“Conservationists will be a lot more effective if they take cities and the people who live in them much more seriously. Cities have a bad name in many quarters of the conservation community . . . Conversely, the conservation movement has a bad name among many who work on urban problems . . . The truth is that protecting nature and improving city life are interdependent goals. Conservation and urban leaders are natural allies. The challenge is in making the right connections.”

— *Ted Trzyna*
The Urban Imperative

Chapter 1 Introduction

1.1 Purpose of this Guidebook

The Oregon portion of the Portland-Vancouver metropolitan region encompasses 25 cities and sections of three counties covering 463 square miles (Figure 1-1). Although Metro's jurisdictional boundary region comprises only 4.7 percent of the state's land area, it has 38.4 percent of the state's population—about 1.4 million people, and 50 percent of the state's jobs. The population in this three-county area is expected to reach 2.4 million residents by 2022.

The Portland metropolitan area is home to a great diversity of fish and wildlife and their habitats, defying the popular myth that urban areas are devoid of natural resources. There are an estimated 1,217 acres of active public and private parks, 1,676 acres of public and private natural areas, 1,257 miles of streams, and 8,617 acres of wetlands within the Portland metropolitan area. Conservation of these habitats, and other often overlooked places, such as backyards, is critical to maintaining the healthy populations of native fish and wildlife that call this landscape home—26 fish species, 16 amphibian species, 13 reptile species, 209 bird species, and 54 mammal species (Hennings 2008).

These native fish and wildlife must navigate the intricate network of urban roads, a vital part of Portland's transportation system. Roads can negatively affect the natural environment—from wildlife-vehicle collisions to fragmenting wildlife habitat—yet the existence and design of roads greatly affects the quality of life for people as well as the health of fish and wildlife populations seeking to obtain their food, water, shelter, and space requirements.

This guidebook, *Achieving Landscape Permeability in an Urban Environment: Wildlife Crossing Guidelines and Considerations*, provides recommendations to enhance the design and effectiveness of transportation planning processes within the context of evolving and complex scientific information and research. Implementing improved transportation planning processes will help to ensure Portland area roadways allow for the greatest possible movement of native fish and wildlife for the conservation of these species, while ensuring the safety of the motoring public. Both enhance the quality of life of Oregonians that value healthy fish and wildlife populations.

This guidebook complements the previous and ongoing work of Metro, including *Metro's Green Streets*, *Trees for Green Streets*, *Creating Livable Streets*, and *Green Trails* guidebooks as well as the work of others in the Portland metropolitan area focused on inventorying, characterizing, and connecting important habitats for native fish and wildlife. The guidebook provides information on:

- where to look for inventory information on wildlife populations in the Portland metropolitan area;
- the ecological effects of roads;
- the importance of identifying wildlife linkages;
- a decision guide to ensure wildlife mitigation planning outcomes achieve goals;
- different types of wildlife crossing structures;
- potential sources of funding;
- the importance of monitoring of wildlife populations and road crossing locations needed to assess landscape permeability;

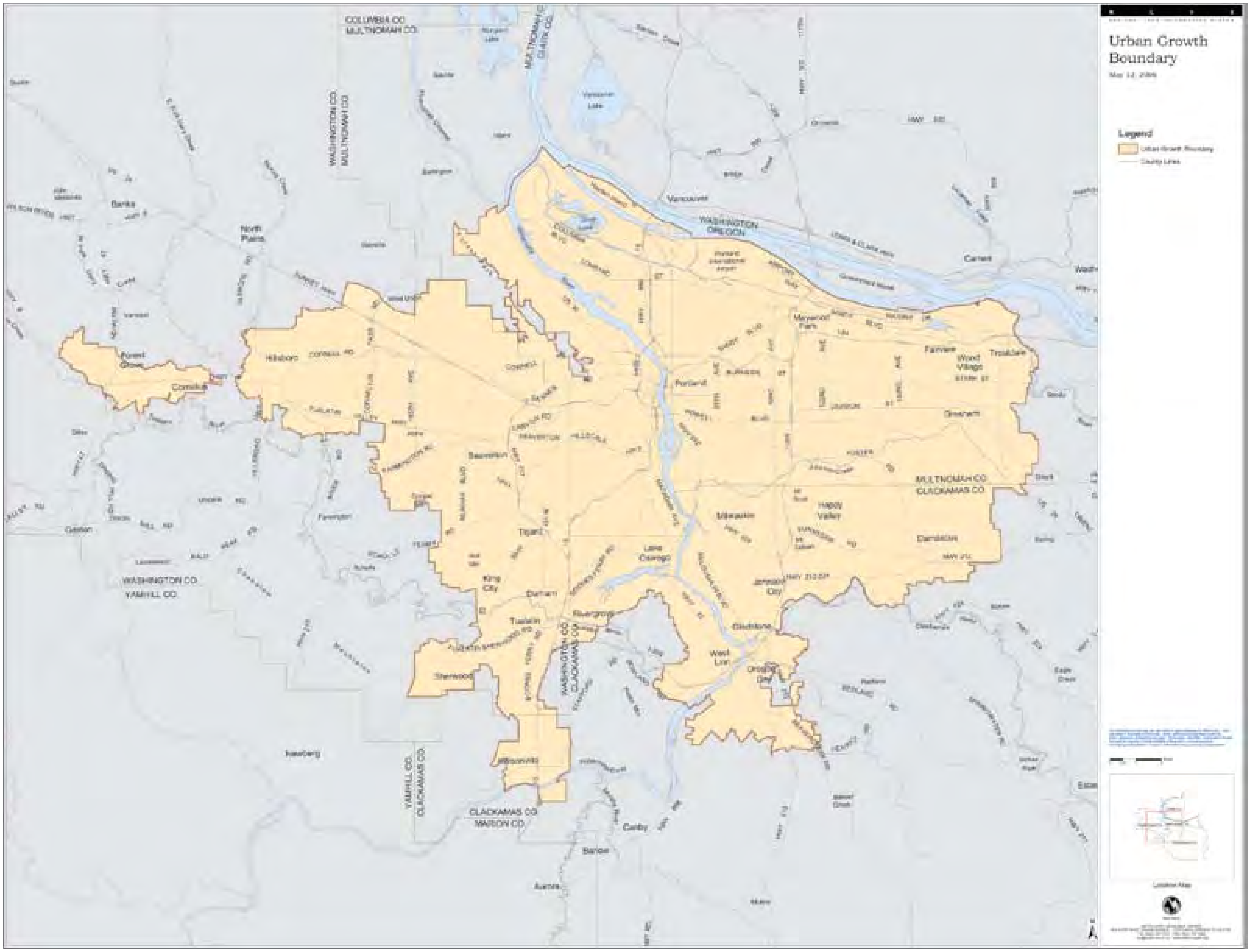

Figure 1-1
Portland metropolitan area showing land within the urban growth boundary (UGB).

- case studies and examples of wildlife crossings; and
- supporting actions that can be taken to help achieve landscape permeability.

1.2 Wildlife Crossings

There are many definitions of wildlife crossings. For the purpose of this guidebook, a crossing is defined as a new or existing passage over or below a roadway or railroad that was designed specifically, or in part, to assist wildlife movement (Bissonette and Cramer 2007). This guidebook focuses on wildlife crossings for native species other than fish (i.e., amphibians, reptiles, birds, and mammals), because there are other well institutionalized avenues for improving fish populations and passage across roadways in Oregon, including the Oregon Plan for Salmon and Watersheds, state fish passage regulations, the Federal Endangered Species Act for listed salmonids, and Portland Metro's culvert program (described on page 13).

Descriptions of different types of wildlife crossings can be found in chapter 5.

1.3 What is Landscape Permeability?

Wildlife require food, shelter, water, and space to survive, reproduce, and maintain healthy populations. The "area over which an animal normally travels in pursuit of its routine activities" is its home range (Jewell 1966). Landscape permeability is the ability of wildlife to move freely throughout their home ranges throughout the year (Bissonette and Cramer 2007).

Urban backyards are an often overlooked component of wildlife home ranges and habitat, however, they can contribute greatly to meeting the needs of some species of wildlife year-round or at specific times during the year. Depending on their proximity to natural areas and wildlife corridors, well-managed backyards with native trees, shrubs, ground covers, and water can contribute to landscape permeability, especially in buffer zones, i.e., areas located between high quality wildlife habitat and those inhospitable to wildlife (Figure 1-2).

Connectivity is the degree to which a landscape helps or disrupts the ability of an animal to move and acquire resources (Fahrig and Merriam 1985). Patches of wildlife habitat that become isolated because of transportation infrastructure, such as roads or bridges, often cannot sustain an abundance or diversity of wildlife species. Reconnecting habitat patches and identifying and maintaining wildlife corridors (Figure 1-3) can help wildlife populations by improving access to habitat, facilitating seasonal migration of wildlife, creating opportunities

Figure 1-2
Well-managed backyards that adjoin natural areas can provide quality habitat to wildlife in an urban landscape. Photo credit: Metro's Habitat Tool at http://www.oregonmetro.gov/index.cfm/go/by.web/.id=8385.

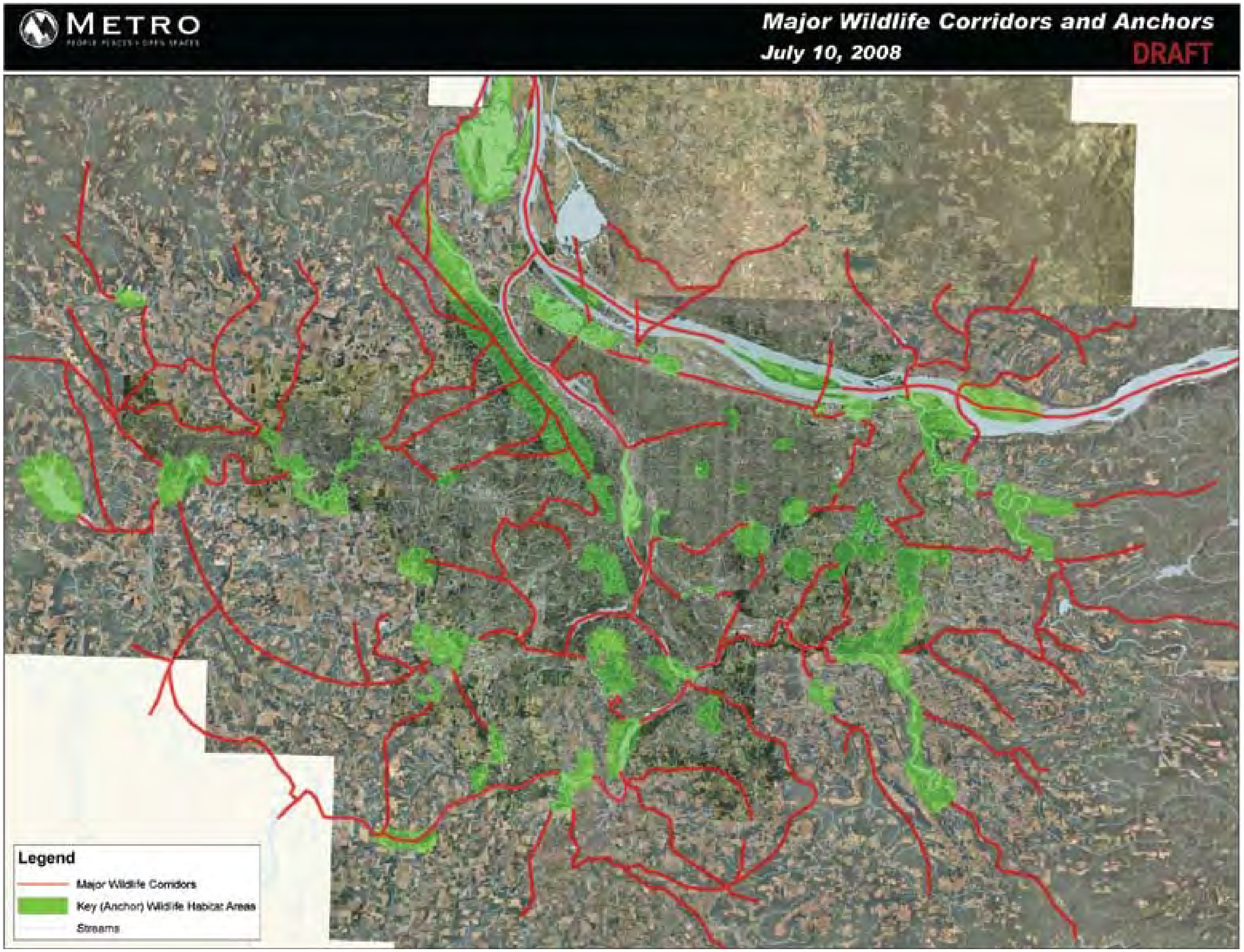

Figure 1-3
Metro identified major wildlife corridors (red) and anchor areas (green) within the Portland metropolitan area. Anchor habitats provide the necessary food, water, and cover for target wildlife species, and are usually capable of maintaining a stable population of these species over time. Note: The City of Portland uses a different definition for anchor habitats—greater than 30 acres in size.

to exchange genes with nearby wildlife populations, and providing for safe passage from habitat that is degrading or is under threat.

Connectivity studies, also called wildlife linkage analyses, emphasize the importance of permeability across landscapes and through transportation systems for wildlife species. Landscape permeability for wildlife can best be achieved by installing several types and sizes of wildlife crossings throughout a transportation corridor. Doing so creates opportunities for fish and wildlife species and individuals from nearby fish and wildlife populations to access and use these structures (and their home range) throughout the year (Bissonette and Cramer 2007), thus helping to maintain daily and seasonal movements for a suite of species in an ecosystem. This type of approach connects wildlife across landscapes, restores the integrity of ecosystems, and is cost-effective (Huijser et al. 2007).

Roads connect people and places, but may act as barriers for movement of wildlife seasonally or throughout the year because of their location and siting. For example, a road bisecting a wetland could act as a barrier to turtles that need to move throughout the wetland during the breeding season. Connectivity becomes permeability when different types and designs of crossings in context-sensitive locations act as sieves that facilitate animal movement, versus funnels that guide wildlife to a limited number of crossings (Bissonette and Cramer 2007). Understanding the wildlife community surrounding a proposed road/structure will help predict the types of wildlife crossing structures and locations to achieve permeability. In the case of the turtles mentioned above, a wildlife crossing below the roadway would facilitate movement between the bisected wetland and enhance connectivity.

1.4 How Is Our Metropolitan Area Changing?

The Portland metropolitan area has lost a great deal of natural functioning habitats. About 10 percent of the region's floodplains are developed, tree canopy cover declined 9 percent from 1972 to 2001, and 12 percent of the region's remaining 131,167 acres of natural areas were lost to development and other uses from 1989 to 1997. Further, the percent of areas within riparian areas is substantially below the historic condition. Many natural areas throughout the region are inundated with invasive species. Streams have been disappearing across the landscape, and numerous reptiles, amphibians, birds, and mammals in the area are threatened by habitat loss and degradation of ecosystems.

Eight evolutionary significant units (ESU) of salmon and five distinct population segments (DPS) of steelhead may use or migrate through watercourses in the Portland metropolitan area (Mike Reed, City of Portland, pers. comm.). Critical habitat for these species include the lower Columbia and Willamette River corridors, portions of Johnson Creek and its tributaries, Tryon Creek, Smith-Bybee Lakes, and the Columbia Slough. All of these habitats have experienced the detrimental effects of development and urban growth.

Every five years, Metro evaluates the land supply within the urban growth boundary, which separates rural from urban land areas of Clackamas, Multnomah, and Washington counties (Figure 1-1). Metro determines if it is necessary to expand the urban growth boundary. In 2002, the Metro Council adopted an expansion of the urban growth boundary, adding 18,600 acres and increasing the land available for urban development by 8 percent. The greatest impact of the new urban growth boundary affects about 13,000 acres in the incorporated area of Damascus south of Gresham as well as 377 acres southeast of Gresham (for industrial development). Significant wildlife habitat, including important wildlife corridors, exists in this area, and design and location of roads in this newly developing area could greatly affect wildlife populations if landscape permeability is not considered.

Loss of Habitat—Forest Heights

The Forest Heights area of Portland is one example of significant loss of natural habitats as a result of development. The headwaters of Cedar Mill Creek begin in the far northwest corner of Multnomah County in the area of the 600-acre Forest Heights development. Cedar Mill Creek joins North Johnson Creek—together, the two watersheds drain 5,400 acres. Development of high urban density in the headwaters of Cedar Mill Creek (Figure 1-4) has directly increased storm water runoff and water pollution, has resulted in loss of open space and wildlife habitat, and has given invasive weeds an opportunity to outcompete native plants, significantly reducing wildlife habitat in this area.

Despite these and other urban pressures, towns and cities within the Portland metropolitan area have attempted to balance the needs of an expanding human population with the values and benefits associated with healthy ecosystems and wildlife habitats. Nature in Neighborhoods, a region-wide initiative that helps to ensure a healthy urban ecosystem, is a good example of a strategic effort to protect water quality and healthy natural

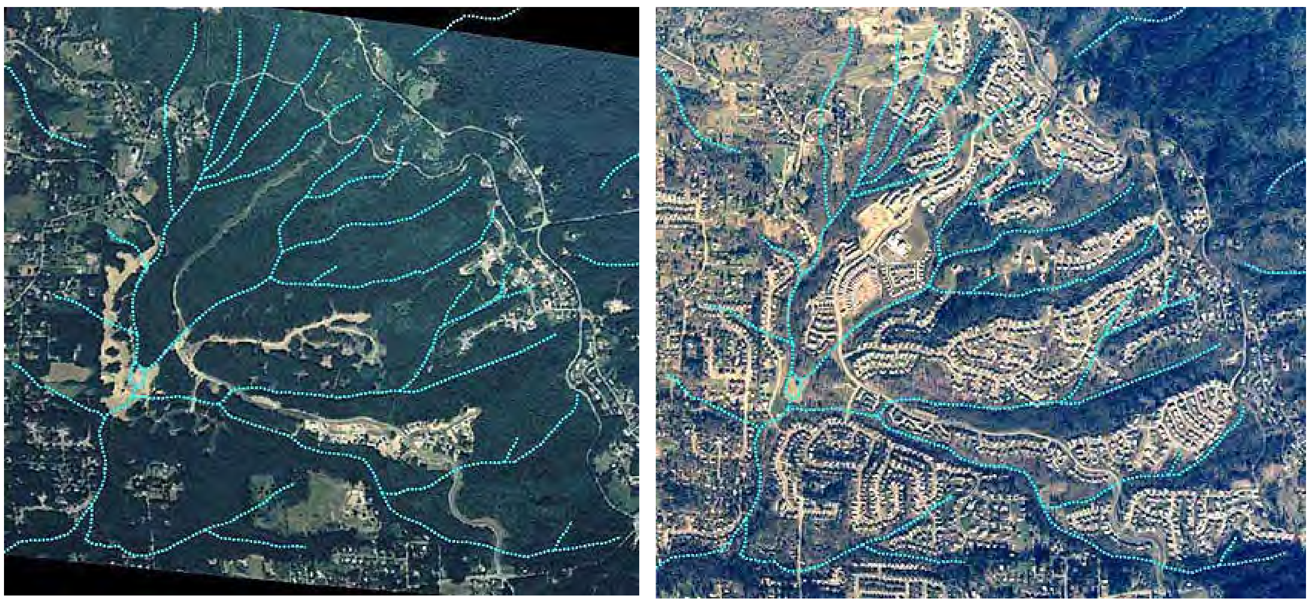

Figure 1-4
Aerial photographs taken in 1990 (left) and again in 2002 (right) show the 600-acre Forest Heights Development in the headwaters of Cedar Mill Creek, which flows west into Washington County from Forest Park. Other tributaries of Rock Creek to the north and west along the crest of the Tualatin Mountains could face similar growth in the future if not protected from development. Photos courtesy of Friends and Advocates of Urban Natural Areas (FAUNA).

areas for fish, wildlife, and people by restoring stream corridors and controlling and preventing water pollution. These and other efforts have resulted in protection of about 30,000 acres of high quality wildlife habitat remaining in the most heavily populated area of the state. Thus, although a significant amount of habitat has been lost, how the remaining habitat is managed and located across the urban landscape is critical to fulfilling the vision for healthy ecosystems.

Other potential and planned transportation projects in the Portland metropolitan area have the potential to affect wildlife populations similar to the Forest Heights development. The Columbia River Crossing, slated to ease traffic woes on the existing I-5 bridge that connects Portland, Oregon to Vancouver, Washington, is scheduled to replace the existing bridge with one that has light rail and rebuilt interchanges, likely increasing the amount of vehicle use on connecting roads. The Columbia River greenway is one of the most feasibly attainable remaining corridors to connect wildlife across the Portland metropolitan area. Wildlife crossings and landscape permeability concepts for wildlife should be considered in this and other projects to protect and retain connections between the best remaining wildlife habitats.

1.5 Who Should Use This Guidebook?

This handbook is designed for:

- transportation planners and engineers interested in exploring the feasibility of wildlife crossings in the larger context of landscape permeability within an urban area as well as those who design habitat restoration projects or culvert retrofits;

- developers, who design and build residential, commercial, or public works, for ideas on how to mitigate environmental impacts associated with development;

- landscape architects and land use planners, who assist in large-scale community planning efforts;

- watershed councils and watershed planners;

- parks and recreation planners;

- wildlife biologists and environmental planners involved in street, site, and regional transportation design that seek to ensure landscape permeability for a suite of wildlife species; and

- citizens concerned with safety, cost, and environmental repercussions of wildlife-vehicle conflicts and that seek to maintain high quality wildlife habitat in an urban area.

1.6 How to Use This Guidebook

Chapter 1 Introduction

This chapter provides the “mechanics” of the guidebook and background information about the Portland metropolitan area, the regulatory environment, and an explanation of landscape permeability.

Chapter 2 Road Ecology—Roads as Barriers or Sieves

This chapter addresses the detrimental effects of roads and describes wildlife in the Portland metropolitan area.

Chapter 3 Corridors — Connecting Wildlife

Across a Landscape

This chapter documents the many data sets that can be used to identify priority wildlife linkages in an urban area as well as the importance of identifying wildlife corridors, connecting habitats, and providing landscape permeability for wildlife.

Chapter 4 Wildlife Crossings—Putting it All Together

This chapter describes a process for developing wildlife crossings to enhance landscape permeability for wildlife.

Chapter 5 Wildlife Crossing Structures—Helping to Achieve Landscape Permeability

This chapter describes several types of wildlife crossing structures and their costs.

Chapter 6 Funding a Vision

This chapter provides sources of funding for new wildlife crossing structures as well as retrofits of existing structures.

Chapter 7 You're Not Finished When You're Done

This chapter explores the strategies that need to be taken to monitor and maintain landscape permeability.

1.7 How This Guidebook Complements Other Key Initiatives

Western Governors' Association Wildlife Corridors Initiative

The Western Governors' Association (WGA) approved a resolution (07-01) in 2007 to identify key wildlife migration corridors and crucial habitat in the West and recommend policy options and tools for preservation. In response, WGA launched the Wildlife Corridor Initiative to promote best practices for development, reduce harmful impacts on wildlife, and integrate migratory and crucial habitat into planning decisions.

This guidebook helps Oregon achieve the policy recommendations in this initiative related to protecting wildlife values at the landscape scale and defining and prioritizing wildlife corridors and crucial habitat.

Oregon's Conservation Strategy

The Oregon Conservation Strategy (Strategy) articulates a vision for healthy fish and wildlife populations in Oregon by maintaining and restoring functioning habitats, preventing declines of at-risk species, and reversing any declines in these resources, where possible. The Strategy further articulates six key conservation issues—large-scale issues that present the greatest threats to fish and wildlife populations and their habitats throughout Oregon. Barriers to fish and wildlife movement is one of the major issues. The goal is to provide conditions suitable for natural movement of animals across the landscape—permeability for wildlife.

The Strategy also describes conservation opportunity areas, landscapes in which broad fish and wildlife conservation goals can be achieved, to focus efforts in specific areas. The conservation opportunity areas identified in the Strategy overlap with Metro 1995 bond measure acquisitions and target areas. This guidebook helps to address the barriers to fish and wildlife movements to and between conservation opportunity areas.

Oregon Wildlife Movement Strategy—A Statewide Habitat Connectivity Analysis

The Oregon Wildlife Movement Strategy (Figure 1-5) is an interagency partnership to inventory and prioritize wildlife movement barriers on the state highway system. This effort directly implements the Oregon Conservation Strategy by addressing the key statewide conservation issue of barriers to animal movement. More than simply identifying and conserving valuable habitat areas, Oregon's Wildlife Movement Strategy stresses the importance of permeability across landscapes.

The goals of the Oregon Wildlife Movement Strategy are to:

- maintain and improve existing conditions suitable for natural movement of animals across the landscape;
- improve safety for the traveling public;
- provide a venue for interagency cooperation and collaboration on wildlife movement issues in Oregon; and
- develop guidance and recommendations for stakeholders to address wildlife movement.

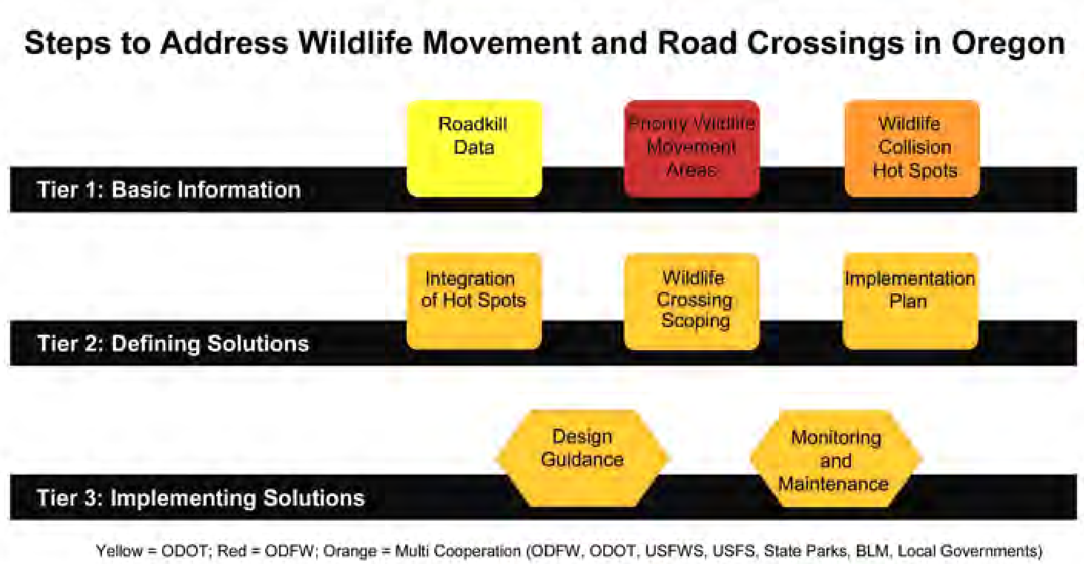

Figure 1-5
Three steps to address wildlife movement and road crossings in Oregon. Source: Oregon Wildlife Movement Strategy Request for Stakeholders, September 2006.

The Oregon Wildlife Movement Strategy identifies and prioritizes wildlife linkage opportunities to enable better decisions regarding transportation planning, design, and mitigation. Data on wildlife linkages and collision hot spots can be used to help reduce animal-vehicle collisions, enhancing landscape permeability for wildlife.

This guidebook provides tools and information to address the goals of the Oregon Wildlife Movement Strategy and all tiers presented in Figure 1-5. Producing regional plans for habitat connectivity is an essential component to the development of a comprehensive system of conserved corridors and effective wildlife crossing structures (Feinberg 2007).

Oregon's Collaborative Environmental and Transportation Agreement for Streamlining (CETAS)

In February 2001, Oregon's state and federal transportation and environmental agencies signed a charter agreement establishing the Collaborative Environmental and Transportation Agreement for Streamlining (CETAS). Environmental aspects of major transportation projects are discussed, with the goal of identifying and implementing collaborative opportunities to help each participating agency realize its mission through sound environmental stewardship, while providing for a safe and efficient transportation system. This guidebook provides tools for participants in the CETAS process, especially relative to criteria for selecting alternatives.

State of Watersheds Monitoring Report

In 2008, Metro published a State of Watersheds Monitoring Report that establishes the baseline, or existing, conditions of the region's watersheds and then tracks watershed conditions over time using a suite of science-based, repeatable watershed health indicators.

There is an overlap in four conservation opportunity areas defined by the Oregon Conservation Strategy and Metro's 1995 bond measure acquisitions and 2006 target areas, namely Oregon white oak savannas and woodlands, native prairie grasslands, wetlands, and bottomland hardwood forests.

This guidebook incorporates information and concepts from the watershed report to describe potential opportunities to enhance landscape permeability for wildlife in the Portland area.

Region 2040 Growth Concept Implementation—Regional Transportation Plan (RTP)

In 1995, the Portland region adopted the 2040 Growth Concept, a long-range plan for managing growth for the next half century. The plan established a new direction for planning in the Portland metropolitan region, linking transportation investments to desired outcomes for the urban area, the economy, and the environment. At the core of the vision is a set of commonly shared values that resonate with residents throughout the Portland metropolitan region, including protection of farms, forests, rivers, streams, and natural areas. The RTP is the 20-year blueprint that guides investments for improving the region's transportation system and helps implement the 2040 Growth Concept.

In January of 2008, Metro finalized its 2035 RTP (www.metro-region.org/rtp) for U.S. Department of Transportation review. The plan considers "urban reserves," which are located outside the urban growth boundary, but are expected to ultimately become urbanized by 2035, and "rural reserves"—agriculture and natural areas, which would not be allowed to become urbanized for at least 40 to 50 years.

This guidebook fulfills the requirement within the RTP to "develop a guidebook to minimize impacts of roadways on wildlife."

Livable Streets Program

This guidebook complements a series of guidebooks that comprise Metro's Livable Streets Program. Metro created the program in 1996 to encourage local jurisdictions to design streets that better support the 2040 Growth Concept. Existing guidebooks include *Green Streets*, *Trees for Green Streets*, *Creating Livable Streets*, and *Green Trails*.

Regionally Significant Fish and Wildlife Habitat Inventory Map

Metro developed the Regionally Significant Fish and Wildlife Habitat Inventory Map to identify key areas of fish and wildlife habitat. This guidebook incorporates these mapping projects into discussions about wildlife connectivity and landscape permeability for wildlife. An online Habitat Tool is available to view:

- the habitat protection concept recommended by the Metro Council;

- the inventory of regionally significant habitat; and

- water, flood, slope, vegetation, and forest data used by Metro to determine habitat designation and protection levels.

The tool is available at http://www.oregonmetro.gov/index.cfm/go/by.web/id=8385.

Nature in Neighborhoods—Titles 3 and 13

Metro's Title 3 (Metro Code Sections 3.07.310–3.07.370) Stream and Floodplain Protection Plan is intended to protect the region's health and public safety by reducing flood and landslide hazards, controlling soil erosion, and reducing pollution of the region's waterways. Title 3 protects streams, rivers, wetlands, and floodplains by avoiding, limiting, or mitigating the impact on these areas from development.

Title 3 contains:

- performance standards to protect against flooding by limiting development in a manner that requires balanced cut and fill and requires floor elevations at least one foot above the flood hazard standard;

- performance standards to protect and enhance water quality by protecting the vegetated corridor of rivers and streams (width of corridor is dependent on the slope of the stream and the number of acres drained by the stream);

- requirements for erosion and sediment control, planting of native vegetation on the stream banks when new development occurs, and prohibition of the storage of new uses of uncontained hazardous material in water quality areas; and

- requirements to establish performance standards to protect regionally significant fish and wild habitat areas.

To implement statewide planning goals 5 (Open Spaces and Natural Resources) and 6 (Air, Water, and Land Resources Quality), the Metro Council approved Nature in Neighborhoods (Title 13) in 2005, a region-wide regulatory and voluntary-based initiative to conserve, protect, and restore a continuous ecologically viable streamside corridor system integrated with upland wildlife habitat and urban landscapes, and to control and prevent water pollution and improve water quality.

Title 13 lists 29 habitat-friendly development practices, including design and construction methods for developing properties that have less detrimental impacts on fish and wildlife habitat than traditional methods. These methods aim to reduce the amount of untreated stormwater surface runoff flowing directly from pavement and buildings into streams and minimize the impacts of development on nearby wildlife corridors (often along streams) and fish passage.

Title 13 includes performance objectives to maintain and enhance wildlife connectivity while avoiding fragmenting existing habitats. The tools and strategies described in this guidebook can be used to help achieve those performance objectives.

Culvert Programs

Metro's culvert program ranks the culverts in the region to identify those needing repair or replacement to accommodate endangered or threatened fish species. The culvert program was initiated after Pacific salmon and steelhead were added to the Endangered Species Act (ESA) listing in the State of Oregon as threatened or endangered species. Although the focus of Metro's culvert program is directed toward fish passage, the redesign of problem culverts presents an opportunity to develop complementary wildlife crossings that accommodate other wildlife as well as fish, increasing landscape permeability for a suite of aquatic-associated native species, such as amphibians.

The Oregon Department of Fish and Wildlife is working with the Oregon Department of Transportation to inventory and prioritize for repair all culverts associated with state- and county-owned roadways in all river basins in Oregon.

Metropolitan Greenspaces Program

The Metropolitan Greenspaces Program defines a vision for an interconnected system of parks, natural areas, greenways, trails, and open spaces. This guidebook complements three goals for the program, including creating a cooperative regional system of natural areas, open space, trails, and greenways for wildlife and people in the four-county metropolitan area (includes Multnomah, Clackamas, Washington, and Clark County); preserving urban plant and animal diversity, using watersheds as the basis for ecological planning; and establishing a system of trails, greenways, and wildlife corridors.

Since 1995, Metro has acquired nearly 9,000 acres of open space, including 74 miles of stream and river frontage as well as wetlands, riparian areas, meadows, forests, and other valuable habitat. Permeability across this landscape for native fish and wildlife species is key for promoting and preserving the region's biodiversity. Effective wildlife crossings are integral to creating an interconnected regional network of natural areas.

City of Portland Terrestrial Ecology Enhancement Strategy

The City of Portland Bureau of Environmental Services is refining acquisition priorities to protect Portland's biodiversity through development of a Terrestrial Ecology Enhancement Strategy. The strategy includes lists of habitats and species of concern used for acquisition priorities.

Conservation Opportunity Areas

In 2006, the Oregon Department of Fish and Wildlife developed a map to identify Conservation Opportunity Areas (COA), landscapes in which broad fish and wildlife conservation goals can be achieved. Four COAs identified in the Oregon

Conservation Strategy overlap with Metro 1995 bond measure acquisitions and target areas, including Oregon white oak savannas and woodlands, native prairie grasslands, wetlands, and bottomland hardwood forests.

1.8 The Regulatory Landscape

Numerous federal, state, and local regulations guide the development of road projects, many which require environmental mitigation measures, such as wildlife crossings, to maintain landscape permeability and habitat connectivity. The following list provides brief explanations of how wildlife crossings may be uniquely affected by federal, state, and local regulations. Additional information can be found in *Green Streets*.

Federal

Clean Water Act—A permit process designed to protect wetland and aquatic habitats by requiring disclosure of expected development impacts. The permit may be required if construction of the wildlife crossing will affect a wetland or waterway. However, wildlife crossings may help a project satisfy the permit process if the project is expected to create substantial negative effects on a wetland or aquatic habitat.

National Environmental Policy Act (NEPA)—This policy triggers the Environmental Impact Statement (EIS) or Environmental Assessment (EA). Wildlife crossings may lower the measured environmental impact of a road project and help meet the obligations of NEPA, thereby removing the need for EIS or EA requirements.

Endangered Species Act (ESA)—The ESA mandates protection and recovery for species in immediate and near-immediate danger of extinction. Chinook salmon, steelhead, chum salmon, coho salmon, and sockeye salmon are listed as federally threatened or endangered species under the ESA. These designations have placed an additional emphasis on protecting fish and wildlife habitat. The application for Section 10 of the ESA requires a habitat conservation plan. Wildlife crossings may be an effective element of a plan designed to protect sensitive species.

Figure 1-6
*The Yellow-Rumped Warbler (*Dendroica coronata*) is a migratory bird and is protected by the Migratory Bird Treaty Act. Photo credit: Michael "Mike" L. Baird, bairdphotos.com.*

SAFETEA-LU—The passage of the 2005 Transportation Act, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—requires environmental considerations (National Environmental Policy Act) to be incorporated during the planning process (versus at the project development phase of the project). SAFETEA-LU has the following components:

- mandates consultation with natural resource agency personnel to identify potential environmental conflicts and mitigation activities;

- includes public comment on the purpose and need of the project—beginning in 2007, the public is notified via the Federal Register if a project is expected to have environmental consequences—as well as stakeholder involvement;

- identifies potential mitigation areas and activities to restore wildlife permeability; and

- mandates a minimum 20-year outlook.

SAFETEA-LU provides for more open discussions when long-range planning is implemented and creates incentives for natural resource agencies to identify wildlife habitat and populations in greatest need of protection.

Migratory Bird Treaty Act—This act, which, passed in 1918, prohibits, except as allowed under specific conditions, the taking, possession, purchase, sale, or bartering of any migratory bird (Figure 1-6), including the feathers or other parts, nests, eggs or migratory bird products. "Taking" is defined as pursuing, hunting, shooting, shooting at, poisoning, wounding, killing, capturing, trapping, or collecting migratory birds. Migratory bird hunting regulations, established by the US Fish and Wildlife Service, allow, during designated seasons, the taking of ducks, geese, doves, rail, woodcock and some other species. The Migratory Bird Treaty Act also provides protections for all native bird species in the Portland metropolitan area, with the exception of a few game birds protected under other regulations.

Fish and Wildlife Coordination Act—This act provides the basic authority for the U.S. Fish and Wildlife Service (USFWS) to evaluate impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive equal consideration to other aspects of a project. It also requires federal agencies that construct, license, or permit water resource development projects to first consult with the USFWS (and the National Marine Fisheries Service in some instances) and state fish and wildlife agencies regarding the impacts on fish and wildlife resources and measures to mitigate these impacts.

State of Oregon

Wetland removal-fill permit—This permit applies to projects that propose to fill a certain amount of wetland, or projects that will affect salmon habitat. Permits may be granted by the Department of State Lands, although they can be difficult to obtain. Bridges and other infrastructure that allow for fish passage and wildlife crossings may help avoid this requirement or increase chances of obtaining the permit.

Highway encroachment permit—The Oregon Department of Transportation (ODOT) requires a permit for projects that cross or encroach on lands managed by ODOT. An agreement for long-term maintenance of the wildlife crossing structure may be needed.

Local

Land use requirements—A wildlife crossing located entirely within the right-of-way would not be held to land use requirements. It may be necessary to obtain a variance if the facility extends beyond the public right-of-way.

Local transportation engineering/traffic control—Local approval may be required if the wildlife crossing affects local transportation corridors. Planners should consult with local traffic engineers to ensure that the crossing facility complies with the American Association of State Highway and Transportation Officials (AASHTO) guidelines for the roadway.

Private

If the crossing infrastructure is located entirely within the existing road footprint, i.e., if it does not extend beyond the area owned and managed by the public agency, it is not likely to trigger any land use processes that would restrict the project from moving forward. Crossings that affect private property may require a permit for approval. It may be useful to pursue an easement or acquire property to ensure that wildlife will be able to access the crossing, even on private property. This may affect project cost and schedule.

Does the site affect a wetland?

If the site is near a wetland, a wildlife crossing may serve as mitigation. This would be a potential source of additional funding, and may also help a roadway project comply with certain environmental regulations. As with any project sited near a wetland, a wildlife crossing must avoid negatively affecting wetland quality, and must replace any wetland acreage filled in the course of the crossing project.

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"Nowhere . . . are the challenges of future growth more apparent today than in places where cities encroach on adjacent open space. Along that ever-expanding edge are all the elements in a classic conflict over land use, transportation planning, water availability, and habitat preservation."

— *Mary D. Nichols*
Secretary for Resources, State of California

Chapter 2 Road Ecology—Roads as Barriers or Sieves

2.1 The Ecological Effects of Roads

Although roads are a necessary part of the human environment (Figure 2-1), they can have negative consequences. Some of these are:

- development that results in loss of wildlife habitat, plants, and animals;
- changes in the density and composition of plants and wildlife beyond the edge of the road;
- habitat created for species that thrive on the edges of habitats;
- wildlife that avoid the road and proximity to the road because of noise, air quality, light, and activity levels;
- wildlife killed by traffic;
- behavioral changes in individuals as well as populations of wildlife;
- fragmentation of habitat that affects the sustainability of wildlife populations and their ability to move to and from habitats;
- improved spread and establishment of some species (e.g., invasive species);
- road runoff affecting water quality and associated aquatic and terrestrial communities; and
- declining water and air quality.

Figure 2-1
Roads are a necessary component of any transportation system. Portland metropolitan area roads provide a public benefit, but contribute to wildlife mortality, loss and fragmentation of habitat, and degradation of natural systems. Well-planned and maintained roads can minimize negative effects to wildlife and the environment and provide avenues for alternative transportation, such as bicycles. Photo credit: BikePortland.org.

All of these, in turn, affect ecosystem services, or the benefits people get from these ecosystems—goods and services, such as food and water, flood and drought regulation, soil health, and recreational and spiritual pursuits.

2.2. Wildlife-Vehicle Collisions

The majority of information published on wildlife-vehicle collisions (WVCs) involve primarily deer, elk, and moose road kills (Figure 2-2). This should be considered when reviewing road kill data or pondering the potential effects of transportation projects on wildlife, particularly in the urban area. Turtles, raccoons, snakes, small mammals, and birds are important components of a healthy urban environment. The fact that vehicle collisions with these and other species is under reported or not reported at all should cause further exploration of their individual habitat needs and possible vulnerability to transportation projects.

Figure 2-2
An unlucky Bend, Oregon driver experienced the trauma of a collision with his vehicle and a deer on Highway 97. Photo credit: Oregon State Police.

The magnitude of road kill in the United States and Canada is significant enough to consider during planning and development of transportation projects, although our understanding is somewhat limited because of inadequate record keeping. WVCs are substantially under reported because:

(1) crash databases typically exclude accidents that have less than $1,000 in property damage;

(2) not all drivers report collisions with animals;

(3) not all law enforcement, natural resource, or transportation agencies have the resources to collect detailed information on WVCs;

(4) injured wildlife wander from the road before they are discovered and counted; and

(5) few, if any, small animal-vehicle collisions are reported.

It is estimated that deer-vehicle collisions are under reported by 50 percent (Conover et al. 1995). In one study, more than 53 percent of people said they did not report to law enforcement when their vehicle collided with an animal (Marcoux 2005).

The most recent estimate indicates there are between one and two million collisions between large animals and vehicles in the United States annually, and that collisions between animals and vehicles comprise 5 percent of all reported motor vehicle collisions (Huijser et al. 2007). Although reported vehicle collisions have been relatively steady from 1990 to 2004, reported animal-vehicle collisions have increased by 50 percent, a likely result of more people driving more miles and increases in deer populations in the United States (Huijser et al. 2007).

Three factors primarily influence WVCs—density of animals, traffic volume, and traffic speed. Characteristics that contribute to areas where WVCs are common include: topographic features such as drainages and ridgelines that encourage animals to use a specific stretch of road or direct animals toward roads; habitat adjacent to roads; food resources that attract animals; and distance to cover (Barnum 2003; Lloyd et al. 2006).

Safety and cost

Wildlife-vehicle collisions cause monetary damage and have indirect and direct effects on people and wildlife. An estimated 4 to 10 percent of reported WVCs involving large animals result in injuries to drivers and their passengers; in the United States, this equates to about 26,000 injuries annually as well as 200 human deaths (Huijser et al. 2007). Collisions with large wildlife are costly in terms of property damage, human injuries, towing, accident investigation, the monetary value of wildlife, and the cost of carcass removal. The total cost of WVCs in the United States annually (including damage to vehicle and medical costs) is estimated to be $8.4 billion (Huijser et al. 2007).

Indirect costs, such as loss of human and animal life, pain and suffering, degraded quality of life, and emotional trauma are difficult to quantify.

Species Most Vulnerable to Collisions

Although there are 21 federally listed threatened or endangered animal species in the United States for which road mortality is among the major threats to survival of the species (Huijser et al. 2007), none of these species are found in the Portland metropolitan area.

However, the long-term survival of local or regional wildlife populations can be threatened by WVCs because of the loss of individual animals and compounding factors of habitat loss, such as urban sprawl. Categories of species at risk of

Figure 2-3
Pond turtles and painted turtles (pictured) can be particularly vulnerable to vehicle collisions, especially if roads parallel versus intersect their habitat. Photo credit: Don VandeBergh, Oregon Department of Fish and Wildlife.

population-level impacts from roads (Jacobson 2008) include:

- movement issues, e.g., wide-ranging species versus slow or immobile species;
- habitat issues, e.g., species attracted to clear zones or those requiring dense cover; and
- behavioral issues, e.g., how animals respond to various stimuli, such as human disturbance, noise, and threats. Some species move faster while others "freeze."

Amphibians and Reptiles

The Arkansas Natural Heritage Commission completed a study of box turtles in 2007 (http://www.naturalheritage.com/citizen-science/boxturtle/) and concluded that "nationally, road mortality is now recognized as a leading threat to box turtle populations." The study found that road kill alone killed enough turtles to reduce local population size, and that female turtles searching for nesting habitat may be more prone to being killed on roads. This skewed mortality can result in male-dominated populations.

Road kill was a major source of amphibian mortality in Indiana (Glista et al. 2008), where water, forest habitat, and urban/residential areas were the variables that best predicted mortality. The study determined that road mortality affects many species, and that amphibians are especially vulnerable because they often migrate across roads in large numbers to and from wetlands where they breed. Western pond turtles (*Actinemys marmorata*) are listed as threatened in Oregon and endangered in Washington. A California study concluded that encounters with automobiles may contribute significantly to the mortality of western pond turtles. In addition, roads parallel to water bodies tend to produce higher rates of trauma and mortality than roads that intersect water bodies (Holland 1991) because of the increased exposure of wildlife to traffic.

Time of Day

Some species of wildlife, such as coyotes and passerine birds, are active during the day, while some, such as bats and owls, are mainly nocturnal. Many wildlife are on the move more often between dusk and dawn and during the spring and fall (seasonal migrations), thus most WVCs occur during these times—when driver visibility is low as well.

Road type

Effects of roads on wildlife vary based on the type of wildlife and road and roadside conditions. However, the following includes some general information about types of roads and their effects on wildlife.

Most WVCs occur on two-lane roads (Huijser et al. 2007). In addition, WVCs occur in clusters at certain locations along roads for many reasons—because geographic features on the landscape guide wildlife to specific locations where they cross (e.g., ravines or valleys); migratory wildlife that traditionally moved across the landscape have routes that are now bisected by highways and roads, yet they continue to attempt to cross at these traditional locations; features of the road such as minimal sight distance and habitat immediately adjacent to the road prevent drivers from seeing wildlife in time to react and safely brake; and ineffective road signs don't provide adequate warning in areas where the volume of wildlife crossings is significant.

Roads with sharp turns or steep slopes may block the view of small animals and may significantly increase the probability of WVCs. In Banff National Park in Canada, slopes less than five percent are considered desirable for wildlife movement (Alexander and Waters 2000). In another study, there were fewer ungulate-vehicle collisions on a section of interstate in Bozeman, Montana, in which the absolute mean slope of the land adjacent to the highway was less than 20 percent (Pellet 2004); further increases in slope led to an increase in collisions, presumably because high slope areas serve to funnel wildlife.

Traffic volume

In addition to road type, traffic volume, adjacent landscape, and road condition are major factors in road kills (Lin 2007). Traffic volume can be an especially significant factor for slow-moving wildlife species (Langevelde and Jaarsma 2004).

The relationship between traffic volume, successful wildlife crossings, and wildlife mortality is dynamic. As traffic volume increases, the number of successful wildlife crossings decrease. This a function of two factors—wildlife mortality and fewer wildlife that attempt to cross the road when traffic reaches a certain volume. Over half of all WVCs occur on roads with less than 5,000 vehicles per day. As traffic volume increases beyond this level, the road creates a barrier and fewer wildlife attempt to cross (Seiler 2003).

Traffic speed

Traffic speed is a complex factor—greater speeds don't always correlate to more WVCs (Huijser et al. 2007). However, it is likely that an increase in vehicle speed, in combination with any other factor, such as steep slopes, thick vegetation along the roadside, and increased number of vehicles on the road, can increase the risk and severity of WVCs as well as the barrier effect of roads.

Artificial Lighting

There are positive and negative consequences to artificial lighting. Lighting, in combination with other mitigation measures, such as fencing and modifications to bridges, reduced WVCs in one study area (McDonald 1991). Artificial lighting can provide more feeding time for birds by enabling nocturnal feeding (Hill 1992). And there are beneficial effects for some bat species feeding on insects attracted to street lamps (Rydell and Racey 1993), though such locations are apparently not exploited by slower flying bat species.

Mountain lions (*Felis concolor*), bears (*Ursus* spp.), and gray wolves (*Canis lupus*) may avoid artificial light, creating an unintentional barrier effect for lighted areas (Beier 1995), or temporarily blinding wildlife species (Beier 2006), potentially increasing their vulnerability to traffic. Nocturnal animals and birds, such as barn owls (*Tyto alba*), are likely to be disturbed by the presence of bright illumination. And urbanization increases both vulnerability and exposure of insect populations to artificial lighting.

Natural Lighting

Natural light in the middle of culverts or under roads may be helpful for prey species hesitant to enter without sufficient ambient light (Jackson 1996; Jackson and Tyning 1989; Krikowski 1989). Maintaining natural lighting through the use of overpasses, large underpasses, or open-top (grated) underpasses help address these concerns. Culverts with open tops that provide light and moisture attract use by amphibians.

Noise

Constructing and maintaining roads creates noise that reduces wildlife populations and air quality, increases erosion and stormwater runoff, and transfers chemicals, such as salt and de-icer, to streams and lakes that affect vegetation (National Research Council 2005). In the Netherlands, breeding birds have declined because of noise loads adjacent to roads (Reijnen et al. 1995; Reijnen and Foppen 1995), and male

Willow Warblers (*Phylloscopus trochilus*) close to highways experienced difficulties in attracting or keeping a mate (Reijnen and Foppen 1994). Constructing and maintaining roads reduces feeding time and the size of the area in which birds can feed, and interferes with breeding (Hill 1992).

The design of road structures influences effects on wildlife. For example, some underpasses are noisy. Overpass systems that incorporate tree and shrub buffers along the edges can be much quieter than underpass systems (Jackson and Griffin 2000).

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"As urban areas throughout the world expand, it is crucial that the ecology of local wildlife be considered to ensure functional connection is maintained between habitat patches, especially for the conservation of species that are highly susceptible to fragmentation."

— S. I. FitzGibbon, D. A. Putland, and A. W. Goldizen

Chapter 3 Corridors—Connecting Wildlife Across a Landscape

3.1 Wildlife Movement Corridors

Conserving wildlife in urban areas through protection of wildlife habitat improves quality of life for people by safeguarding the natural resources that are the underpinnings of the economy (Frampton 2000). Urban parks and open spaces play a significant role in increasing the health of communities, reducing juvenile crime, increasing educational scores, and boosting property values by providing improved air and water quality, contact with nature, habitat for wildlife, reduced storm water runoff, and cooler city temperatures (Frampton 2000).

To protect wildlife in the urban interface, early identification and conservation of movement corridors are as essential as conservation of core areas (Trask 2007). Although urban area plans often have provisions for preservation of large tracts of open space, greenways, and parks, few plans identify one of the most important aspects of healthy wildlife populations—the need for connections between habitat patches for wildlife movement. Wildlife habitat corridors—linear habitats that connect two or more larger areas of habitat (Beier and Noss 1998)—can mitigate the effects of roads and development (Ruediger and Lloyd 2003).

It is important to thinking broadly and prioritize to ensure key corridors are widely defined so that planners and engineers have the opportunity and flexibility to address corridor issues. A variety of data can be used to identify wildlife corridors—aerial photos, vegetation maps, topography maps (to assess drainages), wildlife habitat and range maps, road-kill information, local stakeholder information, known locations of migration corridors, and threatened and endangered species. In addition, the characteristics of traffic — traffic volume, number of lanes, traffic frequency distribution — and diurnal and seasonal movements and needs relative to target wildlife species are key considerations. For example, a road may have high traffic volume during the day, but the target wildlife species moves at night.

The health of wildlife populations is directly related to the total amount, configuration, and condition of available habitat—in both anchor areas and corridors. Many wildlife species move between small habitat "islands" that are individually too small, but collectively add up to a larger home range that meets their habitat requirements throughout the year. This constant movement of wildlife also helps to maintain a healthy gene pool among wildlife populations, which is essential for the survival of regional populations. Subdividing wildlife populations can isolate gene pools, increase susceptibility to disease, cause inbreeding, and substantially increase vulnerability to extirpation.

Identifying important connectivity zones/wildlife movement corridors and providing safe connections between remaining habitat patches can help reduce many of the ecological impacts of habitat fragmentation. Metro worked with the City of Sherwood to develop regionally significant fish and wildlife habitat (Figure 3-1) maps. Sherwood is implementing strategies to retain connections between high priority quality wildlife habitats and buffer zones. In addition, the City of Portland is implementing strategies to retain, expand, restore, and connect habitats.

Corridors facilitate wildlife movements between surrounding larger habitat areas and the urban area. "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" (Soule 1991).

For example, the Pleasant Valley Concept Plan, a plan for a 1,532-acre community located south of Gresham and east of Portland, includes a habitat corridors map (Figure 3-2). This guides

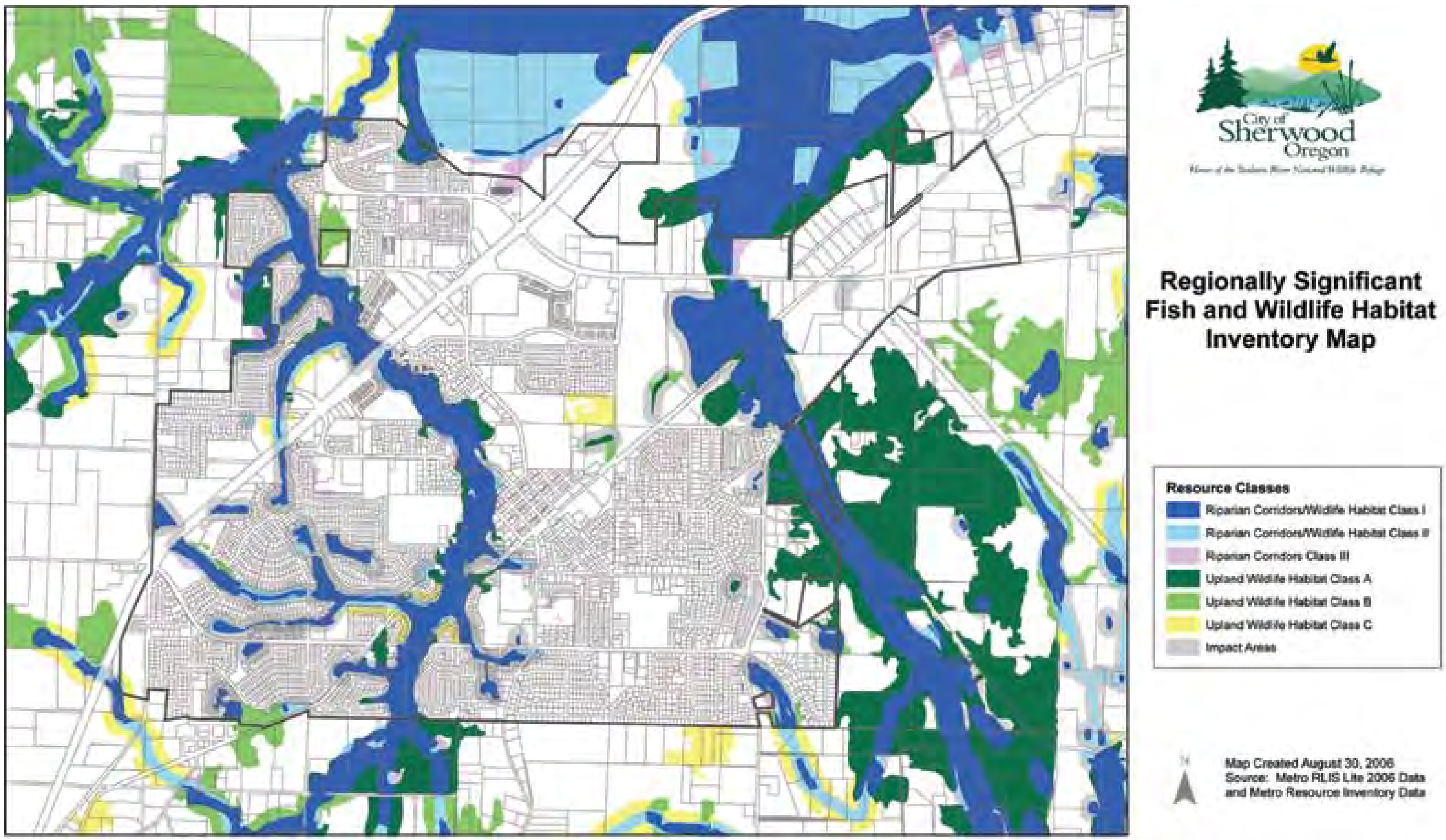

Figure 3-1
Metro identified regionally significant fish and wildlife habitat in the Sherwood area to help ensure that future development considers retaining wildlife corridors between important upland and riparian habitats.

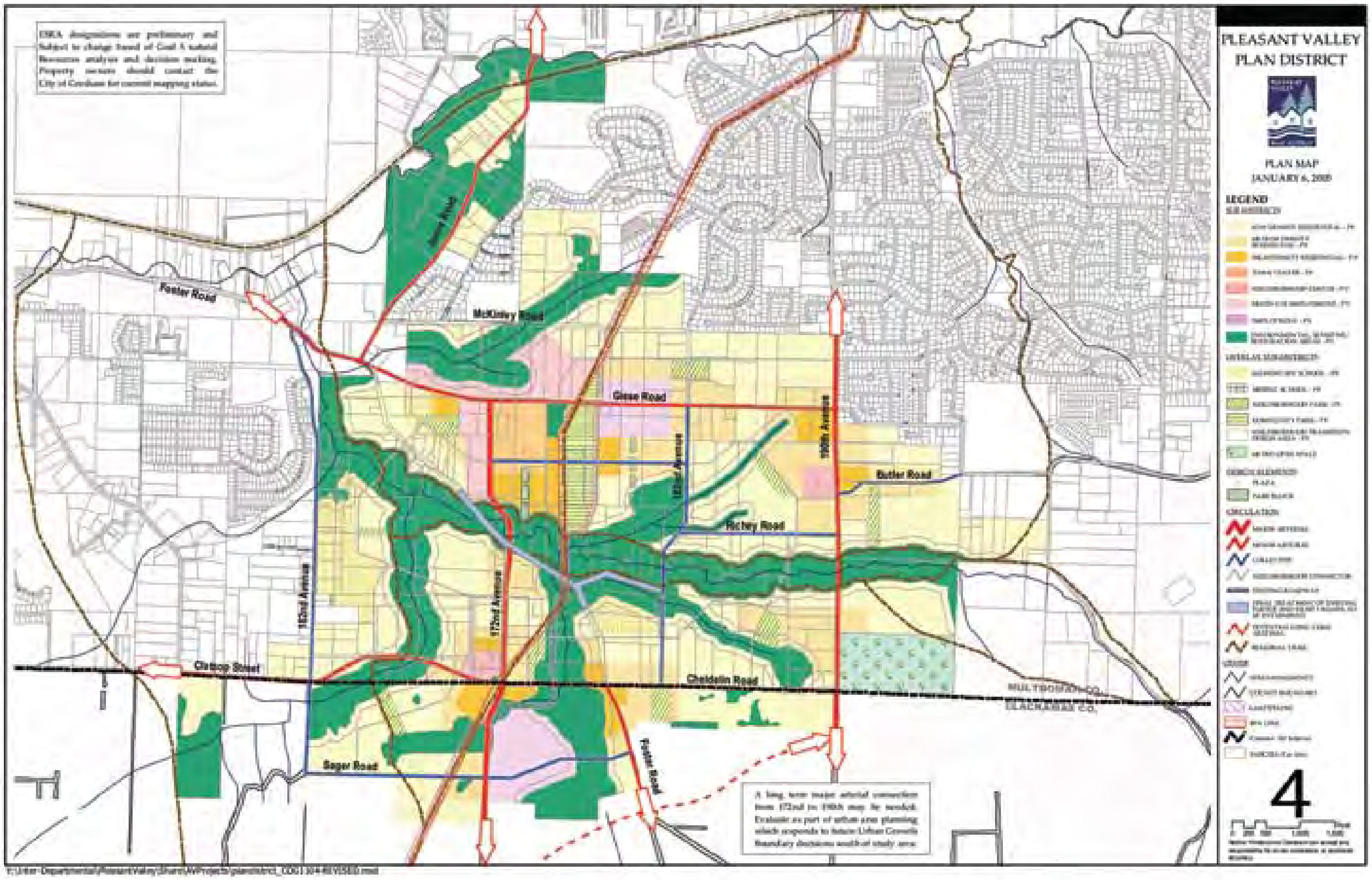

Figure 3-2
Map of Pleasant Valley Critical Habitat Areas and wildlife corridors.

implementation of measures to avoid disturbance of those corridors.

Damascus, the most recent expansion of the urban growth boundary (far eastern edge), includes 10,467 acres of land. The area is rural, with a population of about 9,800 people, but it is expected to become urban, with an influx of 60,000 people in the next several decades. The strategic plan for the area includes protection and maintenance of buttes and other habitats as part of their wildlife corridor connection strategies.

3.2 Loss and Fragmentation of Habitat

Roads fragment wildlife habitat into smaller patches of various shapes and sizes and reduce the connectivity and landscape permeability necessary for maintaining species diversity and preventing local extinctions (Figure 3-3). Large habitat patches help to ensure the long-term viability of species and serve as networks of habitat for movement of wildlife. These “core” areas tend to have a high value to native wildlife because they hold more wildlife

Figure 3-3
The area adjacent to Interstate 205 in West Linn offers a good example of habitat fragmentation and edge. Note the amount of natural habitat in large blocks that remains in the upper right hand corner of the picture. Compare that with the increased amount of edge and lack of natural habitat in the developed area near the bottom of the picture. Also notice how the interstate has bisected the natural habitat that exists on both sides of the highway. Photo credit: Google maps via Metro’s Habitat Tool.

species per acre than smaller patches, and larger habitat patches contain less edge, providing homes to species that avoid edges or require large home ranges. As patch sizes get smaller, interior habitat decreases while the amount of edge habitat increases. This is known as the edge effect, which increases with habitat fragmentation.

Large amounts of edge enhance the spread of invasive species and increase predation and human disturbance. Edge effects change the type of native species a given patch can support. Ultimately, larger patches with more interior habitat have a higher value for native wildlife because they reduce the competition from nonnative and generalist species. Nonetheless, providing safe connections between smaller patches is still important, especially when there are known populations of sensitive, threatened, or endangered species.

3.3 Different Species, Different Needs

Different wildlife species require different types and sizes of habitat for survival. In general, the larger the animal, the more land it needs for survival. Predators require an even larger area of land, because the land must support enough prey for their survival.

Animals can be described as “generalists” and “specialists.” Habitat generalists, such as raccoons and coyotes, can use many different types of habitat and adapt well to the presence of people. Most non-native and invasive species are generalists and thrive in urban areas.

Habitat specialists, however, are more sensitive to roads and human activity and require access to larger patches of habitat. Winter Wren (*Troglodytes troglodytes*) and Swainson’s Thrush (*Catharus ustulatus*) are native specialist species that require relatively undisturbed interior habitat.

Preservation of native species of all types (e.g., large and small, predators and non-predators, aquatic and terrestrial) in urban environments requires a comprehensive, regional effort that establishes and protects wildlife movement corridors and connections between habitat patches. A functioning ecosystem provides habitat and movement corridors for all native wildlife species.

How Much Habitat is Enough?

Providing a mosaic of large habitat patches and connecting wildlife corridors can improve the viability of wildlife populations. Although different wildlife species require different size habitats to acquire the food, water, and shelter they need to survive, local studies indicate that parks and greenspaces greater than 24 acres should be retained because both native tree and mammal species richness increase when the amount of greenspace exceeds this minimum. Also, non-native species decline sharply as the amount of greenspace increases. A national study recommended planners should strive to protect and maintain habitat patches larger than 137.5 acres (Environmental Law Institute 2003). However, in urban areas, all sites with positive attributes for fish and wildlife should be considered on an individual basis when making decisions about management, restoration, and protection of native habitats.

Habitat Connectivity and Watersheds

Riparian areas are critical to urban wildlife and urban health, providing water quality and wildlife habitat functions. In the Metro region, 93 percent of native vertebrate species rely on riparian areas to fulfill a part of their life needs; 45 percent regularly depend on these areas.

Roads commonly follow waterways and often impact stream dynamics and create barriers to wildlife movement by limiting wildlife access to riparian areas. Placing culverts in areas where roads intersect with waterways may mitigate their impact to wildlife, but culverts have typically been designed to allow only for water conveyance, not wildlife movement or habitat connectivity (Figure 3-4). Since the federal listing of several salmon and steelhead species under the Endangered Species Act, significant efforts have focused on restoring fish habitat and stream connections where roads intersect with streams. Some culverts are designed to maintain natural stream dynamics and allow for uninhibited movement of both fish and wildlife. Because riparian areas serve critical habitat functions for nearly all Metro area fish and wildlife, it is also important to restore and maintain connectivity between upland habitat areas and nearby streams. Generally, a minimum width of 150 feet on each side of a stream will provide habitat for a range of species, although buffers may be wider in floodplains, wetlands, or along steep slopes (Metro 2008). See chapter 5 for additional information on culverts.

The City of Portland is implementing its Watershed Management Plan, which evaluates conditions in the city's urban watersheds and implements projects to improve watershed health through watershed-friendly development, installation of new stormwater infrastructure, and the repair and maintenance of existing infrastructure. A component of this plan is the Terrestrial Ecology Enhancement Strategy, which provides science-based information on special status species and their habitats and recommendations for acquisition and connectivity.

3.4 Datasets and Policy That Inform Wildlife Corridors

The following datasets and information can be used to help identify and inform existing and potential wildlife corridors in the Portland metropolitan area.

Figure 3-4
Poorly designed culverts, like this one at the headwaters of Brush Creek (top photo), impede fish passage and create barriers to other species of wildlife (top). Properly designed, installed, and maintained culverts (bottom) have, among other characteristics, a natural sub-strate base, a shallow culvert gradient similar to adjacent streams, a jump height of less than six inches (for fish), and a natural or artifi-cial shelf that allows for passage of wildlife during high water. Photo credits: Calapooia Watershed Council (top) and the Oregon Plan for Salmon and Watersheds (bottom).

Nature in Neighborhoods

To implement statewide planning goals, the Metro Council approved Nature in Neighborhoods (Title 13) in 2005, a region-wide regulatory and voluntary-based initiative to conserve, protect, and restore a continuous ecologically viable stream corridor system integrated with upland wildlife habitat and urban landscapes, and to control and prevent water pollution and improve water quality. It requires local jurisdictions to meet regional performance fish and wildlife habitat standards by January 5, 2009; requests that cities and counties report on non-regulatory watershed improvement activities to Metro every other year (odd-numbered years); and directs Metro staff to monitor watershed conditions over a 10-year period.

Title 13 lists 29 habitat-friendly development practices, including design and construction methods for developing properties that have less detrimental impacts on fish and wildlife habitat than traditional methods. These methods aim to reduce the amount of untreated stormwater surface runoff flowing directly from pavement and buildings into streams and to minimize the impacts of development on adjacent wildlife corridors (often along streams) and fish passage.

Title 13 establishes objectives and indicators to measure progress towards improving streams, wetlands, and wildlife connectivity; conserving large areas of contiguous habitat; maintaining and improving connectivity for wildlife; and conserving special habitats of concern. These special habitats of concern and acreage within watersheds should be evaluated as key areas for wildlife connectivity.

Metro's Regionally Significant Fish and Wildlife Habitat Inventory Map

Metro's Regionally Significant Fish and Wildlife Habitat Inventory Map (Figure 3-5) forms the basis of its fish and wildlife habitat protection and restoration program. The inventory identifies about 80,000 acres of regionally significant habitat within Metro's jurisdictional 280,000-acre boundary. Local jurisdictions may choose to comply with Title 13's regulatory baseline, or bring their own strategies to the Metro Council.

Forest Canopy and Wildlife Habitat

Forest canopy is an indicator of watershed health. A landmark event in the history of Portland's urban forest occurred in 1995 when the City of Portland adopted its first Urban Forestry Management Plan, which contained a goal to "maximize and expand the urban tree canopy."

Data derived from 2002 Landsat imagery indicated that the Portland metropolitan area had 26.3 percent forest canopy (including Forest Park). It is estimated that from 1972 to 2000, mean canopy cover for the City of Portland increased from 25.1 percent to 26.3 percent, although average tree cover in the Willamette/Lower Columbia River Region (including a 9-city area from Vancouver, Washington to Eugene, Oregon) declined from 46 percent in 1972 to 24 percent in 2001(Figure 3-6). Average tree cover in the region's urban areas was 12 percent in 2000, down from 21 percent in 1972.

Damascus—Metro staff collected baseline ecological data for the Damascus/Boring area, where a new urban growth boundary expansion was approved in 2003, and found that the four major stream systems (Rock, Richardson, Noyer, and North Fork Deep Creek) have increasingly wide forested buffers and healthy

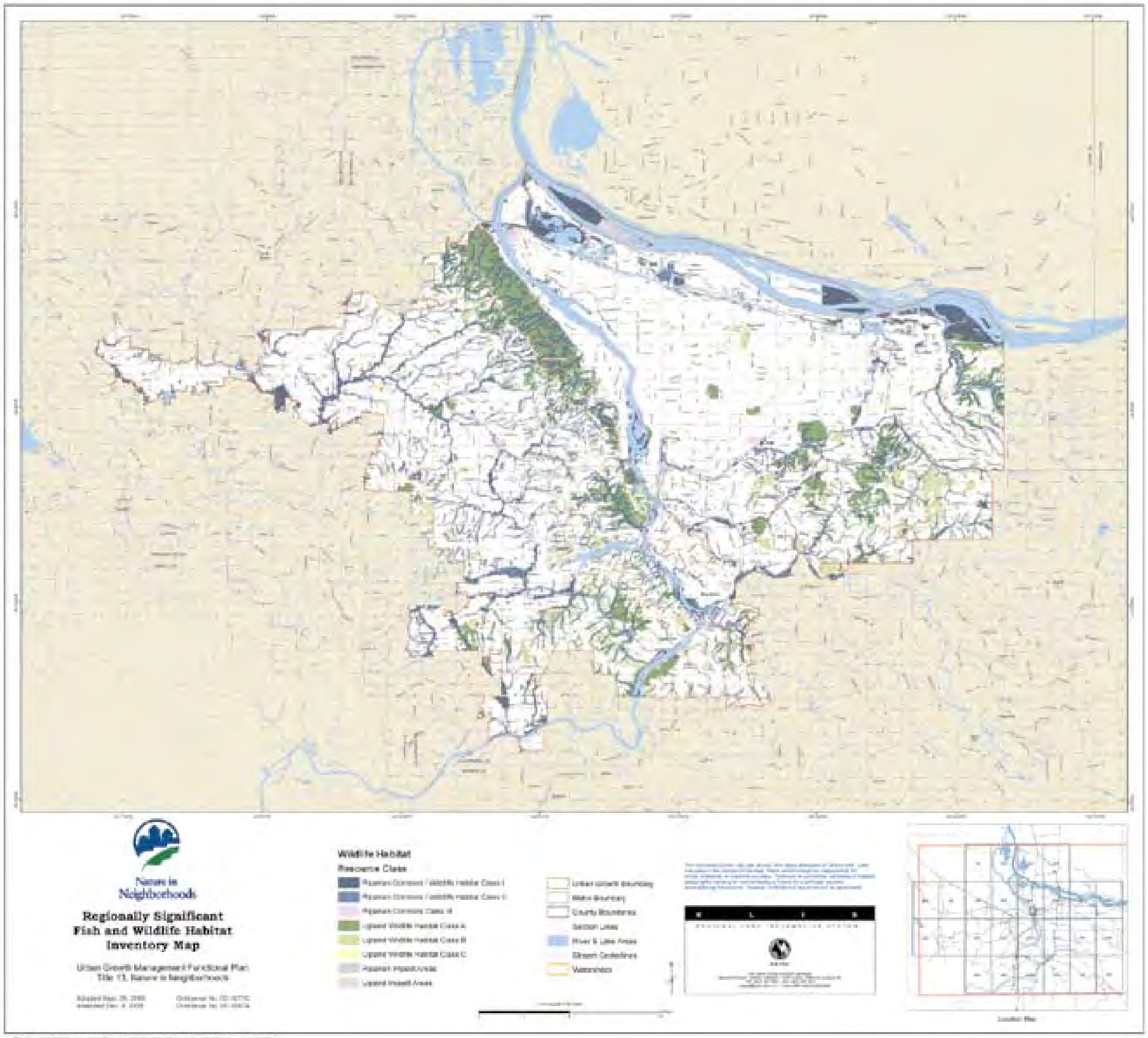

Figure 3-5
Regionally Significant Fish and Wildlife Habitat Inventory Map of the Portland metropolitan area.

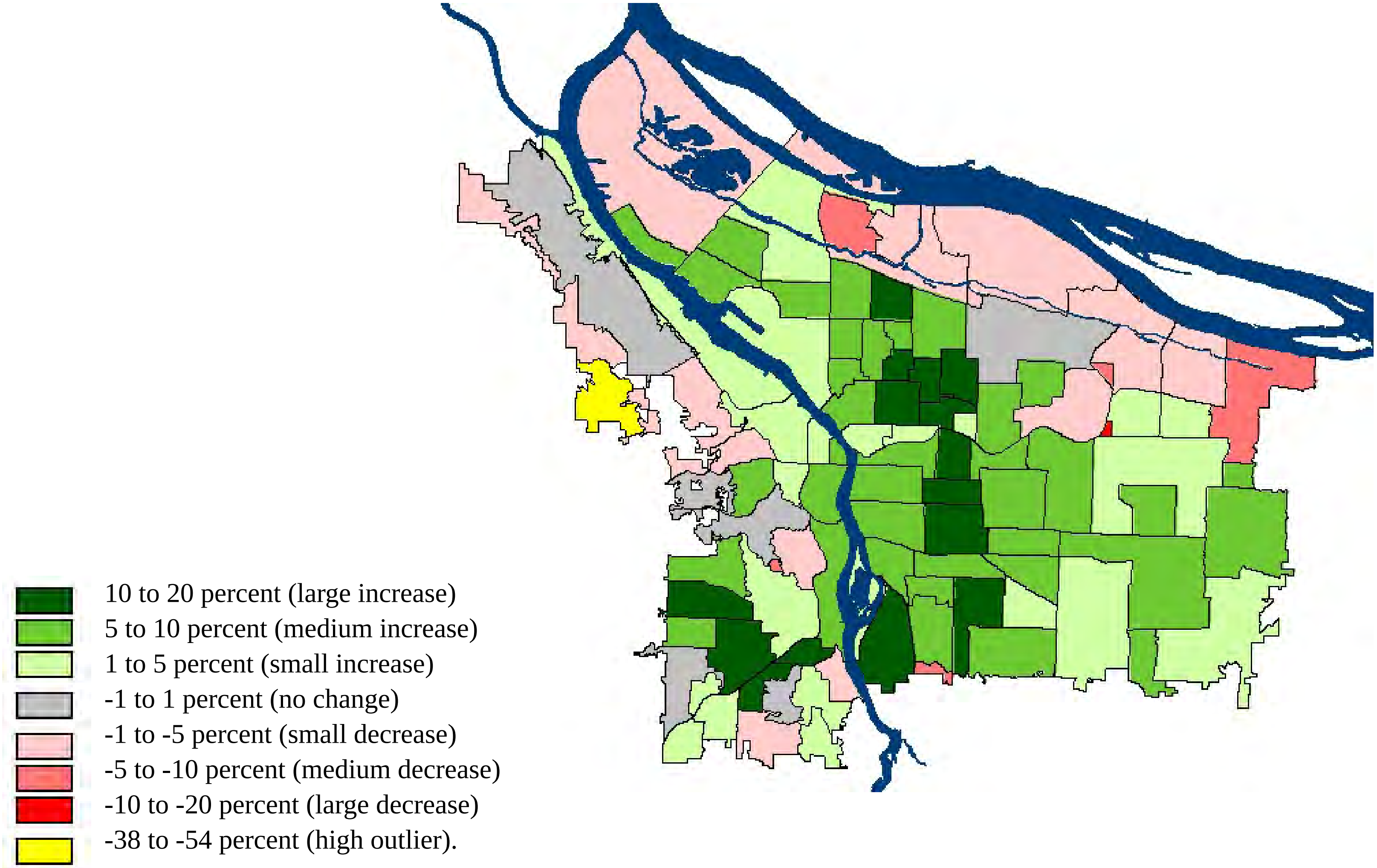

Figure 3-6
Canopy cover change for Portland neighborhoods, 1972 - 2002.[1] *Over a 30-year period, canopy cover increased in the central portions of the city and decreased on the edges.*

1 Poracsky, J., and M. Lackner. 2004. Urban Forest Canopy Cover in Portland, Oregon: 1972 - 2002. Final Project Report, Prepared for Portland General Electric and City of Portland Urban Forestry Commission; 32 pp. plus appendices.

stream conditions from the headwaters to downstream.

Neotropical migratory birds—a group at risk nationally and in the Portland metropolitan area—seem to need larger, less disturbed habitat areas for breeding. Non-native birds, in both winter and spring, are associated with urban residential lands characterized by lawns and non-native shrubs. These results have implications for management of all natural areas within the Portland metropolitan area, particularly those areas recently acquired in the urban growth boundary, and those considered for acquisition, or designation, as urban and rural reserves.

Oregon Department of Transportation Wildlife Collision Hot Spots

The use of road-kill data is one method to identify hot spots to prioritize habitat corridor zones, however, this type of data does not consider changes in land use patterns that can cause changes in animal movements (Huijser et al. 2007) and does not address the barrier effects of highways, i.e., animals that avoid road crossings. Hot spot information can help determine possible locations of wildlife passage improvements that will also improve driver safety.

ODOT and Mason, Bruce, and Girard, Inc., used model-based clustering techniques to analyze existing dispatch carcass reports and identify animal-vehicle collision problem areas, or "hot spots" on all state-managed highways in Oregon, including those in the Portland metropolitan area. They were able to map 56 percent of all of the dispatch records available for the past 12 years, and found distinct hot spots in several locations. The Portland metropolitan area had considerably less data than other areas in Oregon, thus compared to all other state highways, there are no highest or medium-high density hot spots identified. However, when ODOT's Region 1 data (which includes all of the Portland Metro areas as well as adjacent mountains) was evaluated independently of the other regional data sets, hot spots were identified near the southern metropolitan boundary (I-205 west of Oregon City), Gresham (I-84 near Fairview), and approaching the Damascus area (near OR 2112/224 intersection).

Oregon Department of Fish and Wildlife —Wildlife Linkages and Priorities

In 2007, the Oregon Department of Fish and Wildlife (ODFW) held workshops throughout Oregon to identify key movement areas for wildlife, with an emphasis on areas near paved roads. They identified "key movement areas," or corridors, for a suite of focal wildlife species, including big game animals, forest carnivores, amphibians, and reptiles, and used information from the Oregon Conservation Strategy on habitats, land management data sets, and species priorities developed in consultation with district biologists. Wildlife Movement Strategy working group members identified priority linkages based on areas (1) that were identified at the workshops as having serious concerns for populations of one or more species, (2) identified in the Oregon Conservation Strategy as Conservation Opportunity Areas, and (3) that overlap with ODOTs Wildlife Collision Hot Spots data set.

Wildlife Species in the Portland Metropolitan Area

There are 26 native fish species, 16 native amphibian species, 13 native reptile species, 209 native bird species, and 54 native mammal species in the Metro region—the Endangered Species Act (as of June 2, 2008) lists 57 species in Oregon as threatened or endangered. Threatened and endangered species, those species that occupy rare or unique habitats, State Critical species, and federal species of concern in the Portland metropolitan area should be given priority when considering landscape permeability and wildlife connectivity.

Metro's Breeding Bird Surveys Species Trends

Breeding bird surveys were conducted from 1966–2005 in the Portland metropolitan area and throughout Oregon. The following illustrates changes in metropolitan area and statewide populations of several bird species. Species with 5.1 to 19.9 percent annual declines in the metropolitan area, with no difference in statewide population:

Hairy Woodpecker (*Picoides villosus*)
Yellow-Breasted Chat (*Icteria virens*)
Yellow Warbler (*Dendroica petechia*)
White-Breasted Nuthatch (*Sitta carolinensis*)
Savannah Sparrow (*Passerculus sandwichensis*)
Western Tanager (*Piranga ludoviciana*)
Black-Headed Grosbeak (*Pheucticus melanocephalus*)
Purple Finch (*Carpodacus purpureus*)
Cedar Waxwing (*Bombycilla cedrorum*)

Species with metropolitan-area declines of 8 to 14.4 percent, but statewide population declines of less than 5 percent:

Chipping Sparrow (*Spizella passerina*)
House Wren (*Troglodytes aedon*)
MacGillivray's Warbler (*Oporornis tolmiei*)
Swainson's Thrush (*Catharus ustulatus*)
Olive-Sided Flycatcher (*Contopus cooperi*)
Ring-Necked Pheasant (*Phasianus colchicus*) (non-native)

Species with no significant change in the metropolitan area with a corresponding increase from 2.4 to 3.6 percent statewide:

Mourning Dove (*Zenaida macroura*)
Pacific-Slope Flycatcher (*Empidonax difficilis*)
Golden-Crowned Kinglet (*Regulus satrapa*)

Species that have increased 1.9 to 6 percent in the metropolitan area, with no significant change statewide:

Violet-Green Swallow (*Tachycineta thalassina*)
Bewick's Wren (*Thryomanes bewickii*)
Vaux's Swift (*Chaetura vauxi*)

Habitat needs of the first nine species listed in the chart—those species with annual declines in the metropolitan area, but with no difference in statewide populations—should be further assessed to determine if improvements to wildlife habitat, including protection of wildlife corridors and expansion of existing core habitats, would help these species.

Oregon's Conservation Strategy

The Oregon Conservation Strategy (Strategy) articulates a vision to maintain healthy fish and wildlife populations in Oregon by maintaining and restoring functioning habitats, preventing declines of at-risk species, and reversing any declines in these resources, where possible. The Strategy further articulates six key conservation issues, large-scale issues that present the greatest threats to fish and wildlife populations and their habitats throughout Oregon. They form the framework for the Strategy. One of the major issues is barriers to fish and wildlife movement.

The goal of the Strategy is to provide conditions suitable for natural movement of animals across the landscape. Actions to address this goal are to inventory, prioritize, and remove fish passage barriers; maintain and restore habitat to ensure aquatic connectivity and terrestrial corridors in priority areas (including urban centers); consider the needs of other aquatic species and terrestrial wildlife when planning aquatic passage projects; screen ditch and pump water diversions to protect fish; work with transportation partners to identify and address key areas of wildlife mortality on highways; consider animal movements when planning new roads; and identify, maintain, and restore important stop-over sites for migratory birds.

The Strategy also describes conservation opportunity areas (Figure 3-7), landscapes and natural landscape features that can be considered to enhance landscape connectivity and achieve broad fish and wildlife conservation goals. Focusing efforts with a landscape perspective is a more cost-effective and productive approach than implementing individual projects in areas throughout Oregon.

In addition, the Strategy provides a listing of species present in the state with small or declining populations or that are otherwise at risk. Appendix 5 of the State of Watersheds Monitoring report lists the species, status in the Portland metropolitan area, habitat needs, limiting factors, and conservation actions for the species likely to be found, or formerly present, in this area.

Metro's Natural Areas

In November of 2006, voters approved a $227.4 million bond measure to safeguard water quality, protect fish and wildlife habitat, and ensure access to nature for future generations. The Natural Areas Program will protect between 3,500 and 4,500 acres of land in 27 specifically identified target areas.

Grey to Green Program

The City of Portland's Grey to Green Program includes maps that identify on a broad scale potential to make connections between anchor and other wildlife habitats through land acquisition, street trees, ecoroofs, and other tools.

3.5 Creating Priority Wildlife Corridors in Urban Areas — Art and Science

Identifying priority wildlife corridor areas in an urban environment is a blending of art and science. There is no one formula to use, especially in urban areas, where the complexity of analysis increases significantly because of the number of factors and issues to consider.

A first step in prioritizing corridors is a description of scale—broad scale, mid-scale, and fine scale (Ruediger 2008). In the case of the Portland metro area, broader scale units might be considered watersheds or subwatersheds, or sometimes, jurisdictions and their surroundings.

The following is recommended (modified to best "fit" urban concepts) (Ruediger 2008) to prioritize wildlife corridors:

- Base high priority corridors on the presence of threatened and endangered species and high wildlife-vehicle collision occurrence.
- Base moderate priority corridors on the presence of important (but not threatened or endangered), local, common wildlife species, and average wildlife-vehicle collision occurrence.
- Base low priority corridors on those that do not include either of the above two elements.
- Place the most effort and funding on wildlife crossing structures in the highest priority corridors.

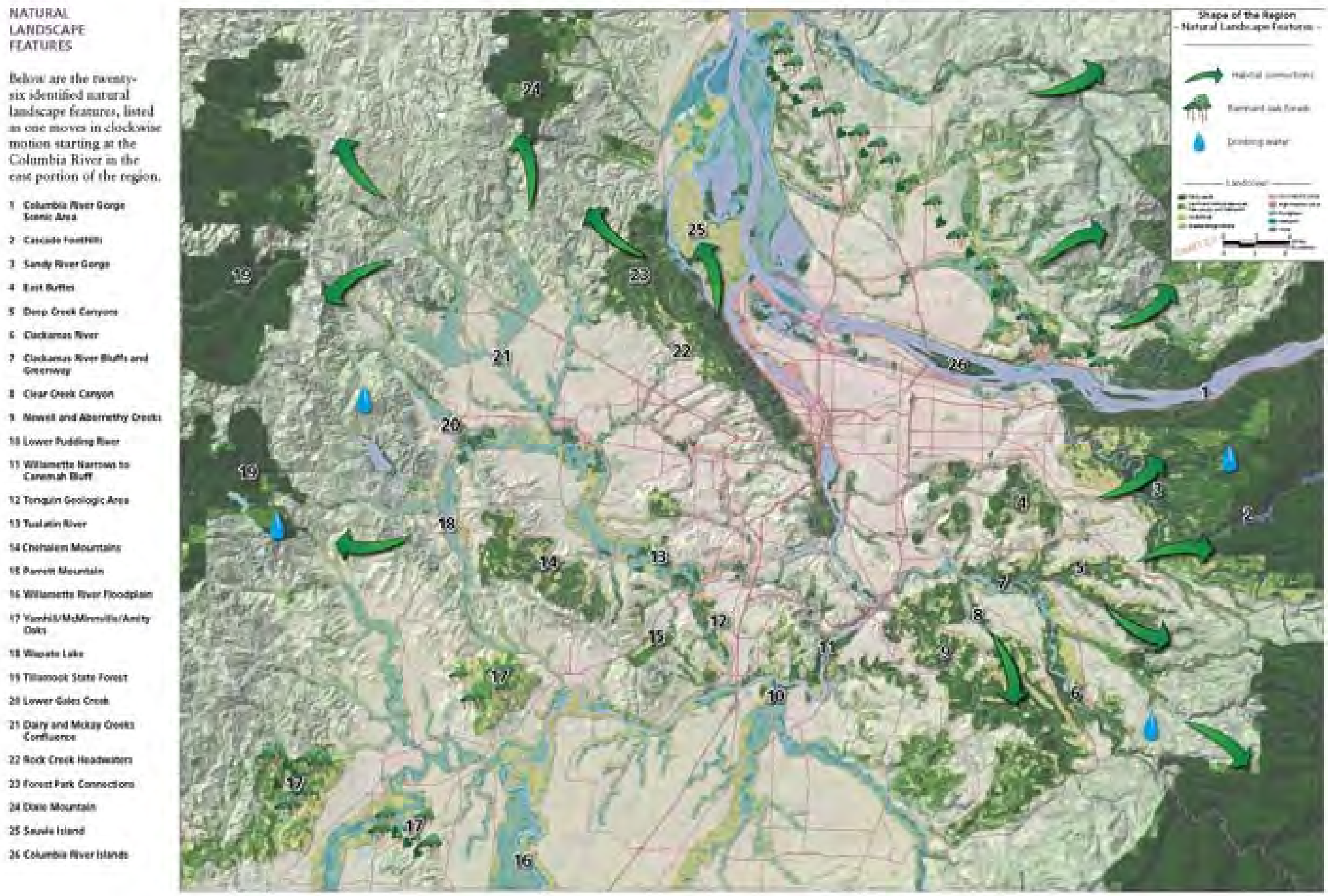

Figure 3-7
A map of the Portland metropolitan area identifying natural landscape features that should be considered when identifying opportunity areas to create wildlife linkages.

3.6 A Portland Metropolitan Case Study—The Rivergate Turtle UnderCrossing

In 1999, the Port of Portland investigated wildlife movement patterns in the Rivergate Industrial District (RID) (Figure 3-8), a Port of Portland-owned 2,800-acre industrial park located on Portland's ocean shipping channel. The Rivergate wetlands (Figure 3-9) support habitat for reptiles, amphibians, and small mammals. The existing transportation corridor within the RID isolated the ponds, and there was a significant new threat to some wildlife populations because of planned expansion of Port facilities in this area. Lombard Street traffic was to be redirected onto Time Oil Road while improvements were made to Lombard (road over rail).

To improve wildlife connectivity between the wetlands, the Port considered a no action alternative, closure of some roads, signage, a wildlife undercrossing, a wildlife overcrossing, and a gated crossing. Action alternatives were considered as part of projected road improvements.

The wildlife undercrossing was determined to be the most feasible, based on documented success of this option in other areas and cost. The Port undertook a study to identify the key elements of a successful design based on similar projects for wildlife undercrossings around the country and overseas.

A 160-foot long, 2.5-foot diameter culvert (Figure 3-10) was designed and installed to provide safe passage for small wildlife between the T-5 Powerline mitigation site west of Time Oil Road and the remaining wetland habitat within the wildlife corridor east of Time Oil Road. The culvert connected the wetlands and reduced the adverse impacts of road development on wildlife in the RID by reducing the number of road kills. The culvert runs below two private roads and a functioning railroad line (Figure 3-11), and the crossing structure was designed to

Figure 3-8
An aerial view of the Rivergate area showing the bisected wetlands. Photo credit: Port of Portland.

Figure 3-9
The Rivergate wetlands support habitat for native amphibians, small mammals, and birds. Photo credit: Carrie Butler, Port of Portland.

Figure 3-10
The culvert was installed with several light boxes along the surface of the culvert to allow natural light to enter. Photo credit: Carrie Butler, Port of Portland.

Figure 3-11
Perpendicular to the culvert, a 300-foot long wall was erected to deter amphibians and small mammals from crossing the road and railroad tracks in unsafe locations, while guiding them, with the help of native landscaping, to the safe crossing. Photo credit: Carrie Butler, Port of Portland.

stop medium to small wildlife from heading toward the street and to guide them into the crossing. Five grates that allow natural light into the culvert were installed.

The under-crossing project was completed in the spring of 2004, and the Port of Portland has made a significant effort to monitor structure performance and response by wildlife. The Port of Portland acquired a motion sensor camera with infrared flash that was installed in the tunnel in the spring of 2005. Coyotes, domestic dogs and cats, black rats, muskrats, nutria, opossum, rabbit, Townsend moles, raccoons, beaver, mallards, turtles, salamanders, wood ducks (Figure 3-12), and squirrels have been observed using the wildlife undercrossing. The total cost of the project was $149,963.05, and the Port of Portland is committed to monitoring wildlife use of the undercrossing indefinitely.

Figure 3-12
A wood duck hen takes her brood through this wildlife crossing. This well-maintained culvert provides safe passage for many kinds of wildlife, including coyotes, raccoons, and turtles. Photo credit: Port of Portland.

Lessons Learned

When asked to look retrospectively at the crossing project and comment on what they would do differently, staff recommended the wildlife crossing structure be in place 2–3 years prior to the road over rail project, so that wildlife would become accustomed to using the structure before the increased traffic occurred. In addition, they recommended using a North American-owned infrared camera company because of the down time they have experienced as a result of repairs and reconfiguration of the camera that was purchased overseas.

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"Planning is bringing the future into the present so that you can do something about it now."

— Alan Lakein

Chapter 4 Wildlife Crossings—Putting It All Together

Wildlife crossing structures can help mitigate the negative effects of development and urbanization by linking habitats that have become fragmented by roads. In addition, these structures (Figure 4-1) can enhance wildlife connectivity between isolated habitats, increasing overall landscape permeability (chapter 1) for wildlife.

4.1 Decisions, Decisions . . .

How do you know a wildlife crossing is the right solution to enhance landscape permeability? What steps should you follow to address this and other questions? The following section summarizes key pieces of information provided throughout this guidebook and categorizes information to help you explore solutions for different locations and target wildlife species.

In general, it's important to determine if a species is or will be adversely affected by a road. If the answer is "yes," the next step is to characterize what needs to happen to reduce the risk. For example, will reducing the risk allow a targeted wildlife population to continue its daily or migration movements? There are three types of risk factors (Sandra Jacobson, pers. comm.):

- Individuals are affected such that there is an overall population impact, e.g. amphibians moving to seasonal breeding ponds;

- There is an identified habitat barrier (physical) or gap (e.g., lack of vegetation), even where there is no project proposed;

- Less predictable population & metapopulation movement needs relating to dispersal, such as climate change induced needs; and

- Metapopulation needs to maintain genetic diversity and interchange between populations.

The ability to characterize the type of risk factor helps to determine the type of mitigation necessary and the rate at which this mitigation should occur.

Figure 4-1
Choosing the most appropriate wildlife crossing structure for a site requires a thorough decision-making process. The box culvert (top) will provide passage for both terrestrial and aquatic wildlife throughout the year, and has a natural substrate bottom. The key to any successful wildlife crossing project is monitoring. Snakes, frogs, slugs, and birds crossed this track survey (below). Photo credits: Leslie Bliss-Ketchum, Portland State University.

Question 1: Is there a species that is or would be adversely affected by a road (in other words, is there a need for a wildlife crossing)?

Three common scenarios in which you might consider the need for a wildlife crossing include:

- a jurisdiction is planning a new development or road in a location with known or suspected wildlife habitat (particularly for threatened or sensitive species) or a target species present; and

- a jurisdiction is planning on modifying a transportation structure (e.g., road, bridge) and there is a known wildlife crossing barrier and interest in developing an enhancement or retrofit.

If one of these scenarios exists, it is important to ask two additional questions to gauge the extent of the problem and better understand safety and wildlife effect issues:

A. Is there a history of wildlife-vehicle collisions or road-related wildlife mortality near the potential crossing site?

The Oregon Department of Transportation (ODOT) has created maps of wildlife collision hot spots on Oregon highways. If your project is on a state-managed highway, coordinate with ODOT to review the wildlife collision data sets.

If your project is on a local road, many jurisdictions have a variety of data available on road-related wildlife mortality. Although some of these data sets may be inconsistent, these and other sources, such as anecdotal assessments from county animal control departments, parks services, road maintenance departments, property owners, biologists, and the Audubon Society of Portland, can help inform the degree of road-related wildlife mortality. If there is a history of road-related wildlife mortality, additional pre-construction surveys to assess seasonal or peak periods of wildlife mortality can help inform the type of structure or mitigation needed, and can be used with post-construction surveys to assess the effectiveness of the mitigation. If there is no data set to inform history, consider other factors, such as habitat. For example, riparian areas adjacent to roads frequently serve as travel corridors for a variety of terrestrial and aquatic-associated wildlife species.

B. Is the crossing located within a wildlife linkage or wildlife corridor?

The Oregon Department of Fish and Wildlife (ODFW) Wildlife Linkages Map and Conservation Opportunity Areas can help determine if the crossing is located in a designated wildlife linkage corridor at the state level.

At the regional scale, Metro has completed an assessment of regionally significant fish and wildlife habitat in the Portland area (Figure 1-3), as well as wildlife movement corridors—based on wildlife habitat and location of riparian corridors—that serve as important linkage areas to maintain and enhance landscape permeability (see chapter 3).

At the local scale, communities within the Portland area, such as Damascus (Figure 4-2), mapped their wildlife corridors and riparian areas, then created a map of important wildlife corridors connecting these areas (Figure 4-3).

Use all of these tools and information on Portland wildlife species to determine if the crossing is located within a wildlife movement corridor.

Question 2: What types of mitigation are appropriate?

There are finite financial and personnel resources to install and maintain a wildlife crossing. As a result, crossings or other

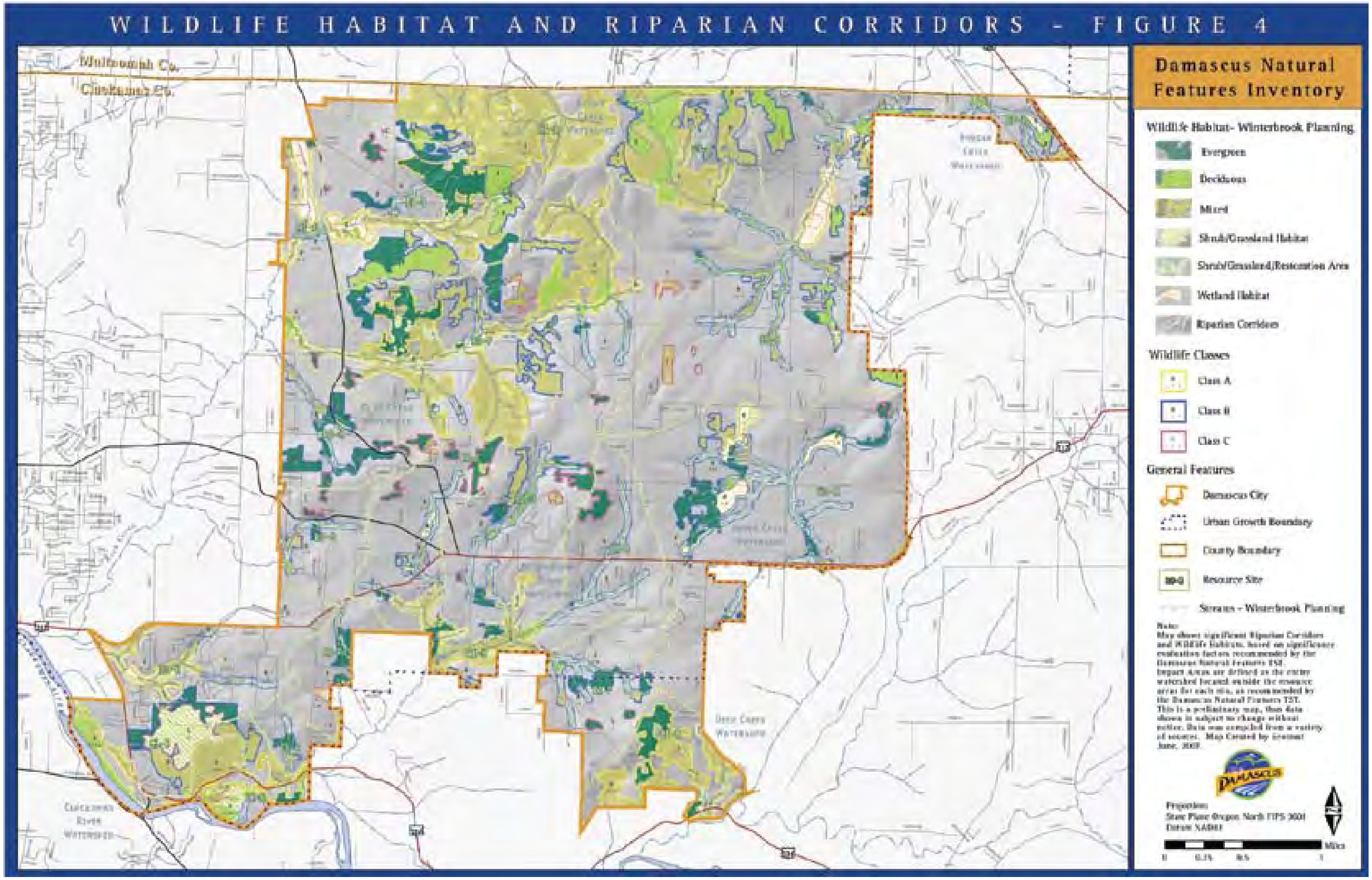

Figure 4-2
The City of Damascus map of wildlife habitat and riparian corridors provides some insights on key anchor habitat areas. To maintain or enhance landscape permeability for wildlife, planners should ensure maintenance of existing quality wildlife habitats and safe passage and connectivity between these habitats.

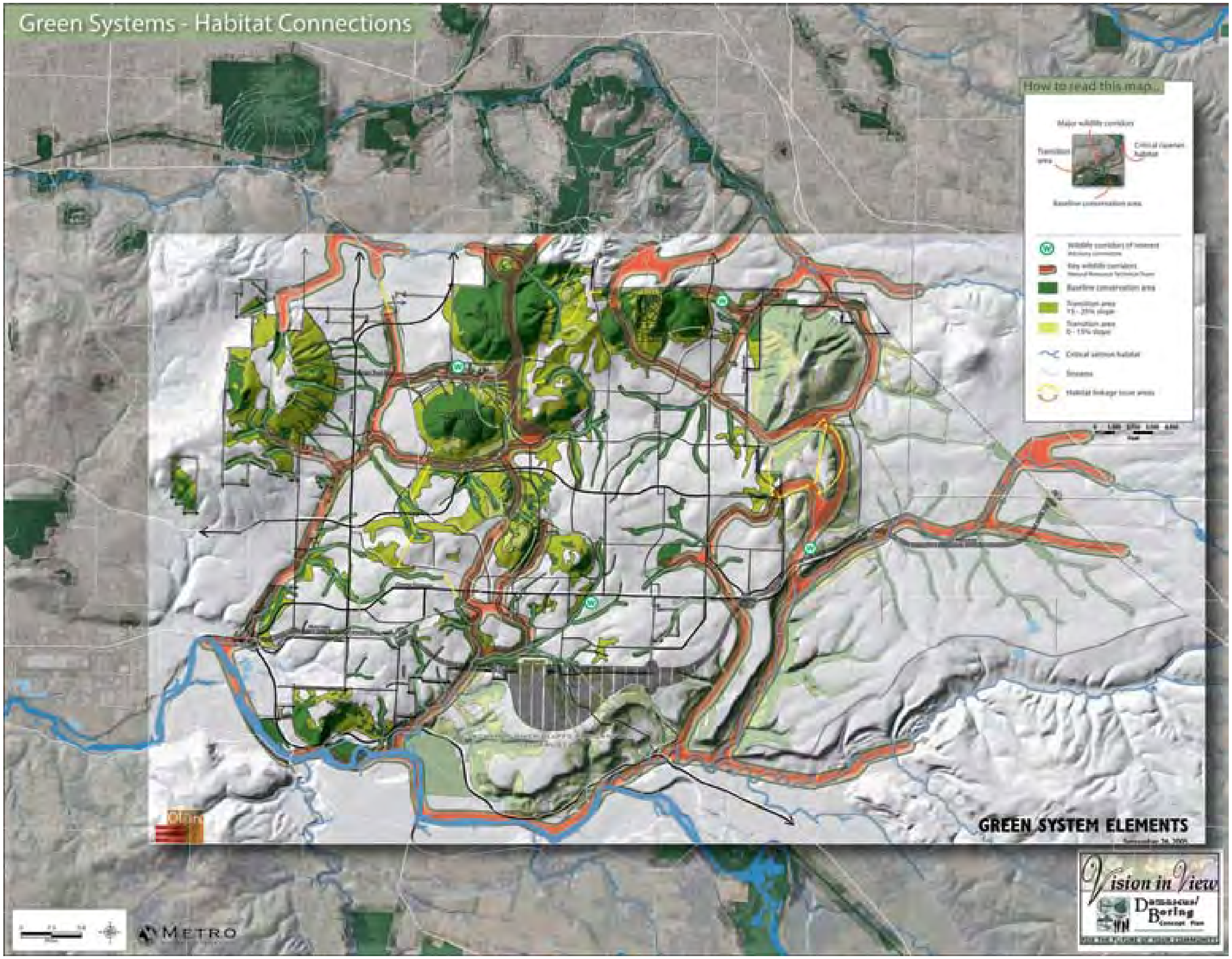

Figure 4-3
Metro described the habitat connections of the Damascus area. Layers of maps begin to paint a picture of critically important anchor habitats and the connecting corridors that will provide travel routes for suites of wildlife species.

mitigation options, such as fencing, should be strategically placed to maximize the use of these resources and provide the greatest potential to enhance landscape permeability.

The following are a few questions that should be considered:

A. What is the existing and potential quality of the habitat?

Does the site contain land worth protecting, now or in the future? A useful method to assess wildlife habitat is Metro's Wildlife Habitat Assessment tool, which involves identifying and evaluating parameters that make existing and potential sites productive wildlife habitat areas. The methodology includes a narrative description of the site as well as a numerical rating of wildlife habitat parameters:

- water—seasonality and quantity; channel morphology, complexity, and alteration; proximity to cover; and diversity;

- food—variety, quantity, and seasonality;

- cover—structural diversity, variety and seasonality, and nesting and denning sites;

- human disturbance—habitat modification and structures (e.g., trails, paved areas, playgrounds); and direct human disturbance;

- wildlife—diversity of wildlife species; the presence of "sensitive" species; rare species, e.g.

- unique or important habitat features (Figure 4-4)—downed wood, old stumps, snags, percent nonnative plants, and interspersion with other habitats.

Each of these features should be analyzed and evaluated for existing and potential land values.

Also, the City of Portland has a Terrestrial Ecology Enhancement Site Assessment Form, which incorporates Metro's assessment tool and is tailored to urban sites.

Question 3: What are the goals of the wildlife crossing project? How will the success of the crossing structure(s) be measured?

The type, size, and location of one or more wildlife crossing structures will depend on many factors. Some questions that may highlight important issues are:

A. Is it important to restore or maintain habitat connectivity, or is the primary goal to reduce wildlife mortality associated with roads and thus increase public safety?

B. Is the crossing intended for a suite of wildlife species, or is jut one sensitive species targeted?

C. Is maintaining the current speed and mobility of the existing road critical, or are speed reduction techniques an option?

D. Does the benefit of combining the wildlife crossing with a bicycle/pedestrian trail outweigh the possibility of reduced animal use due to presence of people?

E. What is the project budget?

F. Are there public safety issues or concerns because of a large population of a wildlife species near a road?

G. Does the project or project area have a barrier to wildlife passage (such as other developments, traffic volume, noise/activity)?

Project effectiveness is directly tied to project goals. If your goal is to reduce deer roadkill, monitoring mortality of deer at the crossing structure and along the crossing structure corridor, and comparing those numbers to pre-construction, will help determine success.

If your goal is to improve connectivity across the landscape for small mammals, incorporating a feature such as a dry shelf within a culvert, and monitoring its use by small mammals, will help determine effectiveness. Other studies, such as DNA analysis of small mammals in the area, will help determine gene transfer across the landscape.

Regardless of the goal, monitoring (Figure 4-5) is key to measuring effectiveness. Pre-construction monitoring can provide excellent baseline information. Monitoring throughout the life of the project (pre- and post-construction) can inform subtle post-construction adjustments to greatly increase effectiveness of existing and potential crossing structures.

Figure 4-4
Many factors are considered when evaluating the quality of wildlife habitat, including unique or important habitat features, such as downed wood. Photo of Forest Park in Portland, Oregon. Photo credit: Wikipedia.

Figure 4-5
Monitoring plans include tracking wildlife use of crossing structures. If target species are not using the structure after a period of time, adjustments may be made. In this photo, biologists have recently set tracking strips to monitor movement of wildlife through an underpass. Note that it can take as long as three years for some wildlife species to begin using crossing structures. Photo credit: Leslie Bliss-Ketchum, Portland State University.

Question 4: What crossing design(s) would be most appropriate?

Given the project goals, the target wildlife species, and site characteristics, such as road type, traffic volume, and topography, the most effective crossing design, or series of crossing designs, can be chosen.

A. What are the target species? And can other species be accommodated?

The size of the animal will, in part, determine the size of the crossing (see chapter 5), and suites of species can be accommodated by incorporating a variety of features into a crossing structure or series of structures. For example, a large box culvert (8 feet x 8 feet) with a natural substrate bottom will accommodate deer, but should have a dry shelf to move small mammals during wet, winter months. Bridge extensions can provide adequate habitat for a variety of terrestrial mammals; in addition, recessed cavities or slots in the ceiling of the bridge could provide roosting habitat for bats. If a culvert is necessary for passage of aquatic wildlife, consider opportunities for a series of smaller upland culverts on either side or both sides of the aquatic crossing structure for terrestrial species.

B. Is there water at the site?

Riparian culverts or viaducts may be appropriate solutions for locations where water is found seasonally or year round. Include dry land on one or both sides of a viaduct to accommodate terrestrial wildlife. Riparian culverts may include dry land, a shelf, or a floating dock for wildlife on one or both sides of the stream.

C. Are there topographical considerations?

Certain topographies lend themselves to specific designs. For example, viaducts are a good solution over a steep ravine or body of water. Discussions with engineers are critical to determine the most-cost effective solutions.

Question 5: What implementation issues might affect the project?

A variety of factors can influence the mitigation solution to enhance landscape permeability:

A. Does the site affect a wetland?

If the crossing site or crossing is near a wetland, funding may be available if the crossing serves as mitigation. In addition, the crossing structure may help the road project comply with environmental regulations. All wildlife crossings must avoid negatively affecting the quality of the wetland and must replace any wetland acreage filled as part of the crossing project.

B. Who owns the land (and will own the land) on which the crossing structure(s) will be built, and who owns the adjoining land?

If the crossing structure(s) is located within the existing road footprint (i.e., doesn't extend beyond the area owned and managed by a public agency), it is not likely to trigger any land use processes that would restrict the project from moving forward. However, if the crossing structure extends onto private property, it will be necessary to pursue an easement or property acquisition from the owner. This may affect cost and schedule.

In addition, consider the effectiveness of the structure(s) long term based on existing and project land ownership patterns.

C. Will the crossing lower wildlife-vehicle collisions, improve safety, and/or enhance landscape permeability?

Projects that achieve these goals may quality for Transportation Enhancement funding. See chapter 6 for more details.

D. Can the construction of the wildlife crossing be integrated into another type of project? Where does this project "fit" among other mitigation priorities, especially given a finite budget and staff resources?

Oregon is in the midst of replacing over 500 bridges in the state as part of their Oregon Transportation Investment Act schedule. State funding for bridge repairs, local capital improvement plans, and fish culvert retrofits may provide cost-sharing opportunities and opportunities to install wildlife crossing structures at reduced costs. Opportunities also exist if the crossing is combined with bicycle/pedestrian facilities or recreational trails, although target wildlife species and their sensitivity to human disturbance needs to be considered.

E. Are there any potential undesired consequences of the crossing project?

Despite best intentions, sometimes targeted wildlife do not use completed crossing structures, or a structure built for one purpose accommodates unintended wildlife (Figure 4-6).

Figure 4-6
The Fort to Sea Trail in Astoria, Oregon is a 6.5 mile pedestrian trail that takes people from Fort Clatsop to Sunset Beach. Elk rarely crossed US Highway 101 west to Camp Rilea prior to the construction of the above underpass, however, elk now frequently use the underpass to access habitat on the army base. This is an example of an unintended consequence of constructing an underpass—the army base is active with live firing, and the presence of elk is problematic for the elk and army operations. Graphic and photo credits: Oregon State Parks.

Anticipate use of planned crossing structures by a variety of wildlife and people based on location, existing and desired public use, local wildlife populations, and wildlife habitat.

4.2 Examples of Crossing Structures

Amherst, Massachusetts

Every spring in Amherst, Massachusetts, spotted salamanders cross a two-lane road to travel to and from fishless, temporary ponds to breed. Salamander roadway mortality was significant until two culverts, slotted and drained to maintain proper light and moisture conditions, were constructed. Monitoring indicates that more than three out of four salamanders that reached the crossing used the culverts successfully (Figure 4-7).

Gainesville, Florida

A segment of highway near Gainesville, Florida (Figure 4-8) had more documented road kills than any other road segment in the state—2,411 animals over a 12-month period (excluding hylid frogs) were killed by traffic on this road section. In response, a 3.5-foot high, 1.8-mile long concrete wall with a 6-inch lip at the top was built to divert amphibians, reptiles, and small mammals to eight highway culverts. Along the rim and barrier sections of the highway, there was an 81 percent reduction in mortality post-construction, excluding hylid frogs. Hylid frog mortality doubled post-construction, contributing overall to a 39 percent post-construction mortality for all species.

4.3 Damascus—A City in Transition

Prior to 2004, the Damascus Community was an unincorporated rural area of about 12,000 acres, including a population of

Figure 4-7
This culvert in Princeton, Massachusetts was designed for passage of spotted salamanders (bottom photo). The structure uses an open top, allowing water into the tunnel to maintain appropriate hydration and migratory cues for amphibians. Studies have shown that poorly designed tunnels or ones constructed with inappropriate materials, such as steel, create an abrupt change in microclimate conditions, and cause salamanders to either hesitate or never enter the crossing structures. Photo credits: Scott Jackson (top) and markpicard.com (bottom).

Figure 4-8
In 1998, the Florida Department of Transportation (FDOT) convened a multidisciplinary working group to discuss methods of reducing wildlife mortality on U.S. 441 across Paynes Prairie. FDOT engineers designed a system of barrier walls and underpasses along the 2-mile section of U.S. 441 across the prairie to provide safe passage for reptiles, amphibians, and small mammals. Note the game trail entering the culvert in the bottom photo. Photo credits: Dwight Forsyth (top) and ecopassagges.org (bottom).

about 12,000 residents living in 4,000 dwelling units. In 2002, Metro Council expanded Portland's Urban Growth Boundary to include 12,200 acres within the Damascus and Boring region of Oregon. Over the next 20 years, about 60,000 people are expected to live in 25,000 housing units in this once rural area.

Areas within this urban growth boundary area have unique geologic features and some of the largest contiguous tracts of wildlife habitat in the region. A group of extinct volcanoes and lava domes in north Clackamas and east Multnomah counties provide wildlife habitat and panoramic vistas. Goals include identifying a regionally and biologically significant natural area between Gresham and Damascus, and protecting several urban buttes and extinct rugged lava domes rising 500 to 1,000 feet above the Willamette Valley floor (Figures 4-2 and 4-3).

The Natural Resources of Damascus

Numerous databases were used to inventory and evaluate the natural resources of Damascus. A natural resources inventory of Damascus was conducted in 2007 by Winterbrook Planning. The following summarizes the natural features identified in that report:

There are 26 wetlands within the city of Damascus—23 of these wetlands total 145.45 acres or 1.4 percent of the total land area, and are deemed "significant." In addition, there are numerous smaller wetlands less than one-half acre in size.

A total of 20 riparian sites were identified along streams and rivers, including reaches of Noyer, Richardson, and Rock Creeks, which are tributaries to the Clackamas River, and Sunshine, Kelley, and Badger Creeks, which are tributaries to Johnson Creek. All mapped streams are considered significant fish and wildlife habitat areas. The total area of significant riparian corridors is 1,674.31 acres, or 15 percent of land within Damascus.

A total of 21 habitat sites, representing wetland, riparian, and upland habitats, and totalling 3,337.82 or 32 percent of the land base, were identified within the city. About 19 percent of land within Damascus is considered high quality habitat.

Inventory information and data from a variety of sources can help identify the critically important factors that can be considered early in the planning processes to determine potential wildlife conflict areas and appropriate mitigation solutions. Possible sources of information to consider include:

• citizen-mapped wildlife sightings, including deer, elk, and large carnivores, and Audubon Society's bird watch list;

• road kill information;

• conservation opportunity areas identified in the Oregon Conservation Strategy;

• Bald Eagle (*Haliaeetus leucocephalus*) and Peregrine Falcon (*Falco peregrinus*) nest survey information;

• Oregon Natural Heritage Information Center sensitive plant and animal information;

• wetland and stream maps;

• local watershed council action plans and other local conservation plans;

• Damascus concept plan information;

• critical salmon habitat and fish-bearing streams;

• core habitat and corridors connecting these habitats;

• connectivity to nearby large open spaces;

• sensitive species, Metro's species of concern, and vertebrate species lists;

• Metro's State of the Watersheds Report and regional transportation plan;

• local jurisdiction total maximum daily load (TMDL) management plans;

• local shade assessments;

• the City of Portland Terrestrial Ecology Enhancement Strategy, fish study, Willamette tributary study, and inventory update;

• City of Portland Watershed Characterizations and Plans;

• City of Portland Parks and Recreation vegetation inventories; and

• City of Portland Planning Bureau inventories.

Once target species and important areas are identified and goals are affirmed (as well as performance measures to help determine success), the city can begin identifying the most appropriate locations and types of mitigation needed to ensure landscape permeability for wildlife. It is important to emphasize the development of monitoring plans as part of this step.

The city could then proceed with the remaining three steps that include developing an implementation plan, constructing wildlife crossings, and monitoring and evaluation. By following this process, the citizens of Damascus and Portland can ensure healthy and viable wildlife populations well into the future.

4.4 Best Management Practices for Wildlife Crossings

American Wildlands published the 10 best management practices for wildlife crossings in their 2007 book, *Safe Passages: A User's Guide to Developing Effective Highway Crossings for Carnivore's and Other Wildlife*. The practices are scored (0-100) according to overall importance:

1. Wildlife monitoring & evaluation- before and after the crossing structure is built is a MUST. (15pts)

2. Species appropriate crossing structure design—consideration of the best design for the species in question is NECESSARY. (15pts)

3. Location—the structure NEEDS TO BE in an appropriate location based on natural wildlife movement patterns (thus the need for pre structure monitoring). (15pts)

4. Fencing—fencing to guide wildlife to the crossing structure is a MUST. Ideally it is built to the top of the crossing structure, not the bottom. (15pts)

5. Long-term planning of surrounding landscape—NEED to know that the wildlife habitat surrounding the crossing structure will be conserved into the future. (10pts)

6. System of crossings—construction of more than one crossing structure, especially if the structures are smaller (such as culverts) is BENEFICIAL and helps ensure best possible movement results. (10pts)

7. Site(s) chosen are within important wildlife linkage areas—because there are limited funds to support wildlife crossing structures, it is IMPORTANT to choose sites wisely. (5pts)

8. Naturalness—the crossing structure needs to appear and feel as natural AS POSSIBLE to the animals. This includes the crossing structure material matching the surrounding landscape. (5pts)

9. Escape ramps—Structures built SHOULD be accompanied by escape ramps. (5pts)

10. Cooperation and diversity of funding—Engineers, biologists and conservation groups SHOULD work cooperatively through the pre-monitoring, crossing structure design, implementation, and post-construction monitoring phases. (5pts)

4.5 A Case Study

To demonstrate how the scoring may be used, they offer a case study: Nugget Canyon, Highway 30 Case Study.

In the fall of 2008, the final installation of six 12'x20'concrete box culverts along a 13-mile stretch of Highway 30, in southwestern Wyoming (near the Idaho border) between Cokeville and Kemmerer (Figure 4-9), will be completed.

The construction of the culverts was the result of 20 years of planning and design to reduce wildlife vehicle collisions and improve wildlife movement in Nugget Canyon along Highway 30. Back in the mid-1980s the Wyoming Department of Transportation (WYDOT) experimented with signs as a means to reduce the wildlife vehicle collision rates, however, they had little success. Since that time, between 200–300 mule deer have died annually due to collisions with motorists on this section of highway. The final solution was a set of box culverts (Figure 4-10), with a total construction cost of $3.8 million (the cost was shared by WYDOT, Wyoming Game and Fish (WG&F), special appropriations by the state, and a local wildlife club).

It is estimated 5,000-10,000 mule deer, as part of the 30,000 Wyoming Range herd, migrate through this area each year. In harsh winters, up to 1,000 elk may cross through this area. Pronghorn and moose are also species of concern, but were not the target species in this project (as they were not being killed at the rates seen in mule deer).

In 1989, an 8-foot deer fence was built from milepost 28–35.5 (about half of the Nugget Canyon section of US Highway 30). One crossing area was left unfenced at milepost 30. Wing fences, escape ramps (Figure 4-11), and lights were used to help make the crossing more successful. Although the fencing resulted in an overall reduction of vehicle collisions with mule deer, an increase in animal kill concentrations were identified at milepost 30 (the unfenced crossing area) at the east end of the fence system. Also, because there was only one crossing area in the 7.5 miles, deer mortalities from the railroad increased. To improve the fence effectiveness, in 2001, the first of the six culverts was constructed. It was deemed an "experimental box"—both agencies could determine the best size and design for accommodating mule deer under the highway. In the end, due to a desire to accommodate a suite of species, the box culverts were built larger than mule deer specifications required.

WYDOT and WYG&F also integrated pre-construction monitoring to identify the best locations for the additional 5 culverts. The major mule deer migration in this section of Wyoming occurs in the winter months. The tracking was conducted by WYDOT over three winters to determine best locations for the crossing structures and to determine pre-construction rates of mule deer movement across the highway. A camera was installed in the first experiment box and monitored over two winter seasons.

In the fall of 2008, cameras were installed on all the culverts, at both ends, to track wildlife movement levels, as well as identify the behavior of wildlife as they move through the crossing structures. The cameras will be monitored throughout the year for three years, and will determine the extent to which elk, moose, and antelope use the structures. The 13-mile stretch runs from milepost 28 to 41 and is entirely fenced. Jump-out escape ramps are also included.

This project originated due to the high levels of concern, voiced by a local wildlife club (the Outthrust Wildlife Club) regarding the high levels of deer deaths on the highway. A local senator championed the cause in the state Senate.

Scoring this project according to the best management practices scoring system, the project received a 91 out of 100 points.

1. Pre-construction and plan for post-construction monitoring. Conducted three years of snow tracking with a post-construction plan of 3 years with cameras; GPS movement study. (14/15)

2. Three years testing wooden box culvert designs. (14/15)

3. Tracked mule deer migration movements, used wildlife vehicle collision data and natural terrain features to determine locations. (15/15)

4. Included fencing. Fencing runs to the bottom "wings" of the culverts rather than to the top because of highway right-of-way fence requirements. They installed additional fencing along the wings to limit animals' ability to get into the highway corridor by jumping out along the crossing structure wings. Also included "lay down" fence to for cattle movement. (12/15)

5. Area is 60–70 percent public, BLM ownership. Remainder is private. However, location is remote and away from any city centers, therefore unlikely to be developed. (8/10)

6. System of crossings. Yes—6 of them. This was based on their understanding that mule deer would travel along fences for only

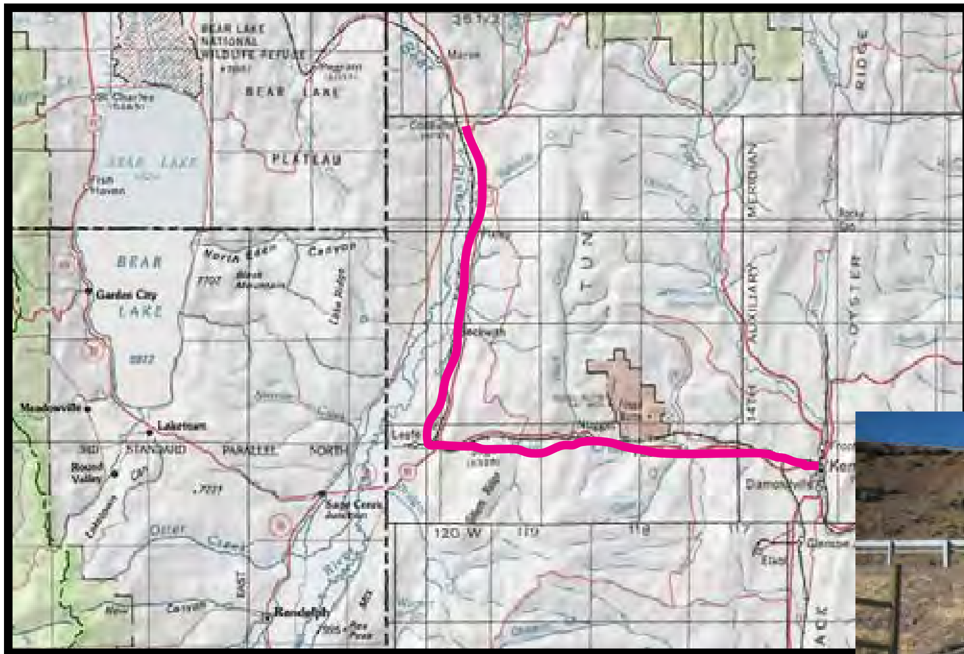

Figure 4-9
Wildlife crossings were installed along US Highway 30 in Wyoming between Colville and Kemmerer. Map credit: American Wildlands.

Figure 4-10
This is one of several box culverts installed along highway 30 to reduce vehicle collisions with mule deer. Photo credit: American Wildlands (www.wildlands.org/)

Figure 4-11
This escape ramp provides mule deer and other wildlife with a safe escape route over a tall fence along highway 30. Photo credit: American Wildlands (www.wildlands.org/programs/safepassages).

a limited distance.(10/10)

7. Important linkage area? Yes. Firmly established mule deer migration connectivity area. (5/5)

8. Naturalness. Using existing soil from surrounding area. Sides are vertical, instead of a better sloped design. Animals travel as far from the edges as possible, directly down the center (3/5)

9. Escape ramps? Yes (5/5)

10. Highly cooperative, including work between WYDOT and WY Game and Fish, as well as USGS, academic institutions, and local citizen's wildlife group. (5/5)

Success will be measured in how well the crossing structures and fencing reduce wildlife vehicle collisions and how much of the mule deer population continues to move across their home ranges. The goal is to reduce WVCs in the area by 80 percent.

Lessons learned: What would they do differently? Increase focus on crossing structure design to include other non-deer species, such as elk, and broaden pre-monitoring to include evaluation of elk movement and possibly other wildlife species.

Although every wildlife crossing project is different, over the years, best management practices have been developed to guide wildlife crossing decisions. This chart is based on the work of Bissonette and Cramer (2007).

Table 4-1. Best management practices for wildlife crossings.

Characteristics of Wildlife Crossing Structures	
Size	Critical size thresholds for passage structures vary from species to species, however, in general, the larger the crossing, the more it will be used by a greater number and populations of species. The size of underpasses relative to width of the roadway is more important than absolute size. However, some small mammals may prefer small underpasses.
Cover	Cover is important at the ends of, and, for some species, inside the passage. The presence of cover on the approaches (i.e., vegetation, rocks, and logs), may enhance use by a variety of mammals, although vegetation and high shelf-like structures may deter mammals wary of conditions that provide ambush opportunities for predators.
Natural Light	Natural light in the middle of tunnels or under road passages may be helpful for most prey species that are hesitant to enter underpasses that lack sufficient ambient light.
Noise	Reduce noise. Certain underpass designs (those with expansion joints and those with uncovered medians) can be noisy, thus open-top designs would be inappropriate for species that are sensitive to traffic noise. Overpass systems that incorporate tree and shrub buffers along the edges may be much quieter than underpass systems.
Pathways/Shelves	Pathways or shelves for wildlife to pass through underpasses or culverts with water benefit large and small mammals.
Median Barriers	Mitigative designs for raised median barriers should be used where barriers bisect natural or semi-natural areas that provide habitat for wildlife, such as raised median barriers—funnel animals toward wildlife underpasses or bridge spans over creeks and rivers; continuous concrete median barriers—provide scuppers (basal cutouts) at intervals that correspond to the movement requirements of the least mobile wildlife species; concrete, metal, or cable barriers—opt for the more permeable metal or cable designs for the benefit of primarily small- to mid-sized species, and secondarily large wildlife species; on undivided two-lane roads, consider rumble strips to improve motorist attentiveness, reduce risk of WVCs, and increase permeability of roads to wildlife movements; vegetated medians—minimize shrubbery that is likely to attract wildlife (e.g., fruit-bearing) and increase vehicle-caused mortality (Clevenger and Kociolek 2006). Median barrier openings should be about 9-inches high and have 39-inch wide cutouts along the bottom, accounting for at least 20 percent of the barriers or one every fifth barrier (Cooper 1999).

Structure Considerations	
Underpasses vs. overpasses	Wildlife overpasses may accommodate more species of wildlife than do underpasses.
Human Use and Activity	In general, reduced human use, especially at night, is thought to facilitate passage.
Openness	Deer and perhaps other ungulates require a larger openness ratio (Openness = [Height (m) * Width (m)]/Length (m)] (Gordon and Anderson 2002) than other mammals. Deer in urban-suburban situations will use pre-existing structures that are smaller than what their counterparts in more natural landscapes will use. Generally, larger highway systems require larger crossing structures, and smaller wildlife species prefer structures in which they can see the "end" or openings (Sandra Jacobson, pers. comm.).
Moisture	Amphibians need wet, cool tunnels. Shrews may prefer wet substrates for traveling. Underpasses at stream crossings may provide for species that use stream or streamside habitats; flowing water may deter use by species that do not use running water. Maintaining or replicating stream bed conditions within over-sized culverts may facilitate use by salamanders, frogs, small mammals, and aquatic invertebrates, thereby maintaining habitat continuity in the area of stream crossings (Jackson and Griffin 2000). Open-top (grated or slotted) underpasses provide sufficient moisture for crossings that lack flowing water. Innovative stormwater systems might be designed for closed-top systems that would provide enough water to maintain moist travel conditions without creating flooded or stream-like conditions. Proper drainage is important, because some wildlife species are less likely to use structures when they contain standing water. Temperature and substrate are considerations, —use small (e.g. 2'x 2') amphibian and reptile passages wherever roadways pass along the boundary between wetlands and uplands (Jackson and Griffin 2000). Small underpasses may create temperature disparities (inside vs. outside) that deter use by some amphibians (Langton 1989), thus consider using larger underpasses or open-top systems.
Cover	Small mammals need cover in the form of logs, rocks, and bushes. Rows of stumps in an underpass seem to facilitate use by small mammals. Certain species with very specific substrate requirements may require special attention at wildlife crossings.
Predator vs. Prey	The use of wildlife passages by predators may occasionally inhibit use by prey species (Clevenger and Waltho 1999, 2000; Hunt et al. 1987).
Riparian Crossings	Use oversized culverts and expanded bridges at stream crossings, and selectively use viaducts instead of bridges at important stream or river crossings.
Fencing	When exclusion fencing is used, it is essential to include accompanying mitigation, such as escape ramps, because large animals often access fenced right-of-ways. Avoid highway fencing and Jersey barriers if these structures are not accompanied by wildlife passage structures. Fencing should be combined with other measures, such as escape ramps, and ways for animals to cross the highway right-of-way without encountering traffic (Young and Vokurka 2007). Consider measures that mitigate a potential concentration of wildlife-vehicle collisions at fence ends where wildlife can tend to concentrate. There are perceived negative aesthetic effects of fencing; direct and indirect mortality, such as predators running prey into fencing or birds colliding with fences; and blocked access to the recreating public. Some species are relatively good at circumventing fences by climbing over or digging under standard fencing, therefore consideration should be given to installing dig barriers at the base of fences. Standard fencing is also ineffective for small animals.
Surrounding Landscape	Ensure conservation protection for lands and waterways on both sides of the passage.
Line of Sight	Allow for a straight line of site through a passage for animals. Tunnel layouts that allow animals to see the opposite end of a wildlife passage are positively correlated with use for some species.

Important Planning Considerations	
Local Biologists	Involve local biologists in all phases of project.
Adaptive Management	Use adaptive management to monitor and improve future designs and maintenance based on monitoring results.
Suites of Species	To help restore permeability, provide several different types of crossings, or crossings adapted for suites of species. For example, provide cover, wildlife shelves or paths, small tubes, a culvert within a culvert, and similar modifications.
Habitat Connectivity	Incorporate habitat connectivity as a strategic goal in transportation planning. Use landscape-based analyses to identify “connectivity zones” where a variety of mitigation efforts can be concentrated to maintain ecosystem processes. Incorporate WVC reduction into the early stages of planning and design for transportation projects, and develop and apply wildlife population viability models to assist in locating and designing mitigation measures. Use conservation plans and connectivity analyses to inform the transportation programming/planning/design process on where mitigation is needed and how it may be implemented. Preparation of statewide or regional plans for habitat connectivity (wildlife habitat linkages)—that take into account each state’s Statewide Improvement Transportation Plan (STIP)—is an essential part of developing a comprehensive system of effective wildlife crossing structures.
Retrofits	Incorporate into plans and schedules wildlife crossing options that can be accomplished by maintenance crews simply by retrofitting existing facilities.
Maintenance	Passages and accompanying mitigation elements, e.g., passage floors and holes in fencing, need to be continually maintained and repaired to help ensure continued use.
Monitoring	Monitor passage use for at least 3 years after construction. Develop and implement guidelines to evaluate and monitor mitigation measures. The cost of monitoring programs should be included in the overall budget for new infrastructure schemes, and a budget for maintenance of measures needs to be integrated in infrastructure planning and design.
Goals	Incorporate project goals to determine success. Review project goals to determine whether or not mitigation efforts are successful. For mitigation projects built for the primary purpose of preventing animal-vehicle collisions, a more direct measure of success is reduction in the number of collisions or the risk of collisions. Where wildlife conservation is the primary concern, long-term effects on wildlife populations are the only direct measure of success. Goals may also include a measurable increase in daily movements of target species through crossings, documentation of restored or continued migrations of species, documented dispersal of isolated or small populations, recolonization of areas, or maintenance or restoration of ecosystem-level processes.
Data	Use available wildlife information that already exists before creating new data.

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“The problems of habitat isolation that arise from fragmentation can be mitigated by connecting natural areas by corridors or zones of suitable habitat.”

— Reed Noss

Chapter 5 Wildlife Crossing Structures—Helping to Achieve Landscape Permeability

5.1 Characteristics of Wildlife Crossings

Successful wildlife crossings (Figure 5-1) generally have the following characteristics:

- grade separation—Crossings for wildlife (e.g., overpasses and underpasses) are at a different level than the highway (i.e., above or below highway grade);
- vegetation, fencing, and other measures to guide animals to safe crossings;
- strategic location to enhance habitat connectivity and landscape permeability as well as complement wildlife movement corridors; and
- adjacent land use and zoning that is conducive to long-term habitat protection.

Site-specific conditions, cost, target wildlife species, adjacent terrain, and engineering issues are just a few factors that need consideration when determining the size and type of a crossing structure. General guidelines for structure type and size are suggested in this chapter based on published works and best estimates of potential for success in an urban environment. There is, however, no blueprint for success. Creating and building successful wildlife crossing structures is as much art as it is science. A generally accepted principle is that structures built for large terrestrial animals (e.g., deer) will be adequate for smaller terrestrial animals, as well (www.CarnivoreSafePassage.org).

Figure 5-1
The Boeckman Road Extension Project in Wilsonville has elements of a successful wildlife crossing. There is an elevated bridge over a wetland, native vegetation plantings, fencing, and land ownerships to maintain the wildlife corridors in perpetuity. Photo credit: Lisa Nead, City of Wilsonville.

Table 5-1. Common myths about wildlife crossings.

Common Myths About Wildlife Crossings	
Myth	**Reality**
1. Wildlife are not abundant in the Portland region.	Wildlife do exist in this region. Metro’s Goal 5 program has developed a list of wildlife species that includes over 200 species of birds and over 50 species of mammals that live in the Portland metropolitan area, including deer, elk, bobcat, and peregrine falcons.
2. Wildlife crossings will increase the number of unwanted wildlife species in residential and commercial areas built for humans.	Metro’s Greenspaces Master Plan (http://www.oregonmetro.gov/index.cfm/go/by.web/id=24253) will help connect land acquired by Metro for habitat linkage and to enhance landscape permeability of the Portland metropolitan area for wildlife. If designed properly, crossings can work to divert wildlife from entering residential and commercial areas built for humans, by providing a direct corridor of designated wildlife habitat to and from important core habitat areas.
3. Project budgets are very tight, and there is no extra money available to build wildlife crossings.	Wildlife crossings are eligible for federal and state funding, and in many cases this funding is additive. This means that building a crossing may not impact the overall project budget, just provide more “bang for the buck.” In addition, incorporating wildlife crossing considerations into the design of a new project or a retrofit of an existing project is less expensive long-term than designing and constructing a wildlife crossing.
4. My proposed development impacts environmentally sensitive areas, and I don’t want to add anything to my project for fear that the permit will not be approved.	Wildlife crossings can be an effective way of meeting environmental mitigation requirements set by federal reviewing agencies. Instead of triggering a permit, the crossing may help a permit get approved.
5. Building a wildlife crossing will require special review and approvals, which will delay my project and put it over budget.	The majority of wildlife crossings can be built within an existing roadway footprint. Building or retrofitting any structure over a wetland or stream will require participation from regulatory agencies. However, as stated above, a wildlife crossing is typically seen as a way to mitigate an environmental concern.
6. Our environmental focus is only on endangered species, and especially salmon.	When retrofitting a fish culvert to improve salmon (or other fish) passage, consider increasing the size of the culvert or adding shelves to accommodate other wildlife. Combined fish/wildlife culvert projects have potential cost-sharing and funding opportunities. Also consider replacing the culvert with a bridge and incorporate elements to accommodate bats.

5.2 Fencing

Wildlife fencing serves two primary purposes—to prevent wildlife from crossing roads in unsafe locations and to guide wildlife to safe crossings. Wildlife fencing should always be constructed with associated safe wildlife crossings (Figure 5-2). Failure to do so may affect access to critical habitat and ultimately affect the long-term viability of urban wildlife populations that may not travel long distances along fence lines.

Many wildlife crossings are not effective because they lack appropriate fencing. Although maintenance of fencing is one of the most costly aspects of any wildlife crossing, fencing can reduce WVCs and can help wildlife populations that experience significant road mortality (Figure 5-3).

One study documented a 60 percent reduction in WVCs with fencing (Knapp et al. 2004). At a highway reconstruction project in Arizona, a 5-mile section of highway was reconstructed from a two- to four-lane divided highway, and was opened to traffic 6 months before installation of elk- and deer-proof fencing that would ultimately link four wildlife underpasses. During this 6-month period, the incidence of WVCs increased over threefold. After installation of fencing, the incidence of elk collisions declined 87 percent (Dodd et al. 2007).

On the I-90 Snoqualmie Pass East Corridor Project in Washington State, the Washington Department of Transportation (WSDOT) will use exclusionary methods, including fencing, for all mitigation projects within the entire corridor (R. Giles, Project Engineer, WSDOT, pers. comm.).

Deer, elk, mountain lions, and black bears are the most commonly encountered large mammals in the Portland area. The following (Table 5-2) are suggested fence characteristics for these species.

Figure 5-2
Fencing (in lower left portion of photo) is effectively used with wildlife overpasses to reduce wildlife vehicle collisions on and near highways. Photo credit: Scott Jackson.

Figure 5-3
This fence was erected along Highway 97A in Washington to prevent large mammals from crossing at inappropriate locations. Maintenance of fencing is critical to the success of any wildlife crossing project. Photo credit: Mitchell S. Reister, Washington Department of Transportation.

Table 5-2. Recommended exclusionary fence characteristics for large mammals (Huijser et al. 2008) found in the Portland area.

Species	Fence recommendations
Deer	8-9 foot tall woven metal wire fence - mesh size 6” x 6” (Figure 5-3)
Elk	8-9 foot woven metal wire fence - mesh size 6” x 6” (Figure 5-3)
Mountain Lion	11-foot tall woven metal wire fence with a finer mesh size overhang or barbed wire overhang to prevent climbing over the fence (Figure 5-4)
Black Bear	8-9 foot woven metal wire fence with mesh size smaller than 6” x 6” and a barbed wire overhang to prevent climbing over the fence (Figure 5-5)

If the goal of a fencing project is to exclude only large mammals, and coyotes are not common in the area, consideration should be given to allow passage underneath the fence by small mammals by including adequate spacing at the base of the fence (Figure 5-4).

Because coyotes are very common in urban areas, most fencing for large mammals should be buried two feet under the ground or bent and placed at an angle to the fence to prevent coyotes and other urban wildlife from digging under the fence (Figures 5-5, 5-6).

Fencing may be used to guide wildlife to crossing structures. Natural features, such as streams, ravines, or other topographic features can minimize the need to use fences to channel wildlife, as they can serve as natural corridors. One factor to keep in mind is that fencing can easily be damaged by vehicles, people, animals, and severe weather (i.e., snow). Maintenance needs to be factored into any fencing proposal, weighing the cost/benefit of maintaining fence with reduced carcass pick-up

Figure 5-4
This 8-mile long 8-foot high fence is being installed on the west side of 97A in Chelan County, Washington, to reduce mule deer mortality by 50 percent. The fence is under construction in 2008 at a cost of $1.6 million. Because the primary goal of this fence is to prevent deer from crossing, smaller mesh fencing is not attached to the base of the larger mesh fence. Top and bottom photo credits: Washington Department of Transportation. Middle photo credit: wallpaper.searchrealm.com.

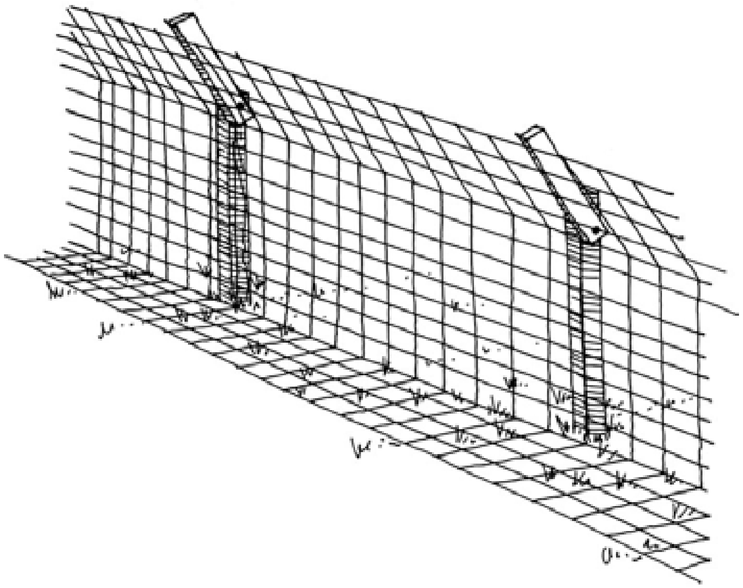

Figure 5-5
The top photo depicts an 8-foot chain link fence with barbed wire overhang that would prevent black bears from climbing the fence. Photo credit: The Backyard Depot. The bottom photo is a graphic of a fence with extensions to prevent coyotes from jumping over or digging. The top of the fence is angled out about 15 inches and the base has a wire apron in front of it to prevent digging. Another option to keep coyotes from digging underneath the fence is to bury the fence at least two feet deep. Top photo credit: Mark Campbell, The Backyard Depot. Bottom Graphic Credit: Jennifer Rees, Washington Department of Fish and Wildlife.

Figure 5-6
This high-tensile steel wire game-proof electric fence in Shamata, Kenya keeps larger mammals from crossing, while the smaller non-electric mesh fence attached at the base of the taller fence and buried 3 feet keeps burrowing animals, such as porcupines, from crossing. Photo credit: RHINO ARK.

and disposal and collisions.

Other factors to consider when fencing include:

- Materials: Metal and wood are the most commonly used materials for non-electric fences. Pressure-treated wood posts at least 5 inches in diameter for line posts and 7 inches in diameter for braces and corner posts are recommended for woven metal wire wildlife fences. It is recommended posts be placed at least 2 feet into the ground, however, the type of substrate will influence post depth. It is recommended posts be placed every 14–18 feet. If more expensive metal posts are used, such as when chain link fencing is erected (Figure 5-7), reinforced cable on wooden posts or metal tubing on metal posts is recommended (Huijser et al. 2008).

- Length of fence: Consider the home range of targeted wildlife species when estimating the length of fence needed. Animals with smaller home ranges will require shorter fences. In addition, behavioral attributes of local wildlife species should be considered. For example, mule deer will usually not travel long distances along fence lines in deep snow. Thus wildlife crossings should be adequately spaced along fence lines or fencing should not be used.

- Fence ends: Wildlife-vehicle collisions tend to concentrate at fence ends, therefore, incorporate safe wildlife crossing opportunities or ensure that terrain or other existing habitat features deter wildlife from crossing the road at fence ends (Figure 5-8).

- Escape opportunities: Wildlife may become enclosed between fences, creating the potential for wildlife-vehicle collisions or wildlife mortality. Incorporate escape opportunities for wildlife in the form of gates, jump-outs, ramps, or other objects that create opportunities for wildlife to exit the road.

- Aesthetics: Fencing in urban areas can be a public relations issue. The visual effects of a fence can be lessened by incorporating plants along the fence, using dark-colored fencing material, and minimizing fence height where possible, especially in residential and urban areas (Figure 5-7).

Figure 5-7
The low black fence adjacent to the Boeckman Road Extension Project is barely visible from the road, improving the visual appeal of the overall project, yet serving its utility to keep small- and medium-sized mammals from crossing the roadway in places other than designated wildlife crossings. Photo credit: Lisa Nead, City of Wilsonville.

Figure 5-8
ElectroMAT™ (top and middle right) acts like an electric fence laid flat on the ground. It has been used in places like New Mexico (pictured) and Arizona to deter wildlife such as deer and elk from entering highways. ElectroBraid™ (lower left) is a permanent electric fence to exclude deer, moose, elk, caribou, bear, coyote and other animals from crops, airfields, and highways. Photo credits: Andrew Byson, ElectroBraid.

5.3 Wildlife Overpasses

Wildlife overpasses are structures over roads (Figure 5-9, 5-10, 5-11). Overpasses range from multi-million dollar structures landscaped to mimic adjacent habitat to basic crossing structures with natural substrate and little or no vegetation. In general, they are expensive structures that accommodate the most number of wildlife species. Overpasses are effective reconnecting tracts of wildlife habitat bisected by roads, and can serve as a greenway used by people for recreation purposes (during daylight hours). Wildlife overpasses are used by some wildlife species that will not use underpasses or other types of road crossings.

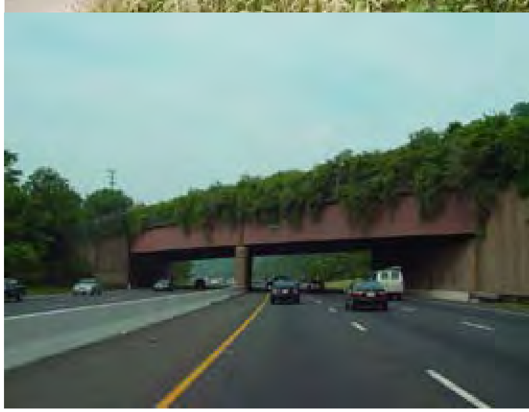

Figure 5-9
A row of tree stumps, grass-herb-shrub vegetation, and a road (Ericaweg) overpass (Wallenburg) across the A28 motorway near the town of "Zeist," the Netherlands. The overpass was initially designed without the vegetation features. Photo credit: Marcel Huijser ©. This wildlife overpass (left) crosses busy I-78 New Jersey. Photo credit: Jim K. Georges.

Figure 5-10
This overpass was constructed in Florida to reconnect a greenway bisected by the highway. The sand substrate of the 52-foot wide greenway, and accompanying trees and vegetation, allow small and medium-size mammals as well as people safe passage across an interstate that serves 50,000 vehicles daily. A unique irrigation system waters the vegetation, which protects the wildlife from traffic noise and headlight glare when they cross it during the night. Photo credits: Top photo, DMJM Harris; bottom photo, Alan Bryant, Florida Department of Transportation.

Figure 5-11
This overpass in Banff National Park, Canada on the Trans-Canada highway was constructed in 1997 at a cost of $1.85 million. All large mammals in the park use the crossing structure except for bighorn sheep. The design of this overpass (arched structure) requires animals to climb up onto the structure without being able to see across the road until they reach the top of the overpass. Future designs will improve animal visibility by siting the structure at the base of ravines. Photo credit: Wikipedia.

5.4 Wildlife Underpasses

Wildlife underpasses (Figures 5-12, 5-13, 5-14, 5-15) allow wildlife to cross underneath roads, and include viaducts, bridge extensions, and culverts (culverts described in section 5.5).

Although less expensive than overpasses, certain types of underpasses (e.g., viaducts) can be fairly costly. The length of an underpass varies based on the geographic features of the area, cost, target wildlife species. Fencing for large and medium-sized mammals is required for underpass systems to be effective. Fencing is crucial to the success of a bridge extension as a wildlife passage because it guides/funnels animals to use

Figure 5-12
The Puento-Chino Hills Wildlife Corridor near Los Angeles, California is surrounded by urban development, yet contains regionally and globally significant habitat and associated wildlife species. This $1.2 million underpass has a 20-foot span, 17-foot rise, and is 160-feet long. Bobcats, mule deer, and coyotes have used the structure. Photo credit: Andrea Gullo, Puento Hills Landfill Native Habitat Preservation Authority.

Figure 5-13
The underpass on SR240 in Washington was constructed for about $700,000 and was built for deer, coyote, and other small mammals. Photo credit: Washington Department of Transportation.

Figure 5-14
The Lakeside underpass (left) in Portland, Oregon provides passage for fish and small and large mammals. The natural substrate, rock shelf, and concrete walkway are wildlife-friendly features in this $600,000 structure. Photo credit: Lori Hennings, Metro. The Millau Viaduct (right) is the tallest bridge in the world and connects Paris to Barcelona. It is an excellent example of a transportation structure that spans a large gorge, providing transportation for people, yet minimizing impacts to the natural environment by allowing for safe passage below the structure. It cost $410 million to construct. Photo credit: Energy Efficient Building Network.

[*The Oregon Department of Transportation's Programmatic Endangered Species Act consultation for the OTIA III Bridge Program has bat performance standards to help bridge engineers understand day and night roosting needs of native Oregon bats (http://www.oregon.gov/ODOT/HWY/OTIA/news_bats.shtml)].

Figure 5-15
The $1.65 million Minter Bridge Road bridge replaced two bridges spanning the Tualatin River south of Hillsboro, Oregon in 2003. Native bats benefit from this new bridge design, which incorporates roosting habitat. Photo credits: Oregon Department of Transportation.

the structure and minimizes unsafe road crossings.

Wildlife underpasses can serve multiple purposes. In addition to providing safe crossings for wildlife, they can be designed to effectively move water year round or during peak precipitation periods (Figure 5-13), serve as part of a trail network for public recreation, and transport vehicles or rail cars.

To accommodate large mammals such as mountain lions and deer, wildlife underpasses should have a minimum walkway width of 6.5 feet and a minimum clearance between the walkway and ceiling of the underpass of 10 feet (Huijser et al. 2008). For small mammals, such as raccoons, wildlife underpasses should have a minimum walkway width of 2 feet and a minimum clearance between the walkway and ceiling of the underpass of at least 2 feet (Huijser et al. 2008).

Viaducts—Viaducts are elevated roadways (Figure 5-14), typically crossing streams, rivers, and adjacent valleys. They range in size from large structures that span significant landscape features to those that simply cross a stream. All provide safe passage for wildlife below with minimal impact to the natural landscape.

Bridge extensions—Bridge extensions are elevated span structures that are shorter in length than viaducts (Figure 5-15). Bridge extensions may provide some habitat for bats, small mammals, reptiles, and amphibians. Designs with no piers and abutments are much noisier than structures with those features and may be less suitable for species that are sensitive to human disturbance. Human activity within or around bridge extensions may significantly reduce their effectiveness for wildlife. Adjustments to bridge extensions (Figure 5-15) can be made to improve their utility by bats, reptiles, and amphibians, including vertical crevices for bat day and night roosts, and removal of vegetation along fences as well as use of pipes and culverts in combination with bridge extensions to facilitate movement.

5.5 Culverts

Different species of wildlife prefer different size and type culverts. Smaller-sized culverts can provide more closely spaced wildlife passages than larger, more expensive structures that are spaced more widely. Box culverts are generally preferable over pipes because they provide more vertical and horizontal clearance, and larger culverts generally provide for more species. Culverts with open tops provide light and moisture, desired attributes for amphibians, which, like turtles, benefit from structures that allow them to safely move between wetlands. Retrofitting an existing fish culvert is an opportunity to create passage for terrestrial wildlife, amphibians, and reptiles. It is especially important to ensure that barriers to terrestrial wildlife are not created by enhancing structures for fish passage (Figure 5-16).

Road culverts that pass water (Figure 5-17) can successfully serve as wildlife passages if they are large enough. Natural substrates, including large boulders and shelves, or benches along the sides of the culvert, allow for wildlife passage during high water. Culverts are much less expensive than underpasses, but are also less effective because of their smaller size and more confined spaces.

Characteristics

- Crossing built below grade for both water and animal passage.

- Follows a year-round or seasonal stream or waterway (stream culvert), or is constructed over dry land (upland culvert).

Benefits

- If modification of an existing culvert to accommodate

Figure 5-16
All fish passage projects should consider effects on wildlife passage because some retrofits actually hinder wildlife passage. This is a culvert that was retrofitted to provide fish passage, but created a barrier to terrestrial wildlife passage, as well. Photo credit: Ken Cannon, Oregon Department of Transportation.

fish is required, incorporating accommodations for terrestrial wildlife may be relatively inexpensive. Constructing upland culverts on dry land is also inexpensive.

Disadvantages

- Depending on its size, the culvert can limit the size of animal that can pass through.

- Terrestrial animals may avoid riparian culverts unless features, such as ledges, floating docks, or unsubmerged land are incorporated in the design.

Figure 5-17
These different-sized culverts in close proximity to one another will provide safe crossing for small and large mammals and reptiles and amphibians along the Boeckman Road Extension Project in Wilsonville, Oregon. Photo credit: Lisa Nead, City of Wilsonville.

- Some animals avoid culverts because of the enclosed space.

Comments

- Bottomless culverts are preferable because they preserve the natural substrate that is habitat for some small mammals and amphibians.

- Build the crossing as large as is feasible to accommodate larger animals, but provide cover for smaller animals.

- Consider opportunities to allow natural light, moisture, and vegetation conditions in and adjacent to the crossing.

- Incorporate fencing or railing to funnel animals to crossing.

- Some animals dislike enclosed spaces, while some prefer enclosed spaces. The openness of the design should be based on target wildlife species.

Additional Project Considerations

- Riparian culvert projects for wildlife can be combined with fish culvert projects, creating cost-share opportunities, potentially qualifying the project for additional funding sources.

- Certain designs (corrugated) and materials (concrete, metal with protective coatings) for pipe culverts will maximize the life of the culvert and minimize maintenance costs.

- Improper design or placement of the culvert can lead to heightened water velocities and require frequent maintenance because of scour, soil erosion, sedimentation, and debris blockage.

- Culverts need to be open and accessible. This requires controlling vegetation and disposing of sediment at the mouth of the culvert.

The appropriate size of a culvert is based on many factors—primarily the size of the target wildlife species and the width of the road under which the culvert passes. A good rule of thumb is that as the width of the road increases, the diameter of the culvert must also increase.

Openness ratio is a good indicator of the suitability of the size of a culvert for wildlife:

Openness ratio = (culvert height x culvert width)/culvert length.

In general, large mammals, such as deer, bears, coyotes, and bobcats, will use culverts that have an openness ratio of at least 0.75 (although at least 0.9 is recommended). Some studies recommend that culverts for deer and mountain lions be at least 10-feet high, however, wildlife in urban areas have used much smaller structures. Therefore, it is recommended that round culverts be at least 8-feet high, with the appropriate accompanying fencing (8-foot page wire for mountain lions and deer, and 4-foot wire mesh for coyotes). Box culverts should be at least 8-feet high x 16-feet wide for mountain lions and deer, again with the appropriate accompanying fencing.

Round culverts for mid-sized wildlife, such as coyotes and bobcats, should have an openness ratio of at least 0.4 and be at least 4-feet in diameter, with accompanying 4-foot wire mesh fencing. Box culverts for mid-sized wildlife should be at least 4-feet square with 4-foot wire mesh fencing.

Round culverts for small mammals, such as raccoons, should be at least 3-feet in diameter, with 4-inch x 2-inch page wire, small mesh fencing. If the goal is for culverts to provide passage for both small- and mid-sized wildlife, the finer mesh fencing can be overlaid on the larger mesh fencing.

Figure 5-19
Not all wildlife crossing budgets have big price tags. This rock shelf was constructed in a culvert in Loraine, Oregon to provide passage for terrestrial wildlife when water is in the culvert. Photo credit: John Levenhagen.

Reptiles (Figure 5-18) and amphibians will use culverts if they are at least 1-foot high, have natural vegetation approaches, have a moist (amphibian) or sandy (reptile) substrate, have openings that allow ambient light, air, and moisture to move through the culvert, and have accompanying fencing or a 1.5-foot to 2.5-foot wall or fence with a lipped overhang to prevent these species from crawling over.

Terrestrial wildlife will use culverts that pass water if an elevated concrete walkway or shelf (preferably at least 18 inches wide and 12 inches high) is constructed along the inside of the culvert (Figures 5-19, 5-20, 5-22, 5-23, 5-24, 5-25). Culverts that pass water and have no shelving, may be barriers for some species (Figure 5-21).

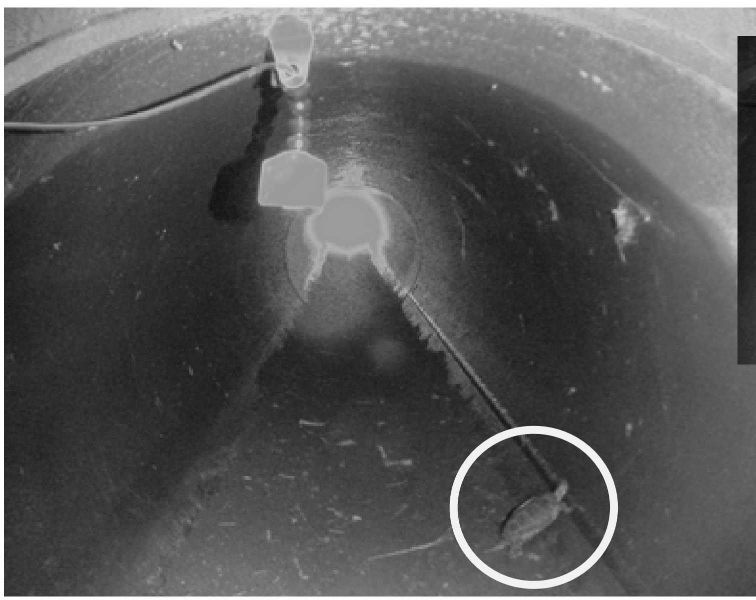

Figure 5-18
The western painted turtle (bottom photo) and raccoon (top photo) are moving through this culvert in northeast Portland at different times. Several light boxes at the top of the culvert provide ambient light for wildlife as they make their way through the passage. Photo credit: Port of Portland.

Figure 5-20
High speed railroad in Europe created the need for combination wet and dry culverts. Light shafts installed every 65 to 100 feet allow for passage of terrestrial and aquatic wildlife. Photo credit: Rijkswaterstaat. HSL-Zuid/Ton Poortvliet.

Figure 5-21
South of Powell Butte Nature Park, where Johnson Creek crosses SE Foster Road, just east of SE 145th Street, is a wildlife corridor for wildlife moving between Powell Butte and Mount Scott (numerous deer crossing signs exist along this roadway). A recently renovated bridge over Johnson Creek now has steep, almost vertical concrete slopes on both sides underneath the bridge, preventing terrestrial crossings of any kind. This structure presents an opportunity for retrofitting to enhance wildlife passage. Photo credit: Lisa DeBruyckere.

Figure 5-22
The 7th Street Crossing in Gresham, Oregon (top photo) demonstrates the successful integration of public and wildlife use. The Springwater Trail, a pedestrian bike and walking path, runs parallel to this underpass (lower photo), which spans Johnson Creek and includes a wide dirt shelf to accommodate terrestrial wildlife. Photo credits: Lisa DeBruyckere.

Figure 5-23
The Critter Crossing™ structure was placed inside this drainage culvert under Highway 93 between Stevensville and Florence, Montana. Suspended shelves allow small mammals safe passage throughout the year. Some of the culverts carry water 4-6 months per year, while others carry water year round. Photo credit: Kerry R. Foresman.

Figure 5-24
Many species of small mammals will use elevated crossing structures within culverts. The raccoon (right) was photographed walking on a shelf suspended inside a culvert that had 2 feet of water. The short-tailed weasel (left) (winter) was photographed walking on this shelf in a culvert that had 1 foot of water. Photo credit: Kerry R. Foresman.

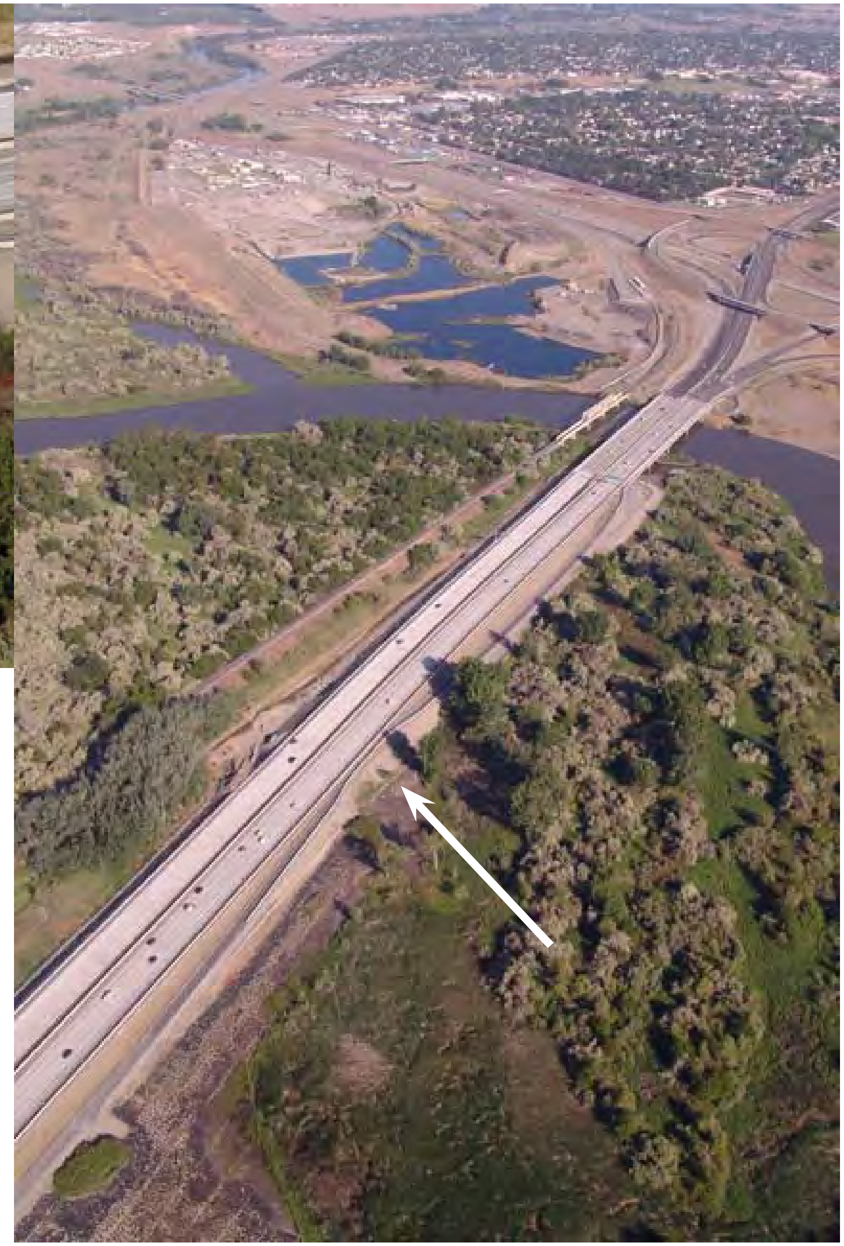

Figure 5-25
In the summer of 2008, the Washington Department of Transportation installed a wildlife underpass with a dirt base on SR 240, a highway with 55,000 daily motorists. Although 10 acres of wetlands were lost because of the highway expansion, Washington Department of Transportation partnered with other organizations to preserve 60 acres in the nearby Amon Creek Basin. In addition, a 12-foot wide bicycle path was constructed along the highway to accommodate the number of commuter cyclists. Photo credit: Washington Department of Transportation.

The Boeckman Road Extension Project in Wilsonville

Wilsonville sought to relieve traffic congestion within their community by extending Boeckman Road from 95th Avenue to 110th Avenue, however, doing so would affect the environmentally sensitive Coffee Lake Wetland. The project gave the community an opportunity to incorporate trail and natural resource considerations into the new 3,300-foot roadway, which included a 405-foot bridge crossing the Coffee Lake Wetland (Figure 5-26). The new roadway bisecting the wetland includes several wildlife crossing features and improved wildlife habitat, a bridge crossing to facilitate wildlife movement, and a 10-foot wide multi-use bike/pedestrian path connecting park and open space to a regional trail system. The total cost of the wildlife features on this project was $667,019.

Figure 5-26
The Coffee Lake Wetland was bisected with the Boeckman Road Extension Project. Photo credit: Lisa Nead, City of Wilsonville.

5.6 At-Grade Crossing Mitigation

Signs, speed reducers

Roadway Signs—The most common WVC mitigation measure is roadway wildlife warning signs that alert drivers to the potential presence of wildlife. Warning signs must be reliable, placed in locations where the potential for encountering wildlife on the road exceeds a certain minimum risk of WVC, and, in the case of seasonal reflective signs, should be posted during times of the year when wildlife frequently cross roads (Huijser et al. 2007).

Standard deer warning signs—diamond-shaped panel with black symbol (Figure 5-27)—are generally considered ineffective. Some studies documented no evidence of these types of signs reducing WVCs or vehicle speed. However, enhanced wildlife warning signs (i.e., illuminated, large,

Figure 5-27
Traditional deer warning signs are not very effective; efficacy is improved if posted only during those periods of the year when animals are most likely to be crossing the road.

reflective, etc.) have been shown to reduce vehicle speed, and, in at least one study, result in earlier braking. One study showed that posted seasonal reflective and flashing wildlife signs reduced mule deer-vehicle collisions by 51 percent, yet there was no difference in deer-vehicle collisions three years in a row when seasonal wildlife signs with no reflective material or illumination were used (Rogers 2004).

Design Speed—Reducing the design speed of a road (i.e., sharper curves, narrower lane widths, and narrower shoulders) may be more effective in reducing vehicle speed than reducing the posted speed limit (Huijser et al. 2007). A Yellowstone National Park study concluded that roads reconstructed with higher design speeds experienced an increase in road kill (Gunther et al. 1998).

Speed Bumps reduce the speed of vehicles on roads (Figure 5-28), and can vary from 3 inches to 14 feet in length. Planning

Figure 5-28
This speed bump was installed to reduce vehicle speed for nearby Hawaiian goose breeding, roosting, and feeding areas in Volcanoes National Park, HI. Photo credit: Marcel Huijser ©.

for speed bumps should incorporate the advantages of reducing vehicle speed with documented potential disadvantages, such as vehicle damage, diversion of traffic to other roads.

Median Barriers—Median barriers (concrete, metal beam, cable, rumble strips, and vegetated medians)—Transportation agencies are not typically concerned about the effects of median barriers (Figure 5-29) on wildlife (National Research Council 2005); the American Association of State Highway and Transportation Officials (AASHTO) Roadside Design Guide does not address the effects of median barriers on wildlife, and Oregon's Highway Design Manual does not address modifications to medians for wildlife considerations. Yet, numerous studies have documented median barriers increase wildlife mortality via collisions with vehicles and impede

Figure 5-29
In 2006, Caltrans responded to a known hot-spot for deer-vehicle collisions and cross-median traffic accidents along 2 miles of State Route 52 by installing barriers on the highway median and leaving 3-foot wide gaps between barrier sections. Since installation of the barriers, deer are no longer trapped on the highway, and the number of deer-vehicle collisions has decreased. Photo credit: Caltrans.

movement of wildlife. Median barriers affect the movements of many large and small wildlife, yet raised concrete median barriers (Figures 5-29, 5-30, 5-31, 5-32) continue to be installed on highways today. There, are however, techniques that can be used to improve driver safety and provide for wildlife needs.

Figure 5-30
This 32-inch tall, 5-mile long median barrier was constructed along highway 1 in California to reduce crossover vehicle accidents. Two types of cutouts were made along the base of the median barrier for small- and mid-sized mammals to cross. Photo credit: California Department of Transportation.

To lessen their potential as structures that hinder wildlife crossing, highway engineers should consider cable barriers as an option to concrete Jersey barriers. If concrete barriers are used, basal cutouts that allow small mammals safepassage (Figures 5-30, 5-31, 5-32), and gaps between barriers at strategic locations to allow larger mammals escape routes and opportunities to cross (Figure 5-26), should be considered.

Vegetation Management—Vegetation along roadways and in medians can have positive or negative effects. In a multi-year Canadian study, birds were 85 percent more likely to be killed on roads with vegetated medians (Figure 5-33) (Clevenger et al. 2003). Many agencies attempt to enhance driver visibility and road safety by minimizing tree growth and encroaching shrubs in medians and along roadsides, however, these practices create attractive forage for deer and other wildlife species. Because the quality of deer forage is directly related to the time of year when it is cut, roadside brush be cut early in the growing season versus mid-summer to reduce its attractiveness to deer (Rea 2003). In some instances, vegetated medians along low-traffic roadways can provide at-grade connectivity for birds and faster-moving terrestrial species.

Figure 5-31
Long sections of median barriers are thought to increase road mortality and reduce animal movements across the road. Note that the small cutouts at the bottom of concrete median barriers are designed for drainage, but also allow small animal species to cross under the median barriers. Photo credit: Marcel Huijser ©.

Lighting—Roadway lighting (Figure 5-34) can improve the ability of drivers to see and respond to wildlife on or approaching roads, and in combination with other mitigation measures, such as fencing and modifications to bridges, can reduce WVCs. Some species may avoid artificial light, which creates an unintentional barrier, or temporarily blinds wildlife species, potentially increasing their vulnerability to traffic.

Figure 5-32
Media barrier cutouts allow for both drainage and movement of small mammals such as meadow voles (pictured on right), however, small cutouts frequently fill with dirt and debris, therefore, maintenance of cutouts is critical to long-term wildlife crossing success. Photo credits: Median - Howard Diep, Oregon Department of Transportation. Meadow Vole - US Fish and Wildlife Service.

Figure 5-33
Birds are 85 percent more likely to be killed on roads with vegetated medians, like Interstate 85 in Texas. Photo credit: Houstonfreeways.com.

Figure 5-34
Highway lighting may reduce or increase WVCs, depending on their design and location. Photo credit: Jan Teunis.

5.7 Animal Detection Systems

There are over 30 locations in North America in which animal detection sensor systems inform drivers that a large animal may be on or near the road (Figures 5-35, 5-36, 5-37). Variability in driving speeds is related to the type of warning signal and signs, whether the warning signs have accompanying speed limit reductions, road and weather conditions, and whether the driver resides in the area and is familiar with the road.

Maintenance costs, the size of wildlife (these systems are generally effective only with large mammals such as deer and elk), weather, land use along the right-of-way, and numerous other factors contribute to the effectiveness of these systems.

Figure 5-35
This wildlife detection system on highway 191 near Pinedale, Wyoming triggers illuminated signage when sensors detect mule deer approaching the road. Installed in 2005, WYDOT initially dealt with effectiveness issues because of false positives. The $898,000 project consists of both motion and presence sensors. Photo credit: Wyoming Department of Transportation.

Figure 5-36
This wildlife detection system was installed along highway 160 in Colorado. The top left photo features an illuminated sign that becomes lit when sensors are triggered by large animals approaching the roadway. The top right photo is the same location showing the wildlife detection system during evening hours.Photo credits: Michael D. McVaugh, Colorado Department of Transportation.

Colorado DOT's New Idea to Reducing Wildlife/Vehicle Collisions

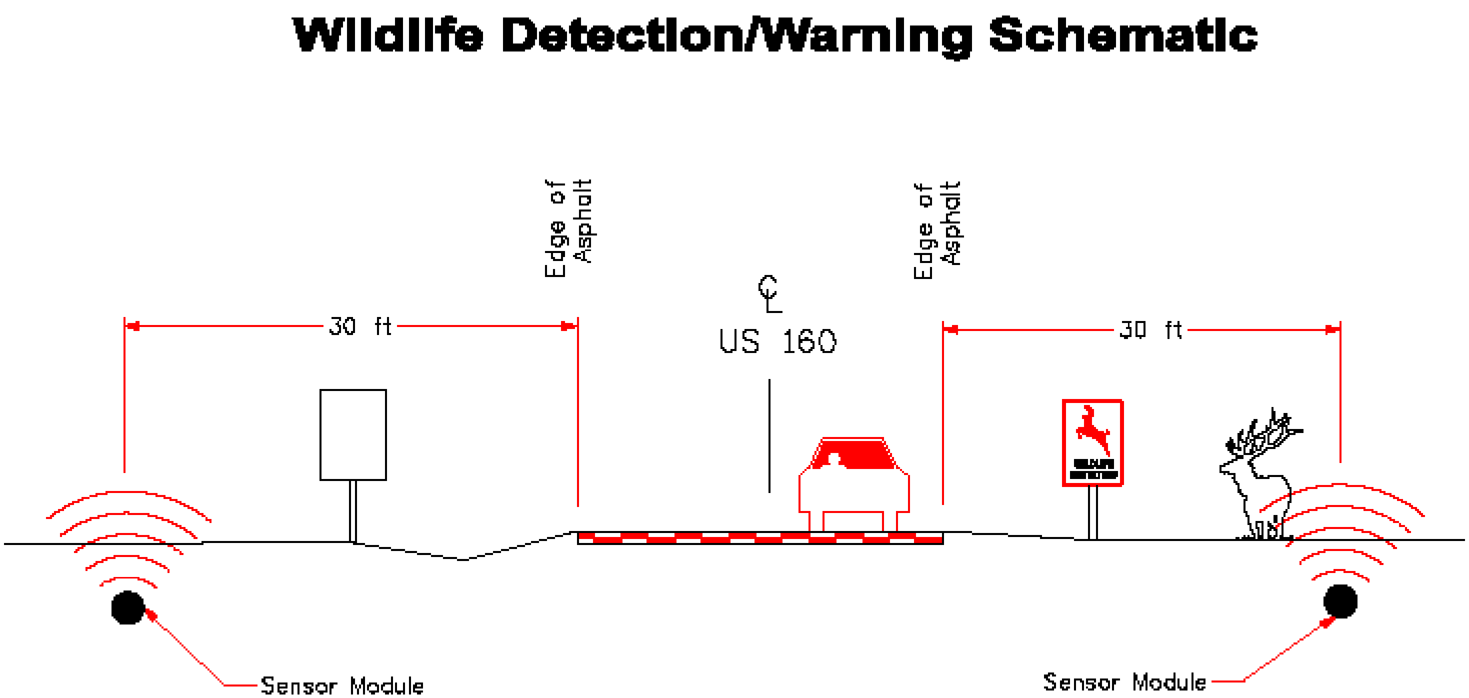

Figure 5-37
The schematic demonstrates Colorado's approach to reducing wildlife-vehicle collisions by installing warning detection systems within 30 feet of the edge of the road, and on both sides of the road. Photo and schematic credits: Michael D. McVaugh, Colorado Department of Transportation.

5.8 Other Examples

Figure 5-38
This overpass on the 26 Motorway in the Hardt Forest in Germany is an excellent example of incorporating vegetation features of the natural environment into an overpass to create a seamless crossing for wildlife. Photo credit: Javier Martinez de Castilla, Ferrovial Agroman.

Figure 5-39
This underpass at the south exit of Immokalee Road in Florida, demonstrates the importance of allowing vegetation to grow adjacent to the crossing structure to provide cover and protection for wildlife that live in the Corkscrew Regional Ecosystem Watershed. Photo credit: Dan Pennington, 1000 Friends of Florida.

Figure 5-40
Texas Department of Transportation engineers were planning a drainage culvert under U.S. 83 in Webb County, and modified the plans to include bat roosts—with five recessed, square "domes" (middle) built into the ceiling of the culvert and a rough-textured roosting surface made with recycled plywood forms. The culvert houses thousands of bats. Retrofitting the culvert was simple, and planning ahead saved taxpayers more than $300,000. Photo credits: Mark Alvarado and Melissa Montemayor, Texas Department of Transportation.

Figure 5-41
This is a graphic rendering of the wildlife overpass proposed for I-70 west of Vail Pass in Colorado. Graphic credit: Digital Animation Services.

Figure 5-42
This upland culvert is one of many wildlife crossing structures on the Trans-Canada highway constructed primarily for elk, deer, and moose. Photo credit: Scott Jackson.

Figure 5-43
This small underpass is 1 of 4 along Route 2 in Massachusetts was constructed during a retrofit of a highway expansion project. Target wildlife species include small and medium-sized wildlife, although deer occasionally use them. Photo credit: Scott Jackson.

Figure 5-44
This Florida underpass on Alligator Alley (I-75) in South Florida was built primarily for Florida Panthers, however, it will provide passage for many species of wildlife. Photo credit: Scott Jackson.

5.9 Costs of Wildlife Crossing Structures

The cost to build and maintain a wildlife crossing will depend on the type, location, and size of the project. Costs can vary considerably, even within crossing design types. The most significant cost factor is the size of the crossing. Maintenance costs tend to be more constant within each crossing type, however, maintenance costs can vary greatly by the type of crossing. There are some general cost-saving principles regardless of which type of crossing is being considered.

Cost-Saving Principles

Do it right the first time—If wildlife will be affected by a new road or you have an opportunity to reconnect one or more wildlife populations that were previously disconnected by a road or development, find the money to incorporate a crossing into construction of the road. It is a lot more expensive to do a retrofit later.

Coordinate with other capital improvement projects—Wildlife crossings can be relatively inexpensive if installation is incorporated into other planned road improvements.

Extend a bridge—Oregon is repairing or replacing over 500 bridges in the next decade. Repairing or replacing a bridge presents an opportunity to create a wildlife crossing by extending the bridge structure onto dry land to provide terrestrial animals a pathway adjacent to the water.

Expand a culvert—Many culverts in the Portland metropolitan area need to be retrofitted to comply with Endangered Species Act regulations for fish passage and water flow. Adding shelves or floating docks in the new culvert for terrestrial animals can be done at relatively low cost.

Table 5-3 lists the ballpark costs of some wildlife crossing measures. Some of the examples presented are costs, in 2007 dollars, of actual projects. Others provide ballpark estimates of types of measures and accessories, such as daylight inlets and retaining walls, associated with crossing structures.

* Cost estimates from this table came from the following sources:

1 Sullivan, T. L., A. E. Williams, T. A. Messmer, L. A. Hellinga, and S. Y. Kyrychenko. 2004. Effectiveness of temporary warning signs in reducing deer vehicle collisions during mule deer migrations. Wildl. Soc. Bull. 32 (3): 907–915.

2 Knapp, K. K., X. Yi, T. Oakasa, W. Thimm, E. Hudson, and C. Rathmann. 2004. Deer vehicle crash countermeasure toolbox: A decision and choice resource. Final report. DVCIC-02. Midwest Regional University Transportation Center, Deer vehicle Crash Information Clearinghouse, University of Wisconsin-Madison, Madison, WI.

3 Mode, N. A., E. J. Hackett, and G. A. Conway. 2005. Unique occupational hazards of Alaska: Animal-related injuries. Wilderness and Environmental Medicine 16:185–191.

4. Huijser et al. 2008. Wildlife-vehicle collision reduction study: Best practices manual. DTFH61-05-D-00018. 184pp.

5. Boeckman Road Extension Project staff, City of Wilsonville, Oregon, personal communication.

Table 5-3. Common types of wildlife crossing measures and their associated actual and estimated costs.

Measure	Cost
Fencing	\$2.51–\$6.41/ft² for 8-ft high fence with wooden treated posts and a smaller mesh fence with a dig barrier at the base. The small mesh fence costs about \$1.11/ft²
Underpasses	
Open-span bridges	Bridge 98 ft wide x 39.4 ft high spanning 2 lanes — \$435,340 Bridge 39 ft wide x 16.4 ft high spanning 4 lanes — \$675,000–\$965,000 Single span bridge 15 ft wide x 9 ft tall — \$200—\$300/ft²
Large mammal underpasses (23–26 ft wide x 13–16.4 ft high)	23 ft wide x 13.1 ft high spanning 4 lanes — \$217,000–\$241,000 Arch culvert 23–26 ft long x 16.4 ft high on a 60–71.8 ft road — \$74,333 Arch culvert 24 ft wide x 12 ft high x 178 feet long — \$150,000 Elliptical corrugated metal culvert 13 ft high x 23 ft long — \$1,100/linear ft
Medium mammal underpasses (2.6–9.8 ft wide x 1.6–8.2 ft high)	Culvert 9.8 ft wide x 8.2 ft high spanning 4 lanes — \$173,725 Culvert 9.8–13.1 ft wide x 9.8–13.1 ft wide spanning 2 lanes — \$940,000 Box culverts 4–6 ft wide x 4–6 ft high, 90 feet long — \$70,932 Box culvert 4 ft high x 4 ft wide by 9-feet long — \$180–\$200/linear foot
Small and medium mammal culverts (1–2 feet diameter)	2 foot diameter culvert — \$297–\$509/ft
Amphibian wall, including footing	\$100–\$150/linear foot
Daylight inlets for culverts	\$2,000 each
Retaining walls	\$50 to \$150/ft²
Overpasses	170.6 ft wide x 229.7 ft tall over 4 lanes — \$1,688,993 An overpass over a 2 lane road — \$1,542,000–\$2,467,200
Signs	
Standard (no illumination or sensors) wildlife warning signs	\$94/sign (plus costs of maintenance and replacement) (1975 figure) (ODOT, pers. comm.)
Seasonal wildlife signs (2 per mile, one in each direction)	\$435/mile
Variable message sign	\$100,000–\$200,000 depending on whether sign is permanent or moveable
Animal Detection Systems	\$65,000-\$154,000 \$20,000 if system is used simply to cover gaps in a fence (versus an entire sensor system for a length of roadway)

5.10 Lessons Learned. . . A Wildlife Population in Decline

During the planning phases of Interstate 84 in southern Idaho, it was known that the highway would bisect the historic migration route of mule deer herds (Figure 5-45). However, no accommodations were made for the deer when the highway was built, and when it was completed, in 1969, deer mortality skyrocketed. Shortly after the highway was completed, road improvements were constructed, presenting another opportunity to build undercrossings. Yet the crossings were deemed too expensive to build. Instead, wildlife reflectors and diversion fences were installed, to little effect. Starvation soon became a problem because the highway kept the deer from reaching their winter feeding grounds, and an extremely expensive feeding program was instituted (a trust fund for the feeding program would have needed $1.3 million in 1982 dollars to feed 1,900 deer over 50 years.) Today, few deer cross the highway, because the herd no longer travels to its traditional winter feeding grounds. By 2001, the herd numbered 1,500 animals, down from 4,000–5,000 deer in the 1960s.

Lessons learned: Incorporate needed crossings into the initial design of transportation projects.

Figure 5-45
Construction of I-84 in southern Idaho (top photo: Courtesy of Idaho Department of Transportation) bisected mule deer habitat, which prevented them from accessing winter feeding grounds. Photo of mule deer by Len Carpenter.

5.11 Other Sources of Information and Examples

US Department of Agriculture, Forest Service, San Dimas Technology and Development Center, with the Utah State University Berryman Institute. Wildlife Crossing Toolkit
http://www.wildlifecrossings.info/beta2.htm

US Department of Transportation, Federal Highway Administration. Critter Crossings: Linking Habitats and Reducing Roadkills.
http://www.fhwa.dot.gov/environment/wildlifecrossings/main.htm

Keeping it Simple: Easy Ways to Help Wildlife Along Roads
http://www.fhwa.dot.gov/environment/wildlifeprotection/

Wildlife Habitat Connectivity Across European Highways
http://www.international.fhwa.dot.gov/wildlife_web.htm

US Geological Survey, Paynes Prairie Ecopassage Project
http://cars.er.usgs.gov/Amphibians_and_Reptiles/Paynes_Prairie_Project/paynes_prairie_project.html

US Fish and Wildlife Service
Refuge Roads Progam : Ecology and Biology Online Resources
http://www.fws.gov/refuges/roads/road_ecol_biol.html

Center for Transportation and the Environment
Wildlife, Fisheries, and Transportation Web Gateway
http://cte.ncsu.edu/CTE/gateway/home.asp

Wildlife Crossing Structures Field Course
www.itre.ncsu.edu/CTE/gateway/banff_index.asp

Converge: Where Transportation and the Environment Meet. Wildlife, Fisheries, Ecosystems
http://www.converge.ncsu.edu/topics/topics_display.asp?topic_ref=21

Defenders of Wildlife, Habitat and Highways Campaign
http://www.defenders.org/habitat/highways/
http://www.defenders.org/habitat/highways/new/library.html#3

Other Organizations

International Conference on Ecology and Transportation: useful links - http://www.icoet.net/links.asp

CORDIS. COST 341: Habitat Fragmentation caused by Transportation Infrastructure
http://cordis.europa.eu/cost-transport/src/cost-341.htm

Natural Resource Defense Council. The End of the Road: Adverse Ecological Impacts of Roads and Logging: Bibliography - http://www.nrdc.org/land/forests/roads/refer.asp

Surface Transportation Policy Project: The CMAQ Program: Funding Cleaner Air
http://www.transact.org/library/decoder/cmaqdecoder.pdf

World Bank: Roads and the Environment Handbook: Table of Contents
http://www.worldbank.org/transport/publicat/reh/toc.htm

National Cooperative Highway Research Program: Interaction Between Roadways and Wildlife Ecology: A Synthesis of Highway Practice (Synthesis 305)
http://www.floridahabitat.org/wiki/pdf/transportation-infrastructure-and-wildlife-conservation/Roadways-EcologyNCHRP305.pdf

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"The practice of conservation must spring from a conviction of what is ethically and aesthetically right, as well as what is economically expedient. A thing is right only when it tends to preserve the integrity, stability, and beauty of the community, and t*he community includes the soil, waters, fauna, and flora, as well as people."*

— Aldo Leopold

Chapter 6 Funding a Vision

Improving landscape permeability for wildlife addresses protection and/or restoration of fish and wildlife habitat, water quality, and endangered species. A wide variety of funding options—from federal, state, and private sources—are available because of the diversity of wildlife crossings and the potential to incorporate other objectives, such as hiking trails, into the project. If a crossing project provides accommodations for sensitive species, it may qualify for funds dedicated for Endangered Species Act compliance. Or, if a crossing is linked wit a hiking trail, it may qualify for recreational trail improvement funds. These examples demonstrate how incorporating multiple objectives into wildlife crossing projects improves access to a broad array of funding opportunities. This section highlights just a few of the funding sources that may be available to enhance landscape permeability for wildlife.

6.1 Federal programs

To date the federal government has appropriated $10.4 billion for transportation enhancements via federal transportation bills (Table 6-1).

Table 6-1. Federal appropriations for transportation enhancements, 1991–2009.

ISTEA	1991–1997	$2.8 billion
TEA-21	1998–2005	$3.6 billion
SAFETEA-LU	2005–2009	$4 billion
	1991–2009	Total: $10.4 billion

For more information on SAFETEA-LU
Federal Highway Administration Web pages:
http://www.fhwa.dot.gov/safetealu/index.htm
http://www.fhwa.dot.gov/reauthorization/

Transportation Enhancement

The Transportation Enhancement (TE) program is part of SAFETEA-LU, and provides federal highway funds for projects that add to the cultural, aesthetic, or environmental value of the transportation system. These funds may be used for local agency projects and local roads. There are 12 TE activities, one of which is “Environmental mitigation to address water pollution due to highway runoff or to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity: Runoff pollution mitigation, soil erosion controls, detention and sediment basins, river cleanups, and wildlife crossings.” This category makes provisions for wildlife crossings and planning for habitat connectivity. Types of projects funded in this category (Figures 6-1, 6-2, 6-3, 6-4) have focused on wetland restoration and the management of stormwater runoff. But the list of funded projects also includes a wildlife mortality study, technology for wildlife highway warning systems, and crossings to improve linkages in wildlife corridors (Figure 6-1). The federal government reimburses 80 percent of the costs of a TE project; the project sponsor pays the non-federal 20 percent match, with some exceptions in states with large amounts of federal lands.

“From 1998 through 2006, state transportation agencies programmed just $53 million for TE projects, most of which went to stormwater projects. Only $11.5 million was programmed to ‘reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.’ Of the 23,000 TE projects, only 71 have been related to wildlife habitat connectivity. Just 20 states have implemented wildlife-related TE projects, averaging $161,971 per project. Conservation advocates and natural resource managers are missing a golden opportunity. Since TEA-21 in 1998, $8.1 billion has been authorized for all TE projects. If each of the twelve categories received equal portions, that would mean $675 million for wildlife, more than $61 million per year.” — *Defenders of Wildlife*

Figure 6-1
US Highway 27 is a four-lane highway that was built directly across a 3/4-mile portion of northwest Lake Jackson in Florida, isolating part of the lake to the west now known as Little Lake Jackson. US Highway 27 is virtually impassable to turtles and other wildlife, as 23,500 vehicles traveling along it each day. In the past eight years (as of April 2008), monitoring this area for wildlife mortality has revealed that over 11,270 animals of 61 different species (not including birds) attempted to cross the half-mile section of US Highway 27 at Lake Jackson. Until a permanent structure (see graphic) can be built, temporary fences (seen in photo to the left) guide wildlife to a culvert under the road. Local wildlife enthusiasts hope to obtain the funding to construct permanent fences. This project would be eligible for TE funds. A total of $545,000 was spent on feasibility study and design. The cost to construct the entire project will be $6,078,981. Photo credit: Matthew J. Aresco.

Figure 6-2
This Sauvie Island wetland is an example of a wetland that has been restored. Wetland restoration and acquisition projects meet the eligibility requirements for TE funds if they reduce the impacts of water pollution due to highway runoff or reduce vehicle-caused wildlife mortality while maintaining habitat connectivity. Photo credit: Bruce Taylor, Defenders of Wildlife.

Figure 6-3
The Hawthorne Hostel in southeast Portland now has an ecoroof and rainwater harvesting system ($130,000) that includes two-4,000 gallon cisterns that collect rainwater from the roof. The bioswale seen in the lower portion of the photo will help to filter pollutants from the street as well as handle overflow from the cistern. Photo credit: Jennifer Goodridge, City of Portland Bureau of Environmental Services.

Figure 6-4
Bioswales (photos on left) and ecoroofs (photos on right) are projects eligible for Transportation Enhancement funds (stormwater management) and can enhance overall landscape permeability in the Portland metropolitan area. Notice the cutout in the parking lot in the lower left photo. This allows for water runoff as well as small mammal movement. Photo credits: City of Portland, Bureau of Environmental Services.

Currently, the Oregon Department of Transportation (ODOT) administers the distribution of all TE funds in the state. This process is completed in two-year cycles.

Possible projects for TE dollars include:

- wildlife crossing structures, including the necessary project feasibility, planning, research, scoping, designing, engineering and construction;

- bridge extensions to accommodate terrestrial crossings;

- habitat acquisition to re-establish habitat connectivity;

- installing wildlife exclusionary fencing or other structures to guide wildlife toward crossings;

- installing technologies to deter wildlife-vehicle collisions, such as radio collars or remote-sensing devices which trigger warnings to drivers;

- monitoring and data collection on habitat fragmentation;

- wildlife-vehicle collision data collection;

- identifying collision hotspots through tracking, telemetry, and wildlife cameras;

- researching and mapping wildlife habitat threatened by fragmentation;

- creating or updating state or regional habitat connectivity plans;

- researching migration patterns, habitat use, distribution, and crossing behaviors;

- restoring aquatic passages and watersheds to provide adequate wildlife corridors and stream flows;

- evaluating roadside vegetation, removing invasive species and planting native species along right-of-ways and neighboring properties to provide wildlife habitat, erosion control, and storm water management;

- training and planning related to wildlife-vehicle collision reduction and habitat connectivity; and

- education to reduce wildlife-vehicle collisions.

To learn more the TE program, visit:
Oregon Department of Transportation (503) 986-3528
http://www.enhancements.org/

http://www.defenders.org (to read The $61 Million Question: How Can Transportation Enhancements Benefit Wildlife?)

Recreational Trails Program

Recreational Trails Program funds are available for a number of purposes, including the development of trail linkages in urban areas (Figure 6-5), restoration of existing trails, and the acquisition of property and right-of-way for trails. The funds provide an 80 percent federal share, and allow applicants to use other federal funding programs to cover the remaining 20 percent. Public parks that host nature trails, particularly green corridors, such as the Springwater Trail Corridor that runs east/west from northeast Portland to Boring, may be appropriate locations to consider additional enhancements to landscape connectivity. Recreational Trails Program funds may provide an incentive to explore this option.

Figure 6-5
The Springwater Trail is a green corridor that provides wildlife habitat and connectivity in the Portland metropolitan area. Multi-use trails that provide for hiking, biking, and other pedestrian uses, should be evaluated for additional opportunities to enhance wildlife connectivity and landscape permeability.

For more information on Recreational Trails funding:
Oregon Parks and Recreation Department
State Trails Coordinator, (503) 986-0711

Highway Safety Improvement Program

The Highway Safety Program at ODOT implements highway safety improvement projects to reduce traffic fatalities and serious injuries using funds from SAFETEA-LU. Highway Safety funds are programmed in the Statewide Transportation Improvement Program (STIP). The Oregon Transportation Commission (OTC) has allocated about $28 to $29 million dollars a year to the ODOT Highway Safety Program for 2006 through 2009 for infrastructure improvements.

"An eligible project is defined as any identified highway safety project to correct or improve a hazardous road location or address a highway safety problem . . . and includes the addition or retrofitting of structures or other measures to eliminate or reduce crashes involving vehicles and wildlife."

For more information on the Highway Safety Improvement Program:
Oregon Department of Transportation
Traffic-Roadway Section, (503) 986-3568
http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/

6.2 State Programs

Statewide Transportation Improvement Programs (STIP)—Road Modernization Funds

ODOT appropriates funding for the design, engineering, construction, and preservation of projects through the STIP process, Oregon's four-year transportation capital improvement program. The process identifies funding for, and scheduling of, transportation projects and programs, including projects for city and county transportation systems and multi-modal projects (highway, passenger rail, freight, public transit, bicycle, and pedestrian).

For more information on STIP, contact:
Oregon Department of Transportation, (503) 986-4124

Highway Bridge Replacement and Rehabilitation

Bridges are defined by the National Bridge Inventory as any crossing structure that is 20 feet or longer. The Oregon inventory of bridges includes crossings longer than 6 feet. Recognizing that 350 of the state's bridges were nearing the end of their 50 years of planned use, and 1,000 bridges were vulnerable to earthquakes, ODOT launched a State Bridge Delivery Program to invest $3.8 billion to make the necessary repairs. This presents an opportunity to integrate wildlife crossings into bridge retrofit designs because the incremental cost of adding facilities for safe wildlife passage is relatively low.

For more information on ODOTs Bridge Delivery Program, contact: Oregon Department of Transportation, (503) 986-3985

Bicycle / Pedestrian Facilities

The State of Oregon requires that "reasonable amounts" of state highway funds be directed to facilities for bicycle and pedestrian travel. Walkways and bikeways that combine wildlife passage may help satisfy this requirement and provide a cost-sharing opportunity that should not be overlooked, particularly in urban areas.

For more information on ODOT's Bicycle and Pedestrian Program, contact:
Oregon Department of Transportation, (503) 986-3555

6.3 Regional Programs

In the Portland metropolitan region, most federal and state funds are channeled through Metro, the regional Metropolitan Planning Organization (MPO), where local government representatives allocate funds based on regional needs. Metro funding is allocated through the Metropolitan Transportation Improvement Program (MTIP). The MTIP is a multi-year intermodal program of transportation projects that is consistent with the regional transportation plan. The MTIP offers an opportunity to incorporate a wildlife crossing into current or upcoming transportation projects. A regional assessment to identify candidate locations for crossings should be conducted, and identified locations should then be integrated into current and upcoming MTIP projects.

For more information on MTIP or how to participate in upcoming processes for input:
Metro, Transportation Planning
(503) 797-1757
http://www.metro-region.org/pssp.cfm?ProgServID=2

6.4 Capital Improvement Plans

Local jurisdictions prioritize new projects and retrofits or improvements in the Capital Improvement Plan (CIP). Project funding is allocated based on this priority list. CIPs represent a five-year planning horizon and are reviewed periodically to account for changing conditions. Ideally, wildlife crossings would be included in the original project proposal. However, the CIP review offers another opportunity to incorporate a wildlife crossing into an existing transportation project.

6.5 The Value of Partnerships

Partnerships are critical to the success of any project or set of projects that enhance landscape permeability for wildlife, including wildlife crossings. Involving partners in the earliest stages of project planning results in buy-in and ownership of the project, and potential sources of funding to match federal and state contributions. In addition, long-term monitoring and research (Section 7) can be achieved through strong partnerships.

For example, the I-90 Wildlife Bridges Coalition in the State of Washington was created to advocate for high quality wildlife passages (Figures 6-6, 6-7) as part of the I-90 expansion east of Snoqualmie Pass in the Cascades. The Department of Transportation is expanding I-9 from four to six lanes, which would further bisect critical north-south wildlife corridors. Many organizations came together to acquire critical wildlife habitat along the transportation corridor, raise funds, and further develop this transportation corridor.

In Montana, a $229,000 underpass at Austin Crossroad (Figure 6-8) was constructed as part of a shoulder-widening project along highway 206 to enhance landscape permeability for elk and grizzly and black bears, providing safe passage for them

Figure 6-6
*Biologists found Pacific giant salamanders (*Dicamptodon *spp.) (lower left) and tailed frogs (*Ascaphus truei*) in Hudson Creek, which flows under I-90 (top left) in Washington. The middle left graphic is a rendering of the proposed underpass that would be constructed as part of the I-90 expansion. Highway photos and graphic rendering credits: Washington Department of Transportation. Pacific giant salamander photo credit: U.S. Geological Survey.*

Figure 6-7
Easton Hill (top right) is an important wildlife corridor for elk (lower right) and deer along I-90 in Washington. The middle right graphic is a rendering of the proposed wildlife overpass that would allow deer and elk to safely cross the highway. Highway photos and graphic rendering credits: Washington Department of Transportation. Elk photo credit: Ginger Holser.

as they move from Glacier National Park and the Swan Range to the Flathead River. The wildlife crossing, a 9.5-foot x 13.5-foot arch with a dirt base, was made possible by a public/private partnership that worked together to initiate a fundraising campaign. Although part of the project was funded from federal aid dollars, the balance came from Flathead County; Montana Fish, Wildlife and Parks; American Wildlands; the Yellowstone to Yukon initiative; the Wildlife Land Trust; and the developer of a nearby subdivision. Local landowners donated their right-of-way allocation (worth about $21,000); in turn, they now have a safe crossing for their livestock.

Lessons learned: Local landowners noted two key factors made this project a success—recognize opportunities to install wildlife crossings during transportation planning stages, and be willing to forge relationships outside of existing networks to leverage resources.

6.6 Explore Cost-Sharing Opportunities

Building wildlife crossings as part of an initial construction project is, overall, far less expensive than retrofitting an existing roadway—it avoids the disruption of excavating, traffic management, and disruption to pavement, shoulders, utilities, and the natural landscape. However, when retrofits are unavoidable, combining wildlife crossings projects with other types of retrofit projects is a good way to defray some of the costs. Wildlife crossings could be added to a culvert retrofit to provide a more ecologically balanced retrofit (see Section 5.5).

Figure 6-8
The Austin Crossroad project in Montana is an excellent example of how partnerships can help raise adequate funds for crossing structures and meet multiple objectives. Local landowners donated right-of-way for this crossing structure targeted for use by elk. In addition, these landowners can use the crossing to safely move their livestock during key seasonal periods. Photo credit: Pat Basting, Montana Department of Transportation.

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“The causes of biodiversity decline must be understood in order to devise effective countermeasures. None of this can take place without the participation of society at large, who have to be convinced about the importance of biodiversity if there is to be any real hope of implementing meaningful measures.”

— Ilkka Hanski
University of Helsinki, Finland

Chapter 7 You’re Not Finished When You’re Done

7.1 Monitoring and Maintenance

Completing construction of a wildlife crossing to enhance landscape permeability for wildlife doesn’t end when the structure is completed. Impediments to effective wildlife crossings fall primarily into two categories: mis-location of structures and lack of maintenance and accompanying fences to guide wildlife (Bissonette and Cramer 2007). Monitoring of the structure ensures that the structure is achieving, over time, what was intended when it was designed and installed.

Wildlife crossings that are not properly monitored or maintained can experience the detrimental effects of the weather (i.e., snow) and people (i.e., camping within structures). Because maintenance is important to the long-term success of wildlife structures, the cost of monitoring programs should be included in the overall budget.

Monitoring and maintenance of wildlife crossing structures helps ensure the structures continue to function over time and that knowledge gained can be used to further refine mitigation techniques (Jackson and Griffin 2000). Effective monitoring, combined with adaptive management, can lead to refinement and enhanced effectiveness of passage structures and accompanying fencing (Gagnon 2008), which can help to ensure increased wildlife permeability and habitat connectivity.

Time . . . Patience

In an evaluation of 18 studies spanning 30 years, the average monitoring period of wildlife crossing structures was 17.3 months. Wildlife use of crossing structures tends to increase over time, as animals need time to learn their location and learn that they are safe to use (Huijser et al. 2007) (Figure 7-1). Also, it may take at least two years for wildlife to adapt to crossing structures, especially if they use the area only for seasonal migration (Bissonette and Cramer 2007). In a comprehensive study of wildlife crossing structures at Banff National Park in Canada (Clevenger et al. 2002), there was an increase in the use of the structures by wildlife over time. For example, grizzly bears, wolves, and black bears increasingly used overpasses over time, especially between years three and five. In addition, use of overpasses and underpasses by deer and elk increased significantly over a 5-year period.

What Does “Monitoring” Mean?

Monitoring helps determine wildlife use of crossing structures, but is limited in the ability to determine landscape-level impacts to wildlife populations (Bellis 2007)—at best, data on the movement of individual animals through a passage structure is only an indirect measure of the success of a mitigation project. As a result, instead of focusing solely on wildlife use of crossing structures, wildlife movements surrounding the structure should be surveyed. Nevertheless, if funding for monitoring is limited, surveying wildlife use of the structures is considered a minimum effort that should be expended. Opportunities exist to partner with universities and other educational institutions to minimize cost (see Boeckman Road Extension Project on next page). It is important to consult with biologists when developing a monitoring plan to ensure rigor and statistical validity of the project.

Small mammal trapping, track beds/plates, remote camera sensing, snow tracking, road kill surveys, amphibian recording devices, snake pit tagging, surface crossing tracking surveys, camera monitoring, mark-recapture techniques, telemetry studies, genetic analyses, and observational studies have been used to determine the effectiveness of wildlife crossings and

Figure 7-1
It takes time for some wildlife species to begin using wildlife crossings on a regular basis. At this wildlife crossing in north Portland, infrared cameras detected rodents and small mammals, such as raccoons and nutria, using the structure in the first year. In the second year of monitoring, coyotes (pictured) began using the structure. During the third year of monitoring, one of the primary intended species for the structure, western painted turtles, were observed using the crossing. Because of these results, staff that worked on the design and implementation of the crossing structure recommended installing the structure several years before other major construction started in the area to ensure wildlife had a safe, established crossing structure before additional construction disrupted their movement patterns. Photo credit: Port of Portland.

enhanced landscape permeability for wildlife.

The first step in any monitoring program is establishing the right questions and effectiveness measures (Haas 2008). Before-After Control-Impact (BACI) and monitoring approaches are two sound study design methodologies. The steps in designing a monitoring program are as follows (Haas 2008):

(1) determining the focal species, including their detectability, scale, and seasonality;

(2) selecting effective monitoring techniques that can support the study questions;

(3) developing a BACI study design that includes before and after improvements, a control not subjected to highway improvements, and the impacted section of roadway;

(4) monitoring approaches to the roadway to better understand animal behavior and activity;

(5) data that can ultimately be stored in regional databases to enhance understanding of wildlife linkages at different scales;

(6) use of adaptive management principles to enhance long-term mitigation success (e.g., additional measures to draw animals to crossing structure entrances); and

(7) incorporation of long-term monitoring.

A Case Study - Monitoring the Boeckman Road Extension Project Wildlife Crossing in Wilsonville

In Wilsonville, Oregon, a road construction project known as the Boeckman Road Extension opened to traffic in July of 2008. Wildlife passage was incorporated into the design of the project, and includes a 405-foot long bridge ranging from 5 to 8 feet high, 2 9-foot x 4-foot box culverts, 4 24-inch and 6 18-inch round concrete culverts to facilitate wildlife passage as well as an amphibian wall and deer fence to prevent wildlife from entering the road surface. Both 9-foot x 4-foot culverts and 2 24-inch culverts include grating that allows natural light to penetrate the culvert.

The Boeckman Road Extension Project is an excellent example of how partnering with a local university (in this case, Portland State University), reduced monitoring costs by providing a student with the opportunity to earn a college degree, while allowing the City of Wilsonville to monitor use of the structure over time.

A mammal wildlife survey was conducted at the Boeckman Road Extension Project site prior to construction. There was evidence of black-tailed deer (*Odocoileus hemionus*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), nutria (*Myocaster coypus*), beaver (*Castor canadensis*), mink (*Neovison vison*), and river otters (*Lontra canadensis*). Adjacent lands are considered prime red-legged frog (*Rana aurora aurora*) habitat, and the presence of a pond as well as an upland island could potentially provide western pond turtle (*Actinemys marmorata*) habitat.

Surveys are conducted using motion detection cameras, sand track data and direct observations to determine the types, frequency, and preferences of wildlife passage use (Figure 7-2). Each passage structure is monitored by at least one method (camera or tracks) while others, such as the bridge, include combinations of methods. Transects at 25 and 100 meters distant from and parallel to the road are monitored by at least three motion detect cameras in combination with pit traps. Pit traps are also used at strategic locations along the amphibian/ reptile wall to verify its use and effectiveness and to determine species present. Motion detect cameras document approach to passageways as well as entrance into them to help determine whether animals are guided to passageways, and whether they ultimately use the passageways. Parallel transects nearest to the road help determine approach to the road and proximity to a structure. Transects will also allow for a comparison of animal activity to determine level of animal avoidance of the road.

Transects and passage structures are monitored for two

Figure 7-2
Infrared cameras monitor wildlife use of the Boeckman Road Extension Project crossing structures in Wilsonville, Oregon. Photo credit: Leslie Bliss-Ketchum, Portland State University.

weeks of each month over the course of one year to account for seasonality. Road kill surveys are conducted and are coupled with observation periods track data to determine the comparative rate of successful road crossings.

Some of the culverts have modifications that allow natural light to enter. Diurnal and nocturnal use of these passageways—relative to ones without natural lighting—is documented. Light levels in the large and small culverts are manipulated by introducing artificial light and/or blocking natural light. All combinations of light manipulations are completed within each season, then repeated the following season to control for natural variation in animal presence.

During monitoring, the passages are assessed for conditions, such as standing water and sediment accumulation, or erosion. These factors could inhibit passage by creating a physical barrier, or promote passage by providing favorable conditions, such as increased moisture for amphibian crossings. Within the passage structures, light level, temperature and humidity are measured.

Human factors that are monitored include traffic (speed and volume) and presence. Traffic levels are expected to increase over time as new development occurs. A general vegetation site assessment is conducted once per season and focuses on the vicinity of passage entrances, but includes the span of all transects.

Ideally, the City of Wilsonville will continue monitoring use of the structures well past the initial two-year post-construction (Figure 7-3).

Figure 7-3
Monitoring the Boeckman Road Extension Project over time, especially as development increases in the area, will be critical to long-term project success. Photo credit: Lisa Nead, City of Wilsonville.

7.2 The Importance of Maintaining Land Use Goals

The best wildlife crossings are ineffective if the habitats they connect are degraded, therefore it is critical the land surrounding crossing structures be managed for the structures to be effective (Patty Garvey-Darda, U.S. Forest Service, pers. comm.).

One of the most important factors in accelerating loss of biodiversity is fragmentation, and human land use is the primary driving force. Reconnecting habitat otherwise fragmented by development is a key step in preserving biodiversity and essential ecological processes (Feinberg 2007).

The elements needed to protect the biological diversity of the region encompassing Portland, Oregon, include habitat patch size, shape of patches to reduce adverse edge effects relative to invasive species and structural complexity, proximity to other habitat areas, uninterrupted wildlife corridors, vegetation cover maps (Figure 7-4), and availability of water. Metro's Title 13 will help to conserve, protect, and restore remaining tracts of high quality viable wildlife habitat in the densely populated Portland metropolitan area. Such legislation is necessary to ensure sufficient wildlife habitat remains as the area urbanizes.

7.3 Updating the Datasets and Using Technology

Sophisticated technology is advancing the development and maintenance of data sets used to make decisions about enhancing landscape permeability for wildlife as well as the elements of the wildlife structures themselves.

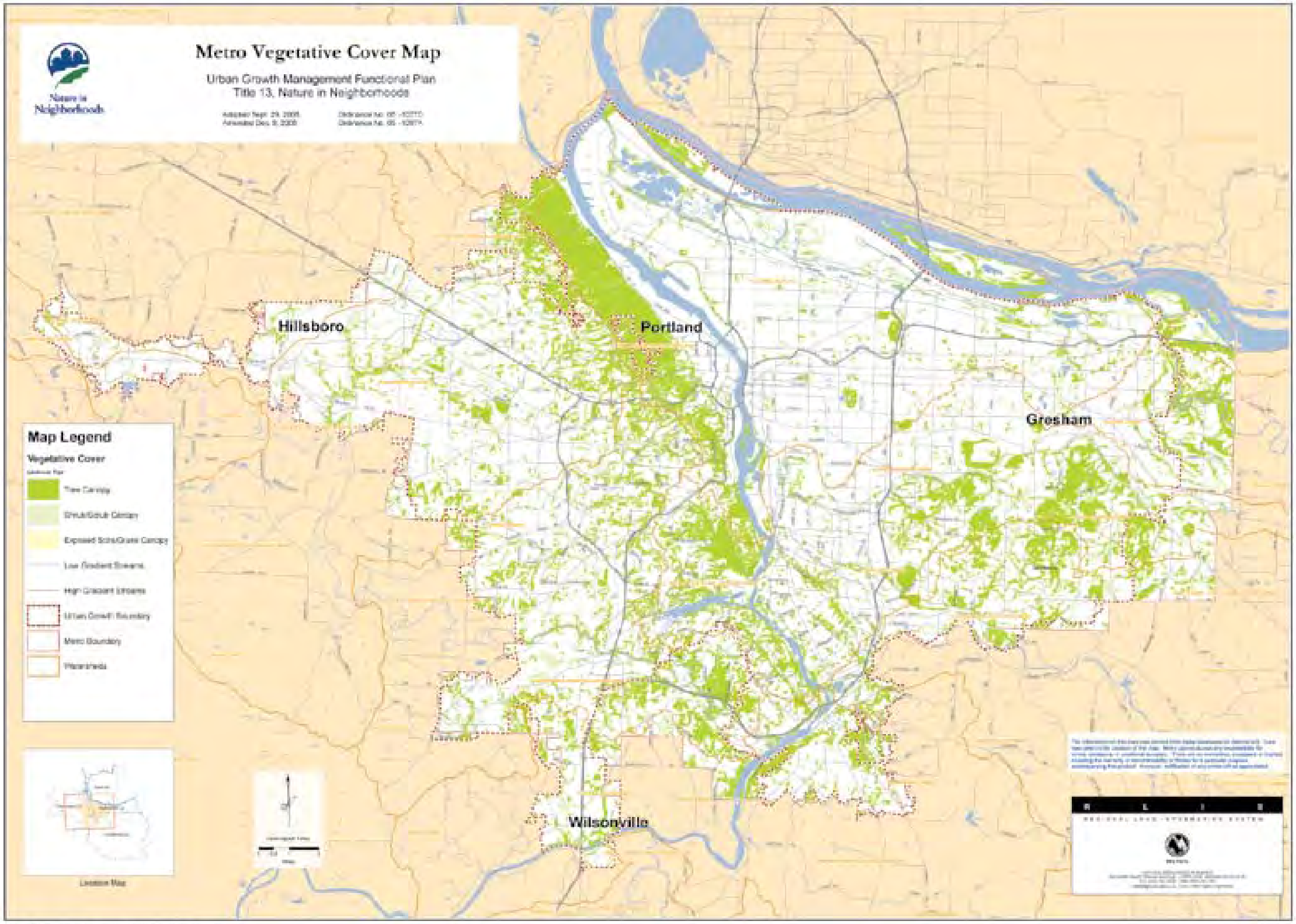

Figure 7-4
Evaluating vegetative cover maps and other data sets will help identify critical habitats and wildlife corridors that need to be maintained and conserved to provide for landscape permeability and ensure biological diversity in the Portland metropolitan area.

Geographic information system advancements allow for layering of data sets to determine the best locations for wildlife crossings as well as significant barriers to landscape permeability. Computer technology simulations provide for the creation of 3-D views of crossing structures at multiple scales and throughout the design and construction phases. And development of products such as ElectroMATs© and ElectroBRAID© at highway entrances use electricity to deter wildlife from entering major roads at hot spot locations. Increasing technological advancements will provide biologists and planners with sophisticated tools to make informed, efficient, and effective decisions to enhance landscape permeability for wildlife.

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