affect this species (ODFW 1996). Habitat specialist: water, herbaceous and riparian wetlands.

Tailed Frogs take about 12 years to reach reproductive maturity, the longest development period of any frog. These animals require cold, fast-flowing perennial streams in forested areas. Adults feed on invertebrates from rocks and downed logs near streams, and are only active during periods of very high humidity. This species has the lowest known temperature requirements and the narrowest temperature ranges of any of our region's frog species. Reasons cited for population declines are environmental changes, including sedimentation and water temperature increases; they disappear from logged or disturbed areas, presumably due to water temperature and microclimatic changes causing local extinctions. These problems are exacerbated by habitat fragmentation. Conservation efforts should include elimination of timber harvest adjacent to aquatic habitats used by these animals, and provision of buffer strips along streams (ODFW 1996). Habitat specialist: riparian wetlands.

Northern Red-legged Frogs inhabit marshes, ponds, and streams with little or no flow, and use seasonal waters if wet until late May or early June. Stems below the water line are needed for egg attachment. These frogs often use dense hardwood stands with heavy ground cover. Possible causes cited for decline include displacement by introduced bullfrogs and pesticide and herbicide runoff (ODFW 1996). Habitat specialist: water, herbaceous and riparian wetlands, westside lowlands coniferous-hardwood forests.

Oregon Spotted Frogs (extirpated) are a highly aquatic species that is now absent from the western side of the Cascade Mountains; they disappeared from the Willamette Valley in the 1950's. It was once common here, and may still occur in isolated sites in western Oregon or Washington that lack bullfrogs. These animals require marshy pond or lake edges, or algae-covered stream overflow pools; in our area they occurred along the edges of slow-moving streams. Their extirpation coincides with the introduction and spread of bullfrogs, which probably predate tadpoles and adults. They are sensitive to toxins (ODFW 1996). Habitat specialist: water, herbaceous and riparian wetlands.

Painted Turtles are one of two native Pacific Northwest turtles, and require slow-moving or still, shallow waters with soft bottoms, basking sites, and an abundance of aquatic vegetation. They may colonize seasonally flooded areas near permanent water. Nesting occurs in soft soil in open areas up to several hundred yards from water. These animals need floating logs for basking sites. Possible reasons for decline include lack of recruitment, possibly due to hatching predation by bullfrogs; habitat destruction; declines in the quality and quantity of wetlands; and human actions including shooting and collecting. Nonnative turtles such as Red-eared sliders pose a threat in terms of transmitting pathogens. Conservation measures should include keeping habitats as free of bullfrogs and carp as possible, prevention of shooting the animals, and prevention of the release of nonnative turtles (ODFW 1996). Habitat specialist: water, herbaceous wetlands.

Western Pond Turtles in our area are the Northwestern subspecies. They require marshes, sloughs, oxbows, ponds, vernal pools, slow-moving sections of rivers and streams, and some reservoirs. They need basking sites such as floating logs, plants, and vegetation mats, as well as rocks, and mud banks. They may hibernate in soil or duff up to 1,600 feet from water; egg-laying may occur up to 1,300 feet overland, with holes dug in moist soil, typically in clayey soils with sparse grass/forb vegetation. Reasons cited for decline may include nest destruction from farm and development practices and aquatic, riparian, and upland (nesting) habitat destruction. Dams, drainage, channelization, and other hydrologic alterations are other possible reasons, generally resulting in simplified riparian ecosystems. Carp, which eat native plants, and reed canary grass invasions are other reasons cited, as well as mortality due to humans from shooting, cars, collection, and an upper respiratory disease. Conservation measures include those cited for Painted turtles (ODFW 1996). Habitat specialist: water, herbaceous and riparian wetlands.

Sharptail Snakes need conifer forest or oak-grassland edges, often near streams or damp areas of stable talus slopes. They may be found in moist rotting logs, moist talus, and under rocks, boards, or other objects. They feed on slugs. These reptiles are rare, declining, and now occur only in isolated populations, putting them at risk of large-scale extirpation. Reasons cited for decline include habitat destruction through urban development, logging, and other land use practices that reduce or destroy decaying logs and other cover (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Horned Grebes regularly occur inland during migration, but are not known to breed in our area. The need marshy areas and wet meadows. Reasons cited for decline include extremely limited population numbers and unstable breeding area conditions. Habitat specialist: water and herbaceous wetlands (ODFW 1996). BBS population trends: Portland route and statewide: insufficient data. US: no significant change.

California Condor occurred in the distant past in Oregon, as detected by the Lewis and Clark expedition. During the Pleistocene era (10,000 to 100,000 years ago) the condor ranged throughout the west; with the extinction of the large Pleistocene Era mammals, condors declined in range and numbers. Another large decline occurred when European settlers arrived on the West Coast, and accelerated during the gold rush of 1849. Current captive breeding and reintroduction programs are underway. Habitat and prey loss, power line deaths, and toxins are implicated in their extirpation. There are currently 58 birds in the wild, and first wild-laid condor chick in 18 years hatched successfully this year (USFWS 2001). No BBS data.

Dusky Canada Geese are medium-large, very dark geese and comprise one of seven subspecies of Canada Goose wintering in western Oregon. They do not breed here, but regularly overwinter in the Willamette Valley. These birds feed in pastures and certain agricultural crops, and rest on water rather closer to brush and trees than other subspecies. Reasons cited for this subspecies' decline include low population numbers, poor recruitment due to predation on the nesting area, and hunting mortality. Management issues have arisen due to conflicts between all Canada Geese and agricultural uses. Hunting restrictions are currently in place (ODFW 1996). Habitat specialist: water, herbaceous wetlands, agricultural lands. No BBS data for subspecies.

Aleutian Canada Geese are another subspecies of Canada Geese; they use the Willamette Valley and Sauvie Island as stopover habitat, and some may winter in western Oregon. In the Willamette Valley, they use pastures and croplands that are in grasses and grains. These birds were federally listed as endangered in 1967, but reclassified to threatened in 1990; a recovery plan has been in place for some time, and included establishment of the Nestucca Bay National Wildlife Refuge on the Oregon Coast. Numbers of the western population have been built up. The primary reasons cited for their decline is predation by introduced foxes in their northern breeding grounds (ODFW 1996). Habitat specialist: water, herbaceous wetlands, agricultural lands. No BBS data for subspecies.

Harlequin Ducks migrate between turbulent mountain streams and the ocean. Pairs have been observed during the breeding season in the Clackamas River. These birds need clean, fast-flowing water with an abundance of riffles and rapids and a mixture of rocky stream bottoms. The eat macroinvertebrates. They nest beneath multi-layered forest canopies in a variety of forest ages. They seem to prefer streams with minimal human activities. This species has low population numbers and low reproduction rates. Potential reasons for decline include forest removal, road building, and other disturbances resulting in altered hydrology, because these birds nest near water and need good macroinvertebrate communities in the stream (ODFW 1996). Habitat specialist: water, riparian wetlands. No BBS data.

Bufflehead are rare breeders in Oregon and the sensitive status only applies to the breeding population; it is unlikely that they breed in our area. They winter throughout the state. During breeding season they require deep water lakes in montane forested areas; during winter they use lowland lakes and estuaries. They are a cavity-nester. Reasons for decline include low population numbers, shortage of natural cavities (loss of snags), and perhaps recreational activities. They will use artificial nest boxes (ODFW 1996). Habitat specialist: water, herbaceous wetlands. BBS population trends: Portland route insufficient data; statewide no significant change; US no significant change.

Barrow's Goldeneyes, like bufflehead, are only considered sensitive during breeding and likely do not breed here. They use montane lake habitats most of the year in Oregon. They are cavity nesters and consumer invertebrates. They are sensitive due to low population numbers combined with reliance on cavities for nesting. They will use artificial nest boxes (ODFW 1996). Habitat specialist: water. BBS population trends: Portland route and statewide, insufficient data; US no significant change.

White-tailed Kites are included here because they appear to be undergoing a range expansion to our area, and now occur in the Willamette Valley with some regularity. In the US, this species was nearly extinct by 1930 or earlier, but has now reoccupied parts of its range, with Oregon breeding records beginning in 1977. These birds prefer savanna, open woodlands, marshes, and agricultural fields, where they typically nest in trees near a marsh. They are not on the state or federal fish and wildlife agencies' at-risk species lists, but are listed as "critically imperiled" during the breeding season by the Oregon Natural Heritage Program (NatureServe Explorer 2001). Habitat specialist: agricultural lands. BBS population trends: Portland route and statewide, insufficient data; US no significant change.

Bald Eagle immatures are often mistaken for Golden Eagles, because they do not attain white heads and tails until they are four or five years old. There are numerous recent breeding records in our area. During breeding season they need large, fish-supporting water bodies with large trees nearby for nesting. These trees are typically within a mile of water and are among the tallest in a stand. They return to the same nest area year after year. Habitat loss, PCB contamination, and residues from the pesticide DDT (now banned but still present in the Willamette Valley) are some of the reasons for this species' decline. DDT residues bioaccumulate in fat, and because Bald Eagles are high up in the food web they accumulate more of this poison, which prevents calcium uptake and results in egg-crushing during incubation. This remains a problem on the lower Columbia River. Many birds are also shot (ODFW 1996). Habitat specialist: water. BBS population trends: Portland route, insufficient data; statewide insufficient data (but trend looks positive); US +10.6%/year.

Northern Goshawks are found in a variety of mature forests, and nest in areas with dense overhead foliage or high canopy cover created by tall trees (typically old-growth). They occur in the Willamette Valley during migration and winter, where they sometimes migrate over or stop in non-forested habitats. They appear to need large habitat patches, and that combined with the need for old-growth forest are likely factors in their decline. Pesticides and human disturbance are also implicated (ODFW 1996). This species is not a specialist as defined in our habitat scheme, but depends primarily on mature and old-growth forest. BBS population trends: Portland route insufficient data; statewide –14.3%/year; US no significant change.

Merlin are a widespread species of falcon that migrate from the north to overwinter in the Willamette Valley, typically in agricultural areas. Although not listed as at-risk by the state or federal wildlife agencies, this species is identified by the Oregon Natural Heritage Program as imperiled in Oregon during the breeding season. Merlin were known to breed historically in our area, but modern-day breeding here is unconfirmed. Merlin have been negatively impacted by pollution, including organochlorine pesticides such as DDT; populations in some areas of the US are now increasing. Habitat loss is also implicated in their population declines (NatureServe Explorer 2001). This species is not considered to be a habitat specialist. BBS population trends: Portland route and statewide, insufficient data; US no significant change.

American Peregrine Falcons are, happily, recovering in our area and now regularly nest on certain Portland bridges, where they catch and eat other birds, especially pigeons. The banning of certain pesticides and carefully planned reintroduction have greatly aided their recovery here. In the Pacific Northwest, they also nest on natural shelves, ledges, and potholes. Their habitat needs are extremely variable. As with Bald Eagles, they are high in the food web and are vulnerable to toxins; these birds were nearly extirpated from the lower 48 states, and their continuing recovery is largely attributed to the ban of organochlorine pesticides such as DDT (ODFW 1996). This species is not considered to be a habitat specialist. BBS population trends: Portland route and statewide, insufficient data; US + 54%/year.

Mountain Quail are largely extirpated from the metro area, although there have been one or two undocumented reports of recent occurrences in the west hills (per Eric Scheuering, Oregon Natural Heritage Program). They prefer hilly, shrubby habitats during the breeding season and usually nest within a few hundred meters of water. These birds are the only seasonally migratory quail in the US, often moving into the lowlands for winter. Declines in northwestern Oregon are suspected, but undocumented; they are still hunted in western Oregon (NatureServe Explorer 2001). The reasons for their present scarcity are not clear. This species is not considered to be a habitat specialist. Portland route: insufficient data. Statewide and US: no significant trend detected.

Band-tailed Pigeons are a large, beautiful native woodland pigeon that tend to use montane coniferous forests and oak woodlands. These birds need mineral springs and mineral graveling sites, especially during nesting, and display strong site fidelity to both mineral and nest areas. They move around based on food availability, and although forest nesters they often forage in towns and agricultural areas, sometimes visiting backyard feeders. Pacific Coast populations have declined steeply, losing an estimated 60% of the population in the last three or four decades. Declines are likely associated with widespread changes in forest landscapes and hunting that continues today; low reproductive rates are also a factor. More studies are needed on this sensitive species (NatureServe Explorer 2001). Habitat specialist: riparian wetlands, westside lowlands coniferous-hardwood forests, oak. BBS population trends: Portland route –3.7%/year; statewide –1.8%/year; US –2.4%/year.

Northern Pygmy Owls are charming little owls about the size of the robin – which they eat, along with other birds and a variety of small mammals, reptiles, and insects. They are unusual for an owl in that they are primarily daytime animals. They are most common along forest edges and openings, and nest in tree cavities. They may be sensitive to habitat patch size and that, combined with their dependence on woodpecker-excavated snags and mixed-age forests, probably contribute to their decline (ODFW 1996). Habitat specialist: westside lowlands coniferous-hardwood forests. Portland route: no data; statewide: insufficient data; US: +3.6%/year.

Northern Spotted Owls are extirpated from our area due to declines in habitat quality, quantity, and increased fragmentation. They are generally associated with old-growth forests and need uneven-aged, multilayered canopies. It is unlikely that they will re-occur here unless their habitat needs change or unless we are able to provide large, old-growth forest patches in the future. (ODFW 1996) No BBS data.

Common Nighthawks were once quite common in our area, but are virtually extirpated as a breeding species now. Nighthawks undergo one of the longest migration distances of any North American bird. Preferring open (often aquatic) habitats with abundant aerial insects, these birds formerly nested on graveled rooftops in the Portland area, but this dropped off precipitously by the 1980's. Nighthawks historically nested on gravely islands of the Willamette River, and may still nest on large riverine islands today (per Birds of Oregon website cited above). Riparian habitat loss, insecticides, loss of nesting substrate (river islands and gravel rooftops), car collisions, and the spread of crows (nest predators) into urban areas are possible reasons for their decline here (NatureServe Explorer 2001). This species is not considered to be a habitat specialist in the Johnson and O'Neil scheme, but individuals are often found near water.

Lewis' Woodpeckers are considered sensitive only to breeding populations, and are now extirpated as a breeding species in our area, but in the past were summer residents in every part of the state. They are sometimes associated with post-burn areas. These birds are declining throughout their range, probably due to oak/Ponderosa pine and cottonwood habitat loss; they need open areas for foraging (they often flycatch) and large trees for nesting. Nest-site competition from European Starlings, fire and flood control are also probably factors (ODFW 1996). Habitat specialist: oak.

Acorn Woodpeckers are oak-obligates, requiring forests with at least an oak component. They need open areas under a high canopy; park-like development in oak groves with the lower vegetation layers removed actually provide desirable habitat for this species. These birds store acorns in excavated holes in thick bark or soft dead wood. They also flycatch and sap-feed. Their presence is well-known at Pacific University in Forest Grove; although the species is declining, the populations here are actually a result of a northward range expansion over the past 40 years. The large oak trees required for this species are hundreds of years old, and most of the oak habitat in our region has been lost. Urbanization is implicated (ODFW 1996). Habitat specialist: oak.

Pileated Woodpeckers, the largest of Pacific Northwest woodpeckers, are widespread but declining. They are considered an indicator species for mature and old-growth national forests in Oregon, although they also use younger forests at times. They require a very large area for nesting and foraging. In western Oregon this species can forage in forests greater than 40 years old, but need 70-year old forests for nesting or roosting, a likely reason for their decline, along with habitat loss and fragmentation. They require an abundance of logs and snags for foraging, another likely reason for their decline (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Yellow-billed Cuckoos, relatives of the familiar roadrunner, were formerly common along the Columbia River west of the cascades, but they are extirpated from our area now. Western states populations' have nearly completely collapsed. These birds need large riparian forests, especially those with cottonwood overstories and willow understories; such formerly extensive habitats are largely vanished from the metro area at present, and where cottonwood is present it tends to be invaded by nonnative blackberries rather than willow. Habitat loss is the most likely reason for their decline. These losses are attributed to conversion of riparian habitats to urbanization, agriculture, drainage, grazing, and disconnection from or development of the floodplain (cottonwoods are typically floodplain-associated). Pesticides and insect control may also be factors (ODFW 1996). Habitat specialist: riparian wetlands.

Olive-sided Flycatchers' "quick-three-beers" song is familiar to many birdwatchers. These birds nest along the edges of lakes, rivers, and beaver meadows and in open forest sites that have been cleared or burned. In our area they are typically found in a large habitat patch with older trees on the edges, a clearing in the middle, and one or more tall snags on which to perch and flycatch. They are widespread across North America and are declining substantially throughout their range. These are one of our longest distance migrants and as such, typically only get one chance at nesting because they arrive late and leave early. Potential causes for this species' decline include fire suppression, urban development, and deforestation along migration routes and on wintering grounds (The Nature Conservancy 1998a). Habitat specialist: westside lowland coniferous-hardwood forests. BBS population trends: Portland route –10.3%/year; statewide –5.0%/year; US –3.8%/year.

Willow Flycatchers are strongly associated with brushy riparian areas of willow and similar shrubs. They breed in our area along streams and other aquatic habitats, and are known to migrate along habitats similar to their breeding sites. They are susceptible to Brown-headed Cowbird parasitism, which reduces reproductive success. Habitat destruction and fragmentation are through to be the principal causes of decline in the west (The Nature Conservancy 1999b). Habitat specialist: riparian wetlands. BBS population trends: Portland route –8.6%/year (the data graph shows a steady decline to zero by 1996); statewide –5.6%/year; US –1.3%/year.

Streaked Horned Larks are grassland obligates, and the nearly complete loss of native grasslands in our area are the most likely reason for their decline here. They were formerly very common breeders in western Oregon, but are now severely depleted in population numbers and are virtually extirpated as a breeding species in the metro region; a few do breed here in very specific areas, and a few also winter here. The sensitive status only applies to breeding populations of this subspecies. These birds need sparsely vegetated open fields, and don't mind inhabiting disturbed areas such as overgrazed pastures; they dig a nest cavity in dry ground with sparse vegetation. Urban development and changes in farming practices are cited as likely reasons for this species' decline; for example, many former pastures are now producing grass seeds, and high nest mortality may result from farm practices such as mowing (ODFW 1996). Habitat specialist: grasslands.

Purple Martins are large, colony-nesting swallows that live along rivers and other water bodies and migrate south for the winter. They require unobstructed airspace to capture high-flying insects. They are cavity nesters and readily nest in artificial nest boxes; at present, the majority in our area are here because of nest boxes. Competition from other species – for nest cavities and foraging space – are among the likely factors for their decline, along with scarcity of nesting cavities. Nonnative European Starlings and House Sparrows probably usurp many suitable cavities prior to this species' arrival on the breeding grounds (ODFW 1996). Habitat specialist: water.

Western Bluebirds are considered a sensitive species in western Oregon interior valleys during the breeding season. This formerly common species has declined dramatically over the past seven decades, and is now confined to scattered sites of suitable habitat with artificial nest boxes. Through efforts such as the Prescott Bluebird Recovery Project in our area, the number of young bluebirds fledged per year has risen steadily over the past five years, with over 1,700 young fledged in 2001 due directly to citizen efforts. Bluebirds are cavity nesters, and their initial decline coincides with the spread of the more aggressive European Starling, which takes over cavity sites. Habitat and snag loss, insect control, and urbanization are other factors implicated in this species' decline (ODFW 1996). Habitat specialist: oak.

Yellow-breasted Chats are the largest of our warblers, and are long-distance migrants. They breed in second growth, shrubby old pastures, thickets, bushy areas, and low wet areas near water sources. They are widespread in the US but are virtually gone from our urban region. Threats to this species include habitat loss due to conversion to agricultural and urban land uses, and cowbird parasitism may also pose a threat. Habitat specialist: riparian wetlands (The Nature Conservancy 1998b). BBS population trends: Portland route –13.0%/year; statewide no significant change; US no significant change.

Oregon Vesper Sparrow is the Pacific Northwest subspecies of the widespread Vesper Sparrow; these birds winter south of the US border. This formerly common species' population is greatly reduced and fragmented, perhaps associated with loss of agricultural lands in our area and changes in farming practices; they are vulnerable to nest loss due to farming equipment. Loss of native grasslands due to urbanization is almost certainly a major factor in their decline here. They still apparently breed here, but only in a very few sites (ODFW 1996). Habitat specialist: grasslands, agricultural lands. BBS population trends: Portland route numbers too low to estimate; statewide no significant change; US –1.1%/year.

Tricolored Blackbirds are rare in our area, but apparently breed in at least one location. They are a colonial nester. In Oregon, these birds are typically found in cattail marshes or in Himalayan blackberry stands bordering wetlands. Reasons cited for sensitive status are small population numbers combined with inconsistent distribution patterns, making habitat protection difficult (ODFW 1996). Habitat specialist: herbaceous wetlands.

Western Meadowlarks are our state bird and were once quite common in the metro region but sadly, breed here only in very rare cases today. Virtually complete loss of native grasslands in our area has depleted this species. Farming practices are also implicated in this insect-eating, ground-nesting species, as is predation by birds and mammals. They appear to be prone to cowbird parasitism. Habitat development for these birds should include providing a variety of grassland types and heights, sparse woody cover, and high forb and grass cover. Protection of known nesting areas should be a priority wherever this species breeds in our area (The Nature Conservancy 1999a). Habitat specialist: grasslands, agricultural lands. BBS population trends: Portland route insufficient data (last occurred during 1968 survey); statewide no significant change; US –0.5%/year.

Yuma Myotis in western Oregon consists of a subspecies, *Myotis ymanensis saturatus*. Apparently widespread in Oregon this species, like many other bat species, will use human-made structures. They occur in urban, riparian, and mature conifer habitats in northwest Oregon, but are particularly associated with water, over which they feed. Little population data is available, and this species' status as a sensitive species appears to be somewhat uncertain. However, this species is especially noisy during rearing of the young, and as a result many colonies have been extirpated or destroyed as pests or through vandalism (ODFW 1996). This species is not considered to be a habitat specialist, although individuals are often seen near water.

Long-legged Myotis in western Oregon consist of the subspecies *Myotis volans longicrus*. As with Yuma Myotis, these bats are widespread in Oregon. In our area they can be found in agricultural, riparian, oak woodlands, and mature conifer forests. Maternity roosts have been found in snags and hollow trees, and maternity and hibernation sites are limited by microclimate (temperature and humidity). This species is listed as sensitive due to absence of information combined with dependence on snags, decadent trees, old and abandoned buildings, bridges, and caves for roosting and hibernacula; most of these components are declining in terms of presence and availability. Human disturbance is also an issue, as is true for all bats that hibernate, because disturbance interferes with energy and fat storage balances during hibernation periods. Riparian protection has also been found to be inadequate (ODFW 1996). Habitat specialist: westside lowland coniferous-hardwood forests.

Fringed Myotis are known to use a variety of habitats including forests, woodlands, and grasslands; nursery colonies and roosts occur in caves, mines, buildings, etc., but more studies are needed to detail their habitat needs. They are considered sensitive due to general rarity and susceptibility to human disturbance (ODFW 1996). This species is not considered to be a habitat specialist, although little is known about life history characteristics.

Long-eared Myotis in our area are the subspecies occurring west of the Cascades, known as *Myotis evotis pacificus*. These bats probably occur statewide in forested and riparian areas, and winter in Oregon, at least in low numbers. Similar to other Myotis species, Long-eared Myotis maternity roosts and hibernation sites occur in buildings, caves and mines. Their status as a sensitive species is somewhat uncertain due to lack of information, but this forest-dwelling bat is likely at risk due to habitat loss, including maternity and hibernation roosts. General dependence on snags, decadent trees, and coarse woody debris also puts them at risk, as does human disturbance. Unlike some other bat species, these bats tend to glean insects off of bark, etc., potentially putting them more at risk due to insecticides than non-gleaners (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Silver-haired Bats are fairly large bats that occur most commonly in forests. These beautiful bats are most abundant in old-growth Douglas-fir/Western hemlock forests and apparently need high snag densities. They roost in cavities in snags, old-growth bark crevices, and similar natural types of habitat; maternity roosts are almost exclusively in cavities and crevices in snags and trees. They forage over water. Silver-haired and other forest bats are assumed to be declining based on habitat loss. In our area, declines in forest cover, snags and large wood, and aquatic habitats are potential reasons for their decline (ODFW 1996). Habitat specialist: westside lowland coniferous-hardwood forests.

Hoary bats are solitary bats except during migration and mother-young associations. This species prefers deciduous and coniferous forests and woodlands, where it needs dense foliage above and open flying room below. Roosts and hibernacula may be found in rock crevices, tree trunks or cavities, and sometimes in a squirrel's nest or moss clump. Females may show high site fidelity. Forested habitat and snag losses are potential reasons for their decline in our area (NatureServe Explorer 2001). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Pacific Western (Townsend's) Big-eared Bats really do have very large ears, and the subspecies encountered west of the Cascades is *Plecotus townsendii townsendii*. They occur in a variety of habitats across the state, but the fragmented nature of their population reflects habitat fragmentation. This species is declining seriously in Oregon, with population declines of 58 percent west of the Cascades since 1975-85. These bats need undisturbed roost, nursery, and hibernation sites, with specific microclimate conditions. Disturbance and habitat destruction are cited as potential reasons for their decline; population declines are occurring in disturbed sites, whereas protected sites contain stable or increasing populations (ODFW 1996). Habitat specialist: water.

Western Gray Squirrels are the largest native squirrel with the bushiest tail in western states. It is often confused with the nonnative Eastern Gray Squirrel, which is likely much more common here now; to distinguish the two, look for silvery frosting, reddish on the backs of the ears, and general absence of reddish elsewhere on the native squirrel. Western Gray Squirrels occur in mixed age forests dominated by pine and/or oaks, and this habitat is greatly reduced in our area. They do occur in urban areas with adjoining natural habitat, and need connectivity in the canopy layer; they typically occur within 600 feet of water, where they eat pine seeds, acorns and hazelnuts. Washington State is currently considering a threatened status for this species. Reasons cited for this species' decline include very substantial habitat loss, fire suppression causing shifts in forest composition from oak to conifer, competition from nonnative species (particularly in urban areas), and forest fragmentation (ODFW 1996). Habitat specialist: oak.

Camas Pocket Gophers are restricted to the Willamette Valley, where habitat has been substantially altered by urbanization and intensive agriculture. These solitary, relatively short-lived (3-year lifespan) animals are important ecosystem components as prey and because they influence soils, habitat heterogeneity, plant diversity, and soil productivity. They use unforested areas with rich soils in lower elevations, where they build complex tunnel systems. Their limited geographic range, combined with habitat loss/alteration, put them at risk (NatureServe Explorer 2001). Habitat specialist: agricultural lands.

White-footed Voles are a species of mouse occur only in western Oregon (primarily west of the Willamette Valley) and northwestern California. They are probably burrowing animals, but little is known about this extremely uncommon species. They occur in a variety of forest conditions, apparently along streams with an alder component, often in heavy cover consisting of downed logs and/or brush. It is considered at-risk due to its general rarity. In our area it is likely that habitat loss, including loss of large wood, contribute to their rarity (ODFW 1996). This species is not a habitat specialist but relies on specific habitat elements, including large wood.

Red Tree Voles' range is limited to western Oregon and possibly northwestern California, where they are thought to have very limited dispersal capability. This species' optimum habitat is old-growth Douglas-fir, although other coniferous forests may be used. Red Tree Voles are also associated with high percent canopy cover, high stump density, and shorter snags and logs. Presumably their sensitive status is due to loss of formerly widespread old-growth coniferous forests, as well as habitat fragmentation (NatureServe Explorer 2001). Habitat specialist: westside lowland coniferous-hardwood forests, oak.

Habitats of Concern: data sources, limitations and applications.

Unlike Species of Concern, Habitats of Concern may add acreage to the inventory or increase an existing habitat patch's relative value in the inventory. The formal criteria for Habitats of Concern are in Appendix 7, and the list of Habitats of Concern that have been accepted into the wildlife habitat inventory is in Appendix 10. The steps for identifying Habitats of Concern are outlined below.

First, Metro consulted with Oregon Department of Fish and Wildlife, US Fish and Wildlife Service, and other conservation organizations, as well as the Goal 5 Technical Advisory Committee to develop criteria for identifying Habitats of Concern. Based on these consultations, the following three categories were acknowledged as appropriate for identifying Habitats of Concern.

The first category recognizes regionally at-risk, or priority conservation, habitats. These habitats are at risk because they formerly covered much more extensive areas, and they tend to be declining in quality where they still remain. Oregon Department of Fish and Wildlife identifies grasslands, deciduous forests (oak and riparian), aquatic habitats, and urban natural area corridors as the top four Willamette Valley habitats at risk (Goggans and Boulay 1999). The Oregon Biodiversity Project, in which ODFW and USFWS are partners, identifies native prairie grasslands, oak habitats, wetlands, and bottomland hardwood forest as conservation priorities in the Willamette Valley (Defenders of Wildlife 2000). The Oregon-Washington chapter of Partners in Flight (ODFW and USFWS are partners; Partners in Flight 2000) considers grassland-savanna, oak woodland, and riparian forests to be priority conservation habitats. From these sources we conclude that native oak habitats, native grasslands, wetlands, and bottomland hardwood forests are priority conservation habitats. Less than one percent of historic Willamette Valley native oak and grassland habitats still exists. Over 70 percent of the bottomland hardwood forests have been lost. In the Willamette Valley, various sources document wetland losses between 40-57 percent of original, with continuing losses of more than 500 wetland acres per year.

Wetlands are a Habitat of Concern in our area and we have excellent GIS data on this important resource. However, the GIS process used to model wildlife habitat patches set forth a minimum patch size of two acres, resulting in the omission of a substantial number of wetlands smaller than two acres. These small wetlands are known to be disproportionately important to the region's wildlife. For example, small wetlands are often free of non-native bullfrogs, unlike many larger wetlands; bullfrogs routinely eat amphibians and their egg masses, ducklings, and young turtles, as well as competing with native species for food and other habitat resources. To address this modeling drawback we added wetlands less than two acres that were excluded from the Wildlife Habitat modeling process into the inventory as Habitats of Concern. The result is that all wetlands in the wetland data layer – which consists of the National Wetlands Inventory, augmented or corrected by local wetland inventory information received by Metro (Appendix 3) – are included either in the Wildlife Habitat inventory or added as an HOC.

The second category recognizes the extraordinary and unique value of riverine islands and delta areas. Riverine islands and deltas provide unique habitat for migrating and nesting shorebirds, waterfowl, nesting terns and gulls, and other wildlife through enriched food resources, sand and mudflats, and protection from predators and disturbance (Iverson et al. 1996; Elliott et al. 1998; Fleskes et al. 2002). Macroinvertebrate communities are denser and more diverse around river islands and deltas (Thorp 1992). Bald eagles winter, breed, and forage on islands in our area, as strongly indicated by sensitive species data we collected and by researchers elsewhere in the Pacific Northwest (Garrett et al. 1993; Elliott et al. 1998; Watson and Pierce 1998; Parrish et al. 2001). Channel complexity and large wood, which are linked to island formation, have been substantially reduced from historic levels; protecting these areas is vital to maintaining healthy ecosystems and the species that depend upon them (Thorp 1992).

The third category recognizes known habitat patches providing unique or critical wildlife functions. Patches providing unique or critical wildlife functions are submitted and considered on a site-by-site basis for their importance in the inventory. Such habitats include areas that provide unusually important wildlife functions, such as major wildlife crossings/pathways or a key migratory pathway, such as an elk migratory corridor. Also eligible are important migratory stopover areas such as grassy hilltops, inter-patch connectors, and biologically or geologically unique areas such as rocky outcrops or talus slopes important to many herptiles and bats. Habitat vital for the life-history requirements of a sensitive wildlife species (for example, nesting or key passage habitat for an existing population of native turtles) or Great Blue Heron rookeries, or habitats that support at-risk plants, also fall into this category. These habitat areas submitted to Metro must be specifically delineated and submitted by wildlife experts or other knowledgeable parties.

Metro requested Habitats of Concern information through the Goal 5 Technical Advisory Committee, Greenspaces Technical Advisory Committee, ODFW, USFWS, Oregon Natural Heritage Program, and various wildlife experts, parks providers, and local jurisdictions (see Consultations, Table 6). Submitted sites were clearly delineated on a map or described in such a way as to allow precise mapping, and rationale given for their inclusion in the inventory as a

Habitat of Concern. Metro evaluated proposed HOCs based on the criteria described above and in Appendix 7 (see also Appendix 10). Sites or portions of sites that did not appear to meet the criteria were excluded, based on examination of the submitted information, criteria matrix, aerial photographs, and other GIS data resources. The Habitats of Concern maps and data were subsequently provided to local jurisdictions' planning directors for review and comment.

Habitats of Concern were mapped as a separate GIS layer and overlaid on the current (GIS-modeled) wildlife habitat inventory. The assumption is that all Habitats of Concern are, by their relative value or scarcity, high value habitats. A majority of submitted sites were already included in the inventory; in fact, only 1.3% of the entire wildlife habitat inventory consisted of HOCS outside of modeled habitat patches. Most HOCs also scored relatively highly in the model, providing positive feedback to the wildlife habitat modeling process and affirming the importance of these sites. However, some sites that did not score highly in the model – for example, low-structure vegetation along important connectivity corridors – were appropriately identified as highly important wildlife resources, providing a means to test and address potential GIS model shortcomings.

Fieldwork to assess mapping criteria

The Goal 5 rule specifically notes that "existing and available information" drives the inventory process, thus no field studies to validate inventory methods are required. However, Metro has undertaken a research program designed to test the GIS model on which its Goal 5 Inventory is based. Outside funding was required to develop the program and was not obtained until August 2001 (from USFWS), thus only partial findings will be available in time for Metro Council's determination of regional significance. The purpose of this study is to evaluate the model so that Metro can proceed with appropriate conservation, protection and/or restoration measures, and/or to identify potential imperfections in the model that can be corrected or improved. The ultimate goal is adaptive management based on biology.

Briefly, the field studies include three components. The first component relates to the wildlife habitat inventory (analyses completed), and the second and third relate to the riparian corridors inventory (analyses not yet completed).

1) Wildlife Habitat Assessments (WHAs): Metro revised an existing methodology (WHA; Appendix 11) based on extensive input from Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and the City of Portland (who has extensively used a previous version of the methodology). This assessment relies on a team of biologists walking through a site, discussing its characteristics and scoring it based on the quality of water resources, vegetation (wildlife cover, food, native vs. nonnative plants, and structural complexity), and human influences. The revised method was successfully field-checked against quantitative data collected at 54 study sites in 1999 (Hennings 2001). It was also performed on 102 additional randomly selected natural areas. Abbreviated results for this part of the study and are presented in the next section.

2) Rapid Stream Assessment Technique (RSAT): Metro modified an existing qualitative methodology with help from other experts (e.g., Clean Water Services and Michael Cole of ABR. This procedure also relies on a biological team to measure parameters such as stream bank erosion, sedimentation within the channel, channel substrate composition, etc. It focuses on capturing the deleterious effects associated with urbanization. RSATs were conducted at all B-IBI sites (described next); sites will be scored and the scores compared against GIS model-generated scores to test for correlations with GIS model scores, similar to the statistical analyses employed to check the Wildlife Habitat model. We will also examine relationships between instream conditions and macroinvertebrate communities (see item 3).

3) Benthic Index of Biological Integrity (B-IBI): A B-IBI looks at the composition of the macroinvertebrate communities living at the bottom of a stream, compared to what is found in relatively undisturbed conditions. Macroinvertebrates are useful indicators of instream conditions because different types of macroinvertebrates respond differently to a variety of environmental parameters (e.g. sedimentation, stream temperatures, dissolved oxygen, etc.). Thus what is in the stream, and what is missing, reveals a great deal of information about stream habitat conditions. We sampled invertebrates at 55 sites in the Metro region based on Oregon Department of Environmental Quality's current methodologies; the samples will be analyzed by Dr. Judith Li's invertebrate lab at Oregon State University, but this data will not be available

until a later date. B-IBI scores will be correlated with GIS model scores to test for relationships. Because altered hydrology is known to negatively influence macroinvertebrate communities, we do not expect to see a tremendously strong correlation between B-IBI scores and GIS model scores (research throughout the US shows a typical downward B-IBI trend line with increasing urbanization). However, we hypothesize that sites with high GIS model scores will also receive higher B-IBI scores, after accounting for the level of urbanization in the watershed.

Results of Wildlife Habitat Assessments.

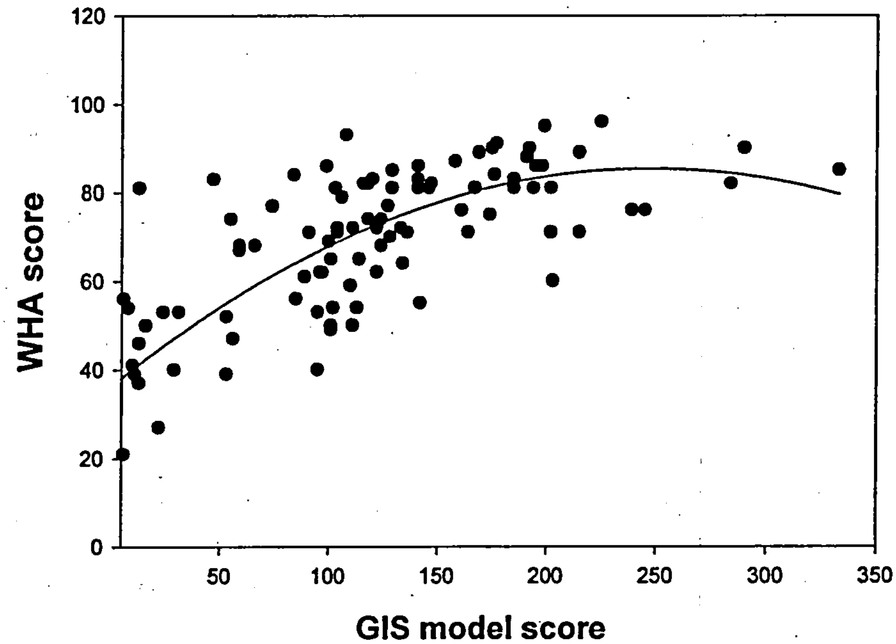
To test the substantially revised WHA protocol (Appendix 11), field crews first assessed 54 study sites for which we had quantitative plant data from 1999 (Hennings 2001). This quantitative data, including structural complexity and the relative amounts of native versus nonnative plants, was distilled into a "megavariable," or a cluster of variables that were statistically related both to one another and to bird communities. As scores for the megavariable increased, bird diversity and species richness increased, while the percentage of nonnative birds decreased. The protocol worked very well, based on linear regression of WHA scores against 1999 field scores ($p < 0.0001$, $r^2 = 0.62$). Thus, the WHA is an appropriate technique to measure the effectiveness of the GIS model in identifying habitat patches important to birds and presumably, other wildlife.

Metro subsequently conducted habitat assessments on 102 randomly selected habitat patches. A predetermined criterion for inclusion in the selection pool was that some part of each patch must include or be adjacent to public lands of some sort, so that field crews would have the ability to access the patch. Field crews also routinely asked for and received permission from landowners to enter the patch.

We statistically assessed (a) WHA scores versus each individual model criterion, and (b) WHA scores versus the model's overall performance. We examined scatterplots and conducted correlation analyses, simple linear regression (for individual variables) and multiple linear regression (for appropriate variable combinations) analyses to determine the significance of each criterion in the GIS model. Except for the species richness criterion, all model variables showed a relatively strong, statistically significant relationship ($p < 0.0001$) with field-based scores. The ONHP species richness criterion was statistically unrelated to field-based scores ($p > 0.1$), possibly due to the large spatial scale at which this data was mapped. The ONHP species richness model is currently being refined, and may well prove useful in the future. Mallow's cP statistic (a variable selection technique) suggested that the most appropriate model included four criteria: habitat patch size, interior habitat, connectivity to other patches, and water resources (Figure 1). The results of these analyses provided input into model refinement.

Field studies also revealed that some habitat patches were poorly defined due to the relatively large (24 m) raster size inherent in the satellite data used in the original model. In such cases we did not conduct WHAs but moved on to the next randomly selected habitat patch that was accurately delineated. However, this revealed the necessity to more accurately define patches based on hand-digitized forest canopy and low-structure vegetation, and the subsequent model version reflected this change.

Figure 1. Wildlife Habitat Assessment (WHA) field-based scores versus revised GIS Wildlife Habitat Model scores (based on size, interior habitat, proximity to other patches, and water resources).



To date Metro has reviewed the scientific literature pertaining to wildlife and habitats in urban ecosystems, created a corresponding model rating existing habitats in the region, and field-tested the model to assess its validity. We have adjusted the model to reflect our findings; the revised GIS wildlife habitat model is ecologically valid based on local field data. The success of the revised model scores in predicting "better" habitats – that is, the good structural complexity, higher percentage of native plants, and good food and water resources associated with enriched native bird communities – allows us to confidently proceed with inventorying the region's wildlife habitats. It provides important information concerning quantity and location of wildlife habitat patches and allows us to differentiate sites based on habitat quality.

Resource site analyses

Definition of resource sites (aggregations of subwatersheds)

The Goal 5 rule defines a "resource site" as "…a particular area where resources are located. A site may consist of a parcel or lot or portion thereof or may include an area consisting of two or more contiguous lots or parcels" OAR 660-23-010 (10). The Goal 5 rule also states that the inventory process may be followed for "a single site, for sites in a particular geographical area, or for the entire jurisdiction or urban growth boundary…." OAR 660-23-030(1). Metro has taken an ecological approach to defining resource sites by delineating subwatersheds and using these geographically specific areas as a focal point (i.e., resource site) for gathering and analyzing information on location, quality and quantity of the resource. A subwatershed is a subdivision within watersheds using the Hydrologic Unit Code (HUC) system, which is described below (see also Appendix 12).

The classic definition of a watershed is any area of land from which water, sediment, and organic and dissolved materials drain to a common point, such as a stream, river, pond, lake or ocean. Watersheds are hierarchical in nature, with small ones nesting within larger ones. In the mid-1970s, the U.S. Geological Survey (USGS) developed a standardized hydrologic unit system, referred to as the Hydrologic Unit Code (HUC) system. A hydrologic unit is a drainage area delineated to nest in a multi-level, hierarchical drainage system. The underlying concept of this system is a topographically defined set of drainage areas, based on scientific hydrologic and mapping principles, organized in a nested hierarchy by size. The advantage of this system is that it is nationally consistent, allowing for efficient sharing of information and resources and assuring the geospatial database is usable with other related Geographic Information System (GIS) databases (NRCS 2000). For these reasons, Metro chose to use the HUC system of delineating watersheds to allow future watershed planning efforts to be standardized and compatible with information generated by other agencies. Due to the standardized size of each unit, this system also allows for more accurate comparisons of watersheds across the region.

The HUC system initially divided the country into 21 regions, 222 sub-regions, 352 basins and 2,149 sub-basins. A hierarchical hydrologic unit code containing 2-digits for each of these four levels was assigned to the hydrologic units, forming the basis for the 8-digit hydrologic unit code. The geographic area (sub-basin) represented by the 8-digit standardized code is too large to adequately serve many types of water resource analysis and management needs. To address this problem, the Natural Resources Conservation Service (NRCS) mapped watersheds (5th level) in the early 1980s for use in natural resource planning. In the mid-1990s, the NRCS along with State agency conservation partners, began a national initiative to delineate and digitize watershed (5th level) and sub-watersheds (6th level). Table 9 shows the six different levels of hydrologic units, the name, average size and an example of the hydrologic numeric coding. Appendix 12 includes information on HUCs, including definitions, HUC standards and maps of 4th, 5th, and 6th field HUCs within the Metro boundary.

Table 9. Hydrologic Unit Code System

Hydrologic Unit Level (field)	Name of level	Size	Example	
			Name	Numeric Code
1	Region (21 units mapped)	Average: 177,560 sq. mi.	Pacific Northwest	**17**
2	Sub-region (222 units mapped)	Average: 16,800 sq. mi.	Willamette River	17**09**
3	Basin (352 units mapped)	Average: 10,596 sq. mi.	Willamette River	1709**00**
4	Sub-basin (2,149 units mapped)	Average: 450,000 acres	Lower Willamette River	170900**12**
5	Watershed (22,000 estimated units mapped)	40,000-250,000 acres	Johnson Creek	17090012**01**
6	Sub-watershed (160,000 estimated units mapped)	10,000-40,000 acres	Kelley Creek	1709001201**02**

Source: NRCS 2000, Metro 2001

Sub-watersheds (6th level HUC) have not yet been delineated by the NRCS for the geographic area within Metro's jurisdiction. Therefore, Metro contracted with Ecotrust to delineate sub-watersheds within its jurisdiction using the HUC system mapping protocol. These delineated areas have not been reviewed by NRCS, but are sufficient for Metro's purpose of collecting and analyzing inventory information.

Table 10 shows the 11 watersheds and 41 subwatersheds that are either fully or partially within Metro's jurisdictional boundary. Some of these watersheds, such as Corral Creek and Chicken Creek, intersect the Metro boundary by only a small area. For ease of data collection and analysis, any subwatershed with less than 3,000 acres inside Metro's boundary is combined with an adjacent subwatershed that has a hydrologic relationship, if possible. In some cases, the sub-watersheds may be adjacent but without a hydrologic relationship. For example, Council Creek and Middle Tualatin River-Gales Creek (Cornelius/Forest Grove area) are combined, but are located in different watersheds (5th level HUC): Dairy Creek and Gales Creek (respectively). The cities of Cornelius and Forest Grove are split by these watersheds.

Combining the smaller subwatershed areas in Metro's boundary resulted in 27 resource sites, as shown in Table 11. The resource site analysis that follows this section provides more information on which subwatersheds were joined for data collection and analysis.

Table 10. HUC watersheds and subwatersheds in the Metro region.

WATERSHED (5th field HUC)	SUB-WATERSHED (6th field HUC)	12 digit HUC code	Total Acres	Acres in Metro
Columbia Gorge Tributaries West	Columbia River	170800010605	8,703.7	2,057.7
Gordon Creek/ Lower Sandy River	Lower Sandy River	170800012805	6,233.3	3,654.6
	Beaver Creek	170800012806	11,581.7	10,336.5
Scappoose Creek	Lower Willamette River	170900120201	32,898.7	32,899.0
	Columbia Slough	170900120202	54,396.3	53,571.9
	Multnomah Channel	170900120203	27,825.2	1,037.6
Johnson Creek	Johnson Creek-Sunshine Creek	170900120101	14,120.2	12,372.9
	Kelley Creek	170900120102	3,175.6	3,175.6
	Middle Johnson Creek	170900120103	8,949.4	8,949.5
	Lower Johnson Creek-Willamette River	170900120104	5,950.1	5,950.2
	Lake Oswego	170900120105	4,168.7	4,168.7
	Tryon Creek	170900120106	4,356.4	4,356.4
	Johnson Creek-Crystal Springs Creek	170900120107	7,844.6	7,844.6
	Mount Scott Creek	170900120108	11,809.5	11,809.6
Lower Clackamas River	North Fork Deep Creek	170900112205	8,757.7	2,644.3
	Richardson Creek	170900112206	17,969.2	3,821.2
	Rock Creek-Clackamas River	170900112208	14,103.1	11,120.6
Abernathy Creek	Corral Creek	170900070401	18,024.7	207.7
	Willamette River-Boeckman Creek	170900070402	19,678.9	7,283.4
	Beaver Creek	170900070403	20,476.0	2,867.1
	Abernathy Creek-Holcomb Creek	170900070404	21,388.4	3,180.3
	Willamette River-Lower Tualatin River	170900070405	6,589.2	5,356.3
Senecal Creek/Mill Creek	Molalla River	170900090105	5,977.6	125.632
Lower Tualatin River	Lower Tualatin River-Lake Oswego Canal	170900100501	15,230.8	15,230.9
	Upper and Middle Fanno Creek	170900100502	11,183.3	11,183.4
	Summer Creek	170900100503	3,900.6	3,769.1
	Lower Fanno Creek	170900100504	9,395.9	8,453.8
	Cedar Creek	170900100505	5,723.3	1,528.4
	Chicken Creek	170900100506	4,033.5	133.5
	Rock Creek (South Washington Co.)	170900100507	4,952.3	2,102.3
	Lower Tualatin River-Willamette River	170900100508	7,859.8	475.1
Rock Creek/Tualatin River	Middle Rock Creek-Tualatin River	170900100401	16,833.4	7,300.1
	Beaverton Creek	170900100402	24,296.7	24,296.8
	Lower Rock Creek-Tualatin River	170900100403	7,557.0	7,496.4
	Middle Tualatin River-Davis Creek	170900100404	6,801.9	1,220.7
	Middle Tualatin River-Gordon Creek	170900100405	9,043.4	3,594.8
	Lindow Creek	170900100407	10,210.0	752.5
Dairy Creek	West Fork Dairy Creek	170900100106	12,297.7	36.1
	Council Creek	170900100107	12,255.9	2,924.9
	McKay Creek	170900100108	20,443.0	3,842.7
Gales Creek	Middle Tualatin River-Gales Creek	170900100206	13,863.7	2,747.2

Source: Metro 2001

Table 11. Resource sites.

Resource site #	Sub-watershed name	Acres in Metro
1	Lower Sandy River-Columbia River	5,712.3
2	Beaver Creek-Sandy River	10,336.5
3	Willamette River-Boeckman Creek	7,616.7
4	Willamette River-Lower Tualatin River	11,403.7
5	Council Creek	5,708.2
6	McKay Creek	3,842.7
7	Middle Rock Creek-Tualatin River	7,300.1
8	Beaverton Creek	24,296.8
9	Lower Rock Creek-Tualatin River	8,717.2
10	Middle Tualatin River-Gordon Creek	4,347.3
11	Lower Tualatin River-Lake Oswego Canal	15,230.9
12	Upper and Middle Fanno Creek	11,183.4
13	Summer Creek	3,769.1
14	Lower Fanno Creek	8,453.8
15	Rock Creek (So. Washington Co.)	4,239.3
16	Richardson Creek	6,465.5
17	Rock Creek-Clackamas River	11,120.6
18	Johnson Creek-Sunshine Creek	12,372.9
19	Kelley Creek	3,175.6
20	Middle Johnson Creek	8,949.5
21	Lower Johnson Creek-Willamette River	5,950.2
22	Lake Oswego	4,168.7
23	Tryon Creek	4,356.4
24	Johnson Creek-Crystal Springs	7,844.6
25	Mount Scott Creek	11,809.6
26	Lower Willamette River	32,899.0
27	Columbia Slough	54,609.5

The sections that follow provide a summary of the information collected for each resource site. The number assigned to each resource site (1-27) corresponds to each map generated for Metro's Goal 5 inventory. The information is organized into eight sections by watershed (5th level HUC) as listed below.

- Columbia Gorge Tributaries West and Gordon Creek/Sandy River watersheds
- Abernathy Creek and Senecal Creek/Mill Creek watersheds
- Dairy Creek and Gales Creek watersheds
- Rock Creek/Tualatin River watershed
- Lower Clackamas River watershed
- Johnson Creek watershed
- Lower Tualatin River watershed
- Scappoose Creek watershed

The data gathered for Metro's inventory provides location, quality and quantity information for riparian corridors and wildlife habitat, which is required by the Goal 5 rule. All data in this document are based on Metro's jurisdictional boundary. Each section provides a summary of general watershed information (see Appendix 13 for additional information). For example,

Table A-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary.

Other information contained in the various tables presented in each section include the following, where available:

- Miles of DEQ 303(d) listed streams
- Road density
- Miles of stream with known anadromous fish presence
- Acres of wetlands and floodplains
- Stream miles by channel type and total stream miles
- Vegetation types within 300 feet of a stream
- Number of building permits since 1996
- Characteristics of stream miles by resource site
- Riparian vegetation by resource site
- Regional zoning by resource site
- Acres within resource site by jurisdiction
- Acres providing ecological function within the riparian corridor
- Breakdown of ecological scores by acre
- Wildlife habitat by resource site
- Breakdown of wildlife model patch scores by resource site
- Breakdown of wildlife patch model scores by criteria
- Estimates of land cover type by resource site
- Estimates of wildlife habitat type availability by resource site
- Information on Habitats of Concern by resource site
- Information on Species of Concern sightings by resource site

The data tables for each 5th field HUC and resource site follow a textual description of the resource characteristics. **Note that all data relates to the area of the subwatershed that is contained within Metro's jurisdictional boundary.** Summary data tables are at the end of the Resource Site Analysis section. These tables allow easier comparison of the relative quantity and quality of riparian corridor and wildlife resources among resource sites.

Appendix 13 includes extensive additional information on resource sites, including stream length survey data by ODFW, water quality data, road density and riparian area widths. In addition, Appendix 14 includes a bibliography of water quality reports. Also included are color site maps for the region (north, east, south and west sections), as well as black and white maps for each resource site depicting riparian and wildlife habitat inventory information.

A. Gordon Creek/Lower Sandy River and Columbia Gorge Tributaries West

General watershed information
Resource sites in the Gordon Creek/Lower Sandy River and Columbia Gorge Tributaries West Watersheds include:

- Lower Sandy River-Columbia River subwatersheds (combined)
- Beaver Creek-Sandy River subwatershed

Watershed assessments and plans

Bureau of Planning, City of Portland, 1989. *The Columbia Corridor Industrial/Environmental Mapping Project, April 20, 1989,* City of Portland: Portland, Oregon.

Community and Economic Development Department, City of Gresham, 1988. *Inventory of Significant Natural Resources and Open Spaces,* City of Gresham: Gresham, Oregon.

Stark, Daniel, 2001. *West of the Sandy River Rural Area, Natural Resource Inventory and ESEE Report,* Fishman Environmental Services: Portland, Oregon.

Watershed councils and related groups

Beaver Creek, Friends of, 104 SE Kibling Street, Troutdale 97060, 503-667-4960, Carolyn Taylor

Columbia Children's Arboretum Preservation Committee, 9509 NE 13th Ave., Portland 97211, Martha Johnson

Sandy Basin Watershed Council, PO Box 868, Sandy 97055, (503) 630-2382, FAX (503) 630-2341

Sandy River, Friends of, 503-663-2672, Rob Galasso

Wetlands, Friends of, 503-253-6247, Alice Blatt

Data descriptions
Table A-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

The Gordon Creek/Lower Sandy River watershed contains two subwatersheds that are partially located within Metro's boundary: Lower Sandy River and Beaver Creek-Sandy River, comprising a total of 13,991 acres within Metro's jurisdictional boundary. Within the Columbia Gorge Tributaries West watershed, only a portion of one subwatershed (Columbia River) is in Metro's boundary (2,058 acres). The Columbia River subwatershed is combined with the Lower Sandy River subwatershed to comprise one resource site (now referred to the Lower Sandy River-Columbia River subwatershed, or Resource Site #1). The Beaver Creek-Sandy River subwatershed stands alone as a resource site (Resource Site #2).

Tables A-1 and A-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table A-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Gordon Creek/Lower Sandy River	1708000128	1	Lower Sandy River	170800012805	3,654.6
		2	Beaver Creek-Sandy River	170800012806	10,336.5
Columbia Gorge Tributaries West	1708000106	1	Columbia River	170800010605	2,057.7

Table A-2. Resource sites: general information.

General information	Lower Sandy	Beaver Creek
Miles of DEQ 303(d) listed streams	6.9	4.6
Road density (road miles/square miles in subwatershed)	3.8	9.4
Miles of stream with known anadromous fish presence+A5	6.0	11.2
Acres of hydrologically connected wetlands	304.4	202.7
Total acres of wetlands	318.3	205.8
Acres of floodplains (100 year FEMA + 1996 inundation area)	1,563.8	2,173.0
Acres of developed floodplains	40.8	59.6
Building permits since 1996 (number)	24.0	1,354.0

Table A-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Lower Sandy-Columbia Rivers	11.2	4.1	0.1	8.3	23.7
Beaver Creek-Sandy River	17.0	0.0	10.7	17.7	45.4

*Stream links are links between surface streams and may be piped or culverted.

Table A-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Lower Sandy-Columbia Rivers	493.9	81.2	709.6	1,075.5
Beaver Creek-Sandy River	789.1	47.6	736.7	540.0

Table A-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Lower Sandy-Columbia Rivers	11.1	2.0	0.0	1,649.3	3,511.4	319.6	20.9
Beaver Creek-Sandy River	345.5	303.8	854.4	1,601.5	2,872.8	3,390.0	578.0

SITE #1: Lower Sandy River-Columbia River subwatershed

Named tributaries: Columbia River, Columbia Side Channel, Beaver Creek, Sandy River, Smith Creek
Communities within the subwatershed: Troutdale, unincorporated Multnomah County (see Table A-6)
Total acreage within Metro's boundary: 5,712.3 (combines Lower Sandy River and Columbia River subwatersheds)
Total acres within riparian corridor: 3,495.8

This site contains two percent of the area comprising Metro's jurisdictional boundary. About seven percent of the site is in the City of Troutdale, with the remainder in unincorporated Multnomah County (Table A-6).

This site is the least developed of all of the resource sites, with approximately 3.8 miles of road per square mile (Table A-2). Reflecting the rural nature of this resource site, the zoning is dominated by rural and public lands/open space (Table A-5); only 24 building permits have been issued here since 1996 (Table A-2).

Riparian resources. This resource site is rich with riparian resources, containing 24 total stream miles (Table A-3), or about 0.0041 miles of non-piped streams per acre (Table 12); only two resource sites contain higher stream densities. The low number of stream links suggest that few surface streams have been piped underground (Table A-3). However, seven miles, or 30 percent of total stream miles, are listed by the DEQ as 303(d) quality-limited (Tables A-2 and A-3). Anadromous fish are known to be present in six stream miles in this site (Table A-2). Low to medium gradient streams are most common here, reflected by the site's strong floodplain (27 percent of total) and wetland (six percent of total) components (Table A-2 and A-3). Less than three percent of the floodplain is developed.

The riparian corridor inventory reflects these characteristics, with this site ranking first among all sites in terms of the percentage of land (61%) within the site that is part of the riparian corridor inventory (Table 12). However, because of the relatively limited amount of this site's land falling within Metro's boundary, it contributes only about four percent of the region's total riparian resources (Table 13).

The quality of the riparian resources is high for this site, with about 40 percent of the acreage that falls within the riparian corridor inventory receiving primary scores for at least three of the five ecological functions (Table A-9). Sixty-three percent of the site's riparian corridors receive at least one primary ecological function score (Table A-9). This reflects, in part, the site's strong forest component (Tables A-4 and A-12), with the highest percentage of land receiving a primary score for *Large wood and channel dynamics* (Table A-8; see also Table 4 and Appendix 7 for description of ecological functions mapping). *Bank stabilization and pollution control* and *Streamflow moderation and water storage* are also key primary functions provided within this resource site. High amounts of streams, wetlands and forest make this site a very valuable natural resource in the region.

Wildlife habitat resources.
As is often the case, the factors that make this a valuable riparian resource site are also important to wildlife. Including Habitats of Concern, half of the lands in this site fall within the wildlife

habitat inventory, ranking it highest among all 27 resource sites (Table 16). Within model patches, a majority – about 65 percent – fall within the top third of the point range (Table A-10). Of the four criteria in the GIS model, this site is most strongly correlated with connectivity, with 86 percent receiving the top score (Table A-11). Notice that all wildlife habitats received low habitat interior scores, and this reflects the high level of stream resources and their linear nature (Table A-11). However, the relatively high percentage receiving mid-range size scores reflects the strong level of connectivity within the site.

Habitat types in this resource site are dominated by conifer/hardwood forest cover, but open water, riparian habitats, grasslands and agriculture also comprise a significant proportions (Table A-15). This site contributes 318 acres of wetlands, or four percent of the region's total, ranking seventh among the 27 resource sites. Herbaceous wetlands are the dominant type.

Species of Concern. Five Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Northern Red-legged Frog
- Bald Eagle
- Pileated Woodpecker

There are very likely many other Species of Concern using this resource site, particularly those relying on Open Water, Herbaceous Wetlands, and forested habitats (see Table A-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under each habitat type. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern. A majority of the riparian corridor and wildlife areas are also identified as Habitats of Concern, attesting to their importance in the regional system of Goal 5 resources. Part of the Columbia River falls within the resource site, encompassing several important riverine islands (Gary, Flag, and part of Chatham Islands) that are HOCs. The Sandy River Delta provides invaluable wildlife habitat. The Habitats of Concern include substantial wetlands and bottomland hardwood forest. Several parks, including the Sandy River Delta parks complex, Troutdale Community Park, Lewis and Clark State Park, Dabney State Park, and some Metro-owned properties provide a significant amount of protection to these riparian areas. Sixty-six percent of all model patches are identified as Habitats of Concern (primarily bottomland hardwood forest and wetlands), and Habitats of Concern outside of model patches comprise about 14% of total inventoried wildlife habitat acreage (Table A-13).

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 19, 90, 91, 92

Resource site data tables: Riparian Corridors

Table A-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Troutdale	378.8
Unincorporated Multnomah County	5,333.6

Table A-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Sandy-Columbia Rivers	5,712.3	3,498.3

Table A-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Lower Sandy-Columbia Rivers	Microclimate & shade	615.8	17.6%	943.2	27.0%
	Streamflow moderation & water storage	1,610.8	46.0%	1,840.2	52.6%
	Bank stabilization & pollution control	1,637.9	46.8%	424.6	12.1%
	Large wood & channel dynamics	1,916.8	54.8%	196.4	5.6%
	Organic material sources	735.4	21.0%	137.7	3.9%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table A-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Sandy-Columbia Rivers	1 to 5	1,306.7	37.4%
	6 to 11	251.6	7.2%
	12 to 17	558.3	16.0%
	18 to 23	686.3	19.6%
	24 to 29	387.3	11.1%
	30	308.1	8.8%
	Total acres	3,498.3	100.0%

Resource site data tables: Wildlife Habitat

Table A-10. Breakdown of total wildlife model patch scores.*

Resource site: Lower Sandy-Columbia Rivers	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	3.0	11.0	193.9	387.5	151.1	134.0	1,609.9	0.0	0.0	2,490.4
Percent of total	0.1%	0.4%	7.8%	15.6%	6.1%	5.4%	64.6%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table A-11. Breakdown of total wildlife patch model scores by criteria.[1]

Resource site: Lower Sandy-Columbia Rivers	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
Model score	620.3	1,408.1	0.0	1,874.9	0.0	0.0	150.6	1,899.4	375.4	38.6	305.1	2,146.7	2,490.4
Percent of total acres in inventory	24.9%	56.5%	0.0%	75.3%	0.0%	0.0%	6.0%	76.3%	15.1%	1.5%	12.3%	86.2%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table A-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Sandy-Columbia Rivers	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ Intact topsoil	Non-forest woody vegetation					
Acres	422.5	39.6	1,722.8	44.1	84.8	176.6	2,490.4
Percent of total	17.0%	1.6%	69.2%	1.8%	3.4%	7.1%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table A-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Sandy-Columbia Rivers	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2490.4	1894.2	392.6	2883.1	5
Percent of total	86.4%	65.7%	13.6%	100.0%	N/A

*Habitats of Concern.

Table A-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Sandy-Columbia Rivers / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	63.37	8.8	2.5%
Barren	38.39	35.1	2.5%
Low structure agriculture	242.78	6.8	8.7%
High structure agriculture	41.36	0.2	1.4%
Deciduous closed canopy	597.10	15.9	21.3%
Mixed closed canopy	899.28	2.7	31.3%
Conifer closed canopy	88.23	0.5	3.1%
Deciduous open canopy	33.25	5.8	1.4%
Mixed open canopy	43.01	0.8	1.5%
Conifer open canopy	2.77	0.0	0.1%
Deciduous scattered canopy	28.80	6.4	1.2%
Mixed scattered canopy	16.07	2.1	0.6%
Conifer scattered canopy	4.11	0.0	0.1%
Closed canopy shrub	38.13	14.5	1.8%
Open canopy shrub	14.38	5.3	0.7%
Scattered canopy shrub	25.05	8.7	1.2%
Meadow/grass	265.95	279.1	18.9%
Not classified	48.42	0.0	1.7%
Total	2,490.43	392.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent *estimates* of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table A-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Lower Sandy-Columbia Rivers	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	618.9	261.4	44.1	318.3	1,746.7	598.5	291.1
Percent of total	21.5%	9.1%	1.5%	11.0%	60.6%	20.8%	10.1%

[1]See Table A-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #2: Beaver Creek- Sandy River subwatershed

Named tributaries: Beaver Creek, Columbia River, Columbia Side Channel, Kelly Creek, Sandy River
Communities within the subwatershed: Gresham, Troutdale, unincorporated Multnomah County
Total acreage within Metro's boundary: 10,336.5
Total acres within riparian corridor: 3,655.5

This site contains three percent of the area comprising Metro's jurisdictional boundary. Almost half (47 percent) of the site is in unincorporated Multnomah County, with the remainder in the cities of Gresham (37 percent) and Troutdale (16) (Table A-16).

Within the overarching watershed this resource site is more developed than the Lower Sandy-Columbia River, with 9.4 miles of road per square mile (Table A-2). The primary zoning is for single family residential, but there is also substantial rural and public/open space (Table A-5). Substantial development has occurred over the last few years; there have been 1,354 building permits issued since 1996 (Table A-2).

Riparian resources. The riparian corridor inventory comprises about 36 percent of the site's total land within the Metro boundary (Table 12). This site contributes about four percent of the region's total riparian resources (Table 13).

This resource site, similar to Site #1, is rich with riparian resources, containing more than 45 total stream miles (Table A-3). Non-piped stream density is slightly lower than Site #1, at 0.0034 miles per acre; the site ranks 15th among the 27 resource sites (Table 12). The miles of stream links, at 10.7, represents approximately 24 percent of the total number of stream miles, suggesting a significant amount of surface streams have been piped or culverted (Table A-3). However, a smaller proportion of streams are DEQ 303(d) water-quality listed in this site than in Site #1 (13 percent; Tables A-2 and A-3). Anadromous fish are known to be present in more than 11 stream miles (Table A-2). Low gradient streams are most common here, reflected by the site's strong floodplain (21 percent of total) and wetland (two percent of total) components (Tables A-2 and A-3). About three percent of the floodplain is developed, well below the average of 10.3 percent (Table 14).

The quality of the riparian resources is very high for this site, with about 58 percent of the acreage that falls within the riparian corridor inventory receiving primary scores for at least three of the five ecological functions (Table A-19). More than 75 percent of the site's riparian corridors receive at least one primary ecological function score (Table A-19). This reflects the site's strong forest component (Tables A-4 and A-22), with the highest percentage of land receiving a primary score for *Large wood and channel dynamics* (Table A-18; see also Table 4 and Appendix 7 for description of ecological functions mapping). *Bank stabilization and pollution control* and *Streamflow moderation and water storage* are also key primary functions provided within this resource site. High amounts of streams, wetlands and forest make this site a very valuable natural resource in the region.

Wildlife habitat resources.
Including Habitats of Concern, 24 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 15th of the 27 resource sites (Table 16). Within model patches, 15 percent

fall within the top third of the point range, in contrast to Site #1 (Table A-20). Of the four criteria in the GIS model, this site tends to score low in size and habitat interior, moderate in water, and medium or high in connectivity (Table A-21). As with Site #1, the low habitat interior scores probably reflect the high level of stream resources and their linear nature (Table A-11). In general, this site's wildlife habitat resources are smaller and less connected than those in Site #1.

Habitat types in this resource site are co-dominated by conifer/hardwood forest cover and open water, with the most open water in this site of all 27 resource sites except Site #27, Columbia Slough. However, grasslands and agricultural lands also provide important habitat (Table A-25). This site contributes 206 acres of wetlands, or more than two percent of the region's total, ranking 12th among the 27 resource sites.

Species of Concern. Five Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Painted turtle
- Northwestern pond turtle
- Red-legged frog
- Pileated woodpecker
- *Rorippa columbiae* (plant species)

There are very likely many other Species of Concern using this resource site, particularly those relying on Open Water, Herbaceous Wetlands, and forested habitats (see Table A-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 19, 89, 90, 91, 92, 143

Resource site data tables: Riparian Corridors

Table A-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gresham	3,845.0
Troutdale	1,617.8
Unincorporated Multnomah County	4,873.6

Table A-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Beaver Creek-Sandy River	10,336.6	3,666.8

Table A-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Beaver Creek-Sandy River	Microclimate & shade	689.9	18.8%	527.4	14.4%
	Streamflow moderation & water storage	2,148.4	58.6%	1,455.3	39.7%
	Bank stabilization & pollution control	2,366.4	64.5%	117.3	3.2%
	Large wood & channel dynamics	2,586.8	70.5%	151.8	4.1%
	Organic material sources	927.4	25.3%	127.6	3.5%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table A-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Beaver Creek-Sandy River	1 to 5	906.4	24.7%
	6 to 11	186.1	5.1%
	12 to 17	444.9	12.1%
	18 to 23	1,260.6	34.4%
	24 to 29	483.0	13.2%
	30	385.9	10.5%
	Total acres	3,666.8	100.0%

Resource site data tables: Wildlife Habitat

Table A-20. Breakdown of total wildlife model patch scores.*

Resource site: Beaver Creek-Sandy River	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	13.0	124.1	518.7	302.5	336.0	502.3	321.7	0.0	0.0	2,118.3
Percent of total	0.6%	5.9%	24.5%	14.3%	15.9%	23.7%	15.2%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table A-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Beaver Creek-Sandy River	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
Model score	1,220.6	87.7	0.0	1,115.1	0.0	0.0	26.6	1,538.1	498.5	230.9	911.2	976.3	2,118.3
Percent of total acres in inventory	57.6%	4.1%	0.0%	52.6%	0.0%	0.0%	1.3%	72.6%	23.5%	10.9%	43.0%	46.1%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table A-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Beaver Creek-Sandy River	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	766.1	44.0	1,118.9	100.9	42.4	46.0	2,118.3
Percent of total	36.2%	2.1%	52.8%	4.8%	2.0%	2.2%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table A-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Beaver Creek-Sandy River	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2118.3	943.7	317.3	2435.6	5
Percent of total	87.0%	38.7%	13.0%	100.0%	N/A

*Habitats of Concern.

Table A-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Beaver Creek-Sandy River / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	43.02	22.6	2.7%
Barren	115.19	61.9	7.3%
Low structure agriculture	179.60	1.1	7.4%
High structure agriculture	118.11	0.8	4.9%
Deciduous closed canopy	745.09	17.6	31.3%
Mixed closed canopy	232.26	2.9	9.7%
Conifer closed canopy	46.98	0.4	1.9%
Deciduous open canopy	126.95	14.2	5.8%
Mixed open canopy	40.29	0.8	1.7%
Conifer open canopy	5.80	0.0	0.2%
Deciduous scattered canopy	59.08	8.4	2.8%
Mixed scattered canopy	30.89	1.4	1.3%
Conifer scattered canopy	5.63	0.2	0.2%
Closed canopy shrub	70.99	8.0	3.2%
Open canopy shrub	28.25	5.1	1.4%
Scattered canopy shrub	35.85	5.2	1.7%
Meadow/grass	234.01	166.6	16.4%
Not classified	0.31	0.0	0.0%
Total	2,118.33	317.3	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent *estimates* of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table A-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Beaver Creek-Sandy River	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	1,195.4	88.4	100.9	205.8	1,339.0	475.1	299.6
Percent of total	49.1%	3.6%	4.1%	8.4%	55.0%	19.5%	12.3%

[1]See Table A-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

B. Abernathy Creek (and a small portion of Senecal Creek/Mill Creek)

General watershed information

Resource sites in the Abernathy Creek watershed include:

- Willamette River-Boeckman Creek (combined – Corral Creek, Molalla River & Willamette River-Boeckman Creek)
- Willamette River-Lower Tualatin River (combined – Abernathy Creek-Holcomb Creek, Beaver Creek, Willamette River-Lower Tualatin River subwatersheds)

Watershed assessments and plans

Bureau of Planning, City of Portland, 2001. *Portland's Willamette River Atlas,* City of Portland: Portland, Oregon.

Lev, Esther, 2001. *Wildlife Habitat Inventory for the Willamette River,* Environmental Consulting: Portland, Oregon.

Oregon Department of Fish and Wildlife (ODFW) and Unified Sewage Agency (USA), 1995. *Distribution of Fish and Crayfish and Measurement of Available Habitat in the Tualatin River Basin, Final Report of Research,* ODFW: Portland, Oregon and Unified Sewage Agency: Hillsboro, Oregon.

Tualatin River Watershed Council, 1999. *Tualatin River Watershed, Action Plan,* Tualatin River Watershed Council: Hillsboro, Oregon.

Tualatin Watershed Council, 2001. *Tualatin River Watershed Atlas,* Tualatin Watershed Council: Hillsboro, Oregon.

United States Geological Service (USGS), 2000. *Willamette Basin Ground-Water Study,* USGS: Portland, Oregon.

USGS, 1995. *NAWQA Willamette Basin Study,* USGS: Portland, Oregon.

Willamette Basin Task Force, Pacific Northwest River Basins Commission, 1969. *The Willamette Basin, Comprehensive Study of Water and Related Land Resources,* Pacific Northwest River Basins Commission: Portland, Oregon.

Willamette Basin Task Force, Pacific Northwest River Basins Commission, 1997. *The Willamette Basin, Recommendations to Governor John Kitzhaber,* Willamette River Basin Task Force: Portland, Oregon.

Willamette Restoration Initiative, 2001. *Restoring A River of Life, The Willamette Restoration Strategy Overview, February 2001,* Willamette Restoration Initiative: Portland, Oregon.

Willamette Restoration Initiative, 2001. *Restoring A River of Life, The Willamette Restoration Strategy – Recommendations for the Willamette Basin Supplement to the Oregon Plan for Salmon and Watersheds, February 2001,* Willamette Restoration Initiative: Portland, Oregon. .

Watershed councils and related groups

Newell Creek Canyon, Friends of, PO Box 3, Oregon City 97045, 503-655-6471, James Dalton

Tualatin Watershed Council, 1080 SW Baseline, Bldg. B, Suite B-2, Hillsboro 97123, (503) 681-0953, FAX (503) 681-9772

Tualatin River National Wildlife Refuge, City of Sherwood, 90 NW Park Street, Sherwood 97140, 503-625-5522, Joan Patterson

Tualatin River Rangers, USA, 155 N First Ave., Hillsboro 97124, 503-640-3516, Linda Kelly

Tualatin Riverkeepers, 16340 SW Beef Bend Road, Sherwood 97140, 503-590-5813, Lauri Mullen

Upper Willamette River, Friends of, 541-752-3942, Sarvahara Judd
Wetlands, Friends of, 503-253-6247, Alice Blatt
Willamette River Restoration Committee, 541-484-9466, Timothy Green

Data descriptions
Table B-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

The Abernathy Creek watershed contains five subwatersheds that are partially located within Metro's boundary: Corral Creek, Willamette River-Boeckman Creek, Beaver Creek, Abernathy Creek-Holcomb Creek, and Willamette River – Lower Tualatin River. Within the Senecal Creek/Mill Creek watershed, only a portion of one subwatershed (Molalla River) is in Metro's boundary. The Corral Creek, Willamette River-Boeckman Creek, and Molalla River subwatersheds are combined to comprise one resource site (now referred to the Willamette River-Boeckman Creek subwatershed, or Resource Site #3). The Beaver Creek, Abernathy Creek-Holcomb Creek, and Willamette River-Lower Tualatin River subwatersheds are combined and referred to as the Willamette-Lower Tualatin River subwatershed, or Resource Site #4.

Tables B-1 and B-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table B-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Abernathy Creek	170900704	3	Corral Creek	170900070401	207.7
			Willamette River-Boeckman Creek	170900070402	7,283.4
		4	Beaver Creek	170900070403	2,867.1
			Abernathy Creek-Holcomb Creek	170900070404	3,180.3
			Willamette River-Lower Tualatin River	170900070405	5,356.3
Senecal Creek/Mill Creek	170900901	3	Molalla River	170900090105	125.6

Table B-2. Resource sites: general information.

General information	Willamette River-	Willamette-Lower
Miles of DEQ 303(d) listed streams	1.5	6.0
Road density (road miles/square miles in subwatershed)	8.7	11.6
Miles of stream with known anadromous fish presence	2.0	8.6
Acres of hydrologically connected wetlands	362.5	85.7
Total acres of wetlands	365.0	85.7
Acres of floodplains (100 year FEMA + 1996 inundation area)	411.2	1,172.3
Acres of developed floodplains	32.8	229.4
Building permits since 1996 (number)	808.0	2,093.0

Table B-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Willamette River-Boeckman Creek	4.5	0.1	9.4	17.7	31.5
Willamette-Lower Tualatin Rivers	14.6	3.1	7.5	17.8	43.0

*Stream links are links between surface streams and may be piped or culverted.

Table B-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Willamette River-Boeckman Creek	675.1	33.0	514.8	766.5
Willamette-Lower Tualatin Rivers	469.9	79.9	1,052.7	1,685.4

Table B-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Willamette River-Boeckman Creek	815.8	1,224.8	1,246.6	4.0	3,548.2	371.4	0.0
Willamette-Lower Tualatin Rivers	725.7	598.0	580.3	0.0	4,806.1	4,273.1	0.0

SITE #3: Willamette River-Boeckman Creek subwatershed

Named tributaries: Boeckman Creek, Coffee Lake Creek, Corral Creek, Mill Creek, Molalla River, Newland Creek, Seely Ditch, Willamette River
Communities within the subwatershed: Wilsonville, unincorporated Clackamas County, unincorporated Multnomah County, unincorporated Washington County
Total acreage within Metro's boundary: 7,616.7 (includes combined – Corral Creek, Molalla River & Willamette River-Boeckman Creek subwatersheds)
Total acreage within riparian corridor: 2,251.7

This site contains three percent of the area comprising Metro's jurisdictional boundary. More than half of the site falls within the City of Wilsonville (58 percent), with another four percent in Tualatin, 15 percent in unincorporated Clackamas County, and 23 percent in unincorporated Multnomah County (Table B-6).

This site contains 8.7 miles of road per square mile, falling in the second quartile (26-50 percent of maximum) of the range of development compared to other resource sites (Table B-2). It is somewhat less developed than the other resource site in the B group. The zoning is dominated by rural development types, but industrial and multi-family residential uses are also important (Table B-5). More than 800 building permits have been issued in this site since 1996 (Table B-2).

Riparian resources. Approximately 22 percent of the land in this site is part of the riparian corridor inventory (Table 12), lower than the regional average of 31 percent; it contributes 2.4 percent of the region's total riparian resources (Table 13).

This resource site contains 31.5 total stream miles, with about 0.0029 non-piped stream miles per acre, ranking it 18th among all resource sites. Thirty percent of all stream miles are stream links, suggesting that a substantial amount of original streams have been piped or culverted (Table 12). However, only seven percent of non-piped stream miles are 303(d) quality-limited (Tables B-2 and B-3). Anadromous fish are known to be present in two stream miles (Table B-2). The floodplain and wetland areas each comprise approximately five percent of the total area within Metro's jurisdiction; about eight percent of the floodplain is developed (Table B-2).

The quality of the riparian resources is moderate for this site, with about 31 percent of the acreage within the riparian corridor inventory receiving primary scores for at least three of the five ecological functions. Fifty-three percent of the site's riparian corridors receive at least one primary ecological function score (Table B-9). More acreage within 300 feet of streams is in low-structure, non-woody vegetation than in woody and forested vegetation (Table B-4). Reflecting this, the highest percentage of land receiving a primary score is *Bank stabilization and pollution control* (Table B-8; see also Table 4 and Appendix 7 for description of ecological functions mapping). *Large wood and channel dynamics, Streamflow moderation and water storage, and Organic material sources* are also important primary functions provided within this resource site.

Wildlife habitat resources.

Including Habitats of Concern, 27 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 10th of the 27 resource sites (Table 16). Within model patches, 24 percent fall within the top third of the point range (Table B-10). Of the four criteria in the GIS model, this site tends to score low in size and habitat interior, moderate to high in water, and moderate to high in connectivity (Table B-11). In general, this site's wildlife habitats are characterized by well-connected habitat patches with good water resources.

Habitat types in this resource site are dominated by conifer/hardwood forest cover, but wetlands and agricultural lands also provide substantial habitat (Table B-15). This site contributes 365 acres of wetlands, or more than four percent of the region's total, ranking fifth among the 27 resource sites.

Species of Concern. Two Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Red-legged frog
- Band-tailed Pigeon
- Pileated Woodpecker

There are very likely many other Species of Concern using this resource site, particularly those relying on Herbaceous Wetlands, and forested habitats (see Table B-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 152, 153, 156

Resource site data tables: Riparian Corridors

Table B-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Tualatin	281.3
Wilsonville	4,387.7
Unincorporated Clackamas County	1,165.2
Unincorporated Washington County	1,782.6

Table B-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Willamette River-Boeckman Creek	7,616.8	2,248.1

Table B-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Willamette River-Boeckman Creek	Microclimate & shade	443.2	19.7%	690.3	30.7%
	Streamflow moderation & water storage	626.1	27.9%	1,468.9	65.3%
	Bank stabilization & pollution control	974.9	43.4%	31.1	1.4%
	Large wood & channel dynamics	859.0	38.2%	118.6	5.3%
	Organic material sources	579.5	25.8%	75.5	3.4%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table B-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Willamette River-Boeckman Creek	1 to 5	1,058.1	47.1%
	6 to 11	288.3	12.8%
	12 to 17	196.0	8.7%
	18 to 23	202.6	9.0%
	24 to 29	321.0	14.3%
	30	182.1	8.1%
	Total acres	2,248.1	100.0%

Resource site data tables: Wildlife Habitat

Table B-10. Breakdown of total wildlife model patch scores.*

Resource site: Willamette River-Boeckman Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	36.7	128.1	361.1	282.0	417.2	320.8	277.6	217.5	0.0	2,041.0
Percent of total	1.8%	6.3%	17.7%	13.8%	20.4%	15.7%	13.6%	10.7%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table B-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Willamette River-Boeckman Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,258.0	252.2	0.0	1,276.5	0.0	0.0	244.0	985.1	721.0	243.3	813.4	984.3	2,041.0
Percent of total acres in inventory	61.6%	12.4%	0.0%	62.5%	0.0%	0.0%	12.0%	48.3%	35.3%	11.9%	39.9%	48.2%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table B-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Willamette River-Boeckman Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	496.8	34.0	1,176.4	86.0	132.4	115.4	2,041.0
Percent of total	24.3%	1.7%	57.6%	4.2%	6.5%	5.7%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table B-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Willamette River-Boeckman Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2041.0	273.7	20.0	2061.0	2
Percent of total	99.0%	13.3%	1.0%	100.0%	N/A

*Habitats of Concern.

Table B-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Willamette River-Boeckman Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	18.79	0.1	0.9%
Barren	150.60	5.7	7.6%
Low structure agriculture	359.22	2.8	17.6%
High structure agriculture	26.00	0.1	1.3%
Deciduous closed canopy	179.76	0.4	8.7%
Mixed closed canopy	258.91	0.5	12.6%
Conifer closed canopy	198.48	0.3	9.6%
Deciduous open canopy	160.40	2.5	7.9%
Mixed open canopy	214.22	0.7	10.4%
Conifer open canopy	69.07	0.3	3.4%
Deciduous scattered canopy	68.78	1.4	3.4%
Mixed scattered canopy	38.56	0.6	1.9%
Conifer scattered canopy	10.24	0.6	0.5%
Closed canopy shrub	74.50	0.2	3.6%
Open canopy shrub	44.53	1.3	2.2%
Scattered canopy shrub	59.79	1.5	3.0%
Meadow/grass	109.14	1.2	5.4%
Not classified	0.00	0.0	0.0%
Total	2,040.99	20.0	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table B-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Willamette River-Boeckman Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	123.5	247.8	86.0	365.0	1,205.6	217.4	388.1
Percent of total	6.0%	12.0%	4.2%	17.7%	58.5%	10.5%	18.8%

[1]See Table B-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #4: Willamette River-Lower Tualatin River subwatershed

Named tributaries: Abernathy Creek, Beaver Creek, Canfield Creek, Holcomb Creek, Mud Creek, Newell Creek, Tanner Creek, Tualatin River, Willamette River
Communities within the subwatershed: Oregon City, West Linn, unincorporated Clackamas County
Total acreage within Metro's boundary: 11,403.7 (combined – Abernathy Creek-Holcomb Creek, Beaver Creek, Willamette River-Lower Tualatin River subwatersheds)
Total acreage within riparian corridor: 4,159.3
Other information: One dam with no known fishway

This site contains four percent of the area comprising Metro's jurisdictional boundary. Forty-one percent of this site is in Oregon City, 17 percent in West Linn, and the remainder (42 percent) is in unincorporated Clackamas County (Table B-16).

This site contains 11.6 miles of road per square mile; although more developed than the other Group B resource site, this site also falls within the second quartile (26-50 percent of maximum) of the range of development compared to all other sites (Table B-2). Rural and single family residential zoning dominates this site almost equally, compared to primarily rural in the other Group B site (Table B-5). More than 2,000 building permits have been issued here since 1996 (Table B-2).

Riparian resources. Thirty-seven percent of this site is part of the riparian corridor inventory (Table 12), and it contributes about four and one-half percent of the region's total riparian resources (Table 13).

This resource site contains 43 total stream miles, or 0.0031 miles of non-piped streams per acre, ranking it 17th among all resource sites. About eight miles, or 17 percent, are stream links and may be piped or culverted – although non-piped stream density is similar, the proportion of stream links in this site is smaller compared to Site #3 (Tables 12 and B-3). About 17 percent of non-piped stream miles are listed by the DEQ as 303(d) quality-limited, more than double that of Site #3 (Tables B-2 and B-3). Anadromous fish are known to be present in approximately nine stream miles (Table B-2). Of streams that are categorized, low to medium gradients are most common; 28 percent of the site is floodplain, and two percent is wetland (Table B-2 and B-3). Twenty percent of the floodplain is developed, substantially higher than the proportion in Site #3; in fact, this site ranks 8th among all 27 resource sites in terms of floodplain development (Table 14).

About 31 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions. Over half of the site's riparian resources are limited to secondary functions, a high proportion compared to the previous three sites (Table B-19). The highest percentage of land receiving a primary score was evenly divided between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table B-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 28 percent of the lands in this site fall within the wildlife habitat inventory, ranking it ninth of the 27 resource sites (Table 16). Within model patches, only eight percent fall within the top third of the point range (Table B-20). Of the four criteria in the GIS

model, this site tends to score low in size and habitat interior, moderate in water resources, and high in connectivity (Table B-21). In general, this site's wildlife habitats are characterized by well-connected (but not very large) habitat patches with moderate water resources.

Habitat types in this resource site are strongly dominated by conifer/hardwood forest cover, but Open Water also provides substantial habitat (Table B-25). This site contributes 86 acres of wetlands, or more one percent of the region's total, ranking 20[th] among the 27 resource sites.

Species of Concern. Ten Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Painted turtle
- Western pond turtle
- Band-tailed Pigeon
- Pileated Woodpecker
- Great Blue Heron nesting colony
- Peregrine Falcon
- *Aster curtus* (plant species)
- *Delphinium leucophaeum* (plant species)

There are very likely many other Species of Concern using this resource site, particularly those relying on Open Water and forested habitats (see Table B-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 119, 145, 148, 149, 150

Resource site data tables: Riparian Corridors

Table B-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Oregon City	4,661.5
West Linn	1,900.7
Unincorporated Clackamas County	4,841.6

Table B-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Willamette-Lower Tualatin Rivers	11,403.7	4,172.2

Table B-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Willamette-Lower Tualatin Rivers	Microclimate & shade	639.9	15.3%	1,588.8	38.1%
	Streamflow moderation & water storage	998.9	23.9%	3,016.7	72.3%
	Bank stabilization & pollution control	1,652.7	39.6%	474.3	11.4%
	Large wood & channel dynamics	1,617.6	38.8%	318.5	7.6%
	Organic material sources	699.8	16.8%	220.4	5.3%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table B-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Willamette-Lower Tualatin Rivers	1 to 5	2,281.1	54.7%
	6 to 11	292.0	7.0%
	12 to 17	318.1	7.6%
	18 to 23	658.1	15.8%
	24 to 29	408.2	9.8%
	30	214.7	5.1%
	Total acres	4,172.2	100.0%

Resource site data tables: Wildlife Habitat

Table B-20. Breakdown of total wildlife model patch scores.*

Resource site: Willamette-Lower Tualatin Rivers	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	41.6	237.2	385.7	191.2	371.6	1,736.6	28.5	240.3	0.0	3,232.5
Percent of total	1.3%	7.3%	11.9%	5.9%	11.5%	53.7%	0.9%	7.4%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table B-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Willamette-Lower Tualatin Rivers	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
Model score	1,859.5	897.8	0.0	2,118.9	240.3	0.0	800.1	1,979.6	291.4	384.6	747.3	2,100.6	3,232.5
Percent of total acres in inventory	57.5%	27.8%	0.0%	65.6%	7.4%	0.0%	24.8%	61.2%	9.0%	11.9%	23.1%	65.0%	na

[1]Does not include Habitats of Concern outside of model patches.
[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.
[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table B-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Willamette-Lower Tualatin Rivers	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	401.9	73.3	2,678.2	18.1	12.1	48.9	3,232.5
Percent of total	12.4%	2.3%	82.9%	0.6%	0.4%	1.5%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table B-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Willamette-Lower Tualatin Rivers	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	3232.5	767.8	7.7	3240.3	10
Percent of total	99.8%	23.7%	0.2%	100.0%	N/A

*Habitats of Concern.

Table B-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Willamette-Lower Tualatin Rivers Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	31.60	3.7	1.1%
Barren	172.38	0.3	5.3%
Low structure agriculture	98.22	0.0	3.0%
High structure agriculture	11.73	0.0	0.4%
Deciduous closed canopy	664.16	0.4	20.5%
Mixed closed canopy	701.24	0.9	21.7%
Conifer closed canopy	283.85	0.6	8.8%
Deciduous open canopy	507.43	0.3	15.7%
Mixed open canopy	111.03	0.1	3.4%
Conifer open canopy	13.81	0.3	0.4%
Deciduous scattered canopy	132.08	0.1	4.1%
Mixed scattered canopy	68.51	0.0	2.1%
Conifer scattered canopy	13.50	0.2	0.4%
Closed canopy shrub	148.87	0.3	4.6%
Open canopy shrub	57.70	0.0	1.8%
Scattered canopy shrub	96.57	0.2	3.0%
Meadow/grass	119.24	0.5	3.7%
Not classified	0.60	0.0	0.0%
Total	3,232.52	7.7	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent *estimates* of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table B-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Willamette-Lower Tualatin Rivers	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	575.7	61.0	18.1	85.7	2,498.5	274.1	109.9
Percent of total	17.8%	1.9%	0.6%	2.6%	77.1%	8.5%	3.4%

[1]See Table B-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

C. Dairy Creek and Gales Creek

General watershed information
Resource sites within the Dairy Creek Watershed include:

- Council Creek subwatershed (combines West Fork Dairy Creek, Council Creek, Middle Tualatin River-Gales Creek subwatersheds)
- McKay Creek subwatershed

Watershed assessments and plans

Breuner, Nancy, 1998. *Gales Creek Watershed Assessment Project,* Tualatin River Watershed Council: Hillsboro, Oregon.

Bureau of Land Management, U.S. Department of the Interior (BLM), 1999. *Dairy-McKay Watershed Analysis,* BLM, Salem District Office, Tillamook Resource Area: Tillamook, Oregon.

Lev, Esther, 1990. *Inventory of Wetlands, Riparian and Upland Wildlife Habitat Areas in Hillsboro, Oregon,* Environmental Consulting: Portland, Oregon.

Oregon Department of Fish and Wildlife (ODFW) and Unified Sewage Agency (USA), 1995. *Distribution of Fish and Crayfish and Measurement of Available Habitat in the Tualatin River Basin, Final Report of Research,* ODFW: Portland, Oregon and Unified Sewage Agency: Hillsboro, Oregon.

Tualatin River Watershed Council, 1999. *Tualatin River Watershed, Action Plan,* Tualatin River Watershed Council: Hillsboro, Oregon.

Tualatin Watershed Council, 2001. *Tualatin River Watershed Atlas,* Tualatin Watershed Council: Hillsboro, Oregon

Watershed councils and related groups

Banks Watershed Council, P.O. Box 428, Banks 97106

Fernhill Marsh Wetland Management Council, PO Box 373, Forest Grove 97116, 503-357-2319, Greg Johnson

Tualatin WC, 1080 SW Baseline, Bldg. B, Suite B-2, Hillsboro 97123, (503) 681-0953, FAX (503) 681-9772

Tualatin River National Wildlife Refuge, City of Sherwood, 90 NW Park Street, Sherwood 97140, 503-625-5522, Joan Patterson

Tualatin River Rangers, USA, 155 N First Ave., Hillsboro 97124, 503-640-3516, Linda Kelly

Tualatin Riverkeepers, 16340 SW Beef Bend Road, Sherwood 97140, 503-590-5813, Lauri Mullen

Wetlands, Friends of, 503-253-6247, Alice Blatt

Yamhill Basin Council, 2200 SW 2nd Street, McMinnville 97128, 503-472-6403, Melissa Leoni

Data descriptions

Table C-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

The Dairy Creek watershed contains three subwatersheds that are partially located within Metro's boundary: West Fork Dairy Creek, Council Creek, and McKay Creek. Within the Gales

Creek watershed, one subwatershed (Middle Tualatin River – Gales Creek) is in Metro's boundary. The West Fork Dairy Creek, Council Creek, and Middle Tualatin River-Gales Creek subwatersheds are combined to comprise one resource site (now referred to the Council Creek subwatershed, or Resource Site #5). The McKay Creek subwatershed comprises Resource Site #6.

Tables C-1 and C-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table C-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Dairy Creek	1709001001	5	West Fork Dairy Creek	170900100106	36.1
			Council Creek	170900100107	2,924.9
		6	McKay Creek	170900100108	3,842.7
Gales Creek	1709001002	5	Middle Tualatin River-Gales Creek	170900100206	2,747.2

Table C-2. Resource sites: general information.

General information	Council	McKay
Miles of DEQ 303(d) listed streams	6.0	1.1
Road density (road miles/square miles in subwatershed)	12.7	12.8
Miles of stream with known anadromous fish presence	2.0	1.1
Acres of hydrologically connected wetlands	255.6	138.9
Total acres of wetlands	256.5	138.9
Acres of floodplains (100 year FEMA + 1996 inundation area)	626.0	344.9
Acres of developed floodplains	24.2	26.4
Building permits since 1996 (number)	1,016.0	1,055.0

Table C-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Council Creek	10.4	0.0	5.4	5.4	21.3
McKay Creek	5.2	0.0	3.8	3.0	12.1

*Stream links are links between surface streams and may be piped or culverted.

Table C-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Council Creek	518.4	2.7	167.4	140.6
McKay Creek	303.5	3.8	127.3	73.9

Table C-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Council Creek	275.9	838.5	643.6	5.1	1,426.8	1,617.3	137.2
McKay Creek	557.5	1,201.5	73.8	0.0	178.7	1,680.2	125.8

SITE #5: Council Creek subwatershed

Named streams/rivers: Council Creek, Dairy Creek, Gales Creek, McKay Creek, Tualatin River
Communities within the subwatershed: Cornelius, Forest Grove, Hillsboro, unincorporated Washington County
Total acreage within Metro's boundary: 5,708.1 (combined – West Fork Dairy Creek, Council Creek, Middle Tualatin River-Gales Creek)
Total acres within riparian corridor: 1,142.3

This site contains two percent of the area comprising Metro's jurisdictional boundary. Fifty-three percent of the site is in the City of Forest Grove, 21 percent is in Cornelius, and less than one percent falls in the City of Hillsboro. The remainder (26 percent) is in unincorporated Washington County (Table C-6).

This resource site, similar to the other site in Group C, falls near the midpoint of the range of development compared to other sites, with 12.7 miles of roads per square mile (Table C-2). Single family residential is the dominant zoning pattern, followed closely by rural; industrial and residential uses are also important in this resource site (Table C-5). Agriculture is a common land use. Over a thousand building permits have been issued here since 1996 (Table C-2).

Riparian resources. Compared to the previous four resource sites, the two sites within Group C contain relatively smaller proportions of riparian resources. Lands within the riparian corridor inventory comprise about 20 percent of total lands in this subwatershed. The site contributes less than one percent of the region's riparian corridors, but that statistic is influenced by the relatively small amount of Site #5's area falling within the Metro boundary (Tables 12 and 13).

This resource site contains approximately 21 total stream miles (Table C-3), or 0.0028 miles of non-piped streams per acre, ranking it 20th among the 27 resource sites (Table 12). About 25 percent of all stream miles are stream links, suggesting a relatively high amount of piping/culverting (Table C-3); 38 percent of non-piped streams are DEQ 303(d) water-quality limited (Tables C-2 and C-3). The dominant stream gradient in this resource site is low to medium (Table C-3); 11 percent of the site is in the floodplain, with more than four percent of the land covered by wetland resources (Table C-2). Less than four percent of the floodplain is developed. Anadromous fish are known to be present in two stream miles (Table C-2).

About 38 percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions (Table C-9). Seventy-three percent of the site's riparian corridors receive at least one primary ecological function score, reflecting the relatively rural/agricultural nature of this resource site that tends toward more vegetation near the stream compared to urbanized areas (Table C-9). Low structure vegetation/intact topsoil is the dominant vegetation cover within 300 ft of streams (Table C-4). The percentage of land receiving a given primary score was divided relatively evenly between *Large wood and channel dynamics* and *Streamflow moderation and water storage* (Table C-8). However, *Bank stabilization and pollution control* and *Organic material sources* were also important primary functions (Table C-8; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 16 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 25th of the 27 resource sites (Table 16). Within model patches, only seventeen percent fall within the top third of the point range (Table C-10). Of the four criteria in the GIS model, this site tends to score low in size and habitat interior, moderate to high in water resources, and moderate in connectivity (Table C-11). In general, this site's wildlife habitat patches are characterized by moderate fragmentation with fairly good water resources.

Habitat types in this resource site are co-dominated by conifer/hardwood forest cover, agricultural lands and wetlands (Table C-15). Wetlands are a very important habitat type in this resource site, comprising an estimated 28 percent of lands. Despite the relatively small amount of acreage falling within the Metro boundary, the site contributes three percent of the region's total wetlands, ranking 10th among the 27 resource sites.

Species of Concern. Two Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Great Blue Heron nesting colony
- Western Meadowlark
- Acorn Woodpecker
- Northern Goshawk
- Merlin

There are very likely many other Species of Concern using this resource site, particularly those relying on wetlands, forested habitats and agricultural lands, which often serve as a surrogate for native grassland habitats (for example, the Meadowlark and Merlin sightings; see Table C-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 38, 39, 41, 43, 44, 45, 46, 165

Resource site data tables: Riparian Corridors

Table C-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Cornelius	1,190.5
Forest Grove	3,040.6
Hillsboro	0.6
Unincorporated Washington County	1,471.1

Table C-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Council Creek	5,708.2	1,142.4

Table C-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Council Creek	Microclimate & shade	146.4	12.8%	120.8	10.6%
	Streamflow moderation & water storage	655.4	57.4%	443.0	38.8%
	Bank stabilization & pollution control	542.6	47.5%	9.8	0.9%
	Large wood & channel dynamics	716.9	62.8%	26.5	2.3%
	Organic material sources	401.1	35.1%	14.1	1.2%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table C-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Council Creek	1 to 5	309.3	27.1%
	6 to 11	106.2	9.3%
	12 to 17	298.5	26.1%
	18 to 23	54.0	4.7%
	24 to 29	274.9	24.1%
	30	99.5	8.7%
	Total acres	1,142.4	100.0%

Resource site data tables: Wildlife Habitat

Table C-10. Breakdown of total wildlife model patch scores.*

Resource site: Council Creek	Number of acres in each wildlife score category: 1	2	3	4	5	6	7	8	9	Total wildlife model patch acres in inventory
Model score	23.7	56.0	315.7	93.0	143.6	114.8	154.5	0.0	0.0	901.4
Percent of total	2.6%	6.2%	35.0%	10.3%	15.9%	12.7%	17.1%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table C-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Council Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	484.5	0.0	0.0	315.6	0.0	0.0	7.4	502.8	363.3	108.6	545.1	247.7	901.4
Percent of total acres in inventory	53.7%	0.0%	0.0%	35.0%	0.0%	0.0%	0.8%	55.8%	40.3%	12.0%	60.5%	27.5%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table C-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Council Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	414.0	2.9	238.5	29.5	87.1	129.4	901.4
Percent of total	45.9%	0.3%	26.5%	3.3%	9.7%	14.4%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table C-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Council Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	901.4	230.4	11.1	912.5	2
Percent of total	98.8%	25.3%	1.2%	100.0%	N/A

*Habitats of Concern.

Table C-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Council Creek / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	49.23	0.0	5.4%
Barren	66.91	4.4	7.8%
Low structure agriculture	238.12	2.7	26.4%
High structure agriculture	40.57	0.0	4.4%
Deciduous closed canopy	51.57	0.1	5.7%
Mixed closed canopy	70.59	0.5	7.8%
Conifer closed canopy	28.77	0.2	3.2%
Deciduous open canopy	28.08	0.4	3.1%
Mixed open canopy	21.57	0.7	2.4%
Conifer open canopy	2.37	0.1	0.3%
Deciduous scattered canopy	48.26	0.6	5.4%
Mixed scattered canopy	32.61	0.4	3.6%
Conifer scattered canopy	4.47	0.0	0.5%
Closed canopy shrub	24.43	0.0	2.7%
Open canopy shrub	21.71	0.2	2.4%
Scattered canopy shrub	45.55	0.3	5.0%
Meadow/grass	126.60	0.6	13.9%
Not classified	0.02	0.0	0.0%
Total	901.41	11.1	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table C-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Council Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	20.7	216.5	29.5	256.5	291.2	194.9	281.4
Percent of total	2.3%	23.7%	3.2%	28.1%	31.9%	21.4%	30.8%

[1]See Table C-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #6: McKay Creek subwatershed

Named streams/rivers: Dairy Creek, McKay Creek, Warble Gulch
Communities within the subwatershed: Hillsboro, unincorporated Washington County
Total acreage within Metro's boundary: 3,842.7
Total acres within the riparian corridor: 677.9

This site contains one percent of the area comprising Metro's jurisdictional boundary. Most of this site (91 percent) is in the City of Hillsboro, with the remainder in unincorporated Washington County (Table C-16).

This resource site falls close to the midpoint of development compared to all other sites, with 12.8 miles of road per square mile (Table C-2). Zoning is primarily single family residential and industrial (Table C-5). More than a thousand building permits have been issued here since 1996 (Table C-2).

Riparian resources. As with the other resource site in Group C, Site #6 contains a relatively smaller proportion of riparian resources compared to the first four resource sites described. Lands within the riparian corridor inventory comprise about 17 percent of total lands in this subwatershed (Table 12). The site contributes less than one percent of the region's riparian corridors, but that statistic is influenced by the relatively small amount of Site #6's area falling within the Metro boundary (Tables 12 and 13).

This resource site has a relatively low stream density, with approximately 12 total stream miles, or 0.0022 miles of non-piped streams per acre, ranking it 23rd out of the 27 resource sites (Table 12). About 31 percent of all stream miles are stream links, suggesting a relatively high amount of piping/culverting (Table C-3); 13 percent of non-piped streams are DEQ 303(d) water-quality limited (Tables C-2 and C-3). The dominant stream gradient in this resource site is low to medium (Table C-3); nine percent of the site is in the floodplain, with approximately four percent of the land covered by wetland resources (Table C-2). Less than eight percent of the floodplain is developed. Anadromous fish are known to be present in one stream mile (Table C-2).

Forty-four percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions (Table C-19). Seventy-one percent of the site's riparian corridors receive at least one primary ecological function score, reflecting the relatively rural/agricultural nature of this resource site that tends toward more vegetation near the stream compared to urbanized areas (Table C-19). Low structure vegetation/intact topsoil is the dominant vegetation cover within 300 ft of streams; however, there is relatively more forest cover along streams here than in Site #5 (Table C-4). The percentage of land receiving a given primary score was divided relatively evenly between *Large wood and channel dynamics*, *Bank stabilization and pollution control,* and *Streamflow moderation and water storage* (Table C-18). However, *Organic material sources* were also important primary functions (Table C-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 13 percent of the lands in this site fall within the wildlife habitat inventory, ranking it last among the 27 resource sites. However, note that the small amount of

this site's land within the Metro boundary may not be characteristic of the entire subwatershed (Table 16). Within model patches, only ten percent fall within the top third of the point range (Table C-20). Of the four criteria in the GIS model, this site tends to score low in size and habitat interior, moderate to high in water resources, and moderate in connectivity, similar to the other resource site in Group C (Table C-21). In general, this site's wildlife habitat patches are characterized by moderate fragmentation with fairly good water resources.

Habitat types in this resource site are co-dominated by conifer/hardwood forest cover, agricultural lands and wetlands (Table C-25). Similar to Site #5, wetlands are a very important habitat type in this resource site, comprising an estimated 29 percent of lands in the resource site. Relative to the site's amount of land within the Metro boundary, it contributes a relatively large percentage of the region's total wetlands (two percent) and ranks 15th among the 27 resource sites.

Species of Concern. There are no recorded Species of Concern sighting locations within this resource site. However, it is likely that this simply indicates a lack of survey data. There are very likely Species of Concern using this resource site, particularly those relying on wetlands, forested habitats and agricultural lands, which often serve as a surrogate for native grassland habitats (see Table C-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 40, 45, 46, 47, 59, 60

Resource site data tables: Riparian Corridors

Table C-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Hillsboro	3,500.6
Unincorporated Washington County	336.7

Table C-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
McKay Creek	3,842.7	635.8

Table C-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
McKay Creek	Microclimate & shade	137.1	21.6%	53.1	8.3%
	Streamflow moderation & water storage	361.6	56.9%	254.5	40.0%
	Bank stabilization & pollution control	334.0	52.5%	0.0	0.0%
	Large wood & channel dynamics	384.0	60.4%	10.0	1.6%
	Organic material sources	274.9	43.2%	3.3	0.5%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table C-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
McKay Creek	1 to 5	182.2	28.7%
	6 to 11	56.3	8.8%
	12 to 17	120.3	18.9%
	18 to 23	19.6	3.1%
	24 to 29	151.4	23.8%
	30	106.0	16.7%
	Total acres	635.8	100.0%

Resource site data tables: Wildlife Habitat

Table C-20. Breakdown of total wildlife model patch scores.*

Resource site: McKay Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	20.3	54.2	152.9	68.0	40.3	97.4	21.5	28.0	0.0	482.7
Percent of total	4.2%	11.2%	31.7%	14.1%	8.4%	20.2%	4.5%	5.8%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table C-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: McKay Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
Model score	234.1	28.0	0.0	179.0	0.0	0.0	2.4	234.2	225.8	148.1	266.2	68.4	482.7
Percent of total acres in inventory	48.5%	5.8%	0.0%	37.1%	0.0%	0.0%	0.5%	48.5%	46.8%	30.7%	55.1%	14.2%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table C-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: McKay Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ Intact topsoil	Non-forest woody vegetation					
Acres	220.6	0.0	125.2	58.9	69.9	8.2	482.7
Percent of total	45.7%	0.0%	25.9%	12.2%	14.5%	1.7%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table C-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: McKay Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	482.7	74.6	1.6	484.4	0
Percent of total	99.7%	15.4%	0.3%	100.0%	N/A

*Habitats of Concern.

Table C-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: McKay Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.00	0.0	0.0%
Barren	49.76	0.0	10.3%
Low structure agriculture	162.02	0.7	33.6%
High structure agriculture	2.70	0.0	0.6%
Deciduous closed canopy	39.44	0.1	8.2%
Mixed closed canopy	37.90	0.0	7.8%
Conifer closed canopy	16.86	0.0	3.5%
Deciduous open canopy	26.87	0.0	5.6%
Mixed open canopy	24.52	0.0	5.1%
Conifer open canopy	3.50	0.0	0.7%
Deciduous scattered canopy	20.48	0.0	4.2%
Mixed scattered canopy	9.21	0.0	1.9%
Conifer scattered canopy	3.08	0.0	0.6%
Closed canopy shrub	15.51	0.1	3.2%
Open canopy shrub	11.54	0.0	2.4%
Scattered canopy shrub	19.15	0.0	4.0%
Meadow/grass	40.18	0.6	8.4%
Not classified	0.00	0.0	0.0%
Total	482.73	1.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table C-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
McKay Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	0.0	78.1	58.9	138.9	182.0	71.6	165.5
Percent of total	0.0%	16.1%	12.2%	28.7%	37.6%	14.8%	34.2%

[1]See Table C-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

D. Rock Creek/Tualatin River

General watershed information

Resource sites in the Rock Creek/Tualatin River Watershed include:

- Middle Rock Creek-Tualatin River subwatershed
- Beaverton Creek subwatershed
- Lower Rock Creek-Tualatin River subwatershed (combined with Middle Tualatin River-Davis Creek)
- Middle Tualatin River-Gordon Creek subwatershed (combined with Lindow Creek)

Watershed assessments and plans

Bureau of Land Management, U.S. Department of the Interior (BLM), 2001. *Middle Tualatin-Rock Creek Watershed Analysis,* BLM, Salem District Office, Tillamook Resource Area: Tillamook, Oregon.

Brown and Caldwell, 1999. *Beaverton Creek Watershed Management Plan.* Unified Sewage Agency: Hillsboro, Oregon.

Lev, Esther, 1990. *Inventory of Wetlands, Riparian and Upland Wildlife Habitat Areas in Hillsboro, Oregon,* Environmental Consulting: Portland, Oregon.

Oregon Department of Fish and Wildlife (ODFW) and Unified Sewage Agency (USA), 1995. *Distribution of Fish and Crayfish and Measurement of Available Habitat in the Tualatin River Basin, Final Report of Research,* ODFW: Portland, Oregon and Unified Sewage Agency: Hillsboro, Oregon.

Portland State University and Metropolitan Regional Government, 1995. *Rock Creek Watershed Atlas, Planning with an Awareness of Natural Boundaries, March 1995,* Portland State University and Metro: Portland, Oregon.

Tualatin River Watershed Council, 1999. *Tualatin River Watershed, Action Plan,* Tualatin River Watershed Council: Hillsboro, Oregon.

Tualatin Watershed Council, 2001. *Tualatin River Watershed Atlas,* Tualatin Watershed Council: Hillsboro, Oregon

Unified Sewage Agency, 1996. *Subbasin Strategies Plans for Upper Rock, Bronson and Willow Creeks,* Unified Sewage Agency: Hillsboro, Oregon.

Walker and Macy, Landscape Architects and Planners, 1989. *Jackson Bottom, Concept Master Plan,* City of Hillsboro, Unified Sewage Agency: Hillsboro, Oregon.

Watershed councils and related groups

Cedar Mill Creek Watershed Watch, 503-292-8713, Gretchen Vadnais

Golf Creek, Friends of, 7277 SW Barnes Road, Portland 97225, 503-292-4549, Bridget McCarthy

Jackson Bottom, Friends of, 503-647-3286, Faun Hosey

Jackson Bottom Wetlands Preserve, 123 W Main Street, Hillsboro 97123, 503-681-6206, Patrick Willis

Rock Creek Environmental Center, 503-690-5402, Bob Mann

Rock Creek Watershed Council, 16747 Timber Road, Vernonia 97064, 503-429-2401, Maggie Belmore

Tualatin Watershed Council, 1080 SW Baseline, Bldg. B, Suite B-2, Hillsboro 97123, (503) 681-0953, FAX (503) 681-9772

Tualatin River National Wildlife Refuge, City of Sherwood, 90 NW Park Street, Sherwood 97140, 503-625-5522, Joan Patterson
Tualatin River Rangers, USA, 155 N First Ave., Hillsboro 97124, 503-640-3516, Linda Kelly
Tualatin Riverkeepers, 16340 SW Beef Bend Road, Sherwood 97140, 503-590-5813, Lauri Mullen
Wetlands, Friends of, 503-253-6247, Alice Blatt
Yamhill Basin Council, 2200 SW 2nd Street, McMinnville 97128, 503-472-6403, Melissa Leoni

Data descriptions
Table D-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

All six of the subwatersheds fall within the same 5th field HUC (Rock Creek/Tualatin River), but they are divided into four resource sites. The Middle Rock Creek-Tualatin River subwatershed comprises the resource site with the same name (Resource Site #7). Similarly, the Beaverton Creek subwatershed also comprises its namesake resource site (Resource Site #8). Resource Site #9 is comprised of two subwatersheds, Lower Rock Creek-Tualatin River and Middle Tualatin River-Davis Creek; this is called Lower Rock Creek-Tualatin River. Resource Site #10, Middle Tualatin River-Gordon Creek, combines its namesake with Lindow Creek.

Tables D-1 and D-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table D-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Rock Creek/Tualatin River	1709001004	7	Middle Rock Creek-Tualatin River	170900100401	7,300.1
		8	Beaverton Creek	170900100402	24,296.8
		9	Lower Rock Creek-Tualatin River	170900100403	7,496.4
			Middle Tualatin River-Davis Creek	170900100404	1,220.7
		10	Middle Tualatin River-Gordon Creek	170900100405	3,594.8
			Lindow Creek	170900100407	752.5

Table D-2. Resource sites: general information.

General information	Middle Rock Creek-Tualatin River	Beaverton Creek	Lower Rock Creek-Tualatin River	Middle Tualatin River-Gordon Creek
Miles of DEQ 303(d) listed streams	4.5	34.8	4.6	3.0
Road density (road miles/square miles in subwatershed)	10.2	15.3	12.6	12.1
Miles of stream with known anadromous fish presence	4.5	0.0	4.6	0.4
Acres of hydrologically connected wetlands	198.6	588.7	918.5	37.8
Total acres of wetlands	199.9	599.8	918.5	38.1
Acres of floodplains (100 year FEMA + 1996 inundation area)	239.2	1,246.1	854.3	83.7
Acres of developed floodplains	8.2	421.9	16.6	13.5
Building permits since 1996 (number)	2,704.0	6,183.0	1,579.0	765.0

Table D-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	High			
Middle Rock Creek-Tualatin River	7.4	5.9	2.2	14.5	30.0
Beaverton Creek	31.6	6.5	20.9	42.9	101.9
Lower Rock Creek-Tualatin River	13.5	0.0	7.7	11.6	32.8
Middle Tualatin River-Gordon Creek	2.7	1.6	0.8	11.0	16.1

*Stream links are links between surface streams and may be piped or culverted.

Table D-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Middle Rock Creek-Tualatin River	682.8	71.7	744.7	923.0
Beaverton Creek	1,141.9	114.0	1,743.8	2,457.0
Lower Rock Creek-Tualatin River	726.4	9.0	451.5	278.6
Middle Tualatin River-Gordon Creek	343.8	20.3	216.2	363.5

Table D-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Middle Rock Creek-Tualatin River	748.7	801.0	751.3	5.2	2,798.8	1,608.0	177.1
Beaverton Creek	1,774.6	1,187.3	2,277.0	103.5	1,250.7	12,211.4	2,065.6
Lower Rock Creek-Tualatin River	1,777.5	1,729.8	649.9	15.7	79.0	3,944.9	413.5
Middle Tualatin River-Gordon Creek	257.5	37.7	237.5	0.0	1,323.3	2,037.0	0.0

SITE #7: Middle Rock Creek-Tualatin River subwatershed

Named tributaries: Abbey Creek, Rock Creek
Communities within the subwatershed: Beaverton, Hillsboro, Portland, unincorporated Washington County
Total acreage within Metro's boundary: 7,300.1
Total acreage within riparian corridor: 2,421.2

This site contains two percent of the area comprising Metro's jurisdictional boundary. About 23 percent of the site is in the City of Hillsboro, seven percent in the City of Portland, less than one percent in Beaverton, with the remainder in unincorporated Multnomah and Washington counties (32 and 39 percent, respectively) (Table D-6).

This resource site falls in the second quartile (26 to 50 percent of maximum) of the range of development compared to other sites, with 10.2 miles of road per square mile (Table D-2). Rural zoning strongly dominates land use, but single family residential zoning is also important; commercial, industrial and multi-family residential uses also cover substantial acreage (Table D-5). More than 2,700 building permits have been issued here since 1996 (Table D-2).

Riparian resources. The percentage of this site in riparian corridors is 33 percent, comparable to Site #4 (Willamette River – Lower Tualatin River) (Table 12). The site contributes approximately three percent of the region's riparian corridors (Table 13).

This resource site has approximately 30 total stream miles, or slightly less than 0.0038 miles of non-piped streams per acre, ranking it seventh among the 27 resource sites (Table 12). Only approximately seven percent of all stream miles are stream links, suggesting a relatively low amount of piping/culverting (Table D-3); 16 percent of non-piped streams are DEQ 303(d) water-quality limited, the lowest of any site in Group D (Tables D-2 and D-3). The site contains a mixture of stream gradients (Table D-3). Slightly over three percent of the site is in the floodplain, with approximately three percent of the land covered by wetland resources (Table D-2). Slightly more than three percent of the floodplain is developed, most similar to Site #9 in this group. Anadromous fish are known to be present in five stream miles (Table D-2).

Twenty-seven percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, similar to Sites #8 and #10 in Group D (Table D-9). Forty-two percent of the site's riparian corridors receive at least one primary ecological function score, similar to all other sites in this group except Site #9, which has more primary-scoring areas (Table D-9). The vegetation types within 300 ft of streams are co-dominated by forested and low-structure vegetation, most similar to Site #8 in this group (Table D-4). The largest percentage of land receiving a given primary score is for *Bank stabilization and pollution control*, but *Large wood and channel dynamics* and *Organic material sources* are also important primary functions (Table D-8; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 33 percent of the lands in this site fall within the wildlife habitat inventory, ranking it eighth of the 27 resource sites (Table 16). Within model patches, a remarkably high 57 percent fall within the top third of the point range (Table D-10). Of the four criteria in the GIS model, this site tends to score low to moderate in size, moderate to high in

interior (excellent compared to many other sites), moderate in water resources, and high in connectivity (Table D-11). In general, this site's wildlife habitat patches are characterized by a low degree of fragmentation, excellent connectivity, and good water resources. There is a substantial amount of interior habitat in this resource site, making it an excellent area for Neotropical migratory birds and other species requiring interior or relatively undisturbed habitats.

Habitat types in this resource site are dominated by conifer/hardwood forest cover, reflecting the strong size and interior habitat scores discussed above (Table D-15). Wetlands comprise an estimated eight percent of lands. This site contributes over two percent of the region's total wetlands, ranking 13th among the 27 resource sites.

Species of Concern. Four Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Acorn Woodpecker
- Willow Flycatcher
- Elk (listed as sensitive here because it is considered in the Goal 5 rule)
- Great Blue Heron nesting colony

There are very likely many other Species of Concern using this resource site, particularly those relying on forest interior habitats (see Table D-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

- UID numbers: 49, 55, 56, 57, 58

Resource site data tables: Riparian Corridors

Table D-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Beaverton	8.8
Hillsboro	1,670.9
Portland	474.8
Unincorporated Multnomah County	2,308.2
Unincorporated Washington County	2,835.9

Table D-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Middle Rock Creek-Tualatin River	7,300.2	2,390.8

Table D-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Middle Rock Creek-Tualatin River	Microclimate & shade	432.5	18.1%	978.6	40.9%
	Streamflow moderation & water storage	310.5	13.0%	2,032.4	85.0%
	Bank stabilization & pollution control	945.3	39.5%	253.5	10.6%
	Large wood & channel dynamics	751.4	31.4%	198.3	8.3%
	Organic material sources	636.8	26.6%	157.9	6.6%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table D-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Middle Rock Creek-Tualatin River	1 to 5	1,382.1	57.8%
	6 to 11	256.3	10.7%
	12 to 17	113.3	4.7%
	18 to 23	86.8	3.6%
	24 to 29	428.5	17.9%
	30	123.9	5.2%
	Total acres	2,390.8	100.0%

Resource site data tables: Wildlife Habitat

Table D-10. Breakdown of total wildlife model patch scores.*

Resource site: Middle Rock Creek-Tualatin River	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	31.1	140.5	326.1	293.3	96.8	133.6	45.3	1,282.4	0.0	2,349.0
Percent of total	1.3%	6.0%	13.9%	12.5%	4.1%	5.7%	1.9%	54.6%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Middle Rock Creek-Tualatin River	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,086.1	638.6	0.0	257.6	638.6	643.8	67.6	1,935.4	280.3	212.5	556.7	1,579.9	2,349.0
Percent of total acres in inventory	46.2%	27.2%	0.0%	11.0%	27.2%	27.4%	2.9%	82.4%	11.9%	9.0%	23.7%	67.3%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table D-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Middle Rock Creek - Tualatin River	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	555.0	69.4	1,540.8	99.6	72.1	12.2	2,349.0
Percent of total	23.6%	3.0%	65.6%	4.2%	3.1%	0.5%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Middle Rock Creek - Tualatin River	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2349.0	234.4	19.4	2368.4	4
Percent of total	99.2%	9.9%	0.8%	100.0%	N/A

*Habitats of Concern.

Table D-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Middle Rock Creek - Tualatin River Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	5.35	0.7	0.3%
Barren	135.08	5.3	5.9%
Low structure agriculture	214.50	2.1	9.1%
High structure agriculture	6.72	0.0	0.3%
Deciduous closed canopy	544.74	1.0	23.0%
Mixed closed canopy	635.98	0.8	26.9%
Conifer closed canopy	56.03	0.9	2.4%
Deciduous open canopy	70.35	1.3	3.0%
Mixed open canopy	61.01	0.6	2.6%
Conifer open canopy	18.22	0.2	0.8%
Deciduous scattered canopy	159.86	0.5	6.8%
Mixed scattered canopy	33.62	0.7	1.4%
Conifer scattered canopy	5.91	0.4	0.3%
Closed canopy shrub	74.12	0.5	3.1%
Open canopy shrub	98.93	0.3	4.2%
Scattered canopy shrub	59.78	0.8	2.6%
Meadow/grass	168.69	3.3	7.3%
Not classified	0.15	0.0	0.0%
Total	2,349.03	19.4	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table D-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Middle Rock Creek - Tualatin River	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	0.0	84.3	99.6	199.9	1,592.1	331.8	223.3
Percent of total	0.0%	3.6%	4.2%	8.4%	67.2%	14.0%	9.4%

[1]See Table D-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #8: Beaverton Creek subwatershed

Named tributaries: Beaverton Creek, Bronson Creek, Cedar Mill Creek, Golf Creek, Johnson Creek, Rock Creek, Wessenger Creek, Willow Creek
Communities within the subwatershed: Beaverton, Hillsboro, Portland, unincorporated Washington County
Total acreage within Metro's boundary: 24,297
Total acres within riparian corridor: 5,822.7

This site contains eight percent of the area comprising Metro's jurisdictional boundary, a relatively substantial amount compared to other Resource Sites (two sites rank higher). Over half of the site (57 percent) is in unincorporated Washington County; 28 percent falls within the City of Beaverton, and four and five percent in the cities of Hillsboro and Portland, respectively. The remaining five percent is in unincorporated Multnomah County (Table D-16).

This site contains 15.3 miles of roads per square mile, placing it in the high end of the third quartile (51-75 percent of maximum) of the range of development compared to all other sites. It is the most developed of the four resource sites in Group D (Table D-2). Zoning is dominated by Zoning is very strongly dominated by single family residential use (Table D-5). More than 6,000 building permits have been issued in this resource site since 1996, more than double that of any other resource site within Metro's boundary (Table D-2).

Riparian resources. Given this site's high development intensity, it is relatively rich with riparian resources; the amount of this site in riparian corridors is 24 percent, comparable to Site #10 in this group (Table 12). The site contributes a substantial amount of the region's riparian corridors, at more than six percent (Table 13).

This resource site has approximately 102 total stream miles, and more than 0.0033 miles of non-piped streams per acre, ranking it 16th among the 27 resource sites (Table 12). Approximately 21 percent of all stream miles are stream links, suggesting a relatively high amount of piping/culverting that is similar to Site #9 (Table D-3). This site has the highest percentage of non-piped streams that are DEQ 303(d) quality limited, at 43 percent (Tables D-2 and D-3). That is not surprising, as research across the country indicates declining stream quality with increasing urbanization (see Metro's Technical Report for Goal 5, Metro 2002). Low to medium gradient streams predominate (Table D-3). Five percent of the site is in the floodplain, with approximately 2-1/2 percent of the land covered by wetland resources (Table D-2). More than a third of the floodplain is developed (the fourth highest level of all resource sites; Table 14), and this probably contributes to decreased stream quality. No anadromous fish are known to be present in this resource site (Table D-2).

Twenty-nine percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, similar to Sites #7 and #10 in Group D (Table D-19). Forty-five percent of the site's riparian corridors receive at least one primary ecological function score, similar to all other sites in this group except Site #9, which has more primary-scoring areas (Table D-19). The vegetation types within 300 ft of streams are co-dominated by forested and low-structure vegetation, most similar to Site #7 in this group (Table D-4). The largest percentage of land receiving a given primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*; however, *Organic* *material sources* is also important primary function (Table D-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 22 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 19th of the 27 resource sites (Table 16). This low ranking relative to the site's substantial lands within the Metro boundary reflects the high urbanization levels. However, within model patches, 40 percent fall within the top third of the point range (Table D-20). The trends for the four criteria in the GIS model are interesting. All of this site's acreage falls in the lowest size category. For habitat interior, there is a dichotomy in which sites are split between the low and high range, with none in the middle; note that only one site (Site #26) contains a higher proportion of the top category for interior habitat. However, nearly all sites score moderate to high in water resources, and the majority are in the highest connectivity score (water and connectivity are likely related) (Table D-21). In general, this site's resources are characterized by small habitat patches, but these are often placed along streams and thus tend to be well connected. This type of resource site is important for wildlife passage, including movements of migratory birds in the spring and fall.

Habitat types in this resource site are strongly dominated by conifer/hardwood forest cover, but wetlands are also important, comprising approximately 12 percent of this site's lands (Table D-25). The site is important to the regional wetland network, contributing over seven percent and ranking third among the 27 resource sites.

Species of Concern. Thirteen Species of Concern sighting locations fall within the site; this high number is partially due to the fact that numerous surveys have been conducted within the resource site, but also likely due to the valuable aquatic habitats and large amount of land in the Metro boundary. It appears to be a very good area for Red-legged frogs. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Red-legged frog
- Band-tailed Pigeon
- Pileated Woodpecker
- Olive-sided Flycatcher
- Willow Flycatcher
- Bufflehead
- Northern Pygmy-owl
- Great Blue Heron nesting colony
- Common Nighthawk
- Western pond turtle

There are very likely many other Species of Concern using this resource site, particularly those relying on forest interior habitats (see Table D-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 14, 50, 51, 52, 53, 54, 58, 93, 107

Resource site data tables: Riparian Corridors

Table D-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Beaverton	6,902.2
Hillsboro	948.0
Portland	1,301.2
Unincorporated Multnomah County	1,246.4
Unincorporated Washington County	13,899.2

Table D-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Beaverton Creek	24,297.0	5,788.0

Table D-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Beaverton Creek	Microclimate & shade	1,190.9	20.6%	2,101.8	36.3%
	Streamflow moderation & water storage	1,069.3	18.5%	4,361.5	75.4%
	Bank stabilization & pollution control	2,364.5	40.9%	340.5	5.9%
	Large wood & channel dynamics	2,160.2	37.3%	423.0	7.3%
	Organic material sources	1,670.9	28.9%	306.6	5.3%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table D-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Beaverton Creek	1 to 5	3,161.9	54.6%
	6 to 11	475.0	8.2%
	12 to 17	450.9	7.8%
	18 to 23	123.2	2.1%
	24 to 29	1,175.7	20.3%
	30	401.3	6.9%
	Total acres	5,788.0	100.0%

Resource site data tables: Wildlife Habitat

Table D-20. Breakdown of total wildlife model patch scores.*

Resource site: Beaverton Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	247.9	425.0	479.4	707.9	516.0	699.8	242.9	1,827.5	0.0	5,146.4
Percent of total	4.8%	8.3%	9.3%	13.8%	10.0%	13.6%	4.7%	35.5%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Beaverton Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
Model score	4,381.9	0.0	0.0	1,392.8	0.0	1,827.5	168.9	3,218.0	1,360.2	1,132.9	1,502.8	2,510.7	5,146.4
Percent of total acres in inventory	85.1%	0.0%	0.0%	27.1%	0.0%	35.5%	3.3%	62.5%	26.4%	22.0%	29.2%	48.8%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table D-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Beaverton Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	710.7	53.8	3,856.1	190.5	286.5	48.7	5,146.3
Percent of total	13.8%	1.0%	74.9%	3.7%	5.6%	0.9%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Beaverton Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	5146.4	529.0	80.0	5226.4	13
Percent of total	98.5%	10.1%	1.5%	100.0%	N/A

*Habitats of Concern.

Table D-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Beaverton Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	12.46	0.3	0.2%
Barren	289.57	24.6	6.0%
Low structure agriculture	107.13	1.4	2.1%
High structure agriculture	27.07	0.0	0.5%
Deciduous closed canopy	964.32	6.4	18.6%
Mixed closed canopy	1,246.04	3.7	23.9%
Conifer closed canopy	667.35	1.1	12.8%
Deciduous open canopy	378.66	11.8	7.5%
Mixed open canopy	257.30	3.6	5.0%
Conifer open canopy	75.65	1.1	1.5%
Deciduous scattered canopy	232.68	7.1	4.6%
Mixed scattered canopy	155.35	2.9	3.0%
Conifer scattered canopy	46.84	0.8	0.9%
Closed canopy shrub	220.71	3.0	4.3%
Open canopy shrub	94.03	2.3	1.8%
Scattered canopy shrub	115.54	3.4	2.3%
Meadow/grass	255.25	6.4	5.0%
Not classified	0.44	0.0	0.0%
Total	5,146.37	80.0	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table D-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Beaverton Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	0.0	335.2	190.5	599.8	4,062.8	476.9	135.6
Percent of total	0.0%	6.4%	3.6%	11.5%	77.7%	9.1%	2.6%

[1]See Table D-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #9: Lower Rock Creek-Tualatin River subwatershed

Named tributaries: Beaverton Creek, Dawson Creek, Rock Creek, Jackson Slough, Tualatin River

Communities within the subwatershed: Hillsboro, unincorporated Washington County

Total acreage within Metro's boundary: 8,717 (combined Lower Rock Creek-Tualatin River and Middle Tualatin-Davis Creek subwatersheds)

Total acres within riparian corridor: 1,808.6

This site contains three percent of the area comprising Metro's jurisdictional boundary. Most of the site lies within the City of Hillsboro's boundaries (88 percent), with the remaining 12 percent in unincorporated Washington County (Table D-26).

Road density, at 12.6 miles per square mile, is similar to the resource sites in Group C and falls close to the mid-range compared to all other resource sites (Table D-2). Single family residential dominates zoning, but commercial and industrial uses are also important land uses (Table D-5). More than 1,500 building permits have been issued here since 1996 (Table D-2).

Riparian resources. The amount of this site in riparian corridors is 20 percent, comparable to Site #10 in this group (Table 12). The site contributes approximately two percent of the region's riparian corridors (Table 13).

This resource site has approximately 33 total stream miles, and more than 0.0029 miles of non-piped streams per acre (Table 12). Approximately 23 percent of all stream miles are stream links, suggesting a relatively high amount of piping/culverting that is similar to Site #8 (Table D-3). This site has the second-highest percentage of non-piped streams that are DEQ 303(d) quality limited, at 29 percent (Tables D-2 and D-3). Low to medium gradient streams strongly predominate (Table D-3). This site also has the highest percentage of the site in the floodplain of all Group D sites, and approximately 11 percent of the land covered by wetland resources, substantially higher than other Group D sites (Table D-2). Only two percent of the floodplain is developed, the lowest of all 27 resource sites. Approximately five stream miles are known to contain anadromous fish (Table D-2).

Scoring ranges for this site indicate high quality riparian resources. Almost half of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, and 78 percent of riparian acreage received at least one primary function score (Table D-29). The vegetation types within 300 ft of streams is dominated by low-structure vegetation, but there is also a substantial amount of forest cover (Table D-4). The largest percentage of land receiving a given primary score is similar for three functional criteria: *Large wood and channel dynamics*, *Bank stabilization and pollution control* and *Streamflow moderation and water storage* (reflecting the strong floodplain and wetland components) (Table D-28). *Organic material sources* is also important primary function (Table D-28; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.

Including Habitats of Concern, 19 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 22nd among the 27 resource sites (Table 16). Within model patches, 41 percent fall within the top third of the point range, similar to Beaverton Creek (Table D-30). Of the four criteria in the GIS model, this site tends to score low in size and interior (there actually is no acreage above the lowest interior class), high in water resources, and very good connectivity (Table D-31). In general, this site's resources are characterized by small to medium habitat patches that are long and narrow, with excellent water resources and connectivity, reflecting the excellent stream and wetland resources in this site. This type of resource site is important for wildlife passage, including movements of migratory birds in the spring and fall.

Habitat types in this resource site are quite mixed, but wetlands are critically important here. Wetlands comprise 57 percent of the site, and contribute 11 percent of the regional wetland network, ranking second highest among the 27 resource sites. Although wetlands cover the highest percentage of land, forests are nearly as high and grasslands and agriculture also provide significant habitat (Table D-35).

Species of Concern. Six Species of Concern sighting locations fall within the site; the site is important to a variety of species, including waterfowl. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Olive-sided Flycatcher
- Willow Flycatcher
- Bald Eagle
- Western Meadowlark
- Bufflehead
- Merlin

There are very likely many other Species of Concern using this resource site, particularly those relying on forest interior habitats (see Table D-35). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 58, 59, 108

Resource site data tables: Riparian Corridors

Table D-26. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Hillsboro	7,640.4
Unincorporated Washington County	1,076.8

Table D-27. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Rock Creek-Tualatin River	8,717.3	1,736.4

Table D-28. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Lower Rock Creek-Tualatin River	Microclimate & shade	482.7	27.8%	190.1	10.9%
	Streamflow moderation & water storage	1,031.5	59.4%	640.7	36.9%
	Bank stabilization & pollution control	1,045.4	60.2%	0.8	0.0%
	Large wood & channel dynamics	1,143.9	65.9%	36.4	2.1%
	Organic material sources	836.1	48.2%	15.3	0.9%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table D-29. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Rock Creek-Tualatin River	1 to 5	380.7	21.9%
	6 to 11	163.2	9.4%
	12 to 17	349.1	20.1%
	18 to 23	55.1	3.2%
	24 to 29	428.7	24.7%
	30	359.6	20.7%
	Total acres	1,736.4	100.0%

Resource site data tables: Wildlife Habitat

Table D-30. Breakdown of total wildlife model patch scores.*

Resource site: Lower Rock Creek - Tualatin River	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	52.4	119.3	210.1	96.5	136.8	327.4	319.5	346.1	0.0	1,608.2
Percent of total	3.3%	7.4%	13.1%	6.0%	8.5%	20.4%	19.9%	21.5%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-31. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Lower Rock Creek - Tualatin River	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	935.7	346.1	0.0	1,015.3	0.0	0.0	7.8	442.2	1,095.0	239.3	596.6	772.4	1,608.2
Percent of total acres in inventory	58.2%	21.5%	0.0%	63.1%	0.0%	0.0%	0.5%	27.5%	68.1%	14.9%	37.1%	48.0%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table D-32. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Rock Creek - Tualatin River	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	321.9	4.4	375.1	318.0	346.0	242.8	1,608.2
Percent of total	20.0%	0.3%	23.3%	19.8%	21.5%	15.1%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-33. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Rock Creek - Tualatin River	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1608.2	314.7	9.2	1617.4	6
Percent of total	99.4%	19.5%	0.6%	100.0%	N/A

Table D-34. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Rock Creek - Tualatin River / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	36.55	1.6	2.4%
Barren	188.02	1.0	11.7%
Low structure agriculture	264.71	0.3	16.4%
High structure agriculture	1.90	0.0	0.1%
Deciduous closed canopy	175.64	0.1	10.9%
Mixed closed canopy	167.41	0.2	10.4%
Conifer closed canopy	100.22	0.0	6.2%
Deciduous open canopy	107.94	1.1	6.7%
Mixed open canopy	56.33	0.7	3.5%
Conifer open canopy	18.67	0.4	1.2%
Deciduous scattered canopy	87.96	1.0	5.5%
Mixed scattered canopy	62.13	0.7	3.9%
Conifer scattered canopy	28.07	0.4	1.8%
Closed canopy shrub	71.92	0.3	4.5%
Open canopy shrub	31.69	0.4	2.0%
Scattered canopy shrub	70.45	0.6	4.4%
Meadow/grass	138.61	0.3	8.6%
Not classified	0.00	0.0	0.0%
Total	1,608.23	9.2	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table D-35. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Lower Rock Creek - Tualatin River	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	3.4	588.8	318.0	918.5	809.1	242.0	266.9
Percent of total	0.2%	36.4%	19.7%	56.8%	50.0%	15.0%	16.5%

[1]See Table D-34 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #10: Middle Tualatin River-Gordon Creek subwatershed

Named tributaries: Butternut Creek, Gordon Creek, Lindow Creek, Rock Creek, Tualatin River
Communities within the subwatershed: Beaverton, Hillsboro, unincorporated Washington County
Total acreage within Metro's boundary: 4,347 (combined Middle Tualatin River-Gordon Creek and Lindow Creek subwatersheds)
Total acres within riparian corridor: 940.4

This site contains one percent of the area comprising Metro's jurisdictional boundary. The majority of the site (97 percent) lies in unincorporated Washington County, with the remainder in Beaverton (two percent) and Hillsboro (one percent) (Table D-36).

Despite that most of this resource site is in unincorporated lands, road density falls near the midpoint of the range compared to all other resource sites (12.1 miles per square mile; Table D-2). Reflecting this level of development, zoning is dominated by single family residential use. However, rural zoning is also an important land use type (Table D-5). More than 750 building permits have been issued here since 1996 (Table D-2).

Riparian resources. The amount of this site in riparian corridors is 22 percent, falling between Sites #8 and #9 in this resource group (Table 12). However, the site contributes only about one percent of the region's riparian corridors (Table 13), because a relatively small portion of the resource site falls within Metro's boundary.

This resource site has approximately 16 total stream miles, and 0.0035 miles of non-piped streams per acre, ranking it 12th among the 27 resource sites (Table 12). Only five percent of all stream miles are stream links, suggesting a relatively minor amount of piping/culverting that is most similar to Site #7 (Table D-3). Twenty percent of non-piped stream miles are DEQ 303(d) quality limited (Tables D-2 and D-3). A mixture of stream gradients is found in this resource site (Table D-3). Only two percent of the site is in the floodplain, with one percent of the land covered by wetland resources (Table D-2). Sixteen percent of the floodplain is developed. Less than half a mile of streams in this site are known to harbor anadromous fish (Table D-2).

Twenty-nine percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, similar to Sites #7 and #10 in Group D (Table D-19). Forty-five percent of the site's riparian corridors receive at least one primary ecological function score, similar to all other sites in this group except Site #9, which has more primary-scoring areas (Table D-19). The vegetation types within 300 ft of streams are co-dominated by forested and low-structure vegetation, most similar to Site #7 in this group (Table D-4). The largest percentage of land receiving a given primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*; however, *Organic material sources* is also important primary function (Table D-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 22 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 18th among the 27 resource sites (Table 16). Within model patches, no acreage falls within the top third of the point range, although nearly 60 percent fall in the middle range (Table D-40). Of the four criteria in the GIS model, all acreage falls in the low size and

habitat interior ranges. Scores for water resources tend to be moderate, while connectivity is spread between the three point categories (Table D-41). In general, this site's resources are characterized by small habitat patches containing no interior habitat, with moderate water resources and varying levels of connectivity.

Conifer and hardwood forest are the dominant habitat types in this resource site, although agricultural lands cover 17 percent of the site's land (Table D-45). Wetlands comprise only four percent of the site, contributing less than one percent of the region's wetlands and ranking 23rd of the 27 resource sites.

Species of Concern. Three Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Band-tailed Pigeon
- Olive-sided Flycatcher

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table D-45). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 107, 108

Resource site data tables: Riparian Corridors

Table D-36. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Beaverton	78.2
Hillsboro	62.2
Unincorporated Washington County	4,206.9

Table D-37. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Middle Tualatin River-Gordon Creek	4,347.3	941.5

Table D-38. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Middle Tualatin River-Gordon Creek	Microclimate & shade	118.7	12.6%	315.6	33.5%
	Streamflow moderation & water storage	88.7	9.4%	756.4	80.3%
	Bank stabilization & pollution control	366.1	38.9%	43.0	4.6%
	Large wood & channel dynamics	304.5	32.3%	58.2	6.2%
	Organic material sources	207.0	22.0%	50.1	5.3%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table D-39. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Middle Tualatin River-Gordon Creek	1 to 5	544.8	57.9%
	6 to 11	94.7	10.1%
	12 to 17	96.9	10.3%
	18 to 23	48.7	5.2%
	24 to 29	131.4	14.0%
	30	24.9	2.6%
	Total acres	941.5	100.0%

Resource site data tables: Wildlife Habitat

Table D-40. Breakdown of total wildlife model patch scores.*

Resource site: Middle Tualatin River - Gordon Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	54.9	129.6	182.7	178.4	208.3	150.4	0.0	0.0	0.0	904.3
Percent of total	6.1%	14.3%	20.2%	19.7%	23.0%	16.6%	0.0%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-41. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Middle Tualatin River - Gordon Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	569.6	0.0	0.0	395.3	0.0	0.0	103.1	655.9	35.7	215.5	344.6	344.2	904.3
Percent of total acres in inventory	63.0%	0.0%	0.0%	43.7%	0.0%	0.0%	11.4%	72.5%	3.9%	23.8%	38.1%	38.1%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table D-42. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Middle Tualatin River - Gordon Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	313.1	21.6	537.4	19.1	12.0	1.2	904.3
Percent of total	34.6%	2.4%	59.4%	2.1%	1.3%	0.1%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table D-43. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Middle Tualatin River - Gordon Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	904.3	214.1	45.1	949.4	2
Percent of total	95.2%	22.5%	4.8%	100.0%	N/A

*Habitats of Concern.

Table D-44. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Middle Tualatin River - Gordon Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.15	0.0	0.0%
Barren	62.00	8.3	7.4%
Low structure agriculture	139.08	21.9	17.0%
High structure agriculture	4.33	0.0	0.5%
Deciduous closed canopy	114.38	0.2	12.1%
Mixed closed canopy	209.37	1.0	22.2%
Conifer closed canopy	80.68	0.0	8.5%
Deciduous open canopy	44.68	1.9	4.9%
Mixed open canopy	58.09	4.0	6.5%
Conifer open canopy	9.80	0.0	1.0%
Deciduous scattered canopy	55.51	0.9	5.9%
Mixed scattered canopy	18.55	0.0	2.0%
Conifer scattered canopy	7.71	0.0	0.8%
Closed canopy shrub	25.88	1.8	2.9%
Open canopy shrub	9.69	1.4	1.2%
Scattered canopy shrub	18.48	3.7	2.3%
Meadow/grass	45.89	0.0	4.8%
Not classified	0.00	0.0	0.0%
Total	904.28	45.1	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table D-35. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Lower Rock Creek - Tualatin River	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	3.4	588.8	318.0	918.5	809.1	242.0	266.9
Percent of total	0.2%	36.4%	19.7%	56.8%	50.0%	15.0%	16.5%

[1]See Table D-34 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

E. Lower Tualatin River

General watershed information

Resource sites in the Lower Tualatin River Watershed include:

- Lower Tualatin River-Lake Oswego Canal subwatershed
- Upper and Middle Fanno Creek subwatershed/Summer Creek subwatershed
- Lower Fanno Creek subwatershed
- Rock Creek (So. Washington Co.) subwatershed (combined with Cedar Creek, Chicken Creek, and Lower Tualatin River subwatersheds)

Watershed assessments and plans

Bureau of Planning, City of Portland, 1994. *The Fanno Creek and Tributaries Conservation Plan, January 19, 1994,* City of Portland: Portland, Oregon.

Kurahashi and Associates, Inc, 1997. *Fanno Creek Watershed Management Plan,* Unified Sewage Agency: Hillsboro, Oregon.

Oregon Department of Fish and Wildlife (ODFW) and Unified Sewage Agency (USA), 1995. *Distribution of Fish and Crayfish and Measurement of Available Habitat in the Tualatin River Basin, Final Report of Research,* ODFW: Portland, Oregon and Unified Sewage Agency: Hillsboro, Oregon.

Portland State University and Metropolitan Regional Government, 1995. *Rock Creek Watershed Atlas, Planning with an Awareness of Natural Boundaries, March 1995,* Portland State University and Metro: Portland, Oregon.

Tualatin River Watershed Council, 1999. *Tualatin River Watershed, Action Plan,* Tualatin River Watershed Council: Hillsboro, Oregon.

Tualatin Watershed Council, 2001. *Tualatin River Watershed Atlas,* Tualatin Watershed Council: Hillsboro, Oregon.

Watershed councils and related groups

Fanno Creek, Fans of, PO Box 25835, Portland 97225, 503-499-0412, Daniel Heagerty

Lake Oswego Land Trust, 503-636-2451, Debbie Craig

Rock Creek Environmental Center, 503-690-5402, Bob Mann

Rock Creek Watershed Council, 16747 Timber Road, Vernonia 97064, 503-429-2401, Maggie Belmore

Three Rivers Land Conservancy, PO Box 1116, Lake Oswego 97035, 503-699-9825, Jayne Cronlund

Tualatin Watershed Council, 1080 SW Baseline, Bldg. B, Suite B-2, Hillsboro 97123, (503) 681-0953, FAX (503) 681-9772

Tualatin River National Wildlife Refuge, City of Sherwood, 90 NW Park Street, Sherwood 97140, 503-625-5522, Joan Patterson

Tualatin River Rangers, USA, 155 N First Ave., Hillsboro 97124, 503-640-3516, Linda Kelly

Tualatin Riverkeepers, 16340 SW Beef Bend Road, Sherwood 97140, 503-590-5813, Lauri Mullen

Wetlands, Friends of, 503-253-6247, Alice Blatt

Data descriptions
Table E-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

All of the resource sites and subwatersheds in Section E fall within the Lower Tualatin River watershed. The Lower Tualatin River/Lake Oswego Canal subwatershed forms its own resource site (Site #11). Similarly, Resource Sites #12, 13 and 14 are formed of only one subwatershed each (Upper and Middle Fanno Creek; Summer Creek; and Lower Fanno Creek, respectively). Site #15 is composed of four subwatersheds – Cedar Creek, Chicken Creek, Rock Creek (south Washington County), and Lower Tualatin River–Lake Oswego Canal.

Tables E-1 and E-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table E-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Lower Tualatin River	1709001005	11	Lower Tualatin River - Lake Oswego Canal	170900100501	15,230.9
		12	Upper and Middle Fanno Creek	170900100502	11,183.4
		13	Summer Creek	170900100503	3,769.1
		14	Lower Fanno Creek	170900100504	8,453.8
		15	Cedar Creek	170900100505	1528.42
			Chicken Creek	170900100506	133.5
			Rock Creek (south Washington County)	170900100507	2,102.3
			Lower Tualatin River - Lake Oswego Canal	170900100508	475.1

Table E-2. Resource sites: general information.

General information	Lower Tualatin River - Lake Oswego Canal	Upper and Middle Fanno Creek	Summer Creek	Lower Fanno Creek	Rock Creek (south Washington County)
Miles of DEQ 303(d) listed streams	13.1	12.8	3.9	8.7	4.9
Road density (road miles/square miles in subwatershed)	9.0	17.3	15.0	15.0	10.3
Miles of stream with known anadromous fish presence	8.7	7.1	0.0	8.6	0.6
Acres of hydrologically connected wetlands	359.3	317.2	118.5	237.8	259.8
Total acres of wetlands	369.2	323.8	118.5	238.3	261.5
Acres of floodplains (100 year FEMA + 1996 inundation area)	1,132.0	517.5	61.8	829.0	315.0
Acres of developed floodplains	283.1	107.8	7.0	87.8	22.8
Building permits since 1996 (number)	878.0	1,057.0	1,095.0	1,104.0	1,366.0

Table E-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Lower Tualatin River - Lake Oswego Canal	28.2	6.4	8.4	21.7	64.7
Upper and Middle Fanno Creek	13.3	5.6	7.6	19.7	46.2
Summer Creek	2.3	0.1	2.6	11.7	16.7
Lower Fanno Creek	12.2	0.8	8.6	16.4	38.1
Rock Creek (so. Washington Co.)	6.1	0.0	2.0	4.8	12.9

*Stream links are links between surface streams and may be piped or culverted.

Table E-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Lower Tualatin River - Lake Oswego Canal	1,374.1	35.4	1,790.8	2,251.8
Upper and Middle Fanno Creek	389.6	8.0	949.3	1,208.1
Summer Creek	182.4	16.5	301.8	381.9
Lower Fanno Creek	376.9	10.2	626.7	551.0
Rock Creek (so. Washington Co.)	330.3	13.3	253.8	434.9

Table E-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Lower Tualatin River - Lake Oswego Canal	622.0	1,433.7	224.2	6.2	8,692.0	3,493.8	0.0
Upper and Middle Fanno Creek	967.2	483.5	747.1	231.5	0.0	7,652.2	37.8
Summer Creek	22.2	5.3	424.4	0.0	185.3	2,340.1	237.0
Lower Fanno Creek	909.2	764.6	761.8	65.5	304.2	4,355.4	223.8
Rock Creek (so. Washington Co.)	340.6	732.2	188.9	0.0	947.6	1,540.3	0.0

SITE #11: Lower Tualatin River-Lake Oswego Canal subwatershed

Named streams: Athey Creek, Fields Creek, Lake Oswego Canal, Nyberg Creek, Pecan Creek, Saum Creek, Tualatin River, Wilson Creek
Communities within the subwatershed: Durham, Lake Oswego, Rivergrove, Sherwood, Tigard, Tualatin, West Linn, unincorporated Clackamas County, unincorporated Washington County
Total acreage within Metro's boundary: 15,231
Total acres within riparian corridor: 5,861.2
Other information: One dam with a fishway present and functioning, and a weir pool. Two additional barriers to fish with unknown impact.

This site contains five percent of the area comprising Metro's jurisdictional boundary. It encompasses portions of nine jurisdictions: unincorporated Clackamas County (51 percent), unincorporated Washington County (10 percent), and the cities of Tualatin (25 percent), Lake Oswego (six percent), West Linn (five percent), and one percent or less of the site in the cities of Durham, Rivergrove, Sherwood, and Tigard (Table E-6).

Road density in this site is 9.0 miles per square mile; this is relatively low compared to all other resource sites, falling within the low end of the second quartile (26 to 50 percent of maximum) (Table E-2). Reflecting the relatively undeveloped nature of this resource site, the primary zoning is rural. Single family residential zoning also covers considerable land area in this site (Table E-5). Considering the relatively large amount of this site's land falling within Metro's boundary, the number of building permits issued since 1996 is relatively low at 878 (Table E-2).

Riparian resources. The percentage of this site in riparian corridors is more than 38 percent, substantially higher than the other four Group E sites (Table 12). The site contributes over six percent of the region's riparian corridors; only two sites contribute more (Sites #26 and 27) (Table 13).

This resource site has approximately 30 total stream miles, or 0.0037 miles of non-piped streams per acre (similar to Sites #12, 13 and 14 in Group E) (Tables E-3 and 12); the site ranks tenth among the 27 resource sites in terms of stream density. Approximately 13 percent of all stream miles are stream links. Twenty-three percent of non-piped streams are DEQ 303(d) water-quality limited, the lowest of any site in Group E (Tables E-2 and E-3). The majority of streams in this site are low gradient (Table E-3). Slightly over seven percent of the site is in the floodplain, similar to Site #15 in this group. Approximately three percent of the land is covered by wetland resources (Table E-2). One quarter of the floodplain is developed, most similar to Site #12 in this group and ranking its floodplains fifth most developed among all 27 resource sites (Table 14); Sites #11 and #12 have the most developed floodplains in this group (Table E-2). Anadromous fish are known to be present in nearly nine stream miles (Table E-2).

Twenty-seven percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions; this is somewhat lower than other sites in this group (Table E-9). Forty-two percent of the site's riparian corridors receive at least one primary ecological function score (Table E-9). The vegetation types within 300 ft of streams are co-dominated by forested (slightly more) and low-structure vegetation (Table E-4). The largest percentage of land receiving a given primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*, but *Organic material* *sources* is also an important primary functions (Table E-8; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 35 percent of the lands in this site fall within the wildlife habitat inventory, ranking it fifth among the 27 resource sites and first among Group E (Table 16). Within model patches, more than 20 percent falls within the top third of the point range, with another 61 percent in the middle range (Table E-10). Of the four criteria in the GIS model, the majority of acreage falls in the low size and habitat interior ranges (Table E-11). However, more than 16 percent falls in the midrange for both criteria, suggesting some fairly large habitat patches that are shaped in such a way as to minimize edge habitat. Wildlife patches in this site have good water resources, with nearly three quarters falling in the midrang and 18 percent in the top score range. Connectivity is excellent, with 65 percent in the top class and another 29 percent in the midrange. In general, this site has strong wildlife habitat resources that tend to be large, well connected, and provide water to wildlife.

Conifer and hardwood forest are the predominant habitat types in this resource site (71 percent), although agricultural lands and grasslands cover another 19 percent (Table E-15). Wetlands are an important wildlife resource here, comprising seven percent of the site. This site contributes more than four percent of the region's wetlands and ranks fourth of the 27 resource sites.

Species of Concern. Three Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Western Bluebird
- Bald Eagle (at least two nests)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table E-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 100, 101, 102, 109, 110, 111, 112, 152

Resource site data tables: Riparian Corridors

Table E-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Durham	78.8
Lake Oswego	914.6
Rivergrove	160.3
Sherwood	104.5
Tigard	3.1
Tualatin	3,873.3
West Linn	779.3
Unincorporated Clackamas County	7,822.1
Unincorporated Washington County	1,495.0

Table E-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Tualatin River - Lake Oswego Canal	15,231.1	5,830.7

Table E-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Lower Tualatin River - Lake Oswego Canal	Microclimate & shade	1,089.0	18.7%	2,196.7	37.7%
	Streamflow moderation & water storage	1,045.3	17.9%	4,674.9	80.2%
	Bank stabilization & pollution control	2,100.2	36.0%	286.3	4.9%
	Large wood & channel dynamics	1,970.0	33.8%	491.4	8.4%
	Organic material sources	1,392.9	23.9%	347.9	6.0%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table E-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Tualatin River - Lake Oswego Canal	1 to 5	3,389.3	58.1%
	6 to 11	501.4	8.6%
	12 to 17	374.1	6.4%
	18 to 23	297.7	5.1%
	24 to 29	886.1	15.2%
	30	382.0	6.6%
	Total acres	5,830.7	100.0%

Resource site data tables: Wildlife Habitat

Table E-10. Breakdown of total wildlife model patch scores.*

Resource site: Lower Tualatin River - Lake Oswego Canal	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	130.9	145.9	708.5	680.3	448.7	2,140.2	223.3	868.0	0.0	5,345.8
Percent of total	2.4%	2.7%	13.3%	12.7%	8.4%	40.0%	4.2%	16.2%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Lower Tualatin River - Lake Oswego Canal	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	3,358.0	868.0	0.0	2,679.2	868.0	0.0	210.6	3,931.8	942.1	335.0	1,570.4	3,440.5	5,345.8
Percent of total acres in inventory	62.8%	16.2%	0.0%	50.1%	16.2%	0.0%	3.9%	73.5%	17.6%	6.3%	29.4%	64.4%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table E-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Tualatin River - Lake Oswego Canal	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ Intact topsoil	Non-forest woody vegetation					
Acres	1,095.0	24.8	3,868.3	110.2	195.7	51.8	5,345.8
Percent of total	20.5%	0.5%	72.4%	2.1%	3.7%	1.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Tualatin River - Lake Oswego Canal	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	5345.8	1019.2	8.6	5354.4	3
Percent of total	99.8%	19.0%	0.2%	100.0%	N/A

*Habitats of Concern.

Table E-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Tualatin River - Lake Oswego Canal / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	23.19	0.0	0.4%
Barren	251.95	1.4	4.7%
Low structure agriculture	595.68	2.1	11.2%
High structure agriculture	28.65	0.0	0.5%
Deciduous closed canopy	1,138.17	0.6	21.3%
Mixed closed canopy	1,394.27	0.4	26.0%
Conifer closed canopy	344.21	0.0	6.4%
Deciduous open canopy	305.56	0.5	5.7%
Mixed open canopy	249.63	1.5	4.7%
Conifer open canopy	68.04	0.2	1.3%
Deciduous scattered canopy	159.55	0.3	3.0%
Mixed scattered canopy	131.43	0.2	2.5%
Conifer scattered canopy	29.00	0.0	0.5%
Closed canopy shrub	229.91	0.1	4.3%
Open canopy shrub	80.29	0.1	1.5%
Scattered canopy shrub	172.79	0.5	3.2%
Meadow/grass	141.81	0.7	2.7%
Not classified	1.66	0.0	0.0%
Total	5,345.81	8.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table E-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Lower Tualatin River - Lake Oswego Canal	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	167.0	247.5	110.2	369.2	3,823.4	396.3	626.5
Percent of total	3.1%	4.6%	2.1%	6.9%	71.4%	7.4%	11.7%

[1]See Table E-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #12: Upper and Middle Fanno Creek subwatershed

Named tributaries: Ash Creek, Fanno Creek, Ivey Creek, Summer Creek, Sylvan Creek
Communities within the subwatershed: Beaverton, Lake Oswego, Portland, Tigard, unincorporated Multnomah County, unincorporated Washington County
Total acreage within Metro's boundary: 11,183
Total acres within riparian corridor: 2,693.5

This site contains four percent of the area comprising Metro's jurisdictional boundary. About 40 percent of the site is in the City of Portland, with the remainder in unincorporated Washington County (23 percent), Beaverton (21 percent), Tigard (12 percent), Multnomah County (four percent), and less than one percent in the City of Lake Oswego (Table E-16).

This site, at 17.3 miles of road per square mile, falls within the top quartile (76 to 100 percent of maximum) of development compared to all other resource sites (Table E-2). Reflecting the relatively urban nature of this site, zoning is strongly dominated by single family residential land use (Table E-5). More than a thousand building permits have been issued in this resource site since 1996 (Table E-2).

Riparian resources. The percentage of this site in riparian corridors is more than 24 percent, close to the proportions in Sites #13, 14 and 15 (Table 12). The site contributes three percent of the region's riparian corridors, the second highest in Group E (Table 13).

This resource site has approximately 46 total stream miles, or 0.0035 miles of non-piped streams per acre (similar to Site #14, and ranking 14th among the 27 resource sites) (Tables E-3 and 12). Approximately 16 percent of all stream miles are stream links, similar to Sites #13 and #15 in this group (Table E-3). Thirty-three percent of non-piped streams are DEQ 303(d) water-quality limited, the second highest in Group E behind Site #15 (Tables E-2 and 12). Five percent of the site is in the floodplain, and two percent of the land is covered by wetland resources (Table E-2). Twenty-one percent of the floodplain is developed, most similar to Site #11 in this group and ranking it seventh most developed among all resource sites (Tables 14 and E-2). Anadromous fish are known to be present in more than seven stream miles (Table E-2).

Nearly a third of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, similar to Site #12 (Table E-19). Forty-seven percent of the site's riparian corridors receive at least one primary ecological function score, again most similar to Site #12 in this group (Table E-19). The most common vegetation type within 300 ft of streams is forest (Table E-4). The largest percentage of land receiving a given primary score is for *Large wood and channel dynamics* and *Bank stabilization and pollution control* and, but *Organic material sources* is also an important primary function (Table E-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 23 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 16th among the 27 resource sites and third within Group E (Table 16). Within model patches approximately six percent falls within the top third of the point range, or about a fourth of the proportion within Site #11. However, another 72 percent falls in the middle range (Table E-20). Of the four criteria in the GIS model, the majority of acreage falls in the low

size and habitat interior ranges, with about 40 percent of acreage containing no habitat interior (Table E-21). Wildlife patches in this site have moderate to good water resources, with nearly 40 percent falling in the midrange and another 30 percent in the top score range. Connectivity is moderate, with 53 percent in the midrange and more than 20 percent in the low and high categories. In general, this site can be characterized as having relatively small habitat patches with little forest interior, but reasonably good water resources and connectivity. The site likely provides substantial habitat for native wildlife, with good migratory corridors but limited breeding habitat for Neotropical migratory birds and other wildlife needing interior habitat or less disturbed areas.

Conifer and hardwood forest are the predominant habitat types in this resource site (83 percent) (Table E-25). Wetlands are an even more important wildlife resource here than in Site #11, comprising nearly 13 percent of the site. However, the site's contribution to regional wetland resources is slightly lower than Site #11 because less land falls within the Metro boundary. This site contributes nearly four percent of the region's wetlands and ranks sixth of the 27 resource sites.

Species of Concern. Seven Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Willow Flycatcher
- Northwestern Pond Turtle
- Bald Eagle roost

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and wetlands (see Table E-25). There are several Willow Flycatcher and turtle sightings here, suggesting that lowland riparian-wetland complexes may provide very important habitat resources to sensitive wildlife species. Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 94, 95, 105

Resource site data tables: Riparian Corridors

Table E-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Beaverton	2,318.9
Lake Oswego	9.5
Portland	4,479.2
Tigard	1,310.6
Unincorporated Multnomah County	465.0
Unincorporated Washington County	2,600.4

Table E-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Upper and Middle Fanno Creek	11,183.5	2,651.7

Table E-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Upper and Middle Fanno Creek	Microclimate & shade	585.4	22.1%	1,116.6	42.1%
	Streamflow moderation & water storage	500.7	18.9%	1,977.8	74.6%
	Bank stabilization & pollution control	1,044.5	39.4%	82.9	3.1%
	Large wood & channel dynamics	1,100.9	41.5%	227.4	8.6%
	Organic material sources	819.4	30.9%	170.4	6.4%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table E-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Upper and Middle Fanno Creek	1 to 5	1,421.1	53.6%
	6 to 11	195.9	7.4%
	12 to 17	205.1	7.7%
	18 to 23	35.1	1.3%
	24 to 29	632.9	23.9%
	30	161.6	6.1%
	Total acres	2,651.7	100.0%

Resource site data tables: Wildlife Habitat

Table E-20. Breakdown of total wildlife model patch scores.*

Resource site: Upper and Middle Fanno Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	135.4	149.5	267.7	307.5	720.6	782.1	8.4	129.9	0.0	2,501.3
Percent of total	5.4%	6.0%	10.7%	12.3%	28.8%	31.3%	0.3%	5.2%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Upper and Middle Fanno Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,865.5	446.3	0.0	1,387.7	0.5	129.4	594.7	987.5	735.8	562.7	1,327.4	611.2	2,501.3
Percent of total acres in inventory	74.6%	17.8%	0.0%	55.5%	0.0%	5.2%	23.8%	39.5%	29.4%	22.5%	53.1%	24.4%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table E-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Upper and Middle Fanno Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	189.5	0.0	1,999.7	98.1	164.8	49.0	2,501.3
Percent of total	7.6%	0.0%	79.9%	3.9%	6.6%	2.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Upper and Middle Fanno Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2501.3	200.7	21.0	2522.3	7
Percent of total	99.2%	8.0%	0.8%	100.0%	N/A

*Habitats of Concern.

Table E-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Upper and Middle Fanno Creek / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	3.86	0.0	0.2%
Barren	117.49	7.3	4.9%
Low structure agriculture	0.00	0.0	0.0%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	433.84	1.7	17.3%
Mixed closed canopy	536.90	0.4	21.3%
Conifer closed canopy	319.75	0.2	12.7%
Deciduous open canopy	303.58	3.3	12.2%
Mixed open canopy	200.26	0.9	8.0%
Conifer open canopy	48.03	0.4	1.9%
Deciduous scattered canopy	120.64	3.3	4.9%
Mixed scattered canopy	86.79	0.7	3.5%
Conifer scattered canopy	20.50	0.1	0.8%
Closed canopy shrub	81.65	0.3	3.2%
Open canopy shrub	52.41	0.7	2.1%
Scattered canopy shrub	43.48	1.1	1.8%
Meadow/grass	132.10	0.6	5.3%
Not classified	0.00	0.0	0.0%
Total	2,501.27	21.0	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table E-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Upper and Middle Fanno Creek	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	0.0	213.8	98.1	323.8	2,081.3	230.4	0.0
Percent of total	0.0%	8.5%	3.9%	12.8%	82.5%	9.1%	0.0%

[1]See Table E-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #13: Summer Creek subwatershed

Named tributaries: Fanno Creek, Summer Creek
Communities within the subwatershed: Beaverton, Tigard, unincorporated Washington County
Total acreage within Metro's boundary: 3,769.1
Total acres within riparian corridor: 826.5

This site contains one percent of the area comprising Metro's jurisdictional boundary. This site is split nearly equally between Beaverton and Tigard (39 and 41 percent, respectively), with another 20 percent in unincorporated Washington County (Table E-26).

The road density in this site is 15.0 miles per square mile, placing it in the third quartile (51 to 75 percent of maximum) compared to development in all other resource sites (Table E-2). The dominant zoning by far is single family residential (Table E-5). More than a thousand building permits have been issued here since 1996, a high number compared to the acreage within Metro's boundary (Table E-2).

Riparian resources. The percentage of this site in riparian corridors is 23 percent, similar to Sites #12 and #14 in this group (Table 12). The site contributes about one percent of the region's riparian corridors (Table 13).

This resource site has approximately 30 total stream miles, or 0.0037 miles of non-piped streams per acre (similar to Sites #12 and #14 in Group E) (Tables E-3 and 12). The site's stream density ranks ninth among the 27 resource sites. Approximately 16 percent of all stream miles are stream links, as in Sites #12 and #15 (Table E-3). A third of non-piped streams are DEQ 303(d) water-quality limited, similar to Site #14 in Group E (Tables E-2 and 12). Two percent of the site is in floodplain, and wetlands comprise three percent of the lands in this resource site (Table E-2). Eleven percent of the floodplain is developed, similar to Site #14 in this group (Table E-2). Anadromous fish are not known to be present in streams within this site (Table E-2).

Thirty-two percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, similar to Site #12 (Table E-29). Nearly half of the site's riparian corridors receive at least one primary ecological function score (Table E-29). The vegetation type within 300 ft of streams is predominantly forested, also with substantial amounts of low-structure vegetation (Table E-4). The largest percentage of land receiving a given primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*, but *Organic material sources* is also an important primary function (Table E-28; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 22 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 17th among the 27 resource sites and fourth within Group E (Table 16). Within model patches less than four percent falls within the top third of the point range, the lowest of the five Group E sites (Table E-30). However, another 72 percent falls in the middle range. Of the four criteria in the GIS model, none of the acreage scored above the lowest class for size or interior ((Table E-31). Wildlife patches in this site have water resources, with this

highest proportion in the midrange but nearly equal percentages for each of the three water classes. Connectivity is moderate, with 43 percent in the midrange and another 29 percent in both the low and high score categories. In general, this site can be characterized as having small habitat patches with little or no forest interior, but reasonably good water resources and connectivity. As with Site #12, this site likely provides substantial habitat for native wildlife, with good migratory corridors but limited breeding habitat for Neotropical migratory birds and other wildlife needing interior habitat or less disturbed areas. A relatively large amount of parklands preserved along Fanno Creek and other tributaries contributes to this site's importance to the region's wildlife.

Habitat types are similar to Site #12. Conifer and hardwood forest are the predominant habitat types in this resource site (80 percent) (Table E-35). Wetlands comprise more than 14 percent of the site, placing it in the middle of the five Group E resource sites. However, the site contributes relatively little (about one and one-half percent of total, ranking 16th of all sites) to regional wetland resources due to the relatively small amount of acreage falling within the Metro boundary.

Species of Concern. There are no known Species of Concern sightings falling within this resource site, although it may provide important habitat resources to sensitive wildlife species. Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 96, 97, 107, 168

Resource site data tables: Riparian Corridors

Table E-26. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Beaverton	1,468.9
Tigard	1,533.8
Unincorporated Washington County	766.5

Table E-27. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Summer Creek	3,769.1	855.6

Table E-28. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres*	% of Total
Summer Creek	Microclimate & shade	203.3	23.8%	339.2	39.6%
	Streamflow moderation & water storage	136.8	16.0%	642.3	75.1%
	Bank stabilization & pollution control	388.5	45.4%	51.1	6.0%
	Large wood & channel dynamics	334.7	39.1%	63.8	7.5%
	Organic material sources	268.4	31.4%	53.3	6.2%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table E-29. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Summer Creek	1 to 5	429.7	50.2%
	6 to 11	90.6	10.6%
	12 to 17	63.7	7.4%
	18 to 23	26.9	3.1%
	24 to 29	190.4	22.2%
	30	54.3	6.3%
	Total acres	855.6	100.0%

Resource site data tables: Wildlife Habitat

Table E-30. Breakdown of total wildlife model patch scores.*

Resource site: Summer Creek	Number of acres in each wildlife score category: 1	2	3	4	5	6	7	8	9	Total wildlife model patch acres in inventory
Model score	19.6	89.9	89.3	177.1	327.1	85.8	29.8	0.0	0.0	818.6
Percent of total	2.4%	11.0%	10.9%	21.6%	40.0%	10.5%	3.6%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-31. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Summer Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	704.7	0.0	0.0	492.2	0.0	0.0	208.6	264.8	260.5	234.6	350.0	234.1	818.6
Percent of total acres in inventory	86.1%	0.0%	0.0%	60.1%	0.0%	0.0%	25.5%	32.3%	31.8%	28.7%	42.7%	28.6%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table E-32. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Summer Creek	Low structure vegetation within 300 feet of stream: Low structure vegetation/ intact topsoil	Low structure vegetation within 300 feet of stream: Non-forest woody vegetation	Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
Acres	102.4	11.5	596.2	45.6	53.3	9.6	818.6
Percent of total	12.5%	1.4%	72.8%	5.6%	6.5%	1.2%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-33. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Summer Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	818.6	91.8	13.7	832.3	0
Percent of total	98.4%	11.0%	1.6%	100.0%	N/A

*Habitats of Concern.

Table E-34. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Summer Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	3.57	0.0	0.4%
Barren	47.57	2.1	6.0%
Low structure agriculture	10.06	0.0	1.2%
High structure agriculture	0.23	0.0	0.0%
Deciduous closed canopy	137.51	1.0	16.6%
Mixed closed canopy	200.04	0.6	24.1%
Conifer closed canopy	128.04	0.3	15.4%
Deciduous open canopy	59.50	2.4	7.4%
Mixed open canopy	38.83	1.5	4.8%
Conifer open canopy	15.38	0.6	1.9%
Deciduous scattered canopy	39.87	2.2	5.1%
Mixed scattered canopy	25.61	0.6	3.1%
Conifer scattered canopy	14.34	0.3	1.8%
Closed canopy shrub	34.76	0.3	4.2%
Open canopy shrub	15.09	0.4	1.9%
Scattered canopy shrub	19.83	1.2	2.5%
Meadow/grass	28.41	0.2	3.4%
Not classified	0.00	0.0	0.0%
Total	818.62	13.7	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table E-35. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Summer Creek	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	0.0	62.9	45.6	118.5	668.6	65.2	10.3
Percent of total	0.0%	7.6%	5.5%	14.2%	80.3%	7.8%	1.2%

[1]See Table E-34 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #14: Lower Fanno Creek subwatershed

Named tributaries: Ball Creek, Bonita Creek, Carter Creek, Fanno Creek, Tualatin River
Communities within the subwatershed: Durham, King City, Lake Oswego, Portland, Tigard, Tualatin, unincorporated Clackamas County, unincorporated Multnomah County, unincorporated Washington County
Total acreage within Metro's boundary: 8,453.8
Total acres within riparian corridor: 1,907.5

This site contains three percent of the area comprising Metro's jurisdictional boundary. This site encompasses portions of nine different jurisdictions: Tigard (52 percent), unincorporated Washington County (19 percent), Lake Oswego (11 percent), Tualatin (five percent), Lake Oswego (four percent), unincorporated Clackamas County (four percent), King City (three percent), Durham (two percent), and less than one percent in unincorporated Multnomah County (Table E-36).

The estimated development density is similar to Site #13, at 15.0 miles of roads per square mile (Table E-2). Similarly, single family residential land use strongly dominates zoning patterns (Table E-5). However, a similar amount of building permits issued since 1996 (Table E-2) but well more than double the amount of acreage within the Metro boundary suggest that development is occurring more rapidly in Resource Site #13 compared to this site.

Riparian resources. The amount of this site in riparian corridors is 22 percent, the lowest of the five Group E sites but similar to Sites #12 and 13 (Table 12). The site contributes two percent of the region's riparian corridors, placing it within the mid-range of sites within this group (Table 13).

This resource site has approximately 38 total stream miles, or 0.0035 miles of non-piped streams per acre (similar to Site #12, and ranking 13th among all resource sites) (Tables E-3 and 12). Twenty-three percent of all stream miles are stream links, the highest proportion in Group D; this implies that a substantial portion of streams in this resource site have been piped underground or culverted (Table E-3). Thirty percent of non-piped streams are DEQ 303(d) water-quality limited (Tables E-2 and 12). The majority of streams in this site are low gradient (Table E-3). Ten percent of the site is in floodplain, and of that, eleven percent is developed (Table E-2). Three percent of the land in this site is covered by wetlands (Table E-2). Anadromous fish are known to be present in nearly nine stream miles (Table E-2).

The ecological criteria scores for this site indicate high-quality riparian resources. Forty-three percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions, the highest of all sites in Group E (Table E-39). More than 65 percent of this site's riparian corridors receive at least one primary ecological function score, also the highest proportion in Group E (Table E-9). The vegetation types within 300 ft of streams is dominated by forest, but there is also a substantial amount of low-structure vegetation near streams (Table E-4).. The largest percentage of land receiving a particular primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*. However, *Organic material sources* and *Streamflow moderation and water storage* are also important primary functions (Table E-38; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, 18 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 24th among the 27 resource sites and last within Group E (Table 16). Within model patches approximately six percent falls within the top third of the point range with another 57 percent in the middle range (Table E-40). Of the four criteria in the GIS model, all of the acreage falls in the low size and habitat interior ranges (Table E-41). However, wildlife patches in this site have very good water resources, with 46 percent falling in the top score category and another 36 percent in the middle category. Connectivity is moderate, with 58 percent in the midrange and the majority of the remainder in the low category. In general, this site can be characterized as having relatively small habitat patches with little forest interior, but reasonably good connectivity and very good water resources. The site likely provides important habitat for native wildlife, with relatively good migratory corridors but limited breeding habitat for Neotropical migratory birds and other wildlife needing interior habitat or less disturbed areas.

Conifer and hardwood forest are the predominant habitat types in this resource site (72 percent), but grasslands may also provide important wildlife habitat (Table E-25). Wetlands comprise more than 15 percent of the site's wildlife habitat, ranking it second among Group E. The site's contribution to regional wetland resources is nearly three percent, and it ranks 11th among the 27 resource sites and fourth among the five Group E resource sites.

Species of Concern. Seven Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Band-tailed Pigeon
- Great Blue Heron rookery

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats, grasslands and wetlands (see Table E-45). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 98, 99, 100, 106

Resource site data tables: Riparian Corridors

Table E-36. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Durham	191.2
King City	282.0
Lake Oswego	919.2
Portland	347.0
Tigard	4,423.1
Tualatin	413.0
Unincorporated Clackamas County	296.4
Unincorporated Multnomah County	0.0
Unincorporated Washington County	1,581.9

Table E-37. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Fanno Creek	8,453.8	1,864.0

Table E-38. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Lower Fanno Creek	Microclimate & shade	523.0	28.1%	442.1	23.7%
	Streamflow moderation & water storage	790.2	42.4%	933.3	50.1%
	Bank stabilization & pollution control	943.2	50.6%	11.5	0.6%
	Large wood & channel dynamics	1,137.1	61.0%	95.7	5.1%
	Organic material sources	740.6	39.7%	80.4	4.3%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table E-39. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Fanno Creek	1 to 5	644.0	34.5%
	6 to 11	118.0	6.3%
	12 to 17	294.8	15.8%
	18 to 23	93.3	5.0%
	24 to 29	423.1	22.7%
	30	290.8	15.6%
	Total acres	1,864.0	100.0%

Resource site data tables: Wildlife Habitat

Table E-40. Breakdown of total wildlife model patch scores.*

Resource site: Lower Fanno Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	121.9	127.4	161.4	331.6	368.9	311.2	87.4	0.0	0.0	1,509.8
Percent of total	8.1%	8.4%	10.7%	22.0%	24.4%	20.6%	5.8%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-41. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Lower Fanno Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,255.2	0.0	0.0	697.7	0.0	0.0	114.2	546.5	689.6	429.6	878.0	202.2	1,509.8
Percent of total acres in inventory	83.1%	0.0%	0.0%	46.2%	0.0%	0.0%	7.6%	36.2%	45.7%	28.5%	58.2%	13.4%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table E-42. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Fanno Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	245.6	9.1	1,037.3	91.6	64.4	61.9	1,509.8
Percent of total	16.3%	0.6%	68.7%	6.1%	4.3%	4.1%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-43. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Fanno Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1509.8	263.5	23.6	1533.4	2
Percent of total	98.5%	17.2%	1.5%	100.0%	N/A

*Habitats of Concern.

Table E-44. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Fanno Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	12.35	0.0	0.8%
Barren	109.57	4.4	7.4%
Low structure agriculture	31.32	2.7	2.2%
High structure agriculture	0.02	0.0	0.0%
Deciduous closed canopy	236.96	1.5	15.5%
Mixed closed canopy	278.06	0.2	18.1%
Conifer closed canopy	140.22	0.1	9.2%
Deciduous open canopy	150.83	2.1	10.0%
Mixed open canopy	99.39	0.2	6.5%
Conifer open canopy	26.67	0.2	1.8%
Deciduous scattered canopy	81.23	1.3	5.4%
Mixed scattered canopy	54.38	0.8	3.6%
Conifer scattered canopy	23.63	0.0	1.5%
Closed canopy shrub	56.86	0.4	3.7%
Open canopy shrub	37.01	0.9	2.5%
Scattered canopy shrub	43.63	1.2	2.9%
Meadow/grass	127.43	7.7	8.8%
Not classified	0.29	0.0	0.0%
Total	1,509.84	23.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table E-45. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Lower Fanno Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	60.7	126.3	91.6	238.3	1,097.7	217.9	34.0
Percent of total	4.0%	8.2%	6.0%	15.5%	71.6%	14.2%	2.2%

[1]See Table E-44 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #15: Rock Creek (South Washington County) subwatershed

Named tributaries: Cedar Creek, Chicken Creek, West Fork Chicken Creek, Goose Creek, Rock Creek

Communities within the subwatershed: Sherwood, Tualatin, unincorporated Washington County

Total acreage within Metro's boundary: 4,239.3 (includes Cedar Creek, Chicken Creek & Lower Tualatin River subwatersheds)

Total acres within riparian corridor: 1,075.1

This site contains one percent of the area comprising Metro's jurisdictional boundary. About 59 percent of the site is in the City of Sherwood, 32 percent in unincorporated Washington County, with the remainder in Tualatin (nine percent) (Table E-46).

The road density in this resource site (10.3 miles per square mile) is relatively low compared to three of four other sites in Group E (Table E-2). Zoning is dominated by single family residential, but rural and industrial land uses are also important in this resource site (Table E-5). The number of building permits issued since 1996 is 1,366 in this site (Table E-2).

Riparian resources. Twenty-six percent of this resource site is within the riparian corridor inventory, second only to Site #11 within Group E (Table 12). The site contributes a little more than one percent of the region's riparian corridors (Table 13).

This resource site has approximately 38 total stream miles, or 0.0035 miles of non-piped streams per acre (similar to Site #12, and ranking 22nd among all resource sites) (Tables E-3 and 12). Twenty-three percent of all stream miles are stream links, the highest proportion in Group D; this implies that a substantial portion of streams in this resource site have been piped underground or culverted (Table E-3). Thirty percent of non-piped streams are DEQ 303(d) water-quality limited (Tables E-2 and 12). The majority of streams in this site are low gradient (Table E-3). Ten percent of the site is in floodplain, and of that, eleven percent is developed (Table E-2). Three percent of the land in this site is covered by wetlands (Table E-2). Anadromous fish are known to be present in nearly nine stream miles (Table E-2).

The ecological criteria scores for this site indicate relatively high-quality riparian resources, second within this group only to Site #14. Thirty-seven percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions (Table E-49). Fifty-eight percent of this site's riparian corridors receive at least one primary ecological function score (Table E-49). Vegetation within 300 ft of streams is co-dominated by low structure vegetation and forest (Table E-4). The largest percentage of land receiving a particular primary score is for *Bank stabilization and pollution control* and *Large wood and channel dynamics*. However, *Organic material sources* and *Streamflow moderation and water storage* also contribute important primary functions (Table E-48; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.

Including Habitats of Concern, more than 25 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 12th among the 27 resource sites and second within Group E (Table 16). Within model patches approximately six percent falls within the top third of the point range with another 79 percent in the middle range (Table E-50). Of the four criteria in the GIS model, all of the acreage falls in the low size and habitat interior ranges (Table E-51). However, wildlife patches in this site have very good water resources, with 27 percent falling in the top score category and another 64 percent in the middle category. Connectivity is excellent, with 63 percent in the midrange and the majority of the remainder in the midrange category. In general, this site can be characterized as having relatively small habitat patches with little forest interior, but very good water resources and excellent connectivity to other natural areas. The site is probably highly important to animals moving between patches, including Neotropical migratory birds. Aside from the importance of water to wildlife, the strong water resources in this well-connected site likely produce great insect resources for migrating songbirds and nesting native birds and other wildlife.

Conifer and hardwood forest are the predominant habitat types in this resource site (72 percent), but wetlands and grasslands are also highly important (Table E-55). Wetlands comprise more than 24 percent of the site's wildlife habitat, ranking it first among Group E. The site's contribution to regional wetland resources is three percent, and it ranks ninth among the 27 resource sites and third among the five Group E resource sites. However, consider that this site's area falling within the Metro boundary is only 38 percent of that in Site #12, but it contributes close to the same amount to the region's wetland resources.

Species of Concern. One Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Peregrine Falcon

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats, grasslands and wetlands (see Table E-55). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 106, 107, 154, 155, 156

Resource site data tables: Riparian Corridors

Table E-46. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Sherwood	2,518.8
Tualatin	383.6
Unincorporated Washington County	1,337.0

Table E-47. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Rock Creek (so. Washington Co.)	4,239.3	1,102.2

Table E-48. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Rock Creek (so. Washington County)	Microclimate & shade	277.4	25.2%	282.9	25.7%
	Streamflow moderation & water storage	413.1	37.5%	647.1	58.7%
	Bank stabilization & pollution control	500.8	45.4%	41.3	3.7%
	Large wood & channel dynamics	486.2	44.1%	38.4	3.5%
	Organic material sources	406.2	36.9%	18.1	1.6%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table E-49. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Rock Creek (so. Washington County)	1 to 5	466.5	42.3%
	6 to 11	131.9	12.0%
	12 to 17	93.0	8.4%
	18 to 23	23.8	2.2%
	24 to 29	240.5	21.8%
	30	146.5	13.3%
	Total acres	1,102.2	100.0%

Resource site data tables: Wildlife Habitat

Table E-50. Breakdown of total wildlife model patch scores.*

Resource site: Rock Creek (so. Washington County)	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	27.3	8.4	118.3	202.3	38.3	574.6	62.2	0.0	0.0	1,031.5
Percent of total	2.6%	0.8%	11.5%	19.6%	3.7%	55.7%	6.0%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-51. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Rock Creek (south Washington County)	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	831.6	0.0	0.0	710.2	0.0	0.0	22.1	659.3	276.7	109.4	273.9	648.3	1,031.5
Percent of total acres in inventory	80.6%	0.0%	0.0%	68.8%	0.0%	0.0%	2.1%	63.9%	26.8%	10.6%	26.5%	62.8%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table E-52. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Rock Creek (so. Washington Co.)	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	187.0	12.9	579.5	94.1	115.5	42.5	1,031.5
Percent of total	18.1%	1.3%	56.2%	9.1%	11.2%	4.1%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table E-53. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Rock Creek (south Washington Co.)	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1031.5	661.0	40.9	1072.5	2
Percent of total	96.2%	61.6%	3.8%	100.0%	N/A

*Habitats of Concern.

Table E-54. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Rock Creek (so. Washington Co.) Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.31	0.0	0.0%
Barren	100.86	10.2	10.4%
Low structure agriculture	66.56	2.2	6.4%
High structure agriculture	3.59	0.0	0.3%
Deciduous closed canopy	92.49	1.6	8.8%
Mixed closed canopy	100.80	0.6	9.5%
Conifer closed canopy	43.38	0.2	4.1%
Deciduous open canopy	51.48	2.4	5.0%
Mixed open canopy	201.02	6.6	19.4%
Conifer open canopy	17.16	0.6	1.7%
Deciduous scattered canopy	35.05	2.0	3.5%
Mixed scattered canopy	20.42	0.9	2.0%
Conifer scattered canopy	3.55	0.2	0.3%
Closed canopy shrub	44.43	1.1	4.2%
Open canopy shrub	36.45	2.3	3.6%
Scattered canopy shrub	102.01	3.4	9.8%
Meadow/grass	111.97	6.5	11.0%
Not classified	0.00	0.0	0.0%
Total	1,031.53	40.9	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table E-55. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Rock Creek (so. Washington Co.)	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	3.4	157.9	94.1	261.5	580.6	262.7	72.3
Percent of total	0.3%	14.7%	8.8%	24.4%	54.1%	24.5%	6.7%

[1]See Table E-54 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

F. Lower Clackamas River Watershed

General watershed information

Resource sites in the Lower Clackamas River Watershed include:

- Richardson Creek subwatershed (combined with North Fork Deep Creek subwatershed)
- Rock Creek-Clackamas River subwatershed

Watershed assessments and plans

Clackamas River Basin Council and Ecotrust, 2000. *Rock and Richardson Creek Watershed Assessment, October 2000,* Ecotrust: Portland, Oregon.

Metropolitan Regional Government, 1995. *Clackamas River Watershed Atlas, September 1995;* Metro: Portland, Oregon.

Portland State University and Metropolitan Regional Government, 1995. *Rock Creek Watershed Atlas, Planning with an Awareness of Natural Boundaries, March 1995,* Portland State University and Metro: Portland, Oregon.

Watershed councils and related groups

Clackamas River Basin Council, PO Box 1869, Clackamas, 97015-1869, (503) 650-1256

Clackamas River, Friends of, 9205 SE Clackamas, #142, Clackamas 97015, 503-492-1593, Scott Forrester

Clackamas River Water, 16770 SE 82nd Drive, Clackamas 97015, 503-722-9241

Rock Creek Environmental Center, 503-690-5402, Bob Mann

Rock Creek Watershed Council, 16747 Timber Road, Vernonia 97064, 503-429-2401, Maggie Belmore

Wetlands, Friends of, 503-253-6247, Alice Blatt

Data descriptions

Table F-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

All three of the subwatersheds fall within the same 5th field HUC (Lower Clackamas River), but they are divided into two resource sites. Resource Site #16 is comprised of the North Fork Deep Creek and Richardson Creek subwatersheds, for a total of 6,486 acres within the Metro Boundary. Resource is comprised only of its namesake, Rock Creek-Clackamas River, and contains 11,121 acres falling within Metro's jurisdictional boundary.

Tables F-1 and F-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table F-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Lower Clackamas River	1709001122	16	North Fork Deep Creek	170900112205	2,644.3
			Richardson Creek	170900112206	3,821.2
		17	Rock Creek - Clackamas River	170900112208	11,120.6

Table F-2. Resource sites: general information.

General information	Richardson Creek	Rock Creek
Miles of DEQ 303(d) listed streams	0.0	4.0
Road density (road miles/square miles in subwatershed)	5.1	8.1
Miles of stream with known anadromous fish presence	4.4	4.4
Acres of hydrologically connected wetlands	99.4	98.1
Total acres of wetlands	99.5	99.7
Acres of floodplains (100 year FEMA + 1996 inundation area)	0.0	761.9
Acres of developed floodplains	0.0	87.1
Building permits since 1996 (number)	141.0	1,404.0

Table F-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	High			
Richardson Creek	0.0	0.8	0.0	29.3	30.1
Rock Creek - Clackamas River	8.0	3.0	5.2	33.3	49.5

*Stream links are links between surface streams and may be piped or culverted.

Table F-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Richardson Creek	1,076.3	57.7	508.4	601.6
Rock Creek - Clackamas River	1,073.3	101.0	1,062.5	1,623.4

Table F-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Richardson Creek	100.7	162.1	0.0	0.0	6,202.7	0.0	0.0
Rock Creek - Clackamas River	266.3	1,705.0	255.9	115.0	6,812.9	1,827.9	105.1

SITE #16: Richardson Creek subwatershed

Named streams: Clackamas River, Elliott Spring, Foster Creek, Goose Creek, Richardson Creek, Dolan Creek, Doane Creek, North Fork Deep Creek, Noyer Creek
Communities within the subwatershed: unincorporated Clackamas County
Total acreage within Metro's boundary: 6,465.5 (includes North Fork Deep Creek subwatershed)
Total acres within riparian corridor: 2,270.7
Other information: Two dams present, unknown impact to fish.

This site contains two percent of the area comprising Metro's jurisdictional boundary. Of this, all falls within unincorporated Clackamas County (Table F-6).

This site is quite undeveloped compared to other sites. The road density, at 5.1 miles per square mile, falls within the lowest quartile (0 to 25 percent of maximum); only Resource Site #1 is lower in road density (Tables A-2 and F-2). This is reflected in the near-complete dominance of rural zoning type (Table F-5). Only 141 building permits have been issued here since 1996 (Table F-2).

Riparian resources. Site #16, similar to the other resource site in Group F, contains a relatively high proportion of riparian resources at 35 percent of its total lands within the Metro Boundary (Table 12). The site contributes almost 2-1/2 percent of the region's riparian corridors (Table 13).

This resource site contains approximately 30.1 total stream miles, none of which are stream links (Table F-3). This suggests minimal piping and culverting. Stream density is 0.0047 miles per acre (Table 12), the second highest of all 27 resource sites. None of the stream miles appear on the DEQ 303(d) water-quality limited list (Table F-2). None of the site is in the floodplain, but the 100 acres of wetlands comprise approximately two percent of this resource site's land (Table F-2). Anadromous fish are known to be present in about four and one-half stream miles (Table F-2).

Twenty-one percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions; 40 percent of the site's riparian corridors receive at least one primary ecological function score (Table F-9). Low structure vegetation/intact topsoil is the dominant vegetation cover within 300 ft of streams, in contrast with the other Group F resource site, which also includes substantial forest (Table F-4). The percentage of land receiving a given primary score was dominated by *Bank stabilization and pollution control*, but *Large wood and channel dynamics* also provided a relatively important primary ecological function (Table F-8; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.
Including Habitats of Concern, more than 34 percent of the lands in this site fall within the wildlife habitat inventory, ranking it sixth among the 27 resource sites (Table 16). Within model patches approximately 21 percent falls within the top third of the point range with another 46 percent in the middle range (Table F-10). Of the four criteria in the GIS model, acreage is split about equally between the lowest and middle size category (Table F-11). A majority of acreage

fell in the lowest category for the interior criterion, but a substantial proportion was also in the middle category. The relatively low total percentages for size and interior (51 percent) suggests that many of the wildlife habitat patches are low structure patches within 300 ft of streams, because these patch types are not scored for size and interior. Thus, low structure vegetation likely provides important connectivity along streams. Water resources were strongly clustered in the middle category, whereas connectivity scored primarily in the high range, with substantial amounts also in the middle category. However, this site rates high for interior habitat relative to most other sites discussed thus far, although the proportion in the other Group F site is even higher. In general, this site can be characterized as having a number of fairly large habitat patches, and many of the larger forested patches contain interior habitat; water resources are very good, and connectivity is excellent. The site is probably highly important to animals moving between patches, including both stopover and breeding territory for Neotropical migratory birds.

Conifer and hardwood forest are the predominant habitat types in this resource site (55 percent), followed by agricultural lands (29 percent) (Table F-15). Wetlands comprise more than four percent of the site's wildlife habitat, proportionally higher than the other Group F site. The site's contribution to regional wetland resources is slightly over one percent, and it ranks 19th among the 27 resource sites.

Species of Concern. One Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Red-legged Frog

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats, agricultural lands, and low-structure vegetation along streams – such as the Red-legged Frog (see Table F-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 139, 140, 141

Resource site data tables: Riparian Corridors

Table F-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Unincorporated Clackamas County	6,465.5

Table F-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Richardson Creek	6,465.5	2,271.8

Table F-8. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Richardson Creek	Microclimate & shade	289.1	12.7%	674.3	29.7%
	Streamflow moderation & water storage	100.8	4.4%	2,095.9	92.3%
	Bank stabilization & pollution control	834.5	36.7%	129.4	5.7%
	Large wood & channel dynamics	589.5	26.0%	143.2	6.3%
	Organic material sources	479.9	21.1%	125.9	5.5%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table F-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Richardson Creek	1 to 5	1,372.2	60.4%
	6 to 11	311.1	13.7%
	12 to 17	110.3	4.9%
	18 to 23	192.1	8.5%
	24 to 29	244.4	10.8%
	30	41.7	1.8%
	Total acres	2,271.8	100.0%

Resource site data tables: Wildlife Habitat

Table F-10. Breakdown of total wildlife model patch scores.*

Resource site: Richardson Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	8.7	84.0	645.2	518.2	91.2	407.6	59.1	394.3	0.0	2,208.1
Percent of total	0.4%	3.8%	29.2%	23.5%	4.1%	18.5%	2.7%	17.9%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table F-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Richardson Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	559.0	568.5	0.0	563.9	402.4	0.0	282.6	1,715.8	169.6	101.5	847.4	1,259.2	2,208.1
Percent of total acres in inventory	25.3%	25.7%	0.0%	25.5%	18.2%	0.0%	12.8%	77.7%	7.7%	4.6%	38.4%	57.0%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table F-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Richardson Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	1,028.7	51.8	1,042.1	41.2	31.6	12.7	2,208.1
Percent of total	46.6%	2.3%	47.2%	1.9%	1.4%	0.6%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table F-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Richardson Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2208.1	436.3	4.5	2212.6	1
Percent of total	99.8%	19.7%	0.2%	100.0%	N/A

*Habitats of Concern.

Table F-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Richardson Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.00	0.0	0.0%
Barren	152.93	0.1	6.9%
Low structure agriculture	593.00	3.2	26.9%
High structure agriculture	45.84	0.0	2.1%
Deciduous closed canopy	161.94	0.0	7.3%
Mixed closed canopy	685.99	0.0	31.0%
Conifer closed canopy	66.21	0.0	3.0%
Deciduous open canopy	122.22	0.0	5.5%
Mixed open canopy	99.17	0.0	4.5%
Conifer open canopy	6.42	0.0	0.3%
Deciduous scattered canopy	48.96	1.1	2.3%
Mixed scattered canopy	21.50	0.0	1.0%
Conifer scattered canopy	4.56	0.0	0.2%
Closed canopy shrub	44.68	0.0	2.0%
Open canopy shrub	18.06	0.0	0.8%
Scattered canopy shrub	25.82	0.0	1.2%
Meadow/grass	110.79	0.1	5.0%
Not classified	0.00	0.0	0.0%
Total	2,208.09	4.5	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table F-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

	Habitat type						
Richardson Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	0.0	44.3	41.2	99.5	1,218.0	154.8	642.1
Percent of total	0.0%	2.0%	1.9%	4.5%	55.1%	7.0%	29.0%

[1]See Table F-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #17: Rock Creek-Clackamas River subwatershed

Named streams: Clackamas River, Cow Creek, Johnson Creek, Rock Creek, Sieben Drainage Ditch, Tour Creek
Communities within the subwatershed: Gladstone, Happy Valley, Oregon City, unincorporated Clackamas County
Total acreage within Metro's boundary: 11,120.6
Total acres within riparian corridor: 4,172.5
Other information: One barrier to fish passage present with unknown impacts to fish.

This site contains four percent of the area comprising Metro's jurisdictional boundary. Most of the site (79 percent) is in unincorporated Clackamas County, but there are also portions in Oregon City, Happy Valley, and Gladstone (eight, seven, and five percent, respectively) (Table F-16).

The site's road density reflects the relatively undeveloped nature of this site; at 8.1 road miles per square mile, it falls at the top end of the lowest quartile (0 to 25 percent of maximum) compared to all other resource sites (Table F-2). However, compared to Site #16 and reflecting a somewhat increased road density, the zoning shows a rural dominance but also important single family residential and industrial components (Table F-5). About 1,400 building permits have been issued here since 1996 (Table A-2), a relatively low number compared to the amount of land falling within the Metro boundary.

Riparian resources. Site #17, similar to the other resource site in Group F, contains a relatively high proportion of riparian resources at 38 percent of its total lands within the Metro Boundary (Table 12). The site contributes four and one-half percent of the region's riparian corridors; only five of the 27 resource sites contribute more (Table 13).

This resource site contains approximately 50 total stream miles, of which 11 percent are stream links, suggesting a relatively low amount of piping or culverting (Table F-3). Non-piped stream density is 0.0040 miles per acre, somewhat lower than Site #16 (Table 12) but still in the top quarter of all 27 resource sites. Of non-piped streams, nine percent are DEQ 303(d) water-quality limited (Table F-2). Seven percent of the site is in the floodplain, and wetlands comprise less than one percent of this resource site's land (Table F-2). Anadromous fish are known to be present in about four and one-half stream miles.

Higher proportions of this site received primary ecological scores, compared to Site #16. Twenty-six percent of the acreage that falls within the riparian corridor inventory in this site received primary scores for at least three of the five ecological functions; more than 43 percent received at least one primary ecological function score (Table F-19). Vegetation near the stream is co-dominated by forest and low structure vegetation, in contrast with the other Group F resource site, which contains primarily low structure vegetation (Table F-4). The percentage of land receiving a given primary score was co-dominated by *Large wood and channel* dynamics and *Bank stabilization and pollution control* (Table F-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources.

Including Habitats of Concern, 34 percent of the lands in this site fall within the wildlife habitat inventory, ranking it seventh among the 27 resource sites, just behind the other Group F resource site (Table 16). Within model patches approximately 31 percent falls within the top third of the point range, ten percent higher than the other resource site in this group. Another 44 percent falls in the middle range (Table F-20). Of the four criteria in the GIS model, the highest proportion of acreage is in the lowest size category, although more than one fourth of this site's land are in the middle size class (Table F-21). Compared to the other resource site in Group F, the percentages for size and interior (71 percent) suggest that approximately 70 percent of wildlife habitat patches within 300 ft of stream are forested, because low-structure patch types are not scored for size and interior (see also Table F-22). A majority of acreage fell in the lowest category for the interior criterion, but a substantial proportion was also in the middle category. Water resources are highest in the middle range followed by the lowest scoring category, whereas connectivity scored primarily in the high range, with substantial amounts also in the middle category. This site rates high for interior habitat relative to most other sites discussed thus far, and has more interior habitat than the other Group F resource site.

In general, this site can be characterized as having large amounts of total and interior habitat; water resources are very good, and connectivity is excellent. The site is probably highly important to animals moving between patches, including both stopover and breeding territory for Neotropical migratory birds. The connectivity with extensive natural areas to the south of this site makes it highly valuable to wildlife, allowing strong possibility of species reintroduction in the event of local extirpations.

Conifer and hardwood forest are the predominant habitat types in this resource site (69 percent) (Table F-25). However, agricultural lands and grasslands comprise another 22 percent. Wetlands cover approximately three percent of the site's wildlife habitat, proportionally lower than the other Group F site. However, at just over one percent the site's contribution to regional wetland resources is about the same as Site #16, ranking 18th among the 27 resource sites.

Species of Concern. One Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Red-legged Frog

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table F-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 121, 123, 138

Resource site data tables: Riparian Corridors

Table F-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gladstone	554.4
Happy Valley	829.5
Oregon City	902.9
Unincorporated Clackamas County	8,833.9

Table F-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Rock Creek - Clackamas River	11,120.7	4,177.9

Table F-18. Number of acres within riparian corridor providing ecological function.

Resource site:	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Rock Creek - Clackamas River	Microclimate & shade	722.8	17.3%	1,165.6	27.9%
	Streamflow moderation & water storage	722.8	17.3%	3,339.3	79.9%
	Bank stabilization & pollution control	1,446.5	34.6%	124.0	3.0%
	Large wood & channel dynamics	1,494.1	35.8%	254.9	6.1%
	Organic material sources	952.9	22.8%	231.6	5.5%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table F-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Rock Creek - Clackamas River	1 to 5	2,372.0	56.8%
	6 to 11	367.9	8.8%
	12 to 17	349.7	8.4%
	18 to 23	280.0	6.7%
	24 to 29	609.5	14.6%
	30	198.8	4.8%
	Total acres	4,177.9	100.0%

Resource site data tables: Wildlife Habitat

Table F-20. Breakdown of total wildlife model patch scores.*

Resource site: Rock Creek - Clackamas River	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	40.6	227.7	695.4	532.5	529.4	574.0	1,089.5	66.0	0.0	3,755.2
Percent of total	1.1%	6.1%	18.5%	14.2%	14.1%	15.3%	29.0%	1.8%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table F-21. Breakdown of total wildlife model patch scores by criteria.*

Resource site: Rock Creek - Clackamas River	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,683.4	1,003.4	0.0	1,335.2	976.8	0.0	1,375.8	1,761.7	429.9	329.2	1,061.9	2,364.0	3,755.2
Percent of total acres in inventory	44.8%	26.7%	0.0%	35.6%	26.0%	0.0%	36.6%	46.9%	11.4%	8.8%	28.3%	63.0%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table F-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Rock Creek - Clackamas River	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	972.6	95.8	2,597.0	30.2	31.2	28.4	3,755.2
Percent of total	25.9%	2.6%	69.2%	0.8%	0.8%	0.8%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table F-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Rock Creek - Clackamas River	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	3755.2	675.9	6.6	3761.7	1
Percent of total	99.8%	18.0%	0.2%	100.0%	N/A

*Habitats of Concern.

Table F-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Rock Creek - Clackamas River Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	54.38	0.0	1.4%
Barren	191.64	1.5	5.1%
Low structure agriculture	478.88	0.6	12.7%
High structure agriculture	35.97	0.0	1.0%
Deciduous closed canopy	713.05	0.3	19.0%
Mixed closed canopy	914.08	0.8	24.3%
Conifer closed canopy	283.57	0.0	7.5%
Deciduous open canopy	220.05	1.1	5.9%
Mixed open canopy	207.61	0.3	5.5%
Conifer open canopy	17.38	0.0	0.5%
Deciduous scattered canopy	127.28	0.5	3.4%
Mixed scattered canopy	59.84	0.0	1.6%
Conifer scattered canopy	30.05	0.0	0.8%
Closed canopy shrub	129.24	0.2	3.4%
Open canopy shrub	56.65	0.2	1.5%
Scattered canopy shrub	66.31	0.3	1.8%
Meadow/grass	168.94	0.7	4.5%
Not classified	0.25	0.0	0.0%
Total	3,755.17	6.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table F-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Rock Creek - Clackamas River	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	132.6	59.6	30.2	99.7	2,575.9	293.1	515.4
Percent of total	3.5%	1.6%	0.8%	2.7%	68.5%	7.8%	13.7%

[1]See Table F-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

G. Johnson Creek

General watershed information

Resource sites within the Johnson Creek Watershed include:

- Johnson Creek-Sunshine Creek subwatershed
- Kelley Creek subwatershed
- Middle Johnson Creek subwatershed
- Lower Johnson Creek-Willamette River
- Lake Oswego subwatershed
- Tryon Creek subwatershed
- Johnson Creek-Crystal Springs Creek subwatershed
- Mount Scott Creek subwatershed

Watershed assessments and plans

Bureau of Planning, City of Portland, 1991. *Johnson Creek Basin Protection Plan, July 17, 1991,* City of Portland: Portland, Oregon.

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Bureau of Planning, City of Portland, 1997. *Portland Environmental Handbook,* City of Portland: Portland, Oregon.

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Community and Economic Development Department, City of Gresham, 1988. *Inventory of Significant Natural Resources and Open Spaces,* City of Gresham: Gresham, Oregon.

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Willamette Restoration Initiative, 2001. *Restoring A River of Life, The Willamette Restoration Strategy – Recommendations for the Willamette Basin Supplement to the Oregon Plan for Salmon and Watersheds, February 2001,* Willamette Restoration Initiative: Portland, Oregon.
Woodward-Clyde Consultants, 1995. *Johnson Creek Resources Management Plan,* Woodward-Clyde Consultants: Portland, Oregon.

Watershed councils and related groups

Clackamas River Basin Council, PO Box 1869, Clackamas, 97015-1869, (503) 650-1256
Clackamas River, Friends of, 9205 SE Clackamas, #142, Clackamas 97015, 503-492-1593, Scott Forrester
Clackamas River Water, 16770 SE 82nd Drive, Clackamas 97015, 503-722-9241
Fairview Creek Watershed Group, 2115 SE Morrison St., Portland 97214, (503) 661-7612, FAX (503) 661-5296
Fairview Creek Watershed Council, PO Box 36, Fairview 97024, (503) 231-2270, Shannon Schmitt
Fairview Creek Watershed Conservation Group, PO Box 36, Fairview 97204, 503-669-6000, Gregory Dresden
Johnson Creek Watershed Council, 525 Logus St., Oregon City 97045, (503) 239-3932, FAX (503) 239-3946
Johnson Creek Watershed Council, 8300 SE McLaughlin Blvd, Portland 97282, 503-239-3932, Kim Hatfield
Johnson Creek, Friends of Beaverton's 503-626-4398, Susan Langston
Johnson Creek, Friends of, 503-257-3161, Clifton Lee Powell
Mt. Scott and Kellogg Creeks, Friends of, PO Box 22373, Milwaukie 97269, 503-653-7875, Steve Berliner
Minthorn Springs, Friends of, 3006 SE Washington Street, Milwaukie 97222, 503-659-8509, Mart Hughes
Tryon Creek Watershed Council, 10750 Boones Ferry Rd., Portland 97219, (503) 823-5596
Tryon Creek State Park, Friends of, 11321 SW Terwilliger Blvd, Portland 97219, 503-636-4398, Louise Shorr
Wetlands, Friends of, 503-253-6247, Alice Blatt
Willamette River Restoration Committee, 541-484-9466, Timothy Green

Data descriptions

Table G-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. In Section G, all subwatersheds also comprise their own resource site, with the same names. All eight of the resource sites fall within the same 5th field HUC (Johnson Creek).

Tables G-1 and G-2 provide general description about the 5th field and 6th field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table G-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Johnson Creek	1709001201	18	Johnson Creek - Sunshine Creek	170990120101	12,372.9
		19	Kelley Creek	170990120102	3,175.6
		20	Middle Johnson Creek	170990120103	8,949.5
		21	Lower Johnson Creek - Willamette River	170990120104	5,950.2
		22	Lake Oswego	170990120105	4,168.7
		23	Tryon Creek	170990120106	4,356.4
		24	Johnson Creek - Crystal Springs Creek	170990120107	7,844.6
		25	Mount Scott Creek	170990120108	11,809.6

Table G-2. Resource sites: general information.

General information	Johnson - Sunshine Creeks	Kelley Creek	Middle Johnson Creek	Lower Johnson Creek	Lake Oswego	Tryon Creek	Johnson - Crystal Springs Creeks	Mount Scott Creek
Miles of DEQ 303(d) listed streams	10.0	0.0	3.6	3.9	2.8	5.2	6.8	2.2
Road density (road miles/square miles in subwatershed)	7.8	5.5	14.7	14.9	15.3	14.6	20.9	14.3
Miles of stream with known anadromous fish presence	9.7	2.3	3.4	4.0	0.4	2.6	8.3	9.2
Acres of hydrologically connected wetlands	111.0	16.0	14.4	38.6	10.2	3.8	39.7	146.1
Total acres of wetlands	111.1	16.0	14.4	38.6	13.1	3.8	46.4	147.0
Acres of floodplains (100 year FEMA + 1996 inundation area)	346.8	34.4	378.9	717.1	590.2	107.7	572.0	706.5
Acres of developed floodplains	11.8	1.2	164.4	74.6	75.8	37.1	295.4	149.6
Building permits since 1996 (number)	622.0	258.0	1,474.0	557.0	417.0	285.0	1,016.0	1,452.0

Table G-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Johnson - Sunshine Creeks	11.9	1.9	3.7	31.3	48.9
Kelley Creek	3.0	0.7	0.2	8.4	12.2
Middle Johnson Creek	4.2	0.6	26.7	5.2	36.7
Lower Johnson Creek - Willamette River	15.5	6.4	7.1	2.5	31.5
Lake Oswego	12.0	1.6	6.1	3.3	23.0
Tryon Creek	1.3	2.4	2.7	17.4	23.8
Johnson - Crystal Springs Creeks	9.2	1.3	20.6	3.8	34.9
Mount Scott Creek	11.1	2.5	16.3	17.4	47.3

*Stream links are links between surface streams and may be piped or culverted.

Table G-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Johnson - Sunshine Creeks	1,201.5	90.5	1,156.8	2,371.5
Kelley Creek	350.1	14.8	339.6	729.7
Middle Johnson Creek	142.2	6.0	408.7	899.8
Lower Johnson Creek - Willamette River	119.3	6.9	691.6	705.0
Lake Oswego	40.6	2.7	376.0	602.0
Tryon Creek	93.7	0.0	949.7	886.2
Johnson - Crystal Springs Creeks	259.4	2.8	227.8	367.8
Mount Scott Creek	447.5	21.0	597.4	1,184.9

Table G-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Johnson - Sunshine Creeks	39.7	306.4	388.4	124.3	7,347.8	3,953.1	213.3
Kelley Creek	7.7	0.0	0.0	2.0	2,569.5	596.5	0.0
Middle Johnson Creek	289.6	348.0	1,415.5	975.1	0.0	5,401.3	517.9
Lower Johnson Creek - Willamette River	254.8	82.9	304.0	164.2	51.5	4,667.3	205.0
Lake Oswego	189.5	0.0	144.6	0.0	85.5	3,260.6	55.4
Tryon Creek	135.7	37.8	137.9	528.6	107.8	3,350.3	58.3
Johnson - Crystal Springs Creeks	223.7	932.1	923.2	679.5	0.0	4,819.3	254.0
Mount Scott Creek	287.6	937.7	555.9	519.3	266.3	7,899.7	1,242.1

SITE #18: Johnson Creek-Sunshine Creek subwatershed

Named streams: Butler Creek, Fairview Creek, Johnson Creek, Kelly Creek, Sunshine Creek
Communities within the subwatershed: Gresham, Portland, unincorporated Clackamas County, unincorporated Multnomah County
Total acreage within Metro's boundary: 12,372.9
Total acres within the riparian corridor: 4,787.5

This site contains four percent of the area comprising Metro's jurisdictional boundary. Forty percent of this site is in unincorporated Clackamas County; 38 percent is in Gresham, 20 percent in unincorporated Multnomah County, and two percent in the City of Portland. About seven percent of the site is in the City of Troutdale, with the remaining two percent in unincorporated Multnomah County (Table G-6).

This site and the next (Site #19) are the two least developed resource sites in Group G (Table G-2). This resource site has a road density of 7.8 miles per square mile, falling in the first quartile (0 to 25 percent of maximum) compared to all other resource sites. Zoning is strongly rural, but single family residential covers nearly half as much acreage (Table G-5), primarily reflecting the portion of the site's land falling with Gresham's boundaries. Over 600 building permits have been issued here since 1996 (Table G-2), but this is a relatively low number compared to the amount of land within Metro's boundary.

Riparian resources. Thirty-nine percent of this site is part of the riparian corridor inventory, the third highest proportion of the eight resource sites in Group G (Table 12). It contributes more than five percent of the region's total riparian resources, the fifth highest amount of all 27 resource sites (Table 13).

This resource site contains 49 total stream miles, and about 0.0037 miles of non-piped streams per acre, ranking it 11th among the 27 resource sites; 3.7 miles, or about eight percent, are stream links and may be piped or culverted (Tables 12 and G-3). About 22 percent of non-piped stream miles are listed by the DEQ as 303(d) quality-limited (Tables G-2 and 12). Anadromous fish are known to be present in approximately 10 stream miles (Table G-2). Three percent of the site is floodplain, and one percent is wetland (Table G-2 and G-3). About 3-1/2 percent of the floodplain is developed, similar to Site #19 in this group.

Approximately 20 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions. However, nearly 70 percent the site's riparian resources are limited to secondary functions, similar to Sites #19 and 20 in Group G (Table G-9). The highest percentage of land receiving a primary score was fairly evenly divided between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table G-8; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 39 percent of the lands in this site fall within the wildlife habitat inventory, ranking it fourth among the 27 resource sites (Table 16). Within model patches approximately 24 percent falls within the top third of the point range, the fourth highest proportion of the eight Group G resource sites; another 59 percent falls in the middle range (Table G-10). Of the four criteria in the GIS model, the proportion of acreage is divided nearly equally between the middle and lowest category, at 39 and 36 percent, respectively (Table G-11). The highest percentage for the interior criterion was the lowest score category (46 percent), although another 23 percent fell in the middle category. These total percentages suggest that nearly one fourth of this site's wildlife resources are low-structure vegetation patches within 300 ft of streams, because these patch types are not scored for these two criteria (see also Table G-12). Water resources were highest in the low range (53 percent) followed by the middle scoring category (36 percent), whereas connectivity scored primarily in the high range (74 percent), with substantial amounts also in the middle category. This site rates high for interior habitat relative to many other sites discussed thus far, and ranks fourth among the generally well-connected resource sites within Group G.

In general, this site can be characterized as having large amounts of total and interior habitat; water resources are moderate, but that is influenced by the unusually large amount of upland habitats in addition to riparian resources. Connectivity to other natural areas is excellent. The site is probably highly important to animals moving between patches, including both stopover and breeding territory for Neotropical migratory birds. The connectivity with extensive natural areas in adjacent watersheds makes it highly valuable to wildlife, allowing potential for species reintroduction in the event of local extirpations.

Conifer and hardwood forest are the predominant habitat types in this resource site (76 percent) (Table G-15). Wetlands cover more than two percent of the site's wildlife habitat, proportionally lower than the many of the 27 resource sites but ranking fourth among the eight resource sites in Group G. The site contributes a little over one percent to the region's wetland resources, ranking 17th among the 27 resource sites.

Species of Concern. Nine Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker (numerous sightings, reflecting strong coniferous component)
- Willow Flycatcher
- Bald Eagle nest site

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 12, 133, 136, 137

Resource site data tables: Riparian Corridors

Table G-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gresham	4,730.0
Portland	244.3
Unincorporated Clackamas County	4,928.2
Unincorporated Multnomah County	2,470.4

Table G-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Johnson - Sunshine Creeks	12,372.9	4,777.5

Table G-8. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Johnson - Sunshine Creeks	Microclimate & shade	751.1	15.7%	1,513.1	31.7%
	Streamflow moderation & water storage	402.3	8.4%	4,282.2	89.6%
	Bank stabilization & pollution control	1,293.2	27.1%	410.2	8.6%
	Large wood & channel dynamics	1,158.2	24.2%	281.7	5.9%
	Organic material sources	929.7	19.5%	233.2	4.9%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table G-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Johnson - Sunshine Creeks	1 to 5	3,297.1	69.0%
	6 to 11	372.7	7.8%
	12 to 17	169.1	3.5%
	18 to 23	136.9	2.9%
	24 to 29	595.5	12.5%
	30	206.2	4.3%
	Total acres	4,777.5	100.0%

Resource site data tables: Wildlife Habitat

Table G-10. Breakdown of total wildlife model patch scores.*

Resource site: Johnson - Sunshine Creeks	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	27.5	131.8	662.4	703.2	777.9	1,298.3	1,133.7	0.0	0.0	4,734.6
Percent of total	0.6%	2.8%	14.0%	14.9%	16.4%	27.4%	23.9%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Johnson - Sunshine Creeks	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,699.3	1,835.1	0.0	2,156.7	1,071.7	0.0	2,506.2	1,681.0	382.1	226.6	994.5	3,513.5	4,734.6
Percent of total acres in inventory	35.9%	38.8%	0.0%	45.6%	22.6%	0.0%	52.9%	35.5%	8.1%	4.8%	21.0%	74.2%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Johnson - Sunshine Creeks	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	1,122.3	77.9	3,430.8	42.5	47.6	13.5	4,734.6
Percent of total	23.7%	1.6%	72.5%	0.9%	1.0%	0.3%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Johnson - Sunshine Creeks	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	4734.6	248.7	87.7	4822.3	9
Percent of total	98.2%	5.2%	1.8%	100.0%	N/A

*Habitats of Concern.

Table G-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Johnson - Sunshine Creeks Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.76	0.0	0.0%
Barren	152.23	7.5	3.3%
Low structure agriculture	396.96	1.3	8.3%
High structure agriculture	121.05	2.0	2.6%
Deciduous closed canopy	1,423.25	2.2	29.6%
Mixed closed canopy	1,348.09	2.7	28.0%
Conifer closed canopy	303.19	0.7	6.3%
Deciduous open canopy	230.76	1.4	4.8%
Mixed open canopy	118.02	0.8	2.5%
Conifer open canopy	11.92	0.2	0.3%
Deciduous scattered canopy	134.68	1.4	2.8%
Mixed scattered canopy	68.13	0.9	1.4%
Conifer scattered canopy	7.34	0.0	0.2%
Closed canopy shrub	158.54	5.3	3.4%
Open canopy shrub	44.25	3.0	1.0%
Scattered canopy shrub	63.53	10.0	1.5%
Meadow/grass	151.95	48.2	4.2%
Not classified	0.01	0.0	0.0%
Total	4,734.65	87.7	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Johnson - Sunshine Creeks	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	25.3	61.1	42.5	111.1	3,655.7	321.0	521.4
Percent of total	0.5%	1.3%	0.9%	2.3%	75.8%	6.7%	10.8%

[1]See Table G-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #19: Kelley Creek subwatershed

Named streams: Kelly Creek, Mitchell Creek
Communities within the subwatershed: Gresham, Happy Valley, Portland, unincorporated Clackamas County, unincorporated Multnomah County
Total acreage within Metro's boundary: 3,175.6
Total acres within the riparian corridor: 1,424.9

This site contains one percent of the area comprising Metro's jurisdictional boundary. Forty-six percent of the site falls within unincorporated Multnomah County; the remainder falls in unincorporated Clackamas County (37 percent), Portland (12 percent), Gresham (four percent), and Happy Valley (two percent) (Table G-16).

This site is the third least developed of all resource sites, with only 5.5 road miles per square mile (Table G-2). It is also the least developed resource site in Group G. The zoning is strongly rural, with some single family residential (Table G-5). About 260 building permits have been issued here since 1996 (Table G-2).

Riparian resources. Forty-five percent of this site is part of the riparian corridor inventory, the second highest proportion of the eight resource sites in Group G (Table 12). However, it contributes only one and one-half percent of the region's total riparian resources due to the relatively small acreage falling within the Metro boundary (Table 13).

This resource site contains 12 total stream miles, and about 0.0038 miles of non-piped streams per acre, ranking it eighth among the 27 resource sites. Two percent of total stream miles are stream links and may be piped or culverted (Tables 12 and G-3). None of the stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in approximately 2 stream miles (Table G-2). One percent of the site is floodplain, and one percent is wetland (Tables G-2 and G-3). About 3-1/2 percent of the floodplain is developed, similar to Site #18 in this group.

Approximately 16 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions (Table G-19). However, 74 percent the site's riparian resources are limited to secondary functions, similar to Sites #18 and 20 in Group G. The highest percentage of land receiving a primary score was for *Bank stabilization and pollution control*, followed by *Large wood and channel dynamics* (Table G-18; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 45 percent of the lands in this site fall within the wildlife habitat inventory, ranking it second among the 27 resource sites and first in Group G (Table 16). Within model patches approximately 43 percent falls within the top third of the point range, the third highest proportion of the eight Group G resource sites; another 38 percent falls in the middle range (Table G-20). Of the four criteria in the GIS model, the highest proportion of acreage is in the middle size score category (43 percent), with another 32 percent in the lowest category (Table G-11). The acreage for the interior criterion was about equally divided between the lowest and middle categories (35 and 34 percent, respectively). These total percentages suggest that approximately 30 percent of this site's wildlife resources are low-structure vegetation patches within 300 ft of streams, because these patch types are not scored for these two criteria (see also Table G-22). Water resources were highest in the medium range (59 percent) followed by the middle scoring category (35 percent), whereas connectivity scored primarily in the high range (76 percent, with another 23 percent in the middle caegory). This site ranks very high for interior habitat relative to many of the 27 resource sites, and ranks third among the generally well-connected resource sites within Group G.

In general, this site can be characterized as having extensive amounts of total habitat, substantial interior habitat, good water resources and outstanding connectivity. Water resources are moderate rather than high due to the unusually large amount of upland habitats in addition to riparian resources. As with other sites with these characteristics, this site is probably highly important to animals moving between patches, including both stopover and breeding territory for Neotropical migratory birds. The connectivity with extensive natural areas in adjacent watersheds makes it highly valuable to wildlife, allowing potential for species reintroduction in the event of local extirpations.

Conifer and hardwood forest are the predominant habitat types in this resource site (76 percent) (Table G-25). Wetlands cover more just over one percent of the site's wildlife habitat, proportionally lower than the many of the 27 resource sites and ranking sixth among the eight resource sites in Group G. The site contributes 0.2 percent to the region's wetland resources, ranking 24th among the 27 resource sites.

Species of Concern. No Species of Concern sighting locations fall within the site. However, there are very likely Species of Concern using this resource site, particularly those relying on forested habitats (see Table G-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 123, 138

Resource site data tables: Riparian Corridors

Table G-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gresham	135.9
Happy Valley	47.7
Portland	369.4
Unincorporated Clackamas County	1,177.5
Unincorporated Multhomah County	1,445.1

Table G-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Kelley Creek	3,175.6	1,423.1

Table G-18. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Kelley Creek	Microclimate & shade	191.5	13.5%	461.8	32.4%
	Streamflow moderation & water storage	49.5	3.5%	1,354.1	95.2%
	Bank stabilization & pollution control	332.3	23.4%	104.9	7.4%
	Large wood & channel dynamics	283.8	19.9%	90.8	6.4%
	Organic material sources	223.9	15.7%	75.3	5.3%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table G-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Kelley Creek	1 to 5	1,046.1	73.5%
	6 to 11	118.4	8.3%
	12 to 17	33.1	2.3%
	18 to 23	33.9	2.4%
	24 to 29	163.7	11.5%
	30	28.0	2.0%
	Total acres	1,423.1	100.0%

Resource site data tables: Wildlife Habitat

Table G-20. Breakdown of total wildlife model patch scores.*

Resource site: Kelley Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	13.8	15.3	234.5	127.7	78.0	331.1	609.5	0.0	0.0	1,410.0
Percent of total	1.0%	1.1%	16.6%	9.1%	5.5%	23.5%	43.2%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-21. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Kelley Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	451.2	609.5	0.0	492.3	476.2	0.0	494.4	832.5	53.9	17.5	318.8	1,073.6	1,410.0
Percent of total acres in inventory	32.0%	43.2%	0.0%	34.9%	33.8%	0.0%	35.1%	59.0%	3.8%	1.2%	22.6%	76.1%	na

[1]Does not include Habitats of Concern outside of model patches.
[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.
[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Kelley Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	334.9	14.4	1,046.8	6.1	5.3	2.4	1,410.0
Percent of total	23.8%	1.0%	74.2%	0.4%	0.4%	0.2%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Kelley Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1410.0	330.0	12.1	1422.0	0
Percent of total	99.2%	23.2%	0.8%	100.0%	N/A

*Habitats of Concern.

Table G-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Kelley Creek / Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.00	0.0	0.0%
Barren	32.23	0.1	2.3%
Low structure agriculture	204.41	2.1	14.5%
High structure agriculture	29.83	0.0	2.1%
Deciduous closed canopy	318.76	1.1	22.5%
Mixed closed canopy	588.09	5.6	41.7%
Conifer closed canopy	49.34	0.1	3.5%
Deciduous open canopy	26.03	0.9	1.9%
Mixed open canopy	37.74	0.6	2.7%
Conifer open canopy	6.03	0.5	0.5%
Deciduous scattered canopy	28.52	0.3	2.0%
Mixed scattered canopy	9.89	0.2	0.7%
Conifer scattered canopy	0.17	0.0	0.0%
Closed canopy shrub	32.55	0.3	2.3%
Open canopy shrub	8.10	0.2	0.6%
Scattered canopy shrub	17.28	0.3	1.2%
Meadow/grass	21.01	0.0	1.5%
Not classified	0.00	0.0	0.0%
Total	1,409.97	12.1	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Kelley Creek	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	0.0	7.8	6.1	16.0	1,073.7	46.8	236.3
Percent of total	0.0%	0.5%	0.4%	1.1%	75.5%	3.3%	16.6%

[1]See Table G-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #20: Middle Johnson Creek subwatershed

Named streams: Fairview Creek, Johnson Creek
Communities within the subwatershed: Gresham, Happy Valley, Portland, unincorporated Clackamas county, unincorporated Multnomah county
Total acreage within Metro's boundary: 8,949.5
Total acres within the riparian corridor: 1,798.9

This site contains three percent of the area comprising Metro's jurisdictional boundary. The majority of the site (82 percent) falls within the City of Portland's boundaries; 16 percent is in Gresham, and one percent or less falls within Happy Valley and unincorporated Clackamas and Multnomah counties (Table G-26).

The road density in this site is 14.7 miles per square mile, falling within the third quartile (51 to 75 percent of maximum) compared to all other resource sites (Table G-2). The zoning is primarily single family residential, but multi-family residential and public space/open lands are also important land uses in this resource site (Table G-5). Nearly 1,500 building permits have been issued here since 1996 (Table A-2).

Riparian resources. Seventeen percent of this site is part of the riparian corridor inventory, ranking it next to last in Group G (Table 12). However, it contributes nearly two percent of the region's total riparian resources (Table 13).

This resource site contains 37 total stream miles, but because most of these (73 percent) are stream links, actual stream density is only 0.0011 miles per acre, ranking it last among all 27 resource sites (Tables 12 and G-3). More than a third of the non-piped stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in approximately 3-1/2 stream miles (Table G-2). Four percent of the site is floodplain, and less than one percent is wetland (Tables G-2 and G-3). Forty-three percent of the floodplain is developed, second only to Site #24 among all 27 resource sites (Table 14).

Approximately 18 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and more than 32 percent received at least one primary score (Table G-29). Approximately 68 percent of the site's riparian resources are limited to secondary functions. The highest percentage of land receiving a primary score was for *Bank stabilization and pollution control* and *Large wood and channel dynamics* (Table G-28; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 18 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 23rd among the 27 resource sites and seventh of the eight Group G resource sites (Table 16). Despite the relatively low proportion of wildlife habitat, what is there tends to be high-scoring; within model patches approximately 55 percent falls within the top third of the point range, the second highest proportion of the eight Group G resource sites; another 33 percent falls in the middle range (Table G-30). Of the four criteria in the GIS model, the highest proportion of acreage is in the middle size score category (55 percent), with another 35 percent in the lowest category (Table G-31). The acreage for the interior criterion all fell in the lowest score category (82 percent). This suggests that there are some long, linear habitat patches along streams in this resource site. The high total percentages for these two criteria suggest that most of the habitat resources within 300 ft of streams are forested, because low-structure patch types are not scored for these two criteria (see also Table G-32). In fact, most of the water resources for this site fell within the middle scoring range (68 percent), confirming what can be seen on the map. In keeping with this resource configuration, most of the acreage scored in the high range for connectivity (85 percent). This site ranks fourth high for connectivity relative to all 27 resource sites, and ranks second among the generally well-connected resource sites within Group G.

In general, this site can be characterized as having high quality wildlife habitat despite fairly intense urbanization. While there is little interior habitat the excellent connectivity and large patch sizes situated along waterways provide a very valuable wildlife habitat complex, and contribute important resources to the regional wildlife habitat system. As with other sites with these characteristics, this site is probably highly important to animals moving between patches, including both stopover and breeding territory for Neotropical migratory birds.

As with other Group G sites, conifer and hardwood forest are the predominant habitat types in this resource site (78 percent) (Table G-35). Wetlands cover one percent of the site's wildlife habitat, proportionally lower than the many of the 27 resource sites and ranking seventh among the eight resource sites in Group G. The site contributes 0.2 percent to the region's wetland resources, ranking 25th among the 27 resource sites.

Species of Concern. Four Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Red-legged Frog
- Bald Eagle nest site
- *Rorippa columbiae* (sensitive plant species)
- *Sidalcea nelsoniana* (sensitive plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-35). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 12, 33, 126, 133, 134, 135, 136, 161

Resource site data tables: Riparian Corridors

Table G-26. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gresham	1,437.2
Happy Valley	78.9
Portland	7,358.3
Unincorporated Clackamas County	58.5
Unincorporated Multhomah County	16.6

Table G-27. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Middle Johnson Creek	8,949.7	1,539.2

Table G-28. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Middle Johnson Creek	Microclimate & shade	233.0	15.1%	549.5	35.7%
	Streamflow moderation & water storage	233.2	15.2%	1,281.3	83.2%
	Bank stabilization & pollution control	353.8	23.0%	81.6	5.3%
	Large wood & channel dynamics	431.5	28.0%	116.9	7.6%
	Organic material sources	271.9	17.7%	88.0	5.7%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table G-29. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Middle Johnson Creek	1 to 5	1,041.5	67.7%
	6 to 11	92.0	6.0%
	12 to 17	122.3	7.9%
	18 to 23	16.9	1.1%
	24 to 29	196.6	12.8%
	30	70.0	4.5%
	Total acres	1,539.2	100.0%

Resource site data tables: Wildlife Habitat

Table G-30. Breakdown of total wildlife model patch scores.*

Resource site: Middle Johnson Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	88.2	24.0	52.2	109.8	298.1	38.8	740.5	0.0	0.0	1,351.7
Percent of total	6.5%	1.8%	3.9%	8.1%	22.1%	2.9%	54.8%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-31. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Middle Johnson Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	478.5	740.5	0.0	1,107.3	0.0	0.0	271.4	920.0	30.2	130.5	72.2	1,149.0	1,351.7
Percent of total acres in inventory	35.4%	54.8%	0.0%	81.9%	0.0%	0.0%	20.1%	68.1%	2.2%	9.7%	5.3%	85.0%	na

[1]Does not include Habitats of Concern outside of model patches.
[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.
[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-32. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Middle Johnson Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	127.6	5.0	1,208.2	4.6	0.0	6.2	1,351.7
Percent of total	9.4%	0.4%	89.4%	0.3%	0.0%	0.5%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-33. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Middle Johnson Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1351.7	425.2	276.4	1628.1	4
Percent of total	83.0%	26.1%	17.0%	100.0%	N/A

*Habitats of Concern.

Table G-34. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Middle Johnson Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.77	0.0	0.0%
Barren	43.96	25.1	4.2%
Low structure agriculture	9.21	0.0	0.6%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	259.65	8.8	16.5%
Mixed closed canopy	437.62	3.3	27.1%
Conifer closed canopy	337.67	0.2	20.8%
Deciduous open canopy	49.61	9.4	3.6%
Mixed open canopy	36.46	10.7	2.9%
Conifer open canopy	21.15	0.2	1.3%
Deciduous scattered canopy	35.08	11.2	2.8%
Mixed scattered canopy	25.67	10.7	2.2%
Conifer scattered canopy	16.39	0.0	1.0%
Closed canopy shrub	39.64	9.1	3.0%
Open canopy shrub	10.43	7.6	1.1%
Scattered canopy shrub	10.43	26.2	2.2%
Meadow/grass	17.95	154.0	10.6%
Not classified	0.00	0.0	0.0%
Total	1,351.69	276.4	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-35. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Middle Johnson Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	12.9	6.3	4.6	14.4	1,273.8	226.5	9.2
Percent of total	0.8%	0.4%	0.3%	0.9%	78.2%	13.9%	0.6%

[1]See Table G-34 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #21: Lower Johnson Creek-Willamette River

Named streams: Clackamas River, Willamette River
Communities within the subwatershed: Gladstone, Lake Oswego, Oregon City, West Linn, unincorporated Clackamas County
Total acreage within Metro's boundary: 5,950.2
Total acres within the riparian corridor: 1,897.1

This site contains two percent of the area comprising Metro's jurisdictional boundary. About 40 percent of the site is in West Linn, 38 percent in unincorporated Clackamas County, and the remainder is in Gladstone (15 percent), Lake Oswego (seven percent) and Oregon City (less than one percent) (Table G-36).

At 14.9 road miles per square mile, this site's road density is similar to several other sites in Group G, placing it in the third quartile (51 to 75% of maximum) compared to all other resource sites (e.g., site #20, 22, 23, and 25) (Table G-2). Zoning is primarily single family residential (Table G-5). About 560 building permits have been issued in this site since 1996 (Table G-2).

Riparian resources. Thirty-two percent of this site is part of the riparian corridor inventory, ranking it in the middle of Group G (Table 12). It contributes two percent of the region's total riparian resources (Table 13).

This resource site contains 32 total stream miles, of which 23 percent are stream links. Non-piped stream density is 0.0041 miles per acre, the fourth highest of all 27 resource sites (Tables 12 and G-3). Sixteen percent of the non-piped stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in approximately four stream miles (Table G-2). Low to medium gradient streams predominate (Table G-3). Twelve percent of the site is floodplain, and one percent is wetland (Tables G-2 and G-3). Approximately 10 percent of the floodplain is developed.

A substantial amount of riparian resources in this site received primary scores. Approximately 44 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and more than 62 percent received at least one primary score (Table G-39). The highest percentage of land receiving a primary score was for *Large wood and channel dynamics,* followed by *Bank stabilization and pollution control. Streamflow moderation and water storage* was also an important primary function in this resource site (Table G-38; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 25 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 13th among the 27 resource sites and fourth of the eight Group G resource sites (Table 16). Within model patches, no acreage falls within the top third of the point range; however, 74 percent falls in the middle range (Table G-40). Of the four criteria in the GIS model, the highest proportion of acreage is in the middle size score category (55 percent), with another 35 percent in the lowest category (Table G-41). The majority of the mid-range scores fell west of the Willamette River, with less total habitat and more fragmentation east of the river.

The acreage for the size and interior criteria all fell in the lowest score category (94 and 72 percent, respectively). This suggests that there are some long, linear habitat patches in this resource site. The high total percentage for the size criterion suggests that most of the habitat resources within 300 ft of streams are forested, because low-structure patch types are not scored for this criterion (see also Table G-42). Most of the water resources for this site fell within the middle or high scoring range (54 and 27 percent, respectively). This is influenced by the fact that the largest habitat is much longer than it is wide wide, and most of the streams run perpendicular through the patch thus lowering the density of water resources in the site. The overall connectivity scores fell primarily in the middle (47 percent) and high (34 percent) range for the site. The habitat patches west of the Willamette River have excellent connectivity; preserving this connectivity will be essential to maintaining the integrity of habitat here. This patch also contains a narrow corridor of connectivity to Mary S. Young State Park and adjacent patches closer to the Willamette River, and maintaining or enhancing that connector is vital.

As with other Group G sites, conifer and hardwood forest are the predominant habitat types in this resource site (87 percent), but open water, at 23 percent, is a very important habitat resource (Table G-45). Wetlands cover nearly three percent of the site's wildlife habitat, proportionally lower than the many of the 27 resource sites and ranking seventh among the eight resource sites in Group G. The site contributes 0.4 percent to the region's wetland resources, ranking 22nd among the 27 resource sites.

In general, this site can be characterized as having relatively high quality wildlife habitat west of the Willamette River, with less habitat that is generally lower in quality east of the river (due to fragmentation and lack of water resources). On the east side of the river a relatively low proportion of the habitat is protected through parks and public lands, but this pattern is improved to the west, where the low scores in habitat interior are mitigated by strong connectivity and good water resources. The proximity to the river and connectivity make the western portion of this site highly important to wildlife movement and an important migratory resource.

Species of Concern. Four Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Band-tailed Pigeon
- Red-legged Frog
- Great Blue Heron nest colony

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-45). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 117, 118, 119, 120, 145

Resource site data tables: Riparian Corridors

Table G-36. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gladstone	921.0
Lake Oswego	402.3
Oregon City	0.3
West Linn	2,354.6
Unincorporated Clackamas County	2,272.0

Table G-37. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Johnson Creek	5,950.3	1,897.0

Table G-38. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Lower Johnson Creek	Microclimate & shade	452.0	23.8%	674.8	35.6%
	Streamflow moderation & water storage	670.6	35.4%	1,134.3	59.8%
	Bank stabilization & pollution control	994.4	52.4%	66.0	3.5%
	Large wood & channel dynamics	1,079.1	56.9%	170.9	9.0%
	Organic material sources	479.7	25.3%	134.9	7.1%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table G-39. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Johnson Creek	1 to 5	705.9	37.2%
	6 to 11	161.5	8.5%
	12 to 17	191.9	10.1%
	18 to 23	365.8	19.3%
	24 to 29	326.1	17.2%
	30	145.7	7.7%
	Total acres	1,897.0	100.0%

Resource site data tables: Wildlife Habitat

Table G-40. Breakdown of total wildlife model patch scores.*

Resource site: Lower Johnson Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	81.7	119.1	174.5	121.1	179.2	781.5	0.0	0.0	0.0	1,457.2
Percent of total	5.6%	8.2%	12.0%	8.3%	12.3%	53.6%	0.0%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-41. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Lower Johnson Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,374.5	0.0	0.0	1,049.9	0.0	0.0	77.2	779.4	392.3	280.5	677.5	499.2	1,457.2
Percent of total acres in inventory	94.3%	0.0%	0.0%	72.1%	0.0%	0.0%	5.3%	53.5%	26.9%	19.2%	46.5%	34.3%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-42. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Johnson Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	80.1	2.5	1,339.4	12.8	11.6	10.7	1,457.2
Percent of total	5.5%	0.2%	91.9%	0.9%	0.8%	0.7%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-43. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Johnson Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1457.2	247.7	14.0	1471.2	4
Percent of total	99.1%	16.8%	0.9%	100.0%	N/A

*Habitats of Concern.

Table G-44. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Johnson Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	14.67	9.0	1.6%
Barren	44.55	1.0	3.1%
Low structure agriculture	0.00	0.0	0.0%
High structure agriculture	0.02	0.0	0.0%
Deciduous closed canopy	284.02	0.3	19.3%
Mixed closed canopy	357.25	0.5	24.3%
Conifer closed canopy	220.15	0.0	15.0%
Deciduous open canopy	154.66	0.4	10.5%
Mixed open canopy	102.28	0.5	7.0%
Conifer open canopy	25.25	0.1	1.7%
Deciduous scattered canopy	65.41	0.4	4.5%
Mixed scattered canopy	47.77	0.3	3.3%
Conifer scattered canopy	15.91	0.0	1.1%
Closed canopy shrub	53.58	0.7	3.7%
Open canopy shrub	22.79	0.2	1.6%
Scattered canopy shrub	21.89	0.2	1.5%
Meadow/grass	26.99	0.3	1.9%
Not classified	0.00	0.0	0.0%
Total	1,457.19	14.0	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-45. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Lower Johnson Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	341.1	22.3	12.8	38.6	1,275.3	72.4	0.0
Percent of total	23.2%	1.5%	0.9%	2.6%	86.7%	4.9%	0.0%

[1]See Table G-44 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #22: Lake Oswego subwatershed

Named streams: Oswego Creek, Spring Brook Creek, Willamette River
Communities within the subwatershed: Lake Oswego, Portland, unincorporated Clackamas county
Total acreage within Metro's boundary: 4,168.7
Total acres within the riparian corridor: 1,541.7
Other information: One dam with unknown impacts to fish. One other barrier to fish passage present with no known fishway.

This site contains one percent of the area comprising Metro's jurisdictional boundary. Most of the site (94 percent) is in Lake Oswego, with the remainder in unincorporated Clackamas County (five percent) and the City of Portland (one percent) (Table G-46).

Road density in this site is 15.3 miles per square mile, placing it in the third quartile (51 to 75% of maximum) compared to all other resource sites (Table G-2). Single family residential is the dominant zoning pattern (Table G-5). About 420 building permits have been issued here since 1996 (Table G-2).

Riparian resources. Thirty-seven percent of this site is part of the riparian corridor inventory, ranking it in fourth of eight sites in Group G (Table 12). It contributes two percent of the region's total riparian resources (Table 13).

This resource site contains 23 total stream miles, of which 27 percent are stream links, suggesting moderately high amounts of piping and culverting. Non-piped stream density is 0.0041 miles per acre, placing it in the top quarter of all resource sites (Tables 12 and G-3). Low to medium gradient streams predominate (Table G-3). Seventeen percent of the non-piped stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in less than one stream miles (Table G-2). Fourteen percent of the site is floodplain, and less than one percent is wetland (Tables G-2 and G-3). Approximately 13 percent of the floodplain is developed.

A substantial amount of riparian resources in this site received primary scores. Approximately 16 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, but nearly 55 percent received at least one primary score (Table G-49). The highest percentage of land receiving a primary score was for *Large wood and channel dynamics*, followed by *Streamflow moderation and water storage* (not surprising, given Oswego Lake's presence in the site) (Table G-48; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 24 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 14th among the 27 resource sites and fifth of the eight Group G resource sites (Table 16). Within model patches, less than one percent of the acreage falls within the top third of the point range; however, 78 percent falls in the middle range (Table G-50). Of the four criteria in the GIS model, by far the highest proportion of the acreage falls in the lowest size and interior score category (97 and 75 percent, respectively) (Table G-51). The high proportion of acreage accounted for in the size criterion indicates that nearly all of the lands within 300 ft of streams are forested, because low-structure patch types are not scored for this criterion (see also Table G-52). Most of the water resources for this site fell within the middle or high scoring range (57 and 30 percent, respectively). The overall connectivity scores fell primarily in the high range (42 percent), with decreasing but still important proportions in the medium and low score categories (37 and 21 percent, respectively). The most substantial habitat patch is north of Oswego Lake and includes important areas of connectivity to the lake; preserving this connectivity will be essential to maintaining the integrity of habitat in this site. A smaller patch just south of the Lake is even more well connected to this important open water resource. Portions of each of these patches are protected by parks. Several other significant habitat patches provide important connectivity to adjacent resource sites.

As with other Group G sites, conifer and hardwood forest are the predominant habitat types in this resource site (89 percent). Open water is not fully accounted for in this site at just three percent, but this habitat type is undoubtedly also a very important habitat resource (Table G-55). Wetlands cover slightly more than one percent of the site's wildlife habitat, proportionally lower than the many of the 27 resource sites and ranking sixth among the eight resource sites in Group G. The site contributes 0.2 percent to the region's wetland resources, ranking 26th among the 27 resource sites.

In general, this site can be characterized as having moderate quality wildlife habitat, but with some important habitat patches connected to Oswego Lake and to adjacent watersheds. The proximity to the lake is important to wildlife species utilizing open water habitats. The lake is known to be important to Bald Eagles, Osprey and waterfowl; it contains substantial development along the shorelines, but also substantial habitat. Retention of as much habitat as possible (particularly tree canopy) should accompany further lakeshore development if maintaining wildlife habitat quality is desired. Habitat enhancement near the lake on developed lots and creating connectors between isolated habitat patches would improve habitat quality over existing conditions in this site.

Species of Concern. Proximity to a large water resource such as Oswego Lake is highly valuable to wildlife and provides for distinctive plant communities, and this is reflected by the high number of Species of Concern sighting locations (11) falling within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Bald Eagle
- Great Blue Heron nest colony
- *Cimicifuga elata* (plant species)
- *Delphinium leucophaeum* (plant species)
- *Sullivantia oregana* (plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-55). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 111 (barely touches this resource site from the south)

Resource site data tables: Riparian Corridors

Table G-46. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Lake Oswego	3,914.3
Portland	57.8
Unincorporated Clackamas County	196.6

Table G-47. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lake Oswego	4,168.7	1,541.7

Table G-48. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Lake Oswego	Microclimate & shade	268.9	17.4%	579.1	37.6%
	Streamflow moderation & water storage	524.0	34.0%	933.3	60.5%
	Bank stabilization & pollution control	323.0	21.0%	109.8	7.1%
	Large wood & channel dynamics	766.7	49.7%	104.4	6.8%
	Organic material sources	214.6	13.9%	76.7	5.0%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table G-49. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lake Oswego	1 to 5	699.5	45.4%
	6 to 11	101.6	6.6%
	12 to 17	488.8	31.7%
	18 to 23	41.5	2.7%
	24 to 29	158.0	10.2%
	30	52.4	3.4%
	Total acres	1,541.7	100.0%

Resource site data tables: Wildlife Habitat

Table G-50. Breakdown of total wildlife model patch scores.*

Resource site: Lake Oswego	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	42.0	49.7	124.7	61.0	78.3	648.3	0.0	1.3	0.0	1,005.3
Percent of total	4.2%	4.9%	12.4%	6.1%	7.8%	64.5%	0.0%	0.1%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-51. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Lake Oswego	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	974.1	1.3	0.0	754.5	1.3	0.0	67.2	570.2	299.8	213.6	372.9	418.8	1,005.3
Percent of total acres in inventory	96.9%	0.1%	0.0%	75.1%	0.1%	0.0%	6.7%	56.7%	29.8%	21.2%	37.1%	41.7%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-52. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lake Oswego	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ Intact topsoil	Non-forest woody vegetation					
Acres	27.2	2.7	965.2	5.3	0.1	4.8	1,005.3
Percent of total	2.7%	0.3%	96.0%	0.5%	0.0%	0.5%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-53. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lake Oswego	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1005.3	0.1	3.0	1008.3	11
Percent of total	99.7%	0.0%	0.3%	100.0%	N/A

*Habitats of Concern.

Table G-54. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lake Oswego Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total Inventoried habitat
Water	12.52	0.1	1.2%
Barren	29.00	1.1	3.0%
Low structure agriculture	11.67	0.0	1.2%
High structure agriculture	0.09	0.0	0.0%
Deciduous closed canopy	194.29	0.4	19.3%
Mixed closed canopy	243.22	0.3	24.2%
Conifer closed canopy	229.59	0.3	22.8%
Deciduous open canopy	69.77	0.2	6.9%
Mixed open canopy	58.34	0.0	5.8%
Conifer open canopy	21.81	0.0	2.2%
Deciduous scattered canopy	34.34	0.1	3.4%
Mixed scattered canopy	25.13	0.0	2.5%
Conifer scattered canopy	19.39	0.1	1.9%
Closed canopy shrub	26.18	0.0	2.6%
Open canopy shrub	10.64	0.1	1.1%
Scattered canopy shrub	10.09	0.0	1.0%
Meadow/grass	9.19	0.2	0.9%
Not classified	0.00	0.0	0.0%
Total	1,005.26	3.0	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-55. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Lake Oswego	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	30.0	4.9	5.3	13.1	897.4	30.3	11.8
Percent of total	3.0%	0.5%	0.5%	1.3%	89.0%	3.0%	1.2%

[1]See Table G-54 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #23: Tryon Creek subwatershed

Named streams: Forest Creek, Tryon Creek, Willamette River
Communities within the subwatershed: Lake Oswego, Portland, unincorporated Clackamas county, unincorporated Multnomah county
Total acreage within Metro's boundary: 4,356.4
Total acres within the riparian corridor: 1,972.8

This site contains one percent of the area comprising Metro's jurisdictional boundary. Sixty-eight percent of the site is in the City of Portland, with another 20 percent in Lake Oswego. The remainder is in unincorporated Clackamas (seven percent) and Multnomah (five percent) counties (Table G-56).

This site's road density of 14.6 miles per square miles places it in the third quartile (51 to 75% of maximum) compared to all other resource sites (Table G-2). Considering the amount of habitat preserved in Tryon Creek State Park and adjacent Marshall Park, combined with the average development intensity falling within the third quartile of all sites, the areas outside of the habitat patches may be considered highly developed. As with the majority of other resource sites in Group G, single family residential is the dominant zoning pattern (Table G-5). However, a relatively low number of building permits (285) have been issued in this site since 1996 (Table G-2).

Riparian resources. More than 45 percent of this site is part of the riparian corridor inventory, second only to Site #1 (Table 12). It contributes two percent of the region's total riparian resources (Table 13).

This resource site contains 24 total stream miles, of which 11 percent are stream links, suggesting relatively low amounts of piping and culverting (Table G-3). Non-piped stream density is 0.0048 miles per acre, the highest in Group G and also the highest of all 27 resource sites (Tables 12 and G-3). However, one quarter of the non-piped stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in nearly three stream miles (Table G-2). Approximately 2-1/2 percent of the site is floodplain, and less than one percent is wetland (Tables G-2 and G-3). Approximately 34 percent of the floodplain is developed, the third highest of all 27 resource sites (Table 14).

Approximately 24 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and 37 percent received at least one primary score (Table G-59). The highest percentage of land receiving a primary score was divided about equally between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table G-58; see also Table 4 and Appendix 7 for description of ecological functions mapping).

Wildlife habitat resources. Including Habitats of Concern, 44 percent of the lands in this site fall within the wildlife habitat inventory, ranking it third among the 27 resource sites and second of the eight Group G resource sites – although it accounts for more habitat within the regional system than the first-ranked site within Group G (2.5 versus 1.9 percent, respectively; Table 16). Within model patches, a remarkable 84 percent of the acreage falls within the top third of the point range (Table G-60). Of the four criteria in the GIS model, by far the highest proportion of the acreage falls in the middle score category for size, interior, and water, while most of the acreage falls in the tope score category for connectivity (84, 84, 91, and 88 percent, respectively) (Table G-61). The high proportion of acreage accounted for in the size criterion indicates that nearly all of the lands within 300 ft of streams are forested, because low-structure patch types are not scored for this criterion (see also Table G-62).

Conifer and hardwood forest strongly predominate habitat types in this resource site (93 percent) (Table G-65). Wetlands cover only 0.2 percent of the site's wildlife habitat, proportionally the lowest of the 27 resource sites. The site contributes little to the region's wetland resources, because wetlands are uncommon in the mid- to high-gradient habitats representative of this resource site.

In general, this highly developed site can be characterized as providing extraordinarily important interior habitat to the region's wildlife, with a substantial proportion protected by parks and public lands. Many Neotropical migratory birds breed in this site and also use it for important stopover habitat, and it abounds with deer, beaver, and other mammal sign. Tryon Creek State Park includes southern connectivity to the Willamette River through a narrow corridor. Many developed areas also contain very important tree cover, providing key connectivity from core areas such as Tryon Creek State Park to peripheral, but very important, habitats at the outer edge of large patches, such as Maricara Nature Park. Some of these areas along streams are steeply sloped and thus receive protection through Title 3. One drawback of this resource site is that it is not well connected with adjacent resource sites (except for Site #26), such as Resource Sites # 12, 14 and 22; increasing connectivity to these sites, primarily along streams, would be a valuable restoration activity. Retaining or improving existing tree canopy in developments connected to the parklands is another important factor that will influence the value of this site's habitat in the future.

Species of Concern. Three Species of Concern sighting locations fall within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Willow Flycatcher
- Northern Pygmy Owl

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-65). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 114

Resource site data tables: Riparian Corridors

Table G-56. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Lake Oswego	876.9
Portland	2,958.2
Unincorporated Clackamas County	294.8
Unincorporated Multhomah County	226.5

Table G-57. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Tryon Creek	4,356.5	1,972.8

Table G-58. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Tryon Creek	Microclimate & shade	454.5	23.0%	1,119.1	56.7%
	Streamflow moderation & water storage	74.4	3.8%	1,850.2	93.8%
	Bank stabilization & pollution control	623.5	31.6%	83.4	4.2%
	Large wood & channel dynamics	651.9	33.0%	289.0	14.6%
	Organic material sources	441.3	22.4%	213.9	10.8%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table G-59. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Tryon Creek	1 to 5	1,239.8	62.8%
	6 to 11	162.2	8.2%
	12 to 17	97.0	4.9%
	18 to 23	44.8	2.3%
	24 to 29	389.9	19.8%
	30	39.1	2.0%
	Total acres	1,972.8	100.0%

Resource site data tables: Wildlife Habitat

Table G-60. Breakdown of total wildlife model patch scores.*

Resource site: Tryon Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	23.6	46.3	81.9	86.2	10.4	50.8	0.0	1,597.8	0.0	1,896.9
Percent of total	1.2%	2.4%	4.3%	4.5%	0.5%	2.7%	0.0%	84.2%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-61. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Tryon Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	219.1	1,597.8	0.0	67.6	1,597.8	0.0	44.3	1,716.4	74.8	94.3	139.2	1,663.4	1,896.9
Percent of total acres in inventory	11.6%	84.2%	0.0%	3.6%	84.2%	0.0%	2.3%	90.5%	3.9%	5.0%	7.3%	87.7%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-62. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Tryon Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	80.0	0.0	1,814.2	2.1	0.0	0.6	1,896.9
Percent of total	4.2%	0.0%	95.6%	0.1%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-63. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Tryon Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	1896.9	646.6	0.6	1897.5	3
Percent of total	100.0%	34.1%	0.0%	100.0%	N/A

*Habitats of Concern.

Table G-64. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Tryon Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	0.94	0.0	0.0%
Barren	32.05	0.4	1.7%
Low structure agriculture	0.00	0.0	0.0%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	521.43	0.0	27.5%
Mixed closed canopy	649.81	0.0	34.2%
Conifer closed canopy	281.44	0.0	14.8%
Deciduous open canopy	112.95	0.0	6.0%
Mixed open canopy	79.98	0.0	4.2%
Conifer open canopy	11.48	0.0	0.6%
Deciduous scattered canopy	54.44	0.0	2.9%
Mixed scattered canopy	43.00	0.1	2.3%
Conifer scattered canopy	7.88	0.0	0.4%
Closed canopy shrub	52.16	0.0	2.7%
Open canopy shrub	16.53	0.0	0.9%
Scattered canopy shrub	13.02	0.0	0.7%
Meadow/grass	19.79	0.0	1.0%
Not classified	0.00	0.0	0.0%
Total	1,896.90	0.6	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-65. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Tryon Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	28.0	0.6	2.1	3.8	1,762.5	49.3	0.0
Percent of total	1.5%	0.0%	0.1%	0.2%	92.9%	2.6%	0.0%

[1]See Table G-64 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #24: Johnson Creek-Crystal Springs Creek subwatershed

Named streams: Crystal Springs Creek, Johnson Creek, Veterans Creek
Communities within the subwatershed: Happy Valley, Milwaukie, Portland, unincorporated Clackamas county, unincorporated Multnomah county
Total acreage within Metro's boundary: 7,844.6
Total acres within the riparian corridor: 1,309.7
Other information: One barrier to fish passage present with unknown impacts.

This site contains three percent of the area comprising Metro's jurisdictional boundary. The majority of the site (63 percent) is in the City of Portland; 16 percent is in Milwaukie, 19 percent in unincorporated Clackamas County, and the remainder is in Happy Valley and unincorporated Multnomah County (about one percent each) (Table G-66).

This site has the highest road density of all resource sites, at 20.9 road miles per square mile (Table G-2). As with other highly urban resource sites, the dominant zoning is single family residential (Table G-5). About 1,000 building permits have been issued in this site since 1996 (Table G-2).

Riparian resources. Fifteen percent of this site is part of the riparian corridor inventory, ranking it last in Group G (Table 12). It contributes a little over one percent of the region's total riparian resources (Table 13).

This resource site contains 35 total stream miles, of which 59 percent are stream links, suggesting very high levels of piping and culverting (Table G-3). As a result, non-piped stream density is 0.0018 miles per acre, ranking it 25^{th} of the 27 resource sites (Tables 12 and G-3). Reflecting the highly urban and modified nature of this resource site, 47 percent of non-piped stream miles are DEQ 303(d) listed (Table G-2). However, anadromous fish are known to be present in more than eight stream miles (Table G-2). Low to medium gradient streams predominate (Table G-3); approximately seven percent of the site is floodplain, and less than one percent is wetland (Tables G-2 and G-3). Approximately 52 percent of the floodplain is developed – the highest level of all 27 resource sites (Table 14).

Approximately 27 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and 44 percent received at least one primary score (Table G-69). The highest percentage of land receiving a primary score was divided about equally between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table G-68; see also Table 4 and Appendix 7 for description of ecological functions mapping). The developed floodplain component of this resource site resulted in high secondary *Streamflow moderation and water storage* percentages.

Wildlife habitat resources. Including Habitats of Concern, 10 percent of the lands in this site fall within the wildlife habitat inventory, ranking it last among the 27 resource sites; this is not surprising considering the site's highly developed nature (Table 16). Within model patches, only one tenth of one percent of the acreage falls within the top third of the point range, with 58 percent in the mid-range and the remainder in the lowest score category (Table G-70). Of the four criteria in the GIS model, virtually all of the acreage falls in the lowest score category for size and interior (Table G-71). The majority of acreage falls in the middle category for waterk although substantial acreage is also in the highest and lowest categories; the connectivity scores fall primarily in the middle and low categories. Together, these factors add up to a fairly sparse, fragmented habitat system that is often typical of highly developed watersheds. The relatively high proportion of acreage accounted for in the size and interior criteria suggest that the majority of the lands within 300 ft of streams are forested, because low-structure patch types are not scored for these criteria (see also Table G-72).

Conifer and hardwood forest are predominant habitat types in this resource site (78 percent), but grasslands, wetlands and open water also contribute important habitat (Table G-75). Wetlands cover six percent of the site's wildlife habitat. The site contributes one-half of one percent to the region's wetland resources, ranking 21st among the 27 resource sites.

In general, this highly developed site can be characterized as providing relatively small amounts of habitat that is generally isolated and fragmented. However, the complex of natural areas comprised of Crystal Springs, Reed College Canyon and Westmoreland Golf Course provides important habitat to the site and is less than half a mile from Oaks Bottom, which has excellent water resources and connects to the Willamette River. Street and backyard trees provide a modest level of connectivity for birds between these natural areas. Johnson Creek and the Springwater Corridor provide key migratory bird stopover habitat; although these areas do not rate highly in the regional wildlife habitat inventory, they are locally very important to wildlife. Several relatively large habitat patches in site's eastern area, including Lincoln Memorial Park and Willamette National Cemetery, provide key habitat in this area and connect to Resource Site #20, following the Johnson Creek complex. Key wildlife habitat improvements in this area might include increasing the forest canopy cover throughout the resource site, including backyard and street trees, but particularly along waterways.

Species of Concern. One Species of Concern sighting location falls within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Great Blue Heron nesting colony

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-75). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 33, 127, 128, 130, 135

Resource site data tables: Riparian Corridors

Table G-66. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Happy Valley	78.5
Milwaukie	1,273.7
Portland	4,909.3
Unincorporated Clackamas County	1,494.5
Unincorporated Multhomah County	88.7

Table G-67. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Johnson - Crystal Springs Creeks	7,844.6	1,176.5

Table G-68. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	Primary Value		Secondary Value	
		Acres*	% of Total**	Acres	% of Total
Johnson - Crystal Springs Creeks	Microclimate & shade	167.7	14.3%	227.0	19.3%
	Streamflow moderation & water storage	306.3	26.0%	802.4	68.2%
	Bank stabilization & pollution control	400.3	34.0%	17.7	1.5%
	Large wood & channel dynamics	460.5	39.1%	47.4	4.0%
	Organic material sources	297.9	25.3%	40.1	3.4%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table G-69. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Johnson - Crystal Springs Creeks	1 to 5	653.0	55.5%
	6 to 11	76.7	6.5%
	12 to 17	134.5	11.4%
	18 to 23	28.8	2.4%
	24 to 29	216.8	18.4%
	30	66.7	5.7%
	Total acres	1,176.5	100.0%

Resource site data tables: Wildlife Habitat

Table G-70. Breakdown of total wildlife model patch scores.*

Resource site: Johnson - Crystal Springs Creeks	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	74.9	157.6	110.1	78.5	334.5	54.1	1.1	0.0	0.0	810.8
Percent of total	9.2%	19.4%	13.6%	9.7%	41.3%	6.7%	0.1%	0.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-71. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Johnson - Crystal Springs Creeks	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	592.9	0.9	0.0	407.5	0.0	0.0	147.1	371.1	173.2	324.5	344.4	141.9	810.8
Percent of total acres in inventory	73.1%	0.1%	0.0%	50.3%	0.0%	0.0%	18.1%	45.8%	21.4%	40.0%	42.5%	17.5%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-72. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Johnson - Crystal Springs Creeks	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	217.0	0.0	551.8	13.4	12.0	16.5	810.8
Percent of total	26.8%	0.0%	68.1%	1.7%	1.5%	2.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-73. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Johnson - Crystal Springs Creeks	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	810.8	91.4	7.7	818.5	1
Percent of total	99.1%	11.2%	0.9%	100.0%	N/A

*Habitats of Concern.

Table G-74. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Johnson - Crystal Springs Creeks Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	10.43	0.1	1.3%
Barren	54.99	0.5	6.8%
Low structure agriculture	0.00	0.0	0.0%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	142.65	0.8	17.5%
Mixed closed canopy	183.26	0.6	22.5%
Conifer closed canopy	78.44	1.0	9.7%
Deciduous open canopy	86.62	1.1	10.7%
Mixed open canopy	44.09	0.5	5.5%
Conifer open canopy	11.48	0.2	1.4%
Deciduous scattered canopy	45.23	0.5	5.6%
Mixed scattered canopy	27.49	0.2	3.4%
Conifer scattered canopy	10.33	0.1	1.3%
Closed canopy shrub	35.20	0.8	4.4%
Open canopy shrub	19.78	0.7	2.5%
Scattered canopy shrub	17.78	0.3	2.2%
Meadow/grass	43.06	0.2	5.3%
Not classified	0.00	0.0	0.0%
Total	810.83	7.7	100.0%

The table below provide s estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-75. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site: Johnson - Crystal Springs Creeks	Habitat type						
	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	24.1	28.5	13.4	46.4	634.7	81.8	0.0
Percent of total	2.9%	3.5%	1.6%	5.7%	77.5%	10.0%	0.0%

[1]See Table G-74 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #25: Mount Scott Creek subwatershed

Named streams: Forest Creek, Johnson Creek, Kellogg Creek, Mount Scott Creek, Phillips Creek, Willamette River

Communities within the subwatershed: Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Portland, unincorporated Clackamas county, unincorporated Multnomah county

Total acreage within Metro's boundary: 11,809.6

Total acres within the riparian corridor: 2,665.7

Other information: Three dams present, two with unknown impacts to fish, one with a present and functioning fishway.

This site contains four percent of the area comprising Metro's jurisdictional boundary. Most of the site falls within three jurisdictions: unincorporated Clackamas County (67 percent), Milwaukie (15 percent) and Happy Valley (14 percent). Two percent is in unincorporated Multnomah County, with the remaining jurisdictions – Gladstone, Johnson City, Lake Oswego, and Portland – containing one percent or less of the site (Table G-76).

This site is similar in development intensity to Resource Sites #20-23, with a road density of 14.3 miles per square mile, falling in the third quartile (51 to 75 percent of maximum) compared to all other resource sites (Table G-2). Similar to those sites, single family residential zoning dominates (Table G-5). About 1,450 building permits have been issued here since 1996 (Table G-2).

Riparian resources. Approximately 23 percent of this site is part of the riparian corridor inventory, ranking it sixth of the eight resource sites in Group G (Table 12). However, because the site has a substantial amount of land within the Metro boundary, it contributes a relatively high amount (three percent) of the region's riparian resources relative to all other resource sites (Table 13).

This resource site contains 47 total stream miles, of which 34 percent are stream links, suggesting moderately high levels of piping and culverting (Table G-3). Non-piped stream density is 0.0026 miles per acre; two of the eight sites in Group G contain lower stream densities (Tables 12 and G-3). Slightly more than two percent of non-piped stream miles are DEQ 303(d) listed (Table G-2). Anadromous fish are known to be present in more than nine stream miles (Table G-2). Six percent of the site is floodplain, and one percent is wetland (Table G-2). Twenty-one percent of the floodplain is developed, ranking this site sixth among all 27 resource sites (Table 14).

Nearly a third of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and 46 percent received at least one primary score (Table G-79). Similar to Site #24, the highest percentage of land receiving a primary score was divided about equally between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table G-78; see also Table 4 and Appendix 7 for description of ecological functions mapping). Sixty-eight percent of this site's riparian corridor acreage received secondary scores for *Streamflow moderation and water storage*, and another 29 percent received secondary scores for *Microclimate and shade*.

Wildlife habitat resources. Including Habitats of Concern, 19 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 21st among the 27 resource sites and sixth among the eight Group G sites (Table 16). Within model patches, only four percent of the acreage falls within the top third of the point range, although 68 percent falls in the mid-range (Table G-80). Of the four criteria in the GIS model, most of the acreage falls in the lowest score category for size and interior (Table G-81). Approximately half of the acreage falls in the middle category for water, with another 28 percent in the lowest score category; the connectivity scores fall primarily in the highest and middle categories. The proportion of acreage accounted for in the size and interior criteria suggest that a relatively small but significant amount of lands within 300 ft of streams are unforested, because low-structure patch types are not scored for these criteria (see also Table G-82).

Conifer and hardwood forest are predominant habitat types in this resource site (77 percent), but open water, grasslands and wetlands also contribute important habitat (Table G-85). Wetlands cover seven percent, the highest of the Group G sites. The site contributes two percent to the region's wetland resources, ranking 14th among the 27 resource sites.

In general, this site can be characterized as providing a moderate amount of wildlife habitat, of moderate quality; however, placed within the urbanized context, the existing habitat is very important to wildlife in that area. A majority of the habitat is aggregated into several relatively large patches, with some important interior habitat. Water resources are moderate, but connectivity is good relative to many other sites with similar development intensity. The key wildlife habitat sites are along or adjacent to streams, with relatively little protection through parks or public lands. Important upland habitat is provided by Mt. Talbert, with important migratory bird stopover habitat.

Species of Concern. Four Species of Concern sighting location falls within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Western Painted Turtles
- Pileated Woodpecker
- *Cimicifuga elata* (plant species)
- *Sidalcea nelsoniana* (plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table G-85). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 18, 21, 32, 116, 123, 124, 138, 162, 166

Resource site data tables: Riparian Corridors

Table G-76. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Gladstone	111.7
Happy Valley	1,645.3
Johnson City	43.7
Lake Oswego	9.0
Milwaukie	1,824.6
Portland	12.4
Unincorporated Clackamas County	7,888.3
Unincorporated Multnomah County	274.6

Table G-77. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Mount Scott Creek	11,809.8	2,662.6

Table G-78. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Mount Scott Creek	Microclimate & shade	469.5	17.6%	780.3	29.3%
	Streamflow moderation & water storage	684.3	25.7%	1,807.3	67.9%
	Bank stabilization & pollution control	1,050.6	39.5%	103.5	3.9%
	Large wood & channel dynamics	1,031.6	38.7%	125.5	4.7%
	Organic material sources	573.9	21.6%	100.1	3.8%

*Number of acres scored within the riparian corridor for each function

**Percent of total acres within the riparian corridor

Table G-79. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Mount Scott Creek	1 to 5	1,428.8	53.7%
	6 to 11	202.8	7.6%
	12 to 17	217.1	8.2%
	18 to 23	282.8	10.6%
	24 to 29	331.4	12.4%
	30	199.8	7.5%
	Total acres	2,662.6	100.0%

Resource site data tables: Wildlife Habitat

Table G-80. Breakdown of total wildlife model patch scores.*

Resource site: Mount Scott Creek	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	129.8	175.3	287.2	350.4	753.8	366.2	4.6	85.2	0.0	2,152.5
Percent of total	6.0%	8.1%	13.3%	16.3%	35.0%	17.0%	0.2%	4.0%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-81. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Mount Scott Creek	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	1,694.6	89.8	0.0	1,208.0	85.2	0.0	600.6	1,064.9	308.9	546.8	697.1	908.5	2,152.5
Percent of total acres in inventory	78.7%	4.2%	0.0%	56.1%	4.0%	0.0%	27.9%	49.5%	14.3%	25.4%	32.4%	42.2%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table G-82. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Mount Scott Creek	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	353.2	14.9	1,650.5	46.7	40.6	46.7	2,152.5
Percent of total	16.4%	0.7%	76.7%	2.2%	1.9%	2.2%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table G-83. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Mount Scott Creek	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	2152.5	544.1	50.5	2203.1	4
Percent of total	97.7%	24.7%	2.3%	100.0%	N/A

*Habitats of Concern.

Table G-84. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Mount Scott Creek Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	8.28	7.6	0.7%
Barren	142.85	13.6	7.1%
Low structure agriculture	7.44	0.5	0.4%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	368.33	2.9	16.9%
Mixed closed canopy	517.64	2.8	23.6%
Conifer closed canopy	282.66	0.8	12.9%
Deciduous open canopy	178.18	4.9	8.3%
Mixed open canopy	115.18	1.0	5.3%
Conifer open canopy	29.80	0.0	1.4%
Deciduous scattered canopy	109.53	1.2	5.0%
Mixed scattered canopy	70.02	1.0	3.2%
Conifer scattered canopy	19.29	0.3	0.9%
Closed canopy shrub	92.98	1.9	4.3%
Open canopy shrub	42.69	0.8	2.0%
Scattered canopy shrub	40.63	1.7	1.9%
Meadow/grass	127.05	9.5	6.2%
Not classified	0.00	0.0	0.0%
Total	2,152.53	50.5	100.0%

The table below provide s estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table G-85. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Mount Scott Creek	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	222.6	87.2	46.7	147.0	1,705.6	222.3	7.9
Percent of total	10.1%	4.0%	2.1%	6.7%	77.4%	10.1%	0.4%

[1]See Table G-84 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

H. Scappoose Creek

General watershed information

Resource sites in the Scappoose Creek Watershed include:

- Lower Willamette River subwatersheds
- Columbia Slough and Multnomah Channel subwatersheds (combined)

Watershed assessments and plans

Bureau of Environmental Services, City of Portland, 2001. *Relationships Between Bank Treatment / Nearshore Development and Anadromous / Resident Fish in the Lower Willamette River,* City of Portland: Portland, Oregon.

Bureau of Planning, 1991. City of Portland, *Balch Creek Watershed Protection* Plan, February, 8, 1991, City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1990. *East Columbia Neighborhood Natural Resources Management Plan,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1990. *Natural Resources Management Plan for Smith and Bybee Lakes, May 8, 1990,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1991. *The Northwest Hills Natural Areas Protection Plan, July 31, 1991,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1992. *The Southwest Hills Resource Protection Plan, January 23, 1992,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1993. *The East Buttes, Terraces and Wetlands Conservation Plan, May 26, 1993,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1994. *Skyline West Conservation Plan, September 21, 1994,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 1997. *Portland Environmental Handbook,* City of Portland: Portland, Oregon.

Bureau of Planning, City of Portland, 2001. *Portland's Willamette River Atlas,* City of Portland: Portland, Oregon.

Community and Economic Development Department, City of Gresham, 1988. *Inventory of Significant Natural Resources and Open Spaces,* City of Gresham: Gresham, Oregon.

Lev, Esther, 2001. *Wildlife Habitat Inventory for the Willamette River,* Environmental Consulting: Portland, Oregon.

Lower Columbia River Estuary Program, 1999. *Lower Columbia River Estuary Plan, Volumes 1-3,* Lower Columbia River Estuary Program: Portland, Oregon.

Moses, Todd, 1993. *Stream Rehabilitation Concepts, Upper Fairview Creek, Gresham, Oregon,* Watershed Applications: Portland, Oregon.

Portland Parks and Recreation, Bureau of Planning, City of Portland, 1995. *Forest Park, Natural Resources Management Plan,* City of Portland: Portland, Oregon.

United States Geological Service (USGS), 2000. *Willamette Basin Ground-Water Study,* USGS: Portland, Oregon.

USGS, 1995. *NAWQA Willamette Basin Study,* USGS: Portland, Oregon.

Wells, Scott, 1997. *Columbia Slough Technical Report*, Portland State University: Portland, Oregon.

Willamette Basin Task Force, Pacific Northwest River Basins Commission, 1969. *The Willamette Basin, Comprehensive Study of Water and Related Land Resources,* Pacific Northwest River Basins Commission: Portland, Oregon.

Willamette Basin Task Force, Pacific Northwest River Basins Commission, 1997. *The Willamette Basin, Recommendations to Governor John Kitzhaber,* Willamette River Basin Task Force: Portland, Oregon.

Willamette Restoration Initiative, 2001. *Restoring A River of Life, The Willamette Restoration Strategy Overview, February 2001,* Willamette Restoration Initiative: Portland, Oregon.

Willamette Restoration Initiative, 2001. *Restoring A River of Life, The Willamette Restoration Strategy – Recommendations for the Willamette Basin Supplement to the Oregon Plan for Salmon and Watersheds, February 2001,* Willamette Restoration Initiative: Portland, Oregon.

Watershed councils and related groups

Arnold Creek, Friends of, 4106 SW Vacuna Street, Portland 97219, 503-244-9958, Amanda Fritz

Balch Creek, Friends of, 5240 NW Cornell Road, Portland 97210, 503-297-3613, Eberhard Gloekler

Blue and Fairview Lakes Land Trust, 503667-4547, Jane Graybill

Blue Fairview Lakes , Friends of, 21130 NE Interlachen Lane, Interlachen 97024, (503) 667-4547, Jane Graybill

Citizens Interested in Bull Run, Inc. 503-665-4777, Frank Gearhart

Columbia Children's Arboretum Preservation Committee, 9509 NE 13th Ave., Portland 97211, Martha Johnson

Columbia Slough Watershed Council, 7040 NE 47th Ave., Portland 97218-1212, (503) 281-1132, FAX (503) 281-5187

Columbia Slough Program, City of Portland, Bureau of Environmental Services, 503-823-7268

Fairview Creek Watershed Group, 2115 SE Morrison St., Portland 97214, (503) 661-7612, FAX (503) 661-5296

Fairview Creek Watershed Council, PO Box 36, Fairview 97024, (503) 231-2270, Shannon Schmitt

Fairview Creek Watershed Conservation Group, PO Box 36, Fairview 97204, 503-669-6000, Gregory Dresden

Forest Park, Friends of, PO Box 2413, Portland 97208, 503-223-5449, Lee Kellogg

Lower Columbia WS Council, 12589 Hwy 30, Clatskanie 97016, 503-728-9015, Margaret Magruder

(Multnomah Channel) Friends of Retaining the Channel Environment, 13010 NW Marina Way, Portland 97231, 503-285-6756, Mark Valeske

Oaks Bottom Wildlife Refuge, 7516 SE 21st, Portland 97202, 503-654-8454, Martha Taylor

Oaks Bottom Management Committee, 2115 SE Morrison Street, Ste. 201, Portland 97214, 503-231-2270, Steve Fedje

Sauvie Island Conservancy, 19300 NW Sauvie Island Road, Portland 97231, 503-621-3049, Donna Matrazzo

Skyline Ridge, Citizens for Preservation of, 15400 NW McNamee Road, Portland 97231, 503-621-3564, Chris Foster

Smith and Bybee Lakes, Friends of, PO Box 83862, Portland 97283, 503-240-0233, Jeffrey Kee

West Hills Streams, Friends of, 6039 Knights Bridge Drive, Portland 97219, 503-246-0449, Liz Callison

Wetlands, Friends of, 503-253-6247, Alice Blatt

Willamette River Restoration Committee, 541-484-9466, Timothy Green

Data descriptions

Table H-1 provides information about the subwatersheds within each watershed, the HUC code, and the acres inside Metro's jurisdictional boundary. Keying in on the resource site number will show how the subwatersheds are aggregated into the resource sites listed above.

Both of the Resource Sites in Section H fall within the Scappoose Creek watershed. Resource Site #26 is comprised only of its namesake subwatershed, Lower Willamette River. Resource Site #27 combines the Columbia Slough and Multnomah Channel subwatersheds.

Tables H-1 and H-2 provide general description about the 5^{th} field and 6^{th} field HUCs. Below these tables are descriptions of the riparian and wildlife habitat resources resource site.

Watershed data tables

Table H-1. Watersheds (5th level HUC), subwatersheds (6th level HUC), and acres within Metro jurisdictional boundary.

Watershed (5th level HUC)	5th field HUC code	Resource site #	Subwatershed (6th level HUC)	6th field HUC code	Acres in Metro
Scappoose Creek	1709001202	26	Lower Willamette River	170900120201	32,899.0
		27	Columbia Slough	170900120202	53,571.9
			Multnomah Channel	170900120203	1,037.6

Table H-2. Resource sites: general information.

General information	Lower Willamette	Columbia Slough
Miles of DEQ 303(d) listed streams	13.3	43.3
Road density (road miles/square miles in subwatershed)	20.4	12.0
Miles of stream with known anadromous fish presence	13.3	21.7
Acres of hydrologically connected wetlands	262.2	3,298.1
Total acres of wetlands	262.2	3,329.7
Acres of floodplains (100 year FEMA + 1996 inundation area)	3,409.4	15,814.1
Acres of developed floodplains	317.8	993.8
Building permits since 1996 (number)	2,775.0	3,414.0

Table H-3. Characteristics of stream miles by resource site.

Resource site	Stream miles by channel type		Miles of stream links*	Miles of streams not categorized by channel type	Total stream miles
	Low to medium	*High*			
Lower Willamette River	17.9	27.2	31.9	10.0	87.0
Columbia Slough	81.5	6.7	33.7	23.7	145.5

*Stream links are links between surface streams and may be piped or culverted.

Table H-4. Riparian vegetation by resource site.

Resource site	Vegetation types within 300 feet of a stream (acres)			Forested vegetation >300 feet from a stream
	Low structure vegetation/intact topsoil	Non-forest woody vegetation	Forested vegetation	
Lower Willamette River	248.5	13.2	2,546.3	5,555.5
Columbia Slough	2,385.6	118.5	1,659.6	3,393.5

Table H-5. Regional zoning by resource site.

Resource site	Acres by zone within each resource site						
	Commercial	Industrial	Multi-family residential	Public/open space	Rural	Single family residential	Mixed use
Lower Willamette River	2,282.3	6,606.4	2,618.6	6,618.3	1,543.8	11,655.0	1,536.7
Columbia Slough	2,597.7	18,256.2	2,923.2	7,167.6	8,308.4	13,636.8	1,247.8

SITE #26: Lower Willamette River subwatershed

Named streams: Balch Creek, Doane Creek, Johnson Creek (west side), Marquam Gulch, Saltzman Creek, Willamette River
Communities within the subwatershed: Milwaukie, Portland, unincorporated Clackamas County, unincorporated Multnomah County
Total acreage within Metro's boundary: 32,899
Total acres within riparian corridor: 10,977.2

This site contains 11 percent of the area comprising Metro's jurisdictional boundary, surpassed only by Site #27, Columbia Slough. Ninety-five percent of the site falls within the City of Portland's boundaries; the remainder is in unincorporated Multnomah County (four percent), unincorporated Clackamas County (one percent), and Milwaukie (less than one percent) (Table H-6).

This site is the second most highly developed of all resource sites, based on the road density of 20.4 road miles per square mile (Table H-2). Zoning is dominated by single family residential use, but industrial lands and public/open space also contribute substantial zoning acreages (Table H-5). Nearly 2,800 building permits have been issued here since 1996, although that number is not outstandingly high considering the resource site's contribution to the Metro boundary's land base (Table H-2).

Riparian resources. One-third of this site is part of the riparian corridor inventory (Table 12). Resource Site #26 contributes nearly 12 percent of the region's riparian corridor resources; together with the other Group H resource site, these two sites comprise a full third of the region's riparian inventory (Table 13).

This resource site contains 87 total stream miles, of which 37 percent are stream links, suggesting high levels of piping and culverting (Table H-3). Despite the strong contribution to regional riparian resources, non-piped stream density is only 0.0017 miles per acre; the site ranks second to last of all 27 resource sites in terms of stream density (Tables 12 and H-3). Twenty-four percent of non-piped stream miles are DEQ 303(d) listed (Table H-2). Anadromous fish are known to be present in more than thirteen stream miles (Table H-2). Stream gradients are mixed, but dominated by high gradients (Table H-3); however, ten percent of the site is floodplain, and one percent is wetland (Tables H-2 and H-3). Approximately ten percent of the floodplain is developed, a relatively low proportion given the site's development intensity.

Approximately 34 percent of this site's acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and 44 percent received at least one primary score (Table H-9). The highest percentage of land receiving a primary score was divided about equally between *Large wood and channel dynamics* and *Bank stabilization and pollution control* (Table H-8; see also Table 4 and Appendix 7 for description of ecological functions mapping). However, *Streamflow moderation and water storage* was also an important primary function in this site, and also provided very substantial secondary functions (70 percent of the site's riparian acreage included this secondary function).

Wildlife habitat resources. Including Habitats of Concern, 27 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 11th among the 27 resource sites and first of the two Group H resource sites (Table 16). Within model patches, 78 percent of the acreage falls within the top third of the point range, ranking second among the 27 resource sites, behind Resource Site #23 (Tryon Creek) (Table 17).

Of the four criteria in the GIS model, 87 percent of the acreage falls in the lowest size score category, with another ten percent in the medium category (Table H-11). For habitat interior, the acreage falls primarily in the top category (66 percent), but nearly one quarter also falls within the lowest score category, with little in the middle class. That is because Forest Park comprises a substantial proportion of the habitat in this site, but much of the remainder consists of relatively small, isolated habitat patches east of the Willamette River. This site scores strongly in the middle score category for water (83 percent), but receives excellent scores for connectivity, with 89 percent of all acreage receiving the top score. Again, this is influenced by Forest Park. The total proportion of acreage accounted for in the size and interior criteria suggest that a relatively small amount of lands within 300 ft of streams are unforested, because low-structure patch types are not scored for these criteria (see also Table H-12).

Conifer and hardwood forest strongly predominate the habitat types in this resource site (92 percent), but open water is also an extremely important habitat type here (Table H-15). A relatively extensive series of oak woodlands are present in this site, identified through Habitats of Concern (based on local expert knowledge). Wetlands cover three percent of this site's wildlife habitat, slightly lower than the other Group H site; this number is negatively influenced by the large amount of habitat covered by Forest Park, a fairly steeply sloped area generally lacking in wetlands. This site contributes three percent to the region's wetland resources, ranking 8th among the 27 resource sites.

In general, this site can be characterized as providing a large amount of very high quality wildlife habitat. Forest Park is one of the most highly rated habitat patches in the entire urban region; it provides very extensive interior habitat for nesting Neotropical migrants and area-sensitive species, is likely a source habitat for species repopulation to other patches, and is an elk migratory corridor. A substantial portion of Forest Park and associated areas is also situated in Resource Site #27, to the north of this site. This resource site includes a long segment of the Willamette River, contributing important open water and riverine island habitat important to Bald Eagle, Osprey, waterfowl, shorebirds and migratory birds. This site is uniquely important to the region's wildlife.

Species of Concern. Twenty-three Species of Concern sighting location falls within the site, attesting to the site's importance in the regional wildlife habitat system. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Band-tailed Pigeon
- Bald Eagle
- Peregrine Falcon
- Purple Martin
- Painted Turtle
- Western Meadowlark

- Bufflehead
- Dusky Canada Goose
- Merlin
- Western Pond Turtle
- Great Blue Heron nesting colony
- *Fluminicola fuscus* (plant species)
- *Rorippa columbiae* (plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and open water (see Table H-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.
The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 1, 2, 3, 4, 16, 22, 23, 24, 26, 27, 28, 29, 30, 31, 33, 49, 50, 75, 76, 77, 79, 81, 115, 129, 130, 132, 162, 167

Resource site data tables: Riparian Corridors

Table H-6. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Milwaukie	66.8
Portland	31,240.2
Unincorporated Clackamas County	178.3
Unincorporated Multnomah County	1,413.8

Table H-7. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Lower Willamette River	32,899.2	10,940.8

Table H-8. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Lower Willamette River	Microclimate & shade	1,052.5	9.6%	4,345.5	39.7%
	Streamflow moderation & water storage	3,112.4	28.4%	7,693.0	70.3%
	Bank stabilization & pollution control	4,521.4	41.3%	2,430.3	22.2%
	Large wood & channel dynamics	4,453.8	40.7%	877.8	8.0%
	Organic material sources	1,140.5	10.4%	566.1	5.2%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table H-9. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Lower Willamette River	1 to 5	6,080.8	55.6%
	6 to 11	460.3	4.2%
	12 to 17	689.8	6.3%
	18 to 23	2,582.0	23.6%
	24 to 29	944.9	8.6%
	30	183.1	1.7%
	Total acres	10,940.8	100.0%

Resource site data tables: Wildlife Habitat

Table H-10. Breakdown of total wildlife model patch scores.*

Resource site: Lower Willamette River	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	317.5	252.0	126.9	280.4	80.7	800.5	1,044.4	5,576.8	0.0	8,479.1
Percent of total	3.7%	3.0%	1.5%	3.3%	1.0%	9.4%	12.3%	65.8%	0.0%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table H-11. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Lower Willamette River	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	7,388.6	881.9	0.0	2,067.0	18.1	5,558.6	472.9	7,047.2	500.4	577.9	347.5	7,553.7	8,479.1
Percent of total acres in inventory	87.1%	10.4%	0.0%	24.4%	0.2%	65.6%	5.6%	83.1%	5.9%	6.8%	4.1%	89.1%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table H-12. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Lower Willamette River	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	198.4	10.2	8,008.3	21.1	6.4	234.7	8,479.0
Percent of total	2.3%	0.1%	94.4%	0.2%	0.1%	2.8%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table H-13. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Lower Willamette River	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	8479.1	5369.6	282.9	8761.9	23
Percent of total	96.8%	61.3%	3.2%	100.0%	N/A

*Habitats of Concern.

Table H-14. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Lower Willamette River Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	220.27	17.1	2.7%
Barren	122.75	19.4	1.6%
Low structure agriculture	2.38	0.0	0.0%
High structure agriculture	0.00	0.0	0.0%
Deciduous closed canopy	2,106.15	56.4	24.7%
Mixed closed canopy	3,075.12	44.2	35.6%
Conifer closed canopy	1,725.21	16.3	19.9%
Deciduous open canopy	289.60	26.6	3.6%
Mixed open canopy	222.09	11.0	2.7%
Conifer open canopy	55.45	2.4	0.7%
Deciduous scattered canopy	201.47	20.2	2.5%
Mixed scattered canopy	116.33	11.7	1.5%
Conifer scattered canopy	37.48	2.8	0.5%
Closed canopy shrub	149.95	21.2	2.0%
Open canopy shrub	50.24	8.6	0.7%
Scattered canopy shrub	42.34	8.7	0.6%
Meadow/grass	61.32	16.4	0.9%
Not classified	0.93	0.0	0.0%
Total	8,479.09	282.9	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table H-15. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Lower Willamette River	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/ WODF[4]	WEGR	AGPA
Total acres	2,497.9	241.1	21.1	262.2	8,020.4	187.6	2.4
Percent of total	28.5%	2.8%	0.2%	3.0%	91.5%	2.1%	0.0%

[1]See Table H-14 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

SITE #27: Columbia Slough subwatershed

Named streams: Arata Creek, Columbia River, Columbia Slough, Fairview Creek, Miller Creek, Multnomah Channel, Willamette River
Communities within the subwatershed: Fairview, Gresham, Maywood Park, Portland, Troutdale, Wood Village, unincorporated Multnomah County
Total acreage within Metro's boundary: 54,610 (combined Columbia Slough and Multnomah Channel)
Total acres within riparian corridor: 20,569.2

This site contains 18 percent of the area comprising Metro's jurisdictional boundary, the highest amount of any of the resource sites. Most of the site (71 percent) falls within the City of Portland's boundaries, but there are also portions in unincorporated Multnomah County (13 percent), Gresham (eight percent), Fairview (four percent), Troutdale (two percent), and one percent or less in Maywood Park and Wood Village (Table H-16).

Compared to the other site in Group H, this site is relatively undeveloped. Road density is 12.0 miles per square mile, placing this site within the second quartile (26 to 50 percent of maximum) compared to all other resource sites (Table H-2). Zoning is mixed in this resource site, but industrial is the most significant land base contributor, followed by substantial acreage zoned for single family residential, as well as rural and public/open space (Table H-5). More than 3,400 building permits have been issued here since 1996 (Table H-2).

Riparian resources. Thirty-seven percent of this site is part of the riparian corridor inventory (Table 12). This site contributes 22 percent of the region's riparian resources, far more than any other resource site in the Metro boundary (Table 13).

This resource site contains 87 total stream miles, of which 37 percent are stream links, suggesting high levels of piping and culverting (Table H-3). Despite the strong contribution to regional riparian resources, non-piped stream density is only 0.0020 miles per acre, ranking it 24th of the 27 resource sites. Nearly 40 percent of non-piped stream miles are DEQ 303(d) listed (Table H-2); however, this site is known to provide very important fish habitat, with anadromous fish known to be present in nearly 22 stream miles (Table H-2). Streams are predominantly low gradient, as indicated by the high proportion of floodplains, at 29 percent; six percent of the floodplains are developed. Six percent of the site's lands are also wetlands, contributing to off-channel fish-rearing habitat and other highly valuable aquatic resources (Table H-3).

Reflecting the strong riparian component of this resource site, approximately 56 percent of its acreage within the riparian corridor inventory received primary scores for at least three of the five ecological functions, and a remarkable 83 percent received at least one primary score (Table H-19). The highest percentage of land receiving a primary score was divided about equally between *Large wood and channel dynamics* and *Streamflow moderation and water storage*, each covering more than three-quarters of the inventory. However, *Bank stabilization and pollution control* also provided primary function to 60 percent of the site's riparian inventory (Table H-18; see also Table 4 and Appendix 7 for description of ecological functions mapping). Secondary functions in this site are relatively minimal because so much of the land is covered by primary ecological functions.

Wildlife habitat resources. Including Habitats of Concern, 21 percent of the lands in this site fall within the wildlife habitat inventory, ranking it 20th among the 27 resource sites and second of the two Group H resource sites (Table 16). Within model patches, 46 percent of the acreage falls within the top third of the point range, ranking sixth among the 27 resource sites and second to Site #27 in Group H (Table 17).

Of the four criteria in the GIS model, 59 percent of the acreage falls in the lowest size score category, with another ten percent in the medium category (Table H-21). For habitat interior, the acreage falls primarily in the lowest score category (36 percent), but portions fall within the middle and high ranges as well (20 and 12 percent, respectively). This site scores very well for water resources, with approximately equal proportions in the middle and high ranges (48 and 44 percent, respectively). The scores are also very good for connectivity, with 57 percent in the highest class and another 29 percent in the middle class. The total proportion of acreage accounted for in the size and interior criteria suggest that a modest amount of lands (approximately 20 percent) within 300 ft of streams are unforested, because low-structure patch types are not scored for these criteria (see also Table H-22).

Open water is a critically important habitat type in this resource site, covering an estimated 65 percent of wildlife habitat, substantially more than any of the other resource sites (Table H-25). Conifer and hardwood forest strongly predominate the habitat types in this resource site (92 percent), but open water is also an extremely important habitat type here (Table H-25). A relatively extensive series of oak woodlands are present in this site, identified through Habitats of Concern (based on local expert knowledge). Wetlands cover three percent of this site's wildlife habitat, slightly lower than the other Group H site; this number is negatively influenced by the large amount of habitat covered by Forest Park, a fairly steeply sloped area generally lacking in wetlands. This site contributes three percent to the region's wetland resources, ranking 8th among the 27 resource sites.

In general, this site can be characterized as providing a large amount of very high quality wildlife habitat. Forest Park is one of the most highly rated habitat patches in the entire urban region; it provides very extensive interior habitat for nesting Neotropical migrants and area-sensitive species, is likely a source habitat for species repopulation to other patches, and is an elk migratory corridor. A substantial portion of Forest Park and associated areas is also situated in Resource Site #27, to the north of this site. This resource site includes a long segment of the Willamette River, contributing important open water and riverine island habitat important to Bald Eagle, Osprey, waterfowl, shorebirds and migratory birds. This site is uniquely important to the region's wildlife.

Species of Concern. Twenty-three Species of Concern sighting location falls within the site, attesting to the site's importance in the regional wildlife habitat system. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Pileated Woodpecker
- Band-tailed Pigeon
- Bald Eagle
- Peregrine Falcon
- Purple Martin

- Painted Turtle
- Western Meadowlark
- Bufflehead
- Dusky Canada Goose
- Merlin
- Western Pond Turtle
- Great Blue Heron nesting colony
- *Fluminicola fuscus* (plant species)
- *Rorippa columbiae* (plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and open water (see Table H-15). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Species of Concern. Attesting to this site's importance to regional wildlife, 34 Species of Concern sighting location falls within the site. Each sighting may include one or more species; if a species occurs more than once in the resource site it is only listed once here. These include the following species:

- Western Painted Turtle
- Bald Eagle
- Oregon Vesper Sparrow
- Purple Martin
- Pacific Fisher
- Pileated Woodpecker
- Streaked Horned Lark
- Band-tailed Pigeon
- Bufflehead
- Western Pond Turtle
- Red-legged Frog
- Elk
- Northern Pygmy Owl
- Merlin
- Common Nighthawk
- Peregrine Falcon
- Western Meadowlark
- Great Blue Heron nesting colony
- *Cimicifuga elata* (plant species)

There are very likely other Species of Concern using this resource site, particularly those relying on forested habitats and agricultural lands (see Table H-25). Examples of species likely to occur in this site may be found by referencing the species list in Appendix 9 and identifying the species with a double "XX" under the habitat. General species needs and potential reasons for their decline are identified in the *Sensitive Species Accounts* section above. More detailed information on all species' needs can be obtained through Johnson and O'Neil (2001).

Habitats of Concern.

The following Habitats of Concern are partially or wholly within this resource site. Using the Unique ID # (UID), please refer to Appendix 10 for information concerning each Habitat of Concern, and Appendix 13 for maps showing UID locations:

UID numbers: 6, 8, 9, 15, 17, 20, 25, 34, 35, 48, 49, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 76, 78, 81, 84, 85, 86, 88, 89, 162, 164

Resource site data tables: Riparian Corridors

Table H-16. Acres within resource site by jurisdiction.

Jurisdiction	Acres within subwatershed
Fairview	2,263.1
Gresham	4,188.9
Maywood Park	107.5
Portland	38,966.3
Troutdale	1,219.7
Wood Village	604.7
Unincorporated Multnomah County	7,258.6

Table H-17. Acres in Metro and riparian corridor.

Resource site	Total acres within Metro	Total acres within riparian corridor
Columbia Slough	54,610.0	20,129.8

Table H-18. Number of acres within riparian corridor providing ecological function.

Resource site	Ecological function	*Primary Value*		*Secondary Value*	
		Acres*	% of Total**	Acres	% of Total
Columbia Slough	Microclimate & shade	2,414.6	12.0%	1,582.3	7.9%
	Streamflow moderation & water storage	15,303.8	76.0%	4,570.4	22.7%
	Bank stabilization & pollution control	12,037.5	59.8%	791.6	3.9%
	Large wood & channel dynamics	15,864.7	78.8%	293.3	1.5%
	Organic material sources	3,541.1	17.6%	191.8	1.0%

*Number of acres scored within the riparian corridor for each function
**Percent of total acres within the riparian corridor

Table H-19. Breakdown of ecological scores.

Resource site	Ecological Score	Acres	% of Total Acres
Columbia Slough	1 to 5	3,442.9	17.1%
	6 to 11	747.1	3.7%
	12 to 17	4,716.2	23.4%
	18 to 23	7,860.0	39.0%
	24 to 29	1,416.1	7.0%
	30	1,947.5	9.7%
	Total acres	20,129.8	100.0%

Resource site data tables: Wildlife Habitat

Table H-20. Breakdown of total wildlife model patch scores.*

Resource site: Columbia Slough	Number of acres in each wildlife score category									Total wildlife model patch acres in inventory
	1	2	3	4	5	6	7	8	9	
Model score	262.1	713.2	1,254.2	978.9	577.5	1,441.6	1,270.8	1,786.3	1,331.3	9,615.9
Percent of total	2.7%	7.4%	13.0%	10.2%	6.0%	15.0%	13.2%	18.6%	13.8%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table H-21. Breakdown of total wildlife patch model scores by criteria.*

Resource site: Columbia Slough	Number of acres by score for each model criterion												Total wildlife model patch acres in inventory
	Size[2]			Interior[2]			Water[3]			Connectivity			
	1	2	3	1	2	3	1	2	3	1	2	3	
	5,654.5	1,929.1	0.0	3,431.4	1,929.1	1,188.5	175.1	4,585.3	4,199.8	1,340.4	2,792.4	5,483.1	9,615.9
Percent of total acres in inventory	58.8%	20.1%	0.0%	35.7%	20.1%	12.4%	1.8%	47.7%	43.7%	13.9%	29.0%	57.0%	na

[1]Does not include Habitats of Concern outside of model patches.

[2]These numbers do not add up to 100.0% because Type 2 patches (low structure vegetation within 300 feet of streams and wetlands) were not ranked for these criteria.

[3]These numbers do not add up to 100% because not all patches contained or were near water resources.

Table H-22. Breakdown of total wildlife model patch area by 2000 Metro photo interpretation landcover and known wetlands.*

Resource site: Columbia Slough	Low structure vegetation within 300 feet of stream		Forested vegetation	Forested wetlands	Grass/shrub wetlands within 300 feet of a stream	Other wetlands	Total wildlife model patch acres in inventory
	Low structure vegetation/ intact topsoil	Non-forest woody vegetation					
Acres	1,965.3	67.0	4,334.2	504.7	359.8	2,384.9	9,615.8
Percent of total	20.4%	0.7%	45.1%	5.2%	3.7%	24.8%	100.0%

*Does not include Habitats of Concern outside of model patches.

Table H-23. Total acres of inventoried wildlife habitat by type and total Species of Concern (SOCs).

Resource site: Columbia Slough	Wildlife patches (acres)	HOCs inside Wildlife patches (acres)*	HOCs outside Wildlife patches (including wetlands <2 acres)	Total inventoried wildlife habitat acres	Total SOCs
Acres	9615.9	6380.7	2083.8	11699.7	34
Percent of total	82.2%	54.5%	17.8%	100.0%	N/A

*Habitats of Concern.

Table H-24. Total area of model patches and Habitats of Concern by 1998 Landsat Landcover Area.

Resource Site: Columbia Slough Landcover type:	Total area of wildlife model patches	Total area of HOCs outside of modeled patches (including wetlands <2 acres)	Percent of total inventoried habitat
Water	1,262.32	160.6	12.2%
Barren	1,087.46	678.1	15.1%
Low structure agriculture	114.51	20.0	1.1%
High structure agriculture	0.29	0.0	0.0%
Deciduous closed canopy	1,469.96	140.3	13.8%
Mixed closed canopy	1,297.42	59.8	11.6%
Conifer closed canopy	883.55	53.1	8.0%
Deciduous open canopy	444.31	72.2	4.4%
Mixed open canopy	206.99	18.6	1.9%
Conifer open canopy	71.39	8.2	0.7%
Deciduous scattered canopy	392.87	62.1	3.9%
Mixed scattered canopy	254.22	38.6	2.5%
Conifer scattered canopy	119.79	29.0	1.3%
Closed canopy shrub	284.14	71.0	3.0%
Open canopy shrub	169.54	48.0	1.9%
Scattered canopy shrub	255.46	46.0	2.6%
Meadow/grass	1,301.60	578.1	16.1%
Not classified	0.06	0.1	0.0%
Total	9,615.88	2083.8	100.0%

The table below provides estimates of each type of the habitats described in Metro's Technical Report for Goal 5, based on Johnson and O'Neil's (2001) habitat scheme. These numbers are provided for subwatershed comparison purposes and represent estimates of available habitat type. Several data types were used to compile this table, and the data sources vary in their precision. For example, the satellite data sources are less accurate than hand-digitized forest canopy cover. There is also slight overlap between certain habitat types. For example, Riparian Wetlands (RWET) are also partially included in Westside Lowland Coniferous Hardwood/Westside Oak and Douglas-fir (WLCH/WODF) because some wetlands also contain forest, and Open Water (WATR) is not always considered part of habitat patches. Therefore, the sums of these habitat types are slightly different from the "Total wildlife habitat acres in inventory" shown in Table 16. Nonetheless, these numbers provide a generalized means of comparing the quality and quantity of habitat available to wildlife among and between subwatersheds. Note also that the estimates for Westside Grasslands (WEGR) probably represent grasslands that are not native rather than true native grasslands, which are largely extirpated from the metro region.

Table H-25. Wildlife habitat availability[1] based on Johnson & O'Neil's (2001) habitat types and species-habitat associations.

Resource site:	Habitat type						
Columbia Slough	WATR[2]	HWET[3]	RWET[3]	TOTWET[3]	WLCH/WODF[4]	WEGR	AGPA
Total acres	7,548.7	2,744.7	504.7	3,329.7	5,622.4	2,398.7	134.8
Percent of total	64.5%	23.5%	4.3%	28.5%	48.1%	20.5%	1.2%

[1]See Table H-24 for land cover types and crosswalk to Johnson and O'Neil's classification scheme.

[2]Note that patch type and data limitations result in an underestimation of open water habitats. For example, medium and small sized stream surfaces are excluded.

[3]Note that HWET and RWET do not represent the full suite of wetlands because some wetlands <2 acres were added in as Habitats of Concern, and some wetlands could not be associated with herbaceous or forested habitats. TOTWET represents the best estimate of all existing wetlands because it includes Habitats of Concern.

[4]Data limitations make it impossible to distinguish between these two habitat types at this time, and no comprehensive oak habitat survey has been conducted for the region. However, known oak habitats are also included in HOCs (see Appendix 10).

Adequacy of information

The second step of the Goal 5 inventory process is to determine if the information collected for the inventory is adequate. According to the Goal 5 rule, the information about a particular Goal 5 resource site shall be deemed adequate if it provides the location, quantity and quality of the resource. A discussion of these three aspects of Metro's Goal 5 inventory follows.

Location

Location information shall include a description or map of the resource area for each site (OAR 660-023-0030(3)(a)). Although this information must be sufficient to determine whether a resource exists on a particular site, the precise location of the resource need not be determined at this stage in the inventory process.[10]

Information about location is sufficient if the local government develops a map that shows that a resource exists on a particular site. Riparian corridors and wildlife habitat have been mapped for the entire area within Metro's jurisdiction (Appendix B). The data for all 27 resource sites is summarized for ease of comparison in Tables 12-17 following this section. Metro's riparian corridor and wildlife habitat inventory maps depict the resource sites to the tax lot level. The inventory also describes the acres of each jurisdiction that fall within a resource site. Resource sites are based on subwatersheds using the Hydrologic Unit Code (HUC) system, as identified by the Natural Resources Conservation Service (NRCS).

The methodologies used to develop the riparian corridor inventory maps were described previously in the *Metro's Goal 5 Inventory Methodology* section of this document. Local jurisdictions, property owners, and other interested parties have extensively reviewed the inventory map. Map corrections have been made and continue to be made to more accurately depict location of the resource.

Quantity

Concerning quantity, Goal 5 requires local governments to estimate the relative abundance or scarcity of the resource (OAR 660-023-0030(c)).

Metro's stream modeling has indicated that the region has lost approximately 400 miles of streams (about 30 percent of the original) (Metro 1997). In addition, 213 miles are listed by the Department of Environmental Quality as water-quality limited (DEQ 1996). Eleven percent of the Metro region's natural areas were lost between 1989-1999, with accompanying adverse effects on watershed hydrology and wildlife habitat (Metro Parks and Greenspaces). The portion of the Willamette River running through the metro region is influenced not only by intensity of urbanization within its own watersheds, but also by cumulative effects from land use and

[10] Prior to amendment, OAR 660-016-0000(2) required a determination of site specific resource location, which included a description or map of the resource site's boundaries and the impact area, if different. For non-site specific resources, determination was to be as specific as possible. *Id.* However, OAR 660-023-0030(3)(a) does not distinguish between site specific and non-site specific resources. Rather, the new rule requires information about location to include a description or map of the resource and to be sufficient enough to conclude whether a resource exists on a particular site. *Id.*

activities upstream. Habitat loss, alteration, and significant increases in the amount of impervious land cover characterize the Metro region.

Information about quantity is adequate if it shows the relative abundance or scarcity of the resource: The number of streams, riparian corridors and upland vegetation lost that historically provided fish and wildlife habitat and the accompanying impacts of urbanization indicate that the riparian corridors and wildlife habitat remaining in this region are correspondingly important. Relative to what once existed, riparian corridor and wildlife habitat resources that were once abundant are now scarce.

The declining quantity and condition of riparian corridor resource is impacting the ability of native fish and wildlife to survive in this region. Thirteen salmonid runs are listed as Threatened or Endangered under the federal Endangered Species Act, and two of these are also listed by the state as Threatened or Endangered. Another run is listed as Endangered only at the state level. Out of the entire genus, only resident rainbow trout are not considered to be at risk. Salmonids are important as an indicator of watershed and riparian corridor health. In addition, 55 other vertebrate species are on the Sensitive Species list, relating directly to habitat loss and alteration in the metro region over time.

Metro's riparian corridor inventory identifies the location of riparian corridors and quantifies the acres within the riparian corridor and the number of stream miles by resource site, as shown in Table 12 below. Based on this inventory there is a total of 93,035 acres within the riparian corridor in the region and 855 miles of streams. In addition, there are approximately 8,524 acres of hydrologically connected wetlands and 35,008 acres of floodplains in the region.

Metro's wildlife habitat inventory identifies the location of wildlife habitat and quantifies the acres within wildlife habitat patches, as shown in Table 16 below. Based on this inventory there is a total of 75,200 acres within the wildlife habitat inventory, including modeled patches (71,359 acres) and Habitats of Concern (3,842 additional acres).

Quality

Quality information shall indicate a resource site's value relative to other known examples of the same resource (OAR 660-023-0030(3)(b)). Although regional comparison of resources is preferred, quality comparisons may be made for resource sites within the jurisdiction, if no other local examples exist (Id). Local governments shall consider any determinations about resource quality provided in available state or federal inventories.

Information about quality is adequate if it indicates "a resource site's value relative to other known examples of the same resource." Riparian corridors occur wherever there is a river, lake, stream or wetland. Wildlife habitat occurs where there are features including forest canopy, wetlands, streams and other water features, important low-structure vegetation areas, and areas that are functionally important such as wildlife passage corridors or migratory stopover areas; these are typically 2-acre patches or larger.

It is important to distinguish "condition" of the resource area from the Goal 5 rule requirement to consider a "site's relative value." The condition of riparian corridors and wildlife habitat in the Metro region varies based on past and present development impacts that may have disturbed the soil, vegetation and terrestrial ecosystem adjacent to streams and wetlands. However, the present condition of the resource does not diminish its value relative to other identified resources. Metro's inventory includes an assessment of ecological function and habitat quality as well as providing specific data on the condition of riparian corridors and wildlife by resource site.

Riparian corridors. Metro's riparian corridor inventory approach considers the ecological functions of the riparian corridor and maps the landscape features providing that function. Areas are given a primary or secondary ecological function score based on widths identified in the scientific literature (see previous discussion of inventory methodology for more information). Metro conducted an extensive scientific literature review that describes the qualities necessary to have a healthy ecosystem for watersheds and riparian corridors (Metro 2002). The ecological function approach to the inventory takes the science and applies it in a practical way to map riparian corridors. This approach provides a tool to identify the resource and to consider relative ecological function within a resource site and across the region.

One comparison that may be made is to consider the amount of the region's total acres of riparian corridor that is found in each resource site. Table 13 below shows the acres of each site within the riparian corridor and the percent of the region's riparian corridors by resource site. Some sites containing a small percentage of the region's riparian corridors may have been more heavily impacted by urban development over the past 200 years than those with a higher percentage. Other sites in headwater areas – typically in the higher elevations – do not naturally contain large quantities of wetlands or floodplains (Table 14). Some sites that provide a high percentage of the region's riparian corridors may contain large areas of floodplains and wetlands. In some sites, substantial floodplain development has occurred. These data allow for adequate comparison of sites across the region.

Another method of comparing the ecological function provided by riparian corridors in resource sites across the region is to look at the ecological function score. Table 15 shows the percent of the riparian corridor receiving scores in five categories. Each site has the potential to receive a score of up to 30 (five primary scores – a primary receives a score of 6) and a minimum of one (a secondary receives a score of one). As can be seen in the table, Site 9: Lower Rock Creek-Tualatin River contains the highest percentage (21%) of area receiving a primary score for all five functions, while several sites contain riparian corridors in which only two percent of the area received a score of 30. Sites that contain high percentages of the riparian corridor that received a score of one through five (secondary scores) most likely contain large forest, agricultural and floodplain areas. Site 19: Kelly Creek includes the largest portion of the riparian corridor receiving a low score (74%) while Site #27: Columbia Slough includes the smallest portion at 17 percent.

Wildlife habitat. Metro's wildlife habitat approach considers the configuration of wildlife habitat within a regional context and maps the landscape features contributing to a high-quality system of regional wildlife habitat. Habitat patches are scored based on size, shape (interior habitat), connectivity to water, and connectivity to other natural areas, based on the information gained through the literature reviewed in Metro's Technical Report for Goal 5 (Metro 2002). This approach provides a straightforward way to apply science to existing habitats based on GIS resources, as modified by adaptive management received via field studies. It allows valid comparison of the relative value of habitat patches, both within resource sites and across the entire region.

Similar to the riparian corridors inventory, one comparison that may be made is to consider the amount of the region's total acres of wildlife habitat that is found in each resource site. Table 16 below shows the acres of each site within the wildlife habitat inventory and the percent of the region's habitat by resource site. Referring back to Table 8 in Metro's Technical Report for Goal 5, every major watershed has experienced substantial loss of closed canopy forest from historic levels; however, some have lost more than others. Some sites containing a small percentage of wildlife habitat may have been more heavily impacted by urban development over the past 200 years than those with a higher percentages. These numbers may reflect overall habitat loss – as with the highly developed Johnson Creek/Crystal Springs site – or conversion to agriculture or other land uses, as in the McKay Creek subwatershed (Table 16). These data allow for adequate comparison of sites across the region.

Another method of comparing the relative value or quality of wildlife habitat in resource sites across the region is to look at the wildlife model score. Table 17 shows the percent of the wildlife habitat receiving scores, from a range of one (low-scoring) to nine. Site #23 (Tryon Creek) contains the highest percentage (84%) of area receiving wildlife scores in the top third of the scoring range, while sites such as #21 (Lower Johnson Creek – Willamette River) and #10 (Middle Tualatin River – Gordon Creek) rank 26th and 27th among the resource sites, respectively. The sites on the lower end of the point scale typically contain more fragmented wildlife habitat resources and a lesser amount of forest canopy cover compared to higher-scoring sites.

In addition to the riparian corridor and wildlife habitat data described above, Metro's inventory includes information on the condition of riparian corridors by resource site. The *Site Analysis* section provides a summary of each data item. The inventory includes regionally consistent data for:

- Miles of DEQ 303(d) listed streams,
- Road density (road miles/square miles in subwatershed),
- Miles of stream with known anadromous fish presence,
- Acres of hydrologically connected wetlands,
- Acres of floodplains (100-year FEMA + 1996 inundation area),
- Building permits since 1996 (number),
- Characteristics of stream miles by resource site, and riparian vegetation by resource site.

Table 12. Quantity of riparian corridor resources in Metro region by resource site.

Resource site#	Resource site name	Total acres in Metro's Boundary	Total acres in riparian corridor	Percent of site in riparian corridor	Non-piped stream miles in resource site
1	Lower Sandy River-Columbia River	5,712.3	3,498.3	61.2%	23.6
2	Beaver Creek-Sandy River	10,336.6	3,666.8	35.5%	34.7
3	Willamette River-Boeckman Creek	7,616.8	2,248.1	29.5%	22.2
4	Willamette River-Lower Tualatin River	11,403.7	4,172.2	36.6%	35.5
5	Council Creek	5,708.2	1,142.4	20.0%	15.8
6	McKay Creek	3,842.7	635.8	16.5%	8.3
7	Middle Rock Creek-Tualatin River	7,300.2	2,390.8	32.7%	27.8
8	Beaverton Creek	24,297.0	5,788.0	23.8%	81.1
9	Lower Rock Creek-Tualatin River	8,717.3	1,736.4	19.9%	25.1
10	Middle Tualatin River-Gordon Creek	4,347.3	941.5	21.7%	15.3
11	Lower Tualatin River-Lake Oswego Canal	15,231.1	5,830.7	38.3%	56.3
12	Upper and Middle Fanno Creek	11,183.5	2,651.7	23.7%	38.6
13	Summer Creek	3,769.1	855.6	22.7%	14.1
14	Lower Fanno Creek	8,453.8	1,864.0	22.0%	29.4
15	Rock Creek (south Washington Co.)	4,239.3	1,102.2	26.0%	10.9
16	Richardson Creek	6,465.5	2,271.8	35.1%	30.1
17	Rock Creek-Clackamas River	11,120.7	4,177.9	37.6%	44.3
18	Johnson Creek-Sunshine Creek	12,372.9	4,777.5	38.6%	45.2
19	Kelley Creek	3,175.6	1,423.1	44.8%	12.1
20	Middle Johnson Creek	8,949.7	1,539.2	17.2%	10.0
21	Lower Johnson Creek-Willamette River	5,950.3	1,897.0	31.9%	24.5
22	Lake Oswego	4,168.7	1,541.7	37.0%	16.9
23	Tryon Creek	4,356.5	1,972.8	45.3%	21.1
24	Johnson Creek-Crystal Springs	7,844.6	1,176.5	15.0%	14.3
25	Mount Scott Creek	11,809.8	2,662.6	22.5%	31.0
26	Lower Willamette River	32,899.2	10,940.8	33.3%	55.1
27	Columbia Slough	54,610.0	20,129.8	36.9%	111.8
Total		295,882.5	93,035.4	na	854.9

Table 13. Percent of the region's riparian corridors by resource site.

Resource site#	Resource site name	Acres of resource site in riparian corridor	Percent of region's riparian corridors in resource site
1	Lower Sandy River-Columbia River	3,498.3	3.8%
2	Beaver Creek-Sandy River	3,666.8	3.9%
3	Willamette River-Boeckman Creek	2,248.1	2.4%
4	Willamette River-Lower Tualatin River	4,172.2	4.5%
5	Council Creek	1,142.4	1.2%
6	McKay Creek	635.8	0.7%
7	Middle Rock Creek-Tualatin River	2,390.8	2.6%
8	Beaverton Creek	5,788.0	6.2%
9	Lower Rock Creek-Tualatin River	1,736.4	1.9%
10	Middle Tualatin River-Gordon Creek	941.5	1.0%
11	Lower Tualatin River-Lake Oswego Canal	5,830.7	6.3%
12	Upper and Middle Fanno Creek	2,651.7	2.9%
13	Summer Creek	855.6	0.9%
14	Lower Fanno Creek	1,864.0	2.0%
15	Rock Creek (south Washington Co.)	1,102.2	1.2%
16	Richardson Creek	2,271.8	2.4%
17	Rock Creek-Clackamas River	4,177.9	4.5%
18	Johnson Creek-Sunshine Creek	4,777.5	5.1%
19	Kelley Creek	1,423.1	1.5%
20	Middle Johnson Creek	1,539.2	1.7%
21	Lower Johnson Creek-Willamette River	1,897.0	2.0%
22	Lake Oswego	1,541.7	1.7%
23	Tryon Creek	1,972.8	2.1%
24	Johnson Creek-Crystal Springs	1,176.5	1.3%
25	Mount Scott Creek	2,662.6	2.9%
26	Lower Willamette River	10,940.8	11.8%
27	Columbia Slough	20,129.8	21.6%
Total		93,035.4	100.0%

Table 14. Percent developed floodplain by resource site.

Resource site#	Resource site name	Floodplain Acres	Developed Floodplain Acres	Percent Developed Floodplain
1	Lower Sandy River-Columbia River	1,563.8	40.8	2.6%
2	Beaver Creek-Sandy River	2,173.0	59.6	2.7%
3	Willamette River-Boeckman Creek	411.2	32.8	8.0%
4	Willamette River-Lower Tualatin River	1,172.3	229.4	19.6%
5	Council Creek	626.0	24.2	3.9%
6	McKay Creek	344.9	26.4	7.7%
7	Middle Rock Creek-Tualatin River	239.2	8.2	3.4%
8	Beaverton Creek	1,246.1	421.9	33.9%
9	Lower Rock Creek-Tualatin River	854.3	16.6	1.9%
10	Middle Tualatin River-Gordon Creek	83.7	13.5	16.1%
11	Lower Tualatin River-Lake Oswego Canal	1,132.0	283.1	25.0%
12	Upper and Middle Fanno Creek	517.5	107.8	20.8%
13	Summer Creek	61.8	7.0	11.3%
14	Lower Fanno Creek	829.0	87.8	10.6%
15	Rock Creek (south Washington Co.)	315.0	22.8	7.2%
16	Richardson Creek	0.0	0.0	0.0%
17	Rock Creek-Clackamas River	761.9	87.1	11.4%
18	Johnson Creek-Sunshine Creek	346.8	11.8	3.4%
19	Kelley Creek	34.4	1.2	3.5%
20	Middle Johnson Creek	378.9	164.4	43.4%
21	Lower Johnson Creek-Willamette River	717.1	74.6	10.4%
22	Lake Oswego	590.2	75.8	12.8%
23	Tryon Creek	107.7	37.1	34.4%
24	Johnson Creek-Crystal Springs	572.0	295.4	51.6%
25	Mount Scott Creek	706.5	149.6	21.2%
26	Lower Willamette River	3,409.4	317.8	9.3%
27	Columbia Slough	15,814.1	993.8	6.3%
Total		**35,008.9**	**3,590.3**	**10.3%**

Table 15. Percent of riparian corridor by ecological function score by resource site (excludes Habitats of Concern outside of model patches).

Resource site#	Resource site name	Ecological function score					
		1 to 5	6 to 11	12 to 17	18 to 23	24 to 29	30
1	Lower Sandy River-Columbia River	37.4%	7.2%	16.0%	19.6%	11.1%	8.8%
2	Beaver Creek-Sandy River	24.7%	5.1%	12.1%	34.4%	13.2%	10.5%
3	Willamette River-Boeckman Creek	47.1%	12.8%	8.7%	9.0%	14.3%	8.1%
4	Willamette River-Lower Tualatin River	54.7%	7.0%	7.6%	15.8%	9.8%	5.1%
5	Council Creek	27.1%	9.3%	26.1%	4.7%	24.1%	8.7%
6	McKay Creek	28.7%	8.8%	18.9%	3.1%	23.8%	16.7%
7	Middle Rock Creek-Tualatin River	57.8%	10.7%	4.7%	3.6%	17.9%	5.2%
8	Beaverton Creek	54.6%	8.2%	7.8%	2.1%	20.3%	6.9%
9	Lower Rock Creek-Tualatin River	21.9%	9.4%	20.1%	3.2%	24.7%	20.7%
10	Middle Tualatin River-Gordon Creek	57.9%	10.1%	10.3%	5.2%	14.0%	2.6%
11	Lower Tualatin River-Lake Oswego Canal	58.1%	8.6%	6.4%	5.1%	15.2%	6.6%
12	Upper and Middle Fanno Creek	53.6%	7.4%	7.7%	1.3%	23.9%	6.1%
13	Summer Creek	50.2%	10.6%	7.4%	3.1%	22.2%	6.3%
14	Lower Fanno Creek	34.5%	6.3%	15.8%	5.0%	22.7%	15.6%
15	Rock Creek (south Washington Co.)	42.3%	12.0%	8.4%	2.2%	21.8%	13.3%
16	Richardson Creek	60.4%	13.7%	4.9%	8.5%	10.8%	1.8%
17	Rock Creek-Clackamas River	56.8%	8.8%	8.4%	6.7%	14.6%	4.8%
18	Johnson Creek-Sunshine Creek	69.0%	7.8%	3.5%	2.9%	12.5%	4.3%
19	Kelley Creek	73.5%	8.3%	2.3%	2.4%	11.5%	2.0%
20	Middle Johnson Creek	67.7%	6.0%	7.9%	1.1%	12.8%	4.5%
21	Lower Johnson Creek-Willamette River	37.2%	8.5%	10.1%	19.3%	17.2%	7.7%
22	Lake Oswego	45.4%	6.6%	31.7%	2.7%	10.2%	3.4%
23	Tryon Creek	62.8%	8.2%	4.9%	2.3%	19.8%	2.0%
24	Johnson Creek-Crystal Springs	55.5%	6.5%	11.4%	2.4%	18.4%	5.7%
25	Mount Scott Creek	53.7%	7.6%	8.2%	10.6%	12.4%	7.5%
26	Lower Willamette River	55.6%	4.2%	6.3%	23.6%	8.6%	1.7%
27	Columbia Slough	17.1%	3.7%	23.4%	39.0%	7.0%	9.7%
Totals		**44.3%**	**6.9%**	**12.1%**	**16.7%**	**13.1%**	**6.9%**

Table 16. Quantity of wildlife habitat resources in Metro region by resource site.

Resource site#	Resource site name	Total acres in Metro's Boundary	Total acres in wildlife patches	% of site in wildlife patches	Total acres HOCs inside patches	% of site in HOCs inside patches	Total acres HOCs outside patches	% of site in HOCs outside patches	Total acres of inventoried wildlife habitat	% of region's inventoried wildlife habitat in resource site
1	Lower Sandy River-Columbia River	5,712.3	2,490.4	43.6%	1,894.2	33.2%	392.6	6.9%	2,883.1	3.8%
2	Beaver Creek-Sandy River	10,336.6	2,118.3	20.5%	943.7	9.1%	317.3	3.1%	2,435.6	3.2%
3	Willamette River-Boeckman Creek	7,616.8	2,041.0	26.8%	273.7	3.6%	20.0	0.3%	2,061.0	2.7%
4	Willamette River-Lower Tualatin River	11,403.7	3,232.5	28.3%	767.8	6.7%	7.7	0.1%	3,240.3	4.3%
5	Council Creek	5,708.2	901.4	15.8%	230.4	4.0%	11.1	0.2%	912.5	1.2%
6	McKay Creek	3,842.7	482.7	12.6%	74.6	1.9%	1.6	0.0%	484.4	0.6%
7	Middle Rock Creek-Tualatin River	7,300.2	2,349.0	32.2%	234.4	3.2%	19.4	0.3%	2,368.4	3.1%
8	Beaverton Creek	24,297.0	5,146.4	21.2%	529.0	2.2%	80.0	0.3%	5,226.4	6.9%
9	Lower Rock Creek-Tualatin River	8,717.3	1,608.2	18.4%	314.7	3.6%	9.2	0.1%	1,617.4	2.2%
10	Middle Tualatin River-Gordon Creek	4,347.3	904.3	20.8%	214.1	4.9%	45.1	1.0%	949.4	1.3%
11	Lower Tualatin River-Lake Oswego Canal	15,231.1	5,345.8	35.1%	1,019.2	6.7%	8.6	0.1%	5,354.4	7.1%
12	Upper and Middle Fanno Creek	11,183.5	2,501.3	22.4%	200.7	1.8%	21.0	0.2%	2,522.3	3.4%
13	Summer Creek	3,769.1	818.6	21.7%	91.8	2.4%	13.7	0.4%	832.3	1.1%
14	Lower Fanno Creek	8,453.8	1,509.8	17.9%	263.5	3.1%	23.6	0.3%	1,533.4	2.0%
15	Rock Creek (south Washington Co.)	4,239.3	1,031.5	24.3%	661.0	15.6%	40.9	1.0%	1,072.5	1.4%
16	Richardson Creek	6,465.5	2,208.1	34.2%	436.3	6.7%	4.5	0.1%	2,212.6	2.9%
17	Rock Creek-Clackamas River	11,120.7	3,755.2	33.8%	675.9	6.1%	6.6	0.1%	3,761.7	5.0%
18	Johnson Creek-Sunshine Creek	12,372.9	4,734.6	38.3%	248.7	2.0%	87.7	0.7%	4,822.3	6.4%
19	Kelley Creek	3,175.6	1,410.0	44.4%	330.0	10.4%	12.1	0.4%	1,422.0	1.9%
20	Middle Johnson Creek	8,949.7	1,351.7	15.1%	425.2	4.8%	276.4	3.1%	1,628.1	2.2%
21	Lower Johnson Creek-Willamette River	5,950.3	1,457.2	24.5%	247.7	4.2%	14.0	0.2%	1,471.2	2.0%
22	Lake Oswego	4,168.7	1,005.3	24.1%	0.1	0.0%	3.0	0.1%	1,008.3	1.3%
23	Tryon Creek	4,356.5	1,896.9	43.5%	646.6	14.8%	0.6	0.0%	1,897.5	2.5%
24	Johnson Creek-Crystal Springs	7,844.6	810.8	10.3%	91.4	1.2%	7.7	0.1%	818.5	1.1%
25	Mount Scott Creek	11,809.8	2,152.5	18.2%	544.1	4.6%	50.5	0.4%	2,203.1	2.9%
26	Lower Willamette River	32,899.2	8,479.1	25.8%	5,369.6	16.3%	282.9	0.9%	8,761.9	11.7%
27	Columbia Slough	54,610.0	9,615.9	17.6%	6,380.7	11.7%	2,083.8	3.8%	11,699.7	15.6%
Total		295,882.5	71,358.7	24.1%	23,108.9	7.8%	3,841.7	1.3%	75,200.3	100.0%

Table 17. Percent of wildlife patch by wildlife model score and resource site (excludes Habitats of Concern).

Resource site#	Resource site name	Wildlife Model Score								
		1	2	3	4	5	6	7	8	9
1	Lower Sandy River-Columbia River	0.1%	0.4%	7.8%	15.6%	6.1%	5.4%	64.6%	0.0%	0.0%
2	Beaver Creek-Sandy River	0.6%	5.9%	24.5%	14.3%	15.9%	23.7%	15.2%	0.0%	0.0%
3	Willamette River-Boeckman Creek	1.8%	6.3%	17.7%	13.8%	20.4%	15.7%	13.6%	10.7%	0.0%
4	Willamette River-Lower Tualatin River	1.3%	7.3%	11.9%	5.9%	11.5%	53.7%	0.9%	7.4%	0.0%
5	Council Creek	2.6%	6.2%	35.0%	10.3%	15.9%	12.7%	17.1%	0.0%	0.0%
6	McKay Creek	4.2%	11.2%	31.7%	14.1%	8.4%	20.2%	4.5%	5.8%	0.0%
7	Middle Rock Creek-Tualatin River	1.3%	6.0%	13.9%	12.5%	4.1%	5.7%	1.9%	54.6%	0.0%
8	Beaverton Creek	4.8%	8.3%	9.3%	13.8%	10.0%	13.6%	4.7%	35.5%	0.0%
9	Lower Rock Creek-Tualatin River	3.3%	7.4%	13.1%	6.0%	8.5%	20.4%	19.9%	21.5%	0.0%
10	Middle Tualatin River-Gordon Creek	6.1%	14.3%	20.2%	19.7%	23.0%	16.6%	0.0%	0.0%	0.0%
11	Lower Tualatin River-Lake Oswego Canal	2.4%	2.7%	13.3%	12.7%	8.4%	40.0%	4.2%	16.2%	0.0%
12	Upper and Middle Fanno Creek	5.4%	6.0%	10.7%	12.3%	28.8%	31.3%	0.3%	5.2%	0.0%
13	Summer Creek	2.4%	11.0%	10.9%	21.6%	40.0%	10.5%	3.6%	0.0%	0.0%
14	Lower Fanno Creek	8.1%	8.4%	10.7%	22.0%	24.4%	20.6%	5.8%	0.0%	0.0%
15	Rock Creek (south Washington Co.)	2.6%	0.8%	11.5%	19.6%	3.7%	55.7%	6.0%	0.0%	0.0%
16	Richardson Creek	0.4%	3.8%	29.2%	23.5%	4.1%	18.5%	2.7%	17.9%	0.0%
17	Rock Creek-Clackamas River	1.1%	6.1%	18.5%	14.2%	14.1%	15.3%	29.0%	1.8%	0.0%
18	Johnson Creek-Sunshine Creek	0.6%	2.8%	14.0%	14.9%	16.4%	27.4%	23.9%	0.0%	0.0%
19	Kelley Creek	1.0%	1.1%	16.6%	9.1%	5.5%	23.5%	43.2%	0.0%	0.0%
20	Middle Johnson Creek	6.5%	1.8%	3.9%	8.1%	22.1%	2.9%	54.8%	0.0%	0.0%
21	Lower Johnson Creek-Willamette River	5.6%	8.2%	12.0%	8.3%	12.3%	53.6%	0.0%	0.0%	0.0%
22	Lake Oswego	4.2%	4.9%	12.4%	6.1%	7.8%	64.5%	0.0%	0.1%	0.0%
23	Tryon Creek	1.2%	2.4%	4.3%	4.5%	0.5%	2.7%	0.0%	84.2%	0.0%
24	Johnson Creek-Crystal Springs	9.2%	19.4%	13.6%	9.7%	41.3%	6.7%	0.1%	0.0%	0.0%
25	Mount Scott Creek	6.0%	8.1%	13.3%	16.3%	35.0%	17.0%	0.2%	4.0%	0.0%
26	Lower Willamette River	3.7%	3.0%	1.5%	3.3%	1.0%	9.4%	12.3%	65.8%	0.0%
27	Columbia Slough	2.7%	7.4%	13.0%	10.2%	6.0%	15.0%	13.2%	18.6%	13.8%
Totals		2.9%	5.5%	12.5%	11.6%	11.4%	20.9%	13.2%	20.2%	1.9%

Summary

The discussion above describes how Metro's Goal 5 inventories for riparian corridors and wildlife habitat meet the requirements of the Goal 5 rule by including regionally consistent information on the location, quantity and quality of resources in the region; fieldwork adds credibility to the inventory methods. Based on this, Metro's inventory is determined to be adequate for purposes of making a significance decision.

Determining regionally significant resources

Goal 5 legal requirements

If the information gathered about a resource site is considered adequate, the Goal 5 process then calls for a determination of whether a resource site is "significant." Significance is determined based upon the location, quantity and quality of the resource. Some of the criteria for determining significance are found in the rules governing specific Goal 5 resources. Local governments also may rely on "any additional criteria adopted by the local government" (OAR 660-023-0030(4)(c)). This represents a broad delegation of authority from the Land Conservation and Development Commission (LCDC) to local governments to add criteria to determine the significance of resource sites.

Identifying significant riparian resources

All of the areas mapped as providing function to the riparian corridor are ecologically significant. As discussed thoroughly in Metro's Science Literature Review, activities throughout the entire watershed impact the health of the riparian corridor and the streams, thus affecting the quality of the habitat for fish and wildlife. The biological integrity of the riparian corridor depends, in part, on the width and condition of the riparian area, which dictates stream functions and ultimately the type of plant and animal species that can live in and around streams. Based on the previously described functional approach and consistent with Goal 5 TAC recommendations, Metro staff has proposed defining the riparian corridor for purposes of the Goal 5 inventory as any site that receives a primary or secondary ecological function score[11].

A landscape perspective of riparian corridors as contiguous, interconnected, and dynamic systems within a nested array of watersheds is critical in determining the significance of a specific riparian corridor. Metro's Science Literature Review identifies and discusses the ecosystem functions of riparian corridors. It emphasizes the value of the connectivity of the linear stream system across the landscape and the width of the riparian corridor as essential components for providing the properly functioning habitat for fish and wildlife. Each riparian corridor is important to enable a properly functioning network of streams and rivers to support fish and wildlife in the Metro region.

[11] The riparian corridor is defined based on five functions: microclimate and shade; streamflow moderation and water storage; bank stabilization, sediment and pollution control; large wood and channel dynamics; and organic material sources.

Based on a landscape approach and supported by the scientific literature, Metro Executive Officer Mike Burton proposes that:

Any area within the riparian corridor boundary (which is any area receiving a primary or secondary functional score) is significant[12].

Scientific basis

To the maximum extent possible, all perennial, intermittent and ephemeral streams should be protected from surrounding land use activities by a buffer (May 2000). The effectiveness of a riparian corridor protection program depends on the percentage of stream miles that are protected; the more miles protected, the more effective a program will be (Wenger 1999). As stated by Fischer et al. (2000): "Continuous buffers are more effective at moderating stream temperatures, reducing gaps in protection from non-point source pollution, and providing better habitat and movement corridors for wildlife."

Several functions important for fish and wildlife are influenced by the entire system of streams. For instance, nearly half of the large woody debris found in low gradient streams is delivered from upstream sources (Pollock and Kennard 1998). Studies have also found that the temperature of streams is influenced not only by the condition of adjacent forest but also by upland forest conditions and upstream conditions (Pollock and Kennard 1998). The hydrologic regime of a stream at any given point is directly related to development patterns and activities in all hydrologically connected upstream drainages (Wigmosta et al. 1994; Booth 2000).

The entire stream network functions as a system, thus removing the connection between intermittent and perennial streams may have detrimental consequences to the physical and biological components of stream ecosystems, particularly in the long term (FEMAT 1993). Naiman et al. (1992) stated that intermittent streams are an important, often overlooked, component of aquatic ecosystems.

Riparian buffers are especially important along the small headwater streams that typically make up the majority of stream miles in any basin (Osborne and Kovacic 1993; Binford and Bucheneau 1993; Hubbard and Lowrance 1994; Lowrance et al. 1997; May et al. 1997a; Fischer et al. 2000). These smaller streams have more interaction with the land and riparian vegetation plays an integral role in reducing sediment and other pollutants, maintaining temperature regimes, and providing large woody debris and other organic inputs (FEMAT 1993). Riparian buffers along larger streams have less of an impact on water quality, however they often are longer and wider thus providing better wildlife habitat (Fischer et al. 2000).

In urban areas the functions of the aquatic ecosystem are altered, as described in the previous section. Increased urbanization causes an increase in negative inputs such as contaminants, sediments and stormwater flow, and also reduces the amount of large woody debris and other

[12] Thus, any site receiving an ecological function score for any of the functional criteria is deemed significant.

organic inputs required for the survival of aquatic life (Booth et al. 1997; Todd 2000). Johnson and Ryba (1992) stated that " a large buffer in an area of high-intensity land use...is more essential than in low-intensity land use areas." FEMAT (1993) recommends 91 m (300 ft) on each side of fish bearing streams in a forested landscape, as well as protecting permanently flowing non-fish bearing streams; constructed ponds, reservoirs, and all wetlands greater than one acre; all lakes and natural ponds; and seasonal or intermittent streams, smaller wetlands, and unstable areas to a lesser extent. The protection of all of these areas is crucial to maintaining habitat for aquatic and riparian-associated wildlife. In an urban area, with the greater impacts associated with urbanization, a protection scheme of less than that recommended by FEMAT in the forested landscape may not be sufficient to fully provide fish and wildlife habitat.

Identifying regionally significant riparian resources

The Goal 5 rule includes language specific to Metro that allows the protection of regional resources. The rule states that a "regional resource is a site containing a significant Goal 5 resource..." (OAR 660-23-080 (1)(b)). The regional resources must be identified on a map adopted by Metro ordinance. This language implies that Metro has considerable leeway in defining a regional resource. Title 3 Section 5 states that Metro will protect "regionally significant resources." Therefore, Metro is considering "regionally significant resources" and "regional resources" to be synonymous. Metro's Regional Framework Plan also calls for protection of "regionally significant parks, natural areas, open spaces, trails and greenways" in Section 3.2.

There are many alternative methodologies that could be selected to identify "regionally significant resources." In July 2001 the Metro Council adopted a Vision Statement that included a vision, goal, and objectives. The document was also endorsed by the Metropolitan Policy Advisory Committee (MPAC), a body that consists of elected officials representing the cities and counties within the Metro region. The language in the Vision Statement reflects the many regional, state, and federal policies that guide Metro in developing a strategy for protecting fish and wildlife habitat. The vision and goal as described in the document are:

> ***Vision:*** Our region places a high priority on the protection of its streams, wetlands and floodplains to maintain access to nature; sustain and enhance native fish and wildlife species and their habitats; mitigate high storm flows and maintain adequate summer flows; provide clean water; and create communities that fully integrate the built and natural environment. As ribbons of green, stream and river corridors maintain connections with adjacent upland habitats, form an interconnected mosaic of urban forest and other fish and wildlife habitat, and contribute significantly to our region's livability. The RUGGOs state that the region should "Manage watersheds to protect and ensure to the maximum extent practicable the integrity of streams, wetlands and floodplains, and their multiple biological, physical, and social values," as well as 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."
>
> ***Goal:*** The overall goal is to conserve, protect and restore a continuous ecologically viable streamside corridor system, from the streams' headwaters to their confluence with others streams and rivers, and with their floodplains in a manner that is integrated with the surrounding urban landscape. This system will be achieved through conservation, protection and appropriate restoration of streamside corridors through time.

In the same document the Metro Council committed to developing a program that is consistent with state Land Use Planning Goal 5 and the federal Endangered Species Act.

Table 18 below shows several alternatives for identifying regionally significant riparian corridors, a brief discussion of each alternative, and an assessment of how well each alternative meets the criteria for identifying regionally significant resources (below). These options were considered by staff, various advisory committees, the executive officer, and the Council, in that order. Staff recommended retaining all areas receiving one or more primary functions as regionally significant. However, after much discussion the MTAC committee recommended retaining everything on the map as significant, to also be regionally significant. Executive officer Mike Burton forwarded this recommendation to Council, as described above, and the full inventory was subsequently accepted as regionally significant. The discussion below follows the thought process providing the basis for this decision.

1. **Science-based** means that the option is compatible with the information presented in Metro's Goal 5 Science Literature Review, and that it is likely to provide some level of protection for each of the five identified Ecological Functional Values addressed in Metro's GIS model.
2. **Watershed approach** implies that the option provides resource protection with the minimum spatial unit considered being a watershed. This is consistent with Metro's Regional Urban Growth Goals and Objectives (RUGGOs) Objective 12 and Metro's Regional Framework Plan (RFP) section 4.13, dealing with watershed management and regional water quality, and is an important component of master planning because conditions in one part of the watershed may be influenced by activities in all other parts of the watershed.
3. **Protects hydrology** within this context suggests that an option will help protect existing hydrologic function from further human-induced alteration. In urbanized watersheds, altered hydrology is a fundamental pathway to ecological and biological degradation. However, it is important to recognize that hydrology in many of the region's watersheds is already substantially altered, and restoration of more natural hydrological regimes will require programs that address the fundamental impacts on hydrology, such as impervious surfaces and piping of stormwater runoff directly to streams.
4. **Promotes connectivity**: Connectivity refers to how tributaries are connected to larger rivers, how groundwater interacts with surface water, how water moves among streams, wetlands and floodplains, and how fish and wildlife move among watershed components (aquatic and terrestrial). The ecological health of a watershed (and its wildlife) depends in part on the connectivity between and among streams and other water resources, as well as the riparian area, over space and time. Well-connected streams and riparian buffers serve as movement corridors for wildlife and plants, allowing re-population of extirpated species, gene flow over space, and dispersal and migration corridors. Metro's Vision Statement reiterates our commitment to regional connectivity: "As ribbons of green, stream and river corridors maintain connections with adjacent upland habitats, form an interconnected mosaic of urban forest and other fish and wildlife habitat, and contribute significantly to our region's livability."
5. **Multispecies benefits** implies protection of vertebrate and invertebrate biological diversity (not just fish). This is consistent with Metro's RUGGOs stating that the region should "Manage watersheds to protect and ensure to the maximum extent practicable the integrity of streams, wetlands and floodplains, and their multiple biological, physical, and social values." To protect the region's biodiversity, options with multispecies benefits provide a more holistic ecological approach, and may help prevent future Endangered Species Act listings of other species.
6. **Restoration potential**: alternatives addressing this criterion will address certain areas within and near the riparian corridor that may be currently degraded, but are important to wildlife and hydrology and could be restored to increase ecological function. While not required by

Goal 5, restoration of such areas is consistent with Metro's RUGGOs and Vision Statement and would likely result in higher levels of ecological function, increase the potential for ESA compliance, and decrease the potential for future ESA listings.

7. **Meets Goal 5 requirements:** alternatives likely to be in compliance with the rules outlined in the Goal 5 rule.
8. **Meets the goals in the Vision Statement:** alternatives that support the goals outlined in Metro's Vision Statement.
9. **Likely to address ESA requirement:** alternatives that are likely to be consistent with National Marine Fisheries Services' matrix of Pathways and Indicators and what is necessary to protect critical fish habitat.

Each alternative in Table 18 is evaluated based on how well it meets all nine of the above criteria for identifying regionally significant resources. Metro staff applied the information in the Technical Report for Goal 5 and best professional judgement in evaluating each alternative against the criteria.

Table 18. Alternatives for determining regionally significant riparian corridors.

Alternatives for determining regional significance	Discussion	Criteria for identifying regionally significant resources								
		Science-based	Watershed approach	Protects hydrology	Promotes connectivity	Multispecies benefits	Restoration potential	Meets state Goal 5 requirements	Meets the goals in the Vision Statement	Likely to address ESA requirements
1. Identifying all areas within Metro's defined riparian corridor as significant regional resources.	A wealth of scientific literature describes the important functions and values of riparian corridors for fish and wildlife habitat. Federal, State, local and Metro policy also identifies the importance of riparian corridors, while public opinion indicates high value placed on streams as well. Protecting riparian corridors is an important part of a salmonid recovery strategy for the Metro region, in response to the ESA listings. While not every riparian corridor in the region contains a salmon-bearing stream, this does not negate the importance of every riparian corridor in the larger picture of salmonid fish populations and habitat for other fish and wildlife species. While some riparian corridors may currently be degraded, the resource still may be deemed significant due to its restoration and enhancement potential. This option provides the most potential for protecting and restoring fish and wildlife habitat in the Metro region.	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Identifying all areas receiving an ecological function score of 3 or more within Metro's defined riparian corridor as significant regional resources.	This alternative would reduce the amount of land that would fall within the area identified as being a regional resource by omitting areas receiving secondary scores for either the water storage or microclimate functions. Forest patches receive a secondary score for microclimate between 101-780 feet from a stream and for water storage until there is a break in the patch.	✓	✓	?	?	✓	✓	✓	✓	✓
3. Identifying all areas receiving an ecological function score of 6 or more within Metro's defined riparian corridor as significant regional resources.	All of the sites receiving an ecological function score provide an important contribution to fish and wildlife habitat. However, the areas receiving primary ecological function scores are the most critical to maintain and restore healthy streams and riparian corridors. Most of the widths delineating primary ecological functions are based on a minimum corridor width identified in the science. As long as vegetation is present, this alternative results in a 150-ft corridor without the presence of steep slopes, which extend it to 200 ft. The minimum corridor width is 50 ft. Based on Metro's Technical Review for Goal 5, this alternative depicts the minimum area likely to provide the basis for a scientifically sound decision.	✓	✓	?	?	✓	?	✓	✓	✓
4. Identifying all areas receiving an ecological function score of 12 or more within Metro's defined riparian corridor as significant regional resources.	This alternative would identify all sites that receive two or more primary ecological function scores as regional resources. The result of this alternative would be a 100-ft corridor (with vegetation present) up to 150 ft with steep slopes, or a 50-ft default for bank stabilization and channel migration. While this alternative may meet state Goal 5 requirements, it is not likely to meet the Council adopted Vision Statement or federal ESA requirements. This option fails to adequately safeguard the full suite of riparian functions necessary to protect fish and wildlife habitat and water quality, such as Ecological Functional Values that often extend spatially beyond the limits outlined here (e.g., Microclimate and Shade, Streamflow Moderation and Water Storage). Ecologically important but degraded areas (e.g., unvegetated but undeveloped areas that could be restored) would be excluded.	✓	✓	?	?	✓	?	✓		

Alternatives for determining regional significance	Discussion	Criteria for identifying regionally significant resources								
		Science-based	Watershed approach	Protects hydrology	Promotes connectivity	Multispecies benefits	Restoration potential	Meets state Goal 5 requirements	Meets the goals in the Vision Statement	Likely to address ESA requirements
5. Identifying only the riparian corridors on fish-bearing streams as regional resources.	This option only addresses the symptoms of ecological degradation (endangered species), not the causes, and is narrowly focused on fish. The data and maps depicting fish-bearing streams are inadequate for the Metro region and therefore using this criterion could exclude many miles of fish-bearing streams, resulting in inconsistent resource protection. It also excludes streams that could bear fish if structural blockages were altered or removed, as well as non-fish-bearing streams that add cold water, large wood, and nutrients that feed into fish-bearing streams. This option is unlikely to adequately protect any of the identified Ecological Functional Values on a regional basis.	✓					?	✓		
6. Identifying only the riparian corridors with high quality habitat as regional resources.	There is no comprehensive database or map of riparian corridor habitat quality for the Metro region. Riparian corridor habitat assessments have been conducted for only selected watersheds around the region. In addition, "high quality" is a judgement call. This project does not exclusively focus on the quality of the riparian corridor habitat because its goals are to protect, restore and conserve riparian corridors regardless of their current condition. If this option were chosen, it would result in identifying a limited and potentially inadequate number of riparian corridor miles as regional resources, and would not adequately protect the identified Ecological Functional Values on a regional basis.					✓		✓		
7. Identifying only the riparian corridors with designated threatened, endangered or sensitive fish and wildlife species present as regional resources.	This option only addresses the symptoms of ecological degradation (endangered species), not the causes, and is narrowly focused on species that are already at risk. The goal described in the Vision Statement is to protect, conserve and restore riparian corridors for all fish and wildlife species that use these corridors for food, shelter, protection and as travel corridors in the Metro region. Lack of comprehensive, consistently collected data would result in inconsistent and inadequate resource protection under this option. This project has used a multi-species approach in order to ensure that the greatest numbers of species are protected. If this option were chosen, it would fail to protect the identified Ecological Functional Values in the region.					✓		✓		
8. Identifying only the riparian corridors currently protected by cities and counties as significant regional resources.	Metro's analysis of Goal 5 fish and wildlife habitat protection programs in the region revealed that Goal 5 protection varies significantly from high levels of protection to little or no protection. Current individual Goal 5 programs do not add up to a regionally consistent or comprehensive protection program for riparian corridor fish and wildlife habitat. If this option were chosen, it would not result in adequate protection of the identified Ecological Functional Values at the regional level.				?	✓	?	✓		

Based on the policies included in the Vision Statement and Goal 5 TAC recommendations, Metro staff recommends utilizing the ecological functions approach to identify regionally significant resources. As described previously, this approach combines GIS mapping technology, scientific recommendations, and fieldwork for an inventory that encompasses the entire Metro region. The approach provides adequate information on the location, quantity, and quality of the riparian corridor resources in the region.

The ecological functions and criteria provide a tool to define the riparian corridor, determine resource significance, and identify regional resources.

Metro Executive Officer Mike Burton recommends that at a minimum, any area within the riparian corridor boundary receiving a score of three or more is regionally significant.

Identifying significant wildlife habitat resources

All of the areas mapped as providing habitat are biologically significant. As discussed in Metro's Technical Report for Goal 5, wildlife habitat loss has been pervasive in our region and has resulted in widespread fragmentation and degradation of remaining habitats. Several habitat types and numerous wildlife species are formally recognized to be at-risk by natural resources agencies in our region.

Important guidelines in developing a conservation plan for wildlife habitat are: large patches are better than small patches; small patches of unique habitat are worth saving; connectivity to other patches is important; and connectivity and/or proximity to water resources is valuable. These factors help determine habitat quality, thus they play key roles in what species can utilize habitat patches and persist over the long term in our region.

A substantial portion of existing wildlife habitat in the region was excluded from Metro's wildlife habitat inventory at the outset. For example, our inventory focused on patches with closed forest canopy, with low-structure vegetation only appearing in the inventory if within 300 feet of a waterway. The inventory also set a minimum patch size of 2 acres (except for wetlands). Thus, upland forested patches that were not in closed canopy conditions were excluded, as were most low-structure patches further than 300 feet from water sources and most patches smaller than 2 acres. Taking this into account and considering the substantial losses of natural cover over time, each habitat patch in the inventory may be important to enable a properly functioning habitat network to support the long-term persistence of wildlife in the Metro region.

A landscape perspective of wildlife habitats as contiguous, interconnected, and dynamic systems within a nested array of watersheds is critical in determining the significance of a specific habitat patch. Metro's Science Literature Review identifies and discusses the ecosystem functions of wildlife habitats. It emphasizes the value of connectivity across the landscape as an essential component for providing properly functioning habitat for wildlife. Based on the previously described inventory approach and consistent with Goal 5 TAC recommendations, Metro Executive Officer Mike Burton has proposed defining wildlife habitat for purposes of the Goal 5 inventory as any site that receives a score of one or more, or any site that has been mapped as a Habitat of Concern.

> Based on a landscape approach and supported by the scientific literature, Metro staff proposes that:
>
> **Any habitat patch receiving a score of one or more, and all Habitats of Concern, are significant.**

Scientific basis

Urban environments have similar ecological problems worldwide, including habitat loss, fragmentation, damage and simplification (instream and terrestrial); introduced species; and human disturbance (see Metro's Technical Report for Goal 5, Impacts of Urbanization section). Native vegetation plays a critical role in a watershed, particularly the longitudinal and lateral connectivity of the riparian corridor but also within specific upland habitat types such as oak. Downed wood and snags (or large woody debris), frequently found in natural ecosystems but often lacking in disturbed environments, are crucial in providing high quality habitat in both aquatic and terrestrial ecosystems; many at-risk species in our region depend on large wood to meet their life-history needs.

The characteristics that Metro has incorporated into its wildlife habitat inventory are designed to conserve the features known to be most critical to a healthy regional system of wildlife habitats. The importance of these characteristics are reviewed in Metro's Technical Report for Goal 5 (Metro 2002). For example, large habitat patches typically contain more large wood, fewer nonnative plants and animals, and better three-dimensional structure than smaller patches. Patch shape also influences these factors. Between-patch connectivity along streams provides both water and passage to wildlife, allowing post-breeding dispersal and natural reintroduction of locally extirpated species. The wildlife habitat inventory represents a regional "backbone" of habitats that have the potential to support healthy, productive and diverse wildlife populations as the region's human population increases over time. This habitat system's value could be further increased by building additional connectivity and improving native conditions through carefully planned habitat restoration; our regional approach to evaluating wildlife habitats provides an excellent opportunity to identify key restoration sites based that may disproportionately, positively influence conditions for wildlife.

Identifying regionally significant wildlife habitat resources

The Goal 5 rule includes language specific to Metro that allows the protection of regional resources. The rule states that a "regional resource is a site containing a significant Goal 5 resource..." (OAR 660-23-080 (1)(b)). The regional resources must be identified on a map adopted by Metro ordinance. This language implies that Metro has considerable leeway in defining a regional resource. Title 3 Section 5 states that Metro will protect "regionally significant resources." Based on habitat loss over time, it could validly be argued that all habitats identified in the inventory are regionally significant and contribute to the vitality of the region's wildlife. However, smaller, more isolated habitat patches lacking in water resources generally provide less value to wildlife than larger, well-connected patches with water; fieldwork confirms what the scientific literature tells us.

There are many alternative methodologies that could be selected to identify "regionally significant resources." Metro's goals in identifying regionally significant wildlife habitats are to meet the vision, goals and objectives in the regional framework plan (described in the regional significance section for riparian corridors, above) and to comply with the Goal 5 rule. The Regional Significance decision should aim for "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." (Metro's Vision Statement)

Table 19 below shows several alternatives for identifying regionally significant riparian corridors, a brief discussion of each alternative, and an assessment of how well each alternative meets the criteria for identifying regionally significant resources (below). These options were considered by staff, various advisory committees, the executive officer, and the Council, in that order.

Each alternative in Table 19 below is evaluated based on how well it meets all five of the criteria for identifying regionally significant wildlife habitat resources. Metro staff applied the information in the Technical Report for Goal 5 and best professional judgement in evaluating each alternative against the criteria.

1. **Meets Goal 5 requirements:** alternatives likely to be in compliance with the rules outlined in the Goal 5 rule.
2. **Meets the goals in the Vision Statement:** alternatives that support the goals outlined in Metro's Vision Statement.
3. **Supports the goals in ODFW's Wildlife Diversity Plan:** Options meeting this criterion should directly support a goal, priority, or strategy stated in ODFW's Wildlife Diversity Plan (ODFW 1993). The Goal 5 rule states that when gathering information regarding wildlife habitat under the standard inventory process in OAR 660-23-030(2), local governments shall obtain current habitat inventory from ODFW and other state and federal agencies. Because such habitat information is limited, Metro has also incorporated ODFW's wildlife diversity goals for the state into the Goal 5 inventory process. The stated goal of ODFW's Wildlife Diversity Plan is: "To maintain Oregon's wildlife diversity by protecting and enhancing populations and habitats of native wildlife at self-sustaining levels throughout natural geographic ranges." The Plan also recognizes that habitat is most often the key to maintaining wildlife populations, and that a multi-species, ecosystem-based approach to research and management should be used whenever possible. Metro's vertebrate species list (Appendix 9) identifies wildlife species that are native to this region (e.g., species whose natural geographic ranges fall within the metro area). Options with a high level of agreement with this criterion should: (1) be science-based, (2) consider at least a watershed approach, and (3) pay particular attention to the protection of at-risk habitats and species (including groups of at-risk species such as Neotropical migratory birds), as manifested in the Habitats of Concern and through patch size and connectivity issues.
4. **Consistent with Metro's Technical Report for Goal 5** means that the option is compatible with the information presented in Metro's Goal 5 Technical Review (scientific literature review), and that it is likely to qualitatively differentiate habitat patches based on each of the four identified habitat characteristics addressed in Metro's GIS model (patch size, shape, connectivity to other patches, and water resources).
5. **Ecosystem approach:** ODFW's Wildlife Diversity Plan recognizes that a multi-species, ecosystem-based approach to research and management should be used whenever possible, stating that:

   > ...Maintaining wildlife diversity means maintaining the full array of native species and populations of those species. To this end, the Plan calls for a multi-species, ecosystem-based approach whenever possible...An ecosystem approach to wildlife management represents (in its broadest sense) a philosophy of natural resource management that emphasizes sustaining ecological values and functions while deriving socially-defined benefits. Ecosystem management considers all natural components, both biological and physical, rather than focusing on single species or groups of species. (ODFW 1993)

   ODFW does not provide a spatially explicit definition of ecosystem, but states that ecosystem management assumes that by preserving adequate amounts, quality and connectivity of habitat, all wildlife species will be maintained. The metro region is largely contained within ODFW's recognized Western Interior Valleys physiographic province, and forms a cohesive ecosystem unit via the influences of the greater Portland region's urbanization patterns, which exert varying (but predictable) degrees of human influence along the urban-rural gradient. Alternatives supporting this criterion should consider the region's wildlife habitats as a cohesive, interrelated system.
6. **Promotes sensitive species/habitat conservation:** the Goal 5 rule states that when gathering information regarding wildlife habitat under the standard inventory process in OAR 660-23-030(2), local governments shall obtain current habitat inventory from ODFW and other state and federal agencies, including at least the following:

- Threatened, endangered, and sensitive wildlife species habitat information;

- Sensitive bird site inventories; and
- Wildlife species of concern and/or habitats of concern identified and mapped by ODFW...
  Sensitive, or at-risk, species and habitats are also identified as priorities by ODFW. Note that neither ODFW nor any other agency has systematically mapped species or habitats of concern specifically for the metro region. Partial information is available from a variety of sources, and Metro used such data to incorporate site-specific sensitive species information into the Habitats of Concern layer (for example, know native turtle nesting and crossing areas). Although site-specific species information is limited, many sensitive species are habitat specialists relying on sensitive habitats, such as riparian or grasslands; regional loss of these habitats contributes to these sensitive species' decline. The Habitats of Concern layer includes all of the sensitive habitat information that Metro has received (verified using aerial photos and GIS data) and that meet our definition of Habitats of Concern (based on ODFW, USFWS, Partners in Flight, and the Oregon Biodiversity Project), including: priority conservation habitats (based on ODFW, USFWS, the Oregon Biodiversity Project, and the Oregon/Washington chapter of Partners in Flight); riverine islands and deltas; and patches providing unique or critical wildlife functions, such as migration corridors and stopover habitat, inter-patch connectors, and biologically or geologically unique areas habitat vital for a sensitive species. Alternatives supporting this criterion should include the full known extent of the Habitats of Concern layer.

7. **Maintains existing connectivity:** Metro's RUGGOs 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." Connectivity in the wildlife habitat context refers to how well fish and wildlife can move among watershed components (aquatic and terrestrial). The ecological health of a watershed and its wildlife depends in part on the connectivity between and among streams and other water resources, as well as the riparian area and upland habitats, over space and time. Well-connected streams, riparian buffers, and upland patches serve as movement corridors for wildlife and plants, allowing re-population of extirpated species, gene flow over space, and migration and dispersal corridors. Within Metro's wildlife habitat inventory, many patches providing important connectivity corridors are not forested, but consist of low-structure vegetation, including agricultural lands; in addition to connectivity, these habitats are very important to wildlife species dependent on non-forested habitats, such as grassland bird and mammal species. Alternatives resulting in significant reduction of existing connectivity, such as substantial omission of low-structure connector patches or options failing to consider connectivity, would not meet this criterion (and would also reduce the amount of available grassland and shrub habitat in the inventory).
8. **Maximizes restoration potential:** alternatives addressing this criterion will address certain areas that may be currently degraded, but are important to wildlife and could be restored to increase wildlife habitat functions and value. The more lower-scoring areas included as regionally significant, the more restoration potential exists in a regional wildlife habitat plan, in terms of improving both habitat quality and connectivity. For example, low-structure vegetation within 300' of streams, or small "stepping-stone" upland habitats providing important inter-patch connectivity for birds, could be enhanced with native plants or improved with connectivity in mind. While not required by Goal 5, restoration of such areas is consistent with Metro's RUGGOs and Vision Statement as well as ODFW's Wildlife Diversity Plan, and would likely result in higher levels of ecological function, increase the potential for retaining sensitive species, and decrease the potential for future ESA listings. Alternatives supporting this criterion would be more inclusive of smaller connector patches, regardless of their current condition.

 Table 19. Options for determining regionally significant wildlife habitats.

Options for determining regional significance	Discussion	Criteria for identifying regionally significant resources							
		Meets Goal 5 requirements	Meets the goals in the Vision Statement	Supports the goals in ODFW's Wildlife Diversity Plan	Consistent with Metro's Technical Report for Goal 5	Ecosystem approach	Promotes sensitive species/habitat conservation	Maintains existing connectivity	Maximizes restoration potential
1. Identify all areas within Metro's wildlife habitat inventory as significant regional resources, including all Habitats of Concern (HOCs).	Considerable research documents the importance of habitat patch size and shape, water resources, and habitat connectivity to wildlife, and Metro's 2001 fieldwork validates the importance of these habitat characteristics in our area. Federal and state wildlife agencies and conservation organizations document significant and continuing losses of the proposed wildlife HOCs, and consistently consider these habitats to be at risk in our area. A habitat network that includes all of the above characteristics is most likely to enhance sensitive species persistence and biological diversity. <u>Risk to the resource</u>: this option provides the most potential to protect and restore the region's wildlife habitat by including all identified wildlife habitat including the smallest forest patches and low structure (non-forest) vegetation within 300 feet of water as regionally significant. The only risk to wildlife habitat resources is to habitat not included in the current inventory.	✓	✓	✓	✓	✓	✓	✓	✓
2. Identify all areas within Metro's wildlife habitat inventory scoring 2 or greater plus HOCs as significant regional resources.	Same as Option 1, except that all habitat patches with a score of 1 would be omitted (approximately 2,070 acres); these patches tend to be in developed settings and may or may not be near other, similar patches. Sizes range: 2 to 20+ acres. <u>Risk to the resource</u>: the most important wildlife functions for these smaller patches are migratory bird stopover habitat, locally important wildlife habitat, and building blocks with which to retain existing and enhance future connectivity through carefully planned restoration or creation of proximal patches.	✓	✓	✓	✓	✓	✓	✓	✓
3. Identify all areas within Metro's wildlife habitat inventory scoring 3 or greater plus HOCs as significant regional resources.	<u>Risk to the resources</u>: same as Option 2, except that all habitat patches with a score of 1 and 2 would be omitted (approximately 6,012 acres). Patches omitted include larger patches compared to option 2 (up to 100+ acres) and some patches with excellent water resources. For example, a narrow 106-acre patch nearly 4 miles long, comprising the riparian vegetation along the Willamette River/Multnomah Channel shoreline across from Smith and Bybee Lakes, would be omitted. This option would likely reduce existing connectivity; reduce potential for restoration of connectivity because important "stepping stones" would be lost; reduce existing connectivity of habitat patches to water; and result in the omission some important riparian habitats. Increased chance of adversely affecting sensitive species.	✓	?	?	✓	✓	✓	?	

Options for determining regional significance	Discussion	Criteria for identifying regionally significant resources							
		Meets Goal 5 requirements	Meets the goals in the Vision Statement	Supports the goals in ODFW's Wildlife Diversity Plan	Consistent with Metro's Technical Report for Goal 5	Ecosystem approach	Promotes sensitive species/habitat conservation	Maintains existing connectivity	Maximizes restoration potential
4. Identify all areas within Metro's wildlife habitat inventory scoring 4 or greater plus HOCs as significant regional resources.	<u>Risk to the resource</u>: same as Option 3 except that all patches with a score of 1,2, and 3 would be omitted (approximately 14,933 acres). Compared to Option 3, this option doubles the acreage of wildlife habitat omitted. Patches omitted include larger patches and substantially larger amounts low-structure vegetation within 300' of water sources compared to Option 3. In addition, some larger habitat upland patches would be omitted compared to Option 3. For example, a 227-acre low-structure patch along a long stream segment would be omitted. These patches are important connectors and provide grassland habitat. Areas with scarce habitat, such as southeast and northeast Portland, would likely be strongly influenced because a significant percentage of their remaining habitat patches could be excluded from the inventory. This option could also have a strong negative influence on the connectivity of the region's wildlife habitat system and is unlikely to provide a regional wildlife habitat system that meets Metro's and ODFW's stated wildlife habitat goals.	✓	?	?	✓	?	✓		
5. Identify only wildlife habitat patches that are already in the existing riparian corridor inventory plus all HOCs.	This option would retain the wildlife score structure, but would consider habitats to be regionally significant only if they fall within the Council-approved riparian corridor inventory except for HOCs. All HOCs would be retained as regionally significant, whether in the riparian inventory or not. Over 90% of wildlife habitats fall within the riparian corridor inventory. <u>Risk to the resource</u>: one result of this option would be omission of habitats in areas generally lacking in water and habitat resources, such as developed areas in northeast and southeast Portland. The forested portions of certain butte tops would be omitted because they do not meet the definition of Habitats of Concern; however, these patches provide important breeding and migratory stopover habitat to songbirds, including Neotropical migrants.	✓	✓	?	?	?	✓	?	✓

Options for determining regional significance	Discussion	Criteria for identifying regionally significant resources							
		Meets Goal 5 requirements	Meets the goals in the Vision Statement	Supports the goals in ODFW's Wildlife Diversity Plan	Consistent with Metro's Technical Report for Goal 5	Ecosystem approach	Promotes sensitive species/habitat conservation	Maintains existing connectivity	Maximizes restoration potential
6. Identify only wildlife habitat patches with known sightings of designated threatened, endangered or sensitive wildlife species as regional resources.	*The Safe Harbor provision in the Goal 5 rule states that local governments may determine that significant wildlife habitat is only those sites where one or more of the following conditions exist: "(a) the habitat has been documented to perform a life support function for a wildlife species listed by the federal government as a threatened or endangered species or by the state of Oregon as a threatened, endangered, or sensitive species; (b) the habitat has document occurrences of more than incidental use by a species described in subsection (a) of this section; (c) the habitat has been documented as a sensitive bird nesting, roosting, or watering resource site for osprey or great blue herons...; (d) the habitat has been documented to be essential to achieving policies or population objectives specified in a wildlife species management plan adopted by the Oregon Fish and Wildlife Commission pursuant to ORS Chapter 496; or (e) the area is identified and mapped by ODFW as habitat for a wildlife species of concern and/or as a habitat of concern..."* Risk to the resource: this option only addresses the symptoms of ecological degradation (at-risk species), not the causes, such as habitat loss and fragmentation. Further, although Metro has collected available information of over 300 sensitive species sightings, there is no comprehensive, consistently collected database or survey of sensitive species in the Metro region, nor does the existing data distinguish between incidental and "more than incidental" use. This option would likely result in inconsistent, and probably inadequate, resource protection; it could fail to protect many important habitat patches solely due to lack of survey data, and would fail to address large-scale patterns of habitat connectivity and fragmentation. This option is not likely to promote biodiversity or the long-term persistence of sensitive species and habitats in the region, nor would it meet the goals in the Vision Statement.	✓					?		

Based on the policies included in the Vision Statement and Goal 5 TAC recommendations, Metro staff recommends utilizing the multi-tiered approach to identify regionally significant wildlife habitat resources. As described previously, this approach combines GIS mapping technology, scientific recommendations, and fieldwork for an inventory that encompasses the entire Metro region. The approach provides adequate information on the location, quantity, and quality of the riparian corridor resources in the region.

The wildlife habitat criteria provide a tool to define wildlife habitats, determine resource significance, and identify regional resources.

Executive Officer Mike Burton recommends Option 2 for identifying regionally significant wildlife habitat resources.

Conclusion

This document contains a detailed description of Metro's Goal 5 inventory approach, methodology, and site analyses for riparian corridors and wildlife habitat. Metro's analysis of how its inventory meets the requirements of the Goal 5 rule by including regionally consistent information on the location, quantity and quality of riparian corridor resources in the region is also covered. Based on this documentation, Metro's inventory has been determined to be adequate for purposes of making a significance decision.

A landscape perspective of both riparian corridors and wildlife habitat as contiguous, interconnected, and dynamic systems within a nested array of watersheds is critical in determining the significance of a specific riparian or wildlife resource. Although the two types of resource may be examined separately, they are closely related, as the substantial overlap between the two inventories indicates. Fish rely on streams, but fish are also a type of wildlife; in turn, terrestrial wildlife relies on healthy riparian areas to meet daily survival needs. Metro's Technical Report for Goal 5 identifies and discusses the ecosystem functions of riparian corridors and the elements that are important to wildlife habitat. It emphasizes the importance of the connectivity of the linear stream system across the landscape, width of the riparian corridor, and configuration of wildlife habitat patches as essential components for providing the properly functioning habitat for fish and wildlife. Riparian areas and wildlife habitat should be considered within the context of the subwatershed, watershed, and regional system. Metro's inventory provides the means to do just that.

Metro's review of the scientific literature, combined with a survey of historic and present conditions and the current negative trend of wildlife and water resources, argue for a strong conservation effort. Each riparian corridor is important to enable a properly functioning network of streams and rivers to support fish and wildlife in the Metro region. Each patch of remaining habitat is important to the region's wildlife, and the removal of any habitat patch should be considered carefully if thoughtful wildlife habitat conservation is to be a regional goal. Such consideration will be undertaken in the next step of the Goal 5 Process, the ESEE analysis (Environmental, Social, Economic and Energy consequences of allowing, limiting, or prohibiting development).

The biological integrity of the riparian corridor depends, in part, on the width and condition of the riparian area, and these factors help dictate stream functions and ultimately the type of plant and animal species that can live in and around streams. Based on the ecological function approach and consistent with Goal 5 TAC and other technical advisory committee recommendations, Executive Officer Mike Burton proposed defining ***significant riparian corridors*** for purposes of the Goal 5 inventory as any site that receives a primary or secondary ecological function score. This recommendation was forwarded to Metro Council, who voted to accept this definition of regional significance in Resolution No. 01-3141C on December 13, 2001 (Appendix 5).

Several alternatives for defining ***regionally significant riparian corridors*** are described in this document. After a period of public review and comments in addition to Metro advisory committee deliberations and recommendations, Executive Officer Mike Burton proposed defining regionally significant riparian corridors as any site that receives a primary or secondary ecological function score. This recommendation was forwarded to Metro Council, who voted to accept this definition of regional significance in Resolution No. 01-3141C on December 13, 2001 (Appendix 5).

The biological integrity of the region's wildlife habitat depends, in part, on the size, shape, and connectivity of habitat patches, in addition to the availability of water resources. Combined with habitat type, these factors help dictate wildlife habitat quality and ultimately the type of plant and animal species that can live in the region. The Habitats of Concern data layer incorporates sensitive species information inasmuch as is possible, through identification of at-risk habitat types with which declining species are associated, and identification of known areas critical to the life-history requirements of sensitive species. Based on the multi-tiered approach to mapping wildlife habitat and consistent with Goal 5 TAC recommendations, Executive Office Mike Burton has proposed defining ***significant wildlife habitat*** for purposes of the Goal 5 inventory as any site that receives a score of one or more, or any site that has been identified as a Habitat of Concern. This recommendation will be forwarded to Metro Council, who is scheduled to deliberate the options and vote to approve one option in the summer of 2002.

Several alternatives for defining ***regionally significant wildlife habitats*** are described in this document. After a period of public review and comments in addition to Metro advisory committee deliberations and recommendations, Metro staff and Executive Officer Mike Burton recommend Alternative 2 to define regionally significant wildlife habitat. These are habitat patches that received a score of two or more in the GIS model portion of the inventory, or patches that have been identified as Habitats of Concern. This recommendation will be forwarded to Metro Council, who is scheduled to deliberate the options and vote to approve one option in the summer of 2002.

The inclusion of a property in the riparian corridor inventory, wildlife habitat inventory, or both does not mean that landowners will be forced to abandon the property or that future development will be prohibited. This document represents only the inventory – that is, what has been identified as part of the Goal 5 riparian or wildlife resource. The ESEE analysis will be followed by a program to conserve, protect, and restore the region's natural resources. Taken together, the inventory, ESEE, and program steps in the Goal 5 process are designed to help ensure an equitable, unbiased decision process that will provide guidance to local jurisdictions in how to protect and improve the ecological integrity of the region's natural resources. Involvement of the public and local jurisdictions has been and will continue to be a vital part of this process.

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M E M O R A N D U M

METRO

Date: July 29, 2002
To: Andy Cotugno
From: Lori Hennings *Lori*
Re: Revisions to Metro's January 2002 Technical Report for Goal 5

I am currently revising Metro's January 2002 Technical Report for Goal 5. These are primarily "housekeeping" issues, and none result in any suggested alterations to Metro's Wildlife Habitat Inventory process. Two of the changes include additional information to document the importance of river islands, deltas and hilltops to wildlife in general, and migrants in particular. A few of the items are in response to the City of Hillsboro's critique of Metro's Goal 5 Technical Report (as prepared by Paul Fishman on behalf of the City of Hillsboro; response attached). The last two bullet items deal with uncompleted items from the previous version. These are described below.

- **Page 59.** Incorporated the following additional information on river islands and deltas (at the end of the section entitled "Wildlife Use of Urban Riparian Corridors"):

  "River islands provide important habitat for many wildlife species, including an additional riparian area available to wildlife in the middle of a river (Thorp 1992). Large wood commonly accumulates on upstream ends of islands, where it influences meander cutoffs, provides cover for juvenile salmonids, and serves as habitat for invertebrate production (Naiman et al. 1992). Doppelt et al. (1993) comment that, "Debris and other physical blockages – such as islands – contribute to the physical structure of large river systems by slowing water velocity and deflecting its course. As water is slowed and deflected, it pushes against the banks and into the soils underlying the adjacent floodplain, thereby contributing to the local water table."

  Thorp (1992) studied three islands on the Ohio River and found that that these islands had a significant positive effect on invertebrate density and diversity, related to changes in physical habitat structure within the river channel. Thorp commented:

  > 'Anthropogenic reductions in braiding, meandering, and snag abundance have diminished habitat heterogeneity of regulated rivers, factors directly influencing island formation, retentive capacity of the ecosystem, and community diversity. Habitat heterogeneity associated with riverine islands should, therefore, be of paramount importance to the ecosystem and may require special management protection...Islands have significant positive effects on invertebrate density and diversity that appear related to changes in physical habitat characteristics. Current velocity and substrate particle size are diminished in narrow channels between islands and shore, and areal extent of the littoral zone is enhanced within an otherwise deepwater region...Because of a relatively low exploitation by humans, islands probably enhance snag formation and input of organic matter, both factors having positive effects on macrofauna. Creation of selected riverine preserves near islands as a management tactic is recommended.'

  River deltas and islands create unique bottomland hardwood forest, including important cottonwood/willow communities, tree types that must be in close contact with the water table. Willow Flycatchers in the southwestern US intensively use river deltas as stopover habitat during migration (Garcia-Hernandez et al. 2001). During migration, the majority of willow flycatchers preferred native broadleaf dominated areas near standing water, such as that found in deltas and many river islands; these areas produce an abundance of flying insects hatched from the enriched aquatic macroinvertebrate community. River deltas are known to provide important winter waterfowl habitat in the west (Fleskes et al. 2002). Bald Eagles commonly use Pacific Northwest river deltas and islands for breeding and foraging (Iverson et al. 1996).

The sand bars and mudflats in river deltas and islands are also vital to certain types of wildlife. Shorebirds rely on the barren and sandy areas in these areas, seeking invertebrates in the mud and silt; other research suggests that shorebirds may be particularly susceptible to human disturbance, thus making islands even more important (Andres 1994).

- **Page 75.** Revised Table 7 per Metro's July 23, 2002 staff response to the City of Hillsboro's critique (response attached). Note that this resulted in a few corrections but did not result in any recommended modifications to Metro's current Wildlife Habitat inventory process.

- **Page 83.** Added the following verbiage documenting the local importance of hilltops to migratory birds:
  "However, certain upland habitats without connectivity to riparian areas may also be highly important to wildlife due to unique features such as topography. In the Portland metro region, vegetated hilltops provide key wildlife habitat, including migratory stopover habitats for many Neotropical migratory bird species (Houck 2002; see also Nehls 2002)."

- **Page 90.** Inserted Figure 11: historical vegetation map.

- **Appendices.** Revise Appendix 1 to reflect addition of Sharp-tailed Snake and other modifications (including corrections on scientific names, per Dr. Richard Forbes). Completed Appendix 6: Selected restoration activities and potential indicators of the effects of management activities.

M E M O R A N D U M

METRO

Date: July 23, 2002
To: Andy Cotugno, Paul Ketcham
From: Lori Hennings
Re: City of Hillsboro's Technical Review (Fishman report): Wildlife portion

You may recall that we received a critique of Metro's riparian corridor inventory prepared by Paul Fishman on behalf of the City of Hillsboro (report date November 2001, available online at http://www.fishenserv.com/metrog5/). Fishman and his staff reviewed Metro's Scientific Literature Review, now entitled "Metro's Technical Report for Goal 5," with special focus on Table 5 (now Table 7 in the January, 2002 science paper draft). At that time we opted to address only non-wildlife components of the critique, and did so in a document dated December 12, 2001 ("Staff Response to City of Hillsboro's Technical Review of Metro Goal 5 Riparian Corridor Program"). We focused on non-wildlife issues because the riparian corridor inventory significance decision was up before Council just a week after we received the critique, and the wildlife habitat component had been decoupled from the riparian inventory.

We are now approaching a final wildlife habitat model and have addressed the remaining criticisms. The attached table details staff response to these criticisms. Because Fishman's critique was riparian-focused, all of the criticisms relate to the Connectivity to Water criterion in our current Wildlife Habitat model. Although after careful review Fishman identified four errors (a relatively minor error rate, considering the volume of material staff covered), there is absolutely no evidence that we should alter any aspect of our existing Wildlife Habitat model. In fact, our 2001 field research validated all four of the criteria currently in the model, including the proximity to water criterion.

Thus I am recommending a few relatively minor changes to Table 7 and related textual information within the next draft of the science paper. As before, Fishman's critique and Metro's analysis of that critique will help strengthen our scientific approach, and our legal standing, in the future.

Please let me know if you have any questions.

cc: Mark Turpel

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Staff response to wildlife-related riparian corridor width recommendation criticisms made by Paul Fishman on behalf of City of Hillsboro.

Reference	Table 7 (formerly Table 5) criterion	GIS model criterion	Fishman's criticism(s)	Metro Staff Response	Comments and relevance to GIS model
Environment Canada 1998	Recommended riparian widths for fish and wildlife; Terrestrial habitat; Movement Corridors function.	Connectivity to water	Metro cited this reference as a buffer width recommendation for wildlife movement on one side of the stream, when in fact the reference meant the recommendation as *total* corridor width.	Agree. Quoted from Environment Canada's report: "Corridors designed to facilitate species movement should be a minimum of 100 metres wide, and corridors designed for specialist species should be a minimum of 500 metres wide. Studies have demonstrated that wider corridors are more effective at facilitating species movement." Note that this is not riparian-specific, thus if a stream is sufficiently wide or deep to be impassable to certain species, it is functionally a one-sided corridor.	**Correct Technical Report, including Table 7 (formerly Table 5).**
May 2000	General wildlife habitat; terrestrial habitat	Connectivity to water	Fishman states: "The basis for May's choice of a 328 ft wildlife buffer is unsubstantiated in his paper. Metro has cited the original text correctly, but the source document is unsound." And also: "The main focus of this article is on in-stream habitat rather than the adjacent riparian habitat. The article only devotes one paragraph and one table to the discussion of wildlife use of the stream-riparian ecosystem and riparian buffer widths for wildlife habitat."	Disagree. First, note that taking the average (using the midpoint if a range of widths is provided) for all terrestrial vertebrates listed in Dr. May's literature review yields a width of 325.8 ft (99.3 m), a difference of less than 2-1/2 feet - less than one percent of Metro's recommendation of 328 feet. Second, consider Dr. May's professional credentials. Christopher May, Ph.D., is an environmental science/engineering researcher at the Applied Physics Laboratory, College of Oceanography and Fisheries at the University of Washington. He is also an adjunct professor at Western Washington University, UW-Tacoma, The Evergreen State College and Seattle University. He has taught courses in stream ecology, conservation biology, salmonid ecology, water pollution and stormwater best management practices (BMPs). He is currently researching the effectiveness of stormwater BMPs in mitigating the ecological effects of urbanization on stream ecosystems. Dr. May's conclusions are based on peer review of his Pacific Northwest based research and thorough literature reviews Third, though the May paper does not include a major discussion of the literature for terrestrial wildlife, it does not negate the importance of the buffer widths obtained from those references.	**No action recommended.**
Knutson and Naef 1997	Terrestrial habitat	Connectivity to water	Fishman: "The reference does not make any new recommendations as to what buffer widths may be appropriate for Pacific Northwest riparian habitats...In order to determine if the reference was cited correctly, it would be necessary to go back to the references used by Knutson and Naef to determine the context in which the buffer recommendations were made..." And also: "No mention of willow flycatcher or western pond turtle or recommended buffer widths for these species was found in the reference..."	Disagree with first part, agree in part with second part. This was a literature review, designed to consolidate information rather than necessarily making new recommendations. The references used in the Knutsen and Naef paper, which was prepared for the Washington Department of Fish and Wildlife and was extensively peer-reviewed. The necessity of revisiting each cited paper to check for citation accuracy seems excessive, as it could be applied to every research paper that cites any other paper. We agree in part with Fishman's second comment – we found numerous mention of Neotropical migrants (the Willow flycatcher is one), but no specific reference to the Willow Flycatcher. Taking the average recommended widths from the Knutson and Naef paper (using the midpoint if a range of widths is provided) for Neotropical migrant species yields a width of 358 ft (109 m), as compared to Willow flycatcher's 123 ft. This approach would increase the width recommendation. With regard to Western pond turtle requirements, these are outlined in the paper's Appendix D, under "Amphibians and Reptiles." This table recommends avoiding disturbance within 400-500 meters (1,312-1,640 feet) around all bodies of water inhabited by Western pond turtles. Thus, the actual recommendation was 1,312-1,640 ft, not the 330 feet cited by Metro.	**No action recommended.**
Prose 1985	Terrestrial habitat	Connectivity to water	Fishman: "...belted kingfishers do not utilize all streams equally, and the reference also states that 'Vegetation along the margins of feeding . waters has both positive and negative implications. Belted kingfishers are seldom seen on ponds or streams that are overgrown with thick vegetation that obscures vision...' " And: "...it seems obvious that it is not necessary to provide a 100 to 200 foot riparian buffer on all streams to allow for kingfisher roosting, since	Disagree. The statement that kingfishers do not utilize all streams equally is probably correct, but there is no scientific evidence cited in support. Metro is using the known scientific literature, most of it peer reviewed (e.g., Knutsen and Naef 1997; May 2000) as its foundation. In the Portland metropolitan region, Metro staff have routinely observed Belted kingfishers perched in very dense vegetation overhanging small streams, such as tributaries flowing into Fernhill Wetlands in Forest Grove, and look in such areas first to locate this species. With regard to the statement that "it seems obvious that it is not necessary to provide a 100 to 200 foot riparian buffer on all streams," Metro has not completed the program step which could include buffer regulations, but also will consider other options such as incentives, acquisition, education and stewardship programs. When Metro does address program choices it is likely that not all streams will receive that level of protection in our	**No action recommended.**

Staff response to wildlife-related riparian corridor width recommendation criticisms made by Paul Fishman on behalf of City of Hillsboro.

Reference	Table 7 (formerly Table 5) criterion	GIS model criterion	Fishman's criticism(s)	Metro Staff Response	Comments and relevance to GIS model
			smaller, densely vegetated streams may not provide the correct habitat for kingfisher."	region because the resource has been inventoried based on what currently exists. In some areas, development has already encroached well into that buffer distance and these structures are unlikely to be removed in the near future.	
Castelle et al. 1992	Terrestrial habitat	Connectivity to water	Fishman begins with the same argument given when criticizing use of the Knutsen and Naef (1997) reference, in that he would need to look up every reference used to validate its appropriate use. Minor arguments/dissuasions regarding many of the species' requirements in the reference.	Disagree. See comments under Knutsen and Naef reference, above, regarding revisiting source literature. Regarding Bald Eagles, the statement is made that: "Although bald eagles are found in the Metro region, most riparian areas do not provide habitat for this species." However, no documentation is provided. This documentation is critical because it controverts basic facts about Bald Eagles as being a riparian-dependent species. In fact, this species does utilize many riparian areas in the region for nesting, roosting and perching, as Metro's Species of Concern data layer indicates (primary data source from ongoing OSU Bald Eagle study data). Bald Eagles rely primarily on fish and waterfowl for food (Johnson and O'Neil 2001), and riparian areas provide vital habitat for such species.	**No action recommended.**
FEMAT 1993	Terrestrial habitat	Connectivity to water	Fishman states that Metro incorrectly inferred a riparian area width range of 100-600 ft when the correct inference would be 100-300. Further, Fishman states that "The riparian reserve buffer widths determined in the reference are based upon preserving habitat for species associated with late successional forests...Therefore, the riparian reserve buffer widths recommended in the reference are not directly applicable to the majority of streams in the Metro region."	Agree in part. Metro inadvertently picked up the upper limit of the buffer range to be 600 ft rather than 300 ft. There is a reference in the document for 600 ft (page V-35), but it refers to both sides of the stream. We will correct that error. However, buffers are intended to protect ecological functions in urban areas, where human impacts are much more severe than in old-growth forest, and therefore logically should be substantially wider than those in old growth forests if the same level of ecological function is to be provided. In any case, altering the recommended width from this reference in no way impacts Metro's current Wildlife Habitat GIS model, which considers connectivity to water within 300 ft of the water source.	**Correct the recommended range in Table 7 to read 100-300 ft rather than 100-600 ft.**
NRCS 1999	Terrestrial habitat	Connectivity to water	Fishman used a different reference than that used by Metro because he could not locate the reference "despite an extensive online search, phone calls to the NRCS and the Government bookstore." Fishman states that Metro used the recommended widths as one-sided when they should have been two-sided.	Agree in part. The 1995 reference used by Metro was a draft document and is not the same document as that reviewed by Fishman. To illustrate the differences in the document, the 1995 reference consisted of 14 pages, while the 1999 document has over 100 pages. The 1995 reference provides general buffer width guidance for selected wildlife species: "Widths below include the sum of buffer widths on one or both sides of water courses and may extend beyond riparian boundaries..." This statement is unclear , but Fishman is probably correct in his interpretation that it means *total* buffer width rather than one-sided width. In Knutsen and Naef's (1997) extensive literature review, the average one-sided buffer width recommendation for reptiles and amphibians is 153 ft (46.7 m); for deer it is 138 ft (42 m, including a much narrower recommendation for eastside deer); and for beaver it is 271 ft (82.6 m). These numbers apply to perpendicular distance from the stream, thus total width excludes the width of the stream. However, given that this document was a draft and not regionally-specific, staff recommends removing it from Table 7. Whether it is retained or not, this information does not change staff recommendations for the 300-ft proximity to water criterion, which is based on numerous other references with wider recommendations for a broad range of species and our own field data as cited.	**Remove this outdated reference from Table 7.**

http://storefront.metro-region.org/drc/aerial/aerial.cfm

REVISED DRAFT

Metro's Technical Report for Goal 5

July 2002

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INTRODUCTION

This chapter provides a summary of recent scientific literature and studies relevant to the protection of fish and wildlife habitat. The purpose of this technical report is to provide a sound scientific foundation for public policy related to the management of fish and wildlife habitat in the region.

Metro's Regional Urban Growth Goals and Objectives (RUGGOs; Metro 1995) state that the region should "Manage watersheds to protect and ensure to the maximum extent practicable the integrity of streams, wetlands and floodplains, and their multiple biological, physical, and social values," as well as 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**." Based on the direction outlined in this policy, Metro is taking a watershed approach in the characterization of the best available science relating to fish and wildlife habitat.

A key goal of this technical report is to provide accessible information to help elected officials, planners, and the general public understand the needs of fish and wildlife, the effects of urbanization on these species, and the biological processes that support them. There are many ways to define "urban" (e.g., May et al. 1997a; Johnson and O'Neil 2001 [see Urban and Mixed Environs in upland habitat descriptions]; McIntyre et al. 2001), often described by the percent imperviousness or human population measures. However, researchers recognize that there is a gradient of urbanization and any classifications within this gradient are arbitrary. Thus for the purposes of this report we define urban as those areas with high human population density, a definition that includes areas that are generally known as "suburban." The technical report will also provide the basis for specific planning activities such as the *inventory* and assessment of watersheds and the riparian corridors and upland habitats that comprise them, identify environmental parameters for the *ESEE analysis*, and guide *program* development.

The main questions guiding this technical report include:
1) What are the key ecological attributes that characterize a healthy watershed?
2) What are the function and values of fish and wildlife habitat and how can they be retained?
3) What are the species of fish and wildlife that characterize the biodiversity of our region?
4) What are the impacts of urbanization on healthy watershed function and fish and wildlife habitat?
5) What is restoration and how is it best approached in an urban context?

The process we used to conduct the technical report is as follows:
- a literature search of major scientific journals and the internet, as well as consulting other literature reviews conducted within the Metro region and the Pacific Northwest,
- consultation with experts on specific issues such as species lists, habitat classification systems, and impacts of urbanization,
- review by Metro's Goal 5 Technical Advisory Committee, and
- peer review by outside entities

This technical report supports a holistic view of watershed function that emphasizes the interconnectedness of the system, including the relationship of riparian corridors with upland habitats and connectivity. This technical report is organized into the following main sections:

- **Watershed perspective**
- **Aquatic and riparian habitat**
- **Upland habitat**
- **Impacts of urbanization**
- **Restoration in an urban environment**

WATERSHED PERSPECTIVE

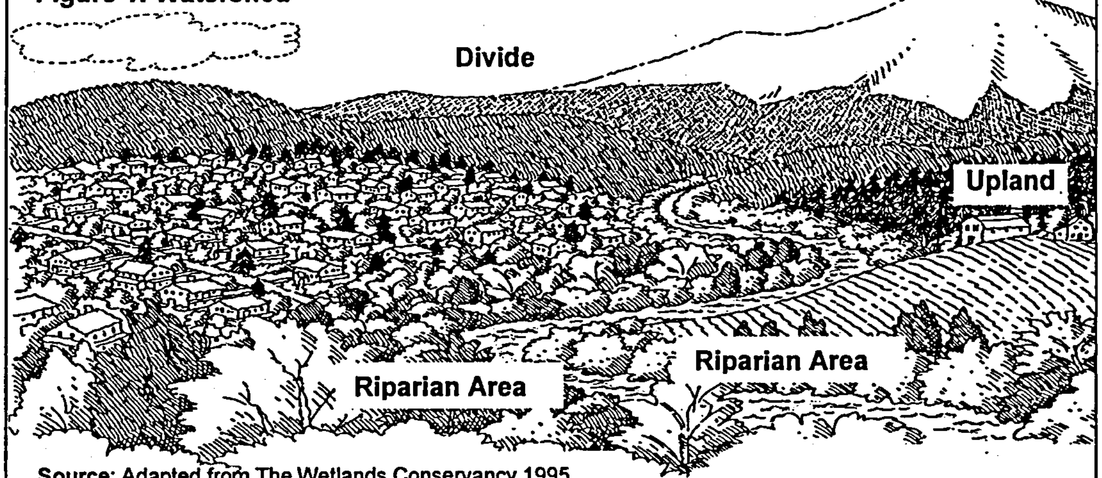
What is a watershed?

An aerial view of the Metro region reveals a network of rivers and streams draining from upland slopes to downstream river valleys. Every tributary, stream or river lies within its own watershed. A **watershed** (or drainage basin) is any area of land from which water, sediment, and organic and dissolved materials drain to a common point, such as a stream, river, pond, lake, or an ocean. According to the Pacific Rivers Council (1993):

> Watersheds are ecosystems composed of a mosaic of different land or terrestrial "patches" that are connected by (drained by) a network of streams. In turn, the flowing water environment is composed of a mosaic of habitats in which materials and energy are transferred and therefore connected through biologically diverse food webs.

Watersheds are hierarchical – small ones nest within larger ones. For example, when two small streams join, their combined drainage areas make up a larger watershed. Each mid-sized watershed contributes, in turn, to a larger watershed. Watersheds can be as large as all the land draining into the Columbia River or as small as 20 acres draining to a pond. Watersheds are separated by a ridge or mountain divide. In natural settings, patterns of drainage are determined by climate, tectonic movements, geomorphic processes and the nature and formation of the rock through which streams erode.

Figure 1: Watershed



Source: Adapted from The Wetlands Conservancy 1995

A common set of terms has been developed by the U.S. Geological Survey (USGS) to describe the hierarchical nature of watersheds, known as hydrologic unit cataloging (HUC). Beginning with the term "region," as the largest order of watershed, the terms "sub-region," "basin," "sub-basin," "watershed" and "sub-watershed" are used to described the relative sizes of drainages within geographic areas (Oregon Professional Network 1999). Under the HUC system, the Metro area is located in the Lower Columbia River and the Willamette River basins. The Tualatin and Clackamas rivers are examples of sub-basins in the region, and Johnson Creek is an example of a watershed. The HUC system is described in more detail in the inventory section.

In this report, the term "watershed" is used in a broad sense, rather than describing a drainage areas of a particular size.

The major components of a watershed include the drainage network of tributaries, streams and rivers and their flow regimes, the associated **riparian vegetation, wetlands** and **floodplains** (the **riparian area**), **groundwater**, the **hyporheic zone** (the interface between groundwater and stream water), features within stream channels (e.g., bedrock, sediment, organic debris), and **upland** areas. The ecological health of a watershed depends on the health and connectivity between these components over space and time (Naiman et al. 1992). Connectivity refers to how tributaries are connected to larger rivers, how groundwater interacts with surface water, how water moves among streams, wetlands and floodplains, and how fish and wildlife move among watershed components.

Hydrologic cycle

Water is a crucial element that sustains life. It is the major vehicle through which **biotic** (living) and **abiotic** (non-living) materials are transferred from higher to lower land and eventually to the sea. Water moves through and across the landscape by means of surface and underground pathways or channels. Much of the water in channels moves downstream and joins to form larger stream or river systems. Hence, water is a key factor in the occurrence and distribution of organisms and the formation of **aquatic** and **terrestrial** habitat. Rivers and streams contain a small fraction of the world's fresh water, yet they perform a critical role in the continuous water cycle.

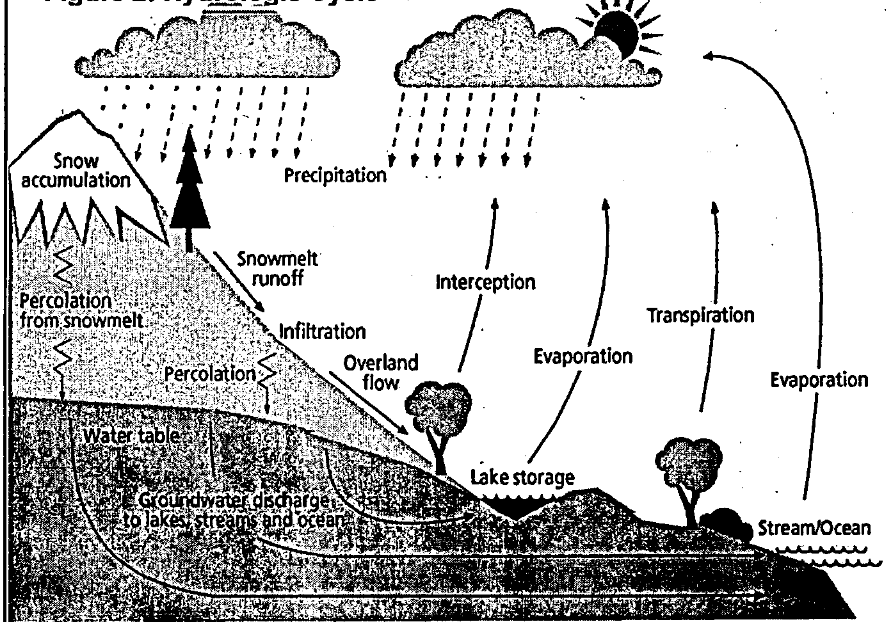


Figure 2: Hydrologic Cycle

Source: Adapted from Dunne and Leopold 1978

The **hydrologic cycle** (Figure 2) provides a useful framework for understanding the continuous cycling of water from the atmosphere to the earth and oceans and back again. The main processes of the hydrologic cycle involve **precipitation, evaporation** and **transpiration.** Precipitation, primarily in the form of rain and snow, transfers water from the atmosphere to the earth. A substantial portion of precipitation returns directly to the atmosphere through evaporation and transpiration. During rainstorms, vegetation and other natural (e.g., leaf litter, humus) and manmade surfaces (e.g., flat rooftops, parking lots) intercept and store a portion of rainwater. Some of this intercepted water evaporates during or immediately after the storm before infiltrating into the ground or being absorbed by plants. In addition, water evaporates from the streams, rivers and lakes, from the surface of the ground, and from moisture held in soil. Plants lose water to the atmosphere through a process called transpiration, during which an exchange of gases necessary for photosynthesis occurs. Transpired water originates from water that is taken in by the plant's roots (Montgomery 1986; Allan 1995; Federal Interagency Stream Restoration Working Group [FISRWG] 1998; Watershed Professional Network 1999). The loss of water due to the combined processes of evaporation and transpiration is referred to **evapotranspiration.**

Precipitation that reaches the ground takes several pathways to reach a stream channel or groundwater, and each affects the timing, quantity and quality of streamflow. The pathway followed is influenced by climate, vegetation, topography, geology, land use and soil characteristics (Allan 1995; Poff et al. 1997). Rainfall can be absorbed by soil up to a maximum rate, or **infiltration capacity**. Porous soils, such as coarse-textured sandy soils, usually have high infiltration capacity, whereas tightly packed, clayey soils have low infiltration capacity. When rainfall exceeds the infiltration capacity of the soil, **stormflow** (runoff) moves downslope as **overland flow**. Stormflow usually reaches the channel in a short time frame. Under normal conditions, relatively little runoff occurs in undisturbed regions that have porous soils and natural vegetative cover. In urban settings where paved and impermeable surfaces abound, substantial overland flow may occur (Allan 1995; FISRWG 1998).

Once water enters the soil it moves downward to the groundwater table where it is slowly discharged to the stream over a long period of time. The **baseflow** (or dry-weather flow) of a river is derived primarily from this groundwater. Shallow, **subsurface flow** occurs when there is a relatively impermeable layer underneath permeable topsoil. Water accumulates in this layer and moves downhill, reaching streams through their banks. This movement is faster than groundwater flow but slower than overland flow. **Saturated overland flow** occurs when the water table rises to the ground surface, usually during a large rainstorm, causing groundwater to break out of the saturated soil and to travel as overland flow (Allan 1995; Poff et al. 1997; FISRWG 1998; Watershed Professional Network 1999).

Billions of gallons of water move through the hydrologic cycle each year. Some of this water is temporarily diverted for human use or stored for extended periods of time (even tens of thousands of years), but it eventually makes its way back into the global water cycle. From the longer perspective of geological history, it is still viewed as moving continually through the hydrologic cycle (Montgomery 1986).

Stream corridor – a three-dimensional view

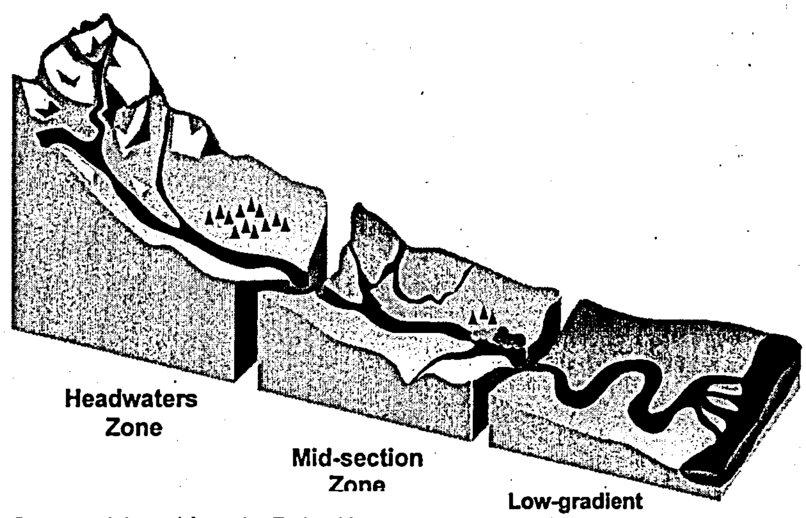
A stream corridor (or riparian corridor) includes the stream channel, the streamside (riparian) vegetation on both sides of the stream, associated wetlands, floodplains as well as other features (see ***Aquatic and Riparian Habitat*** section). Stream and river systems involve three-dimensional processes that connect the longitudinal (upstream-downstream), lateral (floodplains-upland) and vertical (hyporheic-stream channel) system components, all which vary both in space and through time (Naiman et al. 1992; Pacific Rivers Council 1993; Stanford and Ward 1993; FISRWG 1998).

Longitudinal (upstream-downstream)

Watersheds can be divided into three longitudinal zones that correspond to the structural progression that streams commonly exhibit as water flows from headwaters to the mouth (Figure 3). Changes occur in channel size and form; discharge (volume and velocity of water); sediment load, transport, and deposition; nutrients; habitats; and life forms as water flows and materials move downstream from the headwaters zone (FISRWG 1998; Mitchell 1999).

In this region, the **headwaters** zone is generally steeply sloped. Headwater streams carve deep, straight, V-shaped valleys and carry sediment and other materials downstream. The **mid-section** zone receives some of the sediment and other materials from upstream, but transfers much of it downstream. Slopes are typically gentler and the stream or river begins to meander. Narrow and discontinuous floodplains along the channel are temporary storage sites for sediments in long-term transport down the stream corridor. The **low-gradient zone** is where the greatest sediment deposition occurs. Sediments in this zone are smaller than in headwaters and mid-section zones and deposits are sorted by size. Slopes have worn down to low angles. Rivers meander in broad, flat valley floors, working and reworking the floodplain sediments in a dynamic balance of discharge and transport (FISRWG 1998; Mitchell 1999).

Figure 3: Longitudinal view (upstream-downstream)



Source: Adapted from the Federal Interagency Stream Restoration Working Group 1998

Longitudinal changes from the headwaters to the mouth of river ecosystems have been generalized in a conceptual model known as the **River Continuum Concept** (Vannote et al. 1980). Connections between the watershed, floodplain, and stream systems are identified by the model, as well as how biological communities develop and change from the headwaters to the mouth. A limitation to the River Continuum Concept is that it was developed on small streams (Junk et al. 1989).

Lateral (floodplains-upland)

Stream corridors usually exhibit three major components when viewed laterally (across the corridor): the stream channel, the floodplain and the transitional upland fringe (FISRWG 1998). The floodplain, which is an area on one or both sides of a stream channel that is periodically inundated by floodwaters, provides temporary storage for floodwaters and sediment produced by the watershed. Floodplains may be nonexistent or very narrow in steep headwater zones, yet quite expansive in low-gradient zones, where the floor of the stream valley is relatively flat. The transitional upland area serves as the edge or zone of change between the floodplain and the surrounding landscape, and is distinct from the surrounding uplands by its greater connection to the floodplain and stream (FISRWG 1998). Figure 4 in the *Aquatic and Riparian Habitat* section illustrates a cross-sectional view of a stream corridor (or riparian corridor). The transitional upland fringe corresponds to the "zone of influence" in Figure 4.

The **Flood-pulse Concept** describes the lateral interaction of streams with their floodplains. This concept is applicable primarily in unaltered large rivers systems with floodplains. It demonstrates how the predictable advance and retreat of floodwaters in the floodplain nourishes it with sediments, enhancing biological productivity and providing important habitat for insects, amphibians, reptiles and fish spawning (Junk et al. 1989; Bayley 1995; FISRWG 1998).

Vertical (hyporheic-stream channel)

An entire ecosystem, undiscovered until only a few decades ago, exists beneath and along the river. This is the hyporheic zone, or the zone of interchange between the stream and groundwater (see Figure 4 in the *Aquatic and Riparian Habitat* section). The hyporheic zone is most extensive in low-gradient streams, where wide riverbeds are underlain and surrounded by river rocks and gravel, allowing water to seep below the streambed and allowing exchange of water between the river and the sediment of the floodplain (Stanford and Ward 1993; Triska et al. 1993; Fernald et al. 2000).

Properties of both groundwater and channel water are blended in the hyporheic zone, significantly changing the water's chemical composition and stimulating biological activity (Stanford and Ward 1988; Naiman et al. 2000). The jumbled mix of stones and soil provide a wide range of microhabitats that vary in nutrient and oxygen content. A host of specialized insects and microorganisms take advantage of these living quarters, some never emerging to see the light of day. Important biological activities (such as **denitrification**, or the removal of excess nitrogen) take place in the hyporheic zone, mediated by these specialists. In addition, new evidence suggests that salmon in the Columbia River key in on hyporheic flow to select their spawning habitats because the flow replenishes oxygen, carries away waste, and moderates stream temperatures (Brinckman 2000). Thus, the hyporheic zone plays an important role in aquatic **food webs** by moderating nutrients, including providing insect food to instream wildlife.

Preserving the connection between the components of a stream or river system (i.e., upstream-downstream; floodplains-upland; hyporheic-stream channel) is vital to achieving or maintaining ecologically healthy watersheds (Naiman et.al. 1992). The next section explores key attributes of healthy watersheds and the complex array of processes that occur within in them.

Physical, chemical, biological processes in healthy watersheds

The key processes contributing to watershed health are the delivery and routing of water, sediment and woody debris. The resulting stream characteristics are the best indicators of watershed vitality (Naiman et al. 1992). The health of a watershed and the characteristics of streams and rivers are influenced by the geology, topography, climate, natural disturbance regime, land use, soil and vegetation.

Some of the key attributes of watershed health in the Pacific Northwest include (Bisson et al. 1997; Naiman et al 1992; Poff et al. 1997; Hollenbach and Ory 1999):

- Uplands dominated by native forest cover
- Continuous stream corridors with healthy, fully functioning riparian zones
- Floodplains connected with river channels
- Unaltered hydrologic regimes
- Undisturbed hyporheic zones
- Natural input rates of sediment, organic matter, and nutrients that support healthy, productive and diverse fish and wildlife populations
- Lateral, longitudinal and vertical connections between system components
- Natural rates of landscape disturbances

This section provides an overview of the key physical, chemical, and biological processes occurring throughout watersheds that determine stream characteristics and, ultimately, the overall health of a watershed.

Note that a "healthy watershed" does not necessarily equate to pristine conditions. For example, urbanized areas are unlikely to return to pristine conditions within the time frames that matter to people because they are heavily modified and subject to continual human and natural disturbances. Realistically, there is a *gradient* of "healthy" conditions in which the range of possibilities are driven to a large degree by disturbance regime and the system's resiliency to those disturbances. Within this context some (perhaps as yet unknown) modified level of ecological function can be maintained or restored, even in urban areas. Stanford and Ward (1996) comment, "Although restoration to aboriginal state is not expected, nor necessarily desired, recovering some large portion of the lost capacity to sustain native biodiversity and bioproduction is possible by management for processes that maintain normative habitat conditions." Consideration of the key processes in a watershed – including disturbance regime – and the resiliency of the natural system involved can help guide watershed management (Resh et al. 1988; Petraitis et al. 1989).

Physical processes

Diverse stream and floodplain characteristics and plant communities are created by the interaction of the geology, hydrology, climate and **geomorphic** processes, and inputs of organic and inorganic material from hillsides and vegetation within a watershed (Gregory et al. 1991; Naiman et al. 1992; Spence et al. 1996; Rot et al. 2000). The following sections examine how hydrologic patterns influence streamflow, and how streamflow, the physical processes of erosion, sediment transfer, and deposition, and the input of organic and inorganic material form stream channels and create habitat.

Hydrologic pattern and streamflow

The hydrologic cycle, as described earlier, is the continuous cycling of water from the atmosphere to the earth and back again. Hydrologic pattern refers specifically to the type of precipitation, quantity of flow, seasonal water storage, and surface-subsurface water exchanges.

Local and regional streamflow reflects the variability of the hydrologic pattern (Naiman et al. 1992; Poff et al. 1997). Hydrologic connectivity is the water-mediated transfer of matter, energy, and/or organisms within or between elements of the hydrologic cycle; disruptions in hydrologic connectivity may have severe ecological consequences (Pringle 2001).

Precipitation (i.e., rain or snow) is the ultimate source of all streamflow. The intensity, timing and duration of a storm event influence, in part, how quickly water reaches the stream. The variability of climate and land use and their influence on vegetation, soil cover and condition also affect how quickly precipitation reaches streams. Poff et al. (1997) describe the importance of streamflow quantity and timing:

> Streamflow quantity and timing are critical components of water supply, water quality, and the ecological integrity of river systems (Poff and Ward 1989). Indeed streamflow, which is strongly correlated with many critical physiochemical characteristics of rivers, such as water temperature, channel geomorphology, and habitat diversity, can be considered a "master variable" that limits the distribution and abundance of riverine species.

Streamflow has two basic components: stormflow and baseflow (see *Hydrologic Cycle* section). Based on the timing and balance of stormflow and baseflow, three categories of streams are recognized: **perennial, intermittent** and **ephemeral** streams. Perennial streams flow year round, even during periods of no rainfall. Groundwater is a source of much of the water in the channel. Intermittent streams flow only during certain times of the year, but usually more than 30 days per year. Ephemeral streams flow only during or immediately after periods of rainfall, usually less than 30 days per year (FISRWG 1998).

The size and shape of a channel is determined by three variables: **discharge**, the volume of water moving down a channel per unit of time; **gradient**, the slope of the channel; and **sediment load**, the amount and size of sediment being transported. When one factor changes, the others adjust. Adjustment is reflected in seasonal changes in the slope of the water surface, the degree of **sinuosity** (curvature) of a stream, discharge, and sediment load (FISRWG 1998; Mitchell 2000).

A wide range of flow characteristics is key in the formation and maintenance of a variety of habitat features. The next section describes the geomorphic processes along a stream corridor that form drainage patterns, channels, floodplains, and other watershed and stream corridor features.

Physical habitat forming processes in stream channels

The primary geomorphic processes that operate throughout a watershed are **erosion, sediment** (soil particles) transport and sediment deposition (Naiman et al. 1993, FISRWG 1998). The hydrologic pattern within a watershed drives the geomorphic processes. The type of precipitation or disturbance, timing, frequency and magnitude of the event; runoff processes (surface and subsurface flow); gravity; wind; ice; chemical reactions; and vegetation influence the yield and rate of sediment delivery to streams. Stream channels are formed, sustained, and changed by the water, sediment and organic material they carry (Spence et al. 1991; Naiman et al. 1992; FISRWG 1998; Moses and Morris 2001).

Erosion and **sedimentation** occur naturally in a watershed and provide the sources and surfaces necessary for habitat formation for aquatic and terrestrial wildlife species (Naiman et al. 1992). A **disturbance**, be it natural or human-induced, is any significant change in the supply or routing of water, sediment, or woody debris that causes a measurable difference in channel structure and biological community. Natural disturbances such as floods, fire, landslides, plant diseases and insect outbreaks are an integral part of watershed dynamics. These events often result in significant structural changes to the stream channel and biological communities, both in the near term and over time. A natural disturbance, such as a landslide, may destroy aquatic and terrestrial organisms. However, such an event often revitalizes an area by depositing organic material, uncovering buried organic debris, and increasing sunlight by opening forest canopies. These areas often evolve into biologically productive sites over time (Gregory et al. 1991; Naiman et al. 1992).

Although some erosion occurs naturally, many urbanized watersheds experience a higher rate of soil erosion than that of undisturbed landscapes (Pacific Rivers Couneil 1996). Human disturbance, such as land-use practices associated with urbanization, agriculture, livestock grazing and timber harvest, contribute to this higher rate of soil erosion by altering the natural drainage basin. Many of these alterations have resulted in significant consequences such as landslides, flooding, channel erosion and destruction of aquatic habitat. For a full discussion of the impacts of urbanization, see the ***Aquatic and Riparian Habitat*** section.

Erosion begins with the detachment of soil particles from upland areas, from the streambank, and from within the stream channel. Erosion produces sediment that moves in suspension from its site of origin by air, water, or gravity. Eroded particles, regardless of size, are subject to being transported and deposited downstream. Sediment particles can range in size from fine clay to boulders. Small particles are transported more easily and may be suspended in the water column (suspended or wash load) or in solution. Larger particles move downstream by saltation, or sliding, rolling or skipping along the streambed as bedload. Often only high flow events can move the largest particles downstream. Sediments drop out of water or stop moving when streamflow slows, losing power (i.e., slope and discharge) to move them (FISRWG 1998; Mitchell 1999).

As sediment, **large woody debris** (LWD) and other organic and inorganic materials are transported and deposited throughout a watershed, channel characteristics and aquatic and terrestrial habitats are formed. Large woody debris is important beeause it influences the routing and storage of water and sediments, as well as the development of channel bottom topography, including the formation and distribution of pools (Beschta 1979; Booth et al. 1997). Large woody debris is also an important source of aquatic cover and acts as a surface for biological activity by aquatic organisms (Gregory et al. 1991; Naiman et al. 1992). In addition, LWD helps dissipate energy generated from streamflow, slowing erosion and sediment transport rate and retaining organic debris, making it available to organisms living there (Naiman et al. 1992). Large woody debris is discussed in more detail in the ***Aquatic and Riparian Habitat*** section.

The structure and form of the channel changes as it moves from the headwaters to the mid-section and low-gradient zones as described below.

Habitat forming processes in headwater zones

In the Pacific Northwest, the majority of rivers draining into the Pacific Ocean originate in steep, mountainous terrain (Naiman et al. 1992). According to Wenger (1999), headwater streams make up the majority of stream miles in any watershed basin, and most streamflow originates from headwaters (Harr 1976). These streams are typically steep (eight degrees or more), flow in narrow bedrock channels with steep valley sides, and exhibit low to moderate sinuosity (Harr 1976; Naiman et al. 1992). They are naturally prone to catastrophic disturbances such as landslides and debris flows. These events can significantly alter the channel and destroy existing aquatic and terrestrial habitat and organisms. However, headwater streams and the surrounding landscape often are revitalized by these events and evolve into biologically productive areas (Naiman et al. 1992).

Headwater streams are vital to the hydrological, biological and geological processes within the watershed (Harr 1976; Pacific Rivers Council 1996; Meyer et al. 2001). For example, headwater streams typically:

- substantially increase water retention capacity in a watershed, resulting in downstream protection from flooding and channel damage
- retain sediments that would otherwise be deposited downstream
- contain substantial amounts of LWD that store sediments and provide habitat structure and sites for critical metabolic activity
- establish the basic chemical composition of unpolluted streams draining a landscape
- are the sites of most active uptake and retention of nutrients
- provide important thermal refuges for fish and other wildlife
- provide unique habitats for numerous species

Adapted from Meyer et al. 2001

Large woody debris delivered to headwater streams often becomes wedged in the narrow channel. Rapids and waterfalls are common within this zone. Accumulated wood and large boulders create obstructions that form a stair-stepped profile, effectively lowering overall gradient and dissipating energy. This results in less erosion to the streambed and banks, more sediment storage in the channel, and slower downstream movement of organic debris. Headwater streams are occasionally flushed of accumulated sediment and organic debris when natural disturbances such as debris flows occur (Swanson et al. 1982; Gregory et al. 1991; Naiman et al. 1992).

Habitat forming processes in mid-section zones

Mid-section streams are typically larger than headwater streams. They are moderately steep (one to six degree slopes) in narrow valley floors. These streams receive some of the sediment, LWD and other organic material from the headwater zone, as well as from adjacent uplands, but tend to transport sediment rather than storing it for long periods (Naiman et al. 1992). Streambed materials range from gravel to boulders with large woody debris jams that create alternating **pools** and **riffles** (FISRWG 1998). Mid-section streams are usually narrow enough to accumulate large woody debris across the stream (Naiman et al. 1992). The valley within mid-section zones broadens, creating minor floodplains. Streams begin to bend, or **meander** and are typically a single channel, except where woody debris jams and other deposits create streamflow diversions. **Terraces, overflow channels** and **oxbow lakes** are limited because channels tend to contain flood flows. When flooding occurs, however, the duration is shorter than in low-gradient streams and rivers. Wetlands commonly form at the base of hillsides where runoff accumulates in saturated soils (Naiman et al. 1992).

Habitat forming processes in low-gradient zones

Increased sediment deposition and greater water volume occur in low-gradient zones (FISRWG 1998). Channels widen and become deeper. Complexity increases both in structure and in the plant communities that occupy the floodplain (Hughes 1997). The fine sediment particles stored in the floodplain in low-gradient zones easily erode, which favors the development of meandering floodplain channels and the creation of alternating pools and riffles, oxbows, sandbars, backwaters, undercut banks, braided channels, and floodplain pools. High water tables are also noted (Johnson and Ryba 1992; Naiman et al. 1992; Cohen 1997). Wetlands are often present along cutoff meanders and oxbow lakes. Large woody debris is scattered in large rivers but often accumulates at river bends or the upstream portion of islands and sandbars.

Flooding in these areas is not restricted to storm events. Lesser magnitude floods occur because of the dynamic accumulation of sediment, beaver dams and debris jams (Naiman et al. 1992). The floodplain provides temporary storage for floodwaters and sediment as well as some long-term storage of groundwater in deep sediments and wetlands. Floodplains expand and contract depending on the season, climate, precipitation, soil characteristics and local topography. Natural disturbances other than flooding may have limited influences on low-gradient streams because the floodplains are isolated from surrounding hillslopes (Naiman et al. 1992).

Episodic disturbances of the floodplain sediments by the meandering river create pockets of young, broadleafed and annual plants, which are nutrient rich and attractive to both wildlife and insects. The presence of large organic debris in floodplain channels affects local flow velocities, creating local zones of scour and deposition, varied channel topography and corresponding habitats (Mitchell, pers. comm. 2001).

Chemical and biological processes

The quantity, timing and variability of streamflow are important components of a healthy watershed, as described earlier. However, an appropriate flow regime does not guarantee a healthy ecosystem if the water quality is degraded. Sediment load (suspended sediment in water) temperature, and chemical composition of water play important roles in water quality and thus the characteristics of aquatic and terrestrial plant and animal communities. This section provides a brief overview of various chemical and biological components within a watershed, such as water quality, vegetation, carbon, nitrogen and phosphorus, aquatic insects and nutrient cycling.

Water quality

Water quality is a fundamental component of ecologically healthy watersheds. Water interacts with everything it touches. Flowing water carries a variety of materials, including:

- Suspended sediment
- Heat
- Dissolved gases (oxygen, carbon dioxide and nitrogen)
- Dissolved nutrients (various forms of nitrogen, phosphorus and carbon)

- Dissolved major ions and trace metals (e.g., calcium, silicate, sulfate, copper, zinc, lead, etc.)
- Suspended and dissolved organic matter (e.g. leaves, algae, LWD, etc.)
- Suspended inorganic matter (elements such as aluminum, iron, silicon, calcium, potassium, magnesium, sodium and phosphorus)
(Naiman et al. 1992; FISRWG 1998)

Other important parameters relating to water quality include alkalinity, acidity and buffering capacity (buffering causes water to resist changes in pH), potential toxicants (wastes, insecticides, herbicides) and organic nutrients (forms of dissolved organic carbon) (Naiman et al. 1992). An overview is presented in this section of a few key elements of water quality: sediment, temperature and dissolved oxygen.

Sediment
As discussed in the previous section, the transport and deposition of sediment throughout a watershed are key channel and habitat forming processes. However, changes in sediment load and particle size can have negative impacts on water quality and aquatic habitat. Water quality is reduced when excessive amounts of fine sediment such as silt and clay particles enter the stream and become suspended in the water column, causing water to become cloudy, or turbid. In addition, some nutrients and toxic chemicals attach to soil particles on land and enter the water where the pollutants either settle with the sediment or become soluble in water (FISRWG 1998). See ***Aquatic and Riparian Habitat***, *Impacts of Urbanization* for detailed discussion.

Temperature
Water temperature is an important indicator of a watershed's vitality because of its controlling influence on the metabolism, development and activity of aquatic organisms (Naiman et al. 1992). Cold, well-oxygenated water is needed by many aquatic species. Shifting temperatures may have profound effects on aquatic species (e.g., salmon, trout, and invertebrates) that can tolerate only a limited range of temperatures. Water temperature is influenced by many factors including groundwater and surface water flow, riparian vegetation (height and canopy density), incoming solar radiation, elevation, climate, stream size, water velocity and depth and **turbidity**.

Temperature changes as water flows downstream. Small streams in forested headwater zones typically have cooler water and stable temperatures because riparian canopy blocks incoming solar radiation. According to Naiman et al. (1992), these streams typically receive one to three percent of total available solar radiation. Mid-section zones typically receive 10 to 20 percent of total available solar radiation because of the gaps that appear in the riparian canopy. Daily temperatures fluctuate between 2-6° C; seasonal variation can be 5-20° C (Naiman et al. 1992). Low-gradient zones generally have wide gaps in riparian canopy but temperature fluctuation is not as great as mid-section streams. This is because larger rivers tend to be deeper and more turbid, restricting the amount of light penetrating through water (Naiman et al. 1992).

Dissolved Oxygen
Dissolved oxygen (DO) is a basic requirement for most aquatic species. Some species require high concentrations of DO (e.g., salmon and trout), while others can survive at lower levels (e.g., carp). Oxygen gas readily dissolves in water, which absorbs it directly from the atmosphere. In addition, aquatic plants release oxygen to the water as a byproduct of photosynthesis. Increased

temperatures and **salinity** reduce the amount of oxygen the water can hold. Undisturbed streams generally contain an abundant supply of DO. Dissolved oxygen levels depend in part on the internal mixing and turbulence of water and instream characteristics such as waterfalls and rapids (FISRWG 1998).

Oxygen depletion occurs when oxygen-demanding waste (e.g., sewage, industrial waste, etc.) enters the stream. Oxygen-demanding waste loads are described by a parameter known as **biochemical oxygen demand** (BOD), a measure of the amount of oxygen required to break down organic matter. The more organic matter there is in a stream, the higher the BOD. Excessive aquatic plant growth, due to an overload of nutrients such as nitrates and phosphates, can also lead to oxygen depletion. This development is known as **eutrophication**. As plants die off and decompose, they become part of the organic matter load, increasing BOD (Montgomery 1986; FISRWG 1998).

Vegetation

Vegetation plays a critical role in healthy watersheds. Plant communities are dynamic. Soils, nutrients, and woody debris move from one area to another through precipitation and erosion, leaching, wind, natural and human disturbances, and a variety of other means. Eventually, gravity assists some of these materials down to the riparian zone.

Plant communities in riparian areas help determine what, how much, and when materials from upland areas enter the stream ecosystem. For example, a wide, mature riparian forest will capture many soils and sediments, nutrients, and woody debris, adding richness and complexity to soil and plant communities near the water and protecting water from excessive nutrient or soil inputs (Lowrance et al. 1986; Lowrance et al. 1988; Wenger 1999). A fine balance exists between having enough and having too much of these inputs to the stream. Riparian areas, and consequently the structure, functions and processes occurring within and around the stream, are fundamentally altered when significant upland and riparian vegetation is removed.

The River Continuum Concept generalizes the changes that occur in vegetation from the headwaters to the mouth (Vannote et al. 1980). In headwater streams, where forest canopy overhangs and shades the narrow channel, little sunlight is available to plants and algae within the stream, and most nutrients enter the stream from terrestrial sources. Such externally-derived nutrients are termed **allochthonous**, and consist primarily of large wood and leaf litter (Kauffman et al. 2001). Mid-section zone organisms rely more heavily on internally-derived nutrients (**autochthonous**), such as instream algae and plants (more sunlight is available) and fecal matter. However, small particles of pre-processed nutrients from upstream are also available; therefore, mid-reach streams tend to balance inputs from both external and internal sources. Low-gradient streams flow more slowly, receive abundant sunlight, and acquire nutrients from upstream sources, encouraging instream (autochthonous) plant production (Vannote et al. 1980; FISRWG 1998).

Carbon, nitrogen and phosphorus

Carbon, nitrogen and phosphorus are chemicals that play key roles in aquatic food webs (Meyer et al. 1988; Stanford and Ward 1993). Plants, like all life forms, need carbon because carbon forms the backbone of living molecules. Plants obtain and store carbon from carbon dioxide in the air. Animals obtain carbon from organic matter. Carbon becomes available to insects, fish and other wildlife as plants die, drop leaves, lose branches, or leach nutrients via water flow. Such nutrients are generally referred to as "organic matter" (Allan 1995). As the primary carbon source, riparian vegetation strongly influences carbon inputs to the stream.

When organic matter from the land enters water, it may be consumed or decomposed by insects and microorganisms, physically broken into smaller particles through abrasion, or leached and released into the water. These processes vary among vegetation types. For example, hardwood forests have a more seasonal component to nutrient inputs and leaves decompose relatively quickly, whereas coniferous inputs are more constant with relatively slow decomposition rates due to the waxy leaf surface (Gregory et al. 1991). Seasonal patterns of organic inputs help determine biological community composition.

Nitrogen and phosphorus are vital plant nutrients, although excessive inputs to the stream can lead to uncontrolled plant and algae growth (Allan 1995). Natural sources of nitrogen and phosphorus include plant decomposition and rock erosion. Nitrogen-fixing plants such as alder may also obtain atmospheric nitrogen (Pinay et al. 1993). Nitrogen is readily water soluble, while phosphorus is typically carried to the stream attached to soil particles. These differences in transport to the stream, combined with local geology (mineral leaching and erosion) and riparian vegetation, influence the amounts of nitrogen and phosphorus entering aquatic ecosystems.

Aquatic insects

Aquatic insects and microorganisms convert nutrients and organic matter into forms useable by other organisms. As described above, the importance of plants as instream nutrient sources changes between headwater, mid-section, and low-gradient zones. Aquatic insect communities are arranged accordingly, as theorized by the River Continuum Concept described earlier in this chapter (Vannote et al. 1980). For example, headwater insects specialize in breaking down coarse organic matter. In mid-section zones, most insects collect organic matter or graze on plants and **diatoms**. In low-gradient zones, coarse organic matter is relatively rare but fine organic matter is available from plants, decomposing insects, and sediments. Insects in these reaches tend to be collectors. In each zone, predatory insects comprise a relatively small, but important, component of aquatic insect communities. Throughout this downstream continuum, insects play an important role in converting and supplying nutrients to other instream organisms. Many fish species, including **salmonids**, rely on aquatic insects as their primary food resource (Spence et al. 1996).

Nutrient cycling

As discussed above, a variety of plant and animal materials serve as sources of carbon and nutrients within watersheds. Despite the fact that streamwater flows in one direction (downhill), carbon and nutrients are involved in a continuous cycle, known as **nutrient cycling:**

> ...Nutrient cycling describes the passage of an atom or element from a phase where it exists as dissolved available nutrient, through its incorporation into living tissue and passage through perhaps several links in the food chain, to its eventual release by excretion and decomposition and re-entry into the pool of dissolved available nutrients (Allan 1995).

Thus through a complex and variable set of processes relying on sunlight, land, water, plants and animals, essential nutrients are retained in aquatic ecosystems for use by other organisms. The presence, quantity and quality of riparian vegetation are vitally important to this dynamic web of life.

Summary

Many people think of rivers simply as water flowing through a channel. Streams and rivers are not stand-alone units. Every tributary, stream or river lies within its own watershed. A watershed (or drainage basin) is any area of land from which water, sediment, and organic and dissolved materials drain to a common point, such as a stream, river, pond, lake, or an ocean. Watersheds are complex ecosystems that are comprised of a drainage network of tributaries, streams and rivers, floodplains, upland and riparian vegetation, groundwater, the hyporheic zone, and features within stream channels. The ecological health of a watershed and its value for fish and wildlife depends on preserving the connectivity between these components over space and time (Naiman et al. 1992). This highlights why scientists recommend investigating, managing and restoring aquatic and terrestrial systems using a watershed perspective (Forman and Godron 1986; Pacific Rivers Council 1993; Federal Ecosystem Management Assessment Team [FEMAT] 1993; Karr 1991; Karr and Chu 1999; Watershed Professional Network 1999; Naiman et al. 2000).

AQUATIC AND RIPARIAN HABITAT

Introduction

Natural riparian corridors provide valuable habitat for fish and wildlife. For example, in the Metro region, 93 percent of all (non-fish) wildlife species regularly use water-associated habitats, and 45 percent are closely associated with these habitats (Metro's Species List). Riparian corridors are exceptionally productive ecosystems. The interaction between rivers and streams and their adjacent riparian and upland areas provides for a unique and diverse ecological system consisting of:

> ...nonliving parts such as groundwater, rocks, and soil; ground cover, understory, and canopy plants; and animals such as insects, reptiles, birds, and mammals. Organisms and nutrients are moving back and forth between aquatic and upland areas, water levels are fluctuating, the channel is shifting laterally, and the riparian vegetation is many-layered. This complex, dynamic environment sustains a large variety of species, life history patterns, and nutrient cycles (Constantz 1998).

This chapter examines the unique characteristics present in riparian corridors that account for the diversity of plant and animal species found there and covers the following topics:

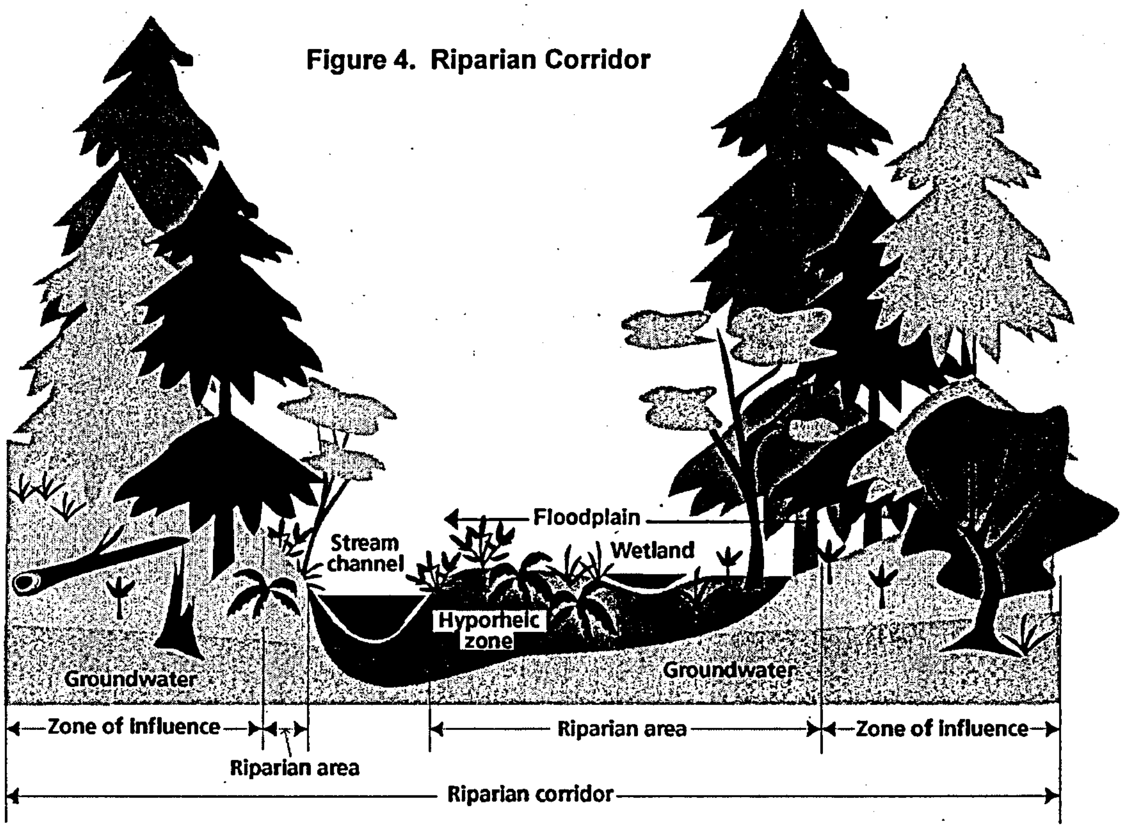
- Definition of a riparian corridor
- Ecological functions of riparian corridors
- Riparian habitat types and species associations
- Impacts of urbanization
- Wildlife use of urban riparian corridors
- Riparian area width

Riparian corridor

The term "riparian" is derived from the Latin word "riparius" meaning "of or belonging to the bank of a river" (Naiman and Decamps 1997). Riparian area refers to the land and vegetation adjacent to waterbodies such as streams, rivers, wetlands and lakes that are influenced by perennial or intermittent water. Riparian areas are dynamic biological and physical systems that act as the interface between terrestrial (land) and aquatic (water) ecosystems (Gregory et al. 1991; Naiman and Decamps 1997). The term **riparian corridor**, as used in this report, includes the stream or river; the riparian vegetation; off-channel habitat such as wetlands, side channels, and the floodplain; the hyporheic zone; and the **zone of influence**, as shown in Figure 4 on the following page.

The spatial extent or width of the riparian area is difficult to delineate. Naiman and Decamps (1997) describe the riparian area as encompassing "the stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the upland where vegetation may be influenced by elevated water tables or flooding and the ability of the soils to hold water." Gregory et al. (1991) further describes riparian areas as "three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems," the boundaries of which "extend outward to the limits of flooding and upward into the canopy of streamside vegetation."

Figure 4. Riparian Corridor



The riparian area may contain stream-associated wetlands. Wetlands may occur adjacent to stream channels and within the floodplain of the riparian corridor. They are defined by hydrology, **hydric soils,** and vegetation that depend on frequent and recurrent shallow inundation or saturation at, or near, the soil surface. Swamps, marshes, bogs and similar areas are generally considered wetlands (FEMAT 1993; FISRWG 1998; Kauffman et al. 2001). Plant communities of wetland habitats are dominated by species adapted to survive and grow under periods of anaerobic (absence of oxygen) soil conditions (FEMAT 1993).

Because wetlands may occur within riparian areas, the scientific literature often treats wetlands and riparian areas as synonymous to simplify discussion (FEMAT 1993). This report uses that same approach in its discussion of the ecological functions of riparian corridors for fish and wildlife habitat. However, wetlands are recognized for their highly valuable and productive habitats in *Riparian Habitat Types and Species Associations*, below. Other important wetland and riparian functions such as water storage, sediment trapping, flood damage reduction, water quality improvement/pollution control and groundwater recharge are examined in Metro's (1997) **Policy Analysis and Scientific Literature Review for Title 3**.

The riparian area includes the entire extent of the floodplain, an integral part of the riparian corridor in low-gradient streams and rivers. A floodplain is defined as the area adjacent to the stream or river channel that becomes inundated with overbank flows during storm events. According to Bayley (1995), the floodplain is "that part of the river-floodplain ecosystem that is regularly flooded and dried, and it represents a type of wetland." Well-developed, complex floodplains are characteristic in large river systems where there are long periods of seasonal flooding, oxbow lakes, wetlands, a diverse forest community and moist soils (Gregory et al. 1991; Naiman et al. 1992; Spence et al. 1996; Poff et al. 1997).

Flood events of different size and frequency play a vital role in maintaining a **diversity** of riparian plant species and aquatic habitat (Junk et al. 1989; Swanson et al. 1998). Biological productivity is enhanced in floodplains because sediment and nutrients are deposited during the advance and retreat of floodwaters (Bayley 1995). Small floods transport fine sediments downstream and laterally, and help create spawning habitat for fish. Intermediate and large floods create opportunities for organic material input, including LWD, and allow for the nourishment and establishment of plant species (Poff et al. 1997).

Most streams have a channel migration zone (CMZ) in reaches where the channel is not constrained by narrow valleys or ravines (e.g., steep headwater channels) (May 2000). Over time, streams move back and forth across the valley floor in a process called lateral migration (FISRWG 1998). The CMZ is the lateral extent of likely channel movement over the past 100-year period (May 2000), or where aquatic or wetland habitat could possibly exist at some time in the future (Pollock and Kennard 1998). The 100-year flood is often used for purposes of delineating the extent of the floodplain (May 2000), although the CMZ includes lower terraces and hillslopes adjacent to the floodplain where the stream is likely to meander (Pollock and Kennard 1998).

The hyporheic zone is another critical component of the riparian corridor. It is the saturated sediment underneath a stream or river channel and below the riparian area where groundwater and channel water mix. Properties of both groundwater and channel water are blended in the hyporheic zone, significantly changing the chemical composition and stimulating biological activity (Stanford and Ward 1988; Naiman et al. 2000).

Beyond the riparian area is the "zone of influence" – the transition area between the riparian area and the upland forest where vegetation is not directly influenced by hydrologic conditions (Naiman et al. 1992; Gregory et al. 1991). Vegetation in this zone still influences the stream by providing shade, microclimate, fine or large woody materials, nutrients, organic and inorganic debris, terrestrial insects, and habitat for riparian-associated wildlife. The extent of the zone of influence depends on stream size and geomorphology. For example, a small headwater stream in a steeply sloped area is influenced by upland vegetation beyond the riparian area that contributes organic material through overland flow and direct leaf-fall. Large streams, on the other hand, are more influenced by the riparian vegetation in the immediate riparian area and inputs from upstream than by upland vegetation (Naiman et al. 1992). The zone of influence may be considered part of the riparian area (Gregory et al. 1991; Naiman et al. 1992; Naiman and Decamps 1997; Knutson and Naef 1997).

Riparian vegetation refers specifically to plant communities occurring within the riparian area that are adapted to wet conditions and are distinct from upland communities (Knutson and Naef 1997). Riparian areas are composed of a mixture of herbs and grasses, shrubs, deciduous trees, and coniferous stands of various ages. Younger vegetation occurs immediately adjacent to the stream channel and commonly consists of deciduous shrubs and trees. Generally, older plant communities such as alder, cottonwood and willow are found in floodplains farther from the channel (Gregory et al. 1991). The distribution, structure and composition of riparian plant communities are largely determined by (derived from: Thomas et al. 1979; Swanson et al. 1982; Gregory et al. 1991; Naiman and Decamps 1997; FISRWG 1998; Naiman et al. 2000):

- climate
- light and water availability
- topographic features
- chemical and physical properties of the soil, including moisture and nutrient content
- the existence of tributary and groundwater flows
- natural disturbance regimes (e.g., floods, wind, fire, insect outbreaks, plant diseases, etc.)

The integrity of the aquatic and terrestrial ecosystems is greatly influenced by the quantity, composition, and structure of riparian plant communities. Plant communities that cover large areas and that have an array of vertical (e.g., trees vs. shrubs) and horizontal (e.g., young stands vs. old growth) structural characteristics can support numerous animal species (O'Neil et al. 2001). In addition, riparian vegetation, through its root system and input of woody debris, influences stream channel characteristics. Riparian vegetation also directly affects aquatic organisms by providing organic materials to the aquatic food web (Gregory et al. 1991).

Riparian plant communities typically change from the headwaters to the mouth because of differences in gradient, hydrology, geomorphology and disturbance regimes (Harr 1976; Kauffman et al. 2001). For example, steep slopes in headwater zones often restrict the extent of the riparian vegetation, which may closely resemble that of upland areas (McGarigal and McComb 1995). Mid-section zones tend to have a band of riparian vegetation that is influenced by channel dynamics (e.g., meandering, flooding). Riparian vegetation in large, low-gradient rivers is generally composed of specialized and disturbance-adapted species that flourish in floodplains where periodic inundation occurs (Naiman et al. 1992). For example, common riparian plant species such as willows and cottonwoods depend on flooding for regeneration.

Ecological functions of riparian corridors for fish and wildlife habitat

The ability of the riparian corridor to attract and support fish and wildlife is dependent on the structural and functional integrity of the aquatic, riparian and upland ecosystems (Knutson and Naef 1997; May et al. 1997b). Metro's Title 3 *Policy Analysis and Scientific Literature Review* (Metro 1997) and this section examine the many functions that riparian corridors provide for fish and wildlife habitat.

Riparian contributions to aquatic habitat

Aquatic insects, amphibians, and fish are strongly influenced by the composition and structure of riparian areas and the contribution of riparian areas to instream habitat (e.g., large and small woody debris) and organic inputs (e.g., leaves, needles, insects). Salmonids are a general indicator of watershed health or degradation. Their survival depends on a high-quality, stable environment from tributary streams through major rivers to the ocean. They require cool, clean flowing water with a high level of dissolved oxygen; clean gravel in the streambed for reproduction, a variety of in-stream cover, sufficient food sources, and unimpeded access from spawning and rearing areas to the ocean. Four important factors influence streams as habitat for salmon: water quality, streamflow, physical structure of the stream corridor, and food supply. Riparian areas provide many functions that are vital for healthy aquatic habitat, including:

- Microclimate and shade
- Bank stabilization and sediment control
- Pollution control
- Streamflow moderation
- Organic matter input
- Large woody debris

The influence riparian areas exert on a stream is related to the size of the stream, its location in the watershed, the hydrologic pattern and local landforms (Naiman et al. 1992; Naiman et al. 1993). Retention of a natural riparian buffer has been shown to partially ameliorate the adverse effects of urbanization on aquatic wildlife (Horner et al. 2001; see also *Impacts of Urbanization* section).

Microclimate and shade

Riparian vegetation exerts strong control on the stream microclimate by protecting it against climatic changes caused by land use activities outside the riparian corridor (Naiman et al. 1992; Pollock and Kennard 1998; Kauffman et al. 2001). The **microclimate** of riparian corridors is uniquely different from upland areas because of its proximity to water, which influences soil moisture, temperature, and relative humidity (Thomas et al. 1979; Swanson et al 1982; Naiman et al. 1992; Pollock and Kennard 1998; Kauffman et al. 2001). Variations in microclimate directly influence ecological patterns and processes (Chen et al. 1999).

The position of riparian areas along streams ensures adequate soil moisture available to riparian-associated plants throughout most of the year. For example, in Oregon headwater streams Olson et al. (2000) found cooler temperatures and increased relative humidity near the stream compared to upslope. Because of these factors, riparian vegetation is buffered from the stress of evapotranspiration during the summer (Swanson et al. 1982; Naiman et al. 2000). During winter months, riparian areas can be warmer than upland areas because they are not exposed to the winds more common in higher elevations (Swanson et al. 1982). According to Swanson et al. (1982), the riparian zone is "one of the best suited portions of the watershed for seasonally prolonged metabolic activity." Microclimate also influences water quality by helping regulate water temperature (Pollock and Kennard 1998).

Shade is another important function of riparian vegetation that influences water temperature. Water temperature is one of the most crucial environmental factors influencing salmon and other aquatic species. Most salmon have evolved to take advantage of temperature regimes in their home streams (Pauley et al. 1989). In general, salmon require cold water ranging in temperatures between 4° C and 17° C (39° F and 63° F) for spawning, incubation and rearing (Beauchamp et al. 1983; Pauley et al. 1986; Pauley et al. 1988; Pauley et al. 1989). Essentially all biological processes in salmon's life cycle are affected by water temperature including the timing of spawning, incubation and emergence from gravel, appetite, metabolic rate, development and growth rate, susceptibility to disease and parasites, timing of **smoltification** and ocean migration (Naiman et al. 1992; Spence et al. 1996).

Daily and seasonal water temperature are influenced by elevation, shade, streamflow, stream velocity, surface area, depth, undercut embankments, organic debris and the inflow of surface water and groundwater (Budd et al. 1987). Riparian vegetation moderates the amount of light reaching the stream channel by blocking or filtering solar radiation. The resulting shade helps to maintain cooler water temperature. The effectiveness of riparian vegetation in producing shade depends on the composition, height, and density of riparian vegetation, and the width of the stream channel and its orientation relative to solar angle (Gregory et al. 1991; Naiman et al. 1992; FEMAT 1993; Spence et al. 1996; Palone and Todd 1997; Kauffman et al. 2001). Riparian vegetation is less effective in providing shade and moderating stream temperature as streams increase in size. It has the greatest impact on headwater streams where it helps maintain temperature of surface water as well as shallow groundwater that feeds the stream. Although shading on larger rivers may have little or no influence on water temperature, overhanging riparian vegetation along the banks creates cooler microhabitat for fish and aquatic organisms (Palone and Todd 1997).

Bank stabilization and sediment control

Riparian vegetation provides bank stabilization and sediment control. Sediment delivered to streams and rivers originates from streambank erosion, from within the channel, from upland land use activities, and from natural disturbances (e.g., debris flows). Sediment occurs naturally in any stream, but changes in the **total sediment load** and particle size that exceed natural rates can have negative impacts on fish and other aquatic habitat (Beauchamp et al. 1983) (see *Impacts of Urbanization*).

Stable streambanks provide resistance to erosion. The root network of riparian vegetation increases resistance to erosion by anchoring soil and stabilizing the bank. Woody riparian species such as willow, alder and dogwood have a dense root network that is effective in protecting streambanks (Bureau of Land Management 1999). During periods of high water flow, streambanks are especially vulnerable to the erosive forces of water. The physical structure provided by riparian vegetation slows water, mechanically filters and stores fine silt and sediment, and holds materials in place (Swanson et al. 1982; Gregory et al. 1991; Knutson and Naef 1997; Naiman and Decamps 1997). This process may also facilitate bank building as sediment is deposited on the streambank and floodplain, allowing the channel to narrow and deepen (Spence et al. 1996). Vegetative material also enters the system during high flows, contributing to the complexity of aquatic habitat.

Streams of all sizes benefit from the regulating influence that riparian vegetation has on the amount of sediment entering aquatic habitats. Riparian vegetation is especially important in headwater zones where many natural disturbances occur and where the cumulative effect of uninhibited sediment entry from many small streams can significantly impact larger downstream reaches (Knutson and Naef 1997). Unconstrained floodplains are important as sites for sediment retention (Kauffman et al. 2001).

Pollution control

Riparian vegetation can be effective in trapping excess nutrients, such as nitrogen and phosphorus found in fertilizers, and pollutants such as insecticides, herbicides and industrial chemicals carried in surface water runoff (see *Impacts of Urbanization*). Riparian vegetation functions as a nutrient filter by retaining sediment from overland flow (Spence et al. 1996; Knutson and Naef 1997; Naiman and Decamps 1997; Kauffman et al. 2001). Pollutants can be found in either the dissolved and particulate forms, although the particulate form is more common. The removal of fine sediment and organic matter also often removes a large percentage of pollutants (May 2000).

Riparian vegetation also takes up nutrients for plant growth from stream-adjacent soil solution and from stream water itself, as in the case of hydrophytic roots (adapted to grow in water). Plants store nutrients in the form of woody (long-term) and non-woody (short-term) plant material. Nutrients are released from dead organic matter by leaching and decomposition. Nutrient uptake also occurs during decomposition (Swanson et al. 1982).

Microbial processes occurring in riparian areas may also reduce excess nutrients. These processes include immobilization of nutrients, denitrification of nitrate and degradation of organic pollutants (Palone and Todd 1997). Microorganisms take up or "immobilize" nutrients just as plants do, and these nutrients are re-released following the death and decomposition of microbial cells and are stored in soil organic matter. Denitrification is the process where anaerobic microorganisms (organisms that can live in the absence of oxygen) convert nitrate to nitrogen gas. Denitrification is a key nitrate removal mechanism in riparian areas (Naiman et al. 1992; Palone and Todd 1997). Degradation of organic pollutants occurs as microorganisms consume organic compounds as food sources (Palone and Todd 1997).

Streamflow moderation

Streamflow variability (i.e., volume and velocity) influences the structure and dynamics of stream ecosystems and creates a variety of habitats (e.g., deep pools, riffles, etc.) for salmonids and other aquatic organisms. Streamflow is the collection of direct precipitation and water that has moved over and through the landscape into the channel. As described in the ***Watershed Perspective*** section, the pathway water follows to reach the channel (i.e., surface water runoff vs. subsurface flow) affects the timing, quantity and quality of streamflow. In urbanized landscapes where surface water runoff, rather than infiltration, is the dominant pathway, increased peak storm flows and decreased summer flows to streams occur, both of which significantly degrade salmon habitat (Booth 1991; Schueler 1994; Booth and Jackson 1997; May et al. 1997; Morgan and Burton 1998; Karr et al. 2000; Booth et al. 2001). In addition, increases in the volume and velocity of surface water runoff often leads to increased frequency and magnitude of flooding (see *Impacts of Urbanization*).

Riparian and upland vegetation helps moderate streamflow by intercepting, absorbing and storing rainfall (Knutson and Naef 1997; Palone and Todd 1997). Streamflow can be affected by the abundance and distribution of riparian vegetation, which creates roughness that helps slow water movement to the stream. The roots of riparian plants increase soil porosity and promote water infiltration (Swanson et al.1982; FISRWG 1998). Riparian-associated wetlands help moderate streamflow by reducing flood flows and the velocity of floodwaters. Wetlands are also important storage areas for flow, particularly during dry seasons, when they become a source of water to the stream (FEMAT 1993).

Healthy soils directly contribute to healthier water resources by storing water and nutrients, regulating the flow of water, and immobilizing and degrading pollutants (FISRWG 1998; Marx et al. 1999; Moses and Morris 2001). Soil is made up many components including inorganic mineral particles of various sizes (clay, silt and sand), organic matter in various stages of decomposition, and many species of living organisms. Healthy soils are vital in the establishment and nourishment of plants and provide habitat for millions of organisms. Areas with natural vegetation cover and leaf litter provide organic matter to the soil and usually have high infiltration rates (FISRWG 1998; Marx et al. 1999). Water that is stored in soil is slowly discharged to the stream through subsurface flow.

Soil quality is typically degraded along urban stream corridors where development activities often include removal of natural riparian vegetation, compaction of soil, and placement of fill (Marx et al. 1999; Moses and Morris 2001). Soil compaction reduces water infiltration and contributes to water runoff.

Organic matter input

Forest ecosystems adjacent to stream corridors provide over 99 percent of the energy and carbon sources in aquatic food webs (Budd et al. 1987). Riparian plant communities determine the quantity, quality, and timing of nutritional resources delivered to the stream channel (Swanson et al. 1982; Gregory et al. 1991; Naiman and Decamps 1997). Leaves, fruit, cones, insects and other organic matter fall directly into the stream channel from the riparian area, or move by wind, erosion or as dissolved materials in subsurface water flowing from the hyporheic zone (Gregory et al. 1991; Naiman et al. 1992). Insects are an essential food source in the early stages in the salmon's life cycle (Cederholm et al. 2000). Fallen insects from riparian vegetation can make up 40 to 50 percent of the diet of trout and juvenile salmon during the summer months (Johnson and Ryba 1992).

Over 80 percent of the plant material input from deciduous riparian forests are leaves that are delivered to the stream over a six to eight week period during autumn. Cones and wood make up 40-50 percent of the material delivered from coniferous riparian forests (Naiman et al. 1992). Leaves from deciduous trees are high in nutrients and break down for processing in four to six months, whereas conifer needles may persist in streams for one to two years. Shrub and herb-dominated riparian communities also provide significant input to many streams (Gregory et al. 1991). These externally-derived materials are processed by detritivorous (shredders) insects that break down wood fragments, needles, leaves and other debris into smaller pieces.

The importance of salmon

In addition to organic material derived from adjacent riparian vegetation and from within the stream, many aquatic and terrestrial species rely on salmon eggs, fry, live adults and carcasses as a food source. Salmon are a key link in biodiversity and productivity of Pacific Northwest streams, and forge a strong connection between aquatic and terrestrial ecosystems through nutrient cycling, as the following example illustrates (Cederholm et al. 2000; Cederholm et al. 2001).

Freshwater macroinvertebrates gain energy and mass by consuming algae, detritus, and bacteria. Every species of salmon fry rely on these spineless creatures (both aquatic and terrestrial) for food (Meehan 1996). The complexity of instream habitat, along with riparian vegetation along streams, increase the number and type of insects available to the tiny fish. The fish grow and some head out towards the Pacific Ocean, where they gather similar nutrients from the saltwater which will be carried back inland. Others are consumed by animals living in water and on land, cycling back into the nutrient pool.

The adult salmon, now ready to spawn, head back to their natal inland stream, where they lay millions of eggs. Many of the eggs are eaten by macroinvertebrates and other fish. A few make it to hatching, where they too are at risk of being eaten. Meanwhile, multitudes of adult fish have completed their life cycle and die in the stream, where they add nutrients that stimulate production of plants, algae and bacteria; are consumed by instream organisms, including salmon; or are consumed by seasonal congregations of wildlife such as Bald Eagles, river otter, gulls, merganser and black bear. A gull eats a salmon carcass, flies upslope and is taken by a Peregrine Falcon. The bear, having gorged on dead and live spawning salmon, moves upslope to eat huckleberries, where its excrement deposits salmon-based nutrients. Invertebrates opportunistically feed on all of these salmon products and disperse throughout the landscape. Animals are fed, soils are built, and plant communities grow.

Pacific Northwest ecosystems are adapted to enormous seasonal inputs of salmon eggs, fry and carcasses. Nearly 140 species of vertebrates have ecological relationships with, and 88 routinely interact with salmon (Cederholm et al. 2001). The significant reduction or loss of salmon in our streams causes a vast reduction in nutrients available in the water and on the land, with the potential to alter entire ecosystems. Salmon conservation will be necessary to recover and preserve the health and ecological integrity of the Pacific Northwest.

Large woody debris

Large woody debris (LWD), such as branches, logs, uprooted trees, and root wads, is an important component of aquatic habitats in the Pacific Northwest, both as a structural element and as cover from predators or protection from high streamflows. Large woody debris helps form channel features such as point bars, pools, riffles, runs, eddies, side channels, meanders, hydraulic complexity (e.g., variation in streamflow) and instream cover (e.g. overhanging vegetation, undercut banks) (Beschta 1979; Booth et al. 1997; Spence et al. 1996). Stream complexity is essential for salmon because at various life cycle stages they require different types of habitat. According to May et al. (1997b), LWD is the most important structural component to salmonid habitat.

Large woody debris also controls the routing of water and sediment, dissipates stream energy, protects streambanks, stabilizes streambeds, helps retain organic matter, and acts as a surface for biological activity (Swanson et al. 1982; Harman et al. 1986; Bisson et al. 1997; Sedell et al. 1988; Bilby and Ward 1989; Gregory et al. 1991; Naiman et al. 1992; FEMAT 1993; Spence et al. 1996; May et al. 1997b). Large woody debris enters streams either directly from the adjacent riparian area or from hillslopes through a variety of mechanisms including toppling of dead trees, windthrow, debris avalanches, undercutting of streambanks and redistribution from upstream (FEMAT 1993; Spence et al. 1996; Naiman et al. 2000).

Over time, the influence of LWD may change, both in terms of its function and location within the watershed, but its overall importance is "significant and persistent" (May 2000). The characteristics of riparian vegetation determine the age, species, diversity, and size of the wood entering the stream, which in turn influences the persistence of LWD in the channel. For example, hardwoods decompose more quickly than conifers (Keim et al. 2000; Naiman et al. 2000). Conifers, therefore, have a greater ability to form and maintain structural features over time (Knutson and Naef 1997).

In steep headwater streams, large woody debris is generally located where it initially fell and is typically large enough to span the entire channel, affecting hydraulic processes by physically obstructing the streamflow and creating pools, riffles, rapids and waterfalls (Naiman et al. 1992). This results in less erosion to the streambed and banks, more sediment storage in the channel, and slower downstream movement of organic debris. By delaying transport of sediment downstream, rapid changes in sediment loading can be avoided (Swanson et al. 1982; Bilby and Ward 1989; Naiman et al. 1992; Spence et al. 1996). The delayed transport of organic material downstream enhances its use as either a nutritional resource or habitat by aquatic organisms (Swanson et al. 1982; Bilby and Ward 1989; Gregory et al. 1991). The ability of the stream to retain organic matter is enhanced when small woody debris, such as branches, sticks, and twigs accumulates, trapping leaves and other organic matter (Gregory et al. 1991).

Large woody debris becomes increasingly important in creating salmonid habitat in mid-section zones where it is a dominant channel-forming feature. In streams where LWD spans the width of the channel, it redirects the flow of water and alters water velocity, creating complexity and a number of pool types that are used by juvenile salmonids during summer (Beschta 1979; Naiman et al. 1992; Nickelson et al. 1992). Large woody debris in low-gradient zones is less of a channel-forming feature than in mid-section zones. In areas where LWD commonly accumulates, such as along outside bends of riverbanks and on upstream ends of islands, it influences meander cutoffs, provides cover for juvenile salmonids, and serves as habitat for invertebrate production (Naiman et al. 1992).

Riparian contributions to terrestrial habitat

Natural riparian areas are biologically diverse and complex ecosystems that contain more plant, mammal, bird, and amphibian species than the surrounding upland areas (Kauffman et al. 2001). Wildlife use riparian corridors more than any other type of habitat (Thomas et al. 1979). Riparian areas provide several functions important to wildlife, including:

- Food, cover and water
- Movement corridor

- Microclimate

Food, cover and water

Wildlife are attracted to riparian areas because of the abundance of food sources, cover, and proximity of drinking water. Access to water is critical for both riparian-dependent wildlife and for many upland species, especially in urban areas where access can be a limiting factor. Riparian areas are especially important areas during breeding season and provide wildlife with an energy-efficient habitat for rearing young due to the close proximity of food, water and cover, thereby minimizing energy expenditures by the adults and young.

The greater availability of water to plants in riparian areas increases plant biomass production, providing a complex and highly productive food web. Seeds, herbaceous vegetation and fruits, aquatic and terrestrial insects, and fungi are plentiful (Thomas et al. 1979; Mitchell 1998; Johnson and Ryba 1992). Riparian areas also provide predators with an abundance of prey species (Knutson and Naef 1997). In addition, spawning salmon and salmon carcasses also provide a seasonal high-energy food source to many wildlife species. A recent study conducted by Johnson et al. (cited by Cederholm et al. 2000) found that 137 species of birds, mammals, amphibians and reptiles common to Washington and Oregon consume salmon at one or more stages of a salmon's life cycle.

Riparian vegetation in the form of grasses, shrubs, trees and other plants provides wildlife habitat for reproduction, nesting, roosting, foraging and protection from the weather and from competitive and predatory species. Riparian areas often contain unique plant communities, both in composition and structural complexity (Kauffman et al. 2001; O'Neil et al. 2001). Structural complexity exists when there is a diversity of plant species, multiple canopy layers (e.g., deciduous vs. coniferous; shrubs vs. trees), and snags and downed woody material (Thomas et al. 1979; Knutson and Naef 1997; FISRWG 1998).

Many wildlife species are associated with specific plant communities; some require a certain age (e.g., old growth or pioneer species). Some species of invertebrates, birds and mammals rely on snags (standing dead trees) and downed and dead wood for a portion of their life history (see *Riparian Habitat Types And Species Associations*). Downed and dead woody material in various stages of decay provide diversity in the environment and are of varying significance for wildlife habitat (Thomas et al. 1979). Much of the biodiversity and productivity of the riparian area would disappear without this woody debris accumulation (Naiman et al. 1992).

The linear nature of riparian areas maximizes the development of edge habitat, an area where two different plant communities, successional stages, or vegetative conditions meet (Thomas et al. 1979). Some species benefit from the availability of edge habitat because edges contain plant communities that are characteristics to each adjoining habitat (Knutson and Naef 1997). Although edge habitat can promote high wildlife diversity, it can also have a negative impact on some species associated with interior portions of the riparian area (see *Impacts of Urbanization* section).

Movement corridors

Many wildlife populations rely on their ability to move between different types of habitat along riparian corridors, especially for species that would not otherwise cross large openings (Palone and Todd 1997). Riparian corridors, because of their linear shape, enable movement of wildlife between habitat patches (Thomas et al. 1979; Beier and Noss 1998; Palone and Todd 1997). Dispersal and establishment of new territories for feeding and breeding is important for many species. This allows for an exchange of genetic material between species populations and is critical for resilience to disease and other negative impacts (Cohen 1997). At least 95 percent of all terrestrial species in North America depend on corridors (Cohen 1997).

Riparian corridors also play a potentially important role within landscapes as corridors for plant dispersal and, according to Gregory et al. (1991), may be an important source of most colonists through the landscape.

Microclimate

Riparian and upland vegetation create a microclimate in riparian areas as described in *Riparian Contributions to Aquatic Habitat.* The microclimate of riparian areas is generally more moist and mild (cooler in summer and warmer in winter) than the surrounding area (Knutson and Naef 1997). This creates diverse habitat characteristics that are desirable to many species, particularly for amphibians year-round and for ungulates and other large mammals during hot, dry summers and severe winters (Knutson and Naef 1997).

Riparian habitat types and species associations

We have described, in general terms, the natural disturbance regime and the geomorphology, hydrology, and vegetative interactions that make riparian areas so biologically rich and variable. In this section we describe the riparian habitat types found in the Metro region and the wildlife species associated with them.

Each type of habitat is unique in terms of the specific functions and values it provides to wildlife. In turn, each wildlife species has its own set of requirements, thus different habitats and structural conditions are important to different species. To gain a better understanding of how wildlife in the Metro region uses various habitats, Metro compiled a list of all vertebrate species (Metro's Species List, Appendix 1) and their associations with habitat types and structural conditions that occur in the region. The following sections describe the number of species associated with each habitat type, and Table 1 provides an overview of riparian habitat use by wildlife in the region. For more information on the relative importance of habitats and structural conditions, see Appendix 2.

Table 1. Analysis of the importance of the three water-associated habitats (riparian, wetlands, and open water) for each major group of animals (29 total existing native species; based on Metro's Species List, Appendix 1).

Group	# Native Species	Riparian Dependent	Uses Riparian	Total % Using Riparian
Amphibians	16	11 species 69%	4 species 25%	15 species 94%
Reptiles	13	3 species 23%	6 species 46%	9 species 69%
Birds	209	103 species 49%	96 species 46%	198 species 95%
Mammals	54	15 species 28%	34 species 64%	49 species 91%
TOTAL	292	132 species 45%	140 species 48%	271 species 93%

Note: Fish were excluded because they are 100 percent water-associated. "Riparian Dependent" species are closely associated with at least one of the three habitats; "Uses Riparian" species are generally associated with or known to use at least one of the three habitats. Habitat types and species-habitat associations are based on Johnson and O'Neil's (2001) classification system.

Habitat classification scheme

To provide a general description of habitats in the Metro region we selected the habitat classification system described in **Wildlife-Habitat Relationships in Oregon and Washington** (Johnson and O'Neil 2001). Based on wildlife in our region, the book provides species-habitat relationships and cross-references other widely used habitat classification systems. Johnson and O'Neil (2001) describe wildlife habitat as a concept related to a particular wildlife species. Specifically, **habitat** is "an area with the combination of the necessary resources (e.g., food, cover, water) and environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population), and allows those individuals to survive and reproduce" (Johnson and O'Neil 2001). This habitat scheme is provided as a tool to describe habitats and their relationships with species; Metro is not committed to the sole use of this scheme and will use other systems if they are deemed more appropriate. We have included Johnson and O'Neil's cross-references to other well-known schemes for water-associated habitats.

The broadest classification within this scheme is Habitat Type (e.g., Westside Lowlands Conifer-Hardwood Forest, Urban, etc.). There are five upland and three water-associated habitats (including riparian forest) in the Metro region. Shrub habitats are addressed under Structural Conditions (Appendix 2).

Each habitat type can be subdivided into structural conditions. For example, forested habitat structural conditions are based on average tree diameter at breast height (dbh), percent canopy cover, and number of canopy layers in the forest (described below; see also Appendix 2). This yields 26 possible structural conditions within each of three forest types, or a total of 78 potential forest/structure combinations. Shrubland and grassland (grasslands have less than 10 percent shrubs) structural conditions include 20 possibilities. Agricultural lands may be cultivated cropland, improved pasture, orchards/vineyards/nursery, modified grasslands, or unimproved pasture. Urban habitats are divided into three categories based on urbanization intensity.

These structural conditions deal with terrestrial (land-based) habitats, thus they apply to all upland habitats and two of the three water-associated habitats (Westside Riparian Wetlands and Herbaceous Wetlands). We have ranked the importance of all structural conditions to wildlife in the Metro region based on the species list and Johnson and O'Neil's Species-Structural Conditions relationships; results are presented and discussed in Appendix 2.

Habitat types and structural conditions constitute the level of detail in this paper, addressed through habitat descriptions and Metro's Species List (Appendix 1). The habitat types are sufficiently broad categories to be feasible in large-scale land use planning. Structural conditions provide a wide variety of finer level descriptions of conditions within each habitat type, and these may be useful for future on-the-ground habitat and species conservation, as well as an aid to determine restoration goals and priorities.

The utility of Johnson and O'Neil's habitat scheme is greatly enhanced by species-habitat/structural relationships for all species in the Metro region except fish. Johnson and O'Neil provide further information on what they term "Habitat Elements," those components of the environment believed to most influence wildlife species' distribution and success. Habitat Elements include attributes such as downed wood and leaf litter, shrub layers within forest stands, fungi, and snags (including decay classes for downed wood and snags); Johnson and O'Neil relate each vertebrate species to this level of detail. Thus, within the context of Johnson and O'Neil's habitat classification scheme, the full complement of wildlife habitats (we only address the first two here) would include:

Wildlife Habitats = Habitat Type(s) + Structural Condition(s) + Habitat Element(s)

Below we describe habitat types and each major group of associated species, based on the scientific literature. Upland habitat and wildlife descriptions are based on the same system and follow a similar format, but are discussed in the ***Upland Habitat*** section. Plant species that typically dominate each habitat type are listed in Appendix 3. Other habitat classification schemes for riparian may also provide useful or more detailed approaches (e.g., Franklin and Dyrness 1973; Cowardin et al. 1979; Diaz and Mellen 1996; U.S. Fish and Wildlife Service 1997b; Adamus 1998).

Open water (lakes, rivers and streams)

This habitat type, including ponds and reservoirs, is widely distributed in the Metro area and contains four distinct zones: (1) the **littoral zone** is at the edge of lakes and is the most productive of the zones, with diverse aquatic beds and attached emergent wetlands (part of Herbaceous Wetland habitat). (2) The **limnetic zone** is deep open water dominated by **phytoplankton** and freshwater fish, extending to the limits of light penetration. (3) The **profundal zone** is below limnetic zone, and is devoid of plant life and dominated by **detritivores.** (4) The **benthic zone** includes bottom soil and sediments. Ponds and lakes are typically adjacent to Herbaceous Wetlands, while streams and rivers are often adjacent to Westside riparian wetlands or Herbaceous wetlands. Streams and rivers in the Willamette Valley are productive and typically contain high species diversity (Johnson and O'Neil 2001).

This habitat is called riverine and lacustrine in Anderson et al. (1998), Cowardin et al. (1977), Washington Gap Analysis Project (Cassidy 1997), Mayer and Laudenslayer (1988), and Wetzel

(1983). However, this habitat is referred to as Open Water in the Oregon Gap II Project (Killsgaard 1999) and Oregon Vegetation Landscape-level Cover Types (Killsgaard and Barrett 1998).

Flooding is a major natural disturbance in these systems. In the Willamette Valley, floods are influenced by precipitation (rather than snowmelt runoff) and thus tend to be short duration events, although their influence on this habitat is profound. Seasonal and decadal trends in precipitation also influence water habitats. In the Metro region beavers played a historic role in creating many ponds and marshes, and are still present in reduced numbers. Human disturbances that negatively influence this habitat type include hydrologic changes, excess nutrient inputs, toxins, loss of habitat and water quality and quantity, and others (see *Impacts of urbanization*). Non-native species, including plants, fish and mollusks, pose a major threat to native organisms in this habitat. Management activities that would improve this habitat include planting and/or retaining vegetative buffers along streams to reduce toxins and sediments, reducing pollutant sources, managing stormwater and maintaining or restoring natural flow regimes, and decreasing impervious surfaces (particularly in close proximity to the stream).

Water is clearly an important resource in the Metro region, and a large number of **species at risk** depend on this habitat. Seventy-five Metro region vertebrate species, excluding fish (which are all dependent on this habitat), are closely associated with Open water habitats, second only to Herbaceous wetlands. Ten non-fish vertebrate species closely associated with this habitat are state- or federally-listed species at risk, plus two Canada Goose subspecies and two **extirpated** species. Twenty native fish species or subspecies are at risk (Appendix 1).

Herbaceous wetlands

Herbaceous wetlands are declining locally and nationally. These wetlands (including marshes, and wet sedge meadows) are sometimes termed "freshwater aquatic beds," "emergent wetlands," or "palustrine" habitats. Herbaceous wetlands are permanently, semi-permanently, or seasonally flooded. Patches of this habitat may be found adjacent to all habitats discussed in this section, although most frequently in valley bottoms and high rainfall areas such as the Willamette Valley. These wetlands occur in flat terrain and are typically, but not always, associated with a stream, river channel, or open water. In Willamette Valley riparian corridors, this habitat commonly forms a pattern with Westside riparian-wetlands habitats. Johnson and O'Neil do not make it clear whether springs, seeps and vernal wetlands are included, but our intention is that they be included in this habitat type.

In their widely used wetlands classification system, Cowardin et al. (1979) classify this habitat type as palustrine emergent wetlands. The Oregon Gap II Project (Killsgaard 1999) and Oregon Vegetation Landscape-Level Cover Types (Killsgaard and Barrett 1998) that would represent this type are wet meadow, palustrine emergent, and National Wetland Inventory (NWI) palustrine shrubland.

Herbaceous wetlands include a mixture of emergent herbaceous and grass-like plants, and may include floating or rooting aquatic forbs. A variety of hydrologic regimes limit or exclude woody plant invasion, but in drier areas of the Willamette Valley fire suppression can lead to invasion by Oregon Ash. As with other aquatic habitats, beavers play an important disturbance role in creating and maintaining this habitat. Direct alteration of hydrology (stormwater inputs, channeling, draining and damming) or indirect alteration (road building, vegetation removal, beaver removal) alter the amount and patterns of this habitat.

Excluding fish, 79 vertebrate species in the Metro region are closely associated with this habitat, more than any other habitat. Of these, seven are state or federal at-risk species, plus another two Canada Goose subspecies and one extirpated species. This habitat type also provides important off-channel habitat to salmonids.

Westside riparian-wetlands

Westside riparian-wetlands are patchily distributed along streams and water bodies in lowlands and foothills of the Willamette Valley, and have declined significantly through conversion to urban and agriculture land covers. This habitat often occurs as patches or linear strips within Westside lowlands conifer-hardwood habitats, although Urban and mixed environs is another common habitat within which Westside riparian-wetlands are nested. Herbaceous wetlands and Open water habitats are often nearby. In natural conditions large woody debris is abundant, but tree removal reduces woody debris inputs to terrestrial and aquatic systems.

This habitat includes all palustrine, forested wetlands and scrub-shrub wetlands at lower elevations on the westside, but drier portions of this habitat in riparian floodplains may not qualify as wetlands according to Cowardin's (1977) definition. Much of this habitat is probably not mapped as distinct habitat types by the Gap projects due to the relatively small scale on the landscape and difficulty of distinguishing forested wetlands (Johnson and O'Neil 2001). A portion of this habitat is mapped as the Oregon Gap II Project (Killsgaard 1999) and Oregon Vegetation Landscape-Level Cover Types westside cottonwood riparian gallery, palustrine forest, palustrine shrubland, NWI (National Wetland Inventory) palustrine emergent, and alder/cottonwood riparian gallery (Killsgaard and Barrett 1998).

Riparian plant communities in the Pacific Northwest typically include scattered patches of grasses and herbs on exposed portions of the active channel, with mosaics of herbs, shrubs and deciduous trees in the floodplain (Gregory et al. 1991). Conifers may dominate where surfaces have been stable for long periods of time, such as on old floodplain benches or along lower hillslopes. Forested riparian habitats contain much greater plant volume than non-forested habitats, and quantity and composition of the plants growing along water exert strong influences on animals living in the water and on the land. Much of this remaining habitat in the Metro region is degraded due to human-induced changes in hydrologic and nutrient cycles, but it is nonetheless of primary importance to wildlife in the region.

Riparian habitats are naturally dynamic, formed and regulated to a large extent by natural disturbance regimes. Flood frequency and intensity varies considerably with natural hydrologic regime and geomorphology. Other natural disturbance agents include debris flows, tree windthrow, beavers, and grazing by wild herbivores. Human changes to vegetation along waterways, as well as the addition of impervious surfaces, alter hydrology and otherwise modify this habitat (see *Impacts of urbanization*). Reed canarygrass is an abundant non-native invader in this habitat, along with other non-natives.

This valuable wildlife habitat has more closely associated species (64, excluding fish) than any other terrestrial habitat type, including many amphibians and birds. Eleven of these are species at risk in Oregon and/or nationally; two more are now extirpated from this region. The native turtles appear particularly vulnerable to habitat loss, degradation, fragmentation, and pressure by non-native turtles and bullfrogs (bullfrogs eat young turtles) (Adams 1999; Adams 2000).

Impacts of urbanization

Aquatic habitats in urban and urbanizing areas of the Pacific Northwest are the most highly altered of any land use types (R2 Resource Consultants 1996). Habitat loss, alteration, and significant increases in the amount of impervious land cover characterize the Metro region. The Metro region has lost approximately 400 miles of streams (about 30 percent of the original) (Metro 1997). In addition, 213 miles are listed by the Department of Environmental Quality as water-quality limited (Oregon Department of Environmental Quality 1996). Ninety-six percent of the land in the Willamette basin under 500-feet in elevation is privately owned and has been converted to agricultural or urban use (Willamette Urban Watershed Network 2000). A recent study of tree cover in the Willamette/Lower Columbia Region found a reduction in tree canopy cover from 46 percent in 1972 to 24 percent at present (American Forests 2001). Average tree cover in the region's urban areas is only 12 percent, down from nearly 21 percent in 1972. Eleven percent of the Metro region's natural areas were lost between 1989-1999, with accompanying adverse effects on watershed hydrology and wildlife habitat. Groundwater volume is also declining (McFarland and Morgan 1996).

A relatively large body of scientific literature documents effects due to urbanization that are similar regardless of study area, and these studies are summarized in Appendix 4. Most of urbanization's adverse impacts originate from changes in the amount and timing of water runoff, loss of natural vegetation, or both. Often changes in one result in changes in the other.

Relevance of science in rural forested landscapes to urban systems

Urban ecology is a relatively new scientific field (Murphy 1988). The question arises as to whether the use of scientific data from non-urban ecosystems (e.g., natural forested habitats) is appropriate in an urban setting, where conditions are significantly different from relatively undisturbed systems. The City of Portland raised this issue to their peer review science panel (City of Portland 2000); reviewers concluded that applying science developed within non-urban forested settings was appropriate in urban habitats, provided that urban research was incorporated as available.

However, urban research is sparse. Scientists know a fair amount about impacts of urbanization on waterways and fish, but resulting ecosystem changes and the cascading effects on other wildlife species and habitats may be subtle and complex. Also, unlike naturally forested ecosystems, in urban ecosystems the removal of vegetation and other consequences to riparian and aquatic habitats are often permanent (Booth 1991).

Nonetheless, all of the natural structures, functions and processes occurring in non-urban settings also occur, mediated by human activities, in urban ecosystems. For example, the discussion of impervious surfaces below was founded on knowledge of the natural hydrologic cycle, augmented by regionally specific urban research. The concept of habitat simplification leading to simplified wildlife communities is well understood in non-urban settings, and can be applied to urban ecology. The impacts of nonnative species on native wildlife relate to competition, predation, and changes in **trophic** levels; these foundations in community ecology are not unique to urban environs. Thus scientific research conducted outside urban systems provides a theoretical framework for urban research, as well as providing **reference conditions** against which the differences between relatively undisturbed and human-altered systems can be compared.

Cumulative impacts

It is critical to recognize the cumulative nature of human impacts within a watershed. Watershed condition is a result of the cumulative effects of past and present human activities (May and Horner 2000). The Oregon Watershed Assessment Manual describes this effect (Watershed Professionals Network 1999):

> Cumulative effects can be defined as the changes to the environment caused by the interaction of natural ecosystem processes with the effects of land use and other human activities distributed through time and over the landscape...Individual actions that by themselves are relatively minor may impact resources when combined with other modifications that have occurred in the watershed. The current habitat condition at any location in a stream is a function of the watershed activities that currently occur upslope and upstream, added to the effect of historical activities. For example, in a typical managed forest, historical streamside timber harvest combined with stream cleaning, splash damming, and use of streams as transportation corridors have resulted in a legacy of low LWD frequency. Downstream in an agricultural area, streams were often channelized and riparian forests were removed. These historical changes combined with present-day expansion of suburban areas, for example, resulted in altered channel conditions throughout the watershed. (page 37)

Thus, accounting for cumulative effects remains one of the greatest challenges for managing wildlife habitats in an urban setting. A local example of cumulative effects follows.

The portion of the Willamette River running through the Metro region is influenced not only by the intensity of urbanization within its own watersheds, but also by the cumulative effects from land use and activities upstream. In December 2000, the Portland Harbor was listed as an EPA Superfund Site (U.S. Environmental Protection Agency 2001a). This six-mile reach of the Willamette River between the southern tip of Sauvie Island and Swan Island exemplifies the difficulties in balancing environmental and economic concerns. The harbor is an international commerce and industry portal contributing substantially to the regional economy, but it also provides a critical migratory corridor and rearing habitat for endangered salmonids and other wildlife (U.S. Environmental Protection Agency 2001a). Industrial facilities line the banks on both sides of the river, private and municipal wastewater outfalls add effluent, and sediments and toxins are input from upstream tributaries. Sediments in this reach of the Willamette contain high levels of many contaminants, including PCBs, heavy metals, arsenic, petroleum hydrocarbons, and pesticides such as DDT. A *Remedial Investigation and Feasibility Study* is the next step, designed to determine how much contamination is present, its location and extent, related threats to the public, and potential cleanup alternatives (U.S. Environmental Protection Agency 2001b). A binding agreement to proceed on this step has been signed by parties that voluntarily came forward to participate in the cleanup process; the EPA has not yet determined all potentially responsible parties.

Impervious surfaces and altered hydrology

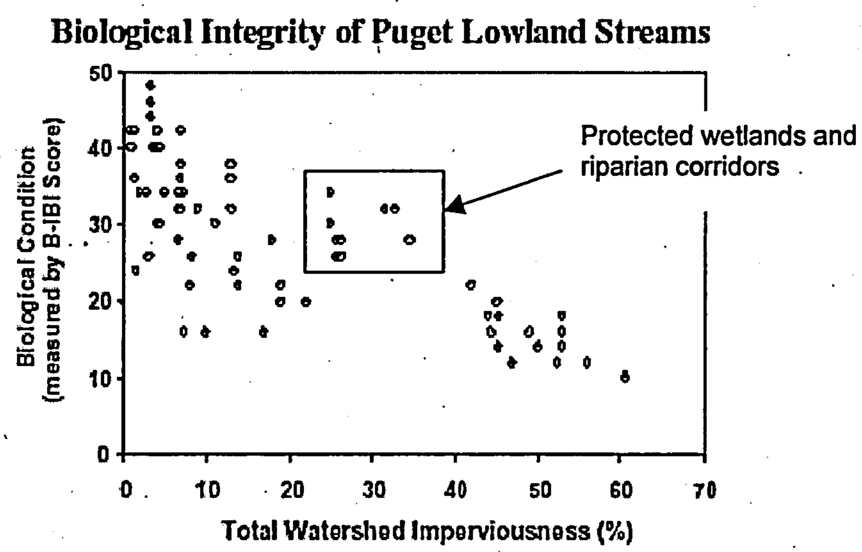
One of the most ubiquitous influences of urbanization on the functions and values of a watershed is the replacement of the natural landscape with pavement and other water-impervious (impenetrable) material such as roads, parking lots, driveways, sidewalks, and rooftops (May et al 1997a; Wilcove et al 1998; Booth 2000). Increased levels of impervious surfaces interrupt the hydrologic cycle, alter stream structure, and degrade the chemical profile of the water that flows through streams. These changes to water storage and delivery harm the environment in a variety of ways, and are cumulative within watersheds (McCarron et al. 1997; May and Horner 2000).

As Metro's (1997) Title 3 white paper indicates, the amount of rainwater that runs off the land rather than infiltrating increases with imperviousness. For example, in areas covered completely with natural vegetation approximately 15 percent of the rainwater runs directly off. In a typical single family home scenario (35-50 percent imperviousness), about 35 percent of the rainwater runs off. In a fully urbanized setting ($\geq$ 75 percent imperviousness), 61 percent of the water may run off the land. Local streams are adapted to local, native conditions; during storm events, all that water running quickly into streams acts like a giant corkscrew auguring right down the stream channel. Streams are **incised** and the beds are widened, more sediments, toxins and water enter the system, and much of the wildlife that once lived in the stream disappears.

The percent of impervious surfaces within a watershed can indicate the intensity of urbanization and associated negative ecological impacts, but there is evidence that these effects can be mitigated. Research in the Pacific Northwest and in other regions indicates that when a watershed's **imperviousness** reaches approximately 5-10 percent, stream ecosystems and biotic communities show measurable evidence of degradation (Schueler 1994; Arnold and Gibbons 1996; Spence et al. 1996; May et al. 1997a); adverse ecological effects typically become quite severe when imperviousness reaches approximately 25-30 percent. Some researchers consider 10 percent imperviousness to be the lower end of an ecological threshold (the "65/10" rule, in which imperviousness targets are <10 percent and forest cover targets are 65 percent; see Booth 2000). However, recent evidence suggests that in fact, there is no lower threshold, and that degradation can occur at any level of imperviousness; further, it appears that activities such as protecting wetlands and riparian areas help lessen the impacts of urbanization (Figure 5) (Booth 2000). Thus, mitigating the effects of imperviousness, combined with maintaining relatively high levels of forest canopy cover, are probably keys to maintaining or improving ecological conditions in an urban setting (see *Restoration section* for some mitigation examples).

In general, the reason for the harmful effects of imperviousness is a combination of factors affecting the quality, quantity, and timing of stormwater delivered to the stream. Impervious surfaces prevent precipitation from infiltrating the soil and moving slowly to the stream, thereby reducing the "sponge" area in a watershed. Water may move quickly from impervious surfaces to the stream overland, or across the surface, carrying with it sediment and pollution; or it may be routed via pipes directly to the stream. The natural patterns of water delivery and filtration are either modified or completely bypassed. Stormwater from pipes is particularly damaging because it is discharged at high volumes and velocities, harming stream channels and altering the wildlife capable of living in or near the stream. The primary concept is that impervious surface and piping effects are highly detrimental to hydrology and waterways, but these effects may be decreased through some mitigation approaches (Figure 5).

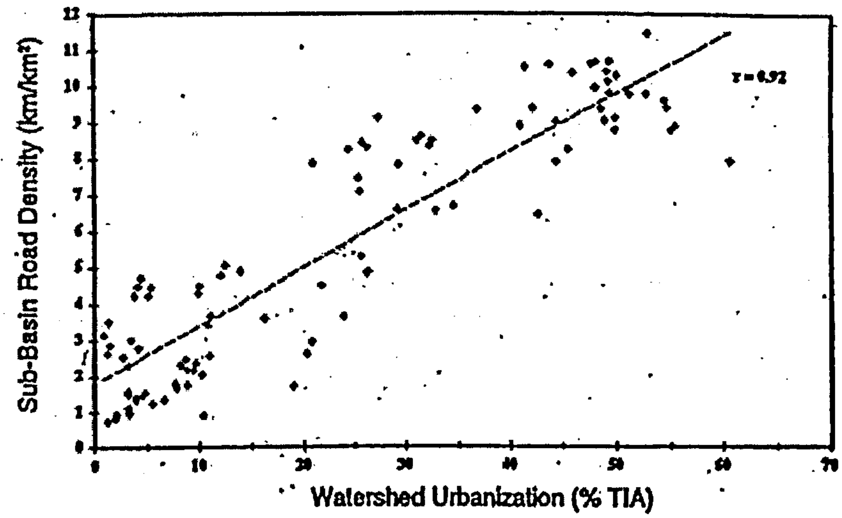
Figure 5. The Influence of protecting wetlands and riparian corridors on aquatic biological integrity.



Compilation of biological data on Puget Lowland watersheds, reported by Kleindl (1995), May (1996), and Morley (2000). The pattern of progressive decline with increasing imperviousness is evident only in the upper bound of the data; significant degradation can occur at *any* level of human disturbance (at least as measured by impervious cover). Modified from Booth 2000 (the "protected wetlands and riparian corridors" portion of this graph was obtained from a talk given by James Karr at the 2001 At Water's Edge conference).

Imperviousness is typically quantified through two methods. The most common method is to measure the proportion of the basin area covered by imperviousness, or the **total impervious area** (TIA) (Schueler 1994). TIA may be measured directly through aerial photos, GIS layers or satellite data. An alternative TIA measure is to use GIS data to calculate the amount of "natural" surfaces (e.g. vegetation and soils), then subtract the proportion of natural surfaces from the total to estimate TIA. Transportation systems (streets and parking lots) typically comprise a majority of impervious surfaces, and road density is sometimes used as a proxy for TIA in jurisdictions lacking better data (Schueler 1995; May et al. 1997b). In the Puget Sound region, roads and parking lots account for over 60 percent of basin imperviousness in suburban areas and is strongly correlated with TIA (May et al. 1997b) (Figure 6). Ideally, however, TIA should be used rather than road density because it provides a more accurate measure of imperviousness.

Figure 6. Sub-basin road density vs. watershed urbanization (percent TIA).



Source: May et al. 1997.

The second method of measuring imperviousness is **effective impervious area** (EIA), referring specifically to the area where there is no opportunity for runoff from an impervious surface to infiltrate into the soil before it reaches a conveyance system (pipe, ditch, stream, etc.) (Washington State Department of Ecology 2000). In other words, impervious surfaces may not be considered part of EIA if the water has a chance to soak in. Table 2 provides an estimate of TIA versus EIA (without impervious mitigation measures) under various development intensities. To illustrate how EIA differs from TIA, consider a building with a driveway and roof, where stormwater runs off these surfaces and is routed through curbs and gutters to a storm drain, flowing directly to the stream. In this case, TIA would be the same as EIA. If the roof gutters were instead routed to a vegetated area, then the EIA would be less than the TIA. EIA could be further reduced by removing curbs along the driveway and allowing water to infiltrate into vegetation, soils or gravel, but TIA would remain the same unless impervious surfaces were removed.

Table 2. Presumed relationship between land use, TIA and EIA.

LAND USE	TIA (%)	EIA (%)
Low density residential (1 unit per 2-5 acres)	10	4
Medium density residential (1 unit per acre)	20	10
"Suburban" density (4 units per acre)	35	24
High density (multi-family or 8+ units per acre)	60	48
Commercial and industrial	90	86

Source: Booth and Jackson (1997)

Currently, EIA may be the most appropriate estimate of human influence on hydrology because it incorporates measures to mitigate adverse impacts. However, EIA may be difficult to measure, in part because the extent to which such mitigation efforts actually work is unknown. When EIA is significantly less than TIA, there is little doubt that imperviousness exerts a weaker influence on the environment than if the two were equal. The magnitude of this difference is unknown, but reducing effective imperviousness is clearly an important strategy in urban ecosystems.

The result of greater stormwater volumes traveling over impervious surfaces and being delivered too rapidly to streams is increased stream **flashiness** (Figure 7) and a reduction in summer base flows, sometimes causing perennial streams to turn intermittent or dry up completely (Harbor 1994). As a result, urbanized watersheds are prone to more frequent and bigger floods (Sovern and Washington 1996). For example, in King County, Washington, downstream from urbanized watersheds the largest floods were two to three times bigger than in nearby natural systems, while the frequency of smaller floods increased as much as tenfold (Booth 2000). Wigmosta et al. (1994) estimate that Pacific Northwest areas covered by impervious surfaces typical of suburban development have 90 percent less water storage capacity than naturally forested areas of the same size.

Floodplain and wetland alterations

Floodplains play a critical role in transporting high flows and moderating the effects of peak floods. Wetlands are usually part of the floodplain system. Stream degradation through incision and artificial barriers such as dams, floodwalls and levees, as well as wetland draining and alteration, may render a stream incapable of dispersing water, soil and nutrients to the floodplain (Rosgen 1993; Spence et al. 1996; Poff et al. 1997).

Dams

Although dams provide many societal benefits including power generation, water storage, flood control, agricultural irrigation, and recreation, they influence watershed functions in fundamental ways (FISRWG 1998). Ecological problems associated with dams include erratic water volume and velocity (altered hydrology), increased streambank erosion, loss and fragmentation of riparian habitat, altered water chemistry, altered instream habitat, and blocked fish and instream wildlife passage (see also Tables 3 and 4). More than 85 percent of the inland waterways within the continental United States are now artificially controlled through dams (National Research Council [NRC] 1992), including all major Metro-region rivers. All salmon and steelhead in the Columbia Basin are affected to some degree by damming activities (Federal Caucus 2000).

Floodwalls and levees

Floodwalls and levees, installed to control floodwater and limit the access of a stream to its floodplain, cause hydrologic fragmentation by disrupting lateral and downstream stream-floodplain interactions. The floodwalls along Portland's downtown area provide a local example. Floodwalls and levees tend to eliminate riparian vegetation, increase flood heights and water velocities, and reduce sinuosity (Poff et al. 1997). In headwater and midsection stream zones, this leads to increased bank and channel erosion and channel incision. In lower reaches where velocity is slower, sediments drop out of the water, leading to excessive sedimentation.

Thus in addition to onsite soil, vegetation and water loss due to these artificial barriers, fish and wildlife habitat is degraded in the area near the structure and downstream (Riley 1998).

Wetland loss and alteration

Natural wetland functions are adversely impacted by urban development when wetlands are fully or partially filled, drained, relocated, or otherwise substantially altered. Altered hydrology modifies wetlands in fundamental ways, including a shift toward upland plants and wildlife (Ehrenfeld and Schneider 1993; Ehrenfeld 2000). Urbanization is implicated in wetland loss in most U.S. watersheds and may account for as much as 58 percent of total wetland loss nationwide (Opheim 1997). Over half of the wetlands in the contiguous U.S. have been lost since the 1780's, and recent research indicates that wetland mitigation programs designed to result in "no net loss" are not working (Whigham 1999; National Academy of Sciences 2001).

In the Willamette Valley, various sources document wetland losses between 40-57 percent of original (Philip Williams and Associates 1996; Morlan 2000). Between 1982 and 1994 alone, 6,549 acres (9.9 square miles) of wetlands were lost in the Willamette Valley, with 28 percent of the total loss due directly to urbanization (Daggett et al. 1998). This excludes small wetlands <0.25 acres, which could not be assessed but may be critical to large-scale amphibian population dynamics (see Gibbs 1993) and surely experienced losses. The Willamette Valley continues to lose more than 500 wetland acres per year (Morlan 2000). For salmon, this translates to loss of off-channel winter salmonid habitat, summer rearing diversity, cool water sources for summer rearing, and flow buffering (Martin 1998). For wetland-dependent species such as amphibians and some bird species, loss of half of the total habitat over time is a severe consequence.

It is important to recognize that not all wetlands are created equal. Whigham (1999) notes, "From an ecological perspective, dry-end wetlands such as isolated seasonal wetlands and riparian wetlands associated with first order streams may be the most important landscape elements. They often support a high biodiversity and they are impacted by human activities more than other types of wetlands." Further, created wetlands may differ quite markedly from natural wetlands, thus achievement of "no net loss" may nonetheless result in substantially reduced wetland ecological functions (Brown and Lant 1999; Whigham 1999).

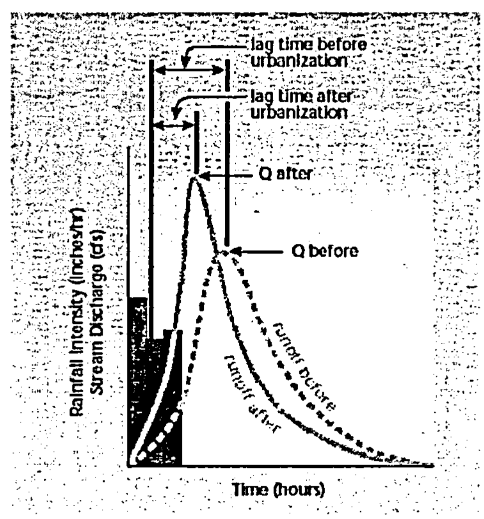


Figure 7. A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams. (Source: FIRSWG 1988)

The vegetation unique to wetland areas is frequently removed as a result of urbanization, and altered stream channels (discussed next) effectively disconnect the stream from the wetlands and natural floodplain. Impervious surfaces such as buildings and parking lots aggravate the problem by causing rapid water runoff, altering the **hydrograph** by affecting the frequency, duration and magnitude of flood events, and reducing wetland infiltration and water storage (Figure 7) (Booth and Jackson 1997). As Figure 7 illustrates, the hydrograph's peak is taller and occurs sooner (a bigger flood that quickly overwhelms water storage) and the shape of the peak is narrower (shorter lag time, e.g., the water is not retained on the land). Many other adverse effects are documented, and some of these are listed in Table 3.

Table 3. Some effects of urbanization on wetland hydrology, geomorphology, plants and animals. Most of these effects also occur in or influence streams and riparian areas.

Hydrology:
Decreased stormwater storage results in increased surface runoff (= increased surface water input to wetland)
Increased stormwater discharge relative to baseflow discharge results in increased erosive force within stream channels
Changes in water quality (increased turbidity, increased nutrients, metals, organic pollutants, decreased O_2, etc.)
Culverts, outfalls, etc. result in more variable baseflow and low-flow conditions
Decreased groundwater recharge results in decreased groundwater flow, which reduced baseflow and may eliminate dry-season streamflow
Increased flood frequency and magnitude result in more scour of wetland surface, physical disturbance of vegetation
Increase in range of flow rates (low flows are diminished; high flows are augmented) may deprive wetlands of water during dry weather
Greater regulation of flows decreases magnitude of spring flush
Geomorphology:
Decreased sinuosity of wetland/upland edge reduces amount of ecotone habitat
Decreased channel sinuosity results in increased stream water discharge velocity to receiving wetlands
Alterations in shape of slopes (e.g., convexity) affects water gathering or water-disseminating properties
Erosion along banks from increased flood peak flow increases cross-sectional area of stream channels
Vegetation:
Large numbers of exotic species present; large and numerous sources for continuous re-invasion of exotics
Large amounts of land with recently disturbed soils suitable for weedy, invasive species
Depauparate species pool
Restricted pool of pollinators and seed dispersers
Chemical changes and physical impediments to growth associated with the presence of trash and pollutants
Small remnant patches of habitat not connected to other natural vegetation
Human-enhanced dispersal of some species
Trampling along wetland edges and periodically unflooded areas
Fauna:
Loss of critical habitat
Benefits species with small home ranges, high reproductive rates
Large predators virtually non-existent; increased small mammal abundance for some species, while others are susceptible to extirpation due to fragmentation and isolation
"Edge" species benefit, to the detriment of forest-interior species
Absence of wetland/upland zones of transition
Human presence and noise disrupt normal behaviors

Source: Modified from Ehrenfeld, 2000.

Stream channel modification

The hydrologic changes discussed above modify the stream channel. Rapid runoff associated with increased stormwater velocity and volume quickly erode and incise **(entrench)** the stream channel and banks. Channels widen and straighten (or are intentionally modified in these ways) to accommodate higher flows. This circumvents the natural evolution process of the channel; LWD, ponds, pools, riffles, streambanks and sandbars are simplified or washed away, eliminating critical habitat for fish, waterfowl, and other species (Arnold and Gibbons 1996; Spence et al. 1996; Prichard 1998). For example, Coho salmon are extremely sensitive to alterations in channel characteristics because of their need for smaller streams, relatively low velocity niches, and large pools typical of undisturbed conditions in the Pacific Northwest. As impervious surfaces increase, fish species diversity and Coho abundance in the Pacific Northwest tend to decline (Lucchetti and Fuerstenberg 1993b).

Piping and culverting

Development practices such as piping and culverting caused the loss of about 400 miles of streams in the Metro Region (Metro 1999). For example, in the City of Portland, the majority of streams that once existed on the inner east side of the Willamette River, as well as significant westside streams, were piped underground, resulting in a loss of the majority of the stream's ecological functions. Water is also frequently piped from rooftops, storm drains, and impervious surfaces. Piping water directly to the stream bypasses natural stream/vegetation interactions such as transport of organic material and sediments, erosion control, and filtration of toxins and excess nutrients; in addition, piping causes high volume, high velocity flows that directly enter the stream channel, altering channel form and functions (Booth 1991; R2 Resource Consultants 2000).

Piped streams and culverts also create impassable fish barriers that block entire stream reaches to migratory fish species and isolate remaining species, putting these populations at risk of reduced genetic diversity and/or extinction (Warren and Pardew 1998; May et. al 1997a; Schueler 1995; R2 Resource Consultants 2000). Fish barriers are addressed further in the ***Restoration*** section.

Channel straightening and armoring

Streams in urban settings are often intentionally widened, deepened, straightened, and sometimes armored with hard materials in order to confine flows, stabilize streambanks and increase a stream's capacity for localized flood control (R2 Resource Consultants 2000). In truth, such activities simply result in moving water more quickly downstream, disconnecting the stream from its floodplain, degrading riparian habitat and creating more problems elsewhere (e.g., Griggs 1981). These changes, accompanied by increased flood frequency and magnitude, result in a loss of stream complexity and off-channel fish and wildlife habitat (Booth 1991; Beechie and Sibley 1997).

Local examples

Johnson Creek watershed

The Johnson Creek watershed, a 135-km (52-square mile) area draining urbanized portions of Clackamas and Multnomah Counties, provides a local example of a watershed profoundly influenced by urbanization, but where important positive changes are taking place. This stream has been altered through clearing of riparian vegetation, damming, widening, deepening and armoring of the channel, and floodplain and upland development. Salmonids were once sufficiently abundant to support a small commercial fishery near SE 45th Avenue and Johnson Creek Boulevard (City of Portland 2000). However, steelhead were ESA-listed in 1998 and a coastal cutthroat trout listing is pending. In most reaches within the Johnson Creek watershed, physical habitat complexity normally associated with salmonid streams has been simplified, modified or eliminated. Water temperatures and fecal coliform levels make this stream among the most polluted in the Metro region (Oregon Department of Environmental Quality 1998; Cude 2001). Flood frequency and severity have increased substantially over the past century.

The City of Portland's Bureau of Environmental Services has mapped the impervious surfaces for sub-units within the watershed using three classes: "sensitive" (0 to 10 percent impervious), "impacted" (11-25 percent), and "non-supporting" (26-100 percent impervious) (Meross 2000). A fourth classification delineates areas where no overland or piped water flows into the stream or its tributaries because water drains to sumps or a combined sewer system. Although the watershed's overall TIA is not provided, road densities suggest a TIA of approximately 35 percent (see Figure 6). However, 35 percent of the watershed is not piped directly to the stream but instead infiltrates groundwater through sump pumps, is directed to Portland's Combined Sewer System, or is hydrologically disconnected (see Map 6 in Meross 2000). Thus, EIA is probably substantially lower than TIA, but the disconnection of a third of the watershed's surfaces from the stream surely alters hydrologic patterns. Development near and within Johnson Creek's floodplains, combined with cumulative effects throughout the watershed, influence the stream system's water quality and hydrologic patterns. These issues illustrate the complex nature of urban effects on natural systems.

Multi-jurisdictional efforts to restore function to the Johnson Creek watershed are currently underway, including small dam removal, reconnecting floodplains and backwater channels to the stream, increasing sinuosity, and adding wetlands, vegetation and LWD. Houses within the floodplain are being purchased and removed from the floodplain in a "willing seller" program. Watershed-scale restoration efforts such as this have a better chance of success than site-specific restoration because they address the cumulative impacts of adjacent land use.

Pleasant Valley area

The Pleasant Valley area is a relatively rural watershed currently under study by the City of Portland and others (Sugnet pers. comm. 2001). The watershed contains seven subwatersheds, including three below 10 percent TIA and four in the 11-25 percent range. All but one of these subwatersheds have been assessed (through GIS modeling and field data) as ecologically impaired, primarily due to past and current agricultural activities. Planners for this developing watershed are exploring whether sufficiently aggressive design standards for reducing EIA may make it possible to approach relatively high levels of TIA (e.g., up to 40 percent) in a subwatershed, yet still maintain properly functioning conditions similar to those typical at much lower TIA levels.

Some uncertainties arise when planning developments to reduce impervious surface impacts. For example, what will the TIA and EIA be at full build-out? How do we urbanize in the most ecologically sound way, and what is the EIA threshold below which it is possible to sustain ecological functions? The precise amount of impact reduction (mitigation) that reducing EIA might have is unknown and probably depends on the particular mitigation activity. Research into this question would benefit land use planning.

Impact of other land uses on stormwater runoff

Urbanization is not the only land use influencing watersheds in the Metro region. Other human activities, such as rural development and agriculture, road and dam building, and forestry, also routinely occur near and upstream of urban areas. Table 4 lists some of the typical negative effects on waterways caused by urbanization and other human-associated activities.

Table 4. Summary of potential effects of various land uses on riparian habitat elements needed by fish and wildlife.

Potential changes in riparian elements needed by fish and wildlife	Land Use					
	Urbanization	Agriculture	Recreation	Roads	Dams	Forestry
Riparian Habitat:						
Altered microclimate	X	X	X	X	X	X
Reduction of large woody debris	X	X	X	X	X	X
Habitat loss/fragmentation	X	X	X	X	X	X
Removal of riparian vegetation	X	X	X	X	X	X
Soil compaction/deformation	X	X	X	X		X
Loss of habitat connectivity	X	X	X	X		X
Reduction of structural and functional diversity	X	X	X	X		X
Stream Banks and Channel:						
Stream channel scouring	X	X	X	X		X
Increased stream bank erosion	X	X	X	X	X	X
Stream channel changes (width, depth)	X	X	X	X	X	X
Stream channelization (straightening)	X	X		X		X
Loss of fish passage	X	X		X	X	X
Loss of large woody debris	X	X	X	X	X	X
Reduction of structural and functional diversity	X	X		X	X	X
Hydrology and Water Quality:						
Changes in basin hydrology	X	X		X	X	X
Reduced water velocity	X	X			X	X
Increased surface water flows	X	X	X	X		X
Reduction of water storage capacity	X	X		X		X
Water withdrawal	X	X	X		X	
Increased sedimentation	X	X	X	X	X	X
Increased stream temperatures	X	X	X	X	X	X
Water contamination	X	X	X	X		X

Source: Knutson and Naef 1997.

Riparian vegetation loss and alteration

Habitat loss

Streams form the backbone for some of the most lush and diverse habitats available in the Metro region because they are highly productive and naturally collect nutrients, seeds, soil, and high quality food resources such as insects. In addition, all animals require water to live. As such, riparian areas are fundamentally important to wildlife (as Metro's Species List demonstrates). Loss of access to these habitats through removal, fragmentation or degradation harms wildlife. Habitat fragmentation is described in the ***Upland Habitat*** section, but also applies to riparian habitats. We described the functions of riparian vegetation above; here we focus primarily on the impacts of riparian habitat loss and hydrologic changes in a watershed.

Severely altered and unpredictable hydrologic regimes may strip riparian vegetation and prevent naturally adapted floodplain plants from colonizing sandbars and streambanks (Booth 1991; Schueler 1995). Groundwater levels may also become less predictable in urbanized watersheds, and riparian-specialist plants such as black cottonwood depend on relatively predictable groundwater levels to become established (Scott et al. 1999; Law et al. 2000). Riparian vegetation filters sediments and soil, slows runoff and stabilizes streambanks; without vegetation, stream banks and channels become damaged. Hydrology and riparian vegetation are linked, and changes in one create changes in the other. Ideally, native riparian vegetation should be present in some amount along every stream in the region.

Altered microclimate

Riparian vegetation creates an instream microclimate that maintains relatively constant water temperatures; when a riparian forest is removed, the monthly mean maximum temperature along smaller streams may increase 7-8° C (Budd et al. 1987). Vegetation also influences microclimates on the land by blocking wind, moderating temperatures, and increasing humidity. Widespread microclimate alterations change plant and animal communities (Saunders et al. 1999; Gehlhausen et al. 2000; Laurance et al. 2000). In terrestrial habitats, microclimate is influenced by edge effects (see also ***Riparian area width***), thus habitat fragmentation, including patch size and shape, influences local riparian microclimates.

Altered forest structure and composition

Forests in an urban setting are prone to structural simplification and invasion by nonnative species, and these effects are exacerbated in narrow forests (Marzluff et al. 1998; Pimental 2000). Local research provides some guidance on riparian corridor widths needed to control these influences (Hennings 2001; see also ***Riparian area width.***)

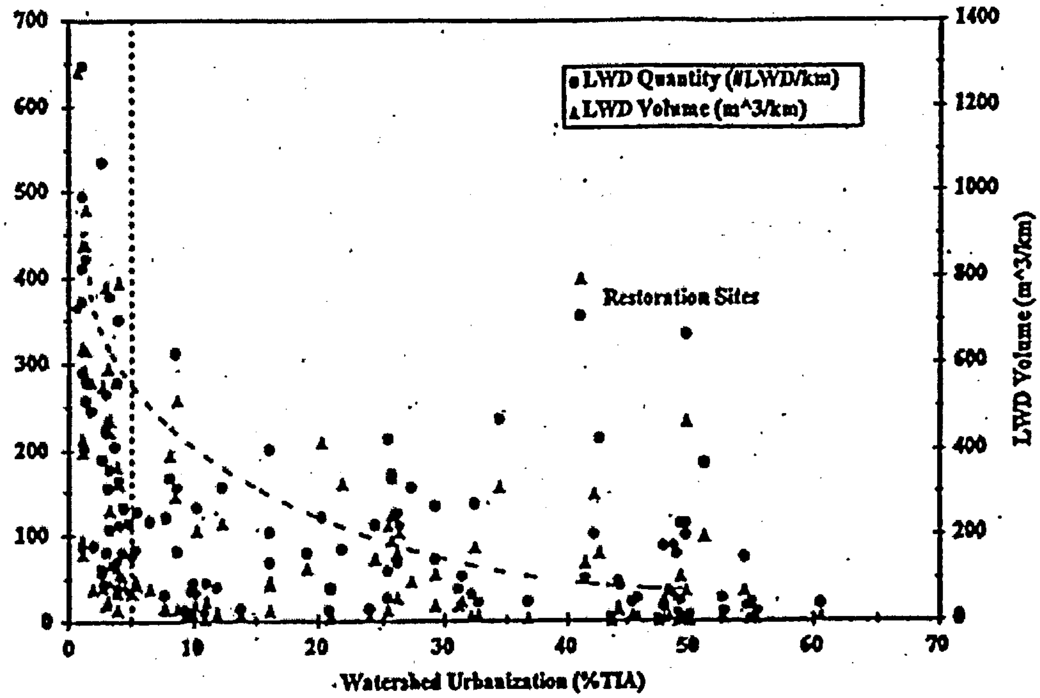
Loss of large woody debris and organic matter

Woody debris and vegetation both in the stream channel and in the floodplain add structural complexity and provide organic matter that becomes part of the food chain (Adams 1994; Prichard et al. 1998). These structures are often intentionally removed; for example, between 1867 and 1912, 88 km (55 miles) of the Willamette River above Albany, Oregon were improved for navigation by removing an average 61 snags per kilometer (Sedell et al. 1990). Large wood may also be removed from streams in an attempt to reduce flooding. In urban streams of the Pacific Northwest, large wood is significantly depleted through washout, downcutting, and direct removal (Booth et al. 1997). In the Puget Sound region, the amount of large woody debris in the channel is related to TIA (Figure 8), and drops off significantly after approximately five percent TIA (May et al. 1997a). The removal of riparian vegetation also results in loss of terrestrial LWD critical to soil health and wildlife habitat (Maser and Trappe 1984; FEMAT 1993). Retention of these materials is vital to a watershed's capacity to support fish and wildlife.

Beyond the structural importance of LWD, other, smaller organic debris provides carbon, the basic fuel for aquatic and terrestrial food webs (Allan 1995). Removing riparian vegetation also removes the primary source of these materials, reducing the stream's **carrying capacity** for organisms (Brown and Krygier 1970). In addition, when flow rates increase and channels are simplified, the retention time of organic debris is decreased because it quickly washes downstream (Webster and Meyer 1997). Thus urbanized streams tend to contain less food than undisturbed watersheds.

Spawning salmon and salmon carcasses provide marine-derived nutrients to many aquatic and terrestrial wildlife species. According to Cederholm et al. (2000): "The loss or severe depletion of **anadromous fish** stocks could have major effects on the population biology (i.e., age-class, longevity, dispersal ability) of many species of wildlife and thus on the overall health and functioning of natural communities…"

Figure 8. LWD quantity and watershed urbanization (percent TIA) in Puget Sound Lowlands streams.



Source: Horner and May 1998.

Pollution – thermal, physical and chemical

Thermal pollution: water temperature and dissolved oxygen

Water temperature is influenced by a variety of factors including streamflow, elevation, amount of shade, surface/groundwater interactions, undercut embankments, surface area, depth, and stream velocity (Budd et al. 1987). Urban streams tend to be warmer than non-urban streams; during warmer months, water flowing over impervious surfaces is often heated to 10 or 12 degrees above the temperature of water that passes through fields and forests (Budd et al. 1987; Schueler 1994). Warmer water cannot hold as much oxygen as cold water. Higher stream temperatures also increase metabolic rates, thus an organism living in warmer water needs more oxygen than the same species in cold water, yet less oxygen is available in warmer water (Spence et al. 1996).

Reduced dissolved oxygen levels can adversely affect salmon egg incubation, growth and development of juveniles, and behavior and physiology of adult fish (Pauley et al. 1986; Spence et al. 1996). For example, a slight increase in temperature at the low end of the optimal temperature range for incubation can cause early emergence of fry from the gravel, increasing exposure to high-flow events and flushing them downstream, in addition to other problems discussed earlier. Most salmon cannot tolerate temperatures above 23-26° C (73-79°F) for an extended period of time (Beauchamp et al. 1983; Pauley et al. 1989).

Physical pollution: sediments and sedimentation

Hydrology, geomorphology and vegetation influence the size and amounts of sediments (including gravel) delivered to the stream system. In urbanized watersheds, fine sediments are increased and approximately two-thirds of all sediments delivered into the stream originates from channel erosion, with the remainder arriving from upland (see Pollution discussion below) and upstream (Trimble 1997; Wood and Armitage 1997). Bank erosion is 30 times more common on non-vegetated streambanks exposed to currents than on vegetated banks (Beeson and Doyle 1995). Construction sites, although somewhat temporary in nature, cause significant erosion and transport of fine sediments to the stream (Spence et al. 1996), and each year in the U.S. an estimated 80 million tons of sediment are washed from construction sites into water bodies (Goldman et al. 1986).

Upon delivery to streams, these sediments are either suspended in the streamwater (creating increased turbidity) or deposited on the streambed (creating sediment build-up and embeddedness). High turbidity clogs fish gills and makes it hard to breath, and adult migrating salmon have been known to stop movement when encountering excessive turbidity (Pauley et al. 1986; Pauley et al. 1989). However, deposited sediments generally have a greater impact on fish than suspended sediments. Salmon, salamanders and many aquatic insects need relatively sediment-free gravel beds with suitable gravel in which to reproduce (Hawkins et al. 1983; May et al. 1997a). Fine sediment deposited on gravel can smother developing salmon eggs, inhibit fry emergence from spawning gravel and limit the production of benthic invertebrates, an important food source for fish and other aquatic species (Beauchamp et al. 1983).

At the same time, storage of sediments in the streambed is an important part of healthy stream function. For example, instream LWD plays an important role in sediment storage; the removal of large organic debris obstructing anadromous fish passage in an Oregon Coast Range stream accelerated downcutting of previously stored sediments, resulting in erosion of more than 5,000 cubic meters of sediment along a 250 m reach the first winter after debris removal (Beschta 1979). Problems occur when the volume of sediments entering waterways overload the stream system's natural capacity to store and transport the sediments.

Chemical pollution

Urban areas are where human population densities are highest. Humans are the primary source of pollutants, thus urbanized watersheds virtually always have pollution and water quality issues. Pollution can destroy food webs within stream systems. Impervious surfaces collect and concentrate pollutants from different sources and deliver these materials to streams during storms, and prevent percolation and natural filtering by soil and vegetation (Booth 1991; Arnold and Gibbons 1996; May et al 1997a). Concentrations of pollutants in streams increase with TIA

(Schueler 1994; May et al. 1997a), and data collected in the Pacific Northwest suggest that pollution from urban areas is harming anadromous salmonids (Spence et al. 1996). Common urban pollutants include nutrients such as phosphorus and nitrogen, pesticides, bacteria, and miscellaneous contaminants such as PCBs and heavy metals. Development type influences the pollutants imposed on the stream system; for example, E. coli and phosphorus tends to be contributed from residential developments, whereas industrial areas tend to contribute high quantities of heavy metals (Table 5) (Giusquiana et al. 1995; Arnold and Gibbons 1996; Morrisey et al. 2000).

Table 5. Typical urban pollutants. Surfaces exhibiting highest levels of runoff-borne pollutants, out of twelve surface types sampled in selected urban areas in Wisconsin.

	SURFACE		
POLLUTANT	**Highest levels**	**Second highest levels**	**Third highest levels**
E. coli (bacteria)	Residential feeder streets	Residential collector streets	Residential lawns
Solids (sediment)	Industrial collector streets	Industrial arterial streets	Residential feeder streets
Total phosphorus	Residential lawns	Industrial collector streets	Residential feeder streets
Zinc	Industrial roofs	Industrial arterial streets	Commercial arterial streets
Cadmium	Industrial collector streets	Industrial arterial streets	Commercial arterial streets
Copper	Industrial collector streets	Industrial arterial streets	Residential collector streets

Source: Arnold and Gibbons 1996

Pesticides

Farming and urban landscaping practices over the last half-century have resulted in an extraordinary increase in pesticide use, but effects on wildlife are not well known. Pesticides in urban areas originate primarily from lawn and garden care (Stinson and Bromley 1991). On a per-acre basis, urban land use contributes more pesticides than agriculture.

Aquatic organisms are particularly susceptible to water-borne toxins and typically have low tolerance levels; for example, low levels of **neurotoxic** pesticides such as Diazanon impair Chinook salmon's defensive olfactory responses and homing behaviors (Scholz et al. 2000). On land, the effects of pesticides have been studied most extensively for birds. Various pesticides have been responsible for numerous bird kills, and non-lethal and indirect exposure of terrestrial species to pesticides can lead to increased susceptibility to predation as well as changes in avian egg incubation behavior. Repeated pesticide exposure also adversely affects nutrition, reproduction and growth of animals such as gamebirds and waterfowl (Bennett 1992).

Some pesticides **bioaccumulate** in the organism and may remain in the environment for many decades. For example, DDT, a highly toxic form of **organochlorine pesticide** that was banned in the 1970's, is still routinely detected in Willamette Valley farm fields and organisms. For example, in the Tualatin Basin concentrations of organochlorine compounds in fish tissue usually exceeded those in streambed sediment concentrations by at least 10-fold (Bonn 1999). In the Portland/Vancouver area of the Columbia River, River otters have abnormally high concentrations of organochlorine and dioxin compounds (McCarthy and Gale 1999). Bald eagle eggs in the Columbia Slough area have been found to contain unsafe levels of DDE (a metabolite of DDT), PCBs, and dioxins and other toxins; the productivity of lower Columbia River eagles is well below levels of other eagle populations in the area (Lower Columbia River Estuary Program [LCREP] 1999).

Fecal coliform

Fecal coliform refers to the group of harmful bacteria present in animal (including human) feces (Pandey and Musarrat 1993). Escherichia coli (E. coli), a common type of fecal bacteria, may be fatal if left untreated (Ries et al. 1992; Carrasco et al. 1997; Oberhelman et al. 1998). In Washington State Taylor et al. (1995) found significant fecal coliform increases in urban wetlands as TIA exceeded 3.5 percent. Urban stormwater discharge, sewer overflows, and sewer pipe and septic system leakage are a primary means of these bacteria reaching urban waterways (Gibson et al. 1998). Fecal coliform may also enter waterways through overland flow, particularly runoff from residential streets, often in the form of pet feces.

The best way to prevent excessive fecal coliform from reaching streams is to remove the source (e.g., direct sewer overflow). Although that fails to prevent contamination from overland flow, appropriate forest buffers may effectively trap fecal coliform arriving through this route. Pennsylvania researchers found greatly reduced fecal coliform levels in areas where at least 50 percent of the riparian vegetation was intact within 100m (328 ft) of the stream (Brenner et al. 1991).

PCBs, heavy metals and other contaminants

Organochlorine compounds such as polychlorinated biphenyls (PCBs), heavy metals, and an assortment of other contaminants harm fish and wildlife (Rutherford and Mellow 1994). Although trace levels of heavy metals occur naturally, higher levels are toxic to fish and wildlife (May et al. 1997a). Metal contaminants increase in proportion with urbanization (Pouyat et al. 1995; Morrisey et al. 2000; Yuan et al. 2001). Industry and automobiles appear to be the primary sources in urban areas. In addition to heavy metals, hydrocarbons (gas and oil), toxins from rooftops, and industrial and household chemicals (e.g., paint, cleaning products) pollute urban streams (Gavens et al. 1982; Ely 1995). In London, Gavens et al. (1982) found a 3- to 10-fold increase in hydrocarbons in river sediments over a 120 year period. Arkoosh et al. (1991) found that juvenile Chinook salmon migrating through an urban estuary contaminated with PCBs bioaccumulated these pollutants and exhibited a suppressed immune response, whereas immune systems of uncontaminated fish in a nearby rural estuary were unaffected.

Nitrogen and phosphorus

Nitrogen and phosphorus exist naturally and provide nourishment to plants and animals. These are also common fertilizer components, and increase with urbanization (Arnold and Gibbons 1996; Giusquiana et al. 1995; Corbett et al. 1997). Phosphorus is typically the biggest problem in urban watersheds, whereas nitrogen is the issue in agricultural watersheds. In Portland, groundwater test wells above and below residential developments showed significantly elevated phosphorus levels downslope of the developments (Sonoda et al. 2001). In Washington, total phosphorus levels in wetlands rose significantly when TIA exceeded just 3.5 percent (Arnold and Gibbons 1996). Increased quantities of nutrients delivered to the stream in the form of **wastewater** effluent, landscaping runoff, and agricultural runoff can lead to unrestricted

Wildlife use of urban riparian corridors

The previous discussion outlined some of the major effects of urbanization on natural ecosystems. This section addresses the general life history requirements and impacts of urbanization specific to each wildlife group (e.g., birds, mammals, etc.). When major changes occur within an ecosystem, the plants and animals depending on that system are altered, either directly or indirectly. Direct effects include altered ecosystem processes, habitat and food supply (Spence et al. 1996; Knutson and Naef 1997; Marzluff et al. 1998). Indirect effects include altered competition and predation patterns, which influence wildlife communities in fundamental ways, and indirect effects caused by urbanization such as disturbance. Thus urbanization causes changes in habitat quality and availability, with ensuing changes in food webs and predator and prey associations, simplification of habitat and wildlife communities, and loss of native biodiversity (May et al. 1997a; Marzluff et al. 1998; May and Horner 2000).

Urbanization affects some species positively, and some negatively. Species that thrive in urban habitats take advantage of abundant food and water, moderated temperatures (cities absorb heat during the day and release it at night), and abundant nesting sites that allow for prolonged breeding seasons, increased survival, and improved reproductive success (Knutson and Naef 1997; Marzluff et al. 1998; May and Horner 2000). However, other species are unable to thrive in areas with scarce natural habitat, reduced habitat quality and intense human activities. These species are out-competed by generalist and/or invasive species that dominate the urban landscape.

Invertebrates

General requirements

Invertebrates are one of the most diverse groups of life on the planet, and although influenced by human activities, can be surprisingly abundant in urban areas (Frankie and Ehler 1978; Dreistadt et al. 1990). This is reflected in Metro's invertebrate species list, which includes more than 425 species and is admittedly incomplete. Examples of this diversity include 119 butterfly species, 40 dragonfly species, and 56 kinds of bees. At least 84 are important prey species for salmonids and other fish (Xerces Society 2001). Nearly 100 are important predators on other species. Forty-nine are known to be important pollinator species, and these insects help form and maintain healthy riparian and upland plant communities. In addition, many aquatic invertebrates eventually emerge as flying terrestrial insects, thus they form a direct link between aquatic and terrestrial ecosystems. Over 150 species of terrestrial snails and slugs have been identified in moist forests of the Pacific Northwest; most have limited geographic ranges because they are poor dispersers (LaRoe et al. 1995). The number of non-native species living in the Metro region is unknown, nor is their potential influence on native species and habitats.

Invertebrates have a spectacular array of life history characteristics, and this adds to their diversity. For example, a given species of dragonfly may hatch in a headwater stream and feed on woody and organic debris. Moving downstream and undergoing several metamorphoses, its feeding strategy may change depending on the predominant food resources available in that stream reach. Finally, near the mouth of the river, the insect emerges from the stream, flies back to the headwaters, and breeds again to begin the cycle anew; this process may take seven years. That is, of course, if it is not eaten by a fish or bird on its way down- or upstream. Thus this instream plant growth (algae blooms); the process of plant decay consumes most of the oxygen in the stream, greatly reducing the quality of aquatic habitat (Arnold and Gibbons 1996; R2 Resource Consultants 2000). Riparian forests act as short- and long-term nutrient filters and sinks (Lowrance et al. 1984; Peterjohn and Correll 1984; Lowrance et al. 1997).

Local examples

Streams such as Fanno Creek appear on DEQ's list of 303(d) water quality-limited streams due to low levels of dissolved oxygen and above-normal temperatures and levels of coliform bacteria and chlorophyll. In the Clackamas River, although oxygen levels are high and nitrogen levels are low, temperatures are elevated. In the Columbia Slough, high nitrogen levels are deteriorating water quality. Johnson Creek makes the list due to high summer temperatures and elevated levels of fecal coliform bacteria found throughout the year, among other problems (Oregon Department of Environmental Quality 1998).

Bonn (1999) found elevated levels of lead and other contaminants locally in Ash Creek, Fanno Creek, and McKay Creek. The most urban site (Beaverton Creek at Cedar Hills Boulevard) contained the most contaminated bed sediments, including very high levels of organochlorines, arsenic, cadmium, lead and mercury.

In 1998 the United States Geological Survey completed a 5-year study of the Willamette River basin as part of a larger national study on water quality and stream ecology (USGS 1998). The study showed that fish communities and stream habitat in the Willamette basin were among the most degraded of the 19 basins in which data was collected. Occurrence of parasites and external lesions on fish were five to ten times above normal in the Willamette basin, and pollution-intolerant fish species (e.g., trout and sculpin) were rare or absent. Elevated phosphorus concentrations in streams promoted nuisance plant growth. Concentrations of nearly 50 pesticides or pesticide breakdown products were found, ten of which exceeded federal guidelines for protection of freshwater aquatic life. Groundwater quality in the Willamette basin was better than surface water quality, but pesticides were detected in about one third of wells sampled. Volatile organic compounds such as fuel additives or degreasing solvents were also detected in groundwater below urban areas.

species' life history revolves around the longitudinal and lateral flow of energy and resources in the stream system. This is just one invertebrate species; when one considers spiders, snails, beetles, butterflies, fleas and flies, the possibilities are vast. Variety at the base of the food web provides for biodiversity at higher levels. Also reflecting the variety of invertebrate species, their environmental needs are many, but water quality, vegetation, woody debris, and other organic matter are important (Schueler 1994; Spence et al. 1996).

Impacts of urbanization

Along with plants, insects form the base of aquatic and terrestrial food webs, thus reduced insect populations lower the land's carrying capacity for wildlife species that rely on insects as a major food source (or other species that rely on those species that prey on insects; ripple effect). Insects are also critically important pollinators that help create habitat. In the Pacific Northwest, watershed imperviousness between 5-10 percent causes macroinvertebrate diversity to drop sharply as pollution- and change-intolerant species are replaced by more resilient species (Schueler 1994; Horner et al. 1996; Spence et al. 1996; May et al. 1997a). Similar findings in many other areas document adverse effects of urbanization on aquatic insects (e.g., Klein 1979; Benke et al. 1981; Garie and MacIntosh 1986; Crawford and Lenat 1989; Schueler and Galli 1992; Dauer et al. 2000).

Because some aquatic insects are highly sensitive to water quality and instream habitat conditions, insects may be used as biological indicators in an **Index of Biological Integrity** (IBI) (Karr and Chu 2000). In southwestern Oregon, an aquatic insect IBI provided a better method of distinguishing disturbed from undisturbed watershed than the Rapid Bioassessment Protocol (RBP) III used by Oregon Department of Environmental Quality (Fore et al. 1996). Numerous studies throughout the country document negative relationships between aquatic insect IBI's and increasing urbanization (e.g., Hachmöller et al. 1991; Kerans and Karr 1994; Elliott et al. 1997; Lerberg et al. 2000; Morley and Karr 2002).

Fish

General requirements

The Metro region provides habitat for 26 native fish species, plus at least one extirpated species. Fifteen more species (37 percent) are nonnative. Seven anadromous Pacific salmonid species (all members of the scientific genus *Oncorhynchus*) are native to Oregon. They include chinook, chum, coho, sockeye, steelhead and cutthroat trout (Brownell, 1999; Cederholm et al. 2000). Salmon survival depends on high-quality, stable environments from mountain streams, through major rivers to the ocean. Thus, salmonid habitat requirements serve as an indicator of the conditions needed for other fish species. Thirteen salmonid runs are federally ESA-listed, with two of these also state Threatened or Endangered. Another run is listed as Endangered only at the state level. Out of the entire genus, only resident rainbow trout are not considered to be at risk.

The Independent Scientific Advisory Board (ISAB) for the Northwest Power Planning Council and the National Marine Fisheries Service produced a recent review of agency salmon recovery strategies for the Columbia River Basin (ISAB 2001). Although the review found these documents to be basically scientifically sound, the ISAB concluded that, "...the overall answer to the question of whether the four documents will lead collectively to salmon recovery actions that have a high chance of succeeding is probably no." Their reasons included a lack of important scientific data necessary to resolve critical uncertainties, lack of clear institutional arrangements to carry the program out, and the fact that the status of many native salmonid stocks has become very grave.

Anadromous fish are born in fresh water but spend a large part of their lives in the ocean before returning to the rivers of their birth to reproduce. Their complex life cycles, or distinct stages of growth and development, are highly variable depending on the particular species and the run within the species. A general description of a salmonid's life cycle includes five stages: (1) spawning and incubation, (2) juvenile rearing in freshwater, (3) seaward migration, (4) growth and maturation, and (5) return migration to freshwater to spawn (Steelquist 1992; NRC 1996; Cederholm et al. 2000).

Salmon require cool, clean flowing water with a high level of dissolved oxygen; clean gravel in the streambed for reproduction, a variety of in-stream cover, a sufficient food source, and unimpeded access to and from spawning areas and the ocean. Four important factors influence streams as habitat for salmon: water quality (temperature, dissolved oxygen level, turbidity), streamflow, physical structure of the stream and food supply. For example, in Bellevue, Washington, environmental disturbances, including habitat alteration, increased nutrient loading, and degradation of the intragravel environment had strong, negative effects on coho salmon (Scott et al. 1986).

Water temperature is probably the most crucial environmental factor influencing salmon and other aquatic species. Essentially all biological processes in a salmon's life cycle are affected by water temperature including the timing of spawning, incubation and emergence from gravel, appetite, metabolic rate, development and growth rate, timing of smoltification and ocean migration (Spence et al. 1996). In general, salmon require cold water ranging in temperatures between 4 C and 17 C (39 F and 63 F) for spawning, incubation and rearing (Beauchamp et al. 1983; Pauley et al. 1986; Laufle et al. 1986; Pauley et al. 1988; Pauley et al. 1989).

Salmon prefer clear water with low concentrations of suspended sediments. The level of dissolved oxygen (DO) is also important for survival. Fish have elaborate gill structures to allow the uptake and use of oxygen needed for reproducing, feeding, growing and swimming (Spence et al. 1996). Salmon also need a variety of streamflow conditions that create a mix of habitat types (e.g., deep pools, riffles). According to Spence et al. (1996), optimum streamflow requirements vary by species, life cycle stage, and season.

The physical structure of a river or stream is important in determining the quality of fish habitat. Structural components include macrohabitat such as pools, eddies, riffles, runs, and side channels, and microhabitat such as cover (e.g., overhanging vegetation, undercut banks), boulders, coarse streambed material, and water velocity and depth. Large woody debris provides critical cover for salmonids (Dooley and Paulson 1998; May et al. 1997b). Stream complexity is essential for salmon because at various life cycle stages they require different types of habitat. Adult spawning salmon use pools for resting on their upstream migration. Once at their spawning grounds they require clean gravel of various sizes, depending on the species, with a minimum amount of sediment to build their redds. Juvenile salmon use a mix of habitat types depending on their life stage, the time of year, availability of food and the presence of other salmon. For example, newly hatched fry live in shallow areas until they increase in size and then shift into deeper, faster water. Pool habitats are favorable to many salmonids in the summer whereas side channels or beaver ponds are preferred during the winter (Spence et al. 1996)

Salmon consume a wide variety of organisms during their life stages. Aquatic and terrestrial insects, however, are their primary food source. Fallen insects from riparian vegetation can make up 40 to 50 percent of the diet of trout and juvenile salmon during the summer months (Johnson and Ryba 1992).

Impacts of urbanization

The adverse effects of urbanization on salmonid habitat include increased temperatures, low dissolved oxygen, increased turbidity and sedimentation, changes in streamflow patterns and floodplain **connectivity**, loss of physical habitat (pools, riffles, gravel beds, off-channel habitats, hyporheic flow), and loss of invertebrate prey (see Appendix 1 for some important prey species). Woody debris is the preferred cover for cutthroat trout and other salmonids (May et al. 1997b; Solazzi et al. 1997), and its documented loss in urban streams degrades salmonid habitat quality (Bauer and Ralph 2001). In general, Pacific Northwest salmonid abundance and habitat quality are considerably reduced when TIA reaches 5-15 percent (Booth 1991; Booth et al. 1997; Horner et al. 1996; Booth and Jackson 1997; May et al. 1997a), similar to patterns seen for macroinvertebrates. This results in a reduction in the load of salmon carcasses to nourish organisms in and near the stream (Fuerstenberg 1997). In Seattle, Lucchetti and Fuerstenburg (1993b) documented a marked shift from less tolerant Coho salmon to more tolerant cutthroat trout populations at 10-15 percent TIA. However, cutthroat trout are also susceptible to the impact of land management activities, particularly those that result in changes in pool depth and complexity. This may reduce habitat suitability and, therefore, the stream's carrying capacity for this species; persistence of this and other species may well depend on arresting the decline in quality and quantity of freshwater habitat (Reeves et al. 1997).

At the Salmon in the City conference (American Public Works Association 1998), participants came to several conclusions regarding salmonid issues in urbanized regions of the Pacific Northwest. First, relatively pristine watersheds that currently or potentially support wild salmonids must be protected. This includes maintaining effective impervious surfaces close to zero, retaining 60-70 percent canopy cover, and retaining broad buffers of undisturbed native vegetation along the majority of riparian corridors. In already urbanized watersheds it will be necessary to address the hydrological impacts of development, protect riparian corridors, restore physical habitat, and improve water quality if we are to maintain or improve salmonid populations.

<u>Amphibians</u>

General requirements

Sixteen native amphibian species live in the Metro region, including twelve salamanders and five frogs (plus one extirpated frog species). An additional species, the Bullfrog, is introduced and places considerable pressure on native species. Amphibians and birds are the two groups in our area most dependent on aquatic and riparian habitats. In the Metro region, 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 Metro-region amphibian species are state-listed species at risk; four species are considered at risk at the federal level.

Amphibians require both aquatic and terrestrial habitats to complete their life cycle, thus changes to either ecosystem may interfere with their 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 1992; Metts et al. 2001). As with salmonids, amphibians have specific habitat requirements and are sensitive to environmental change. For example, Tailed Frogs occur only in streams with temperature ranges from 0-16° C, and increase in abundance as temperature declines; tadpoles require smooth, cobble-sized stones to which they attach with sucking mouthparts (Claussen 1973). Clean, relatively sediment-free water, rocky stream beds and woody debris are important to amphibians in western and southern Oregon (Bury et al. 1991; Welsh and Lind 1991; Butts and McComb 2000).

Impacts of urbanization

Amphibians have suffered worldwide declines over the past 20 years, with particularly noteworthy declines in the Pacific Northwest (LaRoe et al. 1995; Richter and Ostergaard 1999; Semlitsch 2000). Thus this may be the group most sensitive to human-induced habitat loss and alteration such as microclimate changes. For example, habitat fragmentation creates edge habitat, and edge habitats tend to have elevated temperatures and reduced humidity (Saunders et al. 1999; Gehlhausen et al. 2000; Laurance et al. 2000). Unlike other species groups, amphibians' skin is not waterproof, nor are their eggs, and such edge-induced changes may be lethal. Fragmentation and wetland isolation is also a problem because amphibians have small home ranges and cannot travel as freely as birds and mammals (Corn and Bury 1989; Richter and Azous 1995).

In the Puget Sound region, Richter and Azous (1995) found that amphibian **species richness** in 19 wetlands declined with increasing water fluctuation and urbanization (the two are linked); the study also found that small wetlands (< 2 hectares) supported surprisingly high species richness, and are often overlooked in conservation planning. This study suggests that stormwater adversely impacts sensitive aquatic-phase amphibians. In Missouri, Ahrens (1997) found a negative relationship between amphibian species richness and development density. Size and spatial isolation from other wetlands were the most important predictors for amphibian species richness in restored Minnesota wetlands; more species were found in larger, less isolated wetlands (Lehtinen and Galatowitsch 2001).

Urbanization, wetland loss and alteration of hydrologic cycles, which can kill larval amphibians through pond drying (altered hydrology and habitat) or increased predation, probably adversely affect amphibians in the Metro region. Removal of riparian forest overstory is known to harm two at-risk species, Tailed frogs and Torrent salamanders, as well as harming other amphibians (Kauffman et al. 2001).

As with salmonids, instream habitat quality and quantity, excessive sedimentation, and reduced woody debris are major issues for amphibians (Hawkins et al. 1983; Corn and Bury 1989; Butts and McComb 2000). In Seattle, Washington, sharp amphibian declines were documented when

TIA exceeded 10 percent (Taylor 1993). Studies in other parts of the country document adverse effects due to wetland isolation, road density and environmental degradation (Delis et al. 1996; Mensing et al. 1998; Lehtinen et al. 1999; Knutsen et al. 2000). Bullfrogs may pose a major threat to native amphibians in the Metro region, where they both out-compete and predate native species (including non-amphibians such as young turtles and waterfowl) (Adams 1999; Adams 2000; Witmer and Lewis 2001). Bullfrogs are relatively insensitive to water quality and habitat fragmentation and can travel long distances overland, unlike most native amphibians.

Reptiles

General requirements

Thirteen native reptile species live in the Metro region, including two turtle, four lizard, and seven snake species. Two more turtle species are non-native. This is the least riparian-associated group; even so, 23 percent of native reptile species depend on water-related habitats and another 46 percent using them during their lives. Although most lizards and snakes are upland-associated, many species use riparian areas extensively for foraging because of the high density of prey species and vegetation. All of the turtle species are riparian/wetland obligates, and rely on large wood in streams and lakes for basking (Kauffman et al. 2001). The two native turtles are state and/or federal species at risk.

Reptiles are cold-blooded animals, and some species have special habitat requirements in order to collect the sun's energy. This translates into surfaces that are efficient heat collectors. For example, most lizard and snake species rely on **talus**, cliffs and rocky outcrops, or other rocky surfaces for gathering heat during cool periods. Crevices within these structures also provide important refuge during hot spells.

The reasons for species' reliance on riparian habitat are varied, and demonstrate the structural and functional diversity provided by riparian forests. For example, Western pond turtles eat a variety of foods such as insects, mollusks, fish, amphibians, and carrion. These animals require about six inches of forest leaf litter in which to overwinter and five or more inches of soil (with high clay content and good sun exposure) and close proximity to water for nesting (Oregon Department of Fish and Wildlife 2000). Riparian forests provide food and generate soil and leaf litter. The common garter snake, another riparian-dependent species, forages for amphibians, small fish, and earthworms and needs riparian denning sites with good cover, such as downed wood and good shrub and understory.

Impacts of urbanization

Little urban-specific information is available for reptiles in the Pacific Northwest, but in Missouri Ahrens (1997) found that reptile species richness was negatively correlated with high density residential and institutional land uses, but not with other land uses such as low density residential, commercial, industrial, recreational and roads. In Oregon, Western pond turtles are in serious jeopardy due to habitat loss and predation on hatchlings, and have dangerously restricted gene pools in the Metro region due to isolation (Gray 1995; Oregon Department of Fish and Wildlife 2000). Habitat connectivity is probably important to lizards and snakes, as well. Losses of LWD and beaver ponds for turtle basking and use by common garter snake are probably detrimental (Metts et al. 2001). The two non-native turtles with established populations (probably from released pets), common snapping turtle and red-eared slider, pose significant threats to native turtles (Gray 1995; Oregon Department of Fish and Wildlife 2000).

Birds

General requirements

Birds often represent a majority of vertebrate diversity in a region, and the 209 native bird species on Metro's Species List represent a full two-thirds (67 percent) of the region's native vertebrate species. An additional four non-native species have established breeding populations in the area. In the Metro region, about half (49 percent) of native bird species depend on riparian habitats for their daily needs, and 94 percent of all native bird species - the same percentage as amphibians - use riparian habitats at various times during their lives. Twenty-two bird species on Metro's list are state or federal species at risk. Nineteen of these are riparian obligates or regularly use water-based habitats. An additional riparian obligate, the Yellow-billed Cuckoo, is extirpated in the Metro region.

Bird abundance, species richness and diversity is typically higher in riparian habitats compared to other habitat types (Tabor 1976; Stauffer and Best 1980; LaRoe et al. 1995; Kauffman et al. 2001). This reflects greater plant volume and structural diversity (birds are highly 3-dimensional in their habitat use), and food, water and habitat resources associated with riparian vegetation (LaRoe et al. 1995). The occasional study seeming to refute these trends (e.g., McGarigal and McComb 1995; Murray and Stauffer 1995) is typically set in areas where there is little contrast between riparian and upland vegetation. The Oregon-Washington chapter of Partners In Flight offers conservation strategies for landbirds in coniferous forests and lowlands and valleys of western Oregon (Altman 1999; Altman 2000).

Impacts of urbanization

Birds are the most well-studied group of terrestrial urban wildlife. Urban bird communities are characterized by reduced diversity and species richness compared to undisturbed habitats, but increased total abundance due to domination by a few nonnative and urban-associated species (Penland 1984; Blair 1996). There tends to be a loss of species, particularly habitat specialists, over time (Aldrich and Coffin 1980; Hennings 2001). European Starlings, an abundant non-native species, are closely associated with riparian habitats and can comprise 50 percent or more of total birds in the region's narrow riparian forests (Hennings 2001). Neotropical migratory birds appear to respond negatively to development and rely heavily on riparian areas for migratory stopover habitat (Moore et al. 1993; Friesen et al. 1995; Nilon et al. 1995; Theobald et al. 1997; Mancke and Gavin 2000; Hennings 2001). Breeding Bird Survey data from the Pacific Northwest indicate long-term Neotropical migratory bird declines, particularly for those species relying on older or riparian forests (Sharp 1995-1996). Some bird species, such as Rufous Hummingbirds, Winter Wrens, Brown Creepers and Pacific-slope Flycatchers, may be particularly sensitive to habitat fragmentation in the metro area and appear to need large habitat patches (McGarigal and McComb 1995; Hennings 2001). In Connecticut, Askins et al. (1987) found that for forest interior-dwelling bird species, both reduced patch size and increased patch isolation were detrimental.

At least 13 riparian-occurring breeding bird species that have declined significantly more rapidly in the Metro region than statewide over the past 32 years (Hennings 2001; Table 6). Along with fragmentation-sensitive species, these birds may be at risk in the Metro region and merit further study.

Table 6: Examples of some bird species whose trends differ substantially between the Metro area and all BBS routes statewide (1966-1998).

Metro region vs. Oregon 32-year Breeding Bird Survey

Species	Trend Difference (% per year)	Riparian or ag loss	Ground/low nester	Open-cup nester	Cavity or bag nest	Neotropical migrant	Insectivore
Yellow Warbler	-11.9	X		X		X	X
California Quail	-10.3	X	X				
Olive-sided Flycatcher	-7.6			X		X	X
Common Yellowthroat	-7.6	X	X	X		X	X
Brown-headed Cowbird	-7.3	X		X		X	
Swainson's Thrush	-6.4	X	X	X		X	X
Black-headed Grosbeak	-6.4	X		X		X	X
Bushtit	+3.1				X		X
Vaux's Swift	+6.2				X	X	X
Bewick's Wren	+6.4				X		X
Chestnut-backed Chickadee	+6.9				X		X

Source: Hennings and Edge 2001.
Note: Habitat loss is implicit for all species listed. Data compiled from 32-year (1966-1998) Breeding Bird Survey data.

Birds, like insects, can be good indicators of habitat conditions. As a group they are easy to observe, sensitive to environmental changes, and responsive to habitat fragmentation (see the ***Upland Habitat*** section). The Bureau of Land Management (no date) compiled a list of bird species as indicators of riparian vegetation condition in the western U.S., based on geographic area and potential vulnerability of the species. In the Metro region, six species are likely to place over 90 percent of their nests in riparian vegetation (or greater than 90 percent of their abundance occurs in riparian vegetation during the breeding season). These species vary in the vegetation layer used. For example, Common Yellowthroats and Song Sparrows most frequently use understory vegetation. Willow Flycatchers and Yellow-breasted Chats use understory and midstory. Yellow Warblers use midstory and canopy, and Wilson's Warblers use all three vegetation layers. Swainson's Thrush, Lazuli Bunting, Black-headed Grosbeak, and Warbling Vireo also make good indicator species. According to Breeding Bird Survey 32-year trends, each of these species have declined in the Metro region compared to statewide (except Wilson's Warbler and Lazuli Bunting, whose abundance was too low in the Metro region for analysis) (Sauer et al. 2000; Hennings 2001). These species may provide valuable monitoring tools to help assess existing and future riparian habitat conditions in the Metro region.

Mammals

General requirements

Mammals are another diverse group of species in the Metro region, with 54 native species. This is the terrestrial group with the highest number of non-native 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 et al. 2001). In Pacific Northwest forests, multispecies canopies, coarse woody debris, and well-developed understories (dominated by herbs, deciduous shrubs and shade-tolerant seedlings) were important to small mammal biodiversity across a broad suite of spatial scales (Carey and Johnson 1995). Other Pacific Northwest studies have shown increased small mammal abundance and/or diversity with increasing coarse woody debris (McComb et al. 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 et al. 1999; Bellows and Mitchell 2000).

Bats in the Pacific Northwest are more abundant and diverse in habitats with increased roost availability and diversity, including a variety of tree, cliff, and cave roosts; canopy cover and structural complexity is very important to this sensitive group (Wunder and Carey 1996). Bats often roost in artificial structures, and bat-friendly habitats can be provided in both new and existing bridges and other structures at little or no extra cost (Tuttle 1997). This may be as simple as specifying appropriate crevice widths of three-fourths to one inch in expansion joints or other crevices. Tuttle (1997) offers designs for retro-fitting bat-friendly habitats into existing structures; one is called the Oregon Bridge Wedge, designed to provide day-roost habitat in bridges and culverts.

Mammals can profoundly influence habitat conditions for other animals. 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). Beaver can also create nuisance problems due to tree removal and unplanned flooding, but property damage can be minimized by activities such as protecting trees with exclosures (Olson and Hubert 1994; Snodgrass 1997; Oregon Department of Fish and Wildlife 2001). Historically, beavers were nearly extirpated from the Willamette Valley due to trapping, but populations have rebounded somewhat (Oregon Department of Fish and Wildlife 2001). Large herbivores such as deer browse on herbs and shrubs, which can promote vigorous growth (Kauffman et al. 2001). Cattle grazing can have severe detrimental consequences on riparian habitats (Knopf et al. 1988; Grant 1994). Medium-sized **carnivores** keep rodent and small predator populations in check while large carnivores control herbivore populations, with important implications for bird nest success (Berger et al. 2001). Rodents eat Spruce budworm, an insect whose outbreaks can cause significant forest loss (Jennings et al. 1991). Bats help regulate insect populations and may contribute to nutrient cycling, particularly in riparian areas (LaRoe et al. 1995).

Impacts of urbanization

Most mammal research has been conducted outside the urban setting, although Marzluff and Donnelly at University of Seattle are currently researching small mammals and birds in that urban area (Donnelly and Marzluff *in review*). However, Bolger et al. (1997) found that small mammal extirpation rates increased with fragmentation in urban habitats. The loss of habitat, connectivity, forest structural diversity, and LWD common in urban areas probably harm many mammals. Bats are generally intolerant of human disturbance and in western Oregon, are more abundant in old-growth than other forest types; Townsend's big-eared bat abundance has declined by 58 percent west of the Cascades since 1985 because of habitat alteration and human disturbance (LaRoe 1995). Nutria are the primary nonnative mammals using streams in the Pacific Northwest. Introduced for fur, nutria have established populations in at least 15 states, where they inflict wetland and agricultural damage and compete with beaver and muskrat for resources (Pedersen 1998; Abrams 2000). Pets, especially cats and dogs, can be disruptive and/or lethal to native birds and small mammals (see also Uplands chapter, Nonnative species section).

Other important habitats

River islands provide important habitat for many wildlife species, including an additional riparian area available to wildlife in the middle of a river (Thorp 1992). Large wood commonly accumulates on upstream ends of islands, where it influences meander cutoffs, provides cover for juvenile salmonids, and serves as habitat for invertebrate production (Naiman et al. 1992). Doppelt et al. (1993) comment that, "Debris and other physical blockages – such as islands – contribute to the physical structure of large river systems by slowing water velocity and deflecting its course. As water is slowed and deflected, it pushes against the banks and into the soils underlying the adjacent floodplain, thereby contributing to the local water table."

Thorp (1992) studied three islands on the Ohio River and found that that these islands had a significant positive effect on invertebrate density and diversity, related to changes in physical habitat structure within the river channel. Thorp commented:

> Anthropogenic reductions in braiding, meandering, and snag abundance have diminished habitat heterogeneity of regulated rivers, factors directly influencing island formation, retentive capacity of the ecosystem, and community diversity. Habitat heterogeneity associated with riverine islands should, therefore, be of paramount importance to the ecosystem and may require special management protection...Islands have significant positive effects on invertebrate density and diversity that appear related to changes in physical habitat characteristics. Current velocity and substrate particle size are diminished in narrow channels between islands and shore, and areal extent of the littoral zone is enhanced within an otherwise deepwater region...Because of a relatively low exploitation by humans, islands probably enhance snag formation and input of organic matter, both factors having positive effects on macrofauna. Creation of selected riverine preserves near islands as a management tactic is recommended.

River deltas and islands create unique bottomland hardwood forest, including important cottonwood/willow communities, tree types that must be in close contact with the water table.

Willow Flycatchers in the southwestern US intensively use river deltas as stopover habitat during migration (Garcia-Hernandez et al. 2001). During migration, the majority of willow flycatchers preferred native broadleaf dominated areas near standing water, such as that found in deltas and many river islands; these areas produce an abundance of flying insects hatched from the enriched aquatic macroinvertebrate community. River deltas are known to provide important winter waterfowl habitat in the west (Fleskes et al. 2002). Bald Eagles commonly use Pacific Northwest river deltas and islands for breeding and foraging (Iverson et al. 1996).

The sand bars and mudflats in river deltas and islands are also vital to certain types of wildlife. Shorebirds rely on the barren and sandy areas in these areas, seeking invertebrates in the mud and silt; other research suggests that shorebirds may be particularly susceptible to human disturbance, thus making islands even more important (Andres 1994).

Riparian area width

The functions and values of riparian corridors with respect to fish and wildlife, as well as the impacts from urbanization, have been explored in the preceding sections. In this section we review the riparian area widths identified in the scientific literature that are necessary to protect habitat for fish and wildlife. Several recent literature reviews have addressed the effectiveness of various riparian area widths for maintaining specific riparian functions for both protecting water quality and preserving the biologic integrity of the riparian corridor (Budd et al. 1987; Johnson and Ryba 1992; FEMAT 1993; Castelle et al. 1994; Spence et al. 1996; Metro 1997; Wenger 1999; May 2000). The biological integrity of the riparian corridor depends, in part, on the width and condition of the riparian area, which dictates stream functions and ultimately the type of species that can live in and around streams.

A riparian buffer is defined as a strip of land established to mitigate the impacts of human activities on the stream ecosystem (Johnson and Ryba 1992; May 2000). Riparian buffers serve to protect natural functions as well as minimizing impacts of stormwater runoff and preventing property loss due to flooding (May 2000). The riparian buffer includes riparian habitat that provides key functions and values for many wildlife species dependent on the unique environment.

The effects of human activities on riparian and aquatic ecosystems are numerous and pervasive in the urban area, as discussed in the previous sections. A riparian buffer alone is not enough to maintain natural aquatic functions; additional efforts in managing stormwater runoff and protection of upland areas are essential in a comprehensive watershed protection plan (Knutson and Naef 1997). The appropriate size of a riparian buffer is likely to vary depending on the position of a stream in the landscape and the intensity of land use nearby (Todd 2000). Wider buffers may be required in urban areas with higher intensity land uses than in a forested or rural landscape (May 2000; Todd 2000). Wider buffers are critical in retaining functions and values for wildlife that utilize riparian areas. When we refer to a riparian buffer width we are referring to the width *on one side* of a stream, river or other water feature. The buffer is then to be applied on *both sides* of the stream or other water feature.

Fixed width vs. variable width buffer

Riparian buffers are commonly implemented to protect a wide range of functions provided by the riparian area, ranging from water quality and flood control to fish and wildlife habitat. The size, or width, of the buffer depends on the function(s) to be protected and the type of land use that occurs outside of the buffer area. Buffers are implemented as either a fixed width or a variable width requirement.

Fixed width buffers are typically based on a single parameter, such as a specific function (Castelle et al. 1994). They are often developed as a political compromise between protecting ecological functions and minimizing the impact on private property rights (May 2000). This type of buffer is relatively easy to enforce, provides for regulatory predictability, and costs less to administer because those applying the regulations do not need specialized skills (Johnson and Ryba 1992). Fixed width buffers, however, do not account for site-specific conditions, thus the riparian corridor may not be adequately protected in some areas, and in others the buffer might unnecessarily restrict development (Fischer and Fischenich 2000; Todd 2000). May and Horner (2000) stated that "...a one-size-fits-all buffer is not likely to work."

Variable width buffer programs account for site-specific conditions, providing a greater level of protection to important resources while reducing the impact on private property in certain instances (Johnson and Ryba 1992; May 2000). However, this type of buffer program is more expensive and difficult to administer and monitor and offers less predictability for land use planning purposes (Johnson and Ryba 1992; Castelle et al. 1994; Todd 2000).

A hybrid of the fixed and variable width buffer could conceivably address several of the problems with both while drawing on each method's strengths. A variable width buffer based on existing conditions and the intensity of the adjacent land use that is generalized to the extent possible might provide the best protection of the riparian corridor while respecting private property rights (Todd 2000).

Management areas vs. setbacks

Just as important as the width are the activities are allowed within the riparian buffer. Some riparian buffers are implemented as setbacks within which no disturbance is allowed, with the exception of restoration activities. Other riparian buffers are considered "management areas" within which a limited amount of activity may occur. This allows for some level of development as long as guidelines are followed so as to retain riparian functions. Human activities within the riparian buffer should be limited to prevent further degradation of riparian and aquatic habitat.

Extent

To the maximum extent possible, all perennial, intermittent and ephemeral streams should be protected from surrounding land use activities by a buffer (Mitchell 1998; May 2000). The effectiveness of a riparian corridor protection program depends on the amount of stream miles that are protected; the more miles protected, the more effective a program will be (Wenger 1999). As stated by Fischer et al. (2000): "Continuous buffers are more effective at moderating stream temperatures, reducing gaps in protection from non-point source pollution, and providing better habitat and movement corridors for wildlife."

Several functions important for fish and wildlife are influenced by the entire system of streams. For instance, nearly half of the large woody debris found in low gradient streams is delivered from upstream sources (Pollock and Kennard 1998). Studies have also found that the temperature of streams is influenced not only by the condition of adjacent forest but also by upland forest conditions and upstream conditions (Pollock and Kennard 1998).

The entire stream network functions as a system, thus removing the connection between intermittent and perennial streams may have detrimental consequences to the physical and biological components of stream ecosystems, particularly in the long term (Mitchell 1998; FEMAT 1993). Naiman et al. (1992) stated that intermittent streams are an important, often overlooked, component of aquatic ecosystems. For example, juvenile Chinook salmon rely on intermittent streams for rearing habitat (Maslin et al. 1999).

Riparian buffers are especially important along the small headwater streams that typically make up the majority of stream miles in any basin (Osborne and Kovacic 1993; Hubbard and

Lowrance 1994; Lowrance et al. 1997; May et al. 1997a; Fischer et al. 2000). These smaller streams have more interaction with the land and riparian vegetation plays an integral role in reducing sediment and other pollutants, maintaining temperature regimes, and providing large woody debris and other organic inputs (FEMAT 1993). Riparian buffers along larger streams have less of an impact on water quality, however they often are longer and wider thus providing better wildlife habitat (Fischer et al. 2000).

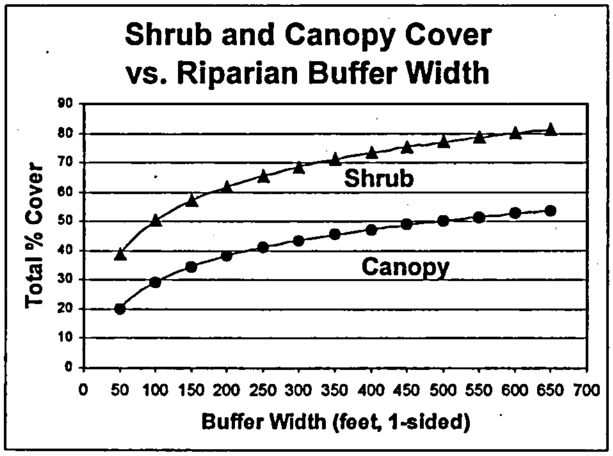
In urban areas the functions of the aquatic ecosystem are altered, as described in the previous section. Increased urbanization causes an increase in negative inputs such as contaminants, stormwater flow, and also reduces the amount of large woody debris and other organic inputs required for the survival of aquatic life (Booth et al. 1997; Todd 2000). Johnson and Ryba (1992) stated that " a large buffer in an area of high-intensity land use...is more essential than in low-intensity land use areas." FEMAT (1993) recommends 91 m (300 ft) on each side of fish bearing streams in a forested landscape, as well as protecting permanently flowing non-fish bearing streams; constructed ponds, reservoirs, and all wetlands greater than one acre; all lakes and natural ponds; and seasonal or intermittent streams, smaller wetlands, and unstable areas to a lesser extent. The protection of all of these areas is crucial to maintaining habitat for aquatic species, with further protection necessary for riparian-associated wildlife. In an urban area, with the greater impacts associated with urbanization, a protection scheme of less than that recommended by FEMAT in the forested landscape may not be sufficient to fully provide fish and wildlife habitat.

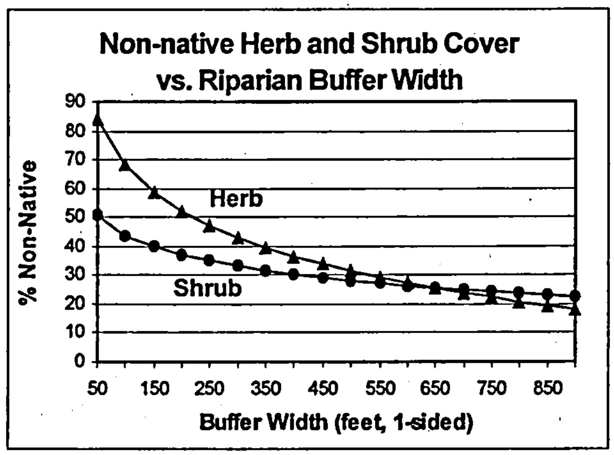
Vegetation

Riparian corridors should consist of native vegetation along the stream where appropriate (May 2000). As described throughout this chapter, native vegetation provides several crucial functions that enable the riparian corridor to provide high value fish and wildlife habitat. The quality of the vegetation in a riparian buffer is crucial to the provision of organic litterfall, large woody debris, shade, and other riparian functions (May 2000).

Forest width plays an important role in urban riparian plant community structure and composition. Watersheds with intact riparian forests are able to retain more riparian functions at higher levels of imperviousness (May et al. 1997b). Within the Metro region, researchers comparing rural versus urban habitats found that riparian forest width was the only significant predictor of native plant species richness (wider forests had more species), while native plant diversity was best explained by perimeter-to-area ratio, a measure of edge (smaller patches had lower diversity) (O'Neill and Yeakley 2000). In another Metro-area study, riparian forest width was the best predictor for nonnative plants along small streams; narrow forests contained higher percentages of nonnative herbaceous, shrub and tree cover than wider sites (Figure 9) (Hennings 2001). In addition, narrow forests were less structurally complex, with reduced shrub and canopy cover.

Figure 9. Relationships between riparian forest width and forest structure and composition measured along 54 small stream sites in the Metro region, surveyed July and August 1999.





Source: Hennings 2001.

Factors that influence buffer width

Several factors should be taken into consideration when determining the size of the riparian buffer. Floodplains, steep slopes, and wetlands are important resources in themselves and strongly influence the ability of the riparian area to provide key functions for fish and wildlife.

Floodplain

One of the important factors determining the width of the riparian area is the presence of floodplains. Unconstrained reaches typically have large floodplains compared to constrained reaches. The linkage between the stream and its floodplain is of critical importance to fish and wildlife (Knutson and Naef 1997; May 2000). The floodplain includes the limits of the stream channel migration zone and also represents the zone of interchange between land and water (Wenger 1999). Stream channels, except for those in steep gullies or canyons, naturally move as the result of seasonal flood events. The floodplain and channel migration zone is the area that could potentially become aquatic habitat, but currently provides riparian habitat (Pollock and Kennard 1998). A buffer zone should be wide enough to permit natural channel migration (Wenger 1999; May 2000).

The entire floodplain plays an important role in contaminant removal. According to the scientific literature, the riparian zone of influence includes the extent of the 100-year floodplain because of the movement of the stream or river across the floodplain through time (Gregory and Ashkenas 1990; Schueler 1995; Spence et al. 1996). It is important to protect the entire width of the floodplain because this area provides essential spawning and rearing habitat for fish and important year round habitat for turtles, beavers, muskrats and other wildlife. Therefore the riparian area width should include the extent of the 100-year floodplain (Wenger 1999; May 2000).

Steep slopes

The slope of the land on either side of a stream is one of the most significant variables in determining the effectiveness of a buffer in trapping sediments, retaining nutrients, preventing contaminants from reaching the stream, and reducing erosion. Steeper slopes have higher velocities of surface water flow, resulting in less time for nutrients and other contaminants to pass through the buffer and reach the stream (Wenger 1999). Mass wasting of unstable slopes contributes to degraded water and riparian habitat quality (Knutson and Naef 1997). Several researchers have observed that very steep slopes are unable to effectively remove contaminants from surface water flow (Wenger 1999). Steep slopes adjacent to all streams should be protected.

Steep slopes often occur on intermittent streams, where it is especially important to protect the slope to prevent increased landslides and erosion and provide habitat for species unique to these areas. FEMAT (1993) recommends buffers ranging from about 12-61m (40-200 ft) on intermittent streams, depending on the stability of the soil.

There is debate as to what constitutes a steep slope. Jurisdictions have defined steep as ranging from 10 to 40 percent slope. Metro defined steep slopes as 25 percent in the Stream and Floodplain Protection Plan (Title 3). May (2000) recommended that for slopes over 25 percent the buffer should be measured from the break in slope to reduce sediment loading from mass wasting events.

Wetlands

Wetland habitats frequently overlap with riparian areas, although some wetlands are isolated from streams or rivers. Isolated wetlands are often small but may have unique characteristics that allow specialized plant species to develop (FEMAT 1993). Wetlands provide many of the same functions as riparian areas, such as maintaining water quality, retaining water and reducing floods. Wetlands comprise a very small proportion of the landscape and yet provide for a significant number of specialized plant and animal species. Thus, riparian wetlands are significant enough to merit automatic inclusion in a protection scheme (FEMAT 1993; Wenger 1999). FEMAT (1993) recommended one site potential tree height or 46 m (150 ft) slope distance for wetlands greater than one acre, and two site potential tree heights or 91 m (300 ft) slope distance for lakes and natural ponds. May (2000) recommended that all riparian wetlands adjacent to the stream channel be protected from disturbance, and that a minimum buffer of 30-50 m (98 – 164 ft) should extend outward from the wetlands.

Site Potential Tree Height

Site potential tree height is often used as a standard of measurement within which several key riparian functions are provided. For example, several studies suggest that in order to supply large woody debris and maintain temperature and streambank stability, the width of the riparian corridor should be at a minimum equal to one site-potential tree height at maturity (FEMAT 1993; Spence et al. 1996; Pollock and Kennard 1998; May 2000). Thus, the term is used to communicate a general riparian standard that allows for the operation of multiple ecological functions; not just the functions directly attributed to trees.

Various definitions for site-potential tree height (SPTH) exist. For example, the Oregon Division of State Lands (DSL) defines the potential tree height as the dominant tree species at maturity. DSL provides a list of common riparian trees in Oregon in their Urban Riparian Inventory & Assessment Guide (Van Staveren et al. 1998) ranging from 15 feet to 120 feet. FEMAT (1993) defines the height of a site-potential tree as the average maximum height of the tallest dominant trees (200 years or more) for a given site class. The NMFS (1998) uses a similar definition but considers the tallest dominant trees within 100 years, given site conditions. According to the NMFS definition, these heights range from about 130 feet to over 200 feet for second-growth conifers in riparian areas; second-growth conifers are commonly found in Portland area forests.

Aquatic Habitat

Most anadromous and resident fish require deep pools for cover and to rest; riffles for foraging; and cold, well-oxygenated, gravel-bottomed streams to spawn and reproduce. The width and composition of the riparian area are factors that assist in maintaining habitat needed to support the various life cycles of fish and other aquatic species.

Temperature regulation and shade

An important factor influencing stream diversity and productivity is shade from riparian vegetation, which keeps stream temperatures cool. Elevated water temperature affects its ability to hold the oxygen required for aquatic life, and is particularly detrimental to cold water fish like salmon and trout. Intact riparian vegetation helps regulate water temperature. Beschta and Taylor (1988) found that many factors influence stream temperature in forested watersheds, one of the most important being intact riparian vegetation. Spence et al. (1996) identified site-specific factors that influence the riparian area's ability to provide shade including vegetation composition, stand height, stand density, latitude (which determines solar angle), topography, and stream orientation. Several studies conducted in the Cascade and Coast Ranges of western Oregon examined the effectiveness of riparian area widths for shade and temperature regulation and concluded that riparian area widths of at least 30 m (98 ft) provide adequate shade to stream systems (Spence et al. 1996). In most instances, riparian area widths maintained for other functions such as LWD are likely to be adequate to protect stream shading (Spence et al. 1996).

The temperature of groundwater entering streams also influences stream temperature (Brosofske et al. 1997). Removal of surrounding riparian and upland forest may increase groundwater temperature. However, on small streams shading is likely to be the most important factor in regulating temperature (Wenger 1999). In a literature review, Osborne and Kovacic (1993) found that buffer widths of 10-30 m (33-98 ft) can effectively maintain stream temperatures. However, newer research has found that buffer widths of 21-24 m (70-80 ft) are not sufficient to maintain stream temperatures that approximate natural conditions (Pollock and Kennard 1998). Brosofske et al. (1997) found that a buffer of 76 m (250 ft) is necessary to maintain natural shade levels and reduce the impact of solar radiation. Factors other than riparian vegetation also impact temperature, such as dams and industrial discharge.

Bank stabilization and sediment removal

Riparian vegetation helps to stabilize streambanks, making them less susceptible to excessive erosion. The Forest Ecosystem Management Assessment Team (FEMAT) (1993) concluded that most of the stabilizing influence of riparian root structure is probably provided by trees within a half of a potential tree height of the stream channel. All streams can be subject to channel erosion if the banks are not properly stabilized, and upstream sediments have a large impact downstream. Ensuring stable banks on the entire stream network, including intermittent and ephemeral streams, is important to maintaining a functioning aquatic system. In their natural state ephemeral streams typically contain dense growth and trap surface water sediment and slow flow, but they can provide a large quantity of in-stream sediment during storm events in disturbed areas. Clinnick et al. (1985) propose a minimum of a 20 m (66 ft) wide buffer on ephemeral streams.

As described in the *Impacts of Urbanization* section, sedimentation can be very detrimental to fish (particularly salmonids) and other aquatic organisms (Hicks et al. 1991). Riparian vegetation helps to control excess sediment from entering streams. In a study on California streams, Erman et al. (1977) found that a 31-meter (100-foot) vegetated buffer was successful in preventing sedimentation and thus maintaining background levels of benthic invertebrates (aquatic insects) in streams adjacent to logging activity. Moring (1982) assessed the effect of sedimentation following logging with and without buffer strips of 30 m (98 ft) and found that increased sedimentation from logged, unbuffered streambanks clogged gravel streambeds and interfered with salmonid egg development.

According to Belt et al. (1992), "Research suggests four things about buffer strip design to trap sediments and nutrients: 1) buffer strips should be wider where slopes are steep, 2) riparian buffers are not effective in controlling channelized flows originating outside the buffer, 2) sediment can move overland as far as 300 feet through a buffer in a worst case scenario, and 4) removal of natural obstructions to flow – vegetation, woody debris, rocks, etc. – within the buffer increases the distance sediment can flow." For a more detailed discussion of buffer widths for sediment see Metro's **Policy Analysis and Scientific Literature Review for Title 3** (1997).

Pollutant removal

In 1998 Metro adopted a plan for protecting water quality and floodplain management, but it did not specifically address wildlife issues. However, excess nutrients, metals, pesticides and other contaminants also impact the quality of habitat for fish and wildlife. Therefore, we revisit these issues briefly here, but for a more detailed discussion see Metro's **Policy Analysis and Scientific Literature Review for Title *3*** (1997).

Excess levels of phosphorous common to urban areas cause eutrophication in the stream system, as described in the *Impacts of Urbanization* section. Most phosphorous is carried to the stream attached to sediment, thus buffer widths that are sufficient to retain sediment should also prevent phosphorous from reaching the stream (Wenger 1999). However, riparian vegetation can only retain phosphorous over a short time period, after which the vegetation becomes oversaturated and actually releases phosphorous into the stream.

Nitrogen also contributes to eutrophication in aquatic ecosystems. A vegetated buffer along a stream is able to remove nitrogen through uptake by vegetation and by denitrification. Several studies have found that total nitrogen removal efficiencies in surface water flow increase with buffer width (Dillaha et. al 1988; Dillaha et. al 1989; Magette et. al 1989). Denitrification occurs under conditions of reduced oxygen availability, which correlates with soil moisture. Wetlands and hyporheic zones play an important role in denitrification. According to Wenger (1999), a minimum width of 15 m (50 ft) is necessary to reduce nitrogen levels, but wider buffers of 30 m (100 ft) or more would be more likely to include areas of denitrification.

Pesticides are meant to be deadly. When pesticides enter the stream they can cause direct mortality to many organisms as well as an array of sublethal effects (Cooper 1993). Pesticides used in landscaping commonly find their way to streams and rivers. Riparian vegetation plays an important role in preventing direct contamination of streams. Buffers can help to remove pesticides from surfacewater flow, but we were unable to locate current research to identify specific widths necessary to prevent them from reaching the stream (Wenger 1999).

Large woody debris and litter inputs

Large woody debris

As discussed previously, large woody debris (LWD) is an important structural component in Pacific Northwest streams west of the Cascade Range. Forested riparian areas are necessary to provide regular inputs of LWD; removal of trees and vegetation can have long-term negative effects (Booth et al. 1997; May et al. 1997b; Wenger 1999). The potential for trees or portions of a tree to enter the stream channel is primarily a function of distance from the stream channel in relationship to tree height and slope angle (FEMAT 1993). A review of the scientific literature shows that the probability that LWD will enter the stream channel is generally low at greater than one site-potential tree height, or the height of the dominant tree species at maturity (McDade et al. 1990; FEMAT 1993; Spence et al. 1996; Wenger 1999).

Sometimes seemingly conflicting science makes management decisions difficult. For example, the literature review for Washington State's Forests and Fish Report (CH2MHILL 2000) stated that, "Of all the inputs from riparian zones to streams, LWD delivery requires the widest riparian management zone (RMZ)." However, the same review showed McDade's (1987) data from small streams of the Cascade and Coast Ranges of Oregon and Washington, in which over 70 percent of the total LWD delivered to the channel originated within 50 feet of the channel, and over 90 percent within 100 feet of the channel. Spence et al. (1996) reviewed the literature and found that most recent studies suggest buffers approaching one site-potential tree height are needed to maintain natural levels of recruitment of LWD. Streams naturally migrate within the valley floor or floodplain, and LWD is also delivered to streams by flooding and landslides. The additional importance of LWD to terrestrial wildlife, as well as the importance of all organic matter to healthy soils (and, therefore, healthy riparian forests), argue for LWD buffers of at least one SPTH.

The Independent Multidisciplinary Science Team's (IMST) 1999 report to the Governor John Kitzhaber stated:

> Sharp demarcations between riparian forest and upslope forest, and between fish-bearing and nonfish bearing streams are not consistent with the historic pattern...Most models of large wood recruitment focus on riparian areas as the source, ignoring the important contributions made by upslope sources, especially from landslides. There is a critical need to restore the ecological processes that produce and deliver large wood to the streams from riparian as well as upslope areas.

In addition to lateral LWD inputs to the stream, studies show that up to half of the large woody debris found in lower gradient streams is transported from upstream sources (Pollock and Kennard 1998). This emphasizes the importance of protecting the entire stream network to allow for a sufficient level of large wood. Management activities such as forest thinning within a buffer also may reduce the amount of large woody debris that is provided to the stream; when possible, removal of large woody debris in riparian areas should be avoided.

Small woody debris and organic litterfall

Branches and other woody material play an important role in providing aquatic habitat. Smaller wood helps to create and maintain pools in smaller streams, often backing up against large wood (Pollock and Kennard 1998). Pollock and Kennard (1998) found that the majority of small woody debris is delivered to small and mid-sized streams from trees further than 31 m (100 ft) from the edge of the stream.

Smaller pieces of organic litter (e.g., leaves, needles and twigs) and terrestrial insects, important food sources for aquatic species, enter the stream primarily by direct leaf or debris fall (Spence et al. 1996). The effectiveness of riparian forests in the delivery of small organic debris decreases at distances further than one-half of a site potential tree height (FEMAT 1993). Benthic invertebrates rely on a supply of organic litter to maintain healthy communities. Erman et al. (1977) found that the composition of benthic communities in streams with buffers of 31 m (100 ft) were basically the same as streams in unlogged watersheds.

Terrestrial Habitat

Riparian areas provide essential life needs – food, water and cover – for many terrestrial species. Each species has unique habitat requirements; therefore, widths to protect wildlife can vary greatly. Riparian buffers established for water quality and to protect aquatic habitat may not meet the habitat requirements of terrestrial wildlife (Gregory and Ashkenas 1990). Narrower buffers may support a limited number of species, but wider buffers – at least in some places – will support a more diverse range of wildlife species. Connections to upland wildlife habitat can be especially important for many species.

Large woody debris and structural complexity

Large woody debris (LWD), both standing and fallen, is an important source of foraging, cover and nest sites for birds, mammals, reptiles, and amphibians. LWD provides nesting habitat for cavity nesting birds such as woodpeckers, chickadees and wrens. Downed logs provide cover for a number of amphibians common to riparian corridors, such as Long-toed salamanders and Torrent salamanders. The greater the width of the riparian area, the more wood that is potentially available for snag and downed wood habitat. The more snags present in the riparian area, the greater the wildlife species diversity tends to be (Cline and Phillips 1983). Just as the ability of forests to contribute LWD to aquatic habitat decreases at distances further than one site potential tree height, the effectiveness of upland forests to contribute snags and downed wood decreases at greater distances (FEMAT 1993).

Edge effect

One of the main reasons interior forest dwelling species do not survive successfully in narrow buffers is because of increased edge habitat (edge habitat is more fully discussed in the ***Upland Habitat*** section). Edge habitat occurs when two different habitat types meet, which provides opportunities for some species but also can lead to an increase in competition and predation, reducing interior habitat specialists. Studies in Virginia showed that interior forest birds only occurred in riparian corridors of at least 50 m (164 ft) wide (Tassone 1981), and another study showed that a minimum buffer of 100 m (328 ft) was recommended to support area-sensitive Neotropical migrants (Keller et al. 1993). In eastern forests the edge effect has been shown to extend up to 600 m (2,000 ft) from the edge (Wilcove et al. 1986).

Noise frequently impacts the ability of wildlife to carry on their natural functions within the urbanized landscape. Harris (1985) found that a mature evergreen buffer of 6.1 meters (20 feet) provides the same level of noise reduction as removing the source of the noise three times farther from the habitat without the vegetation. Groffman et al. (1990) found that a forested buffer of 32 meters (100 feet) would reduce the noise of commercial activity to background levels.

Movement corridors

Riparian buffers often may serve as movement corridors for wildlife and plants. Riparian corridors serve as travel and dispersal habitat even in undisturbed areas, due to the connectivity of streams and the diverse food sources available. Riparian areas and isolated wetlands often provide some of the only habitat available in urban areas, buffers around these features allow wildlife to travel through the urban environment with some level of protection (Castelle et al. 1994). There has been much debate over the functionality of corridors for terrestrial wildlife as a means of conservation, but the general consensus is that corridors are a valuable aspect of any wildlife protection plan (for more details on the pros and cons of corridors, see the ***Upland Habitat*** section).

Riparian corridors provide a logical base for a network of corridors allowing movement between upland habitat patches and riparian habitat. Naiman et al. (1988) found that there are some wetland-dependent birds and animals that require an adjacent upland area to meet their needs. Some amphibians, while they only require riparian habitat for a short time period, are unable to complete their life cycle without it (Castelle et al. 1994). In order to serve the needs of interior habitat specialists, movement corridors should be as wide as possible to provide at least some interior habitat and reduce the edge effect.

Microclimate

Riparian areas have a unique microclimate differentiated from upland habitat by a diversity of vegetation, leading to complex structure in the forest canopy, which impacts the amount of light, heat, and wind that penetrates the area. Moist soils help to keep temperatures lower than in surrounding areas as well. The stream channel width and topography of a riparian area influence the extent of the microclimate (FEMAT 1993). Brosofske et al. (1997) found that a buffer of about 76 m (250 ft) would be needed to approximate natural conditions at the stream. However, as stated in Pollock and Kennard (1998), a 76-m (250-ft) buffer will not maintain the microclimate in the riparian forest itself, which is important for riparian dependent plants and animals. Chen et al. (1995) found that changes in relative humidity could be measured 30-240 m

(98-787 ft) into the forest interior from the edge of a clearcut, while changes in soil temperature extended 60 m (197 ft) into the interior. Based on this information, FEMAT (1993) recommended a buffer width of approximately three tree heights in order to preserve most microclimate functions.

An important consideration with forested riparian buffers is the ability of the forest to withstand the force of high winds (Broderson 1973; Steimblums et al. 1984). For example, in northwest Washington, windthrow (uprooting of trees or tree trunk breakage) averaged 33 percent in riparian forest buffers within 1 to 3 years after clearcut harvest of adjacent timber (Grizzel and Wolff 1998). In a review of several studies, Pollock and Kennard (1998) determined that over 75 percent of buffers less than 24 m (80 ft) wide experienced significant blowdown, while only 14 percent of wider buffers lost a significant number of trees. They concluded that the minimum buffer width to maintain minimal windthrow losses over the long-term is 23 m (75 ft). In Mendocino County, California, researchers found that the prescribed 30-m buffers were inadequate to protect trees from greatly increased mortality (primarily through uprooting via windthrow) (Reid and Hilton 2001). Treefall rates were abnormally high for a distance of at least 200 m from clearcut edges, and these rates persisted for six years with somewhat lesser (but still unnaturally high) tree mortality from 6-12 years after clearcutting.

Wildlife needs

The U.S. Fish and Wildlife Service has published numerous scientific papers and a series of habitat suitability index (HSI) models regarding buffer widths for a variety of wildlife species (e.g., Raleigh 1982; Sousa and Farmer 1983; Doyle 1990; Darveau et al. 1995). These models have demonstrated a need for buffer widths ranging from 3 to 106.7 meters (10 to 350 feet) depending on the particular species (Castelle et al. 1994).

Studies recommending riparian corridor widths sufficient to meet the needs of many wildlife species are scarce, because species have different habitat requirements and may respond differently to the same width. FEMAT (1993) recommends a range of widths based on categories of streams, for example for fish-bearing streams the recommended width is two site-potential tree heights, or 91-m (300-ft) buffers on each side of the stream, and non-fishing bearing streams would have a buffer of 46 m (150 ft) on each side. Oregon's Division of State Lands (Van Staveren et al. 1998) recommends one site-potential tree height [ranging from 5-37 m (15-120 ft), depending on the habitat]. Johnson and Ryba (1992) found that the range of recommended width for terrestrial habitat was 67-200 m (220-656 ft). Wenger (1999) reviewed the scientific literature and determined that a 100-m (328 ft) minimum was required to protect diverse terrestrial riparian wildlife communities, but commented that some wider and larger blocks should be preserved to protect area-sensitive species.

The buffer widths discussed here were based primarily on non-urban habitats. In urban habitats edges may be unnaturally abrupt, biological communities such as predator-prey relationships are altered, and human disturbances are routine. It is possible that wildlife using urban riparian areas need wider buffers compared to non-urban habitats. Studies comparing urban and non-urban buffers in similar habitats would help elucidate such differences. Until more urban information is available, the empirical evidence for buffer widths discussed below provides valuable information, but may underestimate the needs of wildlife in urban ecosystems. Urban areas include concentrations of high intensity land use; thus urban stream buffers often are increased to account for future risk of encroachment and to mitigate for the impacts of adjacent land use (Todd 2000).

Fish

The reliance of fish on LWD and clean, cold water suggest that buffers to protect fish at least meet the minimum buffer widths for these two criteria. Several Pacific Northwest studies offer buffer width recommendations specific to salmonid protection. One salmonid run (Columbia River coho) is state-listed as endangered but not federally listed. In western Washington, Castelle et al. (1992) recommended 61-m buffers (200-ft) to protect the zone of habitat influence for salmonids. Knutson and Naef (1997) recommended 15–61 m (50-200 ft) buffers for Cutthroat trout, Rainbow trout and Steelhead.

In species-specific HSI's, the U.S. Fish and Wildlife Service recommended 30-m (98-ft) buffers for Cutthroat trout, Rainbow trout and Chinook salmon (Hickman and Raleigh 1982; Raleigh et al. 1984; Raleigh et al. 1986). However, these HSI's are old and were typically developed for specific projects. The reference to the 30m (98-foot) buffer was for erosion control and to maintain undercut stream banks characteristic of good trout habitat. Many of the other parameters that get used in the model (such as water temperature, dissolved oxygen, substrate size, percent pools, base flow, stream shading, etc.) require properly functioning conditions. The HSI does not state that these habitat conditions will be present if there is a 98 foot riparian width, and it does not address the broader upstream and upland impacts that may affect site-specific habitat conditions. HSI models are typically used to evaluate the impacts of a specific project and measure the effectiveness of associated mitigation. HSI models are often modified for specific projects to incorporate current and local (the models are used nationwide) information.

Insects

Little is known about buffer widths and terrestrial insects, but several studies have examined riparian corridor width and benthic insects. Erman et al. (1977) studied streams in northern California and commented, "stream invertebrates were far more effective in discerning logging impacts than the physical and chemical parameters measured." This study recommended 30 m (100 ft) as the minimum buffer width for maintenance of benthic communities typical of undisturbed conditions. In Western Oregon, Gregory et al. (1987) recommended a minimum of 30-m (100-ft) buffers to maintain instream macroinvertebrate diversity. Benthic insects are highly dependent on organic debris, and these numbers generally match the range within which the majority of organic debris is contributed from riparian vegetation (Erman et al. 1977; McDade et al. 1990). However, certain species are highly sensitive to water quality and urbanized regions are pollution-prone (see *Impacts of Urbanization*). Although 30-m (100-ft) buffers may suffice for organic matter in urban habitats, wider buffers may be necessary to protect water quality important to aquatic insect communities.

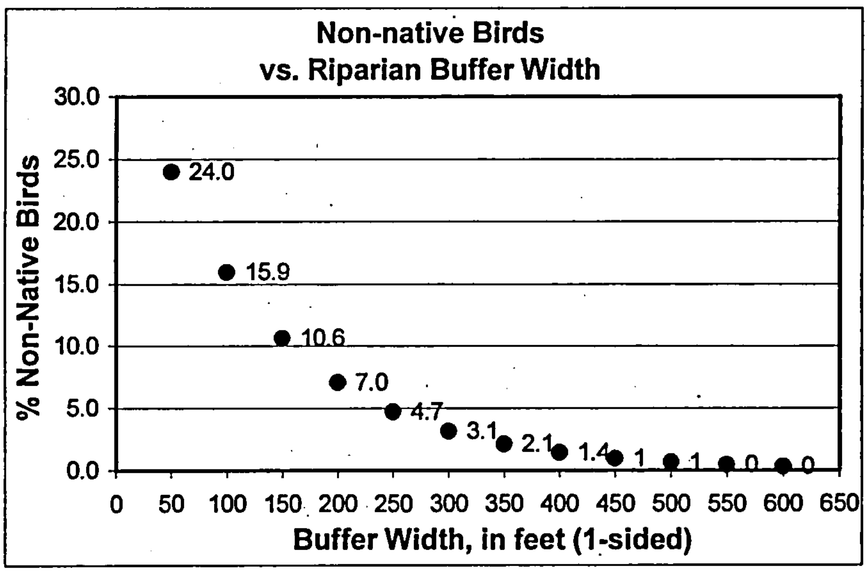
Birds

A relatively large body of literature is available to suggest buffer widths for various single species or groups of birds. In western Oregon, the abundance of four forest-associated bird species (Pacific-slope Flycatcher, Brown Creeper, Chestnut-backed Chickadee, and Winter Wren) increased with increasing buffer width through 70 m (230 ft); four species (Hammond's

Flycatcher, Golden-crowned Kinglet, Varied Thrush and Hermit Warbler) that were relatively common in unlogged sites, rarely occurred even in the widest (70 m) buffers in logged sites (Hagar 1999). These species may be area-sensitive in this region and vulnerable to habitat fragmentation.

As a group, Neotropical migratory songbirds appear to require wider forests than resident and short-distance migratory species. It is unclear whether this is due to numerous area-sensitive species, other habitat requirements such as native shrubs, an aversion to human disturbance, or some combination of these and other variables. However, local data suggests that human disturbance and native shrubs are influential to this group, but that certain species (e.g., Winter Wren, Brown Creeper, Swainson's Thrush and Pacific-slope Flycatcher) may be area-sensitive (Hennings 2001). The data also shows that non-native bird density decreases with greater corridor widths, reducing predation and competition effects on native birds, as shown in Figure 10 below.

Figure 10. Relationship between riparian buffer width and percentage of non-native birds.



Source: Hennings 2001.

Neotropical migrants are often riparian-associated during the breeding season (Gates and Giffen 1991). In Pennsylvania, Croonquist and Brooks (1993) found that sensitive Neotropical migrant bird species did not occur in riparian zones unless undisturbed buffers greater than 25 m (82 ft) per side were present. Hodges and Krementz (1996) document 100 m (328 ft) as the minimum buffer width to support area-sensitive riparian NMB in Georgia. In Maryland and Delaware, Neotropical migratory species richness increased with corridor width, especially between 25-75 m (82-328 ft), while resident and short-distance migrant species remained stable regardless of buffer width (Keller et al. 1993).

In northern boreal forests, forest-breeding birds were sensitive to corridor width and required at least 60 m (197 ft) wide corridors (30 m – 98 ft – on each side of the stream) to maintain their numbers (Darveau et al. 1995). In southeastern British Columbia, 70-m buffers (230 ft) were necessary to accommodate riparian-associated birds (Kinley and Newhouse 1997). Studies in Vermont showed that 90 percent of forest-dwelling bird species were present when buffer widths reached 150-175 m (492-574 ft) (Spackman and Hughes 1995). Jones et al. (1988) recommended 75-200 m buffers (246-656 ft) to maintain native bird communities. In eastern Texas, 30-95 m (98-312 ft) buffers were necessary to maintain bird abundance and retain species preferring mature forest (Dickson et al. 1995).

Reptiles and amphibians

Little is known about buffer width requirements for reptiles and amphibians, but a few studies add important information. For example, Western Pond Turtles appear to need 100-m (330-ft) buffers for nesting (Knutson and Naef 1997), an important consideration because this species is state-listed species at risk and a Federal **species of concern** (Oregon Department of Fish and Wildlife 2000; U.S. Fish and Wildlife Service 2001). In the Carolina Bays, Burke and Gibbons (1995) found that 275-m (902-ft) buffers were required to protect all nesting and hibernation sites for certain freshwater turtle species. In western Oregon, 75-100 m (246-328 ft) may be necessary to protect riparian-dependent reptiles and amphibians (Gomez and Anthony 1998). The NRCS (1995) recommended minimum 30-m (98-ft) buffers to protect frogs and salamanders, and Rudolph and Dickson (1990) recommended the same buffer width for the full complement of reptiles and amphibians. The dependence of amphibians on LWD suggests a minimum of 30-m buffers (100 ft). In addition, connectivity between habitat patches is likely to be of particular importance to this relatively immobile group.

Mammals

Information about buffer width is scarce for this diverse group. However, as with amphibians, small mammals relying on woody debris probably require buffers sufficiently wide to provide woody debris. Jones et al. (1988) recommend minimum 67-93 m (220-295 ft) buffers to support many small mammal species, and similar widths were suggested by Allen (1983). In southwestern Oregon, Cross (1985) found riparian zones in mixed conifer forests supported a higher diversity and density of small mammals than uplands, and 67 m (200 ft) buffers supported small mammal communities comparable to nearby undisturbed sites. For American Beaver the NRCS (1995) recommended 91-m (300-ft) buffers, while Allen (1983) recommended 30-100 m (98-328 ft) buffers.

Less is known about large mammals, but it is likely that some species such as elk require wider buffers to meet food and other natural history needs such as movement, predator and disturbance avoidance (Phillips and Alldredge 2000). The NRCS (1995) suggested 61-m (200-ft) buffers for deer habitat, and Knutson and Naef (1997) proposed 183-m (600-ft) buffers to provide fawning habitat. Jones et al. (1988) recommended 100-m (328-ft) buffers to support large mammal populations.

Range of functional buffer widths

While studies result in a variety of recommended buffer widths for the riparian area, all recommend some level of protection for this important resource for fish and wildlife. If riparian buffers of sufficient width are maintained along streams in the urban area they can provide good quality habitat within an altered landscape (Knutson and Naef 1997). Table 7 below summarizes the range of riparian area widths recommended in the scientific literature to protect fish and wildlife habitat. In an urban area restoration is likely to play an important role in addition to protection of habitat that is currently in good condition (May 2000).

Table 7: Range of functional riparian area widths for fish and wildlife habitat

AQUATIC HABITAT			
Function		Reference	Functional width *(each side of stream)*
Temperature regulation and shade	Shade	FEMAT 1993	100 ft
	Shade	Castelle et al. 1994	50-100 ft
	Shade	Spence et al. 1996	98 ft
	Shade	May 2000	98 ft
	Shade	Osborne and Kovacic 1993	33-98 ft
	Shade/reduce solar radiation	Brosofske et al. 1997	250 ft
	Control temperature by shading	Johnson and Ryba 1992	39-141 ft
Bank stabilization and sediment control	Bank stabilization	Spence et al. 1996	170 ft
	Sediment removal and erosion control	May 2000	98 ft
	Ephemeral streams	Clinnick et al. 1985	66 ft
	Bank stabilization	FEMAT 1993	½ SPTH
	Sediment control	Erman et al. 1977	100 ft
	Sediment control	Moring 1982	98 ft
	Sediment removal	Johnson and Ryba 1992	10 ft (sand) – 400 ft (clay)
	High mass wasting area	Cederholm 1994	125 ft
Pollutant removal	Nitrogen	Wenger 1999	50-100 ft
	General pollutant removal	May 2000	98 ft
	Filter metals and nutrients	Castelle et al. 1994	100 ft
	Pesticides	Wenger 1999	>49 ft
	Nutrient removal	Johnson and Ryba 1992	33 – 141 ft
Large woody debris and organic litter	Large woody debris	Spence et al. 1996	1 SPTH
	Large woody debris	Wenger 1999	1 SPTH
	Large woody debris	May 2000	262 ft
	Large woody debris	McDade et al. 1990	150 ft
	Small woody debris	Pollock and Kennard 1998	100 ft
	Organic litterfall	FEMAT 1993	½ SPTH
	Organic litterfall	Erman et al. 1977	100 ft
	Organic litterfall	Spence et al. 1996	170 ft
Aquatic wildlife	Cutthroat trout	Hickman and Raleigh 1982	98 ft
	Brook trout	Raleigh 1982	98 ft
	Chinook salmon	Raleigh et al. 1986	98 ft
	Rainbow trout	Raleigh et al. 1984	98 ft
	Cutthroat trout, rainbow trout and steelhead	Knutson and Naef 1997	50 – 200 ft
	Maintenance of benthic communities (aquatic insects)	Erman et al. 1977	100 ft
	Shannon index of macroinvertebrate diversity.	Gregory et al. 1987	100 ft
	Trout and salmon influence zone (Western Washington)	Castelle et al. 1992	200 ft

Table 7 (continued) - TERRESTRIAL HABITAT			
Function		**Reference**	**Recommended width *(each side of stream)***
Wildlife needs	Willow flycatcher nesting	Knutson and Naef 1997	123 ft
	Full complement of herpetofauna	Rudolph and Dickson 1990	>100 ft
	Belted Kingfisher roosts	USFWS HEP Model	100 – 200 ft
	Smaller mammals	Allen 1983	214 – 297 ft
	Birds	Jones et al. 1988	246 – 656 ft
	Minimum distance needed to support area-sensitive Neotropical migratory birds	Hodges and Krementz 1996	328 ft
	Western pond turtle nests	Knutson and Naef 1997	330 ft
	Pileated woodpecker	Castelle et al. 1992	450 ft
	Bald eagle nest, roost, perch Nesting ducks, heron rookery and sandhill cranes	Castelle et al. 1992	600 ft
	Pileated woodpecker nesting	Small 1982	328 ft
	Mule deer fawning	Knutson and Naef 1997	600 ft
	Rufous-sided towhee breeding populations	Knutson and Naef 1997	656 ft
	General wildlife habitat	FEMAT 1993	100-300 ft
	General wildlife habitat	Todd 2000	100-325 ft
	General wildlife habitat	May 2000	328 ft
Edge effect	Interior bird species	Tassone 1981	164 ft
	Neotropical migrants	Keller et al. 1993	328 ft
	Effect of increased predation	Wilcove et al. 1986	2,000 ft
	Noise reduction of a mature evergreen buffer	Harris 1985	20 ft
	Reduce commercial noise	Groffman et al. 1990	100 ft
LWD and structural complexity	Snags and downed wood	FEMAT 1993	1 SPTH outside the buffer
	Width necessary to minimize non-native vegetation	Hennings 2001	650 ft
Movement corridors	Travel corridor for red fox and marten	Small 1982	328 ft
	Minimum to allow for interior habitat species movement	Environment Canada 1998	164 ft
Microclimate	Maintain microclimate	May 2000	328 ft
	Prevent wind damage	Pollock and Kennard 1998	75 ft
	Approximate natural conditions	Brosofske et al. 1997	250 ft
	Maintain microclimate	Knutson and Naef 1997	200-525 ft
	Maintain humidity and soil temperature	Chen et al. 1995	98 – 787 ft

Acronyms:
SPTH: site potential tree height
NMFS: National Marine Fisheries Service
NRCS: National Resource Conservation Service
USFWS: U.S. Fish and Wildlife Service
FEMAT: Forest Ecosystem Management Assessment Team

Summary

Riparian areas are "hot spots" of biological diversity and productivity. While they occupy a relatively small proportion of the landscape, they provide a multitude of functions vital to fish and wildlife, watershed health, and society. The word "riparian" is derived from Latin "riparius" which means "of or belonging to the bank of a river." This paper uses the term "riparian corridor" to include the area of open water (stream channel, wetland, or lake), the adjacent riparian vegetation, and the area of direct interaction between the terrestrial (land) and aquatic (water) environment.

Beyond their essential importance to aquatic life such as salmon, riparian areas and adjacent water habitats contain more plant, mammal, bird, and amphibian species than do surrounding uplands.

Urbanization has resulted in the impairment of many of these functions and values provided by healthy riparian corridors. Some of the effects of urbanization include riparian loss, habitat alteration and fragmentation; changes in basin hydrology; filling and damaging of floodplains and wetlands; stream channel modification; and reduced water quality. These effects are cumulative from upstream and within a watershed. For example, studies show that ecosystem impairment begins as watersheds become more heavily urbanized (that is, where total impervious surfaces [pavement, rooftops] exceed 5-10 percent of the watershed area). In the Metro region, most watersheds exceed this level of impervious cover.

This section provides a review of riparian widths identified in the scientific literature that are necessary to protect habitat for fish and wildlife. Many animal species, from invertebrates to fish to mammals, depend on the riparian area for all or part of their life cycles. Deciding on appropriate widths for protection and restoration of riparian areas for fish and wildlife is complex. The literature provides the following guidelines in addressing this issue:

- Due to the pervasive effects of human activities in an urban environment, riparian area protection and restoration is not sufficient in itself to maintain healthy watershed function. Management of stormwater runoff and protection of upland intact forest areas is essential to protect and restore the ecological health of riparian systems for fish and wildlife and other values. Wider riparian corridors may be needed in urban areas with higher intensity land uses than compared to a rural landscape.
- To the maximum extent possible, all perennial, intermittent and ephemeral streams should be protected from surrounding land use activities. The entire stream network functions as a system, and removing the connection between intermittent and perennial streams will compromise the long-term physical and biological functioning of stream ecosystems.
- Riparian corridors should be wide enough to permit natural stream channel migration, and should maintain connectivity within the 100-year floodplain.
- Riparian corridors should consist of native vegetation where possible. Forest widths along streams, wetlands, and rivers play an important role in urban riparian community structure and composition. Urban research within the Metro region found that wider riparian forests had greater native plant diversity and abundance. Narrow forest widths were more likely to contain higher percentages of nonnative plants.

- Stream-associated wetlands, off-channel habitats and oxbows are valuable for fish and wildlife and should be included in protection programs.
- A range of riparian widths is recommended in the scientific literature to protect multiple riparian functions and values (see Table 7).

A comprehensive protection and restoration program should be based on the widths needed to provide for the long-term integrity of these complex and productive ecological systems.

UPLAND HABITAT

Introduction

In the Metro region we are fortunate to have retained some important natural areas such as Forest Park, the East Buttes, Cooper Mountain 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 Metro region passed a $135.6 million bond measure to acquire natural areas within the Portland metropolitan region. Metro has since acquired over 6,000 acres of key habitat. Residents of the region have access to numerous parks and open spaces that provide habitat for a number of wildlife species. This system of parks, riparian corridors, and upland habitat has been called by some "greenfrastructure" and many consider it to be essential in maintaining a high quality of life in an urban area while providing for over 500,000 additional people projected to live in this region within 20 years (Metro 2000).

In this chapter we discuss the importance of upland habitats in the Metro region, including the following topics:

- Ecological definition of upland habitat
- Functions and values of upland habitat
- Upland habitat types in northwestern Oregon
- Impacts of urbanization on upland habitats
- Buffers and surrounding land use
- Upland habitat connectivity and patch size recommendations

Ecological definition of upland habitat

Upland habitat refers to all wildlife habitats that are not riparian, wetland, or open water habitats. However, it should be noted that wetlands are a natural component of upland areas and such wetlands are important for many species, especially during periods of drought (National Academy of Sciences 2001). A habitat can be described as the integration of the landscape and the essential resources of food, water and cover found within it (Linehan et al. 1995). While most species associated with upland habitats 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. These land types provide crucial functions and values for many wildlife species.

Functions and values of upland habitat

All wildlife species depend on the surrounding environment to meet their needs, both long-term and short-term. Some wildlife species live in the Metro region all year round, while others migrate through and some use this region as wintering grounds. For example, elk migrate between upland areas in the summer and lowland areas in the winter. Other species are here only during the breeding season.

Breeding, foraging, dispersal, wintering habitat

All of the upland habitat types described below provide key functions for wildlife at different life stages. Wildlife must have access to areas in which to find food, water, and shelter, and numerous birds spend the winter in the Metro region taking advantage of the relatively mild climate (ODFW 1993). They need foraging habitat that provides food sources such as fruits and berries, or that can support sufficient prey to sustain carnivores. Wildlife species also require habitat suitable for breeding and rearing young. Some upland habitats provide essential areas for breeding species; others are crucial for foraging in both summer and winter. Upland habitat fragments may provide key connections between a variety of other upland and riparian habitats, allowing species to disperse for breeding, foraging, or shelter purposes.

Habitat may be considered in terms of vertical structure that runs the continuum from bare ground to grasses, other herbaceous plants, shrubs, small trees, and tall trees (Forman and Godron 1986). Wildlife species may be vertically stratified, some using the upper canopy, others reliant on the forest floor. Each part of this ecosystem provides important functions and values, both separately and as part of the sum of the whole. Most wildlife species utilize more than one type of habitat in the course of their life cycle (Forman and Godron 1986). Certain plant communities play key roles during specific life events, such as breeding or sheltering young.

Important functions of forested habitats

Forest communities provide essential habitat for wildlife in the Willamette Valley. Douglas-fir is the dominant tree found in this region. In areas that have been burnt, either historically by Native Americans or due to forest fires, Oregon white oak and big-leaf maple may precede forests of Douglas-fir (Larsen and Morgan 1998). Several other trees, while not dominant, provide important food sources for wildlife, including the Pacific madrone, hawthorn, cascara, red-osier dogwood and Pacific dogwood (ODFW 1993). In urban areas forests are frequently made up of second growth trees – trees that have grown after an area has been logged.

A healthy forest contains a multi-story canopy that includes a herbaceous layer, a shrub layer, and an upper canopy of native trees (Forman and Godron 1986). This vegetative community naturally contains downed wood and snags that provide key functions for wildlife such as food and nest cavities. Forests are essential for numerous species of wildlife in the Metro area (see Appendix 1 for species associated with forests in the Metro region). Both coniferous and deciduous forest communities are important. Native trees provide breeding, foraging, dispersal, and wintering habitat for a number of wildlife species. Forest strips may also provide dispersal corridors for interior habitat species.

Three-dimensional structure

The structure of a forest is crucial in terms of the level of function it is able to provide as habitat for wildlife (Guthrie 1974; Goldstein et al. 1986; Short 1986; Germaine et al. 1998). Each layer of the healthy forest multi-story canopy is important to different wildlife species at various life history stages. The horizontal spacing and density of foliage provides cover for protection and escape routes. Vertical layers provide places for perching, roosting, nesting, and feeding. The presence of a multi-story canopy can serve as an indicator for the types of species able to use a forest. For example, most Pileated Woodpecker nests are found in mature or old-growth forests with two or more canopy layers (Marshall et al. 1996). However, in urban areas Pileated Woodpeckers have been found to use second growth forests. The extent to which the canopy is open or closed also impacts the type of vegetation that grows in the forest. An open canopy allows more light lower to the ground, which in turn allows for a more diverse and abundant shrub layer. A healthy understory of native shrubs provides important woody structure for many bird species for nesting purposes.

Snags and downed wood

Dead and downed wood in forests serves a variety of functions for wildlife (Maser et al. 1988; ODFW 1993). Hollows and cavities in standing dead trees as well as logs and stumps provide shelter for many wildlife species. Over 100 wildlife species in the Pacific Northwest use snags, and about 53 of those species are dependent on cavities in the snags (Brown 1985). These species include woodpeckers, owls, bats, small mammals, and amphibians. Many species of birds and small mammals use cavities in standing snags for nesting, roosting, feeding, and overwintering (Maser et al. 1988). Burrowing species use stumps, logs and large tree roots for burrow sites. Soft decaying logs provide habitat for some amphibians and reptiles, and also provide food for other species that eat fungi or invertebrates dependent on decaying wood (Maser and Trappe 1984). Coarse woody material on the forest floor provides moist sites for amphibians to find shelter from predators, foraging areas, and breeding habitat. Downed woody material provides habitat in the winter, catching snow and providing warm, dry areas for shelter (ODFW 1993).

Fallen trees provide opportunities for new plants to become established in the forest, by creating holes in the canopy to allow sunlight to reach the forest floor and by providing nutrients through the process of decay (Maser et al. 1988). Many old-growth trees started life as a seedling nourished by a rotting downed log, often called a "nurse log." Decaying wood is a major source of organic material in the soil (Maser and Trappe 1984). A decomposing fallen tree provides a variety of habitat functions as it proceeds through the stages of decay to finally become part of the forest floor. Woodpeckers and other wildlife species routinely forage for insects on downed logs.

Upland interactions with surrounding landscape

Upland habitat in urban areas is typically fragmented and intermingled with other land uses. Some land uses are more compatible for the functions and values important for wildlife than others. For example, in some cases low-density residential areas may have less of an impact on a habitat patch, depending on the species, than other land uses (Nilon et al. 1994). The type (native vs. nonnative) and abundance of species tends to change across the urban gradient, as the landscape changes from undeveloped, rural land to high intensity land uses in the downtown areas (Blair 1996). Habitat areas provide more functionality to wildlife if they are situated near other patches of similar habitat with some amount of connectivity between the fragments (Soulé 1991a,b; Duerkson et al. 1997).

Corridors and connectivity with surrounding habitat

Habitat corridors provide connections among various habitat patches within a fragmented landscape. Major functions provided by corridors include: habitat for some species within the corridor, opportunity to move between habitat fragments, and a source of environmental and biotic inputs on the surrounding habitat (Forman and Godron 1986). The value of connectivity has been debated in the scientific literature (Duerkson et al. 1997). While corridors provide many benefits, they also allow exotics, including mammals, birds, and plants, to more easily invade native habitats. Another potential downside of corridors is that they may provide opportunities for predation that would not otherwise occur, especially when they are narrow and lacking in vegetative cover. However, the benefits of corridors, particularly in preventing local extinctions, likely outweigh the risks (Soulé 1991a). (See *Impacts of Urbanization, Habitat Fragmentation* for more discussion on corridors).

Connectivity is important to wildlife for several reasons. Many species must migrate seasonally to meet basic needs for food, shelter and breeding, and connections between habitat patches allow this migration to occur (Duerkson et al. 1997). In addition, wildlife populations that are connected to each other are more likely to survive over the long term than an isolated population (Duerkson et al. 1997; Beier and Noss 1998). A population that exists on a connected system of habitats will be more likely to survive a catastrophic event on one patch, and the surviving population may be able to repopulate or revive an area that is in trouble. Finally, connectivity between habitats allows populations to interbreed, which aids in the vigor and survival of the overall population by reducing genetic inbreeding (Duerkson et al. 1997).

Connectivity with riparian areas

Prior to modern land use patterns, the landscape provided fish and wildlife habitat in an interconnected mosaic of habitat types (Forman and Godron 1986). Upland areas were functionally and physically connected with the streams, rivers, wetlands and lakes (riparian areas) that wended their way through valleys.

Most species of wildlife utilize riparian areas at some point in their life history. Many mammals must use riparian areas for water, food, and shelter. Because riparian areas frequently serve as corridors through an urbanized landscape, these areas also provide places for movement and dispersal. Over 60 percent of mammal species in the Northwest use riparian areas for breeding and feeding (Kauffman et al. 2001). In the Metro region, nearly half of all birds, and 45 percent of all non-fish vertebrate species are dependent on water-associated habitats. Nearly all vertebrates (93 percent, excluding fish) use these habitats (see Table 1), yet riparian areas comprise only a small fraction of the landscape. Thus, connections between upland habitats and riparian areas are very important for most wildlife species. Upland habitats that are physically connected to riparian areas will likely be more valuable for wildlife than many other habitats. Local wildlife data affirms the importance of connectivity to water and riparian areas. In 1999, Oregon State University (OSU) conducted spring bird surveys along small streams in the

Portland area. Concurrently, Metro (Parks and Greenspaces Department) developed a model to predict key habitats of interest for future conservation using four variables: size of habitat patch, proximity to other habitat patches, proximity to water resources, and species richness.[1] At Metro's request, OSU analyzed their bird data based on model criteria scores. Each of the four model variables appeared important to bird communities, and analysis suggested that habitat patches with more nearby water resources had higher bird diversity (Hennings 2001).

However, certain upland habitats without connectivity to riparian areas may also be highly important to wildlife due to unique features such as topography. In the Portland metro region, vegetated hilltops provide key wildlife habitat, including migratory stopover habitats for many Neotropical migratory bird species (Houck 2002; see also Nehls 2002).

Upland habitat types in Northwestern Oregon

Prior to settlement by Europeans, the Willamette Valley consisted of a mosaic of large patches of riparian forests and wetlands, open white oak savannas and prairies, and hills of oak, Ponderosa pine and Douglas-fir (LaRoe et al. 1995). Native Americans historically set controlled fires that maintained the prairies, savannas, and oak woodlands throughout much of the valley for many years (ODFW 1993). Settlers were attracted to the Willamette Valley due to the fertile soils and abundant rainfall, providing ideal agricultural conditions. Most of the prairies have since been converted to farmland, and the original forests have almost all been logged (LaRoe et al. 1995; Oregon Natural Heritage Advisory Council 1998). The greatest change in vegetation type has been the loss of grassland and oak savanna; current estimates are that less than one percent of the historic extent still exists in small, scattered patches (Partners in Flight 2000).

Historic vegetation

Using data from land surveys for the General Land Office between 1851 and 1895, the Oregon Natural Heritage Program created a historical vegetation map for Oregon (Christy 1993). The data coverage was created at 1:24,000 scale using survey notes for township and section lines, with standard USGS 7.5-minute topographic maps as a base. This map shows that the Metro region was covered predominantly by closed and open canopy forest interspersed with prairie and savanna habitats especially in the lowlands of the Tualatin, Willamette, and Columbia River basins (see Figure 11 "Historical Vegetation of the Metro Region").

[1] An index of species richness was determined by the Oregon Natural Heritage Program and applied to the natural areas identified by the model.

Figure 11. Historical vegetation of the Metro region

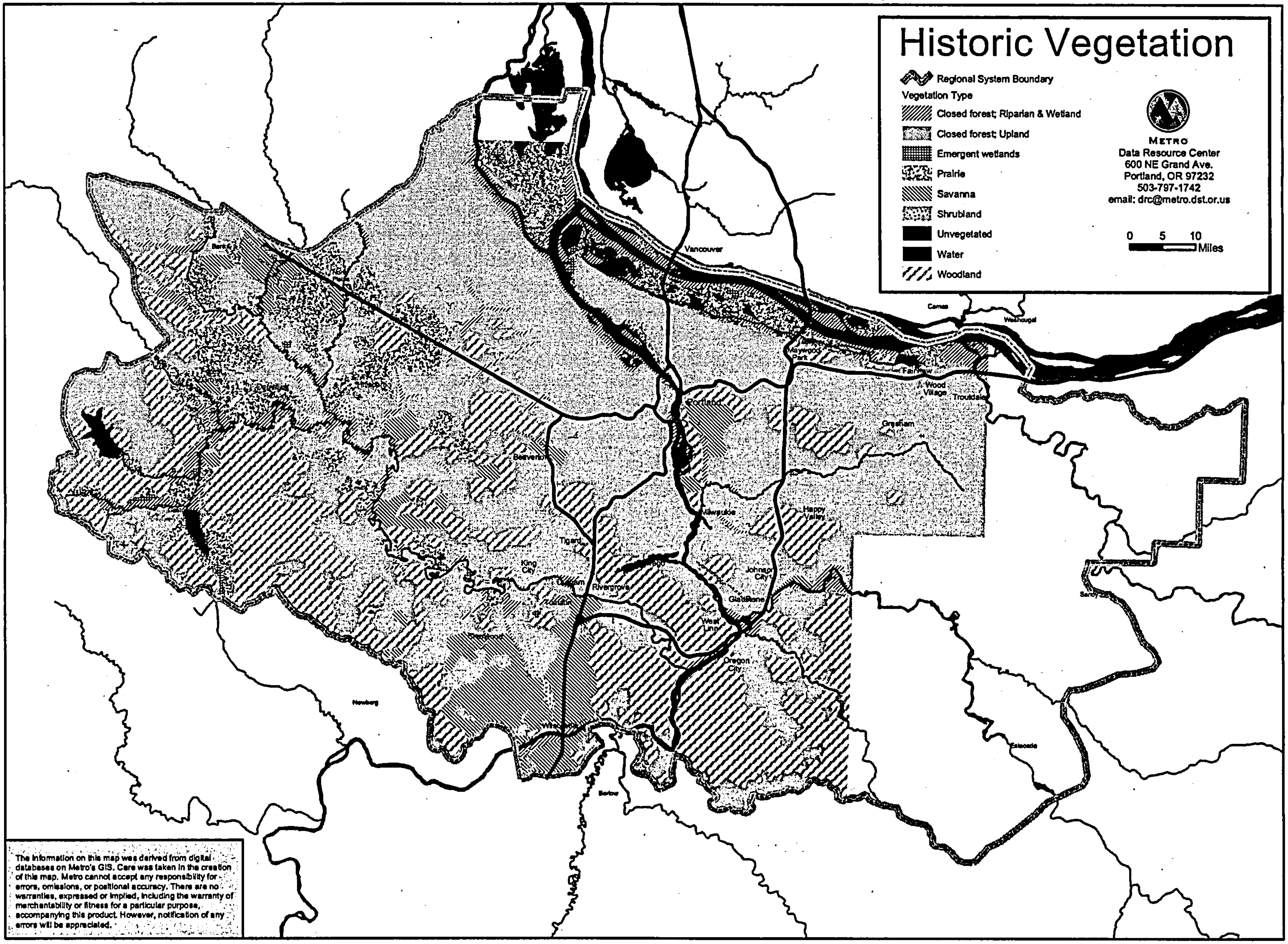


Table 8 gives the percentage breakdown for the types of vegetation that once covered the Metro region compared to current land cover data. The data show that forest canopy covered more than three fourths of the Clackamas, Sandy, Tualatin, and Willamette River basins within the Metro region. The Columbia River and Multnomah Channel contained significant amounts of riparian forest, wetland, dry prairie and savanna, and open water. The Tualatin River basin contained significant amount of dry prairie and savanna habitat.

Table 8. Percentage of vegetation cover for the Metro region: historical versus current

Vegetation Type	WATERSHED						
	Clackamas River	**Columbia River**	**Multnomah Channel**	**Sandy River**	**Tualatin River**	**Willamette River**	**All**
	Percent historic/current	*Percent historic/current*	*Percent historic/current*	*Percent historic/current*	*Percent historic/current*	*Percent historic/current*	*Percent historic/current*
Barren/Urban	<1 / 27	<1 / 52	0 / 3	0 / 45	<1 / 17	<1 / 29	<1 / 24
Upland closed forest canopy	68 / 28	40 / 3	53 / 32	82 / 8	47 / 23	52 / 25	49 / 22
Upland open forest canopy	16 / 9	4 / 10	1 / 3	0 / 16	28 / 8	30 / 15	25 / 10
Riparian/ wetland forest	11 / 2	16 / 2	10 / 2	12 / 4	6 / 1	3 / 2	6 / 1
Wetlands and wet prairies	<1 / <1	4 / 2	8 / 2	<1 / 1	3 / 1	<1 / <1	2 / <1
Dry prairie, savanna, and shrubland	2 / 6	14 / 10	21 / 17	0 / 10	16 / 6	10 / 5	14 / 6
Ag riparian/ wetland	0 / <1	0 / <1	0 / 2	0 / <1	0 / 1	0 / <1	0 / <1
Ag Upland	0 / 25	0 / 2	0 / 35	0 / 10	0 / 43	0 / 19	0 / 31
Water	2 / 2	22 / 19	7 / 3	6 / 6	<1 / <1	4 / 4	4 / 4
Total Acres	14,053	47,252	22,481	6,892	289,985	166,356	547,017

Source: Christy 1993, Metro 1998 land cover data.

Notes:

1) The Urban category underestimates the amount of land covered with urban development because it excludes urban uses that are also intermingled with open and closed forest canopy cover.
2) The table shows a 43 percent decline in forest cover from historic levels. Forest composition has also changed due to loss of old growth forests and white oak woodlands.
3) Current riparian/wetland forest is only 17 percent of historic levels. However, the difference is probably much greater due to the assumptions used to calculate current riparian/wetland forest cover. This cover type was estimated using 200-foot buffers along streams and wetlands. This significantly overestimates the actual amount of riparian forest given existing development patterns.
4) Historic dry prairie, savanna, and shrubland have been converted to non-native grasslands and shrublands.
5) Agriculture and urban categories comprise 55 percent of the land area in the region, representing a total conversion from the original land cover.

Another source of historical data for the metro region is the First Federal Township Survey Map of 1852 (Munch *No date*). This map gives an interesting overview of the region – its first settlement patterns of roads, platted lands, and cultivated fields, as well as natural features such as location of prairies, wetlands, and general topography. It shows that most of the cultivated fields were located in the prairies and savannas that characterized the lowlands of the Tualatin and Willamette valleys. The map shows lakes located in the Willamette River floodplain, now known as the Northwest Industrial District of Portland, and Sucker Lake, which has been renamed Lake Oswego.

The following types of vegetation communities have been particularly impacted by the change in the landscape over the past hundred years (summarized from Christy 1993, Johnson and O'Neil 2001).

Prairies included both wet and dry grasslands. Wet prairies were subject to seasonal floods and were found on poorly drained soils in valley bottoms. Dry prairies were found primarily along the edges of valleys and on well drained soils, and were dominated by perennial grasses. Savanna habitat was similar to dry prairies but also included widely scattered trees with some open tree groves. Trees typically were Oregon white oak, but also included Douglas fir or Ponderosa pine. In prairie habitats, canopy cover was generally less than 25 percent.

Oak woodlands consisted of a relatively open understory and were typified by a canopy of 50 percent or greater Oregon white oak. Other species included Big-leaf maple, Douglas-fir and Pacific madrone. The understory was predominantly poison oak, California hazel, snowberry, oceanspray, serviceberry, and sword fern. Historic distribution of oak woodlands was limited to low elevation dry areas with limited conifer competition. For example, oak woodland and oak savanna habitat once covered approximately 21 percent of the Tualatin Valley within the metro region.

Current Vegetation

Current vegetation in the Willamette Valley has changed dramatically from historic patterns as a result of human alteration of the landscape (Table 8). Key factors include agricultural cultivation, urban development, livestock grazing, exotic species introduction, suppression of natural fires, logging, drainage of wetlands, and **channelization** of streams and rivers (Partners In Flight 2000).

Native grassland has been reduced to only one percent of historic land coverage. Oak woodland habitat has been impacted by conversion of land to agriculture and invasion by exotics due to fire suppression, and current distribution is patchy. Conifer and deciduous forests have overtaken former grassland habitat. These forests are typically dominated by Douglas-fir, often with an understory of exotics such as Himalayan blackberry (Partners in Flight 2000). Riparian associated forests and shrub habitats have been radically changed from pre-settlement conditions. Over 70 percent of the bottomland hardwood forests have been lost.

While land cover data in Table 8 documents the historical loss of native habitats in the Metro region, recent data confirms the loss of habitat is ongoing due to the continuing conversion of land for development and other uses. For example, Metro conducted a study to document the loss of natural areas occurring between 1989 and 1997. The study documented a loss of 12 percent of the original 131,167 acres of natural areas inventoried in 1989 (Metro 1997). With projected population increases of 500,000 people in the metro region over the next twenty years, habitat loss is likely to continue.

Mapping landcover types

One of the difficulties in large-scale ecosystem management is a lack of consistent data at scales fine enough to be biologically meaningful. Detailed habitat characterization over a large area requires a substantial amount of on the ground fieldwork to identify specific vegetative communities across the landscape. The cost of such an effort is prohibitive. To overcome the obstacle of identifying habitat to enable management and protection of wildlife, conservationists and planners have turned to data sources better suited for collecting information consistently on a large scale.

O'Neil et al. (1995) identify three components necessary to accurately assess ecological functionality of a habitat (vegetation composition, vegetation structure, and critical habitat components such as snags and water), but acknowledge that vegetation composition is the only component that is currently measurable. The authors state that "vegetation reflects many abiotic and biotic characteristics of an area…and has therefore been used as a surrogate for ecosystems in conservation assessments." The use of **coarse** (applicable on a large scale) data is appropriate for identifying important habitat areas, rather than focusing on protecting a specific wildlife species (O'Neil et al. 1995). Vegetation composition is measurable at a large scale, based on remote sensing and aerial photography.

One such data source is the Landsat Thematic Mapper (TM) images. In 1999, Metro Parks and Greenspaces Department contracted with Ecotrust to develop several digital products from the Landsat TM images for use in identifying regional natural areas and producing an urban forest canopy map. The Landsat TM data was chosen for several reasons: 1) the entire region is captured in a single scene, 2) the type of spectral information is ideal for classifying vegetation, and 3) Metro had previously used Landsat TM data in 1991, thus comparisons in vegetation changes over time are possible (Ecotrust 1999). Metro and Ecotrust developed a land cover classification scheme for categorizing the data based on the Anderson classification scheme, including 17 mutually exclusive classes (shown in Table 9 below). A two-acre minimum mapping unit was used. Ecotrust utilized digital orthophotos to support the Landsat TM data.

The land cover types contained in the data layer provide a basis for identifying the types of habitat found in the Metro region. The land cover data identifies open versus closed canopy forests, deciduous versus coniferous forests, various types of shrub habitats, and distinguished between agricultural and meadowlands. A limitation of the land cover data is the inability to identify detailed quality aspects of the habitat for wildlife, such as structure and critical habitat components. For example, the land cover data allows the identification of a coniferous closed canopy forest, but does not show if ivy or another invasive species has invaded the understory of that forest.

Ideally the land cover data would be ground-truthed to further identify specific habitat types and thus enable the association of species with mapped areas. However, when working at a regional scale many conservation efforts have chosen to utilize the coarse data in developing habitat protection plans (Robinson et al. 1995). There are several habitat classification schemes that could be used to further refine the land cover data based on fieldwork. As an example, we chose to use a habitat classification scheme developed by Johnson and O'Neil (2001). Although the habitat types described in this biologically based classification scheme cannot currently be mapped at a scale useful in the Metro region; the information provides additional detail on the types of vegetative communities to be found in this region. The scheme also provides species associations with each habitat type. Table 9 below describes the land cover types and provides a crosswalk to show how Johnson and O'Neil's classification scheme fits within Metro's existing data.

Table 9. Land cover types and crosswalk to Johnson and O'Neil's classification scheme

Land Cover Types	Description	Johnson & O'Neil's classification scheme
Water	Major rivers, lakes, ponds, reservoirs, and other standing water (from Metro's existing hydrology data)	Open water – lakes, rivers, streams
Barren and sparsely vegetated	Bare ground, sand, gravel, asphalt, structures, rock with less than 15% vegetated cover and less than 10% trees (no agriculture)	Urban and mixed environs
Agriculture		
Low structure	Pasture and other cultivated cropland with limited vegetative structure	Agriculture, pasture and mixed environs
High structure	Areas with high degree of vegetative structure such as orchards, groves, vineyards, canes, nurseries, Christmas trees	Agriculture, pasture and mixed environs
Forest		
Closed canopy = 75% tree crown closure		
Deciduous closed canopy forest	70% total crown closure deciduous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Mixed closed canopy forest	<70% total crown closure deciduous; <70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Conifer closed canopy forest	70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Open canopy = <75% tree crown closure		
Deciduous open canopy forest	70% total crown closure deciduous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Mixed open canopy forest	<70% total crown closure deciduous; <70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Conifer open canopy forest	70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Scattered canopy = <25% tree crown closure		
Deciduous scattered canopy forest	70% total crown closure deciduous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Mixed scattered canopy forest	<70% total crown closure deciduous; <70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Conifer scattered canopy forest	70% total crown closure coniferous	• Westside lowlands conifer-hardwood forest • Westside oak, dry Douglas-fir forest, woodlands
Shrub		
15% woody canopy cover, <10% crown closure of trees		
Closed canopy	75% total shrub/tree crown closure	No applicable habitat type
Scattered canopy	25% to <75% total shrub/tree crown closure	Westside grasslands
Open canopy	10% to <25% total shrub/tree crown closure	Westside grasslands
Meadow/grass	15% vegetative cover, <15% woody canopy cover, <10% tree cover	Westside grasslands

Source: Metro 2001.

As discussed in the *Aquatic and Riparian Habitat* section, Johnson and O'Neil (2001) describe eight habitats present in significant amounts in the Metro region. Of these, three are water-based classifications and are discussed in the *Aquatic and Riparian Habitat* section. The remaining five habitats 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, and comprise the majority of upland habitats available to native wildlife in this region. Trees, shrubs and herbaceous species common to each of these habitats are listed in Appendix 3. All scientific names (genus and species) and species-habitat associations are included with the species list (Appendix 1). Eighty-nine percent of all terrestrial species in the Metro region are associated with upland habitats, with at least 28 percent depending on these habitats to meet their life history requirements, as shown in Table 10 below. In this section, we provide an abbreviated list of **species at risk** closely associated with each habitat based on state and/or federal status, as described in Appendix 1 (species list).

Table 10. Analysis of the importance of terrestrial habitats within each major group of animals (292 total existing native species; based on Metro's Species List, Appendix 1).

Group	# Native Species	Upland Dependent	Uses Uplands	Total % Using Uplands
Amphibians	16	2 species 13%	13 species 81%	15 species 94%
Reptiles	13	0 species 0%	13 species 100%	13 species 100%
Birds	209	61 species 29%	120 species 57%	181 species 86%
Mammals	54	18 species 33%	32 species 59%	50 species 92%
TOTAL	292	81 species 28%	178 species 61%	259 species 89%

Notes:

1. "Upland Dependent" species are closely associated with at least one of the four upland habitats; "Uses Upland" species are generally associated with or known to use at least one of the four habitats.
2. Note that although the total percent *using* uplands was only 4 percent lower than water-associated habitats, the percent *dependent* upon uplands was considerably lower than water-associated habitats (28 percent versus 45 percent, respectively; see Table 1 in Riparian chapter). Water-associated habitats comprise only 10-15 percent of the land at most, and clearly represent critical wildlife habitat. However, uplands also provide connectivity to water and other natural areas, as well as unique habitat types to habitat specialists throughout the region.

Habitat types

Westside lowlands conifer-hardwood forest

This habitat is widespread and prevalent in the Metro region. 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.

Fire is the primary natural disturbance, with natural fire intervals ranging from less than one hundred to several hundred years. Fires in this habitat type are typically severe (e.g., often kill trees). Other significant sources of natural tree mortality include bark beetles, fungi, and landslides. Human management and disturbances include timber harvest and clearing for development. Widespread deforestation and subsequent reforestation in Douglas-fir monoculture has resulted in a reduction in canopy tree diversity and coarse woody debris in the Pacific Northwest, as well as excluding habitat succession to old growth stages.

Several wildlife species dependent on this habitat are at risk at the state and/or at the 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 Oregongrape, 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.

The natural disturbance regime for this habitat is low to moderate severity fire, occurring every 50-100 years. Well adapted to this disturbance, oaks and madrones may resprout after fire. Because such fires do not kill all trees, varying tree density and multiple forest gaps created by fires are important contributors to structural diversity. Humans often use oak habitats for forestry, livestock grazing, and low-density residential development. Many oak stands in the Willamette Valley are degraded due to fire suppression and human disturbance-induced invasion by Scot's broom, non-native grasses and weedy species. In the absence of fire, this habitat converts to Douglas-fir forest; selective logging of Douglas-fir in oak stands can prevent loss of this important habitat. The historic distribution of oak woodlands was limited to low elevation dry areas with limited conifer competition.

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, limited, and currently declining due to fire suppression, conversion to agriculture and urban habitats, and invasion by non-native species. In the Metro region, this habitat in its native form has virtually disappeared. Sometimes referred to as prairie or, in the Oregon Coast Range, grass balds, this habitat occurs near or adjacent to many other habitats. Often used for grazing and recreation, Westside Grasslands may be grassland or savanna, with less than 30 percent tree or shrub canopy cover. Bunchgrasses dominate native sites, with space between vascular plants covered with mosses, lichens and forbs. Rich diversity of native forbs is typical of sites in good condition. When present, tree and shrub species vary widely. Degraded sites tend to be dominated by exotic grasses. Grassland vegetation provides several essential wildlife functions and values. According to Partners in Flight (2000), 44 breeding bird species are highly associated with grassland/savanna areas in the Willamette Valley. Open meadows are also important to raptors, providing vital hunting grounds and in turn, keeping rodent populations in check.

Historically, dry soils and fire (lightning strikes and intentionally set by indigenous inhabitants to maintain food staples) eliminated or thinned invading trees, but fire suppression over the past century has led to Douglas-fir encroachment, converting many grasslands to shrublands and/or forests. Because grasses have rapid generation turnovers and do not block sun from taller plants, this habitat is particularly vulnerable to invasion by non-native species through human-associated disturbances such as vehicular use or grazing. Prescribed fires and other management activities can help control Scot's broom and Douglas-fir encroachment in these grasslands.

Several bird species dependent on this habitat are state and/or federally at risk, including Streaked Horned Lark (a subspecies of the Horned Lark), Vesper Sparrow and Western Meadowlark. The Western Meadowlark is Oregon's State Bird, and although once common, is now extirpated in the Metro region as a breeding species.

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 et al. 1995). 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 1980's, 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 1960's, 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 prevent or slow urban encroachment and subdivisions into areas zoned as agriculture.

Because this habitat type is human-generated, there is no "natural" disturbance regime. Fire is nearly completely suppressed; in absence of fire or mowing, unimproved pastures become increasingly shrubby. Edges can be abrupt along habitat borders, with important implications for wildlife. Presence of non-cultivated or less intensively managed vegetation such as fencerows, roadsides, field borders and shelterbelts can enhance structural diversity. Integrated pest management plans and similar farming practices can help reduce the impacts of fertilizers and pesticides (Gerard 1995).

Twenty-nine percent of birds and 25 percent of mammals native to Oregon use croplands and pasturelands to meet their habitat needs (ODFW 1993). Agricultural fields left fallow for the winter often provide wintering habitat for migratory birds (ODFW 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 in this scheme 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 non-native species, urban environments provide habitat to some species requiring structures such as cavities, caves, cliffs and rocky outcrops, and ledges. This habitat is subdivided into low-density (10-29 percent impervious surfaces), medium density (30-59 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 et al. 1998). The effects of urbanization on wildlife, including disturbance, habitat loss, conversion and fragmentation, and non-native species invasion, are discussed later in this chapter. Historical natural disturbance patterns are largely absent in urban habitats, although flooding, ice, wind, or fire still occur. Flooding and pollution is more frequent and more severe in areas with significant impervious surface cover and/or modified stream systems. Temperatures are elevated and background lighting is increased; wind velocities are altered by the urban landscape, often reduced except around the tallest structures downtown, where high-velocity winds are funneled around the skyscrapers. Urban development often occurs in areas with little or no slope and frequently includes wetland habitats. This 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). 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, also known by the common name "house bat." This non-migratory species often lives in a variety of artificial structures, eating termites and beetles (Csuti et al. 1997).

Many man-made or artificial structures provide key habitat for wildlife in the urban area (ODFW 1993). For example, bridges provide important bat habitat. Fences, powerlines and poles provide perches from which hawks and falcons search for prey, an important means of rodent control in urban and agricultural settings. 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 a pair of Peregrine Falcons has chosen the Fremont Bridge as a nesting place – similar to the high cliffs that would be attractive in the wild (Sallinger 2000). The bridge provides two important functions for the peregrine falcons: a high, inaccessible nesting spot and easy access to a constant food supply – nonnative pigeons and starlings. Several other nesting Peregrine pairs now also live in the city, and the young produced from these nests represent important contributions to this recovering species.

There are no species at risk dependent upon this habitat.

Impacts of Urbanization

The major impacts of urbanization on upland habitats fall into three main categories: habitat loss, habitat fragmentation, and human disturbance. These impacts change the ecological structure and function of naturally functioning systems in such a way that some wildlife populations decline, others thrive, and new species may arrive on the scene. Urban upland habitats are often fragmented, with residual patches of historic, native vegetation scattered amid urban, residential, and agricultural land uses (Ferguson 2001). The most successful species in the face of a changing landscape are generalists with the ability to adapt and use a variety of habitat types (ODFW 1993). Habitat specialists typically face the most difficulty when confronted with the impacts of urbanization.

Habitat loss and alteration

As discussed above, habitat loss is considered one of the leading causes of global species extinctions (Kerr and Currie 1995). In the Metro region, while we have retained some important natural areas within the urbanized landscape, the vegetation pattern has been dramatically changed since European settlement of the Willamette Valley (see Table 8 for estimated changes).

Habitat loss occurs due to destruction of the natural landscape, but also is a result of a change in the historical patterns of disturbance. Vegetative communities typically go through several stages of succession after a catastrophic event such as a fire or a flood. The historical landscape was composed of a mosaic of vegetation in several stages of succession, providing wildlife with important functions and values. For example, after a fire a typical vegetative community would be a meadow with native grasses. After several years, some shrubs may appear in certain areas, followed by larger trees, such as oak, creating a savanna-like habitat. Without the influence of another fire, conifers may gradually move in, growing taller than the oaks and overtaking the area (ODFW 1993). Each of these vegetative communities is important for a variety of wildlife, and the lack of natural evolutionary processes has reduced the variety of native habitats available. As described in the previous section, current vegetation differs dramatically from the vegetation and habitat historically found in the Metro region.

Habitat fragmentation

Habitat **fragmentation** along with general loss of habitat has been identified as a key factor in the decline of biodiversity throughout the world (Wilcox and Murphy 1985). As urbanization occurs, native habitat is destroyed and the remaining patches become fragmented, similar to islands in a sea of human altered landscape. Urbanization over the past few decades has typically occurred in a leapfrog fashion, and additional wildlife habitat and agricultural land has been converted to an urbanized landscape. Recently, there has been a push towards developing in a compact fashion, reducing the amount of land needed to provide necessary housing, commercial and industrial land. However, there are tradeoffs in encouraging a compact urban settlement pattern that contains sprawl and reduces rural development, as it could encourage habitat fragmentation. In the Metro region policy decisions have been made to simultaneously promote compact urban form that combats rural and habitat fragmentation outside the urban growth boundary and to knit together viable habitats inside the urban growth boundary.

Two theories are especially useful in understanding the unique situations of wildlife species in a fragmented habitat: island biogeography and **metapopulation** theory. Metapopulation theory helps to explain the population dynamics of wildlife species in a fragmented yet connected habitat, whereas island biogeography provides a useful framework for considering patch size, configuration, and connectivity for groups of species at the landscape scale. Both theories may be useful in urban habitats.

The theory of island biogeography has been applied to urban environments to further understand how habitat fragments function and as a basis for developing habitat protection plans (Davis and Glick 1978; Adams 1994; Duerkson et al. 1997). MacArthur and Wilson (1967) proposed the theory to explain species diversity on islands in the Pacific Ocean. It explains the number of species present on various islands based on a relationship between the immigration and extinction rates that are influenced by the size of the island and the distance from the mainland (Adams and Dove 1989). Many researchers have applied this theory to terrestrial habitat "islands", or patches of native habitat surrounded by other hostile land uses (Bolger et al. 1997a). Much of the research has focused on the species-area relationship, which indicates that species richness increases with habitat area (size).

Metapopulation theory can be used to describe subpopulations of wildlife inhabiting a series of connected patches on a landscape scale (Pulliam and Dunning 1997). The subpopulations are linked together by the movements of individuals between patches. A subpopulation on one patch could go temporarily extinct, but as long as the patch is connected to a populated patch it could be recolonized. This is called the **rescue effect**, and is crucial in the maintenance of small populations with limited habitat area (Pulliam and Dunning 1997).

In this section we discuss habitat fragmentation, using island biogeography and metapopulation theory to understand some of the impacts fragmentation has on wildlife. This section covers the issues of:

- Patch size
- Edge effect
- Distance effect
- Age effect
- Connectivity

Patch size

Davis and Glick (1978) first suggested applying island biogeography theory to urban ecosystems, describing each city as a collection of habitat islands. Small cities may be compared to islands close to the mainland, while a large city functions similarly to an island system far from the mainland. Increased urbanization causes more habitat fragmentation and reduces the connectivity necessary for maintaining species richness and preventing local extinctions. An established principle of island biogeography is that the extinction rate in an isolated habitat patch is negatively related to the size of the patch, or the *area effect*. Thus, extinction rates increase as patch size decreases. This phenomenon occurs even in relatively large habitat patches, due to the *edge effects* caused by habitat fragmentation (Soulé 1991a; Bolger et al. 1997a). That is, edge effects increase with increasing levels of fragmentation. Few empirical studies have been conducted to determine the appropriate patch size for various species, especially in an urban landscape (Hostetler and Holling 2000).

Large patches

Several studies have been conducted that indicate a larger habitat patch is better for the survival of native species. Wilcove (1985) studied the level of predation on Neotropical migratory songbirds in the northeastern U.S. and found an increased amount of predation in smaller forest patches. Bolger et al. (1997a), in a study of native rodent populations, found that species diversity increased with patch size. The habitat patches that did not contain native rodents were in general smaller fragments. Larger patches frequently retain more of the functions and values provided by native habitat. For example, many forest interior bird species are dependent on insects for food and a study in Ontario found that invertebrate biomass was 10 to 36 times higher in large forest patches than small forest patches (Burke and Nol 1998).

Much research supports a guideline that a single large patch is more beneficial than several small fragments for vertebrates and potentially other species (Soulé 1991a,b; Bolger et al. 1997a). The basic principle behind this is that extinctions of vertebrate species in similar habitat patches nearly always happens in a regular, predictable order (Patterson and Atmar 1986, quoted by Soulé 1991a). Soulé's studies in canyons near San Diego, California support this theory. In the study the Roadrunner and Black-tailed Gnatcatcher always disappeared prior to other species, as they were most dependent on an undisturbed habitat. Other species would predictably be the last native survivors in an otherwise heavily impacted habitat. Smaller patches by their nature include more edge habitat, which provides more opportunity for habitat generalists and also allows predators increased access to the remaining interior areas.

Long-term trends in wildlife populations are directly related to the area of habitat available – the larger the patch size the longer a population can sustain itself (Duerkson et al. 1997). Some species require a certain amount of territory for foraging and breeding purposes. Other species are limited in population by the amount of resources available within a patch, thus the larger the patch the larger the population. Larger animals typically require a larger amount of land just to support their body mass. For example, a deer forages on a much larger range than a mouse. Predators require an even larger area of land that must support enough of their prey for a sustainable catch (Soulé 1991a).

Large predators play a crucial role in maintaining a functioning ecosystem, and they typically are unable to thrive on small habitat patches (Soulé 1991a; Berger et al. 2001). Large predators such as coyotes or cougars help to maintain biodiversity by suppressing smaller predators such as raccoons and maintaining a more sustainable population of herbivores, which may drastically influence riparian vegetation (Berger et al. 2001). Many smaller predators are extremely destructive to wildlife, especially ground and shrub nesting birds, when their population increases above the equilibrium (Soulé 1991a). Retaining the large predators allows for a functioning system in which populations of various species are kept at natural levels. A study in the Seattle area that characterized the diet of coyotes in an urban environment found that house cats made up 13 percent of a coyote's diet in residential areas (Quinn 1997). House cats have substantial negative impacts on bird and small mammal populations in urbanized areas (Churcher and Lawton 1987). However, this is not to imply that coyote abundance promotes natural biodiversity, just as an example to illustrate the importance of larger predators in an ecological system.

Small Patches

However, there are benefits to preserving smaller habitat patches in certain circumstances. Heske et al. (2001) concluded "...not all small patches are bad..." in a review of several studies on nest predation and songbirds. According to Soulé (1991a) small patches may be sufficient to preserve vegetation communities when the plants are not dependent on fire for regeneration, not subject to loss of genetic variability due to isolation, do not depend on animals for pollination or dispersal, and are able to compete in the absence of the natural disturbance caused by large animals and fire. Many species of rare butterflies are mostly sedentary as adults, and thus require maintenance of specific vegetation in small patches over a larger region (Smallidge and Leopold 1997). Butterflies also may require a series of successional habitats for different lifestages.

Small patches that are well connected to other patches will also provide important functions for wildlife species not dependent on interior habitat. Some species may be able to use small habitat patches that are individually too small by composing a home range made up of multiple habitat fragments (Dunning et al. 1992; Noss and Csuti 1997; Hostetler and Holling 2000). Other species may survive within the urban matrix if they have a series of relatively small patches that are connected by movement corridors (Bolger et al. 1997a). Proximity of small patches to stream corridors and wetlands undoubtedly elevates their significance for wildlife.

Quality of the habitat

The quality of the habitat in a patch is important, large patches that have degraded habitat will not support healthy wildlife populations even though edge effects are reduced (Martin 1993). Haire et al. (2000) found that the plant communities dominated by exotics had a negative effect on the abundance of Western Meadowlarks, demonstrating the importance of native vegetation within a habitat fragment for many species, particularly habitat specialists. In Arizona, Germaine et al. (1998) found a strong correlation between native vegetation and sensitive bird species in the urban area. Beissinger and Osborne (1982) compared bird communities in residential areas with mature trees and nearby undisturbed forests. They found that urbanization impacted the amount of vegetative cover, thus reducing the number of forest insect eating birds and increasing the number and diversity of birds able to glean food from the ground. The type of forest also impacts the quality of the habitat for certain songbirds. Studies have shown that nest predation is higher in coniferous forests than in deciduous forests due to the associated predators such as squirrels found in coniferous forests (Heske et al. 2001).

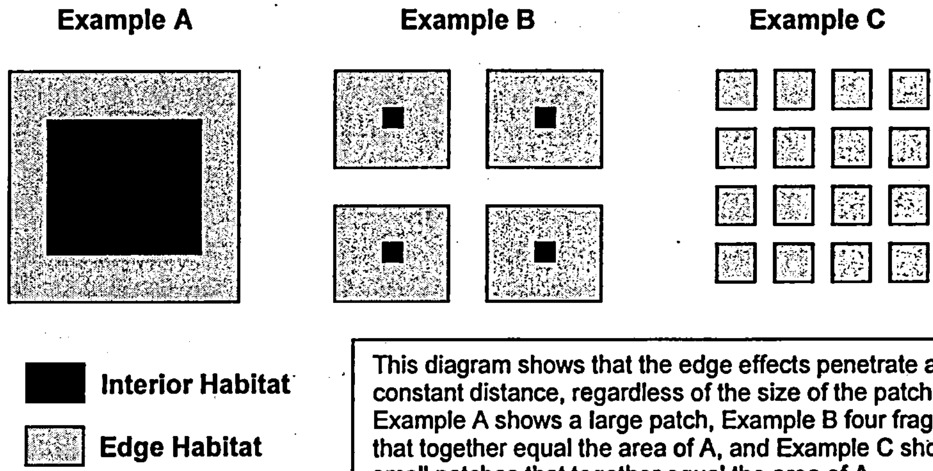
Edge effect

Edge habitat occurs where one habitat type, such as a forest, meets a meadow, stream, road, or other natural or artificial habitat type (Forman and Godron 1986; Lidicker and Koenig 1996). The size of a patch, as well as the relationship with surrounding habitats, has a direct impact on the edge effect on wildlife populations. Species diversity is typically higher in edge habitats, but the number of habitat specialists, or species that require a particular type of habitat for survival, tends to decrease. Patch size and patch configuration both impact the amount of edge habitat – a large square will have less edge habitat and more interior habitat than a long, thinly shaped habitat (Soulé 1991a). Urbanization typically increases habitat fragmentation, providing more edge habitat and reducing the amount of original habitat (Lidicker and Koenig 1996).

The shape of a habitat patch can predict the effectiveness of the area in providing valuable habitat for wildlife. There are two general shapes of patches: circles or squares and rectangles or oblong shapes (Fleury and Brown 1997). Rectangular or oblong patches include more edge habitat and thus are less effective as wildlife habitat, especially for interior species. Circular or square patches often contain more species diversity, allow for increased foraging efficiency, and contain fewer barriers within the habitat patch than rectangular patches (Forman and Godron 1986).

Some species, often called habitat generalists, actually benefit from increased edge effect and fragmentation. Many predators such as foxes and coyotes are better able to hunt along edge habitats, where prey such as birds and small mammals are easier to find. Other species, for example the House Finch, Anna's Hummingbird, deer, and raccoons, have the ability to use resources provided in landscapes that have been altered by humans (Bolger et al. 1997b). Some species rely on interior habitat that is relatively undisturbed, such as the Swainson's Thrush and Winter Wren. Increased fragmentation frequently allows the edge species to thrive while interior dwellers decline (Soulé 1991a; Nilon et al. 1994). Most conservationists agree that too much edge habitat is detrimental for wildlife, and the focus when developing a habitat protection plan should be on retaining as much interior habitat as possible. Soulé (1991a) describes some of the major negative impacts of edge habitats as higher frequency and increased severity of fire; higher rates of hunting and poaching; and higher intensities of predation. Figure 12 below depicts the relationship between patch size and the amount of edge effect.

Figure 12: Relationship between patch size and edge effect.



This diagram shows that the edge effects penetrate a constant distance, regardless of the size of the patch. Example A shows a large patch, Example B four fragments that together equal the area of A, and Example C shows 16 small patches that together equal the area of A.

Source: Adapted from Soulé, 1991.

The edge effect can penetrate far into the interior habitat necessary for certain species. Some studies have shown that certain impacts such as invasion by exotic plants and predation can penetrate up to 500 meters into the forest (Wilcove 1985). Bolger et al. (1997b) found that the abundance of interior habitat bird species was reduced within 200 to 500 meters of an edge. A study in southern Ontario found that ovenbirds, an interior habitat species, select nest sites more than 250 meters from the forest edge, a distance that is not possible in a small habitat fragment (Burke and Nol 1998). Interior habitat specialists may respond to edge effects far from the actual edge habitat (Lidicker and Koenig 1996). Some of the impacts the edge effect may have on interior species include reduced survival rates, reduced reproduction rates and increased emigration from unsuitable habitat (Bolger et al. 1997b). Friesen et al. (1995) found that the edge effects of residential development impacted the diversity and abundance of songbirds in forested habitat patches regardless of the patch size. The response of wildlife movement to edge habitat varies by species, some species will not approach the edge while others will move freely through the edge habitat to another area (Lidicker and Koenig 1996).

Distance effect

Animal movement frequency decreases in direct relation to the distance between habitat patches, and is called the *distance effect*. Increased habitat fragmentation impacts the ability of wildlife to disperse between habitat patches (Soulé 1991a). Dispersal of animals between patches helps to preserve populations by protecting against catastrophes and preventing genetic decline due to inbreeding (Soulé 1991a; Lidicker and Koenig 1996). The distance effect can be observed in compact island archipelagos that have more species diversity than remote islands, because proximity facilitates the rescue of endangered populations and allows for the recolonization of islands where extinctions have occurred. However, the distance between habitat fragments need not be great before it begins to have an impact if a species is unable to move through the matrix of modified habitat (Bolger et al. 1997a).

Age effect

Another impact of fragmentation is called the **age effect.** This refers to the amount of time a fragment has been separated from the "mainland" or the surrounding landscape by urbanization. The length of time that a habitat patch has been fragmented typically correlates to lower native species diversity. Bolger et al. (1997a) found that in a time span of 20-80 years all native rodents had disappeared in over half of the habitat patches studied. Soulé et al. (1988) found that the size of patch along with the length of time a patch had been fragmented explained most of the variation in the number of bird species found within a habitat patch.

Connectivity

"When urbanization is occurring...habitat fragmentation is inevitable, and one of the only practical mitigation measures is the establishment of corridors of natural habitat or linkages, such as underpasses, that permit dispersal across barriers." (Soulé 1991a)

Habitat corridors may be defined as strips of habitat that allow the movement of organisms through the landscape matrix and between habitat patches (Lidicker and Koenig 1996; Beier and Noss 1998). The general consensus is that connections between habitat fragments are crucial to the survival of many species, and that well designed corridors can play a key role in maintaining ecosystem vitality (Adams and Dove 1989; Soulé 1991a,b; Beier and Noss 1998). Corridors provide the opportunity for many species to traverse through habitat that is not suitable for permanent residency to find better habitat, find a mate, dispersal of post-breeding young, or to escape over-predation or other dangers in their current habitat (Lidicker and Koenig 1996). Corridors tend to be most effective if they are not overly long, if there are few gaps, if the width is consistent, and if the corridor does not harbor an excessive number of predators (Lidicker and Koenig 1996). The functional role of corridors is related to the scale at which animals perceive their environment, and little research has been conducted on the kinds of corridors necessary for specific species (Lidicker and Koenig 1996; Clergeau and Burel 1997). Metapopulation theory and modeling provides much of the support for the use of corridors in wildlife conservation (Hess 1993).

Connectivity is important for wildlife for several reasons. Wildlife populations that are connected to each other are more likely to survive over the long term than an isolated population (Lidicker and Koenig 1996; Duerkson et al. 1997). A population that exists on a connected system of habitat fragments will be more likely to survive a catastrophic event on one patch, and the surviving population may be able to repopulate or revive an area that is in trouble (Hess 1994). Many species must migrate seasonally to meet basic needs for food, shelter and breeding, and connections between habitat patches allow this migration to occur (Lidicker and Koenig 1996; Duerkson et al. 1997). Connectivity between habitats allows populations to interbreed, which aids in the vigor and survival of the overall population by reducing genetic inbreeding (Duerkson et al. 1997). Corridors play an important role in urban areas to provide opportunity for migration and movement, especially between upland and riparian habitats.

Several studies show the importance of corridors and connectivity for wildlife. Clergeau and Burel (1997) studied the Short-toed Tree Creeper, a small bird, in an agricultural area of France. Their study confirmed that the birds relied on the habitat connectivity provided by hedgerows to contain home ranges and to avoid long flights. Bolger et al. (1997a) identified the lack of connectivity between habitat fragments as an important possible cause of the extinction of native rodent species in over half of the sites studied near San Diego, California. In a study of the dispersal behavior of three migratory bird species in North Dakota, Haas (1995) found that movements by adult birds between habitat patches occurred more frequently between sites connected by a wooded corridor than between unconnected patches.

The benefits of habitat corridors have been heavily debated in the scientific literature (Simberloff and Cox 1987; Adams and Dove 1989; Soulé 1991a; Lidicker and Koenig 1996). Connectivity is important within a fragmented landscape. However, while corridors provide many benefits, there are some potential disadvantages, although they have not been quantified (Simberloff and Cox 1987; Adams and Dove 1989). Researchers speculate that corridors may allow exotic species, including plants, animals, and birds, easier access to invade native habitats and may serve as reservoirs of edge and introduced species (Simberloff and Cox 1987; Simberloff et al. 1992). Corridors may also allow for easier transmission of disease, faster predator movement, and could concentrate species in one area leaving a population more vulnerable to a catastrophic event (Adams and Dove 1989; Simberloff et al. 1992; Duerkson et al. 1997).

Hess (1993) developed a model that showed a landscape of connected patches generally suffered fewer metapopulation extinctions than a landscape of isolated patches. Beier and Noss (1998) conducted a review of scientific studies on the benefits and negative aspects of corridors. While the overall conclusion was that the literature is not yet sufficient to declare the positive value of corridors, several studies showed that corridors function as travel connections for wildlife in real life, and no studies provided empirical evidence of negative impacts from corridors. The literature appears to indicate that the benefits of a connected landscape typically outweigh the potential negative effects of corridors, especially in urban environments (Soulé et al. 1988; Beier and Noss 1998).

Fleury and Brown (1997) developed a framework for the design of wildlife corridors that considered critical corridor characteristics. Some of the general principles identified in the study were:

- corridors should be oriented perpendicular to habitat patches to direct wildlife through the corridor;
- barriers or breaks in the corridor should be minimized;
- corridors should be as short as possible to reduce the risk of mortality;
- corridor width should be based on the minimum width needed for the target species highest on the food chain; and
- corridors should be shaped as close to a rectangle as possible.

The size and shape of a corridor can have a direct impact on the effectiveness of the corridor for wildlife movement. The most effective corridor shape is a rectangle, directing animals straight through the corridor from one habitat patch to another (Fleury and Brown 1997). Soulé (1991a) concluded that any shape other than rectangular can increase the amount of time that must be spent in edge habitat, and that the most effective corridors have straight sides and a constant width.

Human disturbance

Humans introduce a wide variety of changes to the environment, and the specific effects of these changes remain largely unknown. Because human population has grown so quickly during the past century, changes have been rapid and are accelerating. There is no single solution to the complex environmental challenges posed by humans, but focusing on the most pervasive issues is an effective way to begin addressing the problems. The most obvious result of human disturbance is the loss, alteration and fragmentation of habitat, as discussed above. Here we focus on human disturbance in natural areas and some of the consequences to wildlife and habitat.

Nonnative species

Nonnative species – those that originate from outside the U.S. – pose a major threat to native species. Over 50,000 species have been introduced in the U.S., both intentionally and unintentionally. Of all the species listed as threatened or endangered under the federal Endangered Species Act (ESA), 42 percent are at risk primarily due to nonnative species (Wilcove et al. 1998). Excluding the enormous expenses involved with ESA listings and subsequent recovery efforts, nonnative species cost the U.S. more than $138 billion per year in environmental damage and losses (Pimentel et al. 2000). The rate of species introductions is increasing sharply, and successful nonnative species introductions are usually irreversible (Alan 1995). At least 42 nonnative vertebrate species occur in Oregon and Washington; about half of these have achieved widespread distribution and pose a threat to native biodiversity (Witmer and Lewis 2001). Early detection and rapid response to new invasions are key to controlling nonnative invasions (Toney et al. 1998).

Nonnative plants and animals are typically generalists that can thrive in a variety of habitats. They tend to respond positively to disturbance and often lack natural predators (Parendes and Jones 2000). Native species are not evolutionarily adapted to compete with nonnatives (Alan 1995). Nonnative species may alter habitat, introduce diseases and parasites, change community structure, and compete or hybridize with native species, but predation is a common cause of the replacement of native species with nonnatives (Alan 1995). Nonnative invasions regularly occur in upland, riparian, and aquatic habitats (Witmer and Lewis 2001). In the northwestern U.S., recent decades have seen a shift from primarily herbaceous toward greater proportions of shrub and tree invaders (Toney et al. 1998).

In natural circumstances, one or more types of barriers may prevent nonnative plant or animal invasions. These include biological barriers, such as low seed production; physical barriers affecting travel pathways, such as oceans, mountains, or closed canopy forest; or environmental barriers, such as unsuitable light, soil or moisture conditions (Parendes and Jones 2000). Human disturbance is one common pathway for nonnatives to overcome these barriers (Witmer and Lewis 2001).

Nonnative species have a strong impact on native plants and wildlife in the Metro area. In the Metro region, problematic nonnative plants include Himalayan Blackberries, English Ivy and Reed Canarygrass. Japanese knotweed is gaining a foothold and kudzu, an aggressive nonnative plant that has devastated areas of the south, recently appeared in southwest Portland (Toney et al. 1998; Christ 2000). European Starlings were the most abundant bird species detected in 54 sites in this area (Hennings 2001). Starlings monopolize nest cavities and may eradicate native bird species in some small habitat patches (Weitzel 1988). Other nonnative birds in our area include House sparrow, Rock Dove (pigeon), Monk Parakeet, and Ring-necked Pheasant. Nonnative Fox Squirrels and Eastern Gray Squirrels are contributing to the decline of native Western Gray Squirrel populations (Marshall et al. 1996). House Mouse, Norway Rat, Black Rat and Nutria are other common Metro area nonnative animals. Common Snapping Turtles and Red-eared Sliders are two nonnative turtles that have successfully established breeding populations in our area (Witmer and Lewis 2001). The number of nonnative insects competing with natives (which include critical native plant pollinators) is probably quite significant, but unknown because insects are relatively unstudied. Management activities that minimize favorable conditions for nonnative species would greatly benefit native wildlife in our region.

Increased predation and competition

Urbanization tends to increase predation and competition in native wildlife communities, due to changes in habitat (see *Habitat fragmentation* section above) and wildlife community structure. These effects are well documented for birds (Small and Hunter 1988; Marzluff et al. 1998). In Seattle, Washington researchers are monitoring birds and small mammals across an **urban gradient**. Their data indicates that small mammals tend to increase with urbanization. These increases are accompanied by a decrease in bird nest success, because small mammals such as mice routinely eat bird eggs. Domestic cats pose another threat to native wildlife, and are the primary reason for injured native wildlife brought to the Audubon Society of Portland's Wildlife Rehabilitation Center (Sallinger 2001, personal communication), and in England were shown to cause at least 30 percent of sparrow mortality (Churcher and Lawton 1987). Increased competition from native birds can also be a problem; Brown-headed Cowbirds lay their eggs in host species' nests, effectively decreasing reproductive success of the host. Cowbirds are edge-associated and are quite successful around humans (Lown 1980; Brown 1994; Larison et al. 1998).

Roads

Roads, while important to society, have widespread negative impacts on native plants, fish, and wildlife. Direct road effects include geomorphic (sedimentation and landslides), hydrologic (intercept rainfall and subsurface water moving down hillslopes; concentrate flow; and divert or reroute water), site productivity (remove and displace topsoil, alter soil properties, change microclimate, and accelerate erosion), habitat fragmentation and alteration, and biological invasions (Gucinski et al. 2001). Forman (2000) estimates that one-fifth of U.S. lands are directly ecologically affected by public roads.

Roads are a leading threat to biodiversity, for a variety of reasons (Wilcove et al. 1998; Trombulak and Frissell 2000). Trees and other vegetation are removed to build the road. Roads fragment habitat, increase wildlife mortality, and promote dispersal of nonnative plants because they alter habitats, stress native species, and provide seed resources and dispersal corridors (Parendes and Jones 2000; Trombulak and Frissell 2000). Road networks contribute more sediments to streams than any other land management activity, from both surface erosion and landslides, degrading water quality and smothering gravel beds (Jones et al. 2000; Gucinski et al. 2001; Gucinski et al. 2001; see also Riparian and Aquatic Habitat chapter). Contaminants such as oil, gas and other toxins washing off roadways may pollute adjacent areas and degrade habitat. Roads add substantially to the total load of impervious surfaces in a watershed.

Wildlife most at risk due to roads include species that avoid edge environments, occur in low densities, are unwilling or unable to effectively cross roads (e.g., amphibians), or seek roads for heat (snakes) or food (owls) (Fleury and Brown 1997). In Tennessee, roads significantly depressed the abundance and richness of insects living in the soil (Haskell 2000). In addition, road noise may negatively influence wildlife through behavior modification. For example, birds sing during the breeding season to attract mates and defend their territories, but this effort is wasted if it cannot be heard. Local data suggests that long-distance migratory species such as Black-headed Grosbeak and Common Yellowthroat are especially susceptible to negative road impacts (Hennings 2001); reports elsewhere support this observation (Forman and Deblinger 1999; Ortega and Capen 1999). There is evidence of a time lag between road-building and species loss in wetlands (Findlay and Bourdages 2000), emphasizing the need for long-term studies.

Recreational use and human disturbance

The protection of wildlife and habitat also provides recreational opportunities for people. This is positive in that people desire to connect with nature, and exposure to wildlife and natural areas encourages people to care about preserving those natural values. In addition, many local communities benefit from dollars spent on hunting and wildlife watching (Wiedner and Kerlinger 1990; U.S. Fish & Wildlife Service 1997a). However, recreation in wildlife habitats is negative in that human intrusions lead to alterations in habitat – for example, vegetation trampling, trails and roads – and may alter wildlife behavior, physiology and distribution.

Some wildlife species are more sensitive to human intrusions than others (Major 1990; Gutzwiller et al. 1998), and some life history phases are more vulnerable to disturbance than others. For example, in the Metro region Steller's Jays and Swainson's Thrushes may be especially vulnerable to recreational disturbances during the breeding season (Hennings 2001). Montana studies suggest that breeding birds and young are very vulnerable, and may abandon nests or fail to feed young when disturbed (Montana Chapter, The Wildlife Society 1999). In Madrid, bird abundance and species richness declined when pedestrians walked near sampling points (Fernández-Juricic 2000). Bats are particularly sensitive to human disturbance, especially during breeding or hibernation (Montana Chapter, The Wildlife Society 1999). Carnivores are mixed in susceptibility – some thrive near humans (e.g. skunks, raccoons, coyotes), but others, such as wolves, black bears and fisher, may abandon den sites when disturbed (Montana Chapter, The Wildlife Society 1999), and it may be no coincidence that these former Metro-area inhabitants are now conspicuously absent. In Colorado, elk experienced reproductive failure when repeatedly approached by humans (Phillips and Alldredge 2000).

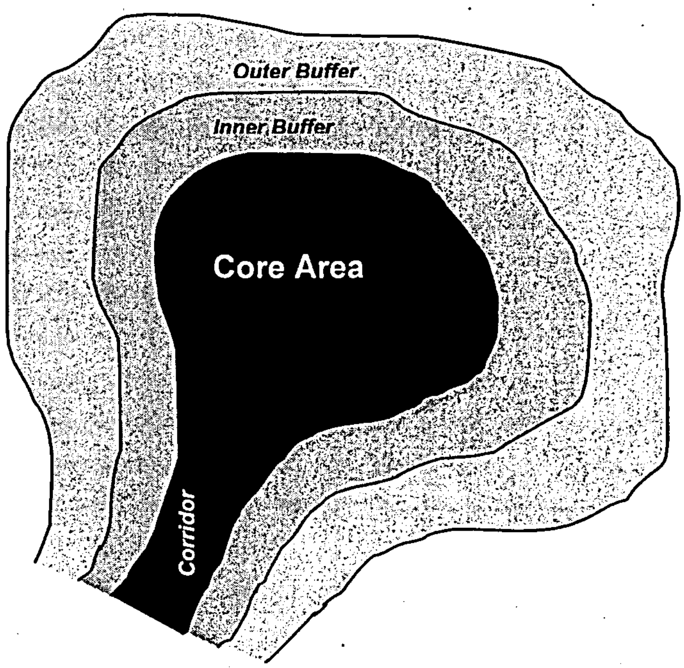
In addition to detrimental effects of roads and trails in natural areas, vegetation changes are another byproduct of recreational use. For example, in Washington State a recreational area was systematically exposed to vegetation trampling. In response, the amount of grasses and herbs increased, while the structurally important woody species decreased (Cole and Trull 1992). In a multi-state study including Washington, researchers found that one night of camping was sufficient to eliminate 30 to 50 percent of the vegetation from high-use portions of the campsite (Cole 1995). A Colorado study of military training on soil and vegetation properties found a 68 percent decrease in total above-ground plant mass, a 91 percent decrease in organic litter, decreased water infiltration and increased soil erosion when comparing high-use sites against a reference site (Whitecotton et al. 2000). As discussed above, roads (and similarly, trails) provide a means of nonnative plant invasion.

Buffers and Surrounding Land Use

The effectiveness of a habitat patch relates to the surrounding land use as well as its size, proximity, and connectivity to nearby patches. The landscape of an urbanized area is composed of habitat patches and connecting corridors embedded within a matrix of land altered by human activity (Linehan et al. 1995). Thus the matrix of the altered landscape covers more area than the habitat patches within it, and correspondingly plays a large role in the landscape dynamics. Friesen et al. (1995) studied the effects of residential development around forested habitat areas on Neotropical migrant songbirds in Ontario, Canada. The study found that the level of residential development drastically reduced the abundance and diversity of the songbirds, regardless of the size of the forest patch. The authors concluded that solely retaining intact forests is not enough to maintain healthy forest ecosystems that are able to support interior habitat specialists.

Habitat patches may be more valuable for wildlife and people if they are surrounded by a buffer zone within which low impact human activities may occur, reducing edge effects and leaving the inner core habitat with as little disturbance as possible. While a buffer zone is by nature edge habitat, the "permeability" or softness of the edge has a direct impact on the ability of species to disperse and populate surrounding areas (Lidicker and Koenig 1996). Some species may be able to move through the matrix of land uses from one habitat fragment to another, while less mobile species may be trapped by the surrounding land uses. Berry et al. (1998) found that some bird

Figure 13. Example of a buffer system protecting a core area for wildlife habitat.



Core area: this area provides the highest level of protection for wildlife, with minimal disturbance allowed

Inner buffer: low impact human activities are allowed in an inner buffer, such as nature trails, wildlife observation areas, and play areas

Outer buffer: more disturbance is allowed in the outer buffer, such as low density or clustered residential development

Source: Adapted from Adams and Dove, 1989.

species are more sensitive to urbanization of the landscape than others, indicating a need for additional buffers to protect habitat for these species.

One approach to counteracting the impact of edge effects is to protect habitat reserves by designing a system of buffers to protect wildlife from surrounding land uses, as well as to allow recreational use of a habitat reserve system. Figure 13 below depicts a core area and two types of buffers surrounding it. Little to no human disturbance would be allowed to intrude within the core area. The inner buffer could include nature trails and other opportunities for low impact human recreation, while the outer buffer could allow for low-density residential development or another low impact development type (Adams and Dove 1989; Adams 1994). Little research is available on the appropriate size of buffer widths and the types of activities that may occur within buffers that do not excessively impact interior habitat specialists.

Low-density residential uses are often seen as having the least impact on wildlife habitat, particularly for birds (Nilon et al. 1994). However, there are still several negative impacts such as an increase in small predators such as domestic cats and dogs, increased fragmentation due to roads and trails, and increased human use of habitat areas for recreation and relaxation. Theobald et al. (1997) found that clustered development patterns reduce the negative impacts of human disturbance on wildlife. The pattern of development was found to be more of an indicator of disturbance level than density. Blair (1996) found that the composition of bird communities changed from predominantly native species in undeveloped areas to nonnative birds in highly developed downtown areas. Studies have shown that habitat patches surrounded by agricultural uses have an especially high rate of nest predation (Heske et al. 2001).

Upland Habitat Patch Size and Connectivity Recommendations

Planning for wildlife habitat reserves in urban areas brings up many considerations, including the issue of providing habitat for species that are often sensitive to human activity while at the same time providing people the opportunity to use open spaces within the city for recreation and wildlife viewing (Johnson 1995). Some wildlife species have the ability to utilize many types of habitat and adapt well to the presence of people. Other species require a specific habitat type, and many species require the ability to migrate from one habitat type to another to fulfill basic needs such as foraging, breeding, and safe shelter. Habitat specialists will require the protection of larger reserves, but other wildlife species can be retained in the city if required habitat elements are provided within the context of urban development (Donnelly and Marzluff *in review*). Wildlife habitat can be provided in many ways: large natural areas, small portions of city parks that are left "wild", cemeteries, schoolyards, bridges and other man-made structures, and even backyards. Retaining native biodiversity will require a protection plan that utilizes an array of strategies to maintain and restore wildlife habitat.

Human impacts on wildlife can be minimized with the proper design of habitat reserves, based on the surrounding land uses. The movement needs of wildlife can be provided for using corridors, which may be described as linear (often narrow) strips of habitat embedded in other land uses that have value for wildlife by connecting fragmented patches of habitat (Adams and Dove 1989; Beier and Noss 1998). The effects of fragmentation can be combated to a certain extent by providing connections between remaining fragments. Soulé (1991a) states: "Wildlife corridors can be viewed as a kind of landscape health insurance policy – they maximize the chances that biological connectivity will persist, despite changing political and economic conditions." Corridor design, however, depends on the specific species or **species guild** that is being planned for as well as accounting for local conditions (Linehan et al. 1995). Human impacts can be further mitigated through management and design regulations for urban development as well as increasing the diversity and abundance of native vegetation in urban parks (Lancaster and Rees 1979).

Corridors often naturally follow utility rights of way, fencerows, trails, and riparian areas. The size of habitat patches are an issue in both rural and urban environments, as larger patch size typically provides more functions and values for wildlife than a smaller habitat area. However, small patches of unique habitat may provide the key in retaining sensitive species within an urban area. A functioning system of small patches can provide an overall benefit to wildlife if designed with connectivity in mind.

The most important conclusion from the scientific literature in planning to protect habitat for wildlife is that "the best way to maintain wildlife and ecosystem values is to minimize habitat fragmentation" (Soulé 1991a). There is no single method for retaining and restoring the natural ecosystems necessary for wildlife in the urbanizing landscape that has been proven to work. However, maintaining a system of habitat patches, large and small, that are as well connected as possible appears to be the most likely solution (Linehan et al. 1995).

While specific guidelines regarding patch size and shape, corridor width, and proximity have been developed in other regions, there are no universally applicable recommendations. For example, the Wildlife Division of Environment Canada (1998) has developed specific recommendations such as providing at least one 200 hectare forest patch that is a minimum of 500 meters in width to provide interior habitat within a subwatershed. In Arizona, Germaine et al. (1998) recommended retaining habitat patches greater than one hectare containing native vegetation throughout the urban matrix to allow provide for sensitive bird species. Table 11 below depicts a summary of planning guidelines derived from the scientific literature. In the future, as more local information becomes available, more precise recommendations may be developed for upland wildlife habitat.

Upland habitat areas play a crucial role in retaining native biodiversity as well as maintaining healthy ecosystems. As discussed above, urbanization of the landscape negatively impacts wildlife through habitat loss, habitat fragmentation, and human disturbance. In the Metro region we still have remnants of the diverse native habitat that blanketed our region prior to settlement in the 1850s. Abundant wildlife supported generations of Native Americans as well as European settlers arriving in the region. Today's residents continue to appreciate the accessibility of wildlife while enjoying the benefits of a city. The Metro region is projected to grow by around 500,000 people in the next twenty years. If retaining access to open spaces and the opportunity to view wildlife in the city is to remain a priority it becomes even more important to plan for a well conceived system of habitat preserves and corridors throughout the region.

Table 11. Planning guidelines for upland wildlife habitat

Guideline	Explanation	Supporting literature
Large patches are better than small patches, and they should be round or square to reduce the amount of edge effect	• Research shows that the edge effect ranges from 200-500 meters • Larger patches provide more interior habitat • Can support a larger number of individuals and a greater diversity of species • Can support a wildlife population for a longer time period • Provides greater opportunity for foraging and dispersal	Wilcove 1985 Forman and Godron 1986 Soulé 1991a Bolger et al. 1997a Duerkson et al. 1997 Fleury and Brown 1997 Germaine et al. 1998 Burke and Nol 1998 Environment Canada 1998
Small patches of unique habitat are worth saving	• Can retain unique vegetation communities • May provide "stepping stones" of habitat if in relatively close proximity, or in combination with habitat corridors • Can provide habitat for generalist and edge species • Especially important if near water resources	Soulé 1991a Dunning et al. 1992 Noss and Csuti 1997 Bolger et al. 1997a Environment Canada 1998 Hennings 2001
Connectivity to other patches is important, corridors should be as wide as possible, and it is cheaper to retain corridors than to create them after the fact	• Can play a key role in maintaining ecosystem vitality and the survival of may species • Connected populations are more likely to survive over the long term • Allows populations to interbreed, maintaining genetic variability • Provides movement corridors for seasonal migration, finding better habitat, finding a mate, dispersal of post-breeding young, and escape routes	Adams and Dove 1989 Soulé 1991a Linehan et al. 1995 Lidicker and Koenig 1996 Bolger et al. 1997a Clergeau and Burel 1997 Fleury and Brown 1997 Environment Canada 1998
Connectivity and/or proximity to water resources is valuable	• Habitat patches near water resources have increased diversity of wildlife • Most wildlife species use riparian areas for some aspect of their life history • Over 60 percent of mammals in the Northwest use riparian areas for breeding or feeding • Riparian corridors frequently serve as travel routes, especially in urban areas	Forman and Godron 1986 Environment Canada 1998 Hennings 2001 Kauffman et al. 2001
Buffers can help protect wildlife from human disturbance	• Surrounding land uses have an impact on the effectiveness of a habitat patch in providing functions and values to wildlife • People like to use natural areas and open space for recreation • A buffer zone allows for human use of a selected part of a habitat patch, while protecting wildlife from excessive disturbance	Adams and Dove 1989 Adams 1994 Nilon et al. 1994 Friesen et al. 1995 Linehan et al. 1995 Lidicker and Koenig 1996

Protecting upland habitat areas in this region will be a challenge while also ensuring enough land for urban development. However, the integration of these two seemingly contradictory goals is a central tenet of the Region 2040 Growth Concept, the Regional Framework Plan, and the Urban Growth Management Functional Plan. It is also much cheaper to protect existing habitat than to attempt to restore degraded habitat. The Metro Parks and Greenspaces Department and local park providers have been purchasing key natural areas throughout the region from willing sellers with the 1995 bond measure. Acquisition of habitat is one of the best methods to ensure a piece of land will remain in its natural state. However, there is not enough money available to purchase the amount of land necessary to provide a functioning system of habitat reserves and corridors that could maintain native biodiversity in the region. Education and incentives for landowners to manage private property to provide wildlife habitat would help to meet objectives of retaining native wildlife. A regulatory program that helps to guide urban development in a way that retains as much functional value for wildlife as possible will most likely be a necessary tool, combined with acquisition and incentive programs, to meet the objective of maintaining the region's biodiversity and implementing the Region 2040 Growth Concept. This approach may be most appropriate when planning for future urban areas that are brought within the urban growth boundary, when it would be possible to plan for wildlife preserves and corridors.

RESTORATION IN AN URBAN ENVIRONMENT

Introduction

Environmental degradation affects everyone. The ecological impacts associated with increasing human populations stress the environment, and it is critical to find ways to reduce these stresses if people, plants and wildlife are to be protected. Rapid population growth and dwindling salmon runs in the Metro region add a sense of urgency to such efforts. There is no quick or easy answer; most people do not want to contribute to fish and wildlife extinctions or widespread environmental degradation, yet few are certain what changes could be made to avert such problems.

Metro's Regional Urban Growth Goals and Objectives (RUGGOs) call for Metro to "protect, restore and ensure to the maximum extent practicable the integrity of streams, wetlands and floodplains, and their multiple biological, physical and social values" (Metro 1995). Accordingly, the purpose of this chapter is to outline an approach to habitat restoration that is based on science, relevant to urban ecosystems, and grounded in reality.

Urbanization negatively affects native fish and wildlife through impairment of the natural functions that create and maintain suitable habitat. Some degree of measurable resource degradation can be detected at virtually any level of urban development, but degradation can be mitigated by activities such as increasing or retaining forest canopy cover and reducing effective impervious surfaces (Shaw and Bible 1996; Booth et al. 1997; Booth 2000). Restoration can assist the recovery of functions necessary for watershed health; in turn, healthy watersheds can support people, fish and wildlife. Efforts to protect and restore habitat can, in many instances, also benefit humans by reducing flood damage and protecting water quality (Lucchetti and Fuerstenberg 1993a,b).

Successful restoration depends on addressing the causes of environmental degradation, rather than the symptoms. Goodwin et al. (1997) suggest asking several questions related to the causes of degradation: Is the disturbance local to the riparian area or does it originate outside in the adjacent upland or watershed? Is the disturbance ongoing, and if so, can it be eliminated? And finally, will recovery occur naturally if the disturbance is removed? The answers to these questions can help guide a restoration plan.

Four major impact categories – altered hydrology, water quality, loss of natural vegetation cover, and impervious surfaces – appear repeatedly in the literature addressing urban ecology. Combined with the presence of humans in the system, these impacts lead to: diminished stream channel and riparian corridor integrity; degraded water quality (chemistry); habitat loss, simplification and fragmentation; altered food webs; nonnative and invasive species invasions; changes to climate and microclimate conditions; and harassment, noise, vibration, light, and other human disturbances to wildlife.

These impacts cannot be realistically addressed through site-specific or small-scale restoration approaches; virtually all recent restoration literature suggests that watersheds are the *minimum* spatial unit for which restoration master planning should occur (e.g., Spence et al. 1996; Dombeck et al. 1997; Goodwin et al. 1997; Hollenbach and Ory 1999; IMST 1999; Watershed Professionals Network 1999). In urbanized regions such as ours, impacts in one watershed may influence adjacent or downstream watersheds. Thus all watersheds within the urban area, plus all adjacent watersheds, should be considered in a master restoration plan. The National Marine Fisheries Service (2000b) commented on the importance of considering restoration projects in a large-scale context:

> Projects planned and carried out based on at least a watershed-scale analysis and conservation plan and, where practicable, a sub-basin or basin-scale analysis and plan, are likely to be the most beneficial. NMFS strongly encourages those involved in watershed restoration to conduct assessments that identify the factors impairing watershed function, and to plan watershed restoration and conservation activities based on those assessments. Without the overview a watershed-level approach provides, habitat efforts are likely to focus on "fixes" that may prove short-lived (or even detrimental) because the underlying processes causing a particular problem may not be addressed.

Much of the information available on restoration deals with waterways because of their importance to humans, fish and wildlife, vulnerability to degradation, and influence on other parts of the landscape. In addition, many regional restoration efforts focus on instream and riparian restoration within limited areas to address ESA-listed salmonid recovery (Spence et al. 1996). These are good reasons to focus on stream systems, but this approach fails to adequately protect functions critical to other wildlife species and also fails to take into account the majority of the watershed: uplands.

Uplands provide unique and important wildlife habitat, such as oak-madrone and native grasslands (Larsen and Morgan 1998). Upland habitats also influence stream functions; for example, the amount of forest canopy cover strongly influences the health of Pacific Northwest streams (Shaw and Bible 1996; Booth et al. 2001). Uplands are vital components in any watershed, and the ecological principles and restoration concepts addressed in this chapter are meant to provide a restoration framework at the watershed scale or larger; therefore, uplands are implicitly included here and should be considered in watershed restoration planning. Well-planned watershed conservation and restoration efforts today may prevent future ESA listings, and will almost certainly benefit people and wildlife.

Definition of restoration and other terminology

Most definitions of ecological restoration involve the functional recovery of human-degraded ecosystems. For example, the Society for Ecological Restoration (SER) defines **ecological restoration** as the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices (SER 2000) (Appendix 5). The Oregon Division of State Lands defines riparian restoration as "the rehabilitation of riparian areas to improve degraded functions" (Van Staveren et al. 1998). Title 3 defines restoration as the process of returning a disturbed or altered area or feature to a previously existing natural area; restoration activities reestablish the structure, function, and/or diversity to that which occurred prior to human impacts (Metro 1998). The National Marine Fisheries Service (NMFS) considers a "habitat restoration activity" to be an activity whose primary purpose is to restore natural aquatic or riparian habitat processes or conditions; it is an activity that would not be undertaken but for its restoration purpose (NMFS 2000b).

Full ecological restoration is probably not possible in urban areas, because some changes are relatively permanent (such as roads and structures) and due to the cumulative nature of changes to urban watersheds (Beschta 1995; Goodwin et al. 1997). In reality, urban "restoration" may represent a range of improvements in function and condition over time, limited in an urban setting to what is actually achievable - in other words, an ecologically, economically and socially acceptable range of options that re-establishes natural functions. The end goal is sustainability, under a new urban equilibrium that is different from that in the original ecosystem, but which supports diverse wildlife communities and healthy ecosystems.

The scientific literature reflects this reality through a variety of terms, all defining lesser versions of full restoration (e.g., restoring targeted functions rather than the full range of original functions). Title 3 defines **Mitigation** as measures used to reduce the adverse effects of a proposed project by considering, in the following order: a) avoiding the impact altogether by not taking a certain action or parts of an action; b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitating or restoring the affected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action by monitoring and taking appropriate measures; and e) compensating for the impact by replacing or providing comparable substitute water quality resource areas (Metro 1998). Mitigation will not necessarily result in a net ecological gain.

Enhancement is the alteration and/or active management of existing habitat to improve particular functions and values (Kauffman et al. 1997); enhancement activities may or may not return the site to pre-disturbance conditions, but create or recreate functions and processes that occur naturally. SER suggests the term **rehabilitation** for projects that are unlikely to achieve full ecosystem restoration, commenting that the term "restoration" is frequently applied inappropriately to site- or species-specific projects, or those designed to attain economic objectives (Clewell et al. 2000). SER is a leading scientific restoration organization and provides standardized terminology that is widely used and understood by restoration specialists. However, outside of scientific circles the term "restoration" is commonly used to refer to activities such as enhancement and rehabilitation. For the purposes of this document we will use the term "restoration" instead of rehabilitation or enhancement, while recognizing that full ecological restoration is unlikely in the urban environment.

Types of restoration

Passive restoration

Passive restoration allows natural processes to return through reducing or halting activities that cause degradation or prevent recovery (Kauffman et al. 1997). In riparian corridors, this often means removing the damaging influences and letting the river or stream do the work (Hollenbach and Ory 1999). Passive restoration techniques include retaining riparian buffers, altering land use designs in a watershed to reduce soil erosion and increase stormwater infiltration, keeping toxic chemicals out of the water, managing the adverse impacts of construction, and reintroducing or allowing the presence of beaver (Horner et al. 2001). Many Best Management Practices (discussed below) are forms of passive restoration.

Active restoration

Active restoration refers to changing the ecosystem to reestablish desired biological and physical functions. Some forms of active restoration – such as planting native vegetation and removing exotic vegetation and fish-blocking culverts – have a relatively low risk of failure, even in an urban setting. Other active restoration efforts – such as making instream improvements – are less likely to succeed in an urban setting because of **cumulative impacts**, and should be used with caution. Some active restoration options are discussed in the BMPs and Site Specific Restoration section (see also Table 13 and Appendix 6).

Elements of successful restoration

A limited set of urban literature and substantial non-urban literature can provide clues as to how to approach urban restoration. Several concepts appear repeatedly in the literature and appear important to successful restoration efforts. These fall under the categories of master planning, using a scientific approach, monitoring and adaptive management, and considering urban-specific impacts.

SER provides a set of general, conceptual guidelines for conceiving, organizing, conducting, and assessing ecological restoration projects (Clewell et al. 2000). These guidelines apply to any ecosystem, terrestrial or aquatic, and are available online at SER's website. SER advises that plans for restoration projects should contain, at a minimum, the following items:

- A baseline ecological description of the kind of ecosystem designated for restoration, which accounts for the regional expression of that ecosystem in terms of the **biota** and poignant features of the abiotic environment.
- An evaluation of how the proposed restoration will integrate with other components of the regional landscape, especially those aspects of the landscape that may affect the long term sustainability of the restored ecosystem.
- Explicit plans and schedules for all on-site preparation and installation activities, including plans for contingencies.
- Well developed and explicitly stated performance standards, by which the project can be evaluated objectively.
- Monitoring protocols by which the performance standards can be measured.
- Provision for the procurement of suitable planting stocks and for supervision to guarantee their proper installation.
- Procedures to expedite promptly any needed post-installation.

Master planning for restoration

Ecosystems are incredibly complex with numerous interactions between components, and any attempts to restore urban ecosystems must start with master planning. Planners should consider the largest spatial and time scales possible for a framework, then use a hierarchical scheme (e.g., basin; subbasin; watershed; subwatershed; stream reach) for master planning, implementation and monitoring (U.S.D.A. Forest Service and U.S.D.I. Bureau of Land Management 1999). The minimum unit considered for the plan should be the watershed, and ecological rather than political boundaries are recommended in order to provide consistent treatment of functionally related areas, and because every part of the watershed can contribute to improved or reduced ecological functions. Watershed assessments should be conducted for all involved watersheds prior to restoration prioritization. Forming a vision that incorporates ecological, socioeconomic, and cultural values prior to embarking on watershed assessment and shaping a plan of action will help keep restoration efforts on track and help identify acceptable restoration strategies (see Fausold and Lilieholm 1999; Fight et al. 2000). Reference sites (relatively undisturbed watersheds that allow comparison to predisturbance conditions) will be necessary to identify functions that have been lost or altered in urban watersheds, and to provide ecological benchmarks of success or failure (Beschta 1995; Harris 1999; FIRSWG 1998).

Long-term funding sources, realistic goal-setting and creating successful partnerships must be addressed at the outset (Grayson et al. 1999). Long-term funding sources for monitoring and evaluation will help ensure implementation of the master plan (see if someone has a list of potential funding sources). Goal-setting must be ecologically and financially feasible and success is unlikely without engaging stakeholders. The creation of successful partnerships is critical, including an interdisciplinary scientific team, agencies, local governments, communities, watershed councils, and other stakeholders. These partnerships will build consensus and increase information resources, expertise, and potential person-hours available for working on the project (FIRSWG 1998). Having one responsible party will help keep the master plan on course and will increase accountability for results.

Scientific approach

One of the difficulties in urban restoration is that land use planners and land managers are typically not scientists and lack the knowledge and vocabulary to take a scientific approach to ecosystem management. Furthermore, planners are obliged to consider conflicting resource needs between humans and wildlife. While societal needs clearly must be considered, the scientific literature indicates that a rigorous scientific approach, including hypothesis formation and testing, is the best way to ascertain what is possible, what might be effective and whether the desired results have been achieved (Bradbury et al. 1995; Henry and Amoros 1995; Dombeck et al. 1997). Henry and Amoros (1995) commented that: "Ecological restoration is a recent discipline that should be conducted scientifically and rigorously to move from a trial-and-error process to a predictive science to increase its success and the self-sustainability of restored ecosystems."

SER offers a set of ecological principles and guidelines for managing land use (Dale et al. 2001) in which they propose five actions to develop the science that is needed by land managers:

1. Apply ecological principles to land use and land management.
2. Explore ecological interactions in both pristine and heavily used areas.
3. Develop spatially explicit models that integrate social, economic, political, and ecological land-use issues.

4. Improve the use and interpretation of onsite and remotely sensed data to better understand and predict environmental changes and to monitor the environment.
5. Communicate relevant ecological science to users (including landowners and the general public).

A scientific approach lends credibility to restoration efforts and also provides systematic, repeatable methodologies that can be applied over large areas for consistency and comparability. The emphasis should be on restoring natural processes, and linkages among soils, geology, hydrology, biota, and other ecosystem components must be recognized (Roni et al. 2001). An interdisciplinary approach addressing physical, biological, and social issues is important because each is a critical factor in ecosystem degradation (Booth et al. 2001).

Consider the metapopulation

A restoration approach should be developed that addresses habitat requirements of populations and metapopulations, not just individual fish and wildlife needs (Lidicker et al. 1996; Hess 1999; Oregon Watershed Professionals Network 1999; Dale et al. 2001; Roni et al. 2001; see also Figure 14). This approach requires addressing connectivity (as discussed in the Habitat Fragmentation section) as well as a hierarchical view of populations and space, with corresponding factors important to protection and restoration of habitat.

Address urban-specific issues

In order to address the cumulative impacts wrought by urbanization, we must know the most common and critical causes of environmental degradation, the reason why restoration efforts most commonly fail, and develop an overall strategy for a more successful approach (Booth et al. 2001). The critical factors in addressing watershed hydrology are impervious surfaces (see City of Olympia 1996), stormwater management (see Urban Watershed Institute 2001), and vegetative cover, with the goal of restoring a more natural flow regime in streams (Poff et al. 1997; Booth et al. 2001; Roni et al. 2001). In terrestrial riparian and upland habitats, controlling exotic species and restoring habitat connectivity and quality is vital. In all watersheds, education and community outreach is not just appropriate but crucial. Considering socioeconomic factors, however, is separate from and in addition to a scientific approach to restoration.

Monitoring

Habitat conditions must be linked to wildlife. Ecological conditions are best assessed by biological response to those conditions, because the complexity and health of natural systems is reflected in the structure and diversity of plant and wildlife communities (Lammert and Allan 1999; Roni et al. 2001). Monitoring may comprise a major portion of restoration budgets, because at least 10 years of monitoring are necessary to detect a biological response to activities and account for natural fluctuations in fish and wildlife numbers (Kondolf and Micheli 1995; Kondolf 2000; Roni et al. 2001).

A monitoring program to measure progress in protecting and restoring urban fish and wildlife habitat should include a set of biological indicators that are particularly responsive to environmental conditions, including urbanization (Bauer and Ralph 2001). In addition, instream measures such as Total Maximum Daily Loads (TMDLs; a set of standards developed by the Oregon Department of Environmental Quality to protect beneficial uses such as drinking water, salmonid spawning, recreation and agriculture) may be necessary (Watershed Professionals Network 1999). Streamflow and discharge measures provide important hydrological monitoring indicators, and these have been empirically developed and tested for the Pacific Northwest (see Booth et al. 2001). Spence et al. (1996) discuss programs for monitoring implementation (compliance) and assessment (effectiveness) and offer a general monitoring framework, as well as recommendations for biological and other types of indicators. McCarron et al. (1997) discuss bioassessment approaches to evaluate cumulative effects. Appendix 6 provides some potential indicators of the success of restoration activities seen repeatedly in the scientific literature.

Adaptive management

Adaptive management is a type of natural resource management that implies making decisions as part of an on-going process, as new information is received and incorporated into plans and activities. Adaptive management provides the opportunity for course correction through evaluation and action, thus it provides a bi-directional flow of information (FIRSWG 1998; National Marine Fisheries Service 1996a; Dombeck et al. 1997; CH2MHILL 2000; Kondolf 2000). Monitoring the results of activities makes adaptive management possible by allowing assessment of whether resource goals, objectives, and targets are being achieved.

General strategy for urban restoration

The success of restoration depends on ecosystem response to anthropogenic (human-caused) disturbances (resistance) and the system's capacity to recover after disturbances are halted (resilience) (Kauffman et al. 1997). Specifically, resistance is the capacity of an ecosystem to maintain natural function and structure after a natural disturbance or an introduction of an anthropogenic perturbation; resilience is the capacity of species or ecosystems to recover after a natural disturbance or following the cessation of an anthropogenic perturbation.

Ecosystem resilience may change with significant alterations to the disturbance regime (Jones et al. 2000). For example, increased flooding and debris flows are a known side effect of road systems, but the patchy nature of these disturbances leave numerous headwater and side-channel refuges for aquatic wildlife. These refuges are part of the resilience of the system. However, if significant portions of the stream network are damaged or removed (e.g., this region's loss of approximately 25 percent of original streams), the system's resilience to disturbance is reduced.

Reduced floodplain connectivity provides another example of loss of ecosystem resilience. A group of scientists convened in 1998 by the Oregon Department of Fish and Wildlife voted the two most critical long-term salmonid conservation measures along the Willamette River to be restoring floodplain function and hydrologic integrity, and improving water quality (Martin 1998). Restoration of the floodplain function and hydrologic integrity would likely result in improved resistance to disturbance (e.g., reduced flooding, fewer sediments and toxins entering the waterway), as well as improved resilience (e.g., biotic recovery after floods, recovery from recreational trampling, etc.). In highly disturbed areas such as urban regions, elements and processes that promote ecosystem resilience and, therefore, recovery should be protected, preserved, and fostered (Ebersole et al. 1997). These include floodplain, hydrologic, and riparian connectivity.

Functional restoration should be based on science, but approached with good business sense by weighing ecological benefits against project costs. How can we achieve the most significant results per restoration dollar? How can watersheds and projects be prioritized to achieve this practical approach? There are a number of references available to assist this process. For example, Nehlsen (1997) described an Oregon-based ecosystem approach to prioritizing watersheds for restoration and salmonid recovery (the Bradbury framework; Bradbury et al. 1995) and provided a sample application that was applied with apparent success at three different spatial scales. Richter (1997) recommended urban-oriented criteria for the restoration and creation of wetland habitats of Pacific Northwest amphibians, as well as a long-term monitoring strategy (Richter and Ostergaard 1999). Schueler (1995) offered an extensive set of recommendations regarding site planning for urban stream protection. May et al. (1997b) published a series of habitat quality indices for urbanization effects in Puget Sound Lowlands streams. In addition, below we offer a general strategy for prioritization of urban restoration sites and projects, based on first preserving the most ecologically intact areas, then prioritizing remaining habitats for functional restoration.

Preserve the best

By the time large-scale efforts to protect, conserve and restore urban watersheds are considered, substantial ecological damage has typically already occurred. Pristine habitats are scarce or absent, and habitats in excellent or good condition are limited. It is much easier to protect a high-quality area than to restore functions to an ecologically degraded area (Bradbury et al. 1995), and in the long run protection may be less expensive than restoration. Thus, the first ecological priority for protecting fish and wildlife habitat in any urbanized region should be to recognize and preserve high-quality, low-development watershed areas. Protection of these areas within Metro's jurisdictional boundary should be included in a restoration master plan; however, any program would need to include an Economic, Social, Environmental and Energy (ESEE) analysis to weigh the consequences of protection plans. Protection may be accomplished through a number of means, including direct land purchase, conservation easements, and land use regulations. A recent urban-rural gradient study suggested that two locations along the gradient – the most remote portions of the landscape, and at the outer envelope of urban expansion – may hold disporportionate influence over water quality in the future (Wear et al. 1998).

Identification of sensitive, critical, or refuge habitats (at-risk habitats and species) to conserve remaining biodiversity provides one way to identify which areas to protect. This can be accomplished through identification and protection of endangered habitats, and through identifying habitats critical to state- or federally-listed species, including specific areas such as known nest sites. Metro's species list includes state- and federally-listed vertebrate species.

The Oregon Biodiversity Project, launched in 1994 to develop a statewide strategy to conserve Oregon's biological diversity, identified four general habitat types – native prairie grasslands, oak savannas and woodlands, wetlands, and bottomland hardwood forest – as conservation priorities in the Willamette Valley (Defenders of Wildlife 2000). These habitats should be identified in the Metro region and protected. Roni et al. (2001) reviewed methods for identifying and prioritizing conservation areas, and Table 12 provides an example of a prioritization scheme for protecting sensitive, critical or refuge habitats in Larimer County, Colorado (note that economic interests are built into the scheme). Other habitat ranking systems are also available in the literature (see Rossi and Kuitunen 1996; Csuti et al. 1997).

Table 12. Example of a prioritization scheme for protecting sensitive, critical or refuge habitats. Local conditions mapped for environmental protection as part of the Partnership Land Use System (PLUS) developed by Larimer County, Colorado.

Environmental Value	Definition	Data Source
Conservation sites	Areas containing one or more imperiled species (plants or animals)	Field surveys by Colorado Natural Heritage Program
Habitat for economically important species	Winter range and migration corridors for mule deer, elk, and pronghorn antelope	Field surveys by Colorado Division of Wildlife
Areas of high species richness	Areas where predicted vertebrate species richness exceeds 95 percent of all areas included in the analysis	Vegetation map derived from Thematic Mapper satellite image Habitat modeled from vegetation associations of all vertebrate species in county
Rare plant communities	Plant communities covering less than 3 percent (individually) of the land area of the county	Vegetation map derived from Thematic Mapper satellite image

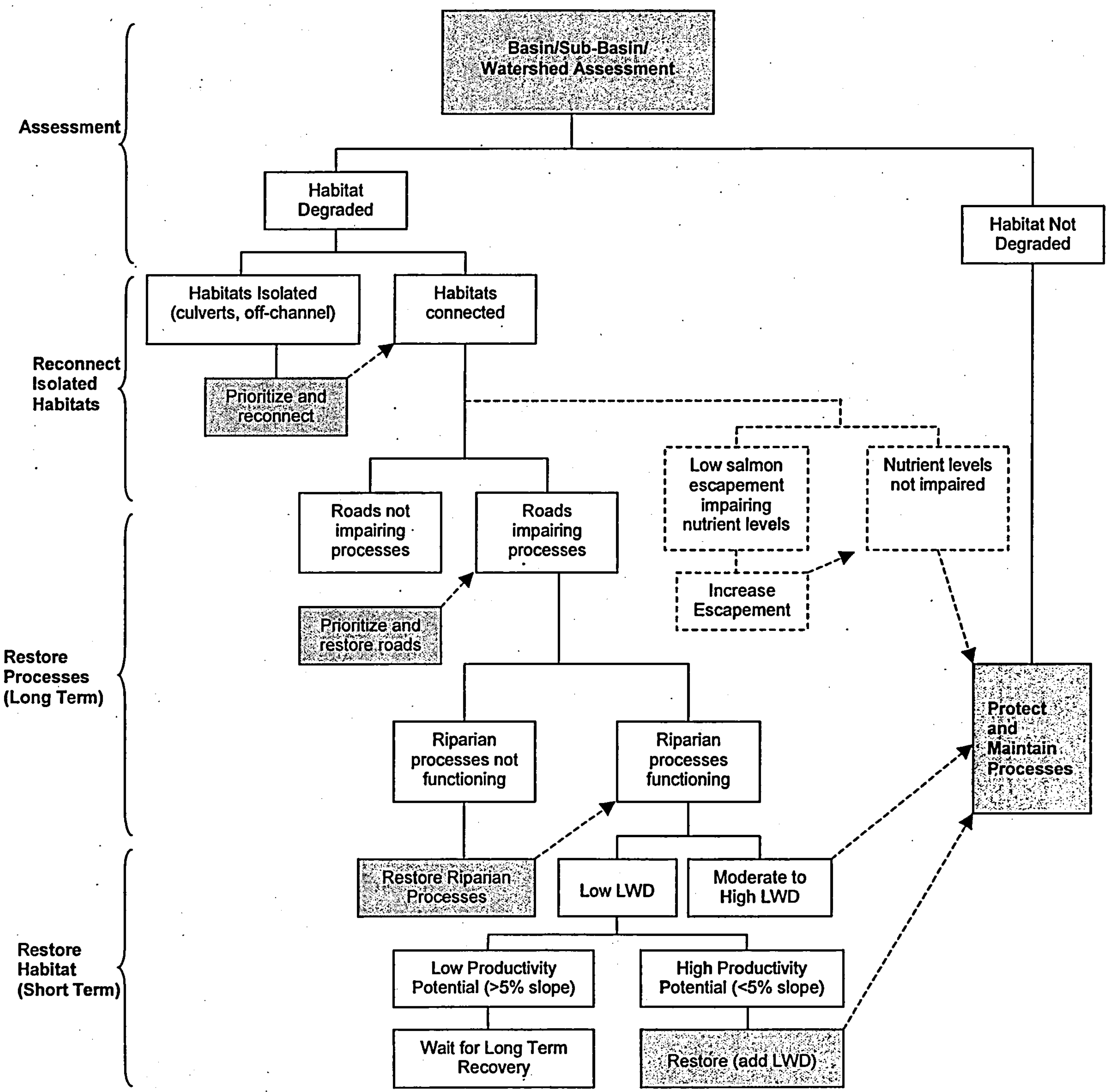
Source: Society for Ecological Restoration (2001).
Note: While the criteria may change geographically, this provides an example of a habitat conservation prioritization scheme.

Home-range sizes vary considerably among different species. Certain species, such as some Neotropical migratory birds, seem to require larger habitat patches to successfully live or reproduce (see *Impacts of Urbanization, Habitat Fragmentation*). In addition, local evidence indicates that Neotropical migrants respond negatively to roads near their habitat patch (Hennings 2001); although unstudied, this is likely to be true for some mammals and other species. Thus preserving as many large habitat patches as possible, particularly those not divided by roads, is another means of preserving the best remaining habitats in the region. The value of these patches is further enhanced if other natural areas are nearby, because animal movement between patches may help prevent local extinctions.

Restore the rest

The scientific literature indicates that the best restoration candidates are moderately degraded areas, because severely degraded areas are much more difficult to restore (Kauffman et al. 1997; Booth et al. 2001). Therefore, the first priority is to aggressively restore streams and other habitats where recovery of ecosystem functions and processes is possible. Next, improve the most degraded sites by analyzing and addressing the acute cause(s) of degradation. Finally, where complete recovery is not feasible but well-selected efforts may yield direct improvement, restore selected elements of moderately degraded urban watersheds. All of these actions should take place under the umbrella of a watershed master plan. Figure 14, on the following page, shows a salmon-oriented hierarchical prioritization scheme.

Figure 14. An example of a salmon-based hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds.



Source: Roni et al. 2001

Develop wisely

Planning for development is an important part of an environmental protection or enhancement plan. Setting an urban growth boundary (UGB) is one example. Another is Metro's 2040 Growth Concept, which defines the form of regional growth and development for the Portland metropolitan region. The Growth Concept was adopted in the Region 2040 planning and public involvement process in December 1995. The 2040 Growth Concept is implemented through the Regional Framework Plan (RFP), adopted in 1998. The RFP includes specific land use guidelines, such as a stream and floodplain protection plan. Metro also has a Greenspaces Master Plan, ensuring the acquisition and protection of natural areas and open spaces within and near the UGB.

It is much more difficult to repair environmental damage than to prevent it. Based on a large volume of scientific literature, much of it specific to the Pacific Northwest, is it clear that responsible development should:

- Plan well to reduce impervious surfaces such as transportation network
- Retain and add forest canopy cover
- Plan storm sewer and runoff systems with past, current, and future hydrology in mind

Figures 15 and 16 illustrate Pacific Northwest examples of how planning can influence environmental conditions. In Figure 15, land planners assess the opportunity to mitigate the influences of urbanization on hydrology through projected land-use changes and construction of proposed detention ponds and bypass pipelines. Note that while the future alternative does not return the hydrology to predevelopment conditions, it projects a marked improvement over current conditions. Figure 16 estimates the interaction of forest canopy cover and imperviousness in a rural setting. The graph suggests that about 65 percent canopy cover is needed to protect stream channel stability under typical rural development conditions.

Control nonnative species

As discussed in previous chapters, nonnative species ("exotics") pose a major threat to native plants and animals in the United States, particularly in urban areas due to the concentration of people. SER (1993) recommends the following regarding nonnative species:

1. The control of exotic species should be an integral component of all restoration projects and programs.
2. Monitoring of exotics and periodic reassessment of their control should be integrated into all restoration plans and programs.
3. Highest priority should be given to the control of those species that pose the greatest threats, namely:
   - Exotics that replace native key (keystone) species.
   - Exotics that substantially reduce native species diversity, particularly with respect to the species richness and abundance of conservative species.
   - Exotics that significantly alter ecosystem or community structure or functions.
   - Exotics that persist indefinitely as sizable sexually reproducing or clonally spreading populations.
   - Exotics that are very mobile and/or expanding locally.
4. Restoration plans and management programs should include contingencies for removing exotics as they first appear and for implementing new control methods as they become available.
5. Control programs should cause the least possible disturbance to native species and communities and, for this reason, may be phased over time.

6. The restoration and management program must, of necessity, be strategic. Protection of native habitats, levels of infestation, appropriate resource allocation, and knowledge of control methods should be integrated into the monitoring and management program.
7. Exotic species should not be introduced to the site in the restoration plan.
8. Native species should also be evaluated for their potential threat to native communities. Weedy native species should be avoided in restoration plans as well as native planting stocks representing non-native ecotypes.

Upland habitat restoration

Most watershed assessment methodologies deal primarily with aquatic and riparian habitat conditions, with little attention paid to upland conditions. This may be appropriate in non-urban watersheds, but upland components play a critical role in urban watershed health (Hollenbach and Ory 1999; Booth et al. 2001). For example, vegetation slows and stores water runoff and pollutants, while impervious surfaces do exactly the opposite. Adding native canopy cover provides one means of mitigating the negative effects of impervious surfaces (Shaw and Bible 1996; Booth et al. 2001). Other potential mitigating effects are offered through various sources (e.g., porous pavement [Cahill 1994]; lawn management techniques [Watershed Protection Techniques 1994]; reducing the effects of imperviousness, Center for Watershed Protection 2001, etc.).

Small streams versus large rivers

Restoration of small streams and large rivers requires different methodologies, due in part to the extensive floodplain interactions associated with large rivers and damming (Sparks et al. 1990; Sparks 1995; Poff et al. 1997), but the two are linked. Local governments, including Metro, have potentially greater influence over small streams that originate or are largely contained within the urban area than over larger rivers, and small streams account for over three quarters of the total stream length in the United States (Lowrance et al. 1997). Restoration of large river systems depends on renewal of physical and biological interactions between the main channel, backwaters, and floodplains, and often involves managed flooding and floodplain reconnection (Sparks et al. 1990; Gore and Shields 1995; Stanford et al. 1996; Molles et al. 1998).

The Willamette River has been confined to a single channel with little sinuosity, high flow velocities, and low levels of habitat diversity to control floods and water resources, and has experienced a fourfold decrease in surface water volume from historic levels (Gore and Shields 1995). Snagging and streamside forest removal has further isolated the river from much of its floodplain (Sedell and Froggatt 1984). Restoration of this river will pose a daunting task, much more so than dealing with small streams; however, small streams must be addressed in order to restore large rivers into which they feed. This re-emphasizes the importance of first addressing the whole system rather than individual components (Regier et al. 1989).

Figure 15. Modeled flow-duration curve for Des Moines Creek, Washington, displaying dramatic improvement in future flow durations relative to current. Analysis assumes projected land-use changes and construction of proposed detention ponds and bypass pipelines. (Source: Booth 2000)

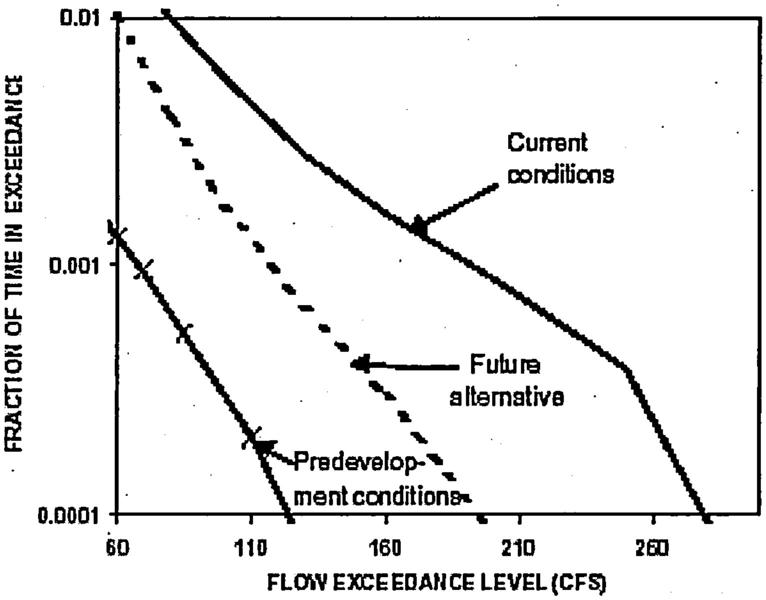
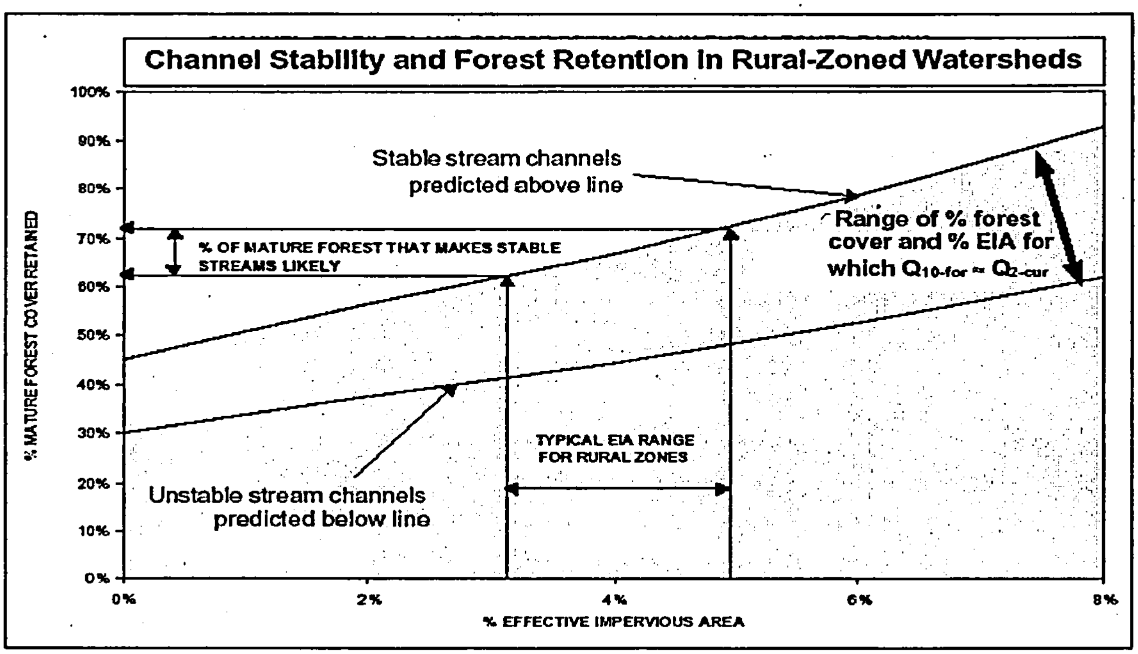


Figure 16. Booth's (2001) model predicting the amount of mature forest needed under rural conditions in order to maintain stable streams. Conditions of forest cover and impervious surface in an HSPF-modeled watershed with moderate slopes and till soils relative to the channel-stability criterion $Q_{2\text{-cur}} = Q_{10\text{-for}}$ [see Booth et al. 2001 for variable descriptions]. The range of forest-retention values reflects uncertainty in the hydrologic parameters; the range of effective impervious areas reflects variation in rural land cover conditions. Note the relatively high range of forest canopy cover predicted to be necessary to maintain stable streams in the typical EIA range for rural zones. Source: Booth et al. (2001)



BMPs and specific restoration activities

Best Management Practices

Some restoration tools are known as Best Management Practices (BMPs), and these tend to be most effective when implemented throughout a watershed. Several examples of BMPs are available online (e.g., Strassler and Strellec 1999; Clark County Washington 2000; O'Brien 2001; Urban Water Resources Research Council 2001; Washington State Department of Ecology Water Quality Program 2001). Many relate to impervious surface management and reducing the impacts of stormwater. Metro's Greenstreets efforts and Metro's Water Resources Policy Advisory Committee recommendations are available now as best management practices for local governments within the region.

BMPs may be site-specific or very general. For example, construction BMPs may require silt fences to reduce sediment inputs to the stream during construction. On the other hand, a BMP may apply over a large spatial scale. For example, riparian/wetland buffers are a common BMP. Horner and May (1999) found that, "The retention of a wide, nearly continuous riparian buffer in native vegetation has greater and more flexible potential than other option to uphold biological integrity when development increases. Upland forest retention also offers valuable benefits, especially in managing any development occurring in previously undeveloped or lightly developed watersheds" (see Figure 5). Buffer issues and design are discussed in detail in the ***Riparian Area Width*** section.

Site-specific restoration activities

Site-specific efforts are essential components of habitat restoration, but cumulative impacts in urban watersheds may cause these projects to fail, and may even cause further damage (Frissell and Nawa 1992; Booth et al. 1997; Dombeck et al. 1997; Hollenbach and Ory 1999; Watershed Professionals Network 1999; Roni et al. 2001). Another common cause of restoration project failure is disregarding geomorphic factors at the watershed scale (Kondolf 2000). In addition, many issues related to long-term persistence of salmonids and other species involve much larger spatial scales and hence require statewide or multistate planning (Spence et al. 1996; IMST 1999; National Marine Fisheries Service 2000a). Few site-specific restoration activities should take place without a watershed assessment and careful master planning, which should including addressing existing and future development through hydrology, impervious surfaces and natural vegetation cover. However, below we will discuss a few methodologies commonly used in urban areas, and their apparent success or failure. In addition Appendix 6 outlines some potential restoration activities, keyed by function, and provides some suggestions for indicators of ecological change based on a literature review.

In the Pacific Northwest, riparian and upland forests are a key contributor to watershed health (Booth et al. 1997; May et al. 1997; Horner and May 1999; Booth 2000; Horner et al. 2001). The value of revegetating stream banks and riparian areas cannot be overemphasized. Pacific Northwest studies show positive relationships between the percentage of intact riparian forest in a watershed and instream biotic integrity (May et al. 1997; Horner et al. 2001; see also Figures 5 and 16). Retaining and adding upland vegetation is also very important for mitigating the hydrologic impacts associated with urbanization (Booth et al. 1997; Horner and May 1999; Booth 2000; Horner et al. 2001). Local watershed councils, the Natural Resources Conservation

Service, and Oregon Department of Fish and Wildlife are good resources for revegetation and site-specific restoration techniques.

Frissell and Nawa (1992) evaluated rates and causes of damage or failure for 161 fish habitat structures in 15 streams in southwest Oregon and Washington after floods with a 2-10 year recurrence interval. The structures were comprised primarily of instream log or boulder clusters. Damage and failure was prevalent, particularly in low-gradient streams with signs of recent watershed disturbance, high or elevated sediment loads, high peak flows, and/or unstable channels; the authors suggested that commonly prescribed structural modifications are often inappropriate and counterproductive in such streams (e.g., those found in this urban region). Only two types of structures – cabled natural woody debris and individual boulder placements – experienced impairment or failure in less than half the cases. All log weir designs had high rates of impairment or failure, and one type, the downstream-V weir, failed or was impaired in every instance. Boulder structures had lower failure rates than log weirs in low-gradient streams, but most boulder structures the authors studied were in relatively stable southwest Washington streams. Shields et al. (1995a, 1995b) found stone weirs to be a successful rehabilitation technique in an incised lowland Mississippi stream.

Booth et al. (1996) provide design approaches for urban channel rehabilitation, with emphasis on large wood and the various hazards associated with such projects in an urban setting. The authors state that while large wood is critical to the health of most Pacific Northwest streams, instream placement of such structures in urban environments is hampered by lack of geomorphic and channel type considerations and greatly increased peak flows (see also Moses and Morris 2001). Possible loss of flood conveyance, the potential for the wood to clog existing channel constrictions, and the possibility of flow diversion causing bank erosion further complicate placement of this critical stream component. This is not meant to imply that large wood placement cannot be a valuable restoration tool in urban settings. However, the complexity and variability of these stream systems mandates a great deal of forethought, careful study of the effectiveness of projects conducted in similar settings, long-term post-project evaluation, and communication of the results to others.

The Oregon Watershed Enhancement Board (OWEB) provides guidelines on conducting restoration projects in a watershed (OWEB 1999). Many other references are available on specific restoration techniques and their effectiveness (e.g., Oregon Department of Forestry and Oregon Department of Fish and Wildlife 1995; Dooley and Paulson 1998; Riley 1998; Morris and Moses 1999; Roni 2001). Table 13, on the following page, shows the typical response time, duration, variability of success and certainty of success of various common restoration techniques.

Table 13. Typical response time, duration, variability in success and certainty of success of common active restoration techniques.

Restoration Type	*Specific Action*	Years to achieve response	Longevity of action (years)	Variability of success among projects	Certainty of success
Reconnect isolated habitats	Culverts	1 to 5	10 to 50+	Low	High
	Off-channel	1 to 5	10 to 50+	Low	High
	Estuarine	5 to 20	10 to 50+	Moderate	Moderate to high
Roads	Removal	5 to 20	Decades to centuries	Low	High
	Alteration	5 to 20	Decades to centuries	Moderate	Moderate to high
Riparian	Fencing	5 to 20	10 to 50+	Low	Moderate to high
	Riparian replanting	5 to 20	10 to 50+	Low	Moderate to high
	Rest-rotation or grazing strategy	5 to 20	10 to 50+	Moderate	Moderate
	Conifer conversion	10 to 100	centuries	High	Low to moderate
Instream restoration	Artificial log structures	1 to 5	5 to 20	High	Moderate[a]
	Natural LWD placement	1 to 5	5 to 20	High	Moderate[a]
	Artificial log jams	1 to 5	10 to 50+	Moderate	Moderate[a]
	Boulder placement	1 to 5	5 to 10	Moderate	Moderate[a]
	Gabions	1 to 5	10	Moderate	Moderate[a]
Nutrient enhancement	Carcass placement	1 to 5	Unknown	Low	Moderate to high
	Stream fertilization	1 to 5	Unknown	Moderate	Moderate to high
Excavate or create new habitats	Off-channel	1 to 5	10 to 50+	High	Moderate
	Estuarine	5 to 10	10 to 50+	High	Low
	Instream	See various instream restoration techniques above			

Source: Roni et al. 2001 (in press)
[a] Low to high depends upon species and project design.

Fish passage

If fish cannot pass through a culvert or other blockage, the entire upstream reach is rendered uninhabitable. The Oregon Department of Fish and Wildlife is the lead state agency for all types of fish passage concerns in Oregon, and has produced guidelines regarding fish passage (Robison et al. 1999). Key measurements of interest in fish-blocking culverts include culvert and adjacent slopes, outlet drop, and outlet pool dimensions, as well as the shape of the culvert and local hydrologic information (Robison et al. 1999). The ODFW guidelines specify maximum velocities, entrance drops, and minimum water depth criteria for culverts. Examples of fish passage-oriented restoration include culvert replacement, connecting upstream reaches of piped streams to lower sections, and "daylighting" of piped streams (from IMST peer review 2001). Further guidance on specific culvert design and implementation strategies are offered in an annotated bibliography by Moore et al. (1999). The Inventory section of this report indicates piped stream sections in the Metro area.

Fish passage issues will necessarily be addressed in Metro's Goal 5 program phase. Metro's Regional Culvert Survey (1999-2000) augmented existing culvert inventories by the Oregon Department of Fish and Wildlife and several local governments by examining culverts located within a geographic area corresponding roughly to the Metro Urban Growth Boundary that had not been included in the previous surveys. Metro's survey identified almost 1,500 unexamined culverts. Fieldwork determined that approximately 150 of these inhibit fish passage. Site-specific structures such as culverts can be more easily addressed than watershed TIA, and their carefully planned removal or appropriate modification represents significant opportunities for stream enhancement. However, both are critical issues that need to be addressed in urban ecosystems, and master planning plays an important role in such efforts; for example, it is sensible to remove downstream barriers before upstream barriers, and to remove barriers blocking larger areas than those blocking smaller areas.

Restoration costs and funding

Funding is clearly a limiting factor in many restoration efforts, particularly when dealing with large-scale efforts such as those necessary to restore urban regions. Funding for large-scale projects is unlikely without collaboration with appropriate partners. Sometimes partial funding may be provided by revenues from restoration activities; for example, the City of Seattle developed a Habitat Conservation Plan (HCP) for the Cedar River Watershed, a relatively undeveloped watershed near the urban region (City of Seattle 1998). Seattle estimates the total HCP costs at $113,078 (in 1998 dollars) and comments that some funding may be generated from the sale of water, timber, and surplus land outside the watershed, in addition to grants and contributions. The Oregon Watershed Enhancement Board, U.S. Fish and Wildlife Service, and numerous other agencies and organizations are potential funding partners for local efforts. Wy'East Resource Conservation and Development (2002), the U.S. EPA (1999), and other online resources provide guidance for restoration funding opportunities.

Measuring success of restoration activities

Ecological conditions are best assessed by biological response to those conditions (Roni et al. 2001), thus wildlife (i.e., aquatic invertebrates, breeding birds, etc.) and plant surveys are appropriate measures of a given site's ecological value. In addition, surveys conducted in a scientifically sound, repeatable way will provide valuable baseline data with which to gauge ecological changes in the future and will add credibility to restoration efforts. However, there are a number of other appropriate non-biological indicators of ecological change, such as water chemistry and sedimentation. May et al. (1997b) offer suggestions on hydrologic parameters of interest for monitoring changes in Pacific Northwest streams over time. Appendix 6 provides some suggestions for indicators of ecological change.

Recommendations of the Oregon Progress Board

The Oregon Progress Board proposes a set of key indicators to guide the state's basic environmental monitoring program, but cautions that these indicators are not sufficient to fully convey environmental conditions (Oregon Progress Board 2000). When possible and appropriate, these indicators should be used in assessment and monitoring efforts in order to standardize methodologies statewide to allow comparisons. The indicators include:

- ***Water Quantity:*** a) the degree to which stream flows meet ecological needs based on the proportion of instream water rights that can be met; b) the proportion of streams and rivers with good to excellent water quality according to the Oregon Water Quality Index

- *Freshwater Wetlands:* change in area of freshwater wetlands as compared to historical distribution (acres/percent)
- *Riparian Ecosystems:* a) the amount of intact or functional riparian vegetation found along streams and rivers; b) trends in the health of stream communities using an index comparing invertebrate populations to those expected in healthy aquatic habitats.
- *Freshwater fish communities:* the percentage of wild, native fish populations, including salmon, that are classified as healthy.
- *Agricultural ecosystems:* a) trends in soil quality and erosion rates; b) area of land in agricultural production.
- *Urban areas:* a) percentage of assessed groundwater that meets the current drinking water standards; b) frequency that the Air Quality Index exceeds the existing standards; and c) the amount of carbon dioxide emitted.
- *Biological diversity:* a) change in area of native vegetation types; b) percentage of at-risk species that are protected in dedicated conservation areas; and c) number of nuisance invasive species.

Proper functioning condition (PFC)

Proper Functioning Condition (PFC) is a qualitative method for assessing habitat conditions developed by the Bureau of Land Management and others; the term PFC describes both a specific assessment process and a defined, on-the-ground condition of a given habitat (Prichard 1998; FIRSWG 1998). PFCs delineate how well the physical processes are functioning in a stream, wetland or other habitat. For example, Prichard (1998) provides a user guide to assessing PFCs in **lotic** (a flowing body of fresh water such as a stream or river) areas and defines riparian-wetland areas to be functioning properly when sufficient vegetation, landform, or large woody debris is present to provide certain functions, including:

- Dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and aid floodplain development;
- Improve floodwater retention and groundwater recharge;
- Develop root masses that stabilize streambanks against cutting action;
- Develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and
- Support greater biodiversity.

The PFC technique is not a substitute for inventory of monitoring protocols designed to yield detailed information on the habitat or populations of plants or animals dependent on an ecosystem. For example, proper functioning condition in a stream does not necessarily indicate the presence of shrub habitat critical to riparian-dependent bird species (FIRSWG 1998). However, PFC can be a useful tool for watershed analysis when combined with other watershed and habitat condition information. National Marine Fisheries Service has developed a PFC system based on a "Matrix of Pathways and Indicators" (NMFS 1996b) and is currently developing an urban-specific set of pathways and indicators (Liverman personal communication 2002).

Grayson et al. (1999) offer advice on the assessment of wetland habitat restoration projects in urban wetlands, commenting that restoration goals have often been unrealistic because they failed to consider that urban wetlands are subjected to ongoing anthropogenic disturbances, which fundamentally alter wetland functions.

Case studies

Skagit Watershed Council

The Skagit Watershed Council (Beamer et al. 2000) developed a two-tiered strategy for identifying stream restoration and protection actions: the Strategy Application and Case by Case Screening. The two tiers result in a final, single prioritization list. In the Strategy Application tier, habitat types are classified and locations identified where six landscape disturbance diagnostics (hydrology, sediment supply, riparian conditions, floodplain conditions, isolated habitat, and water quality) are identified as impaired, partially impaired or functioning. A list of desired restoration and protection actions is created based on habitat type classifications, landscape disturbance diagnostics, and best available information. In the Case by Case Screening tier, proposed projects are screened for consistency with the Strategy on an individual basis using best available information, and a list of projects determined to be consistent with the Strategy is formed. The end product is a prioritization scheme of desired restoration and protection actions for expected costs and benefits. Beamer et al. (2000) used a cost-effectiveness prioritization scheme.

Puget Sound Lowlands

Booth et al. (2001) developed what they consider to be a robust approach to urban stream restoration based on the extensive knowledge gained in the Puget Sound Lowland region over the past few decades. The approach blends knowledge from the physical, biological, and social sciences by documenting the consequences of urban development on urban streams, understanding the causes of the resulting ecological degradation, and using that understanding to evaluate restoration strategies and techniques. They offer specific recommendations for restoration efforts in urbanized watersheds, including:

- ***Evaluate stream conditions:*** Make direct, systematic, and comprehensive evaluation of stream conditions in areas of low to moderate development.
- ***Mitigating urban hydrologic conditions is crucial:*** The hydrologic consequences of urban development cannot be reversed without extensive redevelopment of urban areas, which is infeasible in the near future. Likewise, the recovery of physical and biological conditions of streams is infeasible without hydrologic restoration over a large fraction of the watershed land area. This conflict can be resolved only if there are particular, ecologically relevant characteristics of stream flow patterns that can be managed in urban areas. Effective hydrologic mitigation will require approaches that 1) can delay the timing of stormflow discharges in relatively small storms and 2) can store significant volumes of rain for at least days or weeks. In the long run the goal should be to mimic the hydrologic responses across the hydrograph [a chart that measures the amount of water flowing past a point as a function of time] and not just truncate the high or low flow components. The rate of rise and decline of the hydrograph is just as important as the existence of peaks and lows. This almost certainly requires greater reliance on hillslope ("onsite") storage to better emulate the hydrologic regime of undisturbed watersheds, either through dispersed infiltration, onsite detention, or forestland preservation.
- ***Riparian vegetation is important, but is not enough to maintain biological integrity:*** The effectiveness of localized patches of riparian corridor in maintaining biological integrity varies as a function of basin-wide urbanization. Where overall basin development is low to moderate, natural riparian corridors have significant potential to maintain or improve biological condition. Protecting high-quality wetland and riparian areas that persist in less-developed basins may also serve as a source of colonists (be they plants, invertebrates, fish, etc.) to other local streams that are subject to informed restoration efforts. At the same time, even small patches of

urban land conversion in riparian areas can severely degrade local stream biology. As both a conservation and restoration strategy, protection and re-vegetation of riparian areas is critical for preventing severe stream degradation (Osborne et al. 1993), but these measures alone are not adequate to maintain biological integrity in streams draining highly urban basins.

- ***Education of property owners is crucial:*** Approaches must be developed to address the unanticipated, and unappreciated, consequences on channel conditions of human actions in the name of backyard improvements. Regional and national efforts now fall particularly short in this regard.
- ***Instream projects are unlikely to be effective:*** There is little evidence that instream projects can reverse even the local expressions of watershed degradation in urban channels. Addition of LWD to the urban streams we examined produced more physical channel characteristics typical of undisturbed streams, such as pools and sediment storage sites formed by LWD. Any increase in sediment storage and grade control in these moderate-slope alluvial channels was less assured. The steepest project reaches examined did not store more sediment, although LWD provided more grade control in the steepest reaches. Stabilizing or retaining sediment to reduce downstream sedimentation and associated flooding was not accomplished by adding LWD to the channel. No positive effect on biological condition from the restoration activities was detected over the time scales sampled; the physical characteristics in the reach that did change displayed no clear relationship to biological condition.
- ***Channel stabilization is rarely effective in the urban area:*** Aggressive efforts at channel stabilization during the period of active watershed urbanization will probably achieve only limited rehabilitation gains at high and perhaps unnecessary cost, even though bank armoring projects are constructed in the name of stream-habitat "improvement." Most lowland channels achieve a stable physical form some years or decades following urbanization, with or without human intervention. Yet the restabilization of urban channels, either by natural processes or by direct intervention, is generally incompatible with true "rehabilitation," because the resulting channel is rarely biologically hospitable and often is socially unwelcome as well.

Specific steps to watershed assessment

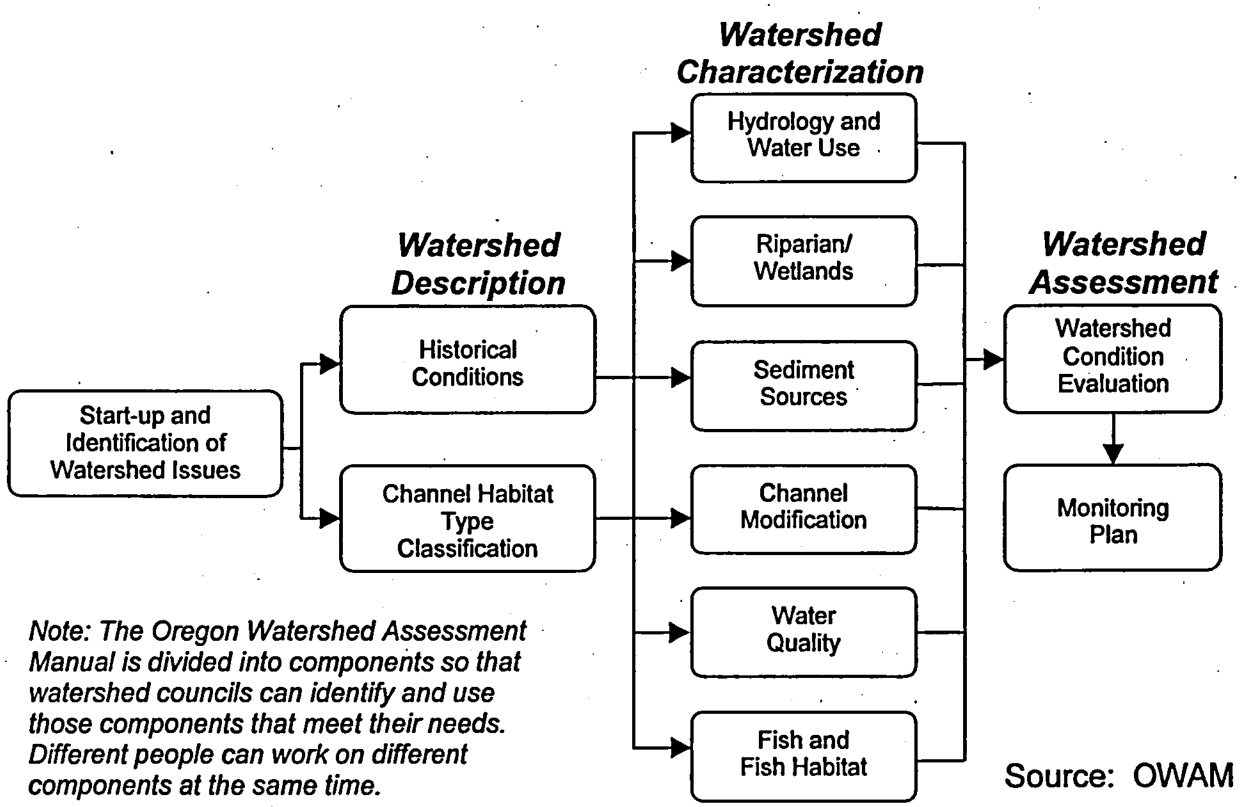
Without clearly defined goals that can be measured by quantifiable data, restoration attempts are likely to fail due to loss of momentum, project "scope creep," and lack of adaptive management. The precise and correct restoration mission, goals, and objectives, and appropriate performance indicators of restoration success or failure, must be defined early in the restoration process (Henry and Amoros 1995). All of the watershed assessment techniques referenced here deal with goal-setting, which is different for each project and hence will not be discussed here. However, assessment of success is less clearly delineated. The following section and Appendix 6 deal with measuring success in restoring ecological functions. This section provides an overview of the watershed assessment process.

Watershed assessment is a process for evaluating how well a watershed is functioning; it includes steps for identifying issues, examining the history of the watershed, describing its features, and evaluating various resources within the watershed. The overall goal is to figure out where, within a given watershed, natural functions relating to fish and wildlife habitat and watershed health should be restored. Specifically, the goals of a watershed assessment are to identify features and processes important to fish habitat and water quality, determine how natural processes are influencing those resources, understand how human activities are affecting fish habitat and water quality, and evaluate the cumulative effects of land management practices over time. This helps us determine which features and processes in a watershed are working well and which are not. Roni et al. (2001) proposed a method to place site-specific restoration within a watershed context. The underlying assessment and restoration objectives are more important than the specific assessment methodology chosen (Booth et al. 2001).

Several step-by-step methodologies exist to guide watershed assessment, but the general frameworks are similar (e.g., Bradbury et al. 1995; Regional Interagency Executive Committee 1995; Spence et al. 1996; U.S.D.A. Forest Service 1997; FIRSWG 1998; Prichard 1998; van Staveren et al. 1998; Watershed Professionals Network 1999; Sholz and Booth 2001). In general, the underlying assessment and subsequent restoration objectives are more important than the specific assessment methodology chosen (Booth et al. 2001), although some methodologies perform best at relatively specific spatial scales (discussed below). Figure 17 outlines one methodology, the Oregon Watershed Assessment Manual (OWAM), that dovetails with statewide efforts to standardize data collection and untangle the complex process of watershed assessment (Watershed Professionals Network 1999). This method, like others, includes components on getting started (e.g., setting up teams, subdividing watersheds, etc.), watershed description (overall characteristics in current and historical contexts), watershed characterization (individual watershed functions or components, such as hydrology and sediment sources), and watershed assessment (evaluation of conditions and formation of a monitoring plan).

Spatial scale is an important consideration in selecting an assessment method. For example, the Interior Columbia Basin Ecosystem Management Project provides assessment protocols for four geographic levels: broad scale (basin-level), mid-scale (subbasin; 4th field HUCs), fine-scale (watershed 5th field HUCs), and site-scale (project/site analysis, including NEPA analysis) (U.S.D.A. Forest Service and U.S.D.I. Bureau of Land Management 1999). The Oregon Watershed Assessment Manual (Watershed Professionals Network 1999) deals with **ecoregions,**

Figure 17. Components of the Oregon Watershed Assessment Manual.



Note: The Oregon Watershed Assessment Manual is divided into components so that watershed councils can identify and use those components that meet their needs. Different people can work on different components at the same time.

Source: OWAM 1999.

or landscapes sharing fundamental characteristics. Ecoregions may be described at different spatial levels; the OWAM assessment procedure uses Level III and IV ecoregions; our region (Level III) is the entire Willamette Valley.

Conducting an assessment of a very large basin, as in the case of the Bradbury Process (Bradbury et al. 1995), may help establish regional priorities, but this coarse-scale approach will not be of much value for specific project prioritization and development (Watershed Professional Network 1999). This is due to the difficulty in compiling and interpreting large amounts of data in meaningful way. On the other hand, comprehensive assessment in a very small basin is too site-specific to be useful in an urbanized region because it fails to address cumulative impacts. However, if the proper method is selected (based on spatial scale), individual assessments may be compiled for larger assessments. For example, using the HUC codes described in the **Inventory Chapter**, 5th field assessments (e.g., the Johnson Creek watershed) can be combined to form a composite assessment of a larger basin or ecoregion.

The OWAM assessment process begins by looking at the entire watershed, because streams and their channels are the result not only of surrounding landform, geology, and climate, but of all upslope and instream influences as well. OWAM relies on existing data, local knowledge of land managers, and field surveys in order to reveal which natural and human-altered processes influence watershed health. The assessment bridges the gap to site-specific conditions by stratifying the stream network into Channel Habitat Types (CHTs), determined by the slope of the channel bottom and valley width. This helps identify segments of the stream network with high potential for biological production and which are sensitive to disturbance, in order to identify:

- Areas with highest potential for improvement
- High-priority areas for restoration
- Types of improvement actions that will be most effective

After analysis and planning identify the restoration actions needed and the actions are implemented, monitoring is used to track progress. The assessment template defines ecological indicators that can be monitored to track the restoration process. Other monitoring methods are available in the literature; for example, Scholz and Booth (2000) offer a monitoring strategy for urban streams in the moist Pacific Northwest that includes riparian canopy, bank erosion and bank hardening, and instream large woody debris.

Regional and local conservation, assessment and restoration efforts

There are numerous local or regional examples of watershed conservation, assessment and restoration efforts. Each may provide valuable insights into how to go about large-scale conservation planning and some, such as Clean Water Services' (formerly Unified Sewerage Agency) Watersheds 2000, may provide data relevant to conservation in the Metro region. Several such projects are described below. The Oregon Watershed Enhancement Board provides a list of current watershed restoration groups in Oregon (OWEB 2002).

There is significant overlap between many of the restoration projects listed here and many more ongoing projects that we have not mentioned. No one particular project addresses the range of problems and opportunities unique to the entire Metro region. All such projects should be brought into a larger regional restoration plan, if possible. This will help prioritize projects on a basin-wide scale and prevent duplicative or harmful projects, thereby making the best use of limited watershed restoration funds.

The Urban Watershed Institute

The Urban Watershed Institute (UWI) was launched in 1999 in response to increasingly complex urban environmental challenges (UWI 2001). While this is not an on-the-ground assessment or restoration effort, it may provide a valuable resource to those embarking on such efforts. UWI offers accredited classes (e.g., urban watershed assessment, wetlands and urban stream ecology, stream and watershed restoration methods, etc.), workshops and conferences to clarify environmental regulations and present strategies for achieving stream protection and regulatory compliance through multi-disciplinary approaches and new techniques and technologies. UWI's mission is to provide multidisciplinary training and encourage innovative partnerships to improve the ecological condition of urban watersheds.

The Gap Analysis Program

This is a nationwide program managed by U.S.G.S. Biological Resources Division (Shaughnessy and O'Neil 2001). The program focuses on working with each state to develop digital data layers used with GIS to identify the "gaps," or natural land cover types and native vertebrate species not adequately represented in existing network of conservation lands. This is a coarse-filter approach, working from the statewide scope to larger geographic regions.

King County, Washington

King County is ahead of the Metro region in regional watershed planning and implementation, reflecting governmental response to habitat degradation caused by the Seattle region's large population and growth rates over the past decades. King County has also collaborated considerably with University of Washington scientists to fill their research needs. Although there are differences, the Seattle and Portland regions are ecologically relatively similar and have been developed over roughly the same time period. Thus we can capitalize on our northern neighbors' successes and review their failures to aid planning and restoration efforts in the Metro region.

King County and others have initiated the Puget Sound Ecosystem Restoration Initiative, a proposed program to restore habitat for salmon and other species throughout the Puget Sound Basin (King County Department of Natural Resources 2001). The initiative's goals are to identify, prioritize, and construct the most effective habitat projects in the 17 watersheds comprising the basin, implemented by the Army Corps of Engineers and other local and state agencies, tribes, and key private interests. Two key elements are comprised in the initiative: identifying the best habitat projects in the Puget Sound basin to construct, and constructing them quickly and effectively. Designed to complement other local, state, and federal programs for salmon recovery, the plan will recognize prior habitat studies and plans, focus new studies and technical assistance where they are most needed, and establish priorities across the entire basin. If implemented, this science-based plan may provide an excellent model for similar efforts in the Portland Metro region.

The Pacific Northwest Ecosystem Research Consortium (PNERC)

PNERC is an interdisciplinary research group comprised of scientists from Oregon's state universities, the U.S. EPA, private research consultants, and others (PNERC 2001). The consortium's goals are to understand the ecological consequences of societal decisions in the Pacific Northwest, develop transferable tools to support management of ecosystems at multiple spatial scales, and strengthen linkages between ecosystem research activities and ecosystem management applications in the Pacific Northwest. Specific objectives are to characterize ecosystem condition and change, identify and understand critical processes, and evaluate outcomes (including modeling alternative future scenarios and potential consequences of these alternatives to humans and the environment). PNERC offers several data products, including maps modeling Willamette Valley land use from the 1850's, existing habitats in the Willamette Valley, and Habitat Suitability Index models for wildlife species in which wildlife trends may be modeled under various future alternatives. All major conservation strategies in the Pacific Northwest should establish contact with PNERC to better plan and coordinate science-based conservation efforts.

The Northwest Power Planning Council

The Northwest Power Act, passed in 1980, created the Northwest Power Planning Council to give the governors of Oregon, Washington, Montana and Idaho valuable tools to address energy, fish and wildlife concerns in the region (Northwest Power Planning Council 1998). These tools include substantial input into investment of power ratepayer money in energy, fish and wildlife initiatives, an open forum for public debate, and the capability to provide high-quality, independent analyses of complex resource issues. The Council's responsibility is to mitigate the impact of hydropower dams on all fish and wildlife in the Columbia River Basin through a program of enhancement and protection, and provides guidance and recommendations on hundreds of millions of dollars per year of projects funded through Bonneville Power Administration revenues. The Council has undertaken a number of important restoration-related activities in recent years, including input on subbasin inventory, assessment and planning; development of a fish and wildlife program for the Columbia Basin; and publication of several major scientific reports.

The Columbia River Inter-Tribal Fish Commission

The Commission developed a tribal approach to salmon recovery through protecting and restoring watersheds in the Columbia Basin (Hollenbach and Ory 1999). This effort emphasizes the importance of the entire watershed, including uplands, to well-functioning rivers and streams based on science, ecology, and traditional Native American understanding and respect for the natural world. It includes healthy human communities as part of healthy landscapes. The Inter-Tribal Fish Commission endorsed the Governor's Watershed Enhancement Board Watershed Assessment Manual as a good watershed assessment resource (although Oregon-specific, and many tribal lands involved are located in Washington). The Inter-Tribal report includes contact information for organizations related to watershed assessment, conservation land acquisition, water acquisition and instream flow conservation, placing instream structures, beaver reintroduction, monitoring and evaluation, and a large section on fundraising opportunities.

The Oregon Plan for Salmon and Watersheds

The Oregon Plan was initiated in 1997 and has provided legislative support and funding for: watershed restoration, local level restoration actions to improve watershed health, water quality, and conserve or restore habitats that support native salmon and trout. In addition, it provides guidance to shape rural and urban communities in an ecologically sound manner. This is the most comprehensive conservation effort ever undertaken by any state (Nicholas 2001). The Willamette Restoration Initiative (see below) is part of The Oregon Plan. The Plan's principles (abbreviated here) are simple but poignant: seek truth, learn, and adapt; be humble about our place on the earth; obey the law and live up to commitments; respect people and nature (the two are inseparable); act voluntarily; exercise patience; build partnerships, make friends, and strengthen community; strive to let rivers be rivers, and untame, a little, our watersheds; share information, decision-making and responsibility for action; consider our children's needs; and (our favorite) never give up hope.

The Oregon Watershed Enhancement Board (OWEB)

OWEB is an independent state agency created by a legislative act (House Bill 3225; an earlier version was GWEB, the Governor's Watershed Enhancement Board) (Nicholas 2001). It is funded by state lottery dollars obtained through Ballot Measure 66, passed by voters in 1998. This agency created the Oregon Watershed Assessment Manual, discussed previously, and ties into The Oregon Plan for Salmon and Watersheds. OWEB provided about $32 million in funds during the 1999-2001 biennium to conduct watershed enhancement projects statewide. OWEB does not yet have a system for verifying watershed investment results. NMFS generally supports OWEB's efforts.

The Oregon Biodiversity Project

The Oregon Biodiversity Project is part of The Biodiversity Partnership, an alliance of organizations and individuals involved in cooperative efforts to conserve Oregon's biological diversity (Defenders of Wildlife 2000). Defenders of Wildlife took the lead on the project, with major participation from The Nature Conservancy and the Oregon Natural Heritage Program. The key idea is to pioneer a collaborative approach to conservation planning, with a large-scale view of identifying conservation priorities for Oregon's native species and the habitats and ecosystems that support them. The Biodiversity Project aims to improve land stewardship with emphasis on private landowner incentives; expand the existing network of conservation lands; improve biodiversity information to enhance decision-making and adaptive strategies; increase public awareness; and demonstrate and test collaborative approaches to biodiversity conservation that could provide a model for other states or regions. Resources produced by this project would be valuable to any Oregon watershed aiming to link wildlife and habitats in a restoration plan.

The Willamette Restoration Strategy

This strategy was developed through the Willamette Restoration Initiative (WRI) to supplement the Oregon Plan for Salmon and Watersheds, as directed by Governor John Kitzhaber and in consultation with the state Legislature (Jerrick 2001). The Strategy focuses on improving fish and wildlife habitat, enhancing water quality, and managing floodplains in the Willamette Basin, within the context of human habitation and projected population growth. Developed through a diverse advisory group including government, natural resource, and business interests, the

Strategy offers four key recommendations and 27 critical actions it believes are necessary to restore the health of the Willamette Basin. The 27 critical actions and Metro's current activities that contribute to these actions are in Appendix 7. The four key recommendations are:

1. Use the Habitat Conservation and Restoration Opportunities map developed by WRI as a tool to guide restoration decisions in the basin.
2. Use environmental indicators from the Oregon State of the Environment Report 2000 (Oregon Progress Board 2000) to guide development of basin-specific restoration targets, and provide a new system for accurately tracking restoration progress.
3. Begin the process of establishing a sound restoration investment plan for the basin by clearly identifying existing assets and forecasting future needs and funding sources.
4. Provide for an organization to continue the refinement of the Willamette Restoration Strategy and track its implementation.

As Appendix 7 indicates, there are many ways in which Metro currently contributes to these efforts. However, Metro could contribute more substantially in the future by directly tying conservation efforts to WRI's restoration targets, thereby strengthening a regional approach to managing watershed health within the Willamette Basin and providing a more unified approach to the multitude of ecological problems facing our region.

The Lower Columbia River Estuary Plan

The Lower Columbia River Estuary Plan's mission is to preserve and enhance the water quality of the estuary to support its biological and human communities (Jerrick 1999). Developed by the Governors of Oregon and Washington, the U.S. EPA and other parties, this project relates to the Metro region because the water, and all of the sediments and pollutants contained therein, derive from or pass through this region to reach the estuary – an excellent example of cumulative effects. The Estuary Plan offers strategies for aquatic ecosystem monitoring, information management, and a program for analysis and inventory. The Estuary Plan's board is currently working with NMFS to tie their efforts more closely to ESA-related salmonid conservation efforts.

City of Portland

The City of Portland, which has jurisdiction over the largest city in the state, has undertaken many efforts to protect the environment. For example, the City's Bureau of Environmental Services has developed: a Clean River plan for the Willamette; a long-term strategy for eliminating combined sewer outflows and incentives for reducing effective impervious areas; and strong public outreach including the Community Watershed Stewardship Program (which funds restoration, education and citizen involvement activities) (City of Portland 2001). The City is also developing a comprehensive, science-based program for watershed restoration and fish recovery program with tie-ins to other local and regional programs. This program has the potential for guiding a regional urban framework for managing watershed health and restoration. A brief description of the City of Portland's response to the ESA is included in Appendix 8.

Watersheds 2000

Clean Water Services' (formerly Unified Sewerage Agency) Watersheds 2000, involving a number of local project partners, is an inventory of the location and condition of streams in Washington County, Oregon, one of the three counties encompassing the Metro region. The project will also identify on-the-ground projects likely to improve the health of these streams and will help Clean Water Services and its partners make informed resource management decisions (Clean Water Services 2000). This effort has collected a large body of quantitative and qualitative stream and riparian corridor data that will be available to Metro and the public beginning approximately June 2001. These data could greatly reduce costs involved in initiating an urban watershed restoration master plan, particularly if the same data collection methodologies could be applied to other jurisdictions within the Metro region.

The Tualatin River Watershed Council

The Tualatin River Watershed Council provides an example of an effective watershed council, with a citizen biological monitoring program, educational activities, native riparian enhancement projects, and cooperative efforts with other local organizations such as Clean Water Services, Friends of Trees, and Stop Oregon Litter and Vandalism (SOLV) (Tualatin River Watershed Council 2001). They have obtained funding from a variety of sources for these activities and have a fully funded watershed coordinator position overseeing all watershed projects, related activities, and communications with other groups. Such efforts can provide valuable information for larger scale planning efforts.

The Johnson Creek Watershed

The Johnson Creek Watershed has received more attention than most watersheds in the Metro region because urbanization greatly increased flood risks in that area. The Portland Multnomah Progress Board, in cooperation with the Johnson Creek Watershed Council and many other governmental and non-governmental organizations, assessed current watershed conditions and prepared a strategy toward salmonid recovery in the Johnson Creek (Multnomah County) watershed (Meross 2000). This and other watershed assessments and restoration plans should be integrated into any regional plans addressing watershed health.

Oregon Department of Fish and Wildlife

The Oregon Department of Fish and Wildlife is directly involved with wildlife conservation in the metro region. For example, ODFW's Wildlife Diversity Program emphasizes protection and management of the 88 percent of the state's native fish and wildlife species that are not hunted, angled or trapped (the so-called "nongame" species; ODFW 1993). The plan is a blueprint for addressing the needs of Oregon's native fishes, amphibians, reptiles, bird and mammals, and contains information on all species and habitats in the state. ODFW also provides technical input to various Metro programs, including Goal 5 (as does the U.S. Fish and Wildlife Service). ODFW's website provides information on naturescaping, threatened and endangered species, timing for instream projects to protect salmonids, exotic species, and various technical reports on fish, wildlife and habitat (see ODFW's website at www.dfw.state.or.us). ODFW also manages the Sauvie Island Wildlife Area, an area remarkably important to migratory songbirds and waterfowl.

USFWS and Metro Greenspaces Program

Since 1991, the U.S. Fish and Wildlife Service (USFWS) has funded the Greenspaces Program to support habitat restoration, natural resource conservation, and environmental education efforts in the Portland, Oregon and Vancouver, Washington metropolitan area. USFWS works in partnership with Metro to award cost-share funding under the following programs:

- Conservation and Restoration Program: This program is designed to benefit fish and wildlife by supporting natural resource conservation, restoration and enhancement projects as well as efforts that will build upon current information and knowledge about local fish and wildlife and their habitats.
- Environmental Education Grant Program: This program supports environmental education programs and projects that teach about ecological principles and local watersheds, foster community involvement in habitat conservation issues, and promote citizen stewardship of urban natural areas.

Summary

The cumulative nature of human impacts in a watershed make return of the full, original range of ecological functions unlikely. The real question is whether we can improve, or even maintain, the range of ecological functions currently existing in the Metro region. Addressing impervious surfaces, natural vegetation cover, and hydrology are keys to success in formulating watershed plans. The danger that we face is that while a number of ambitious, large-scale restoration plans have been made there is no guarantee of follow-through, and in fact many of these efforts have faltered. This loss of project momentum is a common scenario, and results in a tremendous waste of funds that could have been used to make direct watershed improvements. A science-based restoration master plan encompassing the entire Metro region is one way to answer this question. In this way, each jurisdiction could be assured that other jurisdictions are contributing to reducing the cumulative effects of urbanization, with shared efforts and results. Actions are needed now, before all watersheds in the region are degraded beyond the point of repair.

Preventing further degradation and improving current conditions will require a collective effort of everyone in the region. These efforts are vital to protect some of the fundamental values expressed by Oregonians – a healthy environment, access to nature, and a legacy of these values for future generations. The process of restoring health to our environment will cost money, time, and effort, but we believe it can, and in fact *must* be done in order to sustain future generations of people, fish and wildlife.

CONCLUSION

This technical report provides us with a foundation to answer the questions we set out to address, as described below.

What are the key ecological attributes that characterize a healthy watershed?

- Uplands dominated by native forest cover
- Continuous stream corridors with healthy, fully functioning riparian zones
- Floodplains connected with river channels
- Relatively unaltered hydrologic regimes
- Intact hyporheic zones
- Natural (or ecologically sustainable) input rates of sediment, organic matter, and nutrients that support healthy, productive and diverse fish and wildlife populations
- Lateral, longitudinal and vertical connections between system components
- Natural (or ecologically sustainable) rates of landscape disturbances.

What are the functions and values of fish and wildlife habitat and how can they be retained?

- For riparian corridors, we can characterize the main fish and wildlife habitat functions in six main categories: microclimate and shade; streamflow moderation and water storage; bank stabilization and pollution control; large wood and channel dynamics; organic material sources; and riparian wildlife habitat and connectivity.
- Native vegetation plays a critical role in a watershed, particularly the longitudinal and lateral connectivity of the riparian corridor.
- Downed wood and snags (or large woody debris), frequently found in natural ecosystems but often lacking in disturbed environments, are crucial in providing high quality habitat in both aquatic and terrestrial ecosystems.
- Retention of key functions in riparian corridors will require a varying buffer width based on site-specific conditions.
- Upland habitat is important for many wildlife species. Important guidelines in developing a conservation plan for upland habitat are: large patches are better than small patches; small patches of unique habitat are worth saving; connectivity to other patches is important; and connectivity and/or proximity to water resources is valuable.
- Habitat fragmentation is a critical issue; thus buffers and surrounding land use play an important role in maintaining the functions of remaining habitat.

What are the species of fish and wildlife that characterize the biodiversity of our region?

- There are 292 native vertebrate species in the Metro region. Ninety-three percent use riparian areas, with 45 percent dependent on those areas to meet life history requirements. Eighty-nine percent of all terrestrial species in the Metro region are associated with upland habitats, with at least 28 percent depending on these habitats.
- In the Metro region several species of salmonids are listed as threatened under the federal Endangered Species Act. There are also numerous species that are identified as at risk both by the state and federal agencies. However, in this region we still have much habitat worth protecting and restoring for the purpose of retaining existing species and preventing future listings.

What are the impacts of urbanization on healthy watershed function and fish and wildlife habitat?

- Urban environments have similar ecological problems worldwide; including habitat loss, habitat damage and alteration (instream and terrestrial), modified hydrology, introduced species, and human disturbance.
- In the Metro region we have already lost about 400 miles of streams and many of the remaining stream miles suffer from degraded water quality, fragmentation, and simplification of riparian corridors for fish and wildlife.
- Human disturbance has played a major role in modifying fish and wildlife habitat; including the introduction of nonnative species, pollution, and habitat alteration and simplification.

What is restoration and how is it best approached in an urban context?

- Ecological restoration is the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices (SER 2000).
- Urban "restoration" may represent a range of improvements in function and condition over time, limited in an urban setting to what is actually achievable - in other words, an ecologically, economically and socially acceptable range of options that re-establishes natural functions. The end goal is sustainability, under a new urban equilibrium that is different from that in the original ecosystem, but which supports diverse wildlife communities and healthy ecosystems.
- Addressing hydrology, impervious surfaces, and natural vegetation are keys to success.

Metro will utilize the information in this technical report to help in the development of a regional Goal 5 program to protect fish and wildlife habitat. Specifically, the technical report will help to inform the following steps in the Goal 5 process:

- developing criteria to determine significant riparian and upland wildlife habitat and to address the location, quality, and quantity requirements of the Goal 5 rule;
- conducting an ESEE analysis to weigh the consequences of protection of significant fish and wildlife habitat and allowing development of the resources, and to identify the tradeoffs for decision makers; and
- formulating a program to protect fish and wildlife habitat that is scientifically based.

Integrating the needs of people with the needs of fish and wildlife in an urban environment is not an easy task. There has been debate on the value of providing habitat reserves in urban and developing areas, considering the difficulty many species have cohabiting with humans and the economic value of developable land in urban areas (Linehan et al. 1995). However, a large body of evidence indicates that people living in urban areas appreciate access to fish and wildlife habitat (Adams and Dove 1989; Adams 1994; USDA & NOAA 2000). According to the National Survey on Recreation and the Environment, over 86 percent of Americans think it is important to protect wildlife habitat, and 93 percent believe that the natural environment has intrinsic value (USDA & NOAA 2000).

Metro's policies have consistently placed a high level of importance on the protection of the natural environment as a means of maintaining the high quality of life citizens of this region expect. This technical report provides an important framework to guide us in doing just that.

GLOSSARY

Abiotic – something that is not living (e.g., rock).

Age effect – refers to the amount of time a fragment has been separated from the "mainland" or the surrounding landscape by urbanization.

Algal bloom – a condition that occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water.

Allochthonous – refers to something formed somewhere other than its present location. Examples include leaf litter, insects, etc. falling into a stream. Antonym of autochthonous.

Anadromous fish – fish that are born in freshwater, spend a significant portion of their life in the ocean, and return to natal streams as adults to spawn.

Aquatic – having to do with water.

Armoring (channel armoring) – the formation of a resistant layer of relatively large particles resulting from removal of finer particles by erosion.

At risk species, or species at risk – a catch-all term for species that are officially listed in some manner through state and/or federal Endangered Species Act programs (see Species List for technical definitions).

Autochthonous – Refers to something formed in its present location. Example includes instream algae. Antonym of allochthonous.

Baseflow – Streamflow that results from precipitation that infiltrates into the soil and eventually moves through the soil to the stream channel. This is also referred to as ground water flow, or dry-weather flow.

Benthic zone – associated with stream bottoms

Bioaccumulation – storage of a chemical within a living organism at concentrations higher than found in the surrounding environment.

Biological oxygen demand – indicator of organic pollutants in an effluent measured as the amount of oxygen required to support them. The greater the BOD the greater the pollution and less oxygen available for higher aquatic organisms.

Biodiversity – full range of variety and variability within and among living organisms and the ecological complexes in which they occur. The concept of biodiversity encompasses ecosystem processes, species diversity and genetic variation.

Biota – plants and animals living in a habitat.

Biotic – something that is living, or pertaining to living things.

Carnivore – an animal that feeds on other animals.

Carrying capacity – the maximum sustainable size of a population in a given ecosystem.

Channelization – the process of changing and straightening the natural path of a waterway.

Coarse scale data – applicable on a large spatial scale.

Connectivity – for streams, the physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and these water sources. For terrestrial habitat, concept is similar but in this context refers generally to sufficient connectivity to allow wildlife passage between habitat patches.

Cumulative impacts – the sum of effects from all factors that influence the condition of a watershed that together have a greater impact than if each acts alone

Denitrification – reduction of nitrate or nitrite to molecular nitrogen or nitrogen oxides by microbial activity (dissimilatory nitrate reduction) or by chemical reactions involving nitrite (chemical denitrification). Results in the effective removal of substances which, in high amounts, are toxic to animals.

Detritivore – any organism that eats decaying organic matter.

Diatoms – single-celled creatures with hard, silica-based shells. Frequent aquatic residents that form part of the aquatic food web..

Discharge – the volume of water moving down a channel per unit of time. Alternatively, the volume of water released from a dam or powerhouse at a given time, usually expressed in cubic feet per second.

Disturbance – any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment. In aquatic systems, refers to any significant fluctuation in the supply or routing of water, sediment, or woody debris that causes a measurable change in channel morphology and leads to a change in a biological community.

Diversity – see also biological diversity. In ecology, this term usually refers to how many different kinds of plants and animals are found in an area.

Ecoregion – land areas with fairly similar geology, flora and fauna, and landscape characteristics that reflect a certain ecosystem type.

Ecosystem – the totality of components of all kinds that make up a particular environment; the complex of biotic community and its abiotic, physical environment

Edge – the area of transition between two different vegetation communities, such as forest and meadow. Also refers to human-made systems, such as the transition between a natural area and a residential development.

Effective impervious area (EIA) – the area where there is no opportunity for surface runoff from an impervious surface to infiltrate into the soil before it reaches a conveyance system (pipe, ditch, stream, etc.). An example of an EIA is a shopping center parking lot where the water runs off the pavement and directly goes into a catch basin where it then flows into a pipe and eventually to a stream. In contrast, some homes with impervious roofs collect the roof runoff into roof gutters and send the water down downspouts, where it can be directed either into a pipe or dumped on a splash block. Roof water dumped on a splash block then has the opportunity to spread out into the yard and infiltrate into the soil. Such roofs are not considered to be 100 percent effective impervious area.

Endangered Species Act – 1973 Act of U.S. Congress, amended several times subsequently, that elevates the goal of conservation of listed species above virtually all other considerations. The act provides for identifying (listing) endangered and threatened species or distinct segments of species, monitoring candidate species, designating critical habitat, preparing recovery plans, consulting by federal agencies to ensure that their actions do not jeopardize the continued existence of listed species or adversely modify critical habitats, restricting importation and trade in endangered species or products made from them, restricting the taking of endangered fish and wildlife. The act also provides for cooperation between the federal government and the states.

Enhancement – is the alteration and/or active management of existing habitat to improve particular functions and values; enhancement activities may or may not return the site to pre-disturbance conditions, but creates or recreates functions and processes that occur naturally

Entrenchment – the vertical containment of a river and the degree to which it is incised in the valley floor. A stream may also be entrenched by the use of dikes or other structures.

Ephemeral streams – streams that flow only during or immediately after periods of precipitation, generally less than 30 days per year.

Erosion – the movement of soil particles resulting from the actions of water or wind. Erosion produces sediment that moves in suspension from its site of origin by air, water, or gravity.

Eutrophication – rapid increase in the nutrient status of a water body, natural or occurring as a by-product of human activity. Excessive production leads to anaerobic conditions below the surface waters. Especially refers to high concentrations of nitrates and phosphates in water, which may lead to algal bloom.

Evaporation – conversion of liquid water into water vapor. See also evapotranspiration and transpiration.

Evapotranspiration – a collective term that includes water discharged to the atmosphere as a result of evaporation from the soil and surface-water bodies and as a result of plant transpiration. *See* also evaporation and transpiration.

Extinct – complete loss of a species, i.e., no surviving individuals exist.

Extirpated – a species that has gone locally extinct.

Fecal coliform – present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. Some fecal coliform bacteria may cause illness, and if a large number of fecal coliform bacteria (over 200 colonies/100 milliliters (ml) of water sample) are found in water, it is possible that pathogenic (disease- or illness-causing) organisms are also present in the water.

Flashiness – generally refers to high variability of stream flow. The ratio of the flow that is exceeded 90 percent of the time to the flow exceeded 10 percent of the time (90:10 ratio) is indicative of the flashiness or variability of stream flow. Excessive stream flashiness may be caused by human impacts such as impervious surfaces and loss of vegetative cover, resulting in hydrologic alterations that change the biotic communities able to live in and near the stream.

Floodplain – the area immediately adjacent to the stream or river channel that becomes inundated with overbank flows during large storm events.

Flood-pulse concept – identifies the predictable advance and retraction of water on the floodplain of a pristine system as the principal agent in enhancing biological productivity and maintaining diversity in the system (Bayley 1995).

Flow (streamflow) – water flowing in the stream channel. It is often used interchangeably with discharge.

Food web – the complex system of transfer of energy among living things; in other words, what eats what.

Fragmentation – the breaking up of once contiguous habitats or populations that may result in decreasing patch or population size and increasing isolation.

Geomorphic – of or resembling the earth, its shape, or surface configuration. See also geomorphology.

Geomorphology – the study of present-day landforms, including their classification, description, nature, origin, development, and relationships to underlying structures. Also the history of geologic changes as recorded by these surface features. The term is sometimes restricted to features produced only by erosion and deposition.

Gradient – the slope of a stream channel. Also pertains to the ecological concept of change across space or time; for example, an urban gradient refers to differences observed from undeveloped to heavily developed areas.

Groundwater – generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids are filled with water) where the water is under pressure greater than atmospheric.

Habitat – an area with the combination of the necessary resources (e.g., food, cover, water) and environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population), and allows those individuals to survive and reproduce.

Headwaters – the smallest streams that combine to form a larger stream; the uppermost reaches of a river or stream.

Herbivore – animals that eat primarily vegetation.

Hydrograph – a graph showing the water level (stage), discharge, or other property of a river volume with respect to time.

Hydrologic cycle – the continuous cycling of water from atmosphere to earth and oceans and back again.

Hyporheic zone – the saturated sediment underneath a stream or river channel and below the riparian area where groundwater and channel water mix. Properties of both groundwater and channel water are blended in the hyporheic zone, significantly changing the water's chemical composition and stimulating biological activity.

Imperviousness – the ability to repel water, or not let water infiltrate. Pertaining to impermeable surfaces, or materials preventing fluids from passing through.

Index of Biological Integrity (IBI) – an integrative expression of site condition across multiple metrics. An index of biological integrity is often composed of at least seven metrics. The plural form is either indices or indexes.

Infiltration capacity – the maximum rate at which water can enter the soil at a particular point under a given set of conditions.

Insectivore – a species whose primary food is insects.

Intermittent streams – streams that flow only during certain times of the year, but usually more than 30 days per year.

Invertebrates – see macroinvertebrates.

Keystone species – species whose effect on community structure is out of proportion to its abundance.

Large woody debris (LWD) – any large piece of woody material that intrudes into a stream channel or is present in terrestrial habitats. Also known as Large Wood, Large Organic Debris.

Limnetic zone – deep open water dominated by phytoplankton and freshwater fish, extending to the limits of light penetration. Profundal zone below limnetic zone, devoid of plant life and dominated by detritivores. Benthic zone includes bottom soil and sediments.

Littoral zone – at edge of lakes is the most productive with diverse aquatic beds and emergent wetlands (part of Herbaceous Wetland habitat)..

Low-gradient zone – portions of a stream that flow along a gradual or relatively flat slope.

Macroinvertebrates – animals without backbones that can be seen with the naked eye. Includes insects, crayfish, snails, mussels, clams, etc.

Meander – following a winding and turning course. A meandering stream is an alluvial stream characterized by a series of pronounced alternating bends.

Metapopulation – a collection of localized populations that are geographically distinct, yet are genetically interconnected through movement of individuals among populations. See also Rescue effect.

Microclimate – the climate of a small, specific area rather than an entire area. More specifically, the photosynthetically active radiation, air or water temperature, and vapor pressure deficit present at a specific site. Chen et al. (1999) describe microclimate as the suite of climatic conditions measured in localized areas near the earth's surface.

Mid-section zone – the portion of a stream between the headwaters and low-gradient zone, which tends to have a band of riparian vegetation that is influenced by channel dynamics (e.g., meandering, flooding).

Mitigation – measures used to reduce the adverse effects of a proposed project by considering, in the following order: a) avoiding the impact altogether by not taking a certain action or parts of an action; b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitating or restoring the affected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action by monitoring and taking appropriate measures; and e) compensating for the impact by replacing or providing comparable substitute water quality resource areas (Metro 1998).

Nutrient cycling – all the processes by which nutrients are transferred from one organism to another. For instance, the carbon cycle includes uptake of carbon dioxide by plants, ingestion by animals, and respiration and decay of the animal.

Organochlorine pesticide – A class of organic pesticides containing a high percentage of chlorine. Includes dichlorodiphenylethanes (such as DDT), chlorinated cyclodienes (such as chlordane), and chlorinated benzenes (such as lindane). Most organochlorine insecticides were banned or severely restricted in usage because of their carcinogenicity, tendency to bioaccumulate, and toxicity to wildlife.

Organochlorine compound – synthetic organic compounds containing chlorine. As generally used, term refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides, polychlorinated biphenyls (PCBs) and some solvents containing chlorine.

Overflow channel - An abandoned channel in a floodplain that may carry water during periods of high stream or river flows.

Overland flow – precipitation runoff that occurs when the precipitation rate exceeds the infiltration rate of the ground's surface; water flowing over the surface of the earth.

Oxbow – a meander severed from the main channel; an abandoned stream meander.

Oxbow lake – a body of water created after clay, other material, or channel dynamics plugs the oxbow from the main channel.

Passive restoration – allows natural processes to return through reducing or halting activities that cause degradation or prevent recovery.

Perennial stream – a watercourse that flows throughout the year or most of the year (90 percent), in a well-defined channel. Also known as a live stream. Flows continuously during both wet and dry times; baseflow is dependably generated from the movement of groundwater into the channel.

pH – the negative log of the hydrogen ion concentration ($-\log 10\ [H+]$); a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The scale is 0-14. Aquatic organisms tend to be restricted in the pH range in which they can survive.

Phytoplankton – free-floating microscopic aquatic organisms capable of photosynthesis.

Pool – an area of relatively deep slow water in a stream that offers shelter to fish.

Precipitation – any form of water, such as rain, snow, sleet, or hail, that falls to the earth's surface.

Profundal zone – is the deepest part of the ocean or lake where light does not penetrate. This layer usually has fewer nutrients, more silt, and

fewer organisms than the surface.

Reference condition – conditions that represent the optimal or best attainable conditions for habitats or ecosystems.

Rehabilitation – improvements to a natural resource that return it to a good condition but not the condition prior to disturbance.

Rescue effect – see also Metapopulation. A subpopulation on one habitat patch could go temporarily extinct, but as long as the patch is connected to a populated patch it could be recolonized. This effect is crucial in the maintenance of small populations with limited habitat area.

Respiration – the physical and chemical processes by which an organism supplies its cells and tissues with the oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy-producing reactions; any of various energy-yielding oxidative reactions in living matter.

Riffle – area of a stream or river characterized by a rocky streambed and turbulent, fast-moving, shallow water.

Riparian area – the land and vegetation adjacent to waterbodies such as streams, rivers, wetlands and lakes that are influenced by perennial or intermittent water and hydric soils (soils formed under periodic saturation or flooding). Riparian areas are dynamic biological and physical systems that act as the interface between terrestrial (land) and aquatic (water) ecosystems.

Riparian corridor – includes the stream or river; riparian vegetation; off-channel habitat such as wetlands and side channels, and the floodplain; the hyporheic zone; and the zone of influence.

Riparian vegetation – the plant communities occurring within the riparian area that are adapted to wet conditions and are distinct from upland communities.

River Continuum Concept – the best known longitudinal model for rivers, the River Continuum Concept (RCC) attempts to generalize and explain observed longitudinal changes in stream ecosystems. It proposes that rivers exhibit continuous longitudinal changes and identifies the relationships between the progressive changes in stream structure, such as channel size and stream flow, and the distribution of species. According to the RCC, characteristics of particular reaches are associated not only with discrete factors such as water temperature, but with their positions along the length of the river. The model is especially useful at the basin and stream scale, because it accounts for observed longitudinal shifts in biotic communities.

Salinity – the concentration of salt in water, usually measured in parts per thousand (ppt).

Salmonids – fish that belong the Salmonidae family. This includes salmon and steelhead.

Saturated overland flow – runoff that occurs when the water table rises to the ground surface, usually during a large rainstorm, causing groundwater to break out of the saturated soil and to travel as overland flow.

Sediment – particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.

Sediment load – mass of sediment passing through a stream cross section in a specified period of time, expressed in millions of tons (mt). Amount of sediment carried by running water. The sediment that is being moved by a stream.

Sedimentation – occurs when eroded soil is deposited by runoff into rivers, harbors and lakes, degrading water quality.

Smoltification – the physiological changes anadromous salmonids undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.

Sinuosity – the amount of curvature in the channel and is computed by dividing the channel centerline length by the length of the valley centerline.

Species at risk – see At risk species.

Species guild – a group of organisms with similar functional characteristics, such as trophic or migratory levels.

Species of concern – species which the U.S. Fish and Wildlife Service is reviewing for consideration as candidates for listing under the Endangered Species Act.

Species richness – the number of species in a given area or habitat.

Stormflow (stormwater) – precipitation that reaches the channel by moving downslope as overland flow or as shallow subsurface flow.

Substrate – the material forming the underlying layer of streams, may be bedrock, gravel, boulders, sand, clay, etc.; materials such as rocks or logs found in streams that can provide habitat for aquatic organisms

Subsurface flow – precipitation runoff that occurs when the precipitation rate exceeds the infiltration rate of the ground's surface; water flowing under the shallow surface of the earth when there is a relatively impermeable layer underneath permeable topsoil.

Surface water – an open body of water, such as a stream or a lake.

Talus – a sloping heap of loose rock fragments lying at the foot of a cliff or steep slope.

Terrace – a berm or discontinuous segments of a berm, in a valley at some height above the floodplain, representing a former abandoned flood plain of the stream.

Terrestrial – living or growing on land.

Total impervious area (TIA) – the total amount of actual impervious surface on a site or within a drainage area, basin, or subbasin.

Total sediment load – includes bed sediment load, suspended sediment load, and wash load (that part of the suspended load that is finer than the bed material; limited by supply rather than hydraulics).

Transpiration – diffusion of water vapor from plant leaves to the atmosphere; transpired water originates from water taken in by roots.

Trophic – pertaining to feeding and nutrition. Formally, an organism's position in the food chain, determined by the number of energy-transfer steps to that level.

Turbidity – measure of extent to which light passing through water is reduced due to suspended materials. Cloudiness of water, measured by how deeply light can penetrate into the water from the surface. The cloudy appearance of water caused by the presence of suspended material.

Upland – land above water level and beyond ground that is saturated by water for any length of time; they are formed by the larger geologic processes over time. Uplands contain plants that grow in drier soils and may provide habitat for different kinds of animals than a riparian zone.

Urban gradient – an environmental gradient is a spatially varying aspect of the environment which is expected to be related to species composition; the urban gradient is a specific type of environmental gradient representing a gradient of urbanization conditions.

Velocity – speed.

Wastewater – water that carries wastes from homes, businesses, and industries.

Watershed – all the land and tributaries draining to a body of water; a drainage basin which contributes water, organic materials, nutrients, and sediments to a river, stream or lake.

Watershed assessment – is a process for evaluating how well a watershed is functioning; it includes steps for identifying issues, examining the history of the watershed, describing its features, and evaluating various resources within the watershed.

Wetlands – wetlands may occur adjacent to stream channels and within the floodplain of the riparian corridor. They are defined as ecosystems that depend on frequent and recurrent shallow inundation or saturation at, or near, the soil surface. Swamps, marshes, bogs and similar areas are generally considered wetlands. Plant communities of wetland habitats are dominated by species adapted to survive and grow under extended periods of anaerobic (absence of oxygen) soil conditions.

Zone of influence – refers to the transition area between the riparian area and the upland forest where vegetation is not directly influenced by hydrologic conditions, but where vegetation still influences the stream by providing shade, microclimate, fine or large woody materials, nutrients, organic and inorganic debris, terrestrial insects, and habitat for riparian associated wildlife.

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† = derived directly from empirical evidence (primary literature)
‡ = urban study, includes urban study sites or conveys urban-specific information
? = gray area – not entirely empirical or urban specificity is questionable

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Metro Region Species List: Purpose and Limitations

June 19, 2001

The purpose of Metro's Species List is threefold:

1. To identify fish and wildlife species that occur in the Metro region.
2. To identify the relative importance of various types of habitat to fish and wildlife species.
3. To provide a biologically meaningful way in which to describe the biodiversity of the Metro region.

THE LIST IS NOT A STATEMENT OF POLICY. In keeping with Metro's Streamside CPR Vision Statement, the focus of the list is on native fish and wildlife species whose historic ranges include the metropolitan area and whose habitats are or can be provided for in urban habitats. Urban habitats may never be conducive to significant populations of some species, such as black bear and cougar. Further analysis and Metro Council deliberation will help determine (to the extent possible) the type, amount, and location of fish and wildlife habitats that should be protected and/or restored. For example, landowner incentives will be developed for conservation purposes.

This list contains:

1. All known native vertebrate species that currently exist within the Metro region (the final version will include a map of area involved) for at least a portion of the year and could be found in the region through diligent search by a knowledgeable person. Vagrant species (those that do not typically occur every year) are not included on this list.
2. Extirpated (locally extinct) native vertebrate species known to have inhabited the region in the past.
3. Nonnative vertebrate species with established breeding populations in the region.

The species list is based on the opinion of more than two dozen local wildlife experts. The Oregon Natural Heritage Program (ORNHP), Endangered Species Act (ESA), and Oregon Department of Fish and Wildlife (ODFW) status categories were obtained from ORNHP's February, 2001 *Rare, Threatened and Endangered Plants and Animals of Oregon* publication. Habitat associations were obtained from Johnson and O'Neil's new book, *Wildlife Habitats and Relationships in Oregon and Washington*. The taxonomic standards for common and scientific names for birds is based on the American Ornithological Union Check-list. We are also developing a separate aquatic and terrestrial invertebrate list, but this will not be as comprehensive in scope as the vertebrate species list.

Upon completion, these lists will be available to the public through Metro's website. For questions or comments regarding this list, please contact Paul Ketcham (ketcham@metro.dst.or.us, phone 503/797-1726).

Metro Region Species List:
Key to Notations

* Indicates species that are non-native (also known as alien or introduced) to Metro region.

( ) Parentheses indicate a species that was historically present but was extirpated from the Metro region within approximately the last century.

1 **Code** (type of animal)
A = Amphibians
B = Birds
F = Fish
M = Mammals
R = Reptiles

2 **Migratory Status** (indicates trend for the majority of a given species in the Metro region):
A = Anadromous (fish; lives in the ocean, spawns in fresh water)
C = Catadromous (fish; lives in fresh water, spawns in the ocean)
M = Migrates through area without stopping for long time periods
N = Neotropical migratory species (birds; majority of individuals breeding in the Metro region migrate south of U.S./Mexico border for winter)
R = Permanent resident (lives in the area year-round)
S = Short-distance migrant (from elevational to regional migration, e.g., across several states)
W = Winters in the Metro region

3 **Federal Status** is based on current Endangered Species Act listings. **E** = Endangered, **T** = Threatened. Endangered taxa are those which are in danger of becoming extinct within the foreseeable future throughout all or a significant portion of their range. Threatened taxa are those likely to become endangered within the foreseeable future.
LE = Listed Endangered. Taxa listed by the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) as Endangered under the Endangered Species Act (ESA), or by the Departments of Agriculture (ODA) and Fish and Wildlife (ODFW) of the state of Oregon under the Endangered Species Act of 1987 (OESA).
LT = Listed Threatened. Taxa listed by the USFWS, NMFS, ODA, or ODFW as Threatened.
PE = Proposed Endangered. Taxa proposed by the USFWS or NMFS to be listed as Endangered under the ESA or by ODFW or ODA under the OESA.
PT = Proposed Threatened. Taxa proposed by the USFWS or NMFS to be listed as Threatened under the ESA or by ODFW or ODA under the OESA.
C = Candidate taxa for which NMFS or USFWS have sufficient information to support a proposal to list under the ESA, or which is a candidate for listing by the ODA under the OESA.
SoC = Species of Concern. Former C2 candidates which need additional information in order to propose as Threatened or Endangered under the ESA. These are species which USFWS is reviewing for consideration as Candidates for listing under the ESA.

4 **ODFW Status** (state status) is based on current Oregon Department of Fish and Wildlife "Oregon Sensitive Species List," 2001. See Federal Status (above) for definitions of LT and LE.
SC (Critical) = Species for which listing as threatened or endangered is pending; or those for which listing as threatened or endangered may be appropriate if immediate conservation actions are not taken. Also considered critical are some peripheral species which are at risk throughout their range, and some disjunct populations.
SV (Vulnerable) = Species for which listing as threatened or endangered is not believed to be imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring. In some cases the population is sustainable, and protective measures

are being implemented; in others, the population may be declining and improved protective measures are needed to maintain sustainable populations over time.
SP (Peripheral or Naturally Rare) = Peripheral species refer to those whose Oregon populations are on the edge of their range. Naturally rare species are those which had low population numbers historically in Oregon because of naturally limiting factors. Maintaining the status quo for the habitats and populations of these species is a minimum requirement. Disjunct populations of several species which occur in Oregon should not be confused with peripheral.
SU (Undetermined Status): Animals in this category are species for which status is unclear. They may be susceptible to population decline of sufficient magnitude that they could qualify for endangered, threatened, critical or vulnerable status, but scientific study will be required before a judgement can be made.

5 **ORNHP Rank (ABI – Natural Heritage Network Ranks):** ORNHP participates in an international system for ranking rare, threatened and endangered species throughout the world. The system was developed by The Nature Conservancy and is maintained by The Association for Biodiversity Information (ABI) in cooperation with Heritage Programs or Conservation Data Centers (CDCs) in all 50 states, in 4 Canadian provinces, and in 13 Latin American countries. The ranking is a 1-5 scale, primarily based on the number of known occurrences, but also including threats, sensitivity, area occupied, and other biological factors. On Metro's Species List the first ranking (**rank**/rank) is the Global Rank and begins with a "G". If the taxon has a trinomial (a subspecies, variety or recognized race), this is followed by a "T" rank indicator. A "Q" at the end of this ranking indicates the taxon has taxonomic questions. The second ranking (rank/**rank**) is the State Rank and begins with the letter "S". The ranks are summarized below.
1 = Critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences.
2 = Imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation), typically with 6-20 occurrences.
3 = Rare, uncommon or threatened, but not immediately imperiled, typically with 21-100 occurrences.
4 = Not rare and apparently secure, but with cause for long-term concern, usually more than 100 occurrences.
5 = Demonstrably widespread, abundant, and secure.
H = Historical Occurrence, formerly part of the native biota with the implied expectation that it may be rediscovered.
X = Presumed extirpated or extinct.
U = Unknown rank.
? = Not yet ranked, or assigned rank is uncertain.

6 **ORNHP List** is based on Oregon Natural Heritage Program data.
List 1 contains taxa that are threatened with extinction or presumed to be extinct throughout their entire range.
List 2 contains taxa that are threatened with extirpation or presumed to be extirpated from the state of Oregon. These are often peripheral or disjunct species which are of concern when considering species diversity within Oregon's borders. They can be very significant when protecting the genetic diversity of a taxon. ORNHP regards extreme rarity as a significant threat and has included species which are very rare in Oregon on this list.
List 3 contains species for which more information is needed before status can be determined, but which may be threatened or endangered in Oregon or throughout their range.
List 4 contains taxa which are of conservation concern but are not currently threatened or endangered. This includes taxa which are very rare but are currently secure, as well as taxa which are declining in numbers or habitat but are still too common to be proposed as threatened or endangered. While these taxa currently may not need the same active management attention as threatened or endangered taxa, they do require continued monitoring.

7 **Riparian Association** indicates use of any of the 4 water-based habitats. Single "X" in any habitat type (upland or water-associated) indicates general association; "XX" indicates close association, as per Johnson and O'Neil 2001.

8 **Habitat Types** based on Johnson and O'Neil (2001). These habitats are described more fully within the text of the upland and riparian chapters.
WLCH = Westside Lowlands Conifer-Hardwood Forest
WODF = Westside Oak and Dry Douglas-fir Forest and Woodlands
WEGR = Westside Grasslands
AGPA = Agriculture, Pasture and Mixed Environs
URBN = Urban and Mixed Environs
WATR = Open Water - Lakes, Rivers, Streams
HWET = Herbaceous Wetlands
RWET = Westside Riparian-Wetlands

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Appendix 1. ***DRAFT*** 06-07-02 Species list and habitat associations for species normally occurring within the Metro region. Study area is the Metro jurisdictional boundary plus

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8] WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
F	River Lamprey	*Lampetra ayresi*	A	SoC	None	G4/S4	4	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Western Brook Lamprey	*Lampetra richardsoni*	A	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Pacific Lamprey	*Lampetra tridentata*	A	SoC	SV	G5/S3	2	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	White Sturgeon	*Acipenser transmontanus*	A	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	American Shad*	*Alosa sapidissima*	A	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chiselmouth	*Acrocheilus alutaceus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Goldfish*	*Carassius auratus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Common Carp*	*Cyprinus carpio*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Peamouth Chub	*Mylocheilus caurinus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
(F)	(Oregon Chub - extirpated from Metro area)	*Oregonichthys crameri*	R	LE	SC	G2/S2	1	(XX)	(XX)	(XX)	N/A	N/A	N/A	N/A	N/A	N/A
F	Northern Pikeminnow (Squawfish)	*Ptychocheilus oregonensis*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Longnose Dace	*Rhynichthys cataractae*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Leopard Dace	*Rhynichthys falcatus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Speckled Dace	*Rhynichthys osculus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Redside Shiner	*Richardsonius balteatus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Largescale Sucker	*Catostomus macrocheilus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Brown Bullhead*	*Ameiurus nebulosus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	N/A	N/A	N/A	N/A	N/A	N/A
F	Eulachon (Columbia River Smelt)	*Thaleichthys pacificus*	A	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Coastal Cutthroat Trout, SW WA/Col. R. ESU	*Oncorhynchus clarki clarki*	A	PT	SC	G4T2Q/S2	2	XX	XX	X	N/A	N/A	N/A	N/A	N/A	N/A
F	Coastal Cutthroat Trout, Upper Will. R. ESU	*Oncorhynchus clarki clarki*	A	SoC	None	G4T?Q/S3?	4	XX	XX	X	N/A	N/A	N/A	N/A	N/A	N/A
F	Chum Salmon, Columbia River ESU	*Oncorhynchus keta*	A	LT	SC	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Coho Salmon, Oregon Coast ESU	*Oncorhynchus kisutch*	A	LT	SC	G4T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Coho Salmon, Lower Columbia R./Southwest Washington ESU	*Oncorhynchus kisutch*	A	C	LE	G4T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Rainbow Trout (resident populations)	*Oncorhynchus mykiss*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead (anadromous Rainbow Trout), Oregon Coast ESU	*Oncorhynchus mykiss*	A	C	SV	G5T2T3Q/S2S3	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead, Lower Columbia River ESU	*Oncorhynchus mykiss*	A	LT	SC	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead, Upper Willamette River ESU, winter run	*Oncorhynchus mykiss*	A	LT	SC	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead, Middle Columbia River ESU	*Oncorhynchus mykiss*	A	LT	SC/SV	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead, Snake River Basin ESU	*Oncorhynchus mykiss*	A	LT	SV	G5T2T3Q/S2S3	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Steelhead, Upper Columbia River ESU	*Oncorhynchus mykiss*	A	LE	None	G5T2Q/SU	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Sockeye Salmon, Snake River ESU	*Oncorhynchus nerka*	A	LE	None	G5T1Q/SX	1 - ex	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chinook Salmon, Lower Columbia R. ESU	*Oncorhynchus tshawytscha*	A	LT	SC	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chinook Salmon, Upper Will. R spring run	*Oncorhynchus tshawytscha*	A	LT	None	G5T2Q/S2	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chinook Salmon, Snake River Fall-run ESU	*Oncorhynchus tshawytscha*	A	LT	LT	G5T1Q/S1	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chinook Salmon, Snake River Spr/Sum.run	*Oncorhynchus tshawytscha*	A	LT	LT	G5T1Q/S1	1	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Chinook Salmon, Upper Col. R. Spring-run	*Oncorhynchus tshawytscha*	A	LE	None	G5T1Q/SU	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Mountain Whitefish	*Prosopium williamsoni*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Sand Roller	*Percopsis transmontanus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Mosquitofish*	*Gambusia affinis*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	N/A	N/A	N/A	N/A	N/A	N/A
F*	Three-spined Stickleback	*Gasterosteus aculeatus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8] WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
F	Prickly Sculpin	*Cottus asper*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F	Reticulate Sculpin	*Cottus perplexus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Green Sunfish*	*Lepomis cyanellus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Pumpkinseed Sunfish*	*Lepomis gibbosus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Warmouth*	*Lepomis gulosus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Bluegill*	*Lepomis macrochirus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Smallmouth Bass*	*Micropterus dolomieu*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Largemouth Bass*	*Micropterus salmoides*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	White Crappie*	*Pomoxis annularis*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	X	N/A	N/A	N/A	N/A	N/A	N/A
F*	Black Crappie*	*Pomoxis nigromaculatus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Yellow Perch*	*Perca flavescens*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
F*	Walleye*	*Stizostedion vitreum vitreum*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	X	N/A	N/A	N/A	N/A	N/A	N/A
F	Starry Flounder	*Platichthys stellatus*	R	None	None	None	None	XX	XX	?	N/A	N/A	N/A	N/A	N/A	N/A
A	Northwestern Salamander	*Ambystoma gracile*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
A	Long-toed Salamander	*Ambystoma macrodactylum*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
A	Pacific Giant Salamander	*Dicamptodon tenebrosus*	R	None	None	None	None	XX			XX	X	X	X		X
A	Cope's Giant Salamander	*Dicamptodon copei*	R	None	SU	G3/S2	2	XX	X		XX	X				
A	Columbia Torrent Salamander	*Rhyacotriton kezeri*	R	None	SC	G3/S3	2	XX			XX	X				
A	Cascade Torrent Salamander	*Rhyacotriton cascadae*	R	None	SV	G3/S3	2	XX			XX	X				
A	Rough-skinned Newt	*Taricha granulosa*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
A	Dunn's Salamander	*Plethodon dunni*	R	None	None	None	None	X			X	X	X			X
A	Western Red-backed Salamander	*Plethodon vehiculum*	R	None	None	None	None	X			X	X	X			X
A	Ensatina	*Ensatina eschscholtzii*	R	None	None	None	None	X			X	XX	X	X	X	X
A	Clouded Salamander	*Aneides ferreus*	R	None	SU	G3/S3	3					X	X		X	X
A	Oregon Slender Salamander	*Batrachoseps wrighti*	R	SoC	SU	G4/S3	1	X			X	X				
A	Western Toad	*Bufo boreas*	R	None	SV	G4/S4	4	XX	XX	XX	XX	X	X	X	X	X
A	Tailed Frog	*Ascaphus truei*	R	SoC	SV	G4/S3	2	XX			XX	X				
A	Pacific Chorus Frog (tree frog)	*Hyla regilla*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
A	Northern Red-legged Frog	*Rana aurora aurora*	R	SoC	SV/SU	G4T4/S3	2	XX	XX	XX	XX	XX	X	X	X	X
(A)	(Oregon Spotted Frog - extirpated)	*Rana pretiosa*	R	C	SC	G2G3/S2	1	(XX)	(XX)	(XX)	(XX)	(X)	(X)	(X)	(X)	
A*	Bullfrog*	*Rana catesbeiana*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	XX	X	X	X	X	X
R*	Common Snapping Turtle*	*Chelydra serpentina*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	X				X	X
R	Painted Turtle	*Chrysemys picta*	R	None	SC	G5/S2	2	XX	XX	XX	X		X		X	X
R	Northwestern Pond Turtle	*Clemmys marmorata marmorata*	R	SoC	SC	G3T3/S2	1	XX	XX	XX	XX	X	XX	X	X	X
R*	Red-eared Slider*	*Trachemys scripta elegans*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	X				X	X
R	Northern Alligator Lizard	*Elgaria coerulea*	R	None	None	None	None	X			X	X	X	X		X
R	Southern Alligator Lizard	*Elgaria multicarinata*	R	None	None	None	None	X			X	X	X	X	X	X
R	Western Fence Lizard	*Sceloporus occidentalis*	R	None	None	None	None					X	X	X	X	X
R	Western Skink	*Eumeces skiltonianus*	R	None	None	None	None					X	X	X	X	X
R	Rubber Boa	*Charina bottae*	R	None	None	None	None	X			X	X		X	X	X
R	Racer	*Coluber constrictor*	R	None	None	None	None						X	X	X	X
R	Sharptail Snake	*Contia tenuis*	R	None	SV	G5/S3	4	X			X	X	X	X	X	X
R	Ringneck Snake	*Diadophis punctatus*	R	None	None	None	None	X			X	X	X	X	X	X

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
R	Gopher Snake	*Pituophis catenifer*	R	None	None	None	None						X	X	X	X
R	Western Terrestrial Garter Snake	*Thamnophis elegans*	R	None	None	None	None	X		X	X		X	X	X	X
R	Northwestern Garter Snake	*Thamnophis ordinoides*	R	None	None	None	None	X			X	X	X	X	X	X
R	Common Garter Snake	*Thamnophis sirtalis*	R	None	None	None	None	XX		XX	XX	X	X	X	X	X
B	Red-throated Loon	*Gavia stellata*	W / M	None	None	None	None	XX			XX					
B	Pacific Loon	*Gavia pacifica*	W / M	None	None	None	None	XX			XX					
B	Common Loon	*Gavia immer*	W / M	None	None	None	None	XX	X	XX						
B	Pied-billed Grebe	*Podilymbus podiceps*	S / N	None	None	None	None	XX	X	XX	X					
B	Horned Grebe	*Podiceps auritus*	W / M	None	SP	G5/S2B, S5N	2	XX	XX	XX						
B	Eared Grebe	*Podiceps nigricollis*	W	None	None	None	None	XX	XX	XX						
B	Western Grebe	*Aechmophorus occidentalis*	W	None	None	None	None	XX	XX	XX						
B	Clark's Grebe	*Aechmophorus clarkii*	W / M	None	None	None	None	XX	XX	XX						
B	Doubled-crested Cormorant	*Phalacrocorax auritus*	R / S	None	None	None	None	XX	XX	X	X					X
B	American Bittern	*Botaurus lentiginosus*	S / N	None	None	None	None	XX		XX					X	
B	Great Blue Heron	*Ardea herodias*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	XX	X
B	Great Egret	*Ardea alba*	W / M	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
B	Green Heron	*Butorides virescens*	N / S	None	None	None	None	XX	X	XX	XX					
B	Black-crowned Night Heron	*Nycticorax nycticorax*	S	None	None	None	None	XX	XX	XX	X					
(B)	(California Condor - extirpated)	*(Gymnogyps californianus)*	R	LE	None	G1SX	1-ex	(X)			(X)			(X)		
B	Turkey Vulture	*Cathartes aura*	N	None	None	None	None	X		X	X	X	X	X	X	X
B	Greater White-fronted Goose	*Anser albifrons*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Snow Goose	*Chen caerulescens*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Ross's Goose	*Chen rossii*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Canada Goose	*Branta canadensis*	VARIABLE	None	None	None	None	XX	XX	XX	X				XX	
B	Dusky Canada Goose	*Branta canadensis occidentalis*	W / M	None	None	G5T2T3/ S2N	4	XX	XX	XX	X				XX	
B	Aleutian Canada Goose (wintering)	*Branta canadensis leucopareia*	W / M	LT	LE	G5T3/S2N	1	XX	XX	XX	X				XX	
B	Trumpeter Swan	*Cygnus buccinator*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Tundra Swan	*Cygnus columbianus*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Wood Duck	*Aix sponsa*	S	None	None	None	None	XX	XX	X	XX	X			X	
B	Gadwall	*Anas strepera*	W / M	None	None	None	None	XX	XX	XX				X	X	
B	Mallard	*Anas platyrhynchos*	R	None	None	None	None	XX	X	XX	XX				X	X
B	Eurasian Wigeon	*Anas penelope*	W / M	None	None	None	None	XX	XX	X					X	
B	American Wigeon	*Anas americana*	W / M	None	None	None	None	XX	X	XX	X				XX	
B	Blue-winged Teal	*Anas discors*	W / M	None	None	None	None	XX	X	XX				X	XX	
B	Cinnamon Teal	*Anas cyanoptera*	N	None	None	None	None	XX	X	XX				X	XX	
B	Northern Shoveler	*Anas clypeata*	W / M	None	None	None	None	XX	XX	XX				X	X	
B	Northern Pintail	*Anas acuta*	W / M	None	None	None	None	XX	XX	XX					X	
B	Green-winged Teal	*Anas crecca*	S	None	None	None	None	XX	X	XX	X			X	X	
B	Canvasback	*Aythya valisineria*	W / M	None	None	None	None	XX	XX	XX						
B	Redhead	*Aythya americana*	W / M	None	None	None	None	XX	XX	XX						
B	Ring-necked Duck	*Aythya collaris*	W / M	None	None	None	None	XX	X	X	XX					
B	Greater Scaup	*Aythya marila*	W / M	None	None	None	None	XX	XX							
B	Lesser Scaup	*Aythya affinis*	W / M	None	None	None	None	XX	XX	XX						

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8] WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
B	Surf Scoter	*Melanitta perspicillata*	W / M	None	None	None	None	X	X							
B	Harlequin Duck	*Histrionicus histrionicus*	W / M	SoC	SU	G4/S2B, S3N	2	XX	XX		XX					
B	Bufflehead	*Bucephala albeola*	W / M	None	SU	G5/S2B,S5N	4	XX	XX	XX	X					
B	Common Goldeneye	*Bucephala clangula*	M	None	None	None	None	XX	XX	X						
B	Barrow's Goldeneye	*Bucephala islandica*	W / M	None	SU	G5/S3B,S3N	4	XX	XX	X						
B	Hooded Merganser	*Lophodytes cucullatus*	W / M	None	None	None	None	XX	XX	X	XX	XX				
B	Common Merganser	*Mergus merganser*	W / M	None	None	None	None	XX	XX		XX	XX				
B	Red-breasted Merganser	*Mergus serrator*	W / M	None	None	None	None	X	X							
B	Ruddy Duck	*Oxyura jamaicensis*	W / M	None	None	None	None	XX	XX	XX						
B	Osprey	*Pandion haliaetus*	N	None	None	None	None	XX	XX		X	X	X		X	X
B	White-tailed Kite (appears to be undergoing range expansion)	*Elanus leucurus*	W / M	None	None	G5/S1B, S3N	2	X			X	X		X	XX	
B	Bald Eagle[a]	*Haliaeetus leucocephalus*	S	LT[a]	LT	G4/S3B, S4N	2	XX	XX	X	X	X	X	X	X	X
B	Northern Harrier	*Circus cyaneus*	N	None	None	None	None	X		X	X			X	X	X
B	Sharp-shinned Hawk	*Accipiter striatus*	N	None	None	None	None	X		X		X	X	X	X	X
B	Cooper's Hawk	*Accipiter cooperii*	S	None	None	None	None	X		X	X	X	X	X	X	X
B	Northern Goshawk	*Accipiter gentilis*	W / M	SoC	SC	G5/S3	2	X		X	X	X	X			
B	Red-shouldered Hawk (appears to be undergoing range expansion)	*Buteo lineatus*	?	None	None	None	None	X			X	X			X	
B	Red-tailed Hawk	*Buteo jamaicensis*	S / N	None	None	None	None	X		X	X	X	X	X	XX	X
B	Rough-legged Hawk	*Buteo lagopus*	W / M	None	None	None	None	X		X	X	X	X	X	X	X
B	American Kestrel	*Falco sparverius*	S	None	None	None	None	X		X	X	X	X	X	X	X
B	Merlin	*Falco columbarius*	W / M	None	None	G5/S1B	2	X	X	X	X	X	X	X	X	X
B	American Peregrine Falcon	*Falco peregrinus anatum*	N	None	LE	G4T3/S1B	2	X	X	X	X	X	X	X	X	X
B*	Ring-necked Pheasant*	*Phasianus colchicus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	X		X	X	X	X	XX	XX	X
B	Ruffed Grouse	*Bonasa umbellus*	R	None	None	None	None	XX			XX	XX	X		X	
B	Blue Grouse	*Dendragapus obscurus*	R	None	None	None	None	X			X	XX	X			
B*	Wild Turkey*	*Meleagris gallopavo*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	X			X	X	X	X	X	X
(B)	(Mountain Quail - extirpated)	*Oreortyx pictus*	R / S	SoC	SU	G5/S4?	4	(X)			(X)	(X)	(X)		(X)	(X)
B	California Quail	*Callipepla californica*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Virginia Rail	*Rallus limicola*	R / S	None	None	None	None	XX		XX					X	
B	Sora	*Porzana carolina*	S / N	None	None	None	None	XX		XX					X	
B	American Coot	*Fulica americana*	R / S	None	None	None	None	XX	XX	XX					X	X
B	Lesser Sandhill Crane	*Grus canadensis*	W / M	None	None	None	None	XX		XX					XX	
B	Black-bellied Plover	*Pluvialis squatarola*	M	None	None	None	None	X	X						XX	
B	American Golden-plover	*Pluvialis dominica*	W / M	None	None	None	None	X	X						XX	
B	Semipalmated Plover	*Charadrius semipalmatus*	M	None	None	None	None	XX	XX						X	
B	Killdeer	*Charadrius vociferus*	S / N	None	None	None	None	X		X	X	X	X	X	XX	X
B	Greater Yellowlegs	*Tringa melanoleuca*	W / M	None	None	None	None	XX	XX	XX	X			X	X	
B	Lesser Yellowlegs	*Tringa flavipes*	W / M	None	None	None	None	XX	XX	XX	X			X	X	
B	Solitary Sandpiper	*Tringa solitaria*	W / M	None	None	None	None	XX	XX	XX	XX			X	X	
B	Spotted Sandpiper	*Actitis macularia*	N	None	None	None	None	XX	X	X	XX				X	
B	Semipalmated Sandpiper	*Calidris pusilla*	W / M	None	None	None	None	XX	XX							

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
B	Western Sandpiper	*Calidris mauri*	W / M	None	None	None	None	XX	XX	XX					X	
B	Least Sandpiper	*Calidris minutilla*	W / M	None	None	None	None	XX	X	XX					X	
B	Baird's Sandpiper	*Calidris bairdii*	W / M	None	None	None	None	XX	X	XX					X	
B	Pectoral Sandpiper	*Calidris melanotos*	W / M	None	None	None	None	XX	X	XX					X	
B	Dunlin	*Calidris alpina*	W / M	None	None	None	None	XX	XX	XX					XX	
B	Short-billed Dowitcher	*Limnodromus griseus*	W / M	None	None	None	None	X		X					X	
B	Long-billed Dowitcher	*Limnodromus scolopaceus*	W / M	None	None	None	None	XX	X	XX					XX	
B	Common Snipe	*Gallinago gallinago*	S / N	None	None	None	None	XX		XX				X	XX	
B	Wilson's Phalarope	*Phalaropus tricolor*	W / M	None	None	None	None	XX	X	X						
B	Red-necked Phalarope	*Phalaropus lobatus*	W / M	None	None	None	None	X	X							
B	Bonaparte's Gull	*Larus philadelphia*	M / W	None	None	None	None	XX	X						X	X
B	Mew Gull	*Larus canus*	W / M	None	None	None	None	XX	XX						X	X
B	Ring-billed Gull	*Larus delawarensis*	W / M	None	None	None	None	XX	XX	X					X	X
B	California Gull	*Larus californicus*	S	None	None	None	None	XX	XX	X					X	X
B	Herring Gull	*Larus agentatus*	W / M	None	None	None	None	XX	XX	X					X	X
B	Thayer's Gull	*Larus thayeri*	W / M	None	None	None	None	XX	XX	X					X	X
B	Western Gull	*Larus occidentalis*	R / S	None	None	None	None	X	X							XX
B	Glaucous Gull	*Larus hyperboreus*	W / M	None	None	None	None	XX	XX	X						X
B	Glaucous-winged Gull	*Larus glaucescens*	W / M	None	None	None	None	XX	X							XX
B	Caspian Tern	*Sterna caspia*	N	None	None	None	None	XX	XX	XX						
B	Forster's Tern	*Sterna forsteri*	M	None	None	None	None	XX	XX	XX						
B	Common Tern	*Sterna hirundo*	W / M	None	None	None	None	X	X							
B*	Rock Dove*	*Columba livia*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien							X	XX	XX
B	Band-tailed Pigeon	*Columba fasciata*	S	SoC	None	G5/S4	4	XX			XX	XX	XX		X	X
B	Mourning Dove	*Zenaida macroura*	S	None	None	None	None	XX			XX	X	X	X	XX	X
B	Barn Owl	*Tyto alba*	R / S	None	None	None	None	X		X	X		X	X	XX	X
B	Western Screech-Owl	*Otus kennicottii*	R	None	None	None	None	X		X	X	X	X		X	X
B	Great Horned Owl	*Bubo virginianus*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Northern Pygmy-Owl	*Glaucidium gnoma*	R	None	SC	G5/S4?	4	X		X	X	XX	X		X	X
(B)	(Northern Spotted Owl - extirpated from Metro region)	*(Strix occidentalis caurina)*	(S)	LT	LT	G3T3S3	1					(XX)	(X)			
B	Barred Owl	*Strix varia*	R	None	None	None	None	X			X	XX	X			X
B	Long-eared Owl	*Asio otus*	W / M	None	None	None	None	X		X		X	X	X	X	
B	Short-eared Owl	*Asio flammeus*	W / M	None	None	None	None	XX		XX				X	XX	
B	Northern Saw-whet Owl	*Aegolius acadicus*	R / S	None	None	None	None	X			X	XX	XX		X	X
B	Common Nighthawk (nearly extirpated)	*Chordeiles minor*	N	None	SC	G5/S5	4	X	X	X	X	X	X	X	X	X
B	Vaux's Swift	*Chaetura vauxi*	N	None	None	None	None	XX	XX	X	X	X	X	X		X
B	Anna's Hummingbird	*Calypte anna*	R	None	None	None	None	X			X	XX	X			X
B	Rufous Hummingbird	*Selasphorus rufus*	N	None	None	None	None	X		X	X	X	X	X	X	X
B	Belted Kingfisher	*Ceryle alcyon*	S	None	None	None	None	XX	XX		XX					
B	Lewis's Woodpecker (extirpated as breeding species)	*Melanerpes lewis*	W / M	SoC	SC	G5/S3B, S3N	4	X			X		XX	X	X	X
B	Acorn Woodpecker	*Melanerpes formicivorus*	R	SoC	None	G5/S3?	4						XX	X		X

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
B	Red-breasted Sapsucker	*Sphyrapicus ruber*	S	None	None	None	None	X			X	X	X	X	X	X
B	Downy Woodpecker	*Picoides pubescens*	R	None	None	None	None	XX			XX	X	X		X	X
B	Hairy Woodpecker	*Picoides villosus*	R	None	None	None	None	X			X	X	X	X	X	X
B	Northern Flicker	*Colaptes auratus*	R	None	None	None	None	X			X	X	X	X	X	X
B	Pileated Woodpecker	*Dryocopus pileatus*	R	None	SV	G5/S4?	4	X			X	X	X		X	X
B*	Monk Parakeet*	*Myiopsitta monachus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX			XX		X		X	XX
(B)	(Yellow-billed Cuckoo; extirpated)	*Coccyzus americanus*	N	SoC	SC	G5/S1B	2	(XX)			(XX)					
B	Olive-sided Flycatcher	*Contopus cooperi (= borealis)*	N	SoC	SV	G5/S4	4	X			X	XX				
B	Western Wood-Pewee	*Contopus sordidulus*	N	None	None	None	None	X			X	X	X		X	X
B	Willow Flycatcher (western OR race)	*Empidonax traillii brewsteri*	N	None	SV	G5TU/S1B	4	XX			XX	X	X		X	X
B	Hammond's Flycatcher	*Empidonax hammondii*	N	None	None	None	None					X	X			
B	Dusky Flycatcher	*Empidonax oberholseri*	M	None	None	None	None	X			X	X	X			
B	Pacific-slope Flycatcher	*Empidonax dificilus*	N	None	None	None	None	X			X	XX	X			
B	Say's Phoebe	*Sayornis saya*	N	None	None	None	None							X	X	X
B	Western Kingbird	*Tyrannus verticalis*	N	None	None	None	None						X	X	X	X
B	Northern Shrike	*Lanius excubitor*	W / M	None	None	None	None	X		X				X	XX	
B	Cassin's Vireo	*Vireo cassinii*	N	None	None	None	None					X	XX			X
B	Hutton's Vireo	*Vireo huttoni*	R / S	None	None	None	None	X			X	X	XX		X	X
B	Warbling Vireo	*Vireo gilvus*	N	None	None	None	None	XX			XX	XX	X		X	X
B	Red-eyed Vireo	*Vireo olivaceus*	N	None	None	None	None	XX			XX	X				
B	Steller's Jay	*Cyanocitta stelleri*	R	None	None	None	None	X			X	X	X		X	X
B	Western Scrub-Jay	*Aphelocoma californica*	R	None	None	None	None	X			X	X	XX	X	X	X
B	Gray Jay	*Perisoreus canadensis*	R	None	None	None	None	X			X	X	X			X
B	American Crow	*Corvus brachyrhynchos*	R	None	None	None	None	X		X	X	X	X	X	XX	XX
B	Common Raven	*Corvus corax*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Streaked Horned Lark	*Eremophila alpestris strigata*	S	SoC	SC	G5T2/S2?	2	—	—	—	—			XX	X	X
B	Purple Martin	*Progne subis*	N	SoC	SC	G5/S3B	2	XX	XX	X	X	X	X	X		X
B	Tree Swallow	*Tachycineta bicolor*	N	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
B	Violet-green Swallow	*Tachycineta thalassina*	N	None	None	None	None	X	X	X	X	X	X	X	X	X
B	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	N	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
B	Cliff Swallow	*Petrochelidon pyrrhonota*	N	None	None	None	None	XX	XX	X	XX	X	X	X	X	X
B	Barn Swallow	*Hirundo rustica*	N	None	None	None	None	XX	XX	XX	XX	X	X	X	XX	X
B	Black-capped Chickadee	*Poecile atricapilla*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Mountain Chickadee	*Poecile gambeli*	W / M	None	None	None	None	X			X	X	X			X
B	Chestnut-backed Chickadee	*Poecile rufescens*	R	None	None	None	None	X			X	X	X		X	X
B	Bushtit	*Psaltriparus minimus*	R	None	None	None	None	X			X	X	X		X	X
B	Red-breasted Nuthatch	*Sitta canadensis*	R	None	None	None	None	X			X	X	X		X	X
B	White-breasted Nuthatch	*Sitta carolinensis*	R	None	None	None	None	X			X		X	X	X	X
B	Brown Creeper	*Certhia americana*	R	None	None	None	None	X			X	X	X	X	X	X
B	Bewick's Wren	*Thryomanes bewickii*	R	None	None	None	None	X		X	X	X	X		X	X
B	House Wren	*Troglodytes aedon*	N	None	None	None	None	X			X	X	X	X	X	X
B	Winter Wren	*Troglodytes troglodytes*	R	None	None	None	None	X			X	X	X			X
B	Marsh Wren	*Cistothorus palustris*	N	None	None	None	None	XX		XX						

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
B	American Dipper	*Cinclus mexicanus*	R / S	None	None	None	None	XX	XX	X	XX					
B	Golden-crowned Kinglet	*Regulus satrapa*	R	None	None	None	None	X			X	XX	X			X
B	Ruby-crowned Kinglet	*Regulus calendula*	W / M	None	None	None	None	X		X	X	X	X	X	X	X
B	Western Bluebird	*Sialia mexicana*	S	None	SV	G5/S4B, S4N	4					XX	XX	X	X	X
B	Townsend's Solitaire	*Myadestes townsendi*	W / M	None	None	None	None	X			X	X	X		X	X
B	Swainson's Thrush	*Catharus ustulatus*	N	None	None	None	None	X			X	X	X		X	X
B	Hermit Thrush	*Catharus guttatus*	S	None	None	None	None	X			X	X	X		X	X
B	American Robin	*Turdus migratorius*	S	None	None	None	None	X		X	X	X	X	X	X	X
B	Varied Thrush	*Ixoreus naevius*	W / M	None	None	None	None					XX	X		X	X
B*	European Starling*	*Sturnus vulgaris*	R / S	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX		X	XX	X	X	X	X	XX
B	American Pipit	*Anthus rubescens*	W / M	None	None	None	None	X		X				X	XX	
B	Cedar Waxwing	*Bombycilla cedrorum*	S	None	None	None	None	X		X	X	X	X		X	X
B	Orange-crowned Warbler	*Vermivora celata*	N	None	None	None	None	X			X	X	X	X	X	X
B	Nashville Warbler	*Vermivora ruficapilla*	N	None	None	None	None	X			X	X	X		X	
B	Yellow Warbler	*Dendroica petechia*	N	None	None	None	None	XX			XX					
B	Yellow-rumped Warbler	*Dendroica coronata*	S	None	None	None	None	X		X	X	X	X		X	X
B	Black-throated Gray Warbler	*Dendroica nigrescens*	N	None	None	None	None	XX			XX	XX	XX		X	X
B	Townsend's Warbler	*Dendroica townsendi*	S / N	None	None	None	None	X			X	X	X		X	X
B	Hermit Warbler	*Dendroica occidentalis*	N	None	None	None	None	X			X	XX	X			
B	MacGillivray's Warbler	*Oporornis tolmiei*	N	None	None	None	None	X			X	X	X		X	
B	Common Yellowthroat	*Geothlypis trichas*	N	None	None	None	None	XX		XX	XX	X	X	X		X
B	Wilson's Warbler	*Wilsonia pusilla*	N	None	None	None	None	XX			XX	XX	X		X	X
B	Yellow-breasted Chat	*Icteria virens*	N	SoC	SC	G5/S4?	4	XX			XX	X	X		X	
B	Western Tanager	*Piranga ludoviciana*	N	None	None	None	None	X			X	XX	XX			X
B	Spotted Towhee	*Pipilo maculatus*	R	None	None	None	None	X			X	X	XX		X	X
B	Chipping Sparrow	*Spizella passerina*	N	None	None	None	None	X			X	X	X	X	X	X
B	Oregon Vesper Sparrow	*Pooecetes gramineus affinis*	S / N	SoC	SC	G5T3/S2B, S2N	2							XX	XX	
B	Savannah Sparrow	*Passerculus sandwichensis*	S / N	None	None	None	None	X		X	X			XX	XX	X
B	Fox Sparrow	*Passerella iliaca*	W / M	None	None	None	None	X			X	X	X		X	X
B	Song Sparrow	*Melospiza melodia*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Lincoln's Sparrow	*Melospiza lincolnii*	S / N	None	None	None	None	XX		XX	XX	X			X	
B	Swamp Sparrow	*Melospiza georgiana*	W / M	None	None	None	None	XX		XX	XX				X	
B	White-throated Sparrow	*Zonotrichia albicollis*	W / M	None	None	None	None								X	X
B	Harris's Sparrow	*Zonotrichia querula*	W / M	None	None	None	None								X	X
B	White-crowned Sparrow	*Zonotrichia leucophrys*	S	None	None	None	None	X		X	X	X	X	X	X	X
B	Golden-crowned Sparrow	*Zonotrichia atricapilla*	R	None	None	None	None	X		X	X	X	X	X	X	X
B	Dark-eyed Junco	*Junco hyemalis*	S	None	None	None	None	X			X	X	X		X	X
B	Black-headed Grosbeak	*Pheucticus melanocephalus*	N	None	None	None	None	X			X	X	X		X	X
B	Lazuli Bunting	*Passerina amoena*	N	None	None	None	None	X			X	X	X	X	XX	X
B	Red-winged Blackbird	*Agelaius phoeniceus*	S	None	None	None	None	XX		XX	X			X	X	X
B	Tricolored Blackbird	*Agelaius tricolor*	S	SoC	SP	G3/S2B	2	XX		XX					X	

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
B	Western Meadowlark (extirpated as breeding species)	*Sturnella neglecta*	W / M	None	SC	G5/S5	4	X		X				XX	XX	
B	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	N	None	None	None	None	XX		XX					X	
B	Brewer's Blackbird	*Euphagus cyanocephalus*	S	None	None	None	None	X		X	X		X	X	XX	X
B	Brown-headed Cowbird	*Molothrus ater*	S / N	None	None	None	None	X		X	X	X	X	X	XX	X
B	Bullock's Oriole	*Icterus bullockii*	N	None	None	None	None	XX			XX		XX		X	X
B	Purple Finch	*Carpodacus purpureus*	S	None	None	None	None	XX			XX	X	XX		X	X
B	House Finch	*Carpodacus mexicanus*	R	None	None	None	None	X		X	X	X	X	X	XX	XX
B	Red Crossbill	*Loxia curvirostra*	R / S	None	None	None	None	X			X	X	X			X
B	Pine Siskin	*Carduelis pinus*	S	None	None	None	None	X		X	X	X	X		X	X
B	Lesser Goldfinch	*Carduelis psaltria*	S	None	None	None	None	XX			XX	X	XX	X	X	X
B	American Goldfinch	*Carduelis tristis*	S	None	None	None	None	X		X	X	X	X	X	X	X
B	Evening Grosbeak	*Coccothraustes vespertinus*	W / M	None	None	None	None	X			X	X	X			X
B*	House Sparrow*	*Passer domesticus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien								XX	XX
M*	Virginia Opossum*	*Didelphis virginiana*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	X			X	X	X	X	XX	XX
M	Vagrant Shrew	*Sorex vagrans*	R	None	None	None	None	X		X	X	X	X	X	X	X
M	Pacific Water Shrew	*Sorex bendirii*	R	None	None	None	None	XX		X	XX	X	X			
M	Water Shrew	*Sorex palustris*	R	None	None	None	None	XX			XX	X				
M	Trowbridge's Shrew	*Sorex trowbridgii*	R	None	None	None	None	X			X	XX	X		X	X
M	Shrew-mole	*Neurotrichus gibbsii*	R	None	None	None	None	X		X	X	XX	X		X	X
M	Townsend's Mole	*Scapanus townsendii*	R	None	None	None	None	X		X	X	X	X	X	X	X
M	Coast Mole	*Scapanus orarius*	R	None	None	None	None	X			X	XX	X	X	X	X
M	Yuma Myotis	*Myotis yumanensis*	R / S	SoC	None	G5/S3	4	XX	XX	XX	XX	X	X	X	X	X
M	Little Brown Myotis	*Myotis lucifugus*	R / S	None	None	None	None	X	X	X	X	X	X	X	X	X
M	Long-legged Myotis	*Myotis volans*	R / S	SoC	SU	G5/S3	4	X	X	X	X	XX	X	X	X	X
M	Fringed Myotis	*Myotis thysanodes*	R / S	SoC	SV	G4G5/S2?	2	X	X	X	X	X	X		X	X
M	Long-eared Myotis	*Myotis evotis*	R / S	SoC	SU	G5/S3	4	X	X	X	X	X	X	X	X	X
M	Silver-haired Bat	*Lasionycteris noctivagans*	L	SoC	SU	G5/S4?	4	X	X	X	X	XX	X	X	X	X
M	Big Brown Bat	*Eptesicus fuscus*	R / S	None	None	None	None	X	X	X	X	X	XX	X	XX	XX
M	Hoary Bat	*Lasiuris cinereus*	L	None	None	G5/S4?	4	X	X	X	X	X	X	X	X	X
M	Pacific Western Big-eared Bat	*Corynorhinus townsendii townsendii*	R / S	SoC	SC	G4T3T4/S2?	2	XX	XX	X	X	X	X	X	X	X
M	Brush Rabbit	*Sylvilagus bachmani*	R	None	None	None	None	X			X	X	X	X	X	X
M*	Eastern Cottontail*	*Sylvilagus floridanus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	X			X				X	X
M	Mountain Beaver	*Aplodontia rufa*	R	None	None	None	None	XX			XX	XX				
M	Townsend's Chipmunk	*Tamias townsendii*	R	None	None	None	None	X			X	XX	X			X
M	California Ground Squirrel	*Spermophilus beecheyi*	R	None	None	None	None					X	X	X	X	X
M*	Eastern Fox Squirrel*	*Sciurus niger*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien							XX	XX	XX
M*	Eastern Gray Squirrel*	*Sciurus carolinensis*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien						XX		X	XX
M	Western Gray Squirrel	*Sciurus griseus*	R	None	SU	G5/S4?	3					X	XX		X	X
M	Douglas' Squirrel	*Tamiasciurus douglasii*	R	None	None	None	None		XX	XX	X					
M	Northern Flying Squirrel	*Glaucomys sabrinus*	R	None	None	None	None	X			X	XX	XX			X
(M)	(Western pocket gopher)	*(Thomomys mazama)*	(R)	None	None	None	None					XX	XX	X	X	X

Code[1]	Common Name	Genus/Species	Migratory Status[2]	Federal Status[3]	ODFW Status[4]	ORNHP Rank[5]	ORNHP List[6]	Riparian Assn.[7]	Habitat Type[8]							
									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN
M	Camas Pocket Gopher	*Thomomys bulbivorus*	R	SoC	None	G3G4/S3 S4	3							XX	XX	X
M	American Beaver	*Castor canadensis*	R	None	None	None	None	XX	XX	XX	XX	X	X		X	X
M	Deer Mouse	*Peromyscus maniculatus*	R	None	None	None	None	XX		XX	XX	XX	XX	XX	XX	XX
M	Bushy-tailed Woodrat	*Neotoma cinerea*	R	None	None	None	None	X			X	XX	XX		XX	X
M	Western Red-backed Vole	*Clethrionomys californicus*	R	None	None	None	None	X			X	X				
M	Heather Vole	*Phenacomys intermedius*	R	None	None	None	None	X			X		X			
M	White-footed Vole	*Arborimus (= Phenacomys) albipes*	R	SoC	SU	G3G4/S3	4	XX			XX	XX				
M	Red Tree Vole	*Arborimus (= Phenacomys) longicaudus*	R	SoC	None	G3G4/S3S4	3	X			X	XX	XX			
M	Gray-tailed Vole	*Microtus canicaudus*	R	None	None	None	None							XX	XX	
M	Townsend's Vole	*Microtus townsendii*	R	None	None	None	None	XX		XX	X	X	X	X	X	
M	Long-tailed Vole	*Microtus longicaudus*	R	None	None	None	None	XX		XX	XX	X	X	X	X	
M	Creeping Vole	*Microtus oregoni*	R	None	None	None	None	X			X	X	X	X	X	X
M	Water Vole	*Microtus richardsoni*	R	None	None	None	None	X			X	X				
M	Common Muskrat	*Ondatra zibethicus*	R	None	None	None	None	XX	XX	XX	XX				X	X
M*	Black Rat*	*Rattus rattus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien								X	XX
M*	Norway Rat*	*Rattus norvegicus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien								X	XX
M*	House Mouse*	*Mus musculus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien								XX	XX
M	Pacific Jumping Mouse	*Zapus trinotatus*	R	None	None	None	None	XX		X	XX	X	X		X	
M	Common Porcupine	*Erethizon dorsatum*	R	None	None	None	None	XX		X	XX	XX	XX		X	X
M*	Nutria*	*Myocastor coypus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	XX	XX	XX	XX				X	X
M	Coyote	*Canis latrans*	R	None	None	None	None	X		X	X	X	X	X	X	X
M	Red Fox	*Vulpes vulpes*	R	None	None	None	None	X			X	X	X	XX	X	X
M	Gray Fox	*Urocyon cinereoargenteus*	R	None	None	None	None	X			X	XX	X	X	X	
(M)	(Gray Wolf - extirpated)	*(Canis lupus)*	S	None	None	None	None	(X)			(X)	(X)	(X)	(X)		
M	Black Bear	*Ursus americanus*	S	None	None	None	None	X		X	X	X	X	X	X	X
(M)	(Grizzly Bear)	*(Ursus arctos)*	(R)	LT	None	G4/SX	2-ex	(X)			(X)	(X)		(X)		
M	Common Raccoon	*Procyon lotor*	R	None	None	None	None	XX	X	XX	XX	X	X	X	XX	XX
M	Ermine	*Mustela erminea*	R	None	None	None	None	X			X	X	X	X	X	
M	Long-tailed Weasel	*Mustela frenata*	R	None	None	None	None	X		X	X	X	X	X	X	X
M	Mink	*Mustela vison*	R	None	None	None	None	XX	XX	XX	XX	X	X	X	X	X
M	Striped Skunk	*Mephitis mephitis*	R	None	None	None	None	X		X	X	X	X	X	X	X
M	Western Spotted Skunk	*Spilogale gracilis*	R	None	None	None	None	X			X	X	X	X	X	X
M	Northern River Otter	*Lontra canadensis*	R	None	None	None	None	XX	XX	XX	XX					X
M	Mountain Lion (Cougar)	*Puma concolor*	S	None	None	None	None	X		X	X	X	X		X	X
M	Bobcat	*Lynx rufus*	S	None	None	None	None	X		X	X	X	X	X	X	X
M*	Domestic Cat (feral)*	*Felis domesticus*	R	N/A - alien	N/A - alien	N/A - alien	N/A - alien	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	California Sea Lion	*Zalophus californianus*	S	None	None	None	None	XX	XX							
M	Roosevelt Elk	*Cervus elaphus roosevelti*	S	None	None	None	None	X		X	X	X	X	X	X	X
(M)	(Columbian White-tailed Deer)	*(Odocoileus virginiana leucurus)*	(R)	LE	SV	G5T2QS2	1	(X)		(X)	(X)	(X)	(XX)	(X)	(X)	(X)
M	Mule Deer	*Odocoileus hemionus*	R	None	None	None	None	X		X	X	X	X	X	X	X

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									WATR	HWET	RWET	WLCH	WODF	WEGR	AGPA	URBN

[a] Bald eagle is currently proposed for de-listing at the federal level.

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Class	Order	Family	Genus	Species	Common name	Habitat, Ecoregion, County, and/or Location	Source	Species at Risk?	Important Fish Prey?	Important Predator?	Important Pollinator?	Important Prey?	Other Important Functions?
Arachnida	Acari												
		Subfamily = Hydrocarinae			aquatic mites	Riffle samples in Clackamas tributaries and Tualatin River Basin	1						
Arachnida	Araneae												
		Agelenidae	*Tegenaria*	*agrestis*	House spider, Funnel weaver		2			X			
		Araneidae	*Argiope*	*aurantia*	Black & yellow garden spider	Tualatin Hills Nature Park	2			X			
		Clubionidae	*Cheiracanthium*	*sp*	Yellow sac spider		2			X			
		Linyphiidae	*Linyphia*	*marginata*	Filmy dome spider		2			X			
		Lycosidae	*Lycosa*	*sp.*	Wolf spider		2			X			
		Pholcidae	*Pholcus*	*phalangioides*	Ghost spider, Daddy long legs		2			X			
		Salticidae	*Dendryphantes*	*sp.*	Jumping spider		2			X			
		Salticidae	*Marptusa*	*sp.*	Jumping spider		2			X			
		Salticidae	*Salticus*	*scenicum*	Zebra spider		2			X			
		Thomisidae	*Misumena*	*vatia*	Red-spotted crab spider	Tualatin Hills Nature Park	2			X			
		Thomisidae	*Tibellus*	*spp*	Crab spider		2			X			
Arachnida	Opiliones												
		suborder = Palpatores			Harvestmen, Daddy Long Legs	Tualatin Hills Nature Park	2			X			*Detritivore (feeds on/breaks down dead organic matter)*
Arachnida	Pseudoscorpions												
					Pseudoscorpion	Tualatin Hills Nature park	2			X			
Bivalvia	Unionoida												
superfamily = Corbiculacea	Order?	Corbiculidae	*Corbicula*	*sp*		Tualatin River Basin	3						
superfamily = Corbiculacea	Order?	Sphaeriidae				Tualatin River Basin	3						
superfamily = Unionacea		Unionidae	*Anodonta*	*californiensis*	California floater (mussel)	Cty: Mult. Ecoreg: CR, WV, WC, EC, BM, BR	4	*S1? Federal species of concern*					*Filter organic debris from water, food for fish and other aquatic organisms*
superfamily = Unionacea		Unionidae				Tualatin River Basin	3						
superfamily = Unionacea		Unionidae?	*Unio*	*willamettensis*		Tualatin Hills Nature Park	2						
Chilopoda	Scutigeromorpha												
			Scutigera	*coleoptera*	House centipede		2						
Copepoda													
(Sub-phylum = Crustacea)				*sp*		Tualatin River Basin	3						
Diplopoda													
			Harpaphe	*haydeniana*	Yellow & black forest millipede	Tualatin Hills Nature Park	2						*Detritivore*

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Gastropoda	Mesogastropoda												
		Ancylidae	*Ferrissia*			Tualatin River Basin	3						
		Hydrobiidae				Tualatin River Basin	3						
		Pleuroceridae	*Juga*			Tualatin River Basin	3						
		Vitrinidae	*Oxychilus*	*alliarius*	Garlic glass snail	Tualatin Hills Nature Park	2						
		Pleuroceridae	*Juga*	*sp. nov.*	Brown juga (snail)	Cty: Mult. Ecoreg: WC	4	*S1. ORNHP List 2.*					
		Pleuroceridae	*Juga*	*hemphilli hemphilli*	Barren juga (snail)	Cty: Mult. Ecoreg: WV, WC	4	*S1. ORNHP List 1.*					
			Fluminicola	*columbiana (=F. fuscus)*	Columbia pebblesnail or spire snail	Cty: Mult. Ecoreg: WV, BM, CB	4	*S2. Federal species of concern. ORNHP List 3*					
			Lyogyrus	*sp. nov.*	Columbia duskysnail	Cty: Mult, Clac. Ecoreg: WV, WC, EC	4	*S2. ORNHP List1.*					
			Pristinicola (= Bythinella)	*hemphilli*	Pristine springsnail	Cty: Mult. Ecoreg: WC, EC, BM, CB	4	*S2? ORNHP List 3.*					
Gastropoda	Basommatophora												
		Lymnaeidae	*Fisherola*	*nuttalli*	Shortface lanx (snail) (= giant Columbia River limpet)	Cty: Mult. Ecoregion: WV, CB	4	*S2. List 2.*					
		Physidae	*Physella*	*columbiana*	Rotund physa (snail)	Cty: Mult. Ecoregion: CR, WV, WC	4	*SH. List 1.*					
		Physidae	*Physella*	*sp*		Tualatin River Basin	3						
		Planorbidae	*Vorticifex*	*neritoides*	Nerite ramshom (snail)	Cty: Mult. Ecoregion: CR, WV, WC	4	*SH. List 3.*					
		Planorbidae				Tualatin River Basin	3						
Gastropoda	Stylommatophora												
		Arionidae	*Ariolimax*	*columbianus*	Banana slug	Tualatin Hills Nature Park	2						
		Arionidae	*Arion*	*ater*	Garden slug	Tualatin Hills Nature Park	2						
		Arionidae	*Hemphillia*	*malonei*	Malone jumping-slug	Cty: Mult, Clac. Ecoregion: WC	4	*S1. List 1.*					
		Arionidae	*Prophysaon*	*coeruleum*	blue-grey tail-dropper (slug)	Cty: Mult, Clac. Ecoregion: WV	4	*S1. List 2.*					
		Limacidae	*Deroceras*	*hesperium*	evening fieldslug	Cty: Clac. Ecoregion: CR, WV, WC	4	*S1. List 1.*					
		Polygyridae	*Cryptomastix*	*devia*	Puget Oregonian (snail)	Cty: Mult. Ecotregion: WV	4	*S1. List 3.*					
		Thysanophoridae	*Megomphix*	*hemphilli*	Oregon megomphix (snail)	Cty: Mult. Ecoregion: CR, WV	4	*S2. List 1.*					
Insecta	Coleoptera (Beetles)												
		Buprestidae	*Buprestis*	*aurulenta*	Golden buprestid beetle	Tualatin Hills Nature Park	2						
		Carabidae	*Acupalpus*	*punctulatus*	Marsh ground beetle	Cty: Wash. Ecoregion: WV	4	*S2? List 3.*					
		Carabidae	*Agonum*	*belleri*	Beller's ground beetle	Cty: Clac. Ecroregion: WC	4	*S1? List 2. Sp of concem.*					
		Carabidae	*Carabus*	*nemoralis*	European ground beetle	Tualatin Hills Nature Park	2						

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		Carabidae	*Pterostichus*	*johnsoni*	Johnson's waterfall carabid beetle	Cty: Mult, Clac. Ecoregion: WC	4	*S4? List 4.*					
		Carabidae	*Scaphinotus*	*sp*	Snail eating beetle	Tualatin Hills Nature Park	2			X			*Feed on snails*
		Cerambycidae			Long-horned beetle	Tualatin Hills Nature Park	2						
		Chrysomelid			Leaf beetle	Tualatin Hills Nature Park	2						
		Chrysomelidae	Chrysolina	sp	Chrysolina beetle	Tualatin Hills Nature Park	2						
		Chrysomelidae	*Diabrotica*	*undecimpunctata*	Western spotted cucumber beetle	Tualatin Hills Nature Park	2						
		Chrysomelidae			Tortoise-shelled beetle	Tualatin Hills Nature Park	2						
		Cicindelidae	*Cicindela*	*oregona*	Tiger beetle	Metro area	5			X			
		Cicindelidae	*Cicindela*	*repanda*	Tiger beetle	Metro area	5			X			
		Cicindelidae	*Omus*	*audouini*	Tiger beetle	Metro area	5			X			
		Cicindelidae	*Omus*	*dejeani*	Tiger beetle	Metro area	5			X			
		Coccinellidae	*Hippodamia*	*convergens*	Convergent ladybird beetle	Tualatin Hills Nature Park	2						
		Coccinellidae			Fourteen-spotted ladybug	Tualatin Hills Nature Park	2			X			
		Curculionidae		*sp*	Weevils	Tualatin River Basin	*3*						
		Dytiscidae			predaceous diving beetles	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Elmidae	*Ampumixis (L)*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries.	1						
		Elmidae	*Cleptelmis*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries.	*1*						
		Elmidae	*Heterlimnlius*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Elmidae	*Lara (L)*	*avara (from Tualatin)*	riffle beetle	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Elmidae	*Narpus*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries.	1						
		Elmidae	*Optioservus*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Elmidae	*Ordobrevia (L)*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries.	1						
		Elmidae	*Zaitzevia*	*sp*	riffle beetle	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Gyrinidae	*Gyrinus*	*sp*	Whirligig beetle	Tualatin Hills Nature Park	1						
		Haliplidae	*Haliplus*	*sp*	Crawling water beetle	Tualatin River Basin	3						
		Hydrophilidae	*Ametor*	*sp*	Water scavenger beetle	Tualatin River Basin	3						
		Mordellidae			Tumbling flower beetle	Tualatin Hills Nature Park	2				X		
		Nitidulidae			Sap beetles	Tualatin Hills Nature Park	2						
		Psephenidae	*Acneus(L)*	*sp*	water penny	Riffle samples in Clackamas tributaries.	1						
		Scarabaeidae	*Polyphylla*	*decimlineata*	Ten-lined June beetle	Tualatin Hills Nature Park	2						
		Scarabaeidae			Scarab beetle	Tualatin Hills Nature Park	2						
		Silphidae	*Nicrophorus*	*sp*	Burying beetle	Tualatin Hills Nature Park	2						*Detritivore (helps recycle animal carcasses)*

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Insecta	Diptera (Flies)												
		Athericidae	*Atherix*	*sp*	no-see-ums	Tualatin River Basin	3						
		Athericidae	*Atherix*			Riffle samples in Clackamas tributaries.	1						
		Bibionidae			March flies	Tualatin Hills Nature Park	2						
		Blephariceridae			netwinged midges	Riffle samples in Clackamas tributaries.	1						
		Bombyliidae	*Bombylius*	*sp*	bee fly	Metro area	2						
		Ceratopogonidae	*Atrichopogon*	*spp*	no-see-ums	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Chironomidae	*Tribe: Chironomini*	*sp*	midges	Tualatin River Basin	3		X				
		Chironomidae	*Tribe: Orthocladiinae*	*sp*	midges	Tualatin River Basin	3		X				
		Chironomidae	*Tribe: Prodiamesinae*	*sp*	midges	Tualatin River Basin	3		X				
		Chironomidae	*Tribe: Tanypodinae*	*sp*	midges	Tualatin River Basin	3		X				
		Chironomidae	*Tribe: Tanytarsini*	*sp*	midges	Tualatin River Basin	3		X				
		Chironomidae			midges	Riffle samples in Clackamas tributaries.	1		X				
		Culicidae			Mosquito	Tualatin Hills Nature Park	2		X				
		Dixidae	*Dixa*		Dixid midges	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Dixidae	*Dixella*		Dixid midges	Riffle samples in Clackamas tributaries.	1		X				
		Dixidae	*Meringodixa*		Dixid midges	Riffle samples in Clackamas tributaries.	1		X				
		Dolichopodidae		*sp*	Long-legged fly	Tualatin River Basin	3						
		Empididae	*Chelifera*		dance fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Empididae	*Clinocera*		dance fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Empididae	*Hemerodromia*		dance fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Empididae	*Oregoton*		dance fly	Riffle samples in Clackamas tributaries.	1						
		Empididae	*Wiedemannia*		dance fly	Riffle samples in Clackamas tributaries.	1						
		Ephydridae		*sp*	Shore fly	Tualatin River Basin	3						
		Pelechorynchidae	*Glutops*			Riffle samples in Clackamas tributaries.	1						
		Psychodidae	*Maruina*		Moth fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						

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		Psychodidae	*Pericoma*		Moth fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Ptycopteridae	*Ptycoptera*	*sp*	Phantom crane fly	Tualatin River Basin	3						
		Sciomyzidae		*sp*	Marsh fly	Tualatin River Basin	3						
		Simuliidae	*Simullum*		Black flies	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Stratiomyidae			Soldier flies	Riffle samples in Clackamas tributaries.	1						
		Syrphidae				Tualatin Hills Nature Park	2						
		Tabanidae	*Tabanus*	*sp*	Horse/Deer fly	Tualatin River Basin	3						
		Tachinidae		*spp*		Metro area	2						
		Therevidae			Stiletto fly	Tualatin Hills Nature Park	2						
		Tipulidae	*Antocha*		Crane fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Tipulidae	*Cryptolabis*		Crane fly	Riffle samples in Clackamas tributaries.	1						
		Tipulidae	*Dicranota*		Crane fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Tipulidae	*Hexatoma*		Crane fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
		Tipulidae	*Limonia*		Crane fly	Riffle samples in Clackamas tributaries.	1						
		Tipulidae	*Molophilus*		Crane fly	Tualatin River Basin	3						
		Tipulidae	*Tipula*		Crane fly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
Insecta	Ephemeroptera (Mayflies)												
		Ameletidae	*Ameletus*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Baetidae	*Acentrella*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Baetidae	*Baetis*	*tricaudatus*		Tualatin River Basin	3		X				
		Baetidae	*Baetis*		blue-winged olive	Riffle samples in Clackamas tributaries.	1		X				
		Baetidae	*Centroptilum/Procloeon*			Riffle samples in Clackamas tributaries.	1		X				
		Baetidae	*Diphetor*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Ephemerellidae	*Attenella*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Ephemerellidae	*Caudatella*			Riffle samples in Clackamas tributaries.	1		X				
		Ephemerellidae	*Drunella*	*doddsi*		Tualatin River Basin	3		X				
		Ephemerellidae	*Drunella*	*pelosa*		Tualatin River Basin	3		X				

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		Ephemerellidae	*Drunella*		slate winged olive	Riffle samples in Clackamas tributaries.	1		X				
		Ephemerellidae	*Ephemerlla*		pale morning dun	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Ephemerellidae	*Serratella*	*tibialis*		Tualatin River Basin	3		X				
		Ephemerellidae	*Serratella*			Riffle samples in Clackamas tributaries.	1		X				
		Ephemerellidae	*Timpanoga*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Heptageniidae	*Cinygma*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Heptageniidae	*Cinygmula*			Riffle samples in Clackamas tributaries.	1		X				
		Heptageniidae	*Epeorus*	*longimanus/deceptivus*		Tualatin River Basin	3		X				
		Heptageniidae	*Epeorus*		small yellow may	Riffle samples in Clackamas tributaries.	1		X				
		Heptageniidae	*Heptagenia/Nixe*		pale evening dun	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Heptageniidae	*Ironodes*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Heptageniidae	*Rhithrogena*		western march brown	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Leptophlebiidae	*Paraleptophlebia*		slate-winged mahogany dun	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
Insecta	Hemiptera												
		Cercopidae			Spittle bug	Tualatin Hills Nature Park	2						
		Gerridae	*Gerris*	*remigis*	Water strider	Tualatin Hills Nature Park	2			X			
		Lygaeidae	*Lygaeus*	*kalmii*	Common milkweed bug	Tualatin Hills Nature Park	2						
		Pentatomidae	*Murgantia*	*histrionica*	Harlequin cabbage bug	Tualatin Hills Nature Park	2			X			
		Pentatomidae			Stink bug	Tualatin Hills Nature Park	2						
			Micracanthi	*schuhi*	Schuh's micracanthia shore bug	Cty: Clac. Ecoregion: WC	4	S?. List 3.					
Insecta	Homoptera												
		Aphididae	*Aphis*	*sp*	Aphid	Tualatin Hills Nature Park	2						
Insecta	Hymenoptera												
		Andrenidae	*Andrena*	*amphibola*		Mult, Clac, and/or Wash	*6*				*X*		
		Andrenidae	*Andrena*	*nivalis*		Mult, Clac, and/or Wash AND Portland	6				*X*		
		Andrenidae	*Andrena*	*prunorum prunorum*		Mult, Clac, and/or Wash AND Portland	6				*X*		
		Andrenidae	*Perdita*	*ciliata*		Mult, Clac, and/or Wash	6				*X*		
		Anthophoridae	*Mellisodes*	*sp*		Metro area	2				*X*		
		Apidae	*Apis*	*mellifera*	Honey bee	Metro area	2				*X*		
		Apidae	*Bombus*	*californicus*	Bumble bee	Metro area	2				*X*		

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		Apidae	*Bombus*	*caliginosus*	Bumble bee	Mult, Clac, and/or Wash AND Portland	6				X		
		Apidae	*Bombus*	*huntii*	Bumble bee	Metro area	2				X		
		Apidae	*Bombus*	*melanopygus*	Bumble bee	Mult, Clac, and/or Wash	6				X		
		Apidae	*Bombus*	*occidentalis*	Bumble bee	Mult, Clac, and/or Wash	6				X		
		Apidae	*Bombus*	*rufocinctus*	Bumble bee	Metro area	2				X		
		Apidae	*Bombus*	*sitkensis*	Bumble bee	Mult, Clac, and/or Wash	6				X		
		Apidae	*Bombus*	*ternarius*	Bumble bee	Tualatin Hills Nature Park	2				X		
		Apidae	*Bombus*	*vosnesenskii*	Bumble bee	Metro area	2				X		
		Apidae	*Ceratina*	*acantha*		Mult, Clac, and/or Wash AND Portland	6				X		
		Apidae	*Nomada*	*edwardsii edwardsii*		Mult, Clac, and/or Wash AND Portland	6				X		
		Apidae	*Psithyrus*	*fernaldae*		Mult, Clac, and/or Wash	6				X		
		Apidae	*Psithyrus*	*fernaldae*		Mult, Clac, and/or Wash	6				X		
		Apidae	*Synhalonia*	*edwardsii*		Mult, Clac, and/or Wash AND Portland	6				X		
		Apidae	*Synhalonia*	*frater lata*		Mult, Clac, and/or Wash	6				X		
		Chrysididae	*Chrysis*	*pacifica*	Pacific cuckoo wasp	Tualatin Hills Nature Park	2						
		Colletidae	*Colletes*	*sp*		Metro area	2				X		
		Colletidae	*Hylaeus*	*episcopalis episcopalis*		Mult, Clac, and/or Wash	6				X		
		Cynipidae		*sp*	Gall wasp	Tualatin Hills Nature Park	2						
		Formicidae		*spp*	Ants								
		Halictidae	*Agapostemon*	*femoratus*		Mult, Clac, and/or Wash AND Portland	6				X		
		Halictidae	*Agapostemon*	*texanus*		Mult, Clac, and/or Wash	6				X		
		Halictidae	*Dufourea*	*calochorti sculleni*		Mult, Clac, and/or Wash	6				X		
		Halictidae	*Dufourea*	*campanulae*		Mult, Clac, and/or Wash	6				X		
		Halictidae	*Halictus*	*sp*		Metro area	2				X		
		Halictidae	*Lasioglossum*	*mellipes*		Mult, Clac, and/or Wash AND Portland	6				X		
		Halictidae	*Lasioglossum*	*olympiae*		Mult, Clac, and/or Wash AND Portland	6				X		
		Megachilidae	*Megachile*	*brevis brevis*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*atrocyanea*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*bella*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*exigua*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*juxta*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*kincaidii*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*nigrifrons*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*obliqua*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*paradisica*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*penstemonis*		Mult, Clac, and/or Wash	6				X		

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		Megachilidae	*Osmia*	*texana*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*trifoliama*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Osmia*	*unca*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Stelis*	*foederalis*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Stelis*	*montana*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Stelis*	*rusti*		Mult, Clac, and/or Wash	6				X		
		Megachilidae	*Stelis*	*subemarginata*		Mult, Clac, and/or Wash	6				X		
		Pompilidae		*sp*	Spider wasps	Metro area	2						
		Sphecidae		*sp*	Mud-dauber wasp	Metro area	2			X			
		Tenthredinidae	*Caliroa*	*cerasi*	Pear sawfly	Tualatin Hills Nature Park	2						
		Vespidae	*Polistes*	*sp*	Paper wasp	Metro area	2			X			
		Vespidae	*Vespula*	*maculata*	Bald-faced hornet	Tualatin Hills Nature Park	2			X			
		Vespidae	*Vespula*	*spp*	Yellow jacket					X			
Insecta	Isoptera												
				spp	Termites								
Insecta	Lepidoptera												
		Arctiidae	*Arctia*	*caja COMPLEX*	Garden/Great tiger moth	Cty: Clac, Wash	7						
		Arctiidae	*Cisseps*	*fulvicollis*	Yellow-collared scape moth	Cty: Clac, Wash	7						
		Arctiidae	*Clemensia*	*albata*	Little white lichen moth	Cty: Clac	7						
		Arctiidae	*Crambidia*	*casta*	Pearly-winged lichen moth	Cty: Clac	7						
		Arctiidae	*Ctenucha*	*multfaria*	none	Cty: Clac, Wash	7						
		Arctiidae	*Cycnia*	*oregonensis*	Oregon cycnis	Cty: Clac	7						
		Arctiidae	*Gnophaela*	*vermiculata*	none	Cty: Wash	7						
		Arctiidae	*Grammia*	*ornata*	Ornate tiger moth	Cty: Wash	7						
		Arctiidae	*Hemihyalea*	*edwardsii*	Edwards' glassywing	Cty: Wash	7						
		Arctiidae	*Hyphantria*	*cune*	Fall webworm moth	Cty: Clac	7						
		Arctiidae	*Leptarctia*	*californiae*	none	Cty: Mult, Clac	7						
		Arctiidae	*Lophocampa*	*argentata*	Silver-spotted tiger moth	Cty: Clac, Wash	7						
		Arctiidae	*Lophocampa*	*maculata*	Yellow-spotted tiger moth	Cty: Clac	7						
		Arctiidae	*Phragmatobia*	*fuliginosa*	Ruby tiger moth	Cty: Clac	7						
		Arctiidae	*Platyprepia*	*virginalis*	Ranchman's tiger moth	Cty: Mult, Wash	7						
		Arctiidae	*Pyrrharctia*	*isabella*	Banded woolybear	Cty: Mult, Clac, Wash	7						
		Arctiidae	*Spilosoma*	*pteridis*	none	Cty: Mult, Clac, Wash	7						
		Arctiidae	*Spilosoma*	*virginica*	Yellow woolybear moth	Cty: Mult, Clac, Wash	7						
		Arctiidae	*Tyria*	*jacobaeae*	Cinnabar moth	Cty: Clac; Tualatin Hills Nature Park	2,7						
		Danaidae	*Danaus*	*plexippus*	Monarch	Cty: Mult, Clac, Wash	8				X		*Amazing migrations!*
		Drepanidae	*Drepana*	*arcuata*	none	Cty: Clac	7						
		Drepanidae	*Drepana*	*bilineata*	none	Cty: Clac	7						
		Geometridae			Geometer moth	Tualatin Hills Nature Park	2						
		Hesperiidae	*Ambliscirtes*	*vialis*	Roadside skipper	Cty: Clac	8						
		Hesperiidae	*Atalopedes*	*campestris campestris*	Sachem	Cty: Mult, Clac, Wash.	8						
		Hesperiidae	*Carterocephalus*	*palaemon mandan*	Arctic skipper	Cty: Mult, Clac, Wash.	8						

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		Hesperiidae	*Epargyreus*	*clarus californicus*	Silver-spotted skipper	Cty: Mult, Clac, Wash	8						
		Hesperiidae	*Erynnis*	*icelus*	Dreamy dusky wing	Cty: Clac, Wash	8						
		Hesperiidae	*Erynnis*	*persius ssp.*	Persius dusky wing	Cty: Mult, Clac, Wash	8						
		Hesperiidae	*Erynnis*	*propertius*	Propertius dusky wing	Cty: Mult	8						
		Hesperiidae	*Euphyes*	*vestris vestris*	Dun skipper	Cty: Clac.	8						
		Hesperiidae	*Hesperia*	*juba*	Juba skipper	Cty: Mult, Clac, Wash.	8						
		Hesperiidae	*Ochlodes*	*sylvanoides sylvanoides*	Woodland skipper	Cty: Mult, Clac, Wash.	8						
		Hesperiidae	*Polites*	*sonora siris*	Sonora skipper	Cty: Mult.	8						
		Hesperiidae	*Pyrgus*	*ruralis ruralis*	Two-banded checkered skipper	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Callophrys*	*perplexa perplexa*	? hairstreak	Cty: Clac, Wash	8						
		Lycaenidae	*Celastrina*	*argiolus echo*	Echo blue	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Everes*	*amyntula amyntula*	Western tailed blue	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Everes*	*comyntas comyntas*	Eastern tailed blue	Cty: Mult	8						
		Lycaenidae	*Glaucopsyche*	*lygdamus columbia*	Silvery blue	Cty: Mult, Clac.	8						
		Lycaenidae	*Icaricia*	*acmon acmon/lutzi*	Acmon blue	Cty: Mult, Clac.	8						
		Lycaenidae	*Incisalia*	*augustinus iroides*	Western brown elfin	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Incisalia*	*eryphon sheltonensis*	Western pine elfin	Cty: Wash	8						
		Lycaenidae	*Lycaena*	*helloides helloides*	Purplish copper	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Mitoura*	*grynea plicataria*	Cedar hairstreak	Cty: Mult, Clac, Wash	8						
		Lycaenidae	*Satyrium*	*saepium saepium*	Hedgerow hairstreak	Cty: Wash	8						
		Lycaenidae	*Strymon*	*melinus atrofasciatus*	Gray hairstreak	Cty: Mult	8						
		Noctuidae	*Schinia*	*vacciniae*	none	Cty: Clac	7						
		Noctuidae			Noctuid moth	Tualatin Hills Nature Park	2						
		Notodontidae	*Clostera*	*albosigma*	none	Cty: Clac	7						
		Notodontidae	*Clostera*	*apicalis*	none	Cty: Mult, Clac	7						
		Notodontidae	*Clostera*	*brucei*	none	Cty: Mult	7						
		Notodontidae	*Furcula*	*cinerea*	Gray furcula	Cty: Clac, Wash	7						
		Notodontidae	*Furcula*	*scolopendrina*	none	Cty: Clac, Wash	7						
		Notodontidae	*Gluphisia*	*lintneri*	none	Cty: Clac	7						
		Notodontidae	*Gluphisia*	*septentrionis*	none	Cty: Mult, Clac, Wash	7						
		Notodontidae	*Gluphisia*	*severa*	none	Cty: Mult, Clac	7						
		Notodontidae	*Nadata*	*gibbosa*	none	Cty: Mult, Clac	7						
		Notodontidae	*Notodonta*	*pacifica*	none	Cty: Clac	7						
		Notodontidae	*Oligocentria*	*semirufescens*	none	Cty: Clac	7						

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		Notodontidae	*Pheosia*	*rimosa*	none	Cty: Clac	7						
		Notodontidae	*Schizura*	*ipomoeae*	none	Cty: Clac	7						
		Notodontidae	*Schizura*	*unicornis*	none	Cty: Clac, Wash	7						
		Nymphalidae	*Adelpha*	*bredowii californica*	California sister	Cty: Mult	8						
		Nymphalidae	*Boloria*	*epithore chermocki*	Western meadow fritillary	Cty: Clac, Wash	8						
		Nymphalidae	*Euphydryas*	*chalcedona colon*	Chalcedon checkerspot	Cty: Clac, Wash	8						
		Nymphalidae	*Limenitis*	*lorquini burrisoni*	Lorquin's admiral	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Nymphalis*	*antiopa antiopa*	Mourning cloak	Cty: Mult, Wash.	8						
		Nymphalidae	*Nymphalis*	*californica*	California tortoise shell	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Nymphalis*	*milberti milberti*	Milbert's tortoise shell	Cty: Mult, Clac.	8						
		Nymphalidae	*Phyciodes*	*mylitta mylitta*	Mylitta crescent	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Phyciodes*	*pulchellus pulchellus*	??	Cty: Clac.	8						
		Nymphalidae	*Polygonia*	*faunus rusticus*	Faun anglewing	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Polygonia*	*gracilis zephyrus*	Zephyr anglewing	Cty: Clac.	8						
		Nymphalidae	*Polygonia*	*progne silenus*	Dark anglewing	Cty: Mult, Clac.	8						
		Nymphalidae	*Polygonia*	*satyrus*	Satyr anglewing	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Speyeria*	*cybele pugetensis*	Great spangled fritillary	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Vanessa*	*annabella*	West coast painted lady	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Vanessa*	*atalanta rubria*	Red admiral	Cty: Mult, Clac.	8						
		Nymphalidae	*Vanessa*	*cardui*	Painted lady	Cty: Mult, Clac, Wash	8						
		Nymphalidae	*Vanessa*	*virginiensis*	American painted lady	Cty: Clac.	8						
		Oecophoridae	*Agonopterix*	*alstroemeriana*	none	Cty: Mult	7						
		Oecophoridae	*Agonopterix*	*nervosa*	none	Cty: Clac, Wash	7						
		Oecophoridae	*Agonopterix*	*rosaciliella*	none	Cty: Clac	7						
		Oecophoridae	*Batia*	*lunaris*	none	Cyt: Clac	7						
		Oecophoridae	*Depressaria*	*daucella*	none	Cty: Clac	7						
		Oecophoridae	*Depressaria*	*pastinacella*	none	Cty: Mult	7						
		Oecophoridae	*Hofmannophila*	*pseudospretella*	none	Cty: Mult, Clac	7						
		Oecophoridae	*Semioscopis*	*inornata*	none	Cty: Clac	7						
		Oecophoridae	*Semioscopis*	*megamicrella*	none	Cty: Clac	7						
		Oecophoridae	*Semioscopis*	*merricella*	none	Cty: Clac	7						
		Papilionidae	*Papilio*	*eurymedon*	Pale tiger swallowtail	Cty: Mult, Clac, Wash	8						
		Papilionidae	*Papilio*	*rutulus rutulus*	Western tiger swallowtail	Cty: Mult, Clac, Wash	8						
		Papilionidae	*Papilio*	*zelicaon zelicaon*	Anise swallowtail	Cty: Mult, Clac, Wash	8						
		Papilionidae	*Parnassius*	*clodius claudianus*	Clodius parnassian	Cty: Mult, Clac, Wash	8						
		Pieridae	*Anthocharis*	*sara flora*	Sara orange tip	Cty: Mult, Clac, Wash	8						
		Pieridae	*Colias*	*eurytheme*	Orange sulfur	Cty: Mult, Clac, Wash	8						
		Pieridae	*Colias*	*philodice eriphyle*	Clouded sulfur	Cty: Clac, Wash	8						
		Pieridae	*Neophasia*	*menapia menapia*	Pine white	Cty: Mult.	8						
		Pieridae	*Pieris*	*napi marginalis*	Mustard white	Cty: Mult, Clac, Wash	8						

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		Pieridae	*Pieris*	*occidentalis occidentalis*	Western white	Cty: Mult, Clac.	8						
		Pieridae	*Pieris*	*rapae*	Cabbage white	Cty: Mult, Clac, Wash	8						
		Saturniidae	*Antheraea*	*polyphemus*	Polyphemus moth	Cty: Clac; Deciduous hardwood forests, urban, orchards, wetlands	7						
		Saturniidae	*Hyalophora*	*euryalus*	Ceanothus silkmoth	Cty: Clac, Wash; Conifer forests and chaparral	7	*Not*					
		Satyridae	*Cercyonis*	*pegala ariane*	Large wood nymph	Cty: Mult, Clac, Wash	8						
		Satyridae	*Coenonympha*	*tullia eunomia*	Ringlet	Cty: Mult, Clac, Wash	8						
		Sphingidae	*Hemaris*	*thyshe*	Hummingbird clearwing	Cty: Clac; open and second growth habitat, gardens, suburbs	7						
		Sphingidae	*Hyles*	*lineata*	White-lined sphinx	Cty: Mult, Wash; open deserts, suburbs, and gardens	7						
		Sphingidae	*Paonias*	*excaecatus*	Blinded sphinx	Cty: Clac, Wash; Woods and suburbs	7						
		Sphingidae	*Proserpinus*	*flavofasciata*	Yellow-banded sphinx	Cty: Clac; meadows in coniferous forests	7						
		Sphingidae	*Smerinthus*	*cerisyi*	One-eyed sphinx	Cty: Mult, Clac, Wash; Valleys and streamsides	7						
		Sphingidae	*Sphinx*	*chersis*	Great ash sphinx	Cty: Clac, Wash; Woodlands and western scrublands	7						
		Sphingidae	*Sphinx*	*vashti*	Vashti sphinx	Cty: Clac, Wash; Montane woodlands and prairie streamcourses	7						
		Thyatiridae	*Ceranemota*	*crumbi*	none	Cty: Mult	7						
		Thyatiridae	*Ceranemota*	*fasciata*	none	Cty: Clac	7						
		Thyatiridae	*Euthyatira*	*lorata*	none	Cty: Clac	7						
		Thyatiridae	*Habrosyne*	*scripta*	none	Cty: Clac, Wash	7						
		Thyatiridae	*Pseudothyatira*	*cymatophorcides*	none	Cty: Clac, Wash	7						
			Lymantria	*dispar*	Gypsy Moth								
Insecta	Mantodea												
					Praying mantis					X			
Insecta	Megaloptera												
		Sialidae	*Sialis*	*sp*	alderfly	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3						
Insecta	Neuroptera												
		Hemerobiidae	*Hemerobius*	*pacificus*	Pacific brown lacewing	Tualatin Hills Nature Park	2						
Insecta	Odonates												
		Aeshnidae	*Aeshna*	*californica*	California darner	Metro area	5			X			
		Aeshnidae	*Aeshna*	*multicolor*	Blue-eyed darner	Metro area	5			X			
		Aeshnidae	*Aeshna*	*palmata*	Paddle-tailed darner	Metro area	5			X			
		Aeshnidae	*Aeshna*	*umbrosa*	Shadow darner	Metro area	5			X			
		Aeshnidae	*Anax*	*junius*	Common green darner	Metro area	5			X			
		Calopterygidae	*Calopteryx*	*aequabilis*	River jewelwing	Cty: Clac.	9			X			

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		Coenagrionidae	*Amphiagrion*	*abbreviatum*	Western red damsel	Metro area	5			X			
		Coenagrionidae	*Argia*	*vivida*	Vivid dancer	Metro area	5			X			
		Coenagrionidae	*Enallagma*	*boreale*	Boreal bluet	Metro area	5			X			
		Coenagrionidae	*Enallagma*	*carunculatum*	Tule bluet	Metro area	5			X			
		Coenagrionidae	*Enallagma*	*cyathigerum*	Northern bluet	Metro area	5			X			
		Coenagrionidae	*Ischnura*	*cervula*	Pacific forktail	Metro area	5			X			
		Coenagrionidae	*Ischnura*	*erratica*	Swift forktail	Metro area	5			X			
		Coenagrionidae	*Ischnura*	*perparva*	Western forktail	Metro area	5			X			
		Corduliidae	*Cordulia*	*shurtleffii*	American emerald	Metro area	5			X			
		Corduliidae	*Epitheca*	*canis*	Beaverpond baskettail	Metro area	5			X			
		Corduliidae	*Epitheca*	*spinigera*	Spiny baskettail	Metro area	5			X			
		Gomphidae	*Octogomphus*	*specularis*	Grappletail	Metro area	5			X			
		Gomphidae	*Stylurus*	*olivaceus*	Olive clubtail	Metro area	5			X			
		Lestidae	*Archilestes*	*californica*	California spreadwing	Metro area	5			X			
		Lestidae	*Lestes*	*congener*	Spotted spreadwing	Metro area	5			X			
		Lestidae	*Lestes*	*disjunctus*	Common spreadwing	Metro area	5			X			
		Lestidae	*Lestes*	*unguiculatus*	Lyre-tipped spreadwing	Cty: Mult	9			X			
		Libellulidae	*Erythemis*	*collocata*	*Western pondhawk*	Metro area	5			X			
		Libellulidae	*Leucorrhinia*	*intacta*	*Dot-tailed whiteface*	Metro area	5			X			
		Libellulidae	*Libellula*	*forensis*	*Eight-spotted skimmer*	Metro area	5			X			
		Libellulidae	*Libellula*	*luctuosa*	*Widow skimmer*	Metro area	5			X			
		Libellulidae	*Libellula*	*pulchella*	*Twelve-spotted skimmer*	Metro area	5			X			
		Libellulidae	*Libellula*	*quadrimaculata*	*Four-spotted skimmer*	Metro area	5			X			
		Libellulidae	*Pachydiplax*	*longipennis*	*Blue dasher*	Metro area	5			X			
		Libellulidae	*Pantala*	*hymenaea*	*Spot-winged glider*	Metro area	5			X			
		Libellulidae	*Plathemis*	*lydia*	*Common whitetail*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*corruptum*	*Variegated meadowhawk*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*costiferum*	*Saffron-winged meadowhawk*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*illotum*	*Cardinal meadowhawk*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*madidum*	*Red-veined meadowhawk*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*pallipes*	*Striped meadowhawk*	Metro area	5			X			
		Libellulidae	*Sympetrum*	*vicinum*	*Yellow-legged meadowhawk*	Metro area	5			X			
		Libellulidae	*Tramea*	*lacerata*	*Black saddlebags*	Metro area	5			X			
		Petaluridae	*Tanypteryx*	*hageni*	Black petaltail dragonfly	Cty: Clac. Ecoregion: KM, WC	4	*S3. List 4.*		X			
Insect	Orthoptera												
		Acrididae			Bandwinged grasshopper	Tualatin Hills Nature Park	2						
Insecta	Plecoptera (Stoneflies)												
		Capniidae			winter stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Chloroperlidae	*Paraperla*		little green stone	Riffle samples in Clackamas tributaries.	3		X				
		Chloroperlidae	*Plumiperla*			Tualatin River Basin	3		X				

Appendix 1. ***DRAFT*** Portland Metro Region Invertebrate Species List (June 19, 2001)

Class	Order	Family	Genus	Species	Common name	Habitat, Ecoregion, County, and/or Location	Source	Species at Risk?	Important Fish Prey?	Important Predator?	Important Pollinator?	Important Prey?	Other Important Functions?
		Chloroperlidae	*Sweltsa*		little green stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Leuctridae	*Despaxia*		needle-like stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Leuctridae	*Moselia*		needle-like stone	Riffle samples in Clackamas tributaries.	1		X				
		Nemouridae	*Malenka*		little brown stone	Riffle samples in Clackamas tributaries.	1		X				
		Nemouridae	*Zapada*	*cinctipes*		Tualatin River Basin	3		X				
		Nemouridae	*Zapada*	*wahkeena*	Wahkeena Falls flightless stonefly	Cty: Mult. Ecoregion: WC	4	*S1. List 1. Sp of concern*	X				
		Nemouridae	*Zapada*		little brown stone	Riffle samples in Clackamas tributaries.	1		X				
		Peltoperlidae	*Yoraperla*		roach-like stone	Riffle samples in Clackamas tributaries.	1		X				
		Perlidae	*Calineuria*		golden stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Perlidae	*Hesperoperla*		golden stone	Riffle samples in Clackamas tributaries.	1		X				
		Periodidae	*Isoperla*		little yellow stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Periodidae	*Skwala*		yellow stone	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Pteronarcidae	*Pteronarcella*			Riffle samples in Clackamas tributaries.	1		X				
		Pteronarcidae	*Pteronarcys*		giant stonefly	Riffle samples in Clackamas tributaries.	1		X				
Insecta	Trichoptera (Caddisflies)												
		Brachycentridae	*Amiocentrus*		american grannom	Riffle samples in Clackamas tributaries.	1		X				
		Brachycentridae	*Brachycentrus*		american grannom	Riffle samples in Clackamas tributaries.	1		X				
		Brachycentridae	*Eobrachycentrus*	*gelidae*	Mt. Hood brachycentrid caddisfly	Cty: Mult, Clac. Ecoregion: WC	4	*S2? List 3. Sp of concern.*	X				
		Brachycentridae	*Micrasema*			Riffle samples in Clackamas tributaries.	1		X				
		Glossosomatidae	*Glossosoma*		turtle case caddis	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Hydropsychidae	*Arctopsyche*		filter feeding caddis	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Hydropsychidae	*Cheumatopsyche*		filter feeding caddis	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				

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Class	Order	Family	Genus	Species	Common name	Habitat, Ecoregion, County, and/or Location	Source	Species at Risk?	Important Fish Prey?	Important Predator?	Important Pollinator?	Important Prey?	Other Important Functions?
		Hydropsychidae	*Hydropsyche*		spotted sedge	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Hydropsychidae	*Parapsyche*		filter feeding caddis	Riffle samples in Clackamas tributaries.	1		X				
		Hydroptilidae	*Hydroptila*		microcaddis/purse case	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Hydroptilidae	*Ochrotrichia*	*alsea*	Alsea ochrotrichian micro caddisfly	Cty: Clac. Ecoregion: CR, WV, EC	4	*S2? List 3.*	X				
		Lepidostomatidae	*Lepidostoma*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Leptoceridae		*sp*		Tualatin River Basin	3		X				
		Limnephilidae	*Apatania (=Radema)*	*tavala*	Cascades apatanian caddisfly	Cty: Clac. Ecoregion: WC, EC, BM	4	*S2? List 3. Sp of concern.*	X				
		Limnephilidae	*Dicosmoecus*		fall caddis	Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Limnephilidae	*Ecclisomyia*			Tualatin River Basin	3		X				
		Limnephilidae	*Goera*			Tualatin River Basin	3		X				
		Limnephilidae	*Psychoglypha*			Tualatin River Basin	3		X				
		Philopotamidae	*Dolophilodes*			Riffle samples in Clackamas tributaries.	1		X				
		Philopotamidae	*Wormaldia*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Psychomiidae	*Psychomyia*			Riffle samples in Clackamas tributaries.	1		X				
		Rhyacophilidae	*Rhyacophila*	*Betteni gr.*	green rock worm	Tualatin River Basin	3		X				
		Rhyacophilidae	*Rhyacophila*	*Brunnea gr.*	green rock worm	Tualatin River Basin	3		X				
		Rhyacophilidae	*Rhyacophila*	*fenderi*	Fender's rhyacophilan caddisfly	Cty: Mult. Ecoregion: WV, KM	4	*S3? List 4.*	X				
		Rhyacophilidae	*Rhyacophila*	*Hylineata gr.*	green rock worm	Tualatin River Basin	3		X				
		Rhyacophilidae	*Rhyacophila*	*Lieftincki gr.*	green rock worm	Tualatin River Basin	3		X				
		Rhyacophilidae	*Rhyacophila*	*Sibirica gr.*	green rock worm	Tualatin River Basin	3		X				
		Rhyacophilidae	*Rhyacophila*		green rock worm	Riffle samples in Clackamas tributaries.	1		X				
		Uenoidae	*Farula*	*jewetti*	Mt. Hood farulan caddisfly	Cty: Mult, Clac. Ecoregion: WC, EC	4	*S1? List 3. Sp of concern.*	X				
		Uenoidae	*Neophylax*			Riffle samples in Clackamas tributaries and Tualatin River Basin	1,3		X				
		Uenoidae	*Neothremma*	*andersoni*	Columbia Gorge caddisfly	Cty: Mult. Ecoregion: WC	4	*S1 List 1. Sp of concern.*	X				
Malacostraca	Decapoda												
(Sub-phylum = Crustacea)			*Astacus*	*lenuisculus*	Crayfish	Tualatin Hills Nature Park	2					X	Detritivore
			Pacifasticus	*sp*		Tualatin River Basin	3						

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Class	Order	Family	Genus	Species	Common name	Habitat, Ecoregion, County, and/or Location	Source	Species at Risk?	Important Fish Prey?	Important Predator?	Important Pollinator?	Important Prey?	Other Important Functions?
Malacostraca	Isopoda												
(Sub-phylum = Crustacea)					Pillbug	Tualatin Hills Nature Park	2						
					Sowbug	Tualatin Hills Nature Park	2						
			Caecidotea	*sp*		Tualatin River Basin	3						
Malacostraca	Amphipoda												
(Sub-phylum = Crustacea)			*Gammarus*	sp	Scuds or sideswimmers	Tualatin River Basin	3		X				
			Hyalella	*azteca*	Scuds or sideswimmers	Tualatin River Basin	3		X				
Ostracoda													
(Sub-phylum = Crustacea)				*sp*		Tualatin River Basin	3						
Miscellaneous													
Annelida	Hirudinea					Tualitin River Basin	3						
Annelida	Oligochaeta				Earthworms	Riffle samples in Clackamas tributaries.	1						
Annelida	Oligochaeta				aquatic worms	Riffle samples in Clackamas tributaries and Tualitin River Basin.	1,3						
Branchiobdellida					crayfish symbionts	Riffle samples in Clackamas tributaries.	1						
Nematoda						Riffle samples in Clackamas tributaries.	1						
Platyhelminthes	Turbellaria				flatworms, planaria	Riffle samples in Clackamas tributaries and Tualitin River Basin.	1,3						
			Hydra			Riffle samples in Clackamas tributaries.	1						

Sources:

1 Jeff Adams, Xerces Society
2 Matthew Shepherd, Xerces Society
3 Michael B. Cole (ABR, Inc) -- mcole@abrinc.com
4 ORNHP website (http://listserv.abi.org/nhp/us/or/tabintro.htm)
5 Jim Johnson (contact suggested by Dennis Paulson) - jimjohn@teleport.com
6 Linda Kervin at USU (contacted by Jim Cane)
7 USGS Northern Prairie Wildlife Research Center (www.npwcr.usgs.gov/resource/distr/lepid/moths/or)
8 Dana N. R. Ross and the Evergreen Aurelians (OSU). Common names taken from Dornfield, Ernst J., The Butterflies of Oregon.
9 http://www.ent.orst.edu/ore_dfly/

Appendix 2

Structural Conditions Analysis

Johnson and O'Neil (2001) provide a wildlife habitat classification scheme that correlates species with various habitat types and structural conditions. Structural conditions are a sub-category of habitat types. The species-habitat and species-structural relationships were based on scientific literature (when available) and professional opinion (probably more common). The primary utility of the information below is to provide a general guidance tool, based on native wildlife currently living in the Metro region, to aid on-the-ground activities such as habitat restoration.

Metro has developed a vertebrate species list that includes all known species occurring regularly in the region. We used Johnson and O'Neil's species-structural relationships to estimate the relative importance of each condition to amphibians, reptiles, birds and mammals (by group) on our species list. A species' use of structural conditions may fall within one of four categories: (1) does not use, (2) is known to occur in, (3) regularly uses, or (4) is closely associated with the structural condition. We assigned point values for each category: 0 points for no use, 1 point for known occurrence, 3 points for regular use, and 5 points for close associations. We summed the points for each structural condition then ranked them in order of importance for (1) all vertebrates on Metro's list (excluding fish), and (2) each group of species (e.g., amphibians, etc.). Highest-ranking structures associated with each group are discussed below.

Amphibians

The 16 amphibian species that live in the Metro region appear to rely on shrub structural conditions S20, S17, S19, S16, S2, S18 and S15, in that order (Table A1). These categories primarily describe tall shrub habitats with varying amounts of cover, although S2 describes a grassland condition. The forested structural conditions important to this group (including F26, F25, F24, F22, F21 and F16) appear to involve large trees and moderate to heavy canopy closure, possibly reflecting their need for woody debris on the forest floor. Amphibian species in the Metro region tend to use agricultural conditions A5 (unimproved pasture) and A2 (improved pasture), and decline with urbanization (category U3 received a score of zero).

Reptiles

The Metro region's 13 native reptile species relate most strongly to tall shrub conditions with open overstories (conditions S15, S16, S17) and grassland habitats (S1 and S2). Shrub condition S6, describing low shrub habitats with closed cover, also appear important. The most important forested conditions include sparse to moderate canopy cover and smaller tree size (F6, F1, F17, F14, and F3), reflecting these species' tendency toward more open terrain. Structure F1 describes grasslands with less than 10% canopy cover. Reptiles appear to use agricultural conditions A4 and A5 most frequently, describing modified grasslands and unimproved pastures. Urbanization patterns were similar to amphibians, with heaviest use of U1, less so in U2, and no use of condition U3.

Birds

Shrub conditions S16 and S17, describing tall, mature or old open shrub habitats, may be most important to the region's 211 native bird species. Grasslands with moderate or heavy grass cover (S2 and S1) also appear important, followed closely by S6, describing low, heavily covered shrub habitats. The mature shrub conditions probably reflect the importance of complex vegetation structure for bird cover, nesting and feeding; the importance of S2 and S1 may be explained by the reliance of seed-eating birds such as sparrows, some warblers, and ground-dwelling birds such as quail and Western Meadowlarks, on grassland habitats. There are many forest structures that appear important to birds, but the three top-ranking structures included large tree single story open canopy (F14), medium tree single story open canopy (F11), and large tree multi-story open canopy (F23). In general, larger trees with open to moderate canopy cover appear most important.

Mammals

The shrub structural conditions that appear most important to the Metro region's 53 mammal species include grasslands (S2 and S1), low closed shrub (S6), and tall, mature or old shrubs with open cover (S17, S16 and S15). The highest ranking forested conditions include large or giant trees with open to moderate canopy cover (F23, F24, F14, F26 and F15), possibly reflecting many small mammals' dependence on woody debris on the forest floor. Mammals in the Metro region appear to use all five agricultural habitats, in decreasing order for A5, A3, A2, A1 and A4. They also occur in all urban conditions (U1, U2 and U3), but quickly decline with urbanization.

All Species

Overall, the most important shrub conditions to the Metro region's 293 non-fish vertebrate species appear to include grasslands with a high amount of grass cover (S2), tall open mature or old shrubs, (S16, S17), grasslands with lower amounts of cover (S1), and low, closed canopy shrub habitats (S6). Significantly, 14 of the forested conditions received higher scores than the highest shrub condition (F14, F23, F11, F24, F26, F15, F20, F8, F21, F12, F17, F5, F25 and F3), suggesting the importance of forest to wildlife in the region; however, shrubs are likely also important. In general, larger trees with open to moderate canopy and a variety of stories (canopy layers) appear to receive the most wildlife use. Agricultural conditions used most widely include unimproved and improved pastures, while modified grasslands appear least important. Overall, species' use of habitats declines with urbanization.

Appendix 2

Overview of Johnson and O'Neil's (2001) Structural Conditions Classifications

Shrubland and Grassland structural conditions. All shrub and grassland structural conditions contain less than 10 percent tree canopy cover; structures containing more than 10 percent canopy are considered forest. The shrubland and grassland structural conditions are based upon shrub height, percent shrub cover (or percent grass/forb cover), and shrub age class, as follows:

Shrub Height	
Low	≤ 0.5 m (1.6 ft)
Medium	0.5-2.0 m (1.6-6.4 ft)
Tall	2.0-5.0 m (6.5-16.5 ft)

Percent Shrub Cover	
Open	10-69% shrub cover
Closed	70-100% shrub cover

Shrub Age Class	
Seedling/Young	Negligible crown decadence
Mature	≤ 25% crown decadence
Old	26-100% crown decadence

Forest structural conditions. The forest structural conditions described in Table A1 below are based on tree size (diameter at breast height, or dbh), percent canopy cover (or percent grass/forb cover), and the number of canopy layers present, as follows:

Tree Size (diameter at breast height, or dbh)	
Shrub/Seedling	< 2.5 cm (1")
Sapling/Pole	2.5 – 24 cm (1-9")
Small Tree	25-37 cm (10-14")
Medium Tree	38-49 cm (15-19")
Large Tree	50-75 cm (20-29")
Giant Tree	> 75 cm (30")

Percent Canopy Cover	
Open	10-39%
Moderate	40-69%
Closed	70-100%

Number of Canopy Layers	
Single Story	1 stratum
Multi-story	2 or more strata

Appendix 2

Table A1. Description of Johnson and O'Neil's (2001) Structural Conditions classifications.

Code	Structural Condition	Description	Metro Land Cover Class(es)
SHRUBLAND AND GRASSLAND STRUCTURAL CONDITIONS			
S1	Grass/Forb – Open	Grasslands that have <10% shrub cover and < 10% tree canopy cover. Grasses and forbs cover less than 70% of the ground, and bare ground is evident.	Meadow/Grass
S2	Grass/Forb – Closed	Grasslands that have <10% shrub cover and <10% tree canopy cover. Grasses and forbs cover >70% of the ground.	Meadow/Grass
S3	Low Shrub/ Open Shrub Overstory – Seedling/ Young	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >10% and <70%. May have <10% tree canopy cover. Areas with <10% shrub cover are categorized as Grass/Forb. These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist from pre-disturbance, but occur as scattered singles or widely scattered clumps. Crown decadence is negligible.	Scattered and Open Canopy Shrub
S4	Low shrub – Open Shrub Overstory- Mature	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >10% and <70%. May have <10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is ≤ 25%.	Scattered and Open Canopy Shrub
S5	Low shrub – Open Shrub Overstory – Old	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >10% and <70%. May have <10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is > 25%.	Scattered and Open Canopy Shrub
S6	Low shrub - Closed Shrub Overstory - Seedling/ Young	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >70%. May have <10% tree canopy cover. These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist from before the disturbance, but occur as scattered singles or widely scattered clumps. Crown decadence is negligible.	Closed Canopy Shrub
S7	Low shrub - Closed Shrub Overstory – Mature	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >70%. May have <10% tree canopy cover < 10%. Crown decadence is ≤ 25%.	Closed Canopy Shrub
S8	Low shrub - Closed Shrub Overstory - Old	Shrublands with shrubs < 0.5 m (1.6 ft) tall and shrub canopy cover >70%. May have <10% tree canopy cover. Crown decadence is > 25%.	Closed Canopy Shrub
S9	Medium shrub - Open Shrub Overstory - Seedling/ Young	Shrublands with shrubs 0.5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >10% and <70%. May have < 10% tree canopy cover (areas with less than > 10% shrub cover are categorized as Grass/Forb). These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist from pre-disturbance, but occur as scattered singles or widely scattered clumps. Crown decadence is negligible.	Scattered and Open Canopy Shrub

Appendix 2

S10	Medium shrub - Open Shrub Overstory – Mature	Shrublands with shrubs 0.5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >10% and <70%. May have < 10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is ≤ 25%.	Scattered and Open Canopy Shrub
S11	Medium shrub - Open Shrub Overstory - Old	Shrublands with shrubs 0.5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >10% and <70% and may have < 10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is > 25%.	Scattered and Open Canopy Shrub
S12	Medium shrub - Closed Shrub Overstory- Seedling/ Young	Shrublands with shrubs .5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >70%, and may have < 10% tree canopy cover. These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist from before the disturbance, but occur as scattered singles or widely scattered clumps. Crown decadence is negligible.	Closed Canopy Shrub
S13	Medium shrub - Closed Shrub Overstory – Mature	Shrublands with shrubs .5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >70%, and may have < 10% tree canopy cover. Crown decadence is ≤ 25%.	Closed Canopy Shrub
S14	Medium shrub - Closed Shrub Overstory – Old	Shrublands with shrubs .5 - 2.0 m tall (1.6 - 6.5 ft.) and shrub canopy cover >70%, and may have < 10% tree canopy cover. Crown decadence is > 25%.	Closed Canopy Shrub
S15	Tall shrub - Open Shrub Overstory - Seedling/ Young	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6 - 16.5 ft) and shrub canopy cover >10% and <70%, and may have < 10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb . These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist after the disturbance, but occur as scattered singles or clumps. Crown decadence negligible.	Scattered and Open Canopy Shrub
S16	Tall shrub - Open Shrub Overstory – Mature	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6 - 16.5 ft) and shrub canopy cover >10% and <70% and may have < 10% tree canopy cover. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is ≤ 25%.	Scattered and Open Canopy Shrub
S17	Tall shrub – Open Shrub Overstory – Old	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6 - 16.5 ft) and shrub canopy cover >10% and <70%, and may have tree canopy cover < 10%. Areas with less than 10% shrub cover are categorized as Grass/Forb. Crown decadence is > 25%.	Scattered and Open Canopy Shrub
S18	Tall shrub - Closed Shrub Overstory - Seedling/ Young	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6 - 16.5 ft) and shrub canopy cover >70%, and may have tree canopy cover < 10%. These are post-disturbance regenerating shrublands dominated by seedlings or young shrubs. Mature, legacy shrubs may persist from before the disturbance, but occur as scattered singles or widely scattered clumps. Crown decadence is negligible.	Closed Canopy Shrub

S19	Tall shrub - Closed Shrub Overstory – Mature	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6 - 16.5 ft) and shrub canopy cover >70%, and may have tree canopy cover < 10%. Crown decadence is ≤25%.	Closed Canopy Shrub
S20	Tall shrub - Closed Shrub Overstory – Old	Shrublands with shrubs > 2.0 m and <5.0 m tall (6.6- 16.5 ft) and shrub canopy cover >70%, and may have < 10% tree canopy cover. Crown decadence is > 25%.	Closed Canopy Shrub
FOREST STRUCTURAL CONDITIONS			
Fl	Grass/Forb – Open	Grass/Forb dominated with <70% coverage by grasses and forbs. Shrubs and small seedlings may be present, but do not dominate stand, (seedlings <10% canopy cover), and there can be remnant trees (trees remaining from the previous stand) that can provide <10% canopy cover.	Meadow/Grass
FS	Grass/Forb – Closed	Grass/Forb dominated with >70% coverage by grasses and forbs. Shrubs and small seedlings may be present, but do not dominate stand, (seedlings <10% canopy cover), and there can be remnant trees (trees remaining from the previous stand) that can provide <10% canopy cover.	Meadow/Grass
F3	Shrub/ Seedling – Open	Seedlings are large enough to add structure to the stand but are small enough that the structure is similar to shrubs and may have remnant trees (trees remaining from the previous stand) that can provide <10% canopy cover. There is <70% cover of shrubs or seedlings. Tree size has <1" dbh, and there is only a single canopy stratum.	Scattered and Open Canopy Shrub
F4	Shrub/ Seedling – Closed	Seedlings are large enough to add structure to the stand but are small enough that the structure is similar to shrubs. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is >70% cover of shrubs or seedlings. Tree size has <1" dbh, and there is only a single canopy stratum.	Closed Canopy Shrub
F5	Sapling/Pole – Open	The canopy is open enough that understory vegetation may be abundant. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is 10-39% cover of sapling and pole sized trees. Tree size is 1"-9" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F6	Sapling/Pole – Moderate	Understory development is hampered by available light and moisture. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is 40-69% cover of sapling and pole sized trees. Tree size is 1"-9" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F7	Sapling/Pole – Closed	The understory is depauperate or absent. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is > 70% cover of sapling and pole sized trees. Tree size is 1"- 9" dbh and there is a single canopy stratum.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland

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F8	Small Tree – Single Story – Open	A grass/forb or shrub understory may be present. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is 10-39% cover of small trees, with <10% cover of other tree sizes. Tree size is 10-14" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F9	Small Tree – Single Story – Moderate	Some grass/forb or shrub understory may be present. Remnant trees (green trees remaining from the previous stand) can provide <10% canopy cover. There is 40-69% cover of small trees with <10% cover of other sized trees. Tree size is 10-14" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F10	Small Tree – Single Story – Closed	Grass/Forb or shrub understory minor or absent. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is > 70% cover of small trees, with <10% cover of other sized trees. Tree size is 10-14" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland
F11	Medium Tree – Single Story – Open	A grass/forb or shrub understory may be present. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is 10-39% cover of medium trees, with <10% cover of other sized trees. Tree size is 15-19" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F12	Medium Tree – Single Story – Moderate	Grass/Forb or shrub understory may be present. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is 40-69% cover of medium trees with <10% cover of other sized trees. Tree size is 15-19" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F13	Medium Tree – Single Story – Closed	A grass/forb or shrub understory may be present. Remnant trees (trees remaining from the previous stand) can provide <10% canopy cover. There is >70% cover of medium trees with <10% cover of other sized trees. Tree size is 15-19" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland
F14	Large Tree – Single Story – Open	Grasses, shrubs, and/or seedlings may occur in the understory. There is 10-39% cover of large and/or giant size trees with <10% cover of other sized trees. Tree size is 20"-29" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F15	Large Tree – Single Story – Moderate	Some grass/forb or shrub understory may be present. There is 40-69% cover of large and/or giant trees with <10% cover of other sized trees. Tree size is 20"-29" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F16	Large Tree – Single Story – Closed	Grasses, shrubs, and/or seedlings may occur in the understory. There is >70% cover of large and/or giant trees with <10% cover of other sized trees. Tree size is 20"-29" dbh, and there is a single canopy stratum.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland

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F17	Small Tree – Multi-story – Open	These stands have an overstory of small trees with a distinct subcanopy of saplings and/or poles. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb or shrub understory may be present. There is 10-39% total canopy cover dominated by small trees, at least 10% or more canopy cover of 1 or more other smaller tree sizes. Tree size is 10"-14" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F18	Small Tree – Multi-story – Moderate	These stands have an overstory of small trees with a distinct subcanopy of saplings and/or poles. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb or shrub understory may be present, but is probably limited. There is 40-69% total canopy cover dominated by small trees, at least 10% or more canopy cover of 1 or more other smaller tree sizes. Tree size is 10"-14" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F19	Small Tree – Multi-story – Closed	These stands have an overstory of small trees with a distinct subcanopy of saplings and/or poles. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb or shrub understory extremely limited or absent. There is >70% total canopy cover dominated by small trees, at least 10% or more canopy cover of 1 or more other smaller tree sizes. Tree size is 10-14" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland
F20	Medium Tree – Multi-story – Open	These stands have an overstory of medium trees with a distinct subcanopy of smaller trees. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb or shrub understory may be present, but is probably limited. There is 10-39% total canopy cover dominated by medium trees, at least 10% or more canopy cover of 1 or more smaller tree sizes. Tree size is 15"-19" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F21	Medium Tree – Multi-story – Moderate	These stands have an overstory of medium trees with a distinct subcanopy of smaller trees. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb or shrub understory may be present, but is probably limited. There is 40-69% total canopy cover dominated by medium trees, at least 10% or more canopy cover of 1 or more smaller tree sizes. Tree size is 15"-19" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F22	Medium Tree – Multi-story – Closed	These stands have an overstory of medium trees with a distinct subcanopy of smaller trees. Scattered larger trees may be present but make up less than 10% canopy cover. Grass/forb understory may be present, but is probably limited. There is >70% total canopy cover dominated by medium trees, at least 10% or more canopy cover of 1 or more smaller tree sizes. Tree size is 15"- 19" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland

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F23	Large Tree – Multi-story – Open	These stands have an overstory of large or giant sized trees with one or more distinct canopy layers of smaller trees. Stands > 40% cover of giant trees are classified in the "Giant, multi-storied" stage. In westside forests, stands dominated by large trees, usually have giant trees scattered in the stand, with lower numbers in eastside forests. Grass/Forb or shrub understory often present, especially in canopy gaps. There is 10-39% total canopy cover, with at least 10% or more canopy cover from large and/or giant trees and another 10% or more canopy cover from 1 or more smaller tree size classes. Tree size is 20"-29" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Scattered Canopy Forest Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F24	Large Tree – Multi-story – Moderate	These stands have an overstory of large or giant sized trees with one or more distinct canopy layers of smaller trees. Stands > 40% cover of giant trees are classified in the "Giant, multi-storied" stage. In westside forests, stands dominated by large trees, usually have giant trees scattered in the stand, with lower numbers in eastside forests. Grass/Forb or shrub understory often present, especially in canopy gaps. There is 40-69% total canopy cover, at least 10% or more canopy cover from large trees with another 10% or more canopy cover from 1 or more smaller tree size classes. Tree size is 20"-29" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Open Canopy Forest Forested Riparian Forested Wetland
F25	Large Tree – Multi-story – Closed	Overstory of large or giant sized trees with one or more distinct canopy layers of smaller trees. Stands > 40% cover of giant trees are classified in the "Giant, multi-storied" stage. In westside forests, stands dominated by large trees usually have giant trees scattered in the stand. Grass/Forb or shrub understory often present, especially in canopy gaps. There is >70% total canopy cover, ≥ 10% canopy cover from large trees with another 10% or more canopy cover from 1 or more smaller tree size classes. There are at least two canopy strata.	Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland
F26	Giant Tree – Multi-story	These stands have an overstory of giant sized trees with one or more distinct canopy layers of smaller trees. Stands with <40% canopy cover are classified in the "large tree – multi-story - open", stage. There is > 40% canopy cover. Tree size is > 30" dbh, and there are two or more canopy strata.	Deciduous, Mixed and Conifer Open Canopy Forest Deciduous, Mixed and Conifer Closed Canopy Forest Forested Riparian Forested Wetland
AGRICULTURAL STRUCTURAL CONDITIONS			
A1	Cultivated Cropland	Farmland used to produce annual crops such as vegetables and herbs. Characterized by bare soil and plant debris either in the field or along the periphery. Tends to be along bottomland areas of streams and rivers and areas with a sufficient source of irrigation. Farmland used for production of annual grasses such as wheat, oats, barley and rye is characterized by upland and rolling hill terrain, generally without irrigation. Similar to row crops in pesticide use, irrigation and preparation/harvest. This category includes a wide range of soil conservation practices.	Low Structure Agriculture

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A2	Improved Pasture	Farmland used for the production of perennial grass such as grass seed and hay. Perennial grass is generally grown without irrigation. Perennial crops are treated the same way in regard to the general application of pesticides and cultural techniques.	Low Structure Agriculture
A3	Orchards/ Vineyards/ Nursery	Farmland used tree fruits (apples, peaches, pears, hazelnuts), vineyards (grapes), berries (strawberries, raspberries, blueberries, blackberries), Christmas trees, and nursery stock (ornamental container and greenhouse operations). Generally located in upland areas with access to a high volume of irrigation. The use of chemicals in non-food crops, such as Christmas tree and nursery stock, is considerably different both in materials and time of applications.	High Structure Agriculture
A4	Modified Grasslands	Annual or introduced perennial grasslands. Annual grasslands (and areas of introduced forbs) are often dominated by one or two introduced annuals comprising most of the vegetation. Perennial grasslands are usually dominated by a single planted bunchgrass with introduced annuals and weedy forbs between the bunches. Some environments support rhizomatous perennial grasses. These areas occur mostly on uplands but also include riparian bottomlands that are dominated by non-native grasses.	Low Structure Agriculture
A5	Unimproved Pasture	Farmland lacking active management such as fertilizer application, irrigation or weed control. May be grazed by livestock. May include uncut hay, organic debris from the previous season, uncut standing dead grass, exotic plants like tansy ragwort, thistle, Himalayan blackberry and their debris, patches of shrubs such as hawthorn, snowberry, spirea, poison oak, and encroachment by various tree species. Includes lands designated within the Conservation Reserve Program (CRP) and areas planted with crested wheatgrass (*Apropyron cristatum*).	Low Structure Agriculture
URBAN LAND USE/LAND COVER			
U1	Urban Low Density	Based on the level of urban development as determined by the % of land surface covered by impervious materials. Includes surfaces covered by 10-29% of impervious material. Examples include rural residential areas, large-lot housing (≥ 1 acre).	TIA within Metro region watersheds is unknown. Street density could substitute (see text).
U2	Urban Medium Density	Based on the level of urban development as determined by the percent of land surface covered by impervious materials. Includes surfaces that are covered with 30-59% of impervious material. Examples include single family housing areas (lot size < 1 acre), suburban development.	TIA within Metro region watersheds is unknown. Street density could substitute (see text).
U3	Urban High Density	Based on level of urban development as determined by % of land surface covered by impervious materials. Includes surfaces covered by ≥60% impervious material. Examples include core downtown Portland area, shopping malls and industrial areas, high density housing such as apartment buildings, and transportation corridors such as highways and freeways.	TIA within Metro region watersheds is unknown. Street density could substitute (see text).

Appendix 3. Plant species that typically dominate each habitat type in the Metro region. The last column includes a cross-walk between Johnson and O'Neil's (2001) habitat type classifications and Metro's GIS land cover data.

Habitat Type	**Dominant or Typical Canopy Species**	**Dominant or Typical Shrub Species**	**Dominant or Typical Herbaceous Species**	**Metro/ONHP's GIS Habitat Type Classifications (based on land cover)**
Westside Lowlands Conifer-hardwood Forest	Western hemlock (*Tsuga heterophylla*) Douglas-fir (*Pseudotsuga menziesii*) Western redcedar (*Thuja plicata*) Red alder (*Alnus rubra*) Bigleaf maple (*Acer macrophyllum*)	Salal (*Gaultheria shallon*) Dwarf Oregongrape (*Mahonia nervosa*) Vine maple (*Acer circatum*) Pacific rhododendron (*Rhododendron macrophyllum*) Salmonberry (*Rubus spectabilis*) Trialing blackberry (*Rubus ursinus*) Red elderberry (*Sambucus racemosa*) Oval-leaf huckleberry (*Vaccinium ovalifolium*) Red huckleberry (*Vaccinium parvifolium*)	Swordfern (*Polystichum munitum*) Oregon oxalis (*Oxalis oregana*) Deerfern (*Blechnum spicant*) Bracken fern (*Pteridium aquilinum*) Vanillaleaf (*Achlys triphylla*) Twinflower (*Linnaea borealis*) False lily-of-the-valley (*Maianthemum dilatatum*) Western springbeauty (*Claytonia siberica*) Foamflower (*Tiarella trifoliata*) Inside-out flower (*Vancouveria hexandra*)	Deciduous closed canopy forest Mixed closed canopy forest Conifer closed canopy forest Deciduous open canopy forest Mixed open canopy forest Conifer open canopy forest
Westside Oak and Dry Douglas-fir Forest and Woodlands	Douglas-fir (*Pseudotsuga menziesii*) Oregon white oak (*Quercus garryana*) Pacific madrone (*Arbutus menziesii*) Grand fir (*Abies grandis*) Oregon ash (*Fraxinus latifolia*) occasionally co-dominant with white oak in riparian stands	Oceanspray (*Holodiscus discolor*) Baldhip rose (*Rosa gymnocarpa*) Poison-oak (*Toxicodendron diversiloba*) Serviceberry (*Amelanchier alnifolia*) Hazelnut (*Corylus cornuta*) Trailing blackberry (*Rubus ursinus*) Indian plum (*Oemleria cerasiformis*) Snowberry (*Symphocarpus albus* and *S. mollis*) **When conifers are important in canopy:** Salal Dwarf Oregongrape Pacific rhododendron Hairy honeysuckle Evergreen huckleberry	Western fescue (*Festuca occidentalis*) Alaska oniongrass (*Melica subulata*) Blue wildrye Long-stolon sedge (*Carex inops*) Sword fern Bracken fern Kentucky bluegrass (*Poa pratensis*) is a major non-native dominant in oak woodland understories.	Deciduous closed canopy forest Mixed closed canopy forest Deciduous open canopy forest Mixed open canopy forest Deciduous scattered canopy forest Mixed scattered canopy forest
Westside Grasslands	Common savanna tree species: Douglas-fir Oregon white oak Ponderosa pine (*Pinus ponderosa*)	Common native shrubs: Common snowberry Nootka rose (*Rosa nutkana*) Poison-oak Serviceberry Most common shrub: Exotic Scot's broom (frequently forms open stands over grass)	Roemer's fescue (*Festuca idahoensis* var. *roemeri*) Red fescue (*Festuca rubra*) California oatgrass (*Danthonia californica*) Common camas (*Camassia quamash*) Bracken fern Long-stolon sedge (*Carex inops*) **Major exotic dominants:** Colonial bentgrass (*Agrostis capillaris*) Sweet vernalgrass (*Anthoxanthum odoratum*) Kentucky bluegrass Tall oatgrass (*Arrhenatherum elatius*) Medusahead (*Taeniatherum caput-medusae*) Tall fescue (*Festuca arundinacea*) *Soft brome* (Bromus mollis)	Meadow/grass Open canopy shrub Scattered canopy shrub

Appendix 3 (continued).

Agriculture, Pasture and Mixed Environs	Varies substantially; cultivated croplands include > 50 species of annual and perennial plants in Oregon and Washington. Includes hayfields, pastures, and USDA Conservation Reserve Program lands.	N/A	N/A	Ag riparian? Ag wetland? Barren and sparsely vegetated Low structure agriculture High structure agriculture Meadow/grass (representing pastures)
Urban and Mixed Environs	Extremely variable; often dominated by non-native species.	Extremely variable; often dominated by non-native species.	Extremely variable; often dominated by non-native species.	Barren and sparsely vegetated Deciduous scattered canopy forest? Mixed scattered canopy forest? Conifer scattered canopy forest? Open canopy shrub? Scattered canopy shrub? Closed canopy shrub?
Open Water – Lakes, Rivers, Streams	N/A	N/A	N/A	Water/deep water Deep water Open riparian Open wetland? Urban wetland?
Herbaceous Wetlands	N/A	N/A	Bulrush (*Scirpus* spp.) Cattails Sedges (*Carex* spp.) Rushes (*Juncus* spp.) Spike rushes (*Eleocharis* spp.) American sloughgrass (*Beckmannia syzigachne*) Bluejoint reedgras (*Calamagrostis canadensis*) Mannagrass (*Glyceria* spp.) Tufted hairgrass (*Deschampsi caespitosa*) **Rooted and floating aquatic plants:** Yellow pond lily (*Nuphar lutea*) Pondweed (*Potamogeton* spp.) Duckweed (*Lemna minor*) Water-meals (*Wolffia* spp.) **Permanent and semi-permanent standing water:** Pacific water parsley (*Oenanthe sarmentosa*) Buckbean (*Menyanthes trifoliata*) Water star-warts (*Callitriche* spp.) Bladderworts (*Utricularia* spp.) **Introduced grasses/forbs that can dominate:** Reed canary grass (*Phalaris arundinacea*) Tall fescue (*Festuca arundinacea*) Kentucky bluegrass Bittersweet (climbing) nightshade (*Solanum dulcamara*) Purple loosestrife (*Lythrum salicaria*) Poison hemlock (*Conium maculatum*)	Ag wetland Open wetland Urban wetland

Appendix 3 (continued).

Westside Riparian-wetlands	Red alder Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) Bigleaf maple Oregon Ash Pacific willow (*Salix lucida* ssp. Oregon white oak Western redcedar Western hemlock (*Tsuga heterophylla*) Grand fir Douglas-fir (relatively uncommon)	Willow species (*Salix sitchensis, S. hookeriana*) Douglas' spirea (*Spriea douglasii*) Red-osier dogwood (*Cornus sericea*) Western crabapple (*Malus fusca*) Salmonberry (*Rubus spectabilis*) Stink current (*Ribes bracteosum*) Devil's-club (*Oplopanax horridum*) Vine maple (*Acer circinatum*) Salal Thimbleberry (*Rubus parviflorus*) Common snowberry (*Symphoricarpos albus*) Hazelnut (*Corylus cornuta*) Pacific ninebard (*Physocarpus capitatus*)	Slough sedge (*Carex obnupta*) Dewey sedge (*C. deweyana*) Skunk-cabbage (*Lysichiton americanus*) Coltsfoot (*Petasites frigidus*) Hedge-nettle (*Stachys* spp.) Ladyfern (*Athrium filix-femina*) Youth-on-age (*Tolmiea menziesii*) Oxalis (*Oxalis oregona, O. Trillifolia*) Stinging nettle (*Urtica dioica*) Swordfern (*Polystichum munitum*) Field horsetail (*Equisetum arvense*)	Forested riparian Forested wetland

Appendix 4. Review of key findings of urban stream studies examining the relationship of urbanization on stream quality.

Reference	Location	Biological Parameter	Key Finding
Benke, Willeke, Parrish and Stites 1981	Atlanta	Aquatic insects	Negative relationship between number of insect species and urbanization in 21 streams
Black and Veatch 1994	Maryland	Fish/insects	Fish, insect and habitat scores were all ranked as poor in 5 subwatersheds that were greater than 30% TIA
Booth 1991	Seattle, WA	Fish habitat / channel stability	Channel stability and fish habitat quality declined rapidly after 10% TIA
Booth et al. 1996	Washington	Aquatic habitat	There is a decrease in the quantity of large woody debris found in urban streams at around 10% TIA
Couch et al. 1997	Atlanta, Georgia	Fish, habitat	As watershed population density increased, there was a negative impact on urban fish and habitat
Crawford & Lenat 1989	North Carolina	Aquatic insects and fish	A comparison of three stream types found urban streams had lowest diversity and richness
Galli 1991	Maryland	Stream temperature (aquatic habitat)	Stream temperature increased directly with subwatershed impervious cover
Galli 1994	Maryland	Brown trout	Abundance and recruitment of brown trout declined sharply at 10-15% TIA
Garie and McIntosh 1986	New Jersey	Aquatic insects	Drop in insect taxa from 13 to 4 noted in urban streams
Hicks and Larson 1997	Connecticut	Aquatic insects	A significant decline in various indicators of wetland aquatic macroinvertebrate community health was observed as TIA increased to levels of 8-9%
Horner et al. 1996	Puget Sound, Washington	Insects, fish, water quality, riparian zone	Steepest decline of biological functioning after 6% TIA. There was a steady decline, with approximately 50% of initial biotic integrity at 45% TIA
Jones and Clark 1987	Northern Virginia	Aquatic insects	Urban streams had sharply lower diversity of aquatic insects when human population density exceeded 4 persons/acre (estimated 10-25% TIA)
Jones et al. 1996	Northern Virginia	Aquatic insects and fish	Unable to show improvements at 8 sites downstream of BMPs as compared to reference conditions
Klein 1979	Maryland	Aquatic insects/fish	Macroinvertebrate and fish diversity declines rapidly after 10% TIA
Limburg and Schmidt 1990	New York	Fish spawning	Resident and anadromous fish eggs and larvae declined sharply in 16 tributary streams greater than 10% TIA
Luchetti and Fuersteburg 1993	Seattle	Fish	Marked shift from less tolerant coho salmon to more tolerant cutthroat trout populations noted at 10-15% TIA at 9 sites
MacRae 1996	British Columbia	Stream channel stability (aquatic habitat)	Urban stream channels often enlarge their cross-sectional area by a factor of 2 to 5. Enlargement begins at relatively low levels of TIA.
Maxted and Shaver 1996	Delaware	Aquatic insects and habitat	No significant differences in biological and physical metrics for 8 BMP sites versus 31 sites without BMPs (with varying TIA)
May et al. 1997	Washington	Insects, fish, water quality, riparian zone	Physical and biological stream indicators declined most rapidly during the initial phase of the urbanization process as the TIA exceeded the 5-10% range
MWCOG 1992	Washington, D.C.	Aquatic insects and fish	There was a significant decline in the diversity of aquatic insects and fish at 10% TIA
Pedersen and Perkins 1986	Seattle	Aquatic insects	Macroinvertebrate community shifted to chironomid, oligochaetes and amphipod species tolerant of unstable conditions.

Appendix 4 (continued).

Richards et al. 1993	Minnesota	Aquatic insects	As watershed development levels increased, the macroinvertebrate community diversity decreased
Schueler and Galli 1992	Maryland	Fish	Fish diversity declined sharply with increasing TIA; loss in diversity began at 10-12% TIA
Schueler and Galli 1992	Maryland	Aquatic insects	Insect diversity metrics in 24 subwatersheds shifted from good to poor over 15% TIA
Shaver, Maxted, Curtis and Carter 1995	Delaware	Aquatic insects	Insect diversity at 19 stream sites dropped sharply at 8 to 15% TIA.
Shaver, Maxted, Curtis and Carter 1995	Delaware	Habitat quality	Strong relationship between insect diversity and habitat quality; majority of 53 urban streams had poor habitat
Steedman 1988	Ontario	Aquatic Insects	Strong negative relationship between biotic integrity and increasing urban land use/riparian condition at 209 stream sites. Degradation begins at about 10% TIA
Steward 1983	Seattle	Salmon	Marked reduction in coho salmon population noted at 10-15% TIA at 9 sites
Taylor 1993	Seattle	Wetland plants / amphibians	Mean annual water fluctuation was inversely correlated to plant and amphibian density in urban wetlands. Sharp declines noted over 10% TIA
Taylor et al. 1995	Washington	Wetland water quality	There is a significant increase in water level fluctuation, conductivity, fecal coliform bacteria, and total phosphorus in urban wetlands as TIA exceeds 3.5%
Trimble 1997	California	Sediment loads (aquatic habitat)	About 2/3 of sediment delivered into urban streams comes from channel erosion
U.S. EPA 1983	National	Water quality / pollutant concentration	Annual phosphorus, nitrogen, and metal loads increased in direct proportion with increasing TIA
Weaver 1991	Virginia	Fish	As watershed development increased to about 10%, fish communities simplified to more habitat and trophic generalists
Yoder 1991	Ohio	Aquatic insects / fish	100% of 40 urban sites sampled had fair to very poor index of biotic integrity scores

Sources: Schueler 1994, Caraco et al. 1998

SOCIETY FOR ECOLOGICAL RESTORATION

Guidelines for Developing and Managing Ecological Restoration Projects

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The following guidelines are suggested for conceiving, organizing, conducting, and assessing ecological restoration projects. Adherence to these guidelines will reduce errors of omission and commission that compromise project quality. The guidelines are applicable to any ecosystem, terrestrial or aquatic. They are useful in any context – public works projects, stewardship programs, mitigation projects, private land initiatives, etc. The guidelines are generic and were developed as essential background for managers, policy makers, and the interested public as well as for professional and volunteer restoration practitioners. Design issues and the details for planning and implementing restoration projects lie beyond the scope of these guidelines. We leave such complexities to the authors of manuals and the presenters of workshops who address these topics.

The mission of every ecological restoration project is to reestablish a functional ecosystem of a designated type that contains sufficient biodiversity to continue its maturation by natural processes and to evolve over longer time spans in response to changing environmental conditions. The two attributes of biodiversity that are most readily attained by restoration are species richness and community structure. The restoration ecologist must assure adequate species composition and species abundance to allow the development of suitable community structure and to initiate characteristic ecosystem processes. Concomitantly, the restorationist must provide appropriate physical conditions to sustain these species.

If restoration cannot be fully achieved, then the project should be re-designed as *rehabilitation,* which we define as any ecologically beneficial treatment short of full restoration. Management actions that cause ecological damage do not qualify as restoration. Unfortunately, *restoration* is applied inappropriately to projects that sacrifice biodiversity and impair ecological functions to accomplish single-species management or to attain economic objectives. Continued indiscriminate use will cause *ecological restoration* to lose its meaning as a creditable conservation strategy. Restoration projects can accommodate particular species and can satisfy economic objectives as long as ecosystem integrity is not compromised.

Once a project site is restored, it may require periodic management, as do many other natural areas, to maintain ecosystem health in response to continuing human-mediated impacts. These guidelines do not address post-project management specifically, although some of the guidelines are readily adaptable for that purpose.

The project guidelines are numbered for convenience; they do not necessarily have to be initiated in numerical order. We recommend that a narrative be written in response to the issues raised in each guideline. Collectively, these narratives will comprise a comprehensive guidance document for planning and executing the project.

CONCEPTUAL PLANNING

Conceptual planning identifies the reasons why restoration is needed and the general strategy for conducting it. Conceptual planning is conducted when restoration appears to be a feasible option but before a decision has been made to exercise that option. The written conceptual plan captures the essence and character of the potential restoration.

1. Identify the project site location and its boundaries. Project boundaries are delineated, preferably on a large-scale aerial photograph and also on soil and topographic maps that show the watershed and other aspects of the surrounding landscape.

2. Identify ownership. The name and address of the landowner is given. If an organization or institution owns or manages the land, the names and titles of key personnel are listed. The auspices under which the project will be conducted are noted – public works, mitigation, etc.

3. Identify the need for restoration. Tell what happened at the site that warrants restoration. State the intended benefits of restoration.

4. Identify the kind of ecosystem to be restored and the type of restoration project. The ecosystem to be restored is designated along with any particular habitats and plant or animal communities of that ecosystem that are targeted for restoration. The type of restoration is selected from the following list of five options. It is important to make this initial distinction to avoid misunderstandings later. Restoration projects at diverse project sites may include more than one of these options:

1) *Repair of a damaged ecosystem.* This option attempts to return a site to its historic or preexisting condition. Commonly a few minor aspects of the preexisting ecosystem cannot be fully restored. These should be identified and accepted as exceptions. Restoration work takes place at the same site where damage occurred. Such restoration has been termed *in-kind* (the historic type of ecosystem is restored) and *onsite* (restoration occurs at the same location where the historic ecosystem was damaged). Restoration with respect to the following four options is not necessarily *on-site,* and some are not *in-kind.*

2) *Creation of a new ecosystem of the same kind to replace one that was entirely removed.* The term *creation* signifies that the restored ecosystem must be entirely reconstructed on a site denuded of its vegetation (terrestrial systems) or its benthos (aquatic systems). Creations are commonly conducted on surface mined lands and <u>in</u> brownfields (severely damaged urban and industrial lands).

3) *Creation of another kind of regional ecosystem to replace one which was removed from a landscape that became irreversibly altered.* This option is important for restoring natural areas in an urban context where, for example, original hydrologic conditions cannot be restored.

4) *Creation of a replacement ecosystem where an altered environment can no longer support any previously occurring type of regional ecosystem.* The replacement ecosystem may consist of novel combinations of indigenous species that are assembled to suit novel site conditions as, for example, at a retired solid waste disposal site.

5) *Creation of a replacement ecosystem, because no reference system exists to serve as a model for restoration.* This option is relevant in densely populated regions of Eurasia, where many centuries of land use have obliterated all remnants of original ecosystems.

5. Identify restoration goals, if any, that pertain to social and cultural values. Goals are the ideals that a restoration project attempts to achieve. Goals relating to social and cultural values may be prescribed as long as they are congruent with the primary goal of reestablishing a functional ecosystem that contains sufficient biodiversity to continue its maturation by natural processes and to evolve over longer time spans in response to changing environmental conditions. Social values are largely economic. They may consist of the production of goods such as timber, forage, and fisheries at restored sites. Or they may comprise natural services including the protection of recharge areas and potable water supplies, detention of floodwaters, attenuation of erosion and sedimentation, noise reduction, immobilization of contaminants, transformation of excess nutrients, generation of pollinators for crops, generation of predators of crop pests, and provision of recreational opportunities and consequent tourism. They can also conserve germ plasm of economic species and serve as refugia for wildlife and for rare species. Cultural values include aesthetic amenities and the revival of historical environments as aspects of preserving cultural heritage. If the goal is to restore a fixed cultural landscape, then the project may have to be re-designated as rehabilitation.

6. Identify physical site conditions in need of repair. Some examples of conditions that are amenable to restoration are improvements in water quality, removal of structures to reestablish a more natural hydrologic regime, and improvements to the soil in terms of compaction, organic matter content, and nutrient content.

7. Identify stressors in need of regulation or re-initiation. Stressors are re-occurring external conditions that maintain the integrity of an ecosystem by discouraging the establishment of competitive species that cannot tolerate particular stress events. Examples are fires, anoxia caused by flooding or prolonged hydroperiods, periodic drought, salinity shocks associated with tides and coastal aerosols, freezing temperatures, and unstable substrates caused by water, wind or gravity as on beaches, dunes, and flood plains.

8. Identify biotic interventions that are needed. Some characteristic species of plants and animals may require reintroduction or their existing populations need to be augmented. Nuisance species and exotic species may require removal or control. Mycorrhizal fungi, N-fixing bacteria, and other microbial species may need to be introduced.

9. Identify landscape restrictions, present and future. The biota at a project site is affected by off-site conditions, particularly land usage. Restoration should not be attempted in landscapes that can no longer support the kind of ecosystem designated for restoration or which will likely be compromised later by the effects of land usage offsite. To the extent possible, future threats to the integrity of the restored ecosystem should be minimized by mechanisms such as zoning or binding commitments from neighboring landowners.

Some aquatic ecosystem restoration depends entirely on improving the watershed, and all restoration work is accomplished offsite. Examples of impacts from offsite include water pollution, turbidity, and agricultural runoff. The hydrologic regime in any project site can be altered offsite by dams, drainage projects, diversions of runoff caused by highways and other public works, and by the impervious surfaces characteristic of developed land. Water tables are lowered by transpiration from trees and are raised, sometimes dramatically, by timber harvest. Fire frequency is reduced by intentional suppression and by landscape fragmentation that interrupts the cover of flammable vegetation. Exotic species colonization onsite is commonly traced to infestations offsite. The presence or abundance of birds and other mobile animals depends on the health of other ecosystems in the landscape upon which they partially depend.

10. Identify project-funding sources. Potential external funding sources should be listed if internal funding is inadequate.

11. Identify labor sources and equipment needs. New personnel may have to be hired, volunteers invited, and other labor contracted. The availability of special equipment must be determined.

12. Identify biotic resource needs. Biotic resources include seeds, other plant propagules, nursery-grown planting stocks, and animals for establishment at the project site.

13. Identify the need for securing permits required by government agencies. Dredge and fill permits may be required for tasks involving rivers and wetlands. Other permits may be applicable for the protection of endangered species, historic sites, etc.

14. Identify permit specifications, deed restrictions, and other legal constraints. If restoration is being conducted as mitigation, compliance with permit specifications must be incorporated into the restoration plan or re-negotiated. Restrictive covenants and zoning regulations may preclude certain restoration activities. Legal restrictions on ingress and egress could prevent some restoration tasks from being accomplished. If the restoration is being placed under conservation easement, the timing of the easement must be satisfied.

15. Identify project duration. Short-term restoration projects are generally more costly than longer-term projects. The longer the project, the more the practitioner can rely on natural processes and volunteer labor to accomplish specific restoration objectives that are identified below in Guideline #27. In accelerated restoration programs such as mitigation projects, costly interventions must substitute for these natural processes.

16. Identify strategies for long-term protection and management. Restoration is futile without reasonable assurance that the project site will be protected and properly managed into the indefinite future. Protection could be secured with conservation easements or the legal transfer of the property to a public resource agency or non-governmental organization.

PRELIMINARY TASKS

Preliminary tasks are those upon which project planning depends. These tasks form the foundation for well-conceived restoration designs and programs. Preliminary tasks are fulfilled after conceptual planning results in the decision to proceed with the restoration project.

17. Appoint a restoration ecologist who is responsible for technical aspects of restoration. Restoration projects are complex, require the coordination of diverse activities, and demand numerous decisions owing in part to the stochastic nature of ecological processes. For these reasons, leadership should be vested in an individual who maintains overview of the entire project and who has the authority to act quickly and decisively. The restoration ecologist may delegate specific tasks but retains the ultimate responsibility for the attainment of objectives. Nonetheless, restoration responsibilities are sometimes divided according to the organizational charts of larger corporations and government bureaus. Pluralistic leadership augments the potential for errors in project design and implementation. In mitigation projects, agency personnel become silent co-partners with the restoration ecologist when they mandate particular restoration activities as permit specifications. This practice reduces the restoration ecologist's capacity for flexibility and innovation, including the prompt implementation of adaptive management actions. The preparation of a written guidance document, based upon responses to these guidelines, will help promote the judicious execution of the restoration project in cases of pluralistic leadership and in negotiating permit specifications with government agencies.

18. Appoint the restoration team. The team includes the restoration ecologist, the project manager, other technical personnel who may contribute to the project, and anyone else whose input will critically affect the project. It is essential that the responsibilities of each individual are clearly assigned and that each person be given concomitant authority. The restoration ecologist and the project manager should maintain open lines of communication. If restoration is one component of a larger project, the restoration ecologist should enjoy equal status with other project planners to prevent actions that could compromise restoration quality or inflate costs.

19. Prepare a budget to accommodate the completion of preliminary tasks. Time and resources as well as funding need to be allocated for these tasks.

20. Document existing project site conditions and describe the biota. Project evaluation depends in part upon being able to contrast the project site before and after restoration. Properly labeled and archived photographs are fundamental. Camera locations should be recorded, so that before and after photos can be compared. Videotapes, aerial photographs, and oblique aerial photos from a low-flying aircraft are helpful. Soils and other physical site conditions should be described. To the extent possible, species composition should be listed and species abundance estimated. The structure of all component communities should be described in sufficient detail to permit objective means of evaluating the performance of projects subsequent to their implementation.

21. Document the project site history that led to the need for restoration. The years in which impacts occurred should be recorded. Historical aerial photos are helpful. Disturbance features should be photographed.

22. Conduct pre-project monitoring as needed. Sometimes it is useful or requisite to obtain baseline measurements on such parameters as water quality and groundwater levels for a year or more prior to initial project installation. If so, these measurements will continue after the project begins as part of the monitoring program.

23. Gather baseline ecological information and conceptualize a reference ecosystem from it upon which the restoration will be modeled and evaluated. The kind of ecosystem that has been selected for restoration must be described in sufficient detail to develop restoration objectives and to serve as a comparison for evaluating the completed restoration project. Documentation of the pre-project site conditions (Guideline #20) may contribute substantially to the reference. Generally, no one site contains the range of variability that is representative of the ecosystem designated for restoration. Therefore, the reference system should be conceptualized from the collective attributes of several sites. These attributes should include both the biotic and abiotic (physical) components. They should include seral (developmental) descriptions, because a comparison between an ecologically young restoration site and a mature reference system requires assumptions that are difficult to substantiate. The description of the reference system can be the citation of existing documents, a report of baseline ecological studies conducted by the restoration team, or a combination thereof.

24. Gather pertinent autecological information for key species. The restoration ecologist should have access to whatever knowledge is available regarding the recruitment, maintenance, and reproduction of key species. If necessary, trials and tests can be conducted by the restoration team prior to project installation.

25. Conduct investigations as needed to assess the effectiveness of restoration methods. Novel and unusual restoration methods may require testing prior to their implementation at the project site.

26. Decide if ecosystem goals are realistic or if they need modification. On the basis of information gained from carrying out the aforementioned guidelines, the project team should conduct a feasibility study to determine if the type of restoration (Guideline #4) and the original project goals (Guideline #5) were realistic. If not, modifications should be proposed.

27. Prepare a list of objectives designed to achieve restoration goals. Objectives are the specific activities to be undertaken for the satisfaction of project goals. The restoration ecologist should list all objectives needed to achieve each project goal. Objectives may be executed directly through the establishment of project features or passively through suitable project design. In either case, objectives are explicit, measurable, and have a designated time element. Objectives can cover a wide array of specific actions. They may be hydrological, e.g., the filling of a drainage ditch to improve sheet flow; pedological, e.g., the amendment of organic matter to improve soil texture; or biological, e.g., the prompt removal of a particular exotic species that threatens ecosystem integrity. Other objectives may pertain to re-introducing fire according to a specific prescription, removing an abandoned road, or establishing a windbreak. Certain objectives may require actions that take place offsite to improve conditions onsite. Some restoration projects can be accomplished with one or few objectives. For example, perhaps all that is needed is to install culverts beneath a road to improve drainage, assuming the vegetation can recover passively.

28. Secure permits required by regulatory and zoning authorities. These are the permits identified in guidelines #13 and #14.

29. Establish liaison with other interested governmental agencies. Potential interested agencies should be notified of the project. Later, site tours can be conducted for agency personnel and progress reports dispatched to them. This networking could expedite assistance, should it become needed.

30. Establish liaison with the public and publicize the project. Local residents automatically become stakeholders in the restoration. They need to know how the restored ecosystem can benefit them personally. For example, the restoration may attract ecotourism that will benefit local businesses, or it may serve as an environmental education venue for local schools. If residents favor the restoration, they will protect it and vest it with their political support. If they dislike the restoration, they may vandalize or otherwise disrespect it.

31. Arrange for public participation in project planning and implementation. The restoration team should make every effort to involve local residents or other interested members of the public to participate in project planning and installation. By doing so, the participants develop a feeling of ownership, and they will be more likely to assume a stewardship role for the completed project. Volunteer labor by local residents or by ecotourists may reduce overall project costs. However, such labor requires coordination, special supervision, and additional liability insurance.

32. Install roads and other infrastructure needed to facilitate project implementation. The degree to which infrastructure is provided should be weighed against the costs of down time caused by its absence and against considerations of safety and opportunities for public relations tours.

33. Engage and train personnel who will supervise and conduct project installation tasks. Project personnel who lack restoration experience or knowledge of particular methods will benefit from attending workshops and conferences that provide background information. Otherwise, the restoration ecologist should provide training.

INSTALLATION PLANNING

Installation plans describe how the project will be implemented, i.e., project design. The care and thoroughness with which installation planning is conducted will be reflected by how aptly project objectives are realized.

34. Describe the interventions that will be implemented to attain each objective. The restoration ecologist should identify all actions and treatments needed to accomplish each objective listed in Guideline #27. Detailed instructions are prepared for implementing each of these interventions. Concomitantly, the needs for labor, equipment, supplies, and biotic stocks are identified.

Restoration projects should be designed to reduce the need for mid-course corrections that inflate costs and cause delays. Special care should be given to describing site preparation activities, i.e., those interventions that precede the introduction of biotic resources. Once biotic resources are introduced, it may become exceedingly difficult to repair dysfunctional aspects of the physical environment.

Some interventions can be accomplished concurrently and others must be done in sequence. The need for sequencing should be clearly identified. Some restoration activities require follow-up activities or continuing periodic maintenance following installation. These tasks are predictable and can be written into the implementation plans under their respective objectives. Examples of maintenance tasks include the repair of erosion on freshly graded land and the removal of competitive weeds and vines from around young plantings.

35 State how much of the restoration can be accomplished passively. Restoration tasks initiate or accelerate natural processes. Nearly all manifestations of restoration are accomplished by these processes and not by the direct artifice of the restorationist. For example, a small quantity of plants may be introduced as nursery stock with the expectation that these plants will propagate and increase substantially in density. Many restoration projects make no provision for introducing species of animals. The assumption is that, 'if we build it, they will come.' The restoration plan should acknowledge those aspects that are expected to develop passively, i.e., without intervention. If passive restoration is not realized, then additional interventions must be prescribed (see Guideline #47).

36. Prepare performance standards and monitoring protocols to measure the attainment of each objective. A performance standard (also called a design_criterion) provides evidence on whether or not an objective has been attained. This evidence is gathered by monitoring in accord with a prescribed protocol or methodology. Performance standards require careful selection for their power to measure the completion of an objective. Monitoring tells the restoration ecologist to what degree a given objective has been attained. It is essential that performance standards and monitoring protocols be selected prior to any project installation activity. Otherwise, the objectivity of the performance standard will be compromised by the initial results of installation. Monitoring protocols must be geared specifically to performance standards. Other information is extraneous and inflates project costs. Monitoring protocols should be designed so that data are readily gathered, thereby reducing monitoring costs. They should be empirical to facilitate their objective interpretation.

37. Schedule the tasks needed to fulfill each objective. Scheduling can be complex. Planted nursery stock may have to be contract-grown months or longer in advance of planting and must be delivered in prime condition. Older, root-bound stocks are generally worthless. If direct seeding is prescribed, seed collecting sites will have to be identified. The seed must be collected when ripe, possibly stored, and perhaps pre-treated. Site preparation for terrestrial systems cannot be scheduled when conditions are unsuitable. For example, soil manipulations cannot be accomplished if flooding is likely, and prescribed burning must be planned and conducted in accordance with applicable fire codes. The availability of labor and equipment can further complicate scheduling. Workdays may have to be shortened for safety during especially hot weather and in lightening storms. Wet weather may cause equipment to bog down. Schedules should reflect these eventualities.

Most objectives are implemented within the first or second year of installation. Some objectives may have to be delayed. For example, the re-introduction of plants and animals with specialized habitat requirements may have to be postponed several years until habitat conditions become suitable.

38. Procure equipment, supplies, and biotic resources. Care should be taken to assure that regional ecotypes of biotic resources are obtained to increase the chances for genetic fitness and to prevent needless and harmful introductions of non-indigenous ecotypes and species.

39. Prepare a budget for installation tasks, maintenance events, and contingencies. Budgeting for planned objectives is obvious. However, budgeting for unknown contingencies is just as important. No restoration project has ever been accomplished exactly as it was planned. Restoration is a multivariate undertaking, and it is impossible to account for all eventualities. Examples of contingencies are severe weather events, depredations of deer and other herbivores on a freshly planted site, colonization by invasive species, vandalism, and unanticipated events elsewhere in the landscape that impact the project site. The need to conduct at least some remediation is a near certainty. Generally, the cost of remediation increases in relation to the time it takes to respond after its need is discovered. For these reasons, contingency funds should be available on short notice.

INSTALLATION TASKS

Project installation fulfills installation plans. If planning was thorough and supervision adequate, installation will generally proceed smoothly and within budget.

40. Mark boundaries and secure the project area. The project site should be staked or marked conspicuously in the field. Fencing and fire lanes should be installed as needed. This guideline is sometimes ignored until it results in a contingency, such as a neighbor's cattle escaping into a freshly planted project site.

41. Install monitoring features. Permanent transect lines, staff gauges, piezometer wells, etc., need to be installed and marked.

42. Implement restoration objectives. Restoration tasks were identified in Guideline #34. The restoration ecologist must supervise project installation or delegate supervision to project team members. Responsibility for proper implementation should not be entrusted to subcontractors, volunteers, and labors crews who are doing the work. The cost of retrofitting exceeds the cost of appropriate supervision.

POST-INSTALLATION TASKS

The attainment of objectives may depend as much on follow-up activities as it does to the care given to initial installation activities. The importance of post-installation work cannot be overemphasized.

43. Protect the project site against vandals and herbivory. Project sites attract dirt bike riders, feral swine, deer, geese, nutria, etc. Beaver can destroy a newly planted site by plugging streams and culverts. Appropriate preventive actions should be taken.

44. Perform post-implementation maintenance. Conduct maintenance activities that were described in Guideline #34.

45. Reconnoiter the project site regularly to identify needs for mid-course corrections. The restoration ecologist needs to inspect the project site frequently, particularly during the first year or two following an intervention, to schedule maintenance as needed and to react promptly to contingencies.

46. Perform monitoring as required to document the attainment of performance standards. Measurements of water levels and certain water quality parameters are generally conducted on a regular schedule. Otherwise, monitoring should not be required until monitoring data will be meaningful for decision-making. Monitoring and the reporting of monitoring data are expensive. Regular reconnaissance (Guideline #45) negates the need for frequent monitoring.

47. Implement adaptive management procedures as needed. Adaptive management as a restoration strategy is essential, because what happens at one stage in restoration dictates what needs to happen next. A restoration plan must contain built-in flexibility. If reconnaissance or monitoring reveal that objectives are not being met, then alternative interventions may have to be attempted. The project manager should realize that restoration objectives may never be realized for reasons that lie beyond the control of the restoration ecologist. If so, then new goals (Guideline #5) and objectives (Guideline #27) may have to be adopted if a functional ecosystem is to be returned to the project site.

EVALUATION

The installation of a project does not guarantee that its objectives will be attained or its goals achieved. Restoration differs from most civil engineering projects for which the results are more predictable. Restored ecosystems are dynamic and require evaluation within the context of an indefinite temporal dimension.

48. Assess monitoring data to determine if performance standards are being met. If performance standards are not being met within a reasonable period of time, refer to Guideline #47.

49. Describe aspects of the restored ecosystem that are not covered by monitoring data. This description should commence when project work has been essentially completed. The description should compliment the documentation that was conducted prior to the initiation of restoration activities (Guideline #20) to allow before and after comparisons.

50. Determine if project goals were met, including those for social and cultural values. Based on monitoring data and other documentation (Guidelines #46, #49), evaluate the restoration with respect to its project goals. These will include the primary goal to restore a functional ecosystem that emulates the reference ecosystem at a comparable ecological age (Guideline #4). They will also include any secondary goals with respect to social and cultural values (Guideline #5).

51. Publish an account of the restoration project and otherwise publicize it. Publicity and documentation should be incorporated into every restoration project for the following reasons: Published accountings are fundamental for instituting the long-term protection and stewardship of a completed project site. Policy makers and the public need to be appraised of the fiscal and resource costs, so that future restoration projects can be planned and budgeted appropriately. Restoration ecologists improve their craft by becoming familiar with how restoration objectives were accomplished.

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Appendix 6.

Selected restoration activities and potential indicators of the effects of management activities, based on ecosystem function. Please read the Restoration chapter and take note of cautionary advice regarding planning and implementing restoration activities in an urban setting, particularly instream modifications.

Function or Value	Selected Potential Restoration Activities	Some Potential Indicators of Management Activity Effects
Water quality (sediment filtering, nutrient/pollutant filtering, erosion control and stream bank stability)	• Increase riparian and upland vegetation (especially woody vegetation) in watershed • Vegetative filter strips (VFS) • Control sediment inputs through BMPs and regulatory measures • Promote development of healthy soils through native plant communities (increases soil retention and filtering capacity) • Limit development and impervious surfaces near stream • Remove or modify sewer outfalls • Artificial wetlands (bioswales and water detention structures) • Public education to keep toxins out of storm drains • Reduce or eliminate industrial discharges • Promote alternatives to pesticides and chemical fertilizers • Promote passage of more water through wetlands and undeveloped floodplains • Retain/increase springs, seeps and wetlands • Increase late summer flows	• Benthic index of biological integrity (B-IBI) (Booth 1991; Spence et al. 1996; Karr and Chu 2000; Booth et al. 2001) • Piezometers or small wells to test groundwater and hyporheic water quality (Fernald et al. 2000) • Water quality tests such as temperature, sediment/turbidity, pH, dissolved oxygen, conductivity, nitrogen and phosphorus, herbicides/pesticides, suspended/floating matter, trash loading, odor, and chemical contamination (National Marine Fisheries Service 1996; Spence et al. 1996; FIRSWG 1998; Hollenback and Ory 1999) • Percent catchment in various types of vegetation and wetland cover (Spence et al. 1996) • Total impervious area, effective impervious area, or road density and location (National Marine Fisheries Service 1996; Schueler 1994; May et al. 1997b) • Intergravel dissolved oxygen in sites where fine particulate organic matter is present (Spence et al. 1996)
Microclimate and shade	• Terrestrial: reduce microclimatic edge effects by addressing size, shape of habitat patches • Aquatic: provide vegetative shade over stream • Terrestrial and aquatic: increase forest width	• Terrestrial: measures of air temperature, relative humidity, soil moisture and temperature, solar radiation, and wind speed (Spence et al. 1996; Saunders et al. 1999; Gehlhausen et al. 2000; Laurance et al. 2000) • Aquatic: water temperature (Budd et al. 1987; Beschta et al. 1988)
Sources of stream flow and flood storage (hydrology)	• Reduce impervious surfaces in watershed • Remove or modify sewer outfalls • Add riparian and upland vegetation; increase riparian forest width • Reconnect streams to floodplain • Retain/increase springs, seeps and wetlands (sources of cold water) • Allow channel meanders • Limit development near stream • Control water inputs artificially to mimic natural conditions • Protect natural and create new detention ponds to detain increased peak runoff • Groundwater recharge (increases late summer flows) • Dam removal/modification to more closely mimic natural flow regime • Reintroduce/allow beaver (increases water storage) • Increase late summer flows	• B-IBI (urban land cover correlates equally well in Pacific Northwest with B-IBI at subbasin, riparian, and local scales) (Booth 1991; Spence et al. 1996; Karr and Chu 2000; Booth et al. 2001) • Hydrographs (historic vs present) and stream gauges (Brookes 1987; Hollenbach & Ory 1999) • Annual and interannual streamflow patterns such as T_{qmean}, $T_{0.5}$ yr and CV_{AMF}, quality and timing of peak and low flows (Spence et al. 1996; Booth et al. 2001) • Channel scour (Spence et al. 1996) • Discharge (Spence et al. 1996) • Width/depth ratio, streambank condition, floodplain connectivity, change in peak/base flows, increase in drainage network (National Marine Fisheries Service 1996)

Function or Value	Selected Potential Restoration Activities	Some Potential Indicators of Management Activity Effects
Organic materials	• Increase native vegetation, particularly in riparian areas (although note that small mammals and amphibians require woody debris, thus this should also be addressed in uplands) • In riparian areas, increase conifer:hardwood ratio (large wood from coniferous trees lasts longer instream) • Increase stream connectivity with and ecological integrity of floodplain (floodplain delivers organic materials to stream and riparian areas during flood events) • Addition of fish carcasses to stream	• Measure woody debris and leaf litter or retention time of same (relatively straightforward; Webster and Meyer 1997) • Measure instream nutrient retention time, nutrient spiraling, nutrient cycling (relatively complex; Allan 1995; Cederholm et al. 2000; Cederholm et al. 2001) • GIS: measure forest width and conifer:hardwood ratio or amount and types of vegetative cover (Schueler 1994; Xiang 1996)
Channel dynamics	• Reconnect isolated habitats (instream and terrestrial) • Use a variety of methods (TIA reduction, forest canopy increase, sediment control) to modify flow and sediment regimes to resemble undisturbed conditions • Reduce stream crossings • Control sediment inputs • Remove or modify fish passage barriers • Road removal or alteration • Structural additions (large wood, boulders) • Bank stabilization (vegetation plantings, gabion structures, etc.) • Fencing to avoid livestock grazing • Rest-rotation or grazing strategy • Conifer conversion • Dam removal/modification • Addition of large wood, boulders	• Benthic index of biological integrity (Spence et al. 1996; Karr and Chu 2000; Booth et al. 2001) • Fish-IBI (Regier et al. 1989) • Fraction of bed sediment below a threshold size (measures potentially lethal reductions in permeability allowing flow of oxygenated water to substrate) (Booth et al. 2001) • Cross section and bankfull channel boundary measurements, flood stage surveys, width-to-depth ratios, rates of bank or bed erosion (FIRSWG 1998; Prichard 1998) • Relative Bed Stability Index (Olsen et al. 1997, from Booth et al. 2001) • Riparian forest width measures (Spence et al. 1996) • Channel sinuosity measures (Spence et al. 1996) • Connectivity measures (aerial photography or fragmentation program such as FRAGSTATS) (FIRSWG 1998; FRAGSTATS available at http://www.umass.edu/landeco/research/fragstats/fragstats.html)
Habitat and connectivity	• Reconnect isolated habitats • Consider habitat patch size and shape • Increase native canopy and shrub cover • Control invasive and nonnative plants • Add water sources for wildlife • Plant food resources for wildlife • Manage to increase instream and terrestrial large woody debris • Introduce controlled fire regime to mimic natural disturbances • Improve fish passage	• Bird and wildlife use (FIRSWG 1998) • Large woody debris, instream and terrestrial (Beschta 1979; Dooley and Paulson 1988; FIRSWG 1988; Booth et al. 1997) • Riparian-dependent birds (Spence et al. 1996; Bureau of Land Management 2001) • Aerial photography (FIRSWG 1998) • B-IBI (Booth 1991; Spence et al. 1996; Karr and Chu 2000; Booth et al. 2001) • Sensitive fish (e.g., salmonids) (Spence et al. 1996) • Presence of area-sensitive species (needing large habitat patches) (Keller et al. 1993; Hodges and Krementz 1996; Wenger 1999) • Instream habitat elements: substrate, large woody debris, pool frequency and quality, off-channel habitat, and refugia; % road crossings with inadequate culverts, % unscreened diversions, % impassable dams, frequency of off-channel

Function or Value	Selected Potential Restoration Activities	Some Potential Indicators of Management Activity Effects
		habitats and LWD in riparian zone (National Marine Fisheries Service 1996; Spence et al. 1996) • Terrestrial habitat elements: percent vegetative cover, species density, size and age class distribution, planting survival and reproductive vigor (FIRSWG 1998) • Physical barriers such as culverts (National Marine Fisheries Service 1996) • Nonnative species (Spence et al. 1996) • % riparian zone within 100 m with natural riparian woody plants (Spence et al. 1996) • Beaver sign (Spence et al. 1996)
Reducing human disturbance	• Reduce edge effects • Reduce road effects • Limit trails (especially paved) in large habitat patches for Neotropical migratory birds, which are disturbance-sensitive • Reduce nonnative species through direct removal and/or habitat manipulations • Preserve endangered habitats and habitats critical to endangered species	• Presence, abundance, diversity of sensitive species, or sensitive species index such as B-IBI or Neotropical migratory breeding bird surveys (Spence et al. 1996; Karr and Chu 2000; Booth et al. 2001; Moore et al. 1993; Friesen et al. 1995; Nilon et al. 1995; Theobald et al. 1997; Mancke and Gavin 2000; Hennings 2001) • Bird nesting success studies and studies on associated predators (Small and Hunter 1988; Marzluff et al. 1998; Heske et al. 2001) • Vegetation surveys (Hennings 2001; Roni et al. 2001) • Recreational use surveys (FIRSWG 1998)

Appendix 7. Metro's activities relevant to the Willamette Restoration Initiative's Critical Action Items.

	WRI Critical Action Item	Metro's Activities relating to Action Item
Clean Water	1. Support the Willamette Basin total maximum daily load (TMDL) process, including coordination and communication.	• Green Streets Program – Environmental designs for transportation systems (2002)
	2. Support effective implementation of the agricultural water quality management plan process (Senate Bill 1010) and encourage its use to address species needs.	• Develop agricultural water quality management plans on all leased farm land in the Tualatin River Basin owned by Metro.
	3. Reduce the levels of toxic pollutants in the Willamette Basin.	• Regional Environmental Management (REM) accepts household hazardous waste from throughout the region. This program has been in place since 1986 to reduce risks to water quality from improper disposal of items such as pool chlorine, paint, and motor oil. In the 1988-89 fiscal year, this program collected 2.4 million pounds of hazardous waste, of which 79% was reused, recycled or burned for energy. In 1999-2000 this program collected 2.7 million pounds of hazardous waste, of which 81% was reused, recycled, or burned for energy. • REM operates two permanent facilities where household hazardous waste can be properly disposed of each year. • REM cleans up illegal dumps in the region, many of them in streamside areas. This has resulted in approximately 1,000 sites cleaned up annually. • REM promotes integrated pest management and natural gardening to reduce pesticide use in the region. • Metro Recycling Information fields 100,000 calls annually. It helps the public find acceptable ways to recycle waste oil, household hazardous wastes, and other wastes which otherwise might be buried in area landfills or be improperly disposed of. • Application and potential release of herbicide compounds in the Willamette River Basin is minimized following our integrated pest management (IPM) approach to vegetation management on approximately 6,500 acres. • Green Streets Program – Environmental designs for transportation systems
	4. Provide economic incentives to decrease water pollution.	• REM has sold 60,000 composting bins at below market price to promote composing which minimize erosion, increases water conservation, and reduces the use of lawn fertilizer. • REM accepts household hazardous waste at far below processing cost to provide an economic incentive for proper disposal and recycling. • Metro Transportation Improvement Program (2003) • Green Streets Program (2002)
	5. Promote a developer education/certification program tied to incentives.	
	6. Initiate an effluent and "water quality impact" trading pilot project in the Willamette Basin.	

Appendix 7. Metro's activities relevant to the Willamette Restoration Initiative's Critical Action Items.

WRI Critical Action Item		Metro's Activities relating to Action Item
Water Quantity	7. Support improvements to water quantity management efforts to meet water supply needs for ecological and economic purposes	• REM has continuously promoted composting and "grasscycling" to increase the particle and water holding capacity of the soil. This increases storm water conservation, reduces storm water flow surges, reduces erosion as well as reducing the use of lawn fertilizer. • Working with Water Trust to convert all non-essential water rights to in-stream rights. • Restoration activities on Metro park and open space lands have improved riparian areas and associated wetlands which enhance both water quality and quantity. • Green Streets Program (2002)
	8. Support the Corps of Engineers' ongoing assessment of flood control reservoir operation by helping identify and communicate changes needed to address streamflow issues.	
Habitat & Hydrology	9. Establish science-based riparian area protection guidelines.	• Title 3 and Goal 5 efforts
	10. Support basinwide scientific investigations of how to restore floodplain function.	• Goal 5 efforts
	11. Inventory, map, and conserve priority fish and wildlife habitats in the basin.	• Title 3; Goal 5 inventory, ESEE analysis, and related policies and procedures • Forest canopy inventory; Natural areas inventory; Disappearing natural areas assessment; working with local partners to identify interconnected, region-wide system of parks, natural areas, trails and greenways for benefit of fish, wildlife and people. • Metro Transportation Improvement Program: Regional Culverts program (2003)
	12. Improve both upstream and downstream fish passage at dams, culverts, and water diversions.	• REM installed a screen, approved by the Oregon Department of Fish and Wildlife, to prevent fish from being sucked into the pump intake at St. John's Landfill. • Dam removal project-Johnson Creek (Ambleside properties); dam removal - Smith/Bybee Lakes (replace with fish friendly water control structure). Note: both dam projects are in planning stages. • Metro Transportation Improvement Program: Regional Culverts Inventory program (2003)
	13. Support improvements to hatchery and harvest management systems.	• Participate in ODFW Basin Planning efforts in the Sandy River watershed
	14. Prevent the introduction and control the spread of the most harmful invasive species.	• Volunteer efforts; example = Cooper Mountain habitat restoration, including removal of Himalayan blackberries. • Currently working with other agencies in the region to form a regional weed board. Working with other governmental and NGOs on developing new weed control techniques. In partnership with Nature Conservancy, Metro published and distributed brochures to landowners offering information and guidance for the suppression of Japanese knotweed. • Aggressive efforts to control invasive species on Metro properties involving variety of strategies including volunteers, herbicides, revegetation with native species, water control, mechanical etc.; education integrated into Environmental Education Programs and Volunteer training • In partnership with USFWS—grants to variety of partners to support invasives control/removal on publicly owned lands. Primary target species include Reed canary grass, Japanese Knotweed, Him. Blackberry, English Ivy, Scots broom, purple loosestrife, etc.

Appendix 7. Metro's activities relevant to the Willamette Restoration Initiative's Critical Action Items.

	WRI Critical Action Item	Metro's Activities relating to Action Item
	15. Improve delivery mechanisms for incentive programs, especially the Conservation Reserve Enhancement Program (CREP).	• Published "Protecting Open Space: A Review of Successful Programs and Landowner Perspectives"; with funding assistance from local partners, have awarded contract to Eco NW to develop and propose new incentive programs for natural resource conservation on private lands in PDX metropolitan region (in process).
	16. Support funding for on-the-ground protection and restoration projects.	• USFWS, other volunteer efforts through Metro. See Volunteer Program Year-end Report 2000. • Metro, through RPAG dept. is aggressively supporting proposed Conservation and Reinvestment Act of 2001; In partnership with USFWS, Metro administers successful small grants program supporting restoration and environmental education • Metro developed and forwarded to voters1995 $135.6 million Open Space, Parks and Streams Bond Measure. Approved by voters by a 62% margin, administered by RPAG, these funds have allowed for the acquisition of 7,000 acres including more than 42 mi. of stream and river frontage and funded nearly 100 local greenspace projects in three-county metro region. • Regional Culverts program
Institutions & Policies	17. Increase public and consumer awareness of the Willamette Basin health issues.	
	18. Help grow the market for, and encourage development of, environmentally friendly products.	• Recycling program, including sale of recycled paints • Collected native grasses and forbs seeds and contracted growers to develop plant material sources for native plant materials.
	19. Create new stewardship pathways through agreements and incentives.	• RPAG volunteer program provides numerous opportunities for wide variety of citizens to get involved in stewardship of region's natural resources; RPAG environmental education and special events enhance awareness, understanding and appreciation of natural environment and human relationship/impacts on natural resources. • Green Streets Program (2002)
	20. Reduce tax barriers to conservation on private lands.	
	21. Create an effective and cooperative strategy at the local level to fund and implement watershed action plans.	• Green Streets Program (2002)
	22. Create watershed technical assistance teams.	
	23. Establish a basinwide salmonid recovery coordinating council.	
	24. Coordinate and integrate major regulatory programs and responses to them.	• Title 3, Goal 5 efforts
	25. Improve Willamette Basin information management.	• Goal 5 science paper
	26. Increase usefulness of land use planning and management programs for watershed issues.	• Green Streets Program (2002)
	27. Strengthen agency capacity to implement and administer existing programs, including enforcement.	• Green Streets Program (2002)

Appendix 8

Mike Reed
Overview of the City of Portland's
Endangered Species Act Program
June 6, 2001

THE ENDANGERED SPECIES ACT

The Endangered Species Act first became an issue for the City of Portland when steelhead were listed in March of 1998. Subsequent listings of chinook in March of 1999 and pending listings of coastal cutthroat have created a legal and environmental responsibility for the City. The 4(d) rule was released on June 20, 1999 that makes it illegal to "take" a listed species. The definition of take is broadly defined to mean that a species that is listed under the ESA cannot be killed or harmed in any way. The definition of take has been interpreted to also include habitat conditions. Habitat that the species depends on cannot be destroyed or altered that jeopardizes the species existence.

The following is a brief description of the city-wide response to the ESA.

THE PORTLAND CITY COUNCIL RESPONSE

After the Steelhead was listed as threatened in March of 1998 under the Endangered Species Act, the City Council gave direction to the City's Endangered Species Act Program during an informal work session in May 1998 (City Council Work Session Briefing Packet, 5 May 1998) and again in the Steelhead Resolution in July of 1998 (#35715, Appendices to the Briefing Packet for City Council, 12 January 1999). The City Council included the following recommendations for complying with the Endangered Species Act:

- The ESA program should be an integrated, comprehensive City-wide approach with representation from all affected City agencies.
- Conduct an assessment of City activities that have the potential to impact steelhead and other salmonids.
- Work proactively with NMFS to develop a programmatic response to the ESA listing.
- Work to support the recovery of steelhead populations.
- Work with other regional and state partners.
- Engage the community stakeholders in the development of the ESA response.

THE BEAK REPORT – AN ASSESSMENT OF CITY ACTIVITIES

One of the first actions of the ESA Program was to conduct an assessment of the potential for City activities to impact steelhead and other salmonids. The Beak Report assessment, as it is commonly referred to, consisted of interviews with over 100 City staff.

The assessment found that the following City activities could affect steelhead (and other salmonids as well):

- **Alteration of watershed conditions through permitted development (e.g. reduced vegetation cover and increased impervious surfaces)**
- **Introduction of toxic materials, nutrients, fine sediment, or organic material to the watercourse (e.g., storm water discharge)**
- **Modification of the flow regime (e.g., water diversions)**
- **Influencing water temperature (e.g., modification of the riparian shade canopy)**
- **Influencing riparian vegetation (e.g., riparian removal or alteration)**
- **Influencing fish passage (e.g., installation of culvert stream crossings)**
- **Influencing factors that increases the likelihood of inter- and intra-species predation rates (e.g., installation and/or alteration of bank and instream structures**
- **Influencing the level of direct disturbance to fish (e.g., installation of streambank structures that encourage human activity)**

It was recognized that for any given activity to influence salmonids, it was dependent upon the watershed in which the activity occurred. Sediment delivered into the Willamette River for example, will have much different short and long term affects than sediment delivered into a smaller stream such as Johnson Creek.

The Beak report recognized that a number of watersheds within City of Portland's jurisdiction support steelhead spawning and rearing – Johnson and Tryon creeks. Fish surveys by ODFW and the City of Portland have found that the Johnson Creek watershed also supports chinook rearing in the lower portion of the creek as well as cutthroat rearing and spawning throughout the watershed. Although coho have been found in limited numbers, they are believed to prefer the tributaries and headwaters of Johnson Creek.

Because of their size in relation to the Willamette River, many of the watersheds in the City of Portland are vulnerable to the effects of many City activities, especially those activities that affect sediment delivery and riparian canopy shade. Flow – both low and high flows – and fish passage (culverts) are also impacts that the City can influence.

Because a large portion of the watersheds such as Johnson and Tryon creeks fall within the jurisdiction of the City's comprehensive planning and zoning processes, the City has a greater potential to influence development and the activities conducted in these portions of the watershed. This greater vulnerability and higher level of regulatory influence, combined with the possible year-round presence of steelhead as well as different spatial and temporal distributions of chinook, coho and cutthroat due to various life history strategies, makes these streams more vulnerable to the potential influences of City activities and processes.

On the other hand, with the potential influence of the City, the Endangered Species Act Program believe that Johnson and Tryon creeks likely represent *one of the City's greatest opportunities to protect and benefit salmonids.*

As a result of the Beak Report assessment several city-wide, intra-bureau committees were established to investigate city programs and activities that might need to be updated to meet Endangered Species Act compliance standards. Through the work of these committees, the following City programs have been updated and will have direct influence in the City's watersheds:

- **Erosion Control – The City's Erosion Control Program was expanded and improved to reduce erosion and its impacts on fish and their habitat. The Erosion Control Manual was created to describe proactive practices that should be taken to prevent erosion, releases of sediment and other pollutants generated at a site of ground disturbance. The emphasis is on measures that prevent erosion and control stormwater runoff, over practices designed to strictly control sediment.**

  The measurable and enforceable standard for the Erosion Control code is that "no visible and measurable sediment or pollutant shall exit the site, enter the public right of way or be deposited into any water body or storm drainage system."

- **Stormwater Management – The City's Stormwater Management Program is being updated to obtain ESA compliance for City point source, stormwater, and maintenance discharges. Building upon existing programs, particularly the National Pollution Discharge Elimination System (NPDES) permit renewal with the Department of Environmental Quality, the updates include the creation of effective "Best Management Practices" that will address stormwater impacts on fish. The updates to the program are still in progress.**

- **Environmental Overlay Zone (E-Zone) Review – In response to the ESA as well as regional riparian (streamside) protection standards (Goal5/Title 3), the City has been updating its environmental zoning program for improving riparian protection for the small urban streams and waterways, such as Johnson Creek, Tryon Creek, Fanno Creek, Balch Creek, and the Columbia Slough.**

The goal of these city-wide program updates is to obtain federal recognition under the Endangered Species Act. All of the watersheds in the City of Portland should benefit from these changes. At the same time, there are fundamental watershed specific issues that cannot be effectively addressed at the city-wide level, and yet must be dealt with in order to meet pressing local needs and meet the intent of the ESA. The City's ESA Program is developing a comprehensive strategy that builds

on watersheds where more focused strategies are needed for controlling impacts to listed fish.

WATERSHED PLANNING – THE CITY OF PORTLAND FRAMEWORK FOR WATERSHED AND HABITAT CONSERVATION PLANNING

The City's comprehensive response to the Endangered Species Act consists of several different elements. The City is developing a coordinated city-wide plan based on science including the development of incentives and other means necessary to ensure habitat protection and restoration. The plan will not apply identical approaches to each watershed, but will focus on how the fish use, or need to use, a particular stretch of the river or stream and provide for customized approaches based on that information.

It is fully acknowledged that streams in urban areas, such as Johnson and Tryon Creeks, are nearly always located at the lowest point in a watershed, magnifying the effects of landuse changes in headwater and upland areas. There is near universal acceptance that urban watersheds are degraded. While a return to historic conditions is not possible, the City of Portland believes that urban watersheds still perform important ecosystem functions. The City also believes that those functions can be enhanced and restored to the benefit of salmon and humans.

Using sound scientific principles as a foundation for a comprehensive plan, the city will merge traditional practices with strategies for ecosystem restoration. The result will be an important new role for urban communities – assisting recovery of watersheds, streams and species instead of exacerbating their decline.

FUNDAMENTAL ELEMENTS OF THE WATERSHED APPROACH – VISION, GOALS AND OBJECTIVES

- Vision – A Vision will be created with the cooperation of all interested stakeholders to describe what the City of Portland is trying to accomplish with regard to ESA compliance, fish and wildlife and other desired benefits from the watersheds within the City of Portland. It is important that each watershed contribute a vision. These visions will be integrated and coordinated with visions related to other City objectives (e.g., sustainability, livable neighborhoods, economic vitality, recreation and wildlife).
- Watershed Goals – Watershed Goals are an important ingredient to achieving the stated ideals of the vision. The goals will describe more specifically what the City is trying to achieve with its fish recovery efforts. In the case of Johnson Creek, watershed goals must clearly define the desired characteristics of fish populations that the program is striving to restore within Portland's watersheds. The goals will also acknowledge and refer to other objectives the City needs to meet as an urban center (e.g., jobs, growth

management, affordable housing, and recreation). These goals have the potential to support or conflict with fish recovery goals and it is only through explicit acknowledgement, analysis, and planning that opportunities can be found and potential conflicts can be resolved.

- Watershed Conditions – Watershed Conditions will define ecological characteristics of the watersheds needed to achieve fish recovery. These are based on scientific analysis of the habitat conditions required to support healthy salmon populations and the description of "properly functioning conditions" (PFCs) from the National Marine Fisheries Service. PFCs are those conditions that describe important ecological and watershed conditions that species need to carry out their full life histories. Examples of PFCs include appropriate temperatures, flows, instream conditions that allow salmon to thrive in their freshwater environments.
- Planning and Analysis – The City will take steps to develop and analyze alternative strategies and actions to meet goals and objectives developed in the previous steps. The objective of this step is to develop a broadly supported set of detailed actions – projects, programs, regulations, etc. – that will be adopted by the City Council and ultimately implemented by the City of Portland and its partners.
- Developing watershed and habitat strategies and actions – Analyzing the biological effectiveness of alternative strategies and actions will be accomplished using the Ecological Diagnostic and Treatment (EDT) model. An important advantage of the EDT model is that it provides a structured way to estimate the effects of a particular set of actions. These estimates can be compared for alternative actions to develop priorities for the best strategies to pursue first. EDT's structured approach also will help Portland organize its analysis so assumptions and data are transparent to regulators, stakeholders and policy makers.
- Monitoring and Evaluation – The monitoring and evaluation program will have the following characteristics: structured testable actions, monitoring key watershed attributes, data management and analysis, assess economic effects, fiscal reporting and financial accountability, and evaluation schedule and reporting.
- Adaptive Management – A decision process that institutionalizes integration, strategic reviews and mid-course corrections.