1. Puget Sound Rivers and Salmon Recovery

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A symposium on Restoration of Puget Sound Rivers at the spring 2000 meeting of the Society for Ecological Restoration's Northwest chapter presented an opportunity to synthesize regional expertise on river and stream restoration into a single volume. Largely drawn from presentations at the conference, the chapters of this book span a wide range of backgrounds and interests, including public policy, riparian forestry, stream ecology, hydrology, geomorphology, geology, and civil engineering. Chapters of the book proceed from geological and geomorphological controls on river and stream characteristics and dynamics, to the biological aspects of river systems in the region, to chapters that address social constraints and the application of fluvial geomorphology, civil engineering, riparian ecology, and aquatic ecology to regional river restoration projects and programs. While we recognize that the material presented herein could not be comprehensive given the broad scope of the subject, these chapters have been selected to provide a compilation of state-of-the-art considerations and approaches for developing river restoration programs.

The recent listing of various runs and stocks of Pacific salmon under the Endangered Species Act (ESA) has focused national attention on the condition of rivers and streams of the Pacific Northwest (PNW). In the Puget Sound region, recent ESA listings triggered statewide efforts to improve channel habitat involving ongoing expenditure of many millions of dollars annually and resulted in preparation of a "Statewide Strategy to Recover Salmon" by the Governor's Salmon Recovery Office (GSRO 1999). Public and governmental response to the listing of Puget Sound salmon stocks is a key national test of the ESA, as it represents a listing of an economically, ecologically, and culturally important species in a major metropolitan area.

A multitude of natural processes and human actions influence salmon abundance, and reversing the ongoing decline of salmon in the Puget Sound re-

gion is complicated by the problem that the collective effect of human activities alters the character and dynamics of rivers and streams and therefore aquatic ecosystems. Factors influencing salmon abundance are often generalized into the "Big Four" influences of harvest, hydropower (dams), habitat, and hatcheries (Figure 1). In contrast to the Columbia River system where the era of dam construction (1938-1975) coincides with a precipitous decline in the salmon fishery (Figure 2), dams are not the primary cause of declines in salmon stocks in Puget Sound. Moreover, historically the most productive Puget Sound salmon streams and rivers were low-gradient channels in major river valleys downstream of major dams. The declines in Puget Sound salmon populations are due to the combined effects of habitat degradation and loss, together with over-harvest exacerbated by hatchery practices that adversely impacted wild salmon. Isolating the relative contribution of these impacts on salmon abundance is further complicated by the effect of climate variability on marine productivity and the survival of adult salmon (Pearcy 1997).

A credible salmon recovery strategy emphasizing river restoration as a key program component should clearly articulate the role for river restoration within the context of an overall recovery strategy that addresses each of the primary impact factors (i.e., all four Hs). Although often overlooked in scoping river recovery efforts, the role of a fifth "H," history, is particularly important because river restoration programs need to assess whether the target rivers in fact can be restored. In addition, an understanding of the extent of recent modifications to river systems is central to identifying what it would take to restore rivers so that society can evaluate whether it is willing to accept that cost. Although answers to these questions remain unclear for Puget Sound rivers, a regional program of river manipulation is now proceeding due to the

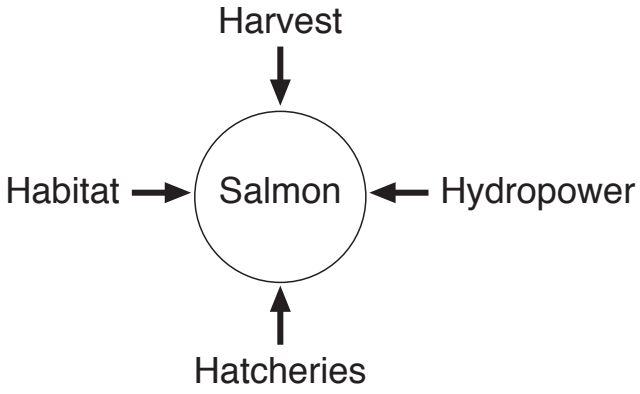

Figure 1. The "Big Four" influences on salmon abundance in the Pacific Northwest.

political need and public desire to act and due to the widespread belief among policy-makers that causes of salmon declines are sufficiently understood so as to be addressed readily.

Yet how well do we know how to restore Puget Sound rivers, let alone the salmon that live in them? What were Puget Sound rivers like prior to European influences? What constraints now exist due to changes in the hydrologic regime from extensive urbanization? How should recovery actions be prioritized or sequenced? This book introduces and discusses various options, opportunities, and constraints on restoration of Puget Sound rivers and streams as part of regional salmon recovery efforts.

Restoration

Restoration means returning something to a prior state. Rivers are dynamic systems in which specific attributes are continually created, altered, and destroyed. Consequently, river restoration means not only reestablishing certain prior conditions but also reestablishing the processes that create those conditions. Although the importance of defining what constitutes the desired state for a restoration effort is obvious, how to define that state is not.

The inevitable lack of data on pre-historic river conditions means that an understanding of the nature, scope, and extent of historical changes is needed to define a reference against which to set restoration objectives. Historical

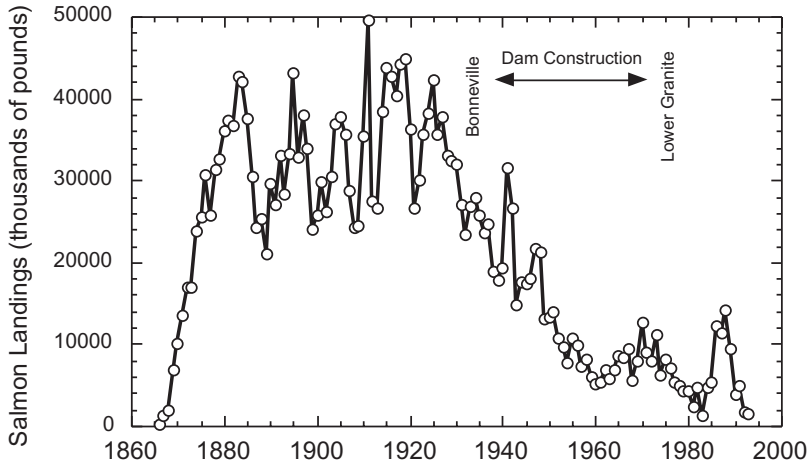

Figure 2. Relation of Columbia River commercial salmon landings (WDFW 1994) to the era of dam construction.

changes to river systems can be interpreted through analysis of historical documents such as maps, surveyors notes, photographs, journals, and other published and unpublished records. Most Puget Sound rivers experienced sweeping disturbances and sustained profound (and in some cases irreversible) changes as Europeans settled the region. Channel-spanning log jams, some of which had been stable enough to support old-growth forests, were cleared in the 1860s through 1880s by early settlers to facilitate up-river navigation and to alleviate local flooding. The Army Corps of Engineers pulled tens of thousands of snags from Puget Sound rivers in a river clearing program that was most active from 1870 to 1920 (Chapter 4*)*. Levee building and diking of wetlands profoundly altered valley bottoms on major rivers from the 1880s through at least the 1940s. Finally, rapid urbanization from the 1950s through 1990s affected hydrologic regimes and channel characteristics (Booth 1991; Chapter 11).

Today's rivers and streams bear little resemblance to those that drained the original forested environment of the Puget Lowlands (Figures 3-6). Although channel conditions have experienced sweeping changes since the last glaciation (Chapter 2), conditions before the extensive anthropogenic changes initiated in the late 19th century define the obvious target for regional river restoration efforts today. Yet each river in the Puget Sound region had different characteristics and dynamics, which have been masked to varying degrees by the extent of subsequent changes. Consequently, watershed-specific reconstruction of historic river conditions provides a useful foundation for river restoration efforts.

Recent work documenting the importance of woody debris recruited from large trees as a source of key members for stable log jams (Abbe and Montgomery 1996) shows the critical importance of riparian forest stand conditions to channel processes and ecosystem functions in Puget Sound rivers. In particular, research on rivers that provide reasonable analogs for river conditions prior to European contact shows that wood-rich river systems had an anastomosing network of floodplain channels controlled by stable log jams, between which a very dynamic main channel periodically avulsed in response to log jam formation (Chapter 4). Because many of the natural habitat-forming processes were mediated or catalyzed by large log jams, restoring Puget Sound rivers to their original dynamic state would require reestablishing recruitment of trees and logs large enough to function as key members and catalyze formation of stable log jams. The fundamental implication therefore is that restoring Puget Sound rivers requires restoring floodplain forests (Chapter 10).

Are we are willing to do what it takes to restore Puget Sound rivers? Some of the earliest historic changes to Puget Sound rivers would be extraordinarily

Figure 3. Riparian buffer in industrial forest land, Tolt River.

Figure 4. Duwamish River in urbanizing King County.

Figure 5. Channel serving as a drainage ditch on the floodplain of the Skagit River.

Figure 6. Historical photograph believed to be Ravenna Creek in Seattle.

difficult to undue. No politician would suggest restoring Olympia Marsh, which once covered much of the floodplain of the Skagit River, even though it was a major salmon nursery before the rivers were cleared of channel-damming log jams. Nor would they offer serious proposals to restore the original drainage outlets of the Cedar and Black Rivers, which were drastically rearranged in the early twentieth century by the lowering of Lake Washington (Chrzastowski 1981). Restoration of floodplain forests is certainly possible in some areas, but it is just as clearly not a viable option for other areas, such as the lower Duwamish River surrounded by paved facilities associated with the Port of Seattle. While restoration is a laudable goal, a more realistic appraisal of constraints and potential opportunities will in many instances lead to adoption of more modest goals—those of river rehabilitation.

Rehabilitation

River rehabilitation aims to improve river conditions but does not necessarily seek re-establishment of natural conditions and dynamics. Given the extensive historic changes to rivers, and the resulting constraints, most projects billed as "river restoration" actually achieve only a form of partial river rehabilitation. Many different types of projects can be considered river rehabilitation efforts. Examples from the Puget Sound region include introduction of spawning gravel to the Cedar River below the Landsburg dam, construction of engineered log jams to retard bank erosion (Chapter 17), and various in-channel structures to promote habitat diversity and channel stability (Chapters 15 and 16). An archetypal example of an urban stream rehabilitation is the proposal to daylight Ravena Creek through the University Village shopping mall in Seattle. While the habitat value of the unearthed channel would be significantly enhanced relative to its present culverted state, the stream would still be flowing through a parking lot. The aim of rehabilitation projects is to improve river conditions, but rehabilitation does not carry the same burden of re-establishing self-sustaining natural conditions associated with the goal of restoration.

Regulation

Regulation means controlling the access to, or the use of, something in order either to prevent undesirable consequences or to promote desirable outcomes. Regulation of the salmon rivers and fisheries of England and Scotland can be traced back before the Norman invasion (Netboy 1974). The earliest known

legislation restricting salmon fishing was probably the edict issued by King Malcolm II of Scotland in 1030 that established a closed season for taking "old salmon." Regulating the effect of dams on salmon fisheries has a long history; an act passed in 1318 during the reign of King Robert the First forbade the erection of fixtures that would prevent the progress of salmon up and down a river. Concern over habitat quality also is long-standing. A statute dating from the reign of Richard the Lion-Hearted declared that rivers be kept free of obstructions so as to permit a well-fed three-year-old pig, standing sideways in the stream, not to touch either side. In other words, the effects of over-fishing, dams, and habitat degradation on salmon have been regulated for centuries. Unfortunately, attempts to recover and restore salmon stocks, dating at least as far back as an act passed in 1712 during the reign of Queen Anne, did not prove particularly successful at preserving English salmon runs.

In the Pacific Northwest today, the political cornerstone of salmon recovery efforts is an emphasis on local control using voluntary measures. In particular, the mantra of "stakeholder involvement" is deeply embedded in our contemporary political landscape, but it is not clear whether salmon are also considered stakeholders with standing equal to economic interests. One way to evaluate the likely effectiveness of salmon recovery efforts founded on such an approach is to examine the past effectiveness of other attempts at local control for salmon management. In New England, for example, acts passed as early as 1741 (by the Colonial legislature) provided for inspection of dams to ensure the adequacy of fish passage. Between 1820 and 1880 over one hundred and fifty fishery laws relating to anadromous species were passed by the state of Maine alone. In these efforts, enforcement of fish passage was provided for at the local level, yet "little or nothing was ever done to implement this legislation—mill dams and weirs multipled [sic] and the fish were locked out in one river after another" (Netboy 1974, p. 180). If there is a lesson here for the Pacific Northwest in regard to salmon recovery efforts, it is that reliance on local control and voluntary measures needs to be guided by an overriding strategy and backed up by regulatory authority, able and willing to evaluate progress and to enforce salmon-conservation measures needed to ensure success of the overall plan.

A final key issue that needs to be incorporated into salmon recovery planning is the demographic trend of ever more people coming into the Puget Sound region (Figure 7). Associations between salmon abundance and land use for Puget Sound rivers indicate that urbanized areas and agricultural lands host low densities of salmon compared to rural and forested areas (Chapter 5). Curiously, most regulatory attention so far has focused on the upland forest environment, even though such areas were probably marginal salmon habitat historically for coho and chinook salmon, the species of greatest

contemporary concern. Salmon recovery strategies have not addressed how to manage lowland habitats for long-term salmon recovery in the face of increasing development. Unless such pressures are addressed, river restoration and rehabilitation programs in place today will simply delay rather than prevent further declines in salmon abundance.

Regulation is the only viable way to address these larger trends. The cumulative effect of individual decisions may not reflect even a strong societal consensus to save salmon, because the emergent outcome of many decisions based on individual or site-specific criteria are likely to produce outcomes at odds with broader societal objectives and desires. Regulatory intervention could be in the form of incentives or outright controls and restrictions, but only the government has the authority to develop and the ability to implement such policies. Although centralized decision making is both vulnerable to slack enforcement and unpopular in today's political climate, decentralized decision-making allows the gradual degradation of river conditions through cumulative compromises. Hence, the region faces a dilemma in attempting to craft a viable, credible long-term strategy for salmon recovery.

Recovery of Puget Sound Rivers and Salmon

As concern over recovery of salmon stocks is a driving motivation behind efforts to restore or rehabilitate Puget Sound rivers, it is appropriate to examine the relation of such efforts to the regional salmon recovery strategy. Unfor-

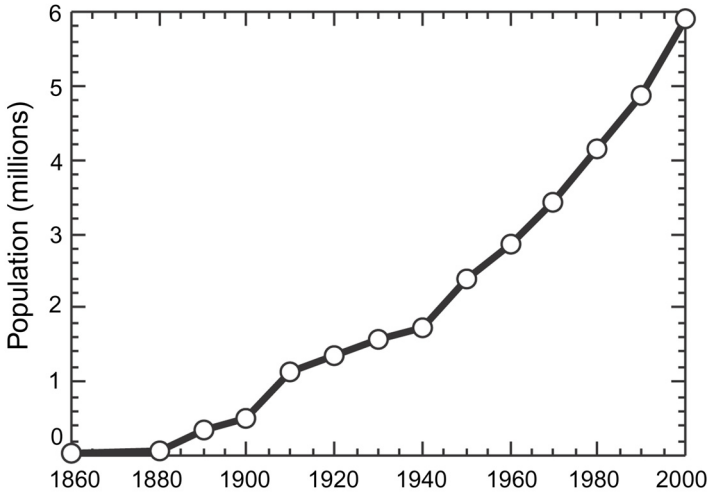

Figure 7. Human population growth in Washington State since 1860.

tunately, this examination is rather difficult because the current "strategy" is only a loose collection of tactics rather than an integrated plan (Currens et al. 2000). Although there are many valuable and ongoing salmon-conservation efforts relevant to Puget Sound rivers, no adopted salmon recovery strategy defines and defends the intended relative emphasis among reduced fishing pressure, river restoration, river rehabilitation, modified hatchery practices, and regulation of watershed development. Yet, a credible salmon recovery strategy needs to prioritize and integrate changes to all of the primary factors that impact salmon abundance, in order to ensure that efforts to address one factor are neither futile nor compromised by inattention to other factors.

An effective regional salmon recovery program needs to include habitat protection, restoration guided by an understanding of historical states, rehabilitation efforts based on assessments of current opportunities, and regulation both to prevent further degradation and to guide or drive implementation of the overall strategy. If salmon *recovery* (rather than a slower rate of decline) is the goal, then any strategy must allow no further increase in the impact resulting from any of the four Hs, unless such impacts would be demonstrably mitigated by reduced impacts from one of the other factors. A recovery plan should, at worst, allow no further harm, because reversing a declining trend obviously first requires changing the direction of the rate of change.

What can be done to reverse current trends and actually increase salmon abundance in the Puget Sound region, in spite of the projected doubling of the human population in the next half century? Two potentially complementary options for Puget Sound rivers are available: (1) reducing fishing pressure; and (2) protecting, restoring, and rehabilitating enough habitat to sustain viable salmon populations. A ban on commercial salmon fishing might produce a rapid response if harvest is a primary contributing factor to suppression of salmon populations—but this option is not even discussed in salmon recovery plans. Of the second set of options, habitat protection can be viewed as an insurance policy for longer-term habitat restoration efforts, as sustained commitment and a substantial investment of time and resources will be needed to trigger significant change and required to evaluate the success (or failure) of habitat-based salmon recovery programs.

A strategic plan consistent with longer-term salmon recovery would be to create a series of greenways along major river valleys. In the Puget Lowland, wide valley bottoms coincide with floodplains on which societal subsidies, in the form of flood control measures and levees, are usually required to sustain economic activity. Re-establishment of valley-bottom riparian forests within a corridor extending beyond the outer envelope defined by channel meanders would allow restoration of natural channel dynamics. Establish-

ment of a system of open-space preserves along river corridors could provide long-term refugia to anchor regional salmon recovery. This strategy could be implemented gradually through a floodplain buyout program, restrictions on development within historically active river corridors, and levee removal. Such efforts would not substitute for efforts to minimize the impacts of upland land use, but they could help ensure that salmon recovery efforts would not ultimately prove futile.

Degradation of Puget Sound rivers and salmon populations occurred progressively over 150 years, as the result of both deliberate and inadvertent effects of evolving decisions and policies. Restoration of Puget Sound rivers could take even longer, but rehabilitation could improve important aspects of river conditions much more rapidly. The degree to which society is willing to give back space in the landscape to rivers will define the degree to which rivers can eventually recover their natural ecological processes, functions, and dynamics. If we are neither willing nor able to provide the space needed to restore dynamic rivers, then rehabilitation efforts will take on greater importance in long-term salmon conservation strategies. Yet if we don't rehabilitate or restore salmon habitat, salmon will continue their slide toward regional extirpation even if we have not chosen deliberately to sacrifice them for short-term economic gain.

Restoration of Puget Sound rivers is not a fanciful daydream. After an absence of well over a century, salmon are returning to the Thames River, once one of the worst sewers of Europe and far more degraded than any of this region's watercourses. The Puget Sound region still has options for allowing salmon to co-exist with a large and growing human population. But these options are increasingly constrained with each passing year. Nonetheless, this region can still choose a vision with abundant salmon in its future and could design policies to achieve that vision. Whatever the plan, recovery of Puget Sound salmon requires clear vision, forceful leadership, and strategic thinking not yet in evidence. The chapters that follow provide perspective and insight from people working to restore Puget Sound rivers.

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