

Chapter 2

Global and Regional Context of Salmonids and Urban Areas

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Although many of the world's surface waters lack salmonids, they range extensively across the Northern Hemisphere and have been introduced successfully into cold Southern Hemisphere waters. Likewise urbanization is a global phenomenon, making the patterns and principles discussed in this book relevant elsewhere. Unlike many urbanized regions of Europe, Asia, and the eastern and north-central United States, salmonid populations continue to persist in urban areas of the Pacific Northwest. In addition, some of the most progressive land use regulations and stream rehabilitation efforts occur in that region, particularly in Oregon. Finally, salmon and trout fisheries are major contributors to local economies in the Pacific Northwest and are a major source of food for many families. In this chapter, we document the regional importance of salmonids and the interest in rehabilitating them via case studies from Idaho, Oregon, and Washington.

2.1 Salmonid Distribution and Decline Worldwide

Salmonid species once ranged throughout much of the Northern Hemisphere (Figs. 2.1 and 2.2). The influence of salmonids has transcended millennia of human development and has formed a key food and economic base for many peoples in

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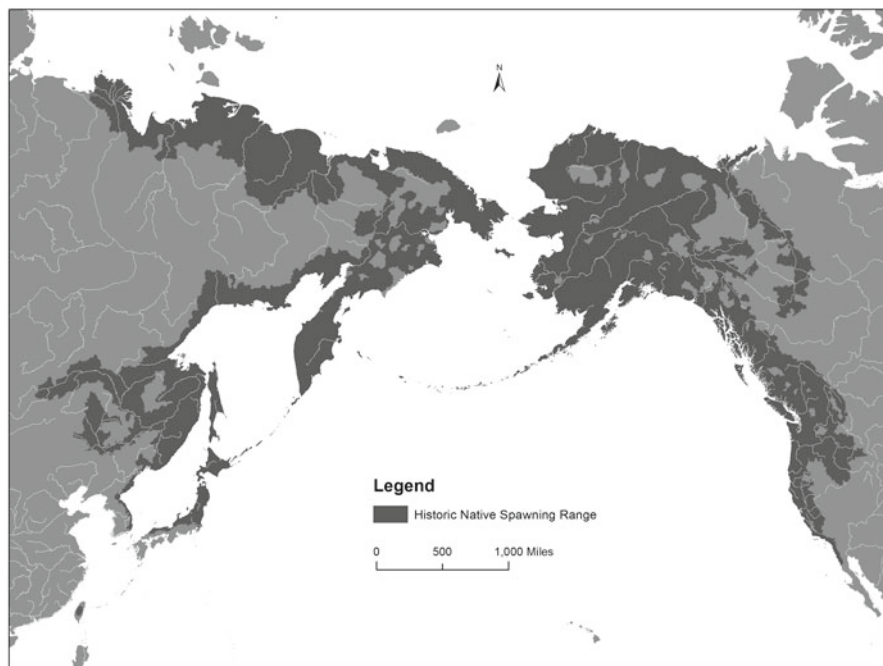


Fig. 2.1 Anadromous Pacific salmon historical ranges. Map based on Augerot (2005)

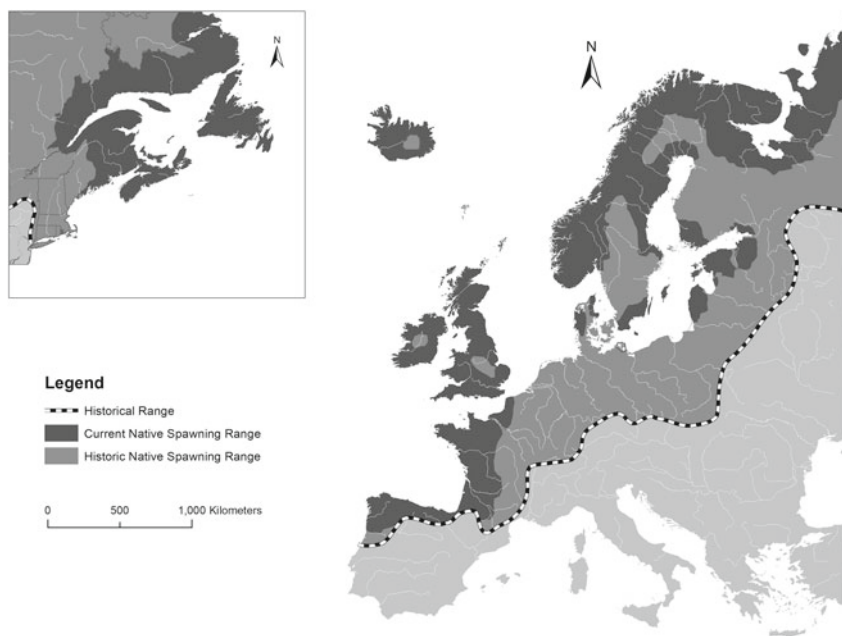


Fig. 2.2 Atlantic salmon (*Salmo salar*) historical and current ranges. Maps based on National Geographic Society (2003) and Department of Fisheries and Oceans (2012, 2013)

North America, Europe, and Asia. Yet, their complex life cycles as well as their marketability as food make salmonids vulnerable to many anthropogenic impacts. The ranges of Atlantic salmon (*Salmo salar*) have been dramatically curtailed in both North America and Europe (Montgomery 2003), but notable reductions in ranges in Pacific salmon (*Oncorhynchus* spp.) have also been seen, particularly in their southern extents. Likewise, the historical ranges of resident trout (*Oncorhynchus* spp.), charr (*Salvelinus* spp.), and whitefish (*Prosopium*, *Coregonus*, and *Stenodus* spp.) have been markedly reduced in North America (Jelks et al. 2008), Europe (Trautwein et al. 2012), and Asia (Dunham et al. 2008).

Numerous accounts have documented reductions in the extent of wild salmonid ranges. Range contractions have gone hand in hand with precipitous drops in population numbers of wild salmon over the past two centuries worldwide (Montgomery 2003; Augerot 2005). When it comes to the causes of the global salmonid decline, urbanization is just a “new kid on the block.” Historical impacts on salmon began in the Pacific Northwest with the high harvest levels that were made possible with the innovation of canning and preservation in the mid-1800s. Cannery production on the west coast of North America peaked between 1882 and 1915, signaling the beginning of the decline in anadromous salmonid populations in those regions (Cobb 1930). The decline of salmon stocks caused the first rise of fish hatchery operations, which resulted in further declines in wild salmon.

In addition to harvest and hatchery impacts, other harmful stressors on salmonids have come in the form of by-products of the industrial economy. These impacts from the industrialized western economy on salmonids include the fur trade (particularly beaver, *Castor canadensis*), mineral mining, timber harvest, grazing, and irrigation practices (Lichatowich 1999), which altered the geomorphology, hydrology, and water quality of salmonid-bearing streams, rivers, and lakes. One of the most blatant of impacts on salmonids came from North American, European, and Asian hydropower industries, with the constructions of dams on salmonid-bearing rivers throughout the Northern Hemisphere beginning in the late 1800s. Large-scale dam and water diversion projects eliminated salmonids in many upstream river segments and tributaries. Taken as a whole, Pacific Northwest fishery managers often categorize the impacts on wild salmonids into four separate categories: harvest, hatcheries, hydropower (dams), and habitat (i.e., the four Hs). Urbanization most dramatically degrades salmonid habitat and also touches on the other three categories, either directly (e.g., via culverts preventing upstream and downstream fish passage) or indirectly (e.g., via concentrated market pressure that increases the demand for natural resources and via energy needs from hydroelectric dams).

2.2 Urbanization as an Accumulation of Past Land Uses

Commonly, urbanization is viewed as a recent phenomenon occurring over the past two centuries beginning with the industrial era. It also might be mistakenly assumed that urbanization converts pristine landscapes into areas dominated by hard

Table 2.1 Variables used to define urbanization

Variable	Definition
Total impervious surface area	The fraction of a watershed covered by materials that prevent water infiltration into soil (Arnold and Gibbons 1996)
Connected (or effective) impervious surface area	Impervious surfaces in a watershed with direct hydrologic connections to streams (Walsh et al. 2005)
Population density	Persons per km ² or mi ² (Brandes et al. 2005)
Percent developed land	The fraction of land cover with low or high intensity development within a defined area (Poff et al. 2006)
Structure density	The number of human built structures per unit area (Burnett et al. 2007)
Urban intensity index	Integrates information from several factors (e.g., land cover, population, and socioeconomic population distributions) that quantify human influence (Tate et al. 2005)

surfaces, houses, and storm and sewer pipes. *Urbanization* is generally the process whereby humans move into cities, resulting in the expansion of residential, commercial, and industrial land uses. Broader definitions of urbanization (Table 2.1), however, suggest that this process has been underway for millennia in some locations, and may include development of landscape outside of cities per se (Independent Multidisciplinary Science Team 2010). Cities often develop along rivers and lakes, starting as nodes of waterborne commerce or trading posts, and hence have direct landscape connections to aquatic ecosystems. Current *urban areas* are often the result of an accumulation of past land use impacts, concentrated in specific areas of human influence. As they develop and grow, cities typically expand into areas previously affected by humans such as former agricultural or timber lands. The present character of a given urban landscape, then, also might be affected by prior agricultural (Harding et al. 1998), industrial, and hydrological (Walter and Merritts 2008) legacies, some of which extend back to long before European colonization of North America (Grimm et al. 2008; Briggs et al. 2009).

Outside of urban areas, *rural-residential* (or exurban) development is usually defined by some minimum number of structures or persons per unit area (Theobald 2005) that also have land use impacts. *Rural-residential areas* are developed land outside of city limits or urban growth boundaries (UGBs, i.e., set boundaries separating urban land from rural land), including unincorporated towns, upon which multiple housing units are situated and include infrastructure (e.g., roads, sewers) to support that housing. Either urban or rural-residential *development* may result in changes to the integrity of the landscape that result in impacts to terrestrial ecosystems (e.g., soil compaction, soil erosion, vegetation removal) that may have direct and indirect impacts on aquatic ecosystems, salmonid habitat, and overall salmonid population viability.

2.3 Urbanization in Salmonid-Bearing Regions Globally

Given the extensive historical range of salmonids throughout the upper latitudes of the Northern Hemisphere (Figs. 2.1 and 2.2), it comes as no surprise that significant overlap exists between the locations of urban centers and salmonid-bearing rivers worldwide. Northern Europe has been the region of the greatest overlap between high-density human population centers and historical salmonid habitat. It is likely not just a random coincidence that northern Europe has also been the scene of the earliest and most complete levels of extinction of salmonid runs worldwide. As discussed extensively by Montgomery (2003), salmon in rivers of countries such as Germany and Belgium were abundant in the 1700s, but were extirpated by 1960 (Fig. 2.2). Over 60 % of salmonid species have been extirpated from the Seine River basin, France (Oberdorff and Hughes 1992). Only Norway, Iceland, Ireland, and Scotland still have healthy salmon runs.

Similarly, northeastern North America has witnessed dramatic losses in salmonid populations. Atlantic salmon once ranged along the Atlantic seaboard as far south as New York City and the Hudson River, and inland along the St. Lawrence River to at least Lake Ontario. The decline of Atlantic salmon in New England and New York was first observed as early as the mid-1700s (Montgomery 2003). Presently, with the exception of Maine, wild Atlantic salmon are extinct from US streams. As Montgomery (2003) put it, “Just like Britain, New England traded its salmon for milldams and factories.” While the dramatic reductions and extinctions of Atlantic salmon have many causes, relating again to the four Hs (harvest, hatcheries, hydro-power, and habitat), the co-location of human population centers and salmonid losses in both Europe and eastern North America is undeniable. In addition, extirpation of lake trout (*Salvelinus namaycush*) and whitefishes (*Coregonus*) in the Laurentian Great Lakes were associated with overharvest, water pollution, and the introduction of nonnative species accompanying commercial shipping to supply the industrial cities of the region (Smith 1972).

2.4 International Salmonid Management Context

In recent decades, treaties have been established to protect and conserve wild salmonids on the international scale. For example, in October 1983, the Convention for the Conservation of Salmon in the North Atlantic Ocean was signed by nations including many from the European Union as well as the former Soviet Union, Canada, and the United States (NASCO 2013). This treaty created NASCO (the North Atlantic Salmon Conservation Organization), an intergovernmental agency with goals to conserve, restore, enhance, and rationally manage wild Atlantic salmon. The Convention also established a large protection zone, where targeted fisheries are prohibited in most areas beyond 22 km from coastlines, which corresponds to Article 66 from the United Nations Convention on the Law of the Sea for anadromous stocks (United Nations 2013).

On the Pacific side, an international treaty was also established shortly after NASCO was formalized. In 1985, Canada and the United States signed the Pacific Salmon Treaty and created the Pacific Salmon Commission (2013) to implement the treaty. While not a regulatory body, the Commission provides regulatory advice and recommendations to both Canada and the United States. The goals of the Commission are to conserve Pacific salmon and steelhead trout and to divide commercial salmon harvests between Canada and the United States so that each country benefits from its investment in salmon management.

While these international treaties were steps forward in the conservation of anadromous salmon, their focus is primarily on oceanic aspects. Regulatory efforts to address the freshwater and shoreline aspects of salmonid conservation are left to individual nations to manage for their respective streams and rivers. Moreover, within each country, a complex regulatory framework to manage salmonids exists, spanning from federal regulations to local ordinances. Matters concerning urbanization effects on salmonids, in particular, have both federal triggers such as specific salmonid runs being listed as threatened under the federal Endangered Species Act (ESA) and state and local regulations, such as Oregon's land use law of 1973. Balancing the protection of these species, while promoting economic growth and development, is a fundamental conflict for regulators and managers at all levels (Czech 2013).

2.5 Rationale for a Focus on the Pacific Northwest

North America's Pacific Northwest provides an ideal region to examine the effect of urbanization on salmonid ecology and sustainability. In this region, a large number of salmonid populations have been extirpated during the past century, with many others threatened (Nehlsen et al. 1991). At the same time, human population and economic growth has been steadily increasing, with particularly explosive growth occurring during the past 2 decades. Moreover, this growth has been accelerating in urban areas, as seen for example in Oregon (Chap. 1, Fig. 1.1). With moderated maritime climate, the Pacific Northwest is also viewed as a potential haven for "climate refugees" as global warming unfolds in the future, thus likely further accelerating urbanization in the region. Yet, as will be discussed, several Pacific Northwest jurisdictions have taken strong steps to rehabilitate salmonid habitat and populations, even in urban areas. Moreover, land use planning in Oregon is unique in the United States, with state level land use laws directed toward containing urban growth within UGBs (Abbott et al. 1994). Thus, with still extant salmon runs, growing cities, progressive land use laws, and active salmonid rehabilitation efforts underway, the Pacific Northwest presents an ideal and ongoing regional case study on whether it is possible for humans and wild salmonids to coexist, if not thrive.

In addition to the present day pressures on salmonids in the Pacific Northwest, the region presents a long history of human and salmonid relations. Native people living in the region practiced a "system of salmon management" that included a set

of customs that functioned to limit their catch and yet harvest the fish efficiently (Lichatowich 1999). That system provided a sustainable salmon-based economy that persisted for up to 4,000 years in the region. Historically, the Columbia River maintained the largest runs of Chinook salmon (*Oncorhynchus tshawytscha*) of anywhere known (Van Hyning 1973). That legacy suggests that there are lessons to be relearned in the region and that the potential for sustainable management exists.

In the intervening years between that era of early aboriginal sustainable salmonid management and the present day, all manner of problems have been introduced to the region. These impacts have come from the canneries and the unfettered harvests of the late 1800s as well as attempts by numerous hatchery operations to restore salmonid levels since then. The impacts have also come from numerous logging campaigns and the splash dams and log sluice operations that served to rearrange the geomorphology of Pacific Northwest streams and rivers, degrading salmonid spawning and rearing habitats. Further, geomorphic damages to streams were introduced via streambed mining operations and agricultural conversions of river side channels and wetland and slough areas. Agricultural impacts on salmonid viability have also come in the form of dewatering of streams for irrigation diversions, reducing stream flows to below those viable for salmonids, particularly in the warmer seasons, resulting in increasingly lethal high water temperatures in Pacific Northwest streams. Agricultural and industrial runoff of toxic compounds further degraded salmonid habitat quality in Pacific Northwest streams, with industrial runoff particularly acute in urban areas. Finally, the implementation of dams, both on the main stems of river systems such as the Columbia River and on smaller tributaries such as the White Salmon River in Washington and the Sandy River in Oregon, literally cut salmon off from their spawning areas and from entire river and stream reaches. Moreover, in urban areas, with high road densities, thousands of stream passage obstructions such as impassable culverts have further reduced habitat accessible to salmonids.

While all these impacts have played out over the past century and a half in the Pacific Northwest, efforts to stem the impacts and recover salmonid populations have been underway as well (Williams 2006). Following the construction of 18 large hydropower-generating dams along the Columbia and Snake Rivers from 1933 to 1975 (Stanford et al. 2006), concerns grew about how to reduce their impact on Columbia Basin salmonids. Three main legal mandates were established in the latter part of the twentieth century, including the 1973 US ESA, the 1980 Northwest Power Planning and Conservation Act, and several federal treaties with Native American tribes. Collectively these legal mandates have resulted in several key organizations with regulatory authority over salmonid conservation: National Marine Fisheries Service (NMFS), US Fish and Wildlife Service, the Northwest Power and Conservation Council, and the Columbia River Inter-Tribal Fish Commission (McConnaha et al. 2006). These organizations, in concert with state and municipal agencies, provide guidance and structure to efforts to better conserve salmonid populations and rehabilitate their habitats in the Pacific Northwest.

2.6 The Unique Planning Approaches and Land Use Laws of Oregon

A great deal of our focus is on the state of Oregon. Many Oregon cities and towns exist along major streams and rivers, so urbanization significantly affects salmonid habitats across the state (Fig. 1.6). In fact, the Portland metropolitan area is the largest urban area in the Columbia Basin. In addition to these clear and present urban threats to salmonid populations and habitat, Oregon also features unique land use laws and planning efforts. In 1973, Oregon passed what became locally known as Senate Bill 100 (Oregon Revised Statute Chapter 197), which launched a state-wide program for land use planning (and discussed more extensively in Chap. 3).

Soon after Senate Bill 100 was passed, several statewide planning goals were implemented to limit the location and density of development on rural lands outside of UGBs, particularly in areas designated for farm or forest uses (Abbott et al. 1994). Two of the land use goals, Goals 5 and 6, include identifying wildlife habitats and aquatic resources and developing local measures to protect these resources from adverse impacts related to development. The UGB serves as a critical component in land use planning for Oregon cities because cities plan for urban development at urban densities within UGBs, thereby discouraging urban sprawl.

In addition to land use laws, Oregon also has taken a unique approach to the problem of rehabilitating salmonid populations by establishing the Oregon Plan for Salmon and Watersheds (Oregon Plan) in 1997 (Oregon Watershed Enhancement Board 2013). The Oregon Plan was a response to the listings of coho salmon and other salmonid populations under the ESA, and has the goal of:

Restoring our native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

The Oregon Plan has several key elements that span the actions of government agencies and private citizens. These elements include: voluntary actions by private landowners; coordinated state and federal and tribal actions; monitoring of watershed and salmonid condition; and strong scientific oversight by an independent panel of scientists (i.e., the Independent Multidisciplinary Science Team). The overall coordination of the Oregon Plan is hosted by the Oregon Watershed Enhancement Board. The Oregon Plan represents yet another aspect of Oregon's unique approach to maintaining its natural resources.

In sum, Oregon's land use planning approach is unique within the United States for at least three reasons that are important for the conservation of salmonids in urbanizing areas. First, the Senate Bill 100 includes specific goals that relate to wildlife habitat and environmental quality. Second, the Senate Bill 100 created a State level oversight process whereby cities and counties must create development plans that meet the varying goals of the Senate Bill 100. Third, the Senate Bill 100 created UGBs to contain urban growth and minimize sprawl. Taken together, the land use statutes of Oregon give the state a unique opportunity to minimize urban impacts on aquatic ecosystems and salmonid habitat.

2.7 Case Studies of Urban Salmonid Management

An additional rationale for examining the relationship between urbanization and salmonid management in the Pacific Northwest rests on the examples of progressive approaches taken by several key cities in the region. In the major cities of the three states that comprise the majority of the US portion of the Pacific Northwest, Idaho, Oregon, and Washington, examples of concerted efforts to restore salmonid populations and habitat have been underway for at least a decade. Among these examples is the successful development of recreational activities for trout fishing in downtown Boise, Idaho. To cover the breadth of Idaho efforts to rehabilitate urban waters, we describe the Boise River Resource Management and Master Plan of Boise, Idaho, and the Teton Creek Restoration Project of Teton County. Also, in Seattle, Washington, efforts to restore several watersheds for coho salmon and steelhead trout have been underway with some success, although much more work remains and the toxicity of urban runoff has resulted in repeated coho salmon die-offs (Scholz et al. 2011). Additionally, Portland, Oregon, responded to the federal listing of several salmon runs as threatened by implementing a city-wide watershed framework plan that put engineers managing sewage and stormwater management in the same room with biologists and planners attempting to restore habitat for wildlife including anadromous fish. Each of these ongoing examples of urban environmental management provides both constructive lessons for how to rehabilitate urban salmonid populations and habitat as well as illustrations of the enormity of the challenges that urban areas face in such efforts.

2.7.1 Boise River Resource Management and Master Plan

Planning. Since 1969, the city of Boise has sought to preserve and protect a greenbelt along the Boise River. In 1999, the Boise Mayor and City Council adopted a plan proposed by the Boise Parks and Recreation Department (City of Boise 1999). In addition to planning consultants, the plan was developed by a steering committee composed of representatives from state and city agencies, recreationalists, water rights proponents, and property owners to represent broad public interests. The planning process included many working meetings, field trips, public hearings, and plan preparation. The objective of the plan is to provide and enhance sustainable water-based and land-based recreational opportunities in and along the Boise River and its floodplain, as well as to protect resident and migratory fish and wildlife including bald eagles (*Haliaeetus leucocephalus*). Plan elements also include public safety, river bank stabilization, water quality, water rights, land mitigation, and private property rights.

Implementation. The planning area covers 16 river kilometers running through the city and includes riverside parks, the greenbelt, and a 21-m setback from bank full flows. In addition to fishing opportunities, the plan has resulted in improved water quality and safety for recreational kayakers and rafters, and provided miles of greenbelt paths for cyclists, joggers, and pedestrians (Fig. 2.3). The path links



Fig. 2.3 Aerial view of a portion of the Boise River Greenbelt in Idaho (2012© Google)

multiple current and future parks and the protected riparian canopy provides wildlife habitat and bird-watching opportunities. Such features have made the greenbelt the recreational focus of the city and the Boise River Valley.

Progress. Although the river flows through the largest city in the state, MacCoy and Blew (2005) reported that this reach of the Boise River supports cold and cool water fish such as nonnative brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), and wild rainbow trout (*Oncorhynchus mykiss*). Downriver, where the water is warmer and the greenbelt protections are lacking, the salmonids are replaced by nonnative common carp (*Cyprinus carpio*), bass (*Micropterus*), and channel catfish (*Ictalurus punctatus*).

Continuing management challenges include a patchwork of private and public land ownership, differing city and county government policies, irrigation diversions, occasional insufficient ecological flows, overuse by recreationalists, and conflicts regarding removing selected snags that may endanger rafters and kayakers but provide refuge and habitat complexity for salmonids.

2.7.2 Teton Creek Restoration Project, Driggs, Idaho

Planning. From 2000 to 2008, Teton County, Idaho, which previously had an agricultural economy, was one of the most rapidly developing counties in the United States. Idaho Code 67-6502 obligates counties to regulate land uses to promote public welfare, health, and safety. Unlike several surrounding counties, Teton County has only small, noncontiguous reserves of protected public lands. In the real

estate boom of the early 2000s, property owners rushed to convert agricultural properties to residential subdivisions. Over 30 % of the private land in Teton County was subdivided into sprawling developments. The unprecedented growth rate resulted in 7,000 vacant lots in a county with 10,000 citizens. The real estate bust in the late 2000s gave county citizens an opportunity to develop a citizen-based comprehensive plan led by over 80 volunteers representing county agencies, and business, natural resource, outdoor recreation, agriculture, and youth interests, together with planning consultants (Teton County 2012).

Teton County is a home to ecologically critical habitat within the Greater Yellowstone Ecosystem and the Teton River and its tributaries host some of the last strongholds of Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*). Along its roughly 4.8-km path from the state line through the City of Driggs, over 600 vacant subdivision lots abut Teton Creek. Those developments were approved prior to the adoption of meaningful environmental, floodplain, stormwater, and other regulations by local planning authorities. As a result, these vacant subdivisions pose a serious threat to future water quality and quantity in Teton Creek from excessive sedimentation, erosion, and other associated stormwater runoff impacts of high-density development along the Teton Creek corridor. Teton Creek also poses an immediate challenge with respect to water quantity and quality in that, as a result of prior streambed damage as well as the demands of local irrigators, the stretch of Teton Creek from the state line to Driggs typically runs dry for several months. The lack of sufficient in-stream flows during those months has prevented Yellowstone cutthroat trout from occupying their historical spawning habitat along this stretch of the creek, further jeopardizing the long-term viability of that species.

Implementation. In 2009 and 2010, Teton County replaced a bridge over Teton Creek to accommodate a 100-year flood, and stabilized approximately 1.2 km of eroding stream banks by reconstructing 150 m of stream, installing two grade-control structures, and revegetating stream banks with native species. Beginning in 2013, 1.2 additional kilometers of Teton Creek are being reshaped to convey a 100-year flood by creating inset floodplains, stabilizing banks, and revegetating 0.043 ha of riparian zones (URS Group 2012; Fig. 2.4).

Progress. Friends of the Teton River (2012) reported that nonnative brook trout (*Salvelinus fontinalis*) and resident Yellowstone cutthroat trout occur in upper Teton Creek. In lower Teton Creek near its confluence with the Teton River, brook trout, nonnative rainbow trout, fluvial Yellowstone cutthroat trout, and mountain whitefish are found. To date, neither nonnative Utah chub (*Gila atraria*) nor nonnative brown trout have been found in Teton Creek, despite their occurrence elsewhere in the Teton Basin.

2.7.3 Seattle, Washington, and Salmonid Habitat Rehabilitation

Planning. In March 1999 NOAA Fisheries listed Puget Sound Chinook salmon as threatened under section 4 of the ESA. The Puget Sound Chinook salmon evolutionarily significant unit (ESU) includes all naturally spawned populations of Chinook



Fig. 2.4 Aerial view of Teton Creek restoration project area, Driggs, Idaho (2012© Google)

salmon from rivers and streams flowing into Puget Sound, as well as 26 artificial propagation programs (Federal Register 2005). In the Seattle metropolitan area, two of the most extensive Watershed Resource Inventory Areas (WRIA) are centered on the Cedar River–Lake Washington watershed (WRIA8) and the Green/Duwamish River (WRIA9). Since the time of the initial listings in 1999, King County and Seattle developed extensive management plans to assist in salmonid recovery and habitat rehabilitation in these urbanized areas (King County 2005a, b).

Implementation. In WRIA9, long-term (50- to 100-year) population targets for wild summer/fall Chinook salmon were set at 27,000 spawning adults, which would represent a three- to tenfold increase over present estimated numbers (King County 2005a). Projected implementation efforts centered on limiting habitats within the Green/Duwamish and Central Puget Sound Watershed, including estuarine transition habitat, marine near-shore rearing habitat, and spawning habitat in the Green River. In the adjacent WRIA8, the most densely populated watershed in Washington with approximately 55 % inside the Urban Growth Area, a salmonid habitat plan was similarly finalized in 2005. The WRIA8 plan identified \$11 million in available funding to help restore salmonid habitat (King County 2005b). Additional habitat plans had also been established for other areas in King County including WRIA7 and WRIA10. By 2012, the Small Habitat Restoration Program (SHRP) had fostered public–private partnerships in King County, and included 41 projects that had



Fig. 2.5 Adult female coho salmon (*Oncorhynchus kisutch*) carcass with high egg retention in Longfellow Creek, Seattle. Shown is a female affected by the mortality syndrome documented by Scholz et al. (2011) in Longfellow Creek (photo Tiffany Linbo, NOAA Fisheries)

resulted in over 3,600 lineal meters of streambank rehabilitated, over 7 ha of riparian buffers enhanced, over 1,000 lineal meters of marine shoreline rehabilitated, and over 37,000 native trees and shrubs planted. Included in these efforts were 20 private property owners who contributed over 4 ha of land for habitat rehabilitation efforts (King County 2012). On a larger scale, the Duwamish/Green River Basin Ecosystem Restoration Project, authorized by Congress in the Water Resource Development Act of 2000, involved 15 cities as well as the Army Corps of Engineers, the Muckleshoot Indian Tribe, King County, and the City of Tacoma. Since 2004, \$10 million in federal funds have been appropriated, and three projects completed that included a hectare of estuarine rehabilitation, culvert replacement, and waterway establishment into Lake Meridian, as well as numerous revegetation, woody debris placement, and gravel replacement projects throughout WRIA9 (King County 2010).

Progress. While numerous urban streams have been rehabilitated physically in the urbanizing Puget Sound area, post-project effectiveness monitoring has revealed anomalous behaviors and high mortality among returning coho salmon. Recent studies have been conducted to determine the cause(s) of these persistent mortality events, which have been observed for more than a decade and have been as high as 90 % of the total runs (Feist et al. 2011; Scholz et al. 2011). Their studies focused on five restored urban streams over an 8-year period, ranging from heavily urbanized (i.e., Longfellow Creek) to lesser degrees of urbanization, as well as a minimally disturbed site (i.e., Fortson Creek). They found that spawner mortality (Fig. 2.5) was positively correlated with the relative proportion of local roads, impervious surfaces, and commercial property within the basin, and ranged from 60

to 100 % of each fall run, versus <1 % in the Fortson Creek site. They found that coho salmon showed evidence of exposure to metals and petroleum hydrocarbons, and concluded that freshwater-transitional coho salmon may be particularly vulnerable to as-yet unidentified toxic contaminant(s) in urban runoff. The implication of this study is that urban stormwater places critical constraints on efforts to conserve and recover salmon populations in urban watersheds or in populations migrating through urban areas (Feist et al. 2011; Scholz et al. 2011). Local-scale morphological changes may not be sufficient to counter watershed-scale alterations in hydrology and water quality when attempting to rehabilitate salmon populations (Doyle and Shields 2012).

2.7.4 Portland, Oregon, and the Watershed Management Plan

Planning. In the late 1990s, the NMFS began listing distinct population segments of steelhead and ESU of anadromous salmon in northern California, Idaho, Oregon, and Washington (National Marine Fisheries Service 2005). These ESUs were listed as threatened under section 4 of the federal ESA. The ESA listings that affected the Portland, Oregon metropolitan area included the Lower Columbia River steelhead ESU (*Oncorhynchus mykiss*) (in August 1997) as well as Lower Columbia River Chinook and coho (*Oncorhynchus kisutch*) salmon ESUs, and the Columbia River chum salmon (*Oncorhynchus keta*) ESU (all in March 1999).

On July 29, 1998 the Portland City Council adopted Resolution No. 35715, entitled *Lower Columbia Steelhead Recovery Plan*. This resolution pledged a city-wide policy to respond to the ESA listing of steelhead with “an integrated, city-wide effort” to create an ESA Steering Committee that spanned all appropriate city bureaus and would work in partnership with NMFS to develop a programmatic response to the listing. Similarly, following the listings of several salmon ESUs in 1999, the City adopted Resolution No. 35894 on June 13, 2000 entitled *Portland Recovery Plan for Salmon and Trout*. With this second resolution, the City committed to the development of a comprehensive framework for developing a recovery plan for all salmonids listed as threatened under the federal ESA by NMFS. Over the next few years, the City developed a comprehensive, watershed-based plan to address the problems of salmonid listings and urban watershed “health.” Approved in 2005, the Portland Watershed Management Plan took a holistic approach that coupled stormwater management with wildlife management, environmental quality, and greenspace provisioning.

Implementation. The Portland Watershed Management Plan consists of six strategies: (1) stormwater management, including the reduction of impervious area; (2) revegetation, to slow runoff and filter contaminants; (3) aquatic and terrestrial enhancement; (4) preservation of natural areas through policy steps; (5) increased pollution and waste management efficiency; and (6) increased education, public involvement and stewardship (City of Portland 2006). To implement the Management Plan, the five major watersheds in Portland (Columbia Slough, Fanno Creek,

Johnson Creek, Tryon Creek and Willamette River) were addressed as whole units to manage. Watershed improvement strategies were developed city-wide, based on criteria ranging from biophysical to socioeconomic, and then implemented for each major watershed.

Implementation of the Portland Watershed Management Plan actually predated its passage. One critical action was the restoration of floodplain area along Johnson Creek, which had historically experienced extensive flooding. The City created the Johnson Creek Willing Seller Land Acquisition Program that offers land owners fair market value for their properties. This program has resulted in extensive gains in riparian habitat along Johnson Creek, in an ongoing effort. Johnson Creek, moreover, has been the site of at least eight major rehabilitation projects that have included major culvert replacements, revegetation projects, bioswale installations, and floodplain enhancements (City of Portland 2012). For all its five major watersheds, the City of Portland has undertaken such efforts, with multiple major rehabilitation and mitigation projects in each.

Progress. Since 1994, the City of Portland has purchased 77 properties (approximately 21 ha) under its willing seller program and helped 60 property owners move out of the East Lents floodplain allowing the City to reconnect a portion of Johnson Creek with its floodplain. From 2002 through 2008, riparian rehabilitation efforts outpaced riparian vegetation losses for Portland, which was in contrast to a pattern of vegetation loss from 1990 to 2002 in Portland, Oregon City, and Hillsboro (Yeakley et al. 2012). The Oregon Department of Fish and Wildlife conducted comprehensive sampling of several major streams in Portland in the mid-2000s, including Balch, Johnson, Saltzman, Stephens, and Tryon Creeks, which indicated mixed results for the condition of salmonid populations in the city. The majority of fish found in these streams were sculpin (62 %), followed by minnows (27 %) and salmonids (9 %). In some creeks, cutthroat trout were the only fish species found, such as Balch Creek, which is hydrologically isolated from the Willamette River. Encouragingly, though, salmonids were present in most streams sampled (as shown for coho salmon in Fig. 2.6). One stream in particular, Stephens Creek, had a high abundance of both coho salmon and Chinook salmon (Tinus et al. 2003). In 2011, the City of Portland has implemented a new status and trends water quality and aquatic biota monitoring program based on US Environmental Protection Agency protocols. Although Portland streams still have a long way to go biologically, the comprehensive watershed planning approach and numerous rehabilitation efforts are thought to be making a positive impact on stream physical and chemical habitat conditions in the city.

2.8 Summary

Salmonids, being generally sensitive to anthropogenic pressures, have experienced global declines in ranges and densities. Their life histories, historical ranges across the Northern Hemisphere, and current ranges in the Southern Hemisphere also

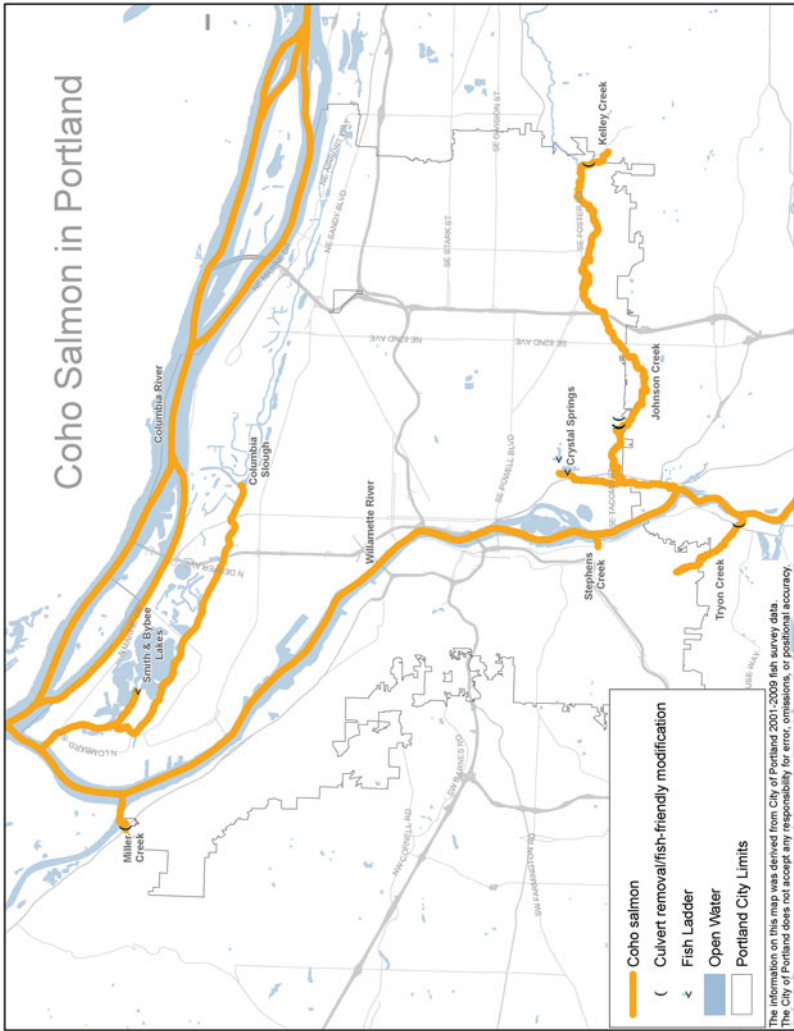


Fig. 2.6 Coho salmon (*Oncorhynchus kisutch*) distribution in Portland, Oregon. Map courtesy of Bureau of Environmental Services, City of Portland

indicate substantial adaptability, genetic diversity, and behavioral plasticity. These biological factors along with increased regulations and rehabilitation efforts may offer a means to reverse salmonid declines, even in urban areas, with some partial success demonstrated in various Pacific Northwest cities. Nonetheless, managed local-scale morphological changes as commonly performed in rehabilitation efforts may not be sufficient to counter watershed-scale alterations in hydrology and water quality when attempting to rehabilitate salmon populations.

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