THE GEOGRAPHY OF HOPE: A REGIONAL STEWARDSHIP STRATEGY FOR PACIFIC SALMON

A White Paper

By

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PART 2

THIS PLACE CALLED HOME: RESTORING SALMON BY RESTORING WATERSHEDS

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"Salmon are born in brooks, creeks, rills – the headwaters of greater streams. They run to the sea for a miraculous sojourn…Mature, they awake to the call of their natal waters, and follow clues subtle and disparate as magnetic fields and the bouquet of stones to the streams of their birth to spawn and die. Loving and dying in home ground is a primordial urge. Salmon embody this for us, our own loving deaths at home in the world. Salmon dwell in two places at once, in our hearts and in the waters, and they know the way home."

(Tom Jay, in "Reaching Home: Pacific Salmon, Pacific People"; Alaska Northwest Books)

1. Introduction

The need for a new approach to salmon restoration

Part 1 of this series of papers described "the salmon crisis" in the Pacific Northwest states of California, Idaho, Oregon and Washington, and noted that fish populations continue to decline despite multi-billion dollar investments in hatcheries and the Federal hydropower system. In light of the ethical, legal and economic imperatives to restore salmon, also described in Part 1, a new approach to salmon restoration is needed which will be both more biologically effective and more economically efficient. This paper, Part 2 of the series, proposes that we can revive salmon populations through "CPR" - conservation, protection and restoration of salmon habitat - and outlines a strategy to restore salmon by restoring the watersheds in which they live. This is not to suggest that existing investments in salmon restoration be eliminated, but that new resources should be directed to "home improvements" - addressing habitat concerns which affect salmon and people alike.

Habitat: the neglected factor

Scientists have identified four factors contributing to salmon declines: mortality associated with passage through the hydropower system[a] (along with other hydropower-related impacts); over-harvesting; interactions with hatchery fish together with the difficulty of managing mixed wild/hatchery populations; and degradation of habitat. Considerable effort has been devoted to addressing the first three factors: spill, barging programs and structural fixes at the dams have all been used to try to mitigate hydropower impacts; ocean and river harvests have been cut back; hatchery reforms are underway. These efforts have been expensive both in terms of direct costs (for example, the Army Corps of Engineer's Columbia River Fish Mitigation Program is anticipated to spend $1.4 billion on improving passage at the dams[1] and an economist estimated that hatchery chinook cost $404 apiece to produce[2]) and also in indirect costs (for example, the decline of fishing-dependent communities) and have met with limited success. The House of

[a] "The hydropower system" refers to the eight Federally-operated dams on the Columbia and Snake Rivers.

Representatives Committee on Appropriations, Subcommittee on Energy and Water, noted in 1998: "The Committee has previously expressed its deep concerns regarding the vast sums of taxpayer dollars pouring into this project with little apparent effect. For all its reliance on technological fixes and fish barging, there is no clear evidence that the salmon recovery efforts in the Northwest are, or will become, successful".

This past focus on reducing the impacts of hydropower, harvest and hatcheries reflected what we now see as a narrow view of the life cycle of salmon, one that views salmon as moving from one water-filled compartment (rivers) to another (the ocean) and back again. In such a technological view, rivers and the ocean could easily be replaced by concrete raceways and aquaculture pens. Of course, such a technological approach to salmon ignores the reality that salmon do not live in pipes and boxes, but in a home that comprises not only rivers but their associated watersheds. The health of salmon populations is therefore tied to the health of land and water – habitat – throughout the Pacific Northwest.

Despite the importance of habitat, relatively little effort has been expended on protecting and restoring it (Figure 1). The major source of Federal funding for habitat activities in the Pacific Northwest is the Bonneville Power Administration; from 1978 through 1999 it spent $390 million on habitat activities [3], an average of $18.5 million per year. Compare this to Federal spending of $81 million in FY '99 on hydropower passage. The lack of attention paid to habitat actions is reflected in the Federal Caucus' [b] Biological Opinion on the Federal hydropower system, in which 66% of the proposed actions to recover salmon address hydropower, and only 7.5% address habitat.[4]

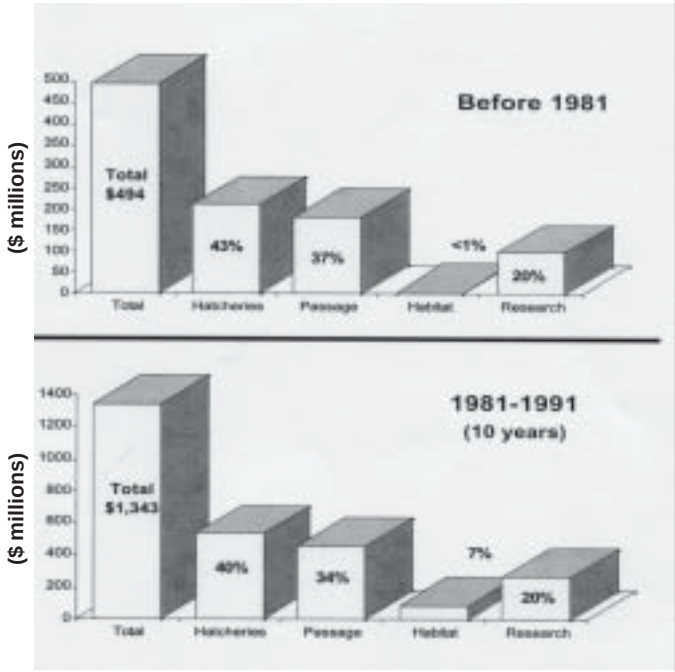


Figure 1. Federal Spending on Salmon Restoration in the Columbia Basin

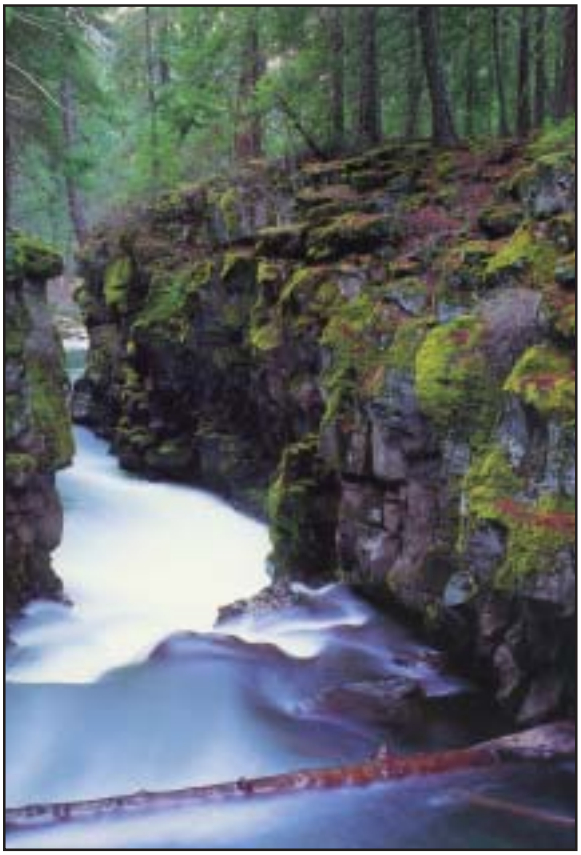
Building consensus on rebuilding habitat

The importance of habitat is now being recognized. The Independent Science Advisory Board of the Northwest Power Planning Council, in a comparison of scientific reports on Columbia salmon, noted that there was considerable dissent among scientists on the value of various proposed technological fixes but that there was unanimity on the importance of restoring salmon habitat[5].

[b] The Federal Caucus consists of the nine Federal agencies with management responsibility for environment and natural resources in the Columbia River Basin: National Marine Fisheries Service, U.S. Fish and Wildlife Service, Bonneville Power Administration, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, Environmental Protection Agency , U.S. Forest Service, Bureau of Land Management and Bureau of Indian Affairs.

As described in Part 1, the Federal government, the States, tribes, local governments and private organizations have begun to develop programs to address salmon habitat issues. Given that "home improvements" for salmon will require changes in the way landscapes are managed throughout the region, a habitat-based strategy will only succeed with the active involvement of the region's landowners, private as well as public. The good news is that many citizens are supportive of habitat work. In a survey conducted by the Tillamook Bay National Estuary Program[6], 82% of respondents agreed that "efforts to improve salmon habitat are necessary even though poor ocean conditions can greatly reduce salmon survival". They were also willing to accept responsibility for habitat efforts: 79% agreed that "landowners should take an active role in improving fish and wildlife habitat".

2. A habitat primer



Habitat: what do salmon need[c]?

What is "habitat"? Habitat is what makes a place home for salmon; it is what salmon need in the places where they live. What do salmon need? One of the most important requirements is clean, cool, abundant water. With few exceptions, salmon spawn in the gravel beds of streams and rivers. At this stage, eggs and fry are vulnerable to landscape disturbances, natural or man-made: sediment inputs, temperature changes and changes in groundwater and surface water flows. Once juvenile fish emerge from the gravel, they require a steady supply of food, and places to hide from predators. Backwater areas, floodplain sloughs, and other channels with woody debris and complex structures provide ideal rearing habitat. Natural disturbances such as fires and floods are critical to maintaining this habitat. After rearing, juveniles migrate to the ocean where they spend 1 – 3 years. Downriver migrating juveniles and upriver returning adults depend on adequate river flows. Returning adults may take weeks to reach the spawning grounds, often holding in river reaches for long periods awaiting optimal flows and temperatures; poor water quality and inadequate flows, whether natural or man-made, can reduce their viability for spawning and so affect the next generation.

[c] Information in this section is taken from National Academy of Sciences, "Upstream: Salmon and Society in the Pacific Northwest".

Salmon in the landscape

When we think of salmon, we think of rivers. Indeed, riverine habitat is critical and must provide: clean, cool water to allow spawning, hatching, rearing and migration; sufficient flow to permit migration, allow eggs to hatch, and enable fish to escape predators; in-channel structures such as pools to provide refuge from predators; stream gravels appropriate for spawning; and a healthy aquatic food web. However, riverine habitat alone is not enough. The health of salmon rivers is dependent on the condition of streamside (riparian) habitat. Riparian habitat contributes directly to the maintenance of riverine habitat, by providing shade to cool the water, trapping sediment, supplying nutrients that support aquatic food webs and contributing woody debris that provides instream habitat. In turn, riparian habitat depends on natural dynamic processes that move sediment, nutrients, water and energy between the river, its floodplain and the uplands. In short, the quality of salmon habitat is dependent upon conditions throughout the watershed.

Human influences on habitat

Many human activities – forestry, agriculture, grazing, mining, industrial uses, residential development, hydropower development and flood control – can adversely affect salmon habitat, either by reducing productivity (for example, by degrading water quality, altering flows or removing streamside vegetation) or by preventing natural disturbances (such as floods) from creating or maintaining productive salmon habitat. Logging eliminates the source of woody debris, and by removing shade can raise stream temperatures. Logging roads are often unstable and contribute large amounts of sediment into streams; by altering surface and groundwater flow they affect stream flows and temperatures. Removing the forest canopy affects snow accumulation and ultimately streamflow, while increasing the likelihood that landslides will occur and deposit sediment in streams. Agriculture commonly removes riparian vegetation and withdraws water for irrigation. Irrigation diversions can block fish passage, and divert fish into fields where they die. Irrigation return water is often warm and may contribute pesticides to streams. Grazing accelerates streambank erosion and destroys riparian vegetation, raising stream temperature and sediment loads. Livestock waste can degrade water quality.

Although mining is no longer widespread, erosion and toxic pollution continue to damage salmon habitat for miles downstream of unreclaimed mine sites. Despite treatment, sewage and effluent from urban and industrial areas have

impaired water quality in many of the rivers that salmon must pass through to reach spawning sites, and the legacy of contaminated sediments from earlier industrial activity continues to pollute many urban estuaries. Stormwater can transport an array of contaminants to urban streams and can alter streamflows and channel habitat. Stream modification for hydropower production and flood control has destroyed riverine habitat upstream and downstream of dams, and broken the connections between rivers and their floodplains.

An overview of habitat condition

The consequences of 150 years of development in the Pacific Northwest have been the loss or alteration of much of the original high-quality habitat. The following figures give some idea of the habitat losses. Since 1850:

- more than 70% of the tidal wetlands in the Columbia river estuary have been lost[7];
- tidal wetlands have been lost from more than 90% of Puget Sound [8];
- 800 miles – over one-third – of the Puget Sound shoreline has been modified by development [9];
- more than 50% and locally up to 90% of Washington's riparian habitat has been lost [10];
- more than 80% of the riparian buffers in Oregon's Willamette Valley have been lost [11];
- channel complexity on the Willamette River has been reduced by 80%[12];
- streams on National Forest land in Oregon show a decrease of 58% in the abundance of deep pools [13];
- water quality in 41% of Washington's streams is in poor condition [14]; and
- 25% of non-Federal forests and rangelands in California are experiencing excessive soil erosion [15].

Section 8 will describe habitat condition, and opportunities for improvement, in more detail.

Responsibility for habitat management

Responsibility for habitat management is highly fragmented: although they are ecologically connected, water resources are managed separately from water quality, which in turn is managed separately from land use. Responsibility is further fragmented between Federal, State and local governments, and even between agencies at the same level of government. Land use planning is the role primarily of local governments acting in conformity with State requirements, but individual land uses may be managed by a variety of State agencies. Federal, State and tribal agencies also own and manage land throughout the region under a variety of authorities. Control of water quality is split between Federal and State agencies, with the Federal government having overall responsibility under the Clean Water Act but having delegated some responsibility for point sources to California, Oregon and Washington. The management of nonpoint pollution remains a State issue. States are also responsible for managing water resources, which directly affect stream flows and indirectly affect water quality.

3. The benefits of a habitat-based strategy

Salmon survival benefits

Scientific analysis supports the intuitive understanding that improving habitat will improve salmon survival. The Cumulative Risk Initiative (CRI), an analytical model sponsored by the Federal Caucus, estimated the rates of salmon mortality at each stage of the salmon lifecycle and found that the greatest mortalities occur in the first year of life and in the transition from freshwater to saltwater [16]. This suggests that the greatest biological benefit will come from improving salmon survival in the tributaries and the estuary. Improving survival in these areas in turn is best done by protecting and restoring habitat.

The CRI suggests that habitat improvements in the tributaries and estuaries will provide greater increases in salmon survival than further modifications to harvest, hatcheries and hydropower. While this analysis indicates the potentially important role of habitat restoration in bringing back salmon, it has proved difficult to quantify the possible improvement in salmon survival from habitat improvements. The Federal Caucus attempted to estimate increases in smolt productivity that might result from improving habitat condition from "fair" to "good" in several basins [17]: in one example, estimates of survival improvements ranged from 0 to 80%; the wide range in improvement estimates reflects our current limited ability to model salmon-habitat relationships. Small-scale studies suggest that restoration of one habitat component, instream flows, can improve salmon productivity up to 8-fold[18]. One study estimated that every acre of estuary habitat restoration can produce an additional 22,000 smolts [19].

Environmental benefits

Healthy watersheds provide what natural resource economists call "ecosystem services". These services include drinking water supplies, climate control, flood control and waste processing. On a global scale, these services are worth an estimated $33 trillion per year[20]. In the Pacific Northwest, forests provide an estimated $5.5 million per year of soil stabilization [21]. If these services are eliminated, we must pay to replace them using artificial systems. The replacement costs of healthy watersheds can be high; for example, an acre of wetlands can provide $36,000 - $51,000 worth of flood control[22]. Reductions in water pollution have been estimated to be worth $3.8 - $18.4 billion per year to rural communities[23].

Economic benefits

At the national level, soil conservation (which helps keep water clean for salmon) is essential for food security. At the regional level, healthy watersheds are necessary to support rural economies: the long-term survival of forestry, fishing and agricultural economies depends on the sustainable use of natural resources. The Center for the Study of Rural America identified "sustaining the rural environment" as one of five critical challenges which rural communities must meet in order to survive [24]. The USDA's Economic Research Service suggests that natural amenities such as clean air and open space will be critical to retaining and attracting population to rural areas in the future [25]. Urban

communities also benefit from habitat activities, becoming more 'livable' when they are designed with ecological processes in mind.[d]

4. Designing a habitat strategy

The challenge: linking salmon, people and the landscape

A habitat-based strategy recognizes that the health of salmon populations is tied to the health of the landscapes across which they journey. We must manage not only the streams in which they are found, but also the land which drains into those streams – tens of millions of acres across the Pacific Northwest, much of it highly productive agricultural area or densely populated urban regions. Therefore, in order to be successful, a habitat strategy must recognize that salmon habitat is also human habitat.

The challenge for the Pacific Northwest is to integrate salmon restoration activities into the human-dominated landscape, whether this is the "working landscape" of forests and farm fields or the "developed landscape" of urban, suburban and industrial areas. In these areas, support for salmon restoration can be built by emphasizing the link between people and fish: both are dependent on the health of their shared watersheds. A focus on watershed health is not only beneficial for salmon, but also provides economic, social and environmental benefits for people, as described in section 3.

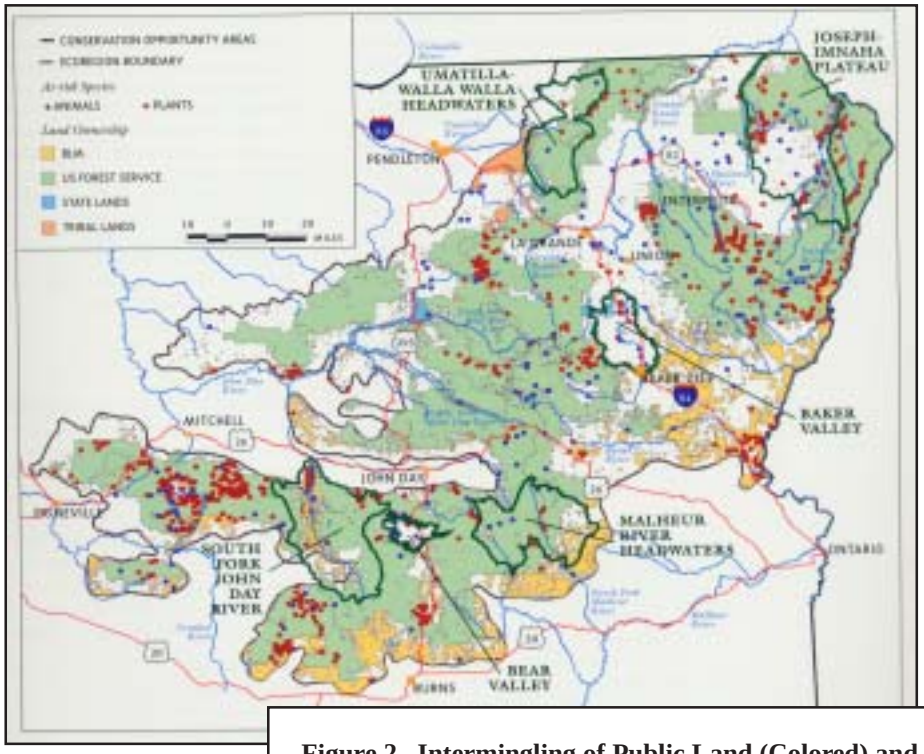


Figure 2. Intermingling of Public Land (Colored) and Private Land (White) in Oregon's Blue Mountains

[d] For more information on ecologically-friendly urban design and 'livable' urban communities, refer toNorthwest Environment Watch's "This Place on Earth 2001".

As Figure 2 shows, private and public lands are closely intermingled and much salmon habitat is in private ownership. A successful habitat strategy will therefore depend not only on government actions but also on cultivating a stewardship ethic in the region's citizens, businesses and communities. A variety of social, regulatory and financial incentives need to be made available to encourage landowners to adopt "salmon-friendly" land and water use practices and to undertake restoration activities; these incentives will be outlined below and described in detail in Parts 3, 4 and 5 of this series.

"CPR": the components of a habitat strategy

Just as we might perform CPR to resuscitate a human patient, so we can perform "CPR" to revive salmon populations. In this case, "CPR" stands for the three components of a habitat strategy: conservation, preservation and restoration:

- Conservation means improving management of human activities in the "working" and "developed" landscapes, so that they are at least "salmon-neutral" and preferably "salmon-friendly";
- Preservation means identifying remaining high-quality habitat and managing it primarily for ecological purposes;
- Restoration means bringing back some of the functions of altered habitat.

Conservation

Conservation of habitat relies on adopting more "salmon-friendly" land and water use practices. Efforts to change land and water use practices have traditionally relied on Federal and State regulations, such as State Forest Practices Acts. These regulations provide a useful environmental baseline, but need to be supplemented by incentives that encourage landowners to adopt better conservation practices. Two reforms are needed: shifting the management emphasis from legal and administrative compliance to environmental outcomes; and providing regulatory certainty to those who upgrade their practices. Both changes would benefit salmon, reduce the regulatory burden on landowners and free up agency resources for education, technical assistance and similar programs. Financial and regulatory incentives, coupled with commitments to certain levels of stewardship, together create a performance-based management system which could supplement the existing regulatory tier. Performance-based management and the State role in administering it will be described in Parts 4 and 5.

Preservation

Preserving functioning habitat is the most effective component of a habitat strategy because it is more certain and less expensive than restoring degraded systems and easier to administer than conservation programs [26]. Relatively unaltered watersheds, together with refugia in altered watersheds, protect populations which can be used to restock depleted areas. This idea is incorporated within the Federal government's Aquatic Conservation Strategy under the Northwest

Figure 3. Location of Healthy Salmon Runs in Oregon and Washington

Forest Plan, and in the Oregon Plan. Figure 3 illustrates the distribution of healthy salmon populations which could be used as core areas from which to rebuild salmon runs, and Figure 4 shows the location of priority areas identified by the Ecotrust. Preserved areas, managed primarily for ecological purposes, can be acquired through purchases, easements, transfer and purchase of development rights. Habitat preservation, and the funding needed to support it, will be discussed in Parts 4 and 5.

Restoration

Preservation and conservation of habitat may prevent further habitat loss and attendant fish declines, but will not be enough to rebuild fish populations. Restoring salmon to sustainable levels will require improving productivity by restoring habitat. Habitat restoration needs are greatest in the farms, forests, urban and industrial areas where the current economic structure provides little incentive for restoration activities. The role of watershed partnerships and incentives in encouraging the private and public sectors to collaborate in habitat restoration will be discussed in Parts 3 and 5.

Integrating the components

A habitat-based strategy needs to be comprehensive – including all three components of conservation, preservation and restoration – but also strategic – adjusting the balance of preservation, conservation and restoration according to the challenges and opportunities of a particular geographic area. Tradeoffs may need to be made at the project scale in order to provide biological benefits at the watershed or larger scale. For example, infill development projects in urban areas provide few opportunities for habitat preservation or restoration, but by combating sprawl such projects can help

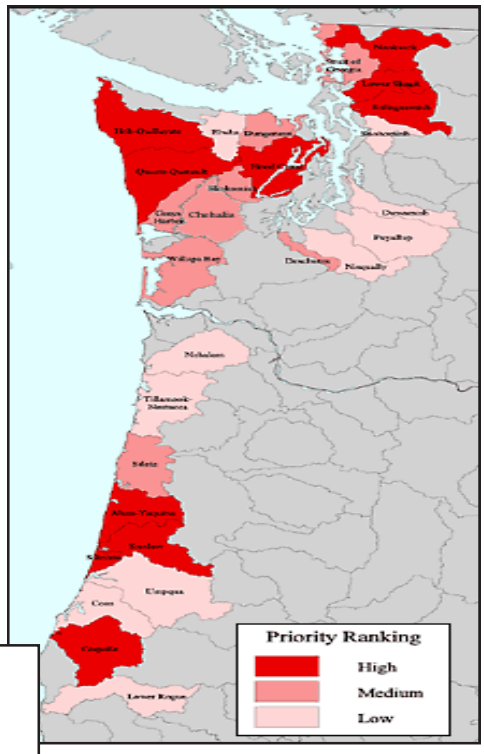


Figure 4. Location of Priority Watersheds for Preservation

protect habitat elsewhere. The same logic applies on a regional scale: not all parts of the landscape are equally important for the production of salmon, so limited resources should be targeted to those watersheds and salmonsheds which will provide the greatest biological benefit. Strategic planning at the watershed, salmonshed and regional level will be discussed in each of Parts 3, 4 and 5.

The need for adaptive management

The need for caution…

Do we know enough to design a habitat strategy? As will be discussed in section 9, there is a need for scientific research to better understand salmon-habitat relationships and evaluate the effects of habitat management. Skeptics may argue that we should not proceed with a habitat strategy until much of this research is done. Certainly there is cause for caution: the history of fish management in the Pacific Northwest is testimony to the folly of assuming that any intervention will inevitably lead to the desired result. Despite a century of interventions, each of which was hailed at the outset as being "the solution" to the salmon crisis, fish runs continue to decline and in many cases the proposed "solution" has been shown to have contributed to this decline.

…and the need for action

However, waiting for definitive science in order to create the perfect strategy will doom salmon to extinction. The reality is that we will never be able to produce the perfect strategy: we will never have all of the scientific answers, and even our best plans will need to be modified in light of changed circumstances which we cannot now foresee. Population growth, economic shifts and climate change will force us to make adjustments to a habitat strategy over the next few decades (see section 10). What we need, in addition to more and better science is true adaptive management, in which we are able to revise the habitat strategy as we acquire more scientific knowledge and as circumstances change. This will require us to identify threshold environmental conditions which will serve as triggers to change management actions, such as rainfall data which might indicate impending drought conditions. We will also need to devise sets of alternative actions – such as changes in river operations - which will be initiated once those triggers are operated.

A phased approach

A phased approach allows us to combine the need for caution with the need for action. Many habitat activities are low-risk, in that their benefits are well-understood, immediate and certain. These include restoration of streamflows, removal of fish passage barriers, installation of fish screens and the treatment and closure of substandard roads on forested land and steep slopes. Other habitat activities, such as restoration of riparian buffers and wetlands, are higher-risk in that their benefits will take a long time to be realized and the conditions which maximize benefits are less well-understood. In a phased approach, early efforts can concentrate on those activities which provide immediate benefits and be coupled with a research program to improve understanding of higher-risk activities which can be implemented in later phases.

Habitat is not enough: linking habitat to other causes of salmon decline

It is important to realize that maintaining and restoring habitat is not a "silver bullet"; the salmon lifecycle is complex, and habitat improvements alone will not be enough if other factors – such as hydropower mortality or unsustainable harvest rates – limit fish access to that habitat. The interactions between habitat and other causes of decline may be subtle; for example, salmon fry rely on nutrients contributed by decaying salmon carcasses, and increased harvest rates will reduce this nutrient supply. Therefore, habitat and harvest programs must be linked. Likewise, hatchery programs must be tied to the carrying capacity of the streams into which juveniles are released. Finally, habitat restoration efforts will be more successful in watersheds where hydropower development does not limit migration.

5. Prospects for success; can a habitat strategy work?

Success stories

A habitat strategy has 3 components: conservation, preservation and restoration. Conservation, by preventing further degradation of habitat, is necessary but not sufficient to bring back salmon populations. Without it, restoration efforts will be offset by continued habitat damage. Preservation not only holds the line, preventing further losses and helping to buffer against future environmental changes, but refugia can help re-seed populations into areas as restored habitat becomes available. For example, a long-term study on the Siuslaw River of coastal Oregon demonstrated that refuges enabled salmon populations to survive record floods and drought [27]: salmon numbers declined precipitously following each of these events, and in each case the following year-class of salmon was derived entirely from the refuges. Had these refuges not existed, it is likely that salmon would have been extirpated from the stream.

Conservation and preservation can protect against future salmon declines. Ultimately, however, salmon restoration will depend on habitat restoration. Does habitat restoration work? In some cases, the results can be seen quite rapidly – within 5 to 10 years. The Haskell Slough Salmon Restoration Project on the Skykomish River in Washington State reconnected the river with its floodplain and improved instream habitat using woody debris. With overwintering habitat restored, tens of thousands of adult and juvenile salmon have been counted in the Slough after fifty years of limited or no production[28]. On the Umatilla River in Oregon, salmon stocks that went extinct in the 1920s are being restored through a combination of habitat restoration and supplementation[e]. By increasing streamflows, improving fish passage and restoring streambanks, habitat was improved to the point that fish could be released into the river. Within a decade, adult fish returns reached 5,000 to 10,000 per year [29]. In Seattle, a degraded urban stream, Pipers Creek, was restored to more natural channel conditions, with the result that gravel became cleaner, insect populations and pool volume increased, and after a few years fish populations increased 8-fold [30]. Providing instream structures such as woody debris increased fish density in northwestern California streams [31].

[e] Supplementation is a technique that uses hatchery production to reestablish natural runs rather than raise numbers of fish for harvest; it recognizes the connection between fish genetics, rearing and habitat by using selected broodstock and in-stream rearing to mimic natural populations genetics and behavior.

These examples show that it is possible to restore salmon by repairing damaged watersheds. There are many more examples of projects which have improved habitat condition, though they have not yet resulted in fish returns. For example, the purchase of water rights and transfer of those rights to instream flows restored year-round flow to Squaw Creek in Oregon [32]. Much of this restoration work has been done by voluntary watershed groups; further examples will be discussed in Part 3. In California, $45 million was spent on fishery restoration projects between 1980 and 1993; some 60% of these projects were rated as "excellent" or "good" in meeting habitat objectives [33]. Improving the effectiveness of restoration projects will be discussed further in Part 3.

Lessons learned

Measuring success: habitat or fish?

The ultimate measure of success of any salmon restoration strategy must be increased numbers of fish. However, in the short term, it is probably more realistic to measure the success of habitat projects in terms of improved habitat, rather than increased fish numbers. This is particularly true as fish returns can be affected by human activities or environmental conditions hundreds or thousands of miles away, downstream or in the ocean. Indeed, even when fish do return, the complexities of salmon ecology will make it difficult to show that a particular habitat project has restored fish populations. Instead, the success of a habitat strategy must be measured in its own terms – success in providing the conditions needed to support sustainable salmon populations.

Ecological time vs. political time

Obviously, certain activities – improving fish passage, restoring flows – can provide immediate benefits. "Build it and they will come" is as true for salmon as for baseball, but in most cases it will take quite a while longer! Seth Zuckerman[34] surveyed a number of watershed groups active since the 1980s, and found few examples where salmon had returned in large numbers; it can decades for natural processes to restore themselves. Given the variability in annual fish returns, scientists estimate it may take 20 or more years before the benefits of habitat work can be demonstrated [35].

The mismatch between the long ecological timescales on which results can be expected and the short political timescales on which results are demanded poses one of the greatest problems for a habitat-based strategy. This suggests two critical ingredients for a habitat-based strategy: a public education program to let people know when they can realistically expect returns from their investment in salmon restoration; and a series of interim benchmarks to demonstrate that progress is being made in improving habitat.

The need for a strategic approach

Freshwater Creek, near Eureka, California, illustrates the problems that can arise from an over-reliance on restoration. The Humboldt Fish Action Council undertook a variety of restoration projects which increased habitat by 33% and helped fish numbers to rise from less than 100 to over 800. However, these restoration gains were wiped out by the effects of clearcutting elsewhere in the watershed; following the clearcut, fish numbers plummeted back to pre-restoration levels [36]. This example illustrates the need for a strategic approach that identifies and addresses all the major problems in a watershed and ensures that environmental gains from one project are not undercut by losses from another. A strategic approach will also ensure that limited resources are directed to actions which are most biologically-effective and cost-efficient. The application of a strategic approach in the watershed context is described in Part 3.

6. Implementing a habitat strategy

In order to successfully implement a habitat strategy, three issues must be resolved: who will do it? how will it be done? and how will it be paid for? The answers to these questions are outlined below and detailed in Parts 3 – 6 of this series.

Who will do it?

As Figure 2 shows, public and private land ownerships are so intermingled that restoring salmon and their watersheds will only be possible if the public and private sectors work in partnership. Public-private partnerships at the watershed and salmonshed scale will be discussed in Parts 3 and 4. In these partnerships, government agencies and private citizens and organizations will likely take on different components of a "CPR" strategy. For example, individual landowners may choose to undertake restoration projects (Part 3), while governments may provide support for such actions and negotiate the regulatory assurances needed to encourage landscape-scale adoption of "salmon-friendly" land and water use practices (Part 4).

How will it be done?

A performance-based system

The challenge is to align Federal and State laws with the self-interest of citizens, businesses and communities. A possible approach uses the Clean Water Act and Endangered Species Act as a backstop for and complement to voluntary actions to promote salmon restoration. The regulatory system provides a floor to limit further decline of salmon and their habitat, while a voluntary approach uses incentives to move beyond the avoidance of jeapordy and towards recovery[f]. As described in parts 3, 4 and 5, a voluntary approach could be performance-based, with individuals,

[f] "Avoidance of jeopardy" and "recovery" refer to ESA requirements to halt population declines and restore self-sustaining populations.

businesses and communities committing to meeting specific environmental goals in exchange for financial and regulatory benefits.

Setting goals

The greatest need is for the regulatory and regulated communities to reach agreement on fish and habitat goals. State and local officials are naturally reluctant to develop and implement salmon management plans that they fear will be inconsistent with Federal ESA-based recovery plans released at a later date. The ESA sets a goal of a self-sustaining population, but the region may prefer other goals: fish populations that will support tribal, sport and commercial harvest, for example, or restoration of fish populations to pre-settlement numbers and distributions. Federally- and regionally- derived goals are not necessarily incompatible, but reconciling them will be a considerable challenge.

Turning fish goals into habitat goals will be a further challenge, which will need to be worked out salmonshed-by-salmonshed and watershed-by-watershed. Other ecosystem restoration projects such as the Chesapeake Bay and Tampa Bay National Estuary Programs have tied biological goals to water quality standards and improvements, but salmon's needs extend beyond water quality. Each watershed will need to establish targets for water quality, flows, riparian buffers, accessible floodplain acreage and similar factors. This is a fertile field for additional scientific research, as described in section 9.

Identifying suitable management practices

Another significant need will be translating habitat goals (performance standards) into management practices. For example, what stormwater management practices are adequate to protect salmon habitat in urban streams? There is a need to reconcile biologically-oriented performance standards (focused on goals) with the pragmatic desire for specified management practices that carry regulatory certainty (focused on means). This will be discussed further in Parts 4 and 5.

Applying "CPR"

Yet another need will be to ensure that that the suite of actions – conservation, preservation and restoration – adds up to the agreed-upon goals. This will require that impacts be cumulatively evaluated on a salmonshed scale, as discussed in Part 4.

How will it be paid for?

Parts 5 and 6 are devoted to answering this question. As discussed in section 8 of this paper, existing Federal and State programs make a substantial contribution to salmon restoration. However, many of these programs are underfunded, over-subscribed or could be revised to produce greater environmental benefits. As noted in section 8 and discussed further in Part 5, certain habitat challenges are currently unmet through lack of applicable programs.

7. Encouraging stewardship

The key to successful habitat restoration is encouraging a stewardship ethic in private landowners throughout the region. What tools are available to encourage stewardship?

Education

Salmon education must emphasize: giving citizens an appreciation of why salmon are important, in themselves and as indicators of watershed health; helping citizens understand the connection between their daily activities and salmon survival; making citizens aware of their legal responsibility to salmon and salmon habitat, as specified in State and Federal laws; and providing citizens with the knowledge, skills and support to contribute to salmon recovery. Most citizens of the region live within a few miles of a stream which supports salmon today or did so in the recent past. Stream monitoring in such areas gives citizens a direct appreciation of the environmental health of their community and helps involve them in identifying problems and determining the effectiveness of solutions. As will be discussed in Parts 3 and 6, volunteer monitoring can be done most effectively in partnership with university-based "watershed clinics".

Technical assistance

Once citizens have become aware of their connection to the salmon lifecycle, translating this awareness into on-the-ground projects to benefit salmon will require technical assistance. Field personnel from the NRCS, Bureau of Reclamation, Forest Service and Bureau of Land Management, together with local Soil and Water Conservation Districts, have a tradition of assistance to the agricultural community. Other agencies, such as NMFS and EPA, have no tradition of field personnel providing assistance. Salmon restoration efforts will succeed only if all relevant agencies can provide technical assistance at the local level. This might be achieved by locating inter-agency field teams in each salmonshed, as discussed further in Part 4.

Financial and regulatory incentives

Vickerman[37] provides an excellent overview of financial and regulatory incentives and their application to biodiversity management. Incentives are discussed here according to their likely applicability in stimulating habitat conservation, preservation and restoration.

Conservation

Habitat conservation is achieved when businesses, citizens and communities adopt "salmon-friendly" land and water use practices.

- Financial incentives, such as cost-shares for Best Management Practices (BMPs), can encourage this. As will be discussed further in Part 5, there is precedent, both through the Clean Water State Revolving Fund and Farm Bill programs such as EQIP, for providing Federal funding to meet national environmental goals.
- Even with cost-share provisions, farmers may be reluctant to adopt BMPs for fear that they will reduce productivity and hence farm income; risk insurance programs can address this.
- In addition to cost-share payments, producers may be encouraged to adopt "salmon-friendly" practices if those practices give them increased marketing power. This can occur through stewardship certification programs, coupled with "green marketing". The "salmon-safe" program of Pacific Rivers Council, the "salmon-friendly power" program sponsored by For the Sake of the Salmon and forest product certification through the Forest Sustainability Council are all examples of this approach.
- Regulatory incentives, in which parties who implement an approved land and/or water use management plan can be provided regulatory "safe harbor", may prove even more attractive than financial incentives. Washington State has recently developed one such program to provide regulatory certainty for communities implementing approved shoreline management practices, and is working to develop a similar program for agricultural practices. This approach will be explored in more detail in Part 4.

Habitat conservation must not only reduce the impacts of existing land uses, but also mitigate the impact of future land use changes, such as continued shoreline development or conversion of agricultural land to residential use. "Avoid, minimize, mitigate" should be the mantra for developing salmon habitat.[g]

- Mitigating habitat loss through off-site habitat banking can stimulate habitat preservation or restoration activities which otherwise might not occur. Future land use changes will likely also increase pollutant loadings and place additional stress on over-appropriated water supplies; while local impacts are unavoidable, the regional impact can be addressed through pollutant trading and water marketing. The use of these tools is explored further in Part 4.

[g] Permitting of wetland development is subject to this "avoid, minimize, mitigate" sequence.

Preservation

Preservation of existing high-quality habitat is most easily achieved through financial incentives.

- States, tribal and local government and Federal agencies can use money from the Land and Water Conservation Fund, Farmland Protection Program and numerous other sources to purchase title or easements on property, though increased funding and flexibility in these programs would allow more preservation (see section 8).
- Land exchanges can also be used to bring high-quality habitat into public ownership while providing private landowners with continued income-generating opportunities on less ecologically valuable public land.
- Habitat can also be preserved through transfer of development rights, habitat banking (in-lieu-fee programs) and the use of tax incentives such as Washington State's Public Benefits Rating System.

Restoration

In general, restoration activities will occur at the watershed level in response to incentives targeted to the individual landowner.

- In addition to cost-shares and tax credits, farmers, foresters and others can be encouraged to restore habitat through a "green payments" program, in which they receive annual income payments in exchange for undertaking specified habitat management/restoration practices. The Conservation Security Act (H.R. 1949/ S.932) introduced in the 107th Congress provides a model of how such a scheme could be structured. Federal income support for habitat restoration practices is discussed further in Parts 3 and 5.
- Market mechanisms such as pollution trading, water marketing and habitat banking have the potential to stimulate private sector investment in restoration activities. These programs can be designed to target restoration to priority areas, as discussed in Parts 4 and 5.

8. Challenges and opportunities in habitat stewardship

How can the ideas discussed in section 7 be translated into programs? Federal, State and local governments, along with regional organizations such as the Northwest Power Planning Council, have developed a number of programs which directly or indirectly benefit salmon habitat (see Appendix 2). This section highlights some program successes ("progress"), notes limitations ("unfinished business") and recommends creation, expansion or revision of programs ("opportunities") for each of 9 challenges. These challenges are arranged within the "CPR" framework of section 4 as shown in Table 1. Although treated separately the challenges – and opportunities for addressing them – obviously overlap. The listing of opportunities below is not intended to be comprehensive, but to provide a sampling of possibilities; although this section emphasizes Federal actions, there are additional opportunities for State, local government and private sector activities, which will be identified in Parts 3 through 6 of this series.

Table 1: Conservation, Preservation and Restoration Challenges

Conservation	Challenge 1	Reduce environmental impact of existing land uses
	Challenge 2	Mitigate impacts of future land use change
Preservation	Challenge 3	Preserve high-quality habitat
Restoration	Challenge 4	Restore water quality
	Challenge 5	Restore flows
	Challenge 6	Restore instream habitat
	Challenge 7	Restore riparian buffers
	Challenge 8	Restore connectivity of wetlands and floodplains
	Challenge 9	Repair "legacy" conditions

Challenge 1: Reduce the environmental impact of existing land uses

Progress

- The impacts of forestry practices on salmon streams are regulated in California, Oregon and Washington; Washington recently revised its Forest Practices law and Oregon is in the process of doing so.
- Oregon recently required agricultural producers in targeted areas to develop water quality management plans to minimize their impacts on salmon.
- Federal regulations require that stormwater be managed to reduce impacts to both water quality and streamflows; pending legislation on Combined Sewer Overflows and other 'wet-weather' events may further reduce urban impacts to salmon.

Unfinished Business

- Despite declines in the extent of livestock grazing on public lands, rangeland riparian areas remain in poor condition; rangeland operators generally do not qualify for agricultural programs that encourage more sustainable practices.
- Work to reduce the extent of stormwater impacts is just beginning. In Washington State, the cost to local governments to manage stormwater for salmon is estimated at $1.3 billion and few localities will be able to afford this [38].
- Water withdrawals for agriculture, municipal and industrial uses contribute to reduced flows in salmon streams, and Western water laws discourage conservation as discussed further in Parts 4 and 5.

Opportunities

- Conservation payments (as proposed in the Conservation Security Act [H.R.1949/S.932] introduced in the 107th Congress and some proposals for the reauthorization of the Farm Bill) can encourage landowners and others to adopt improved land and water use practices while stimulating rural economies.
- Likewise, regulatory assurances for approved practices may encourage the adoption of "salmon-friendly" practices.
- Risk insurance may make adoption of Best Management Practices more attractive, especially to farmers.
- Stewardship certification may provide market benefits in exchange for "salmon-friendly" practices.
- Water quality and water conservation opportunities are discussed under Challenges 4 and 5 respectively.

Challenge 2: Mitigate impacts of future land use change

Progress

- Growth management legislation in both Oregon and Washington has protected environmentally-sensitive areas. As a consequence of this legislation, Oregon reports that the acreage of wetlands and non-Federal forest lands are holding steady at 1990 levels [39]. Conversion of agricultural land to urban development occurs at a national rate of 0.12% per year; Oregon's rate is below this at 0.07%, Washington is slightly above at 0.15% and California loses farmland at more than twice the national average, 0.27% per year [40].
- Washington's revised Shoreline Management Act requires future development to mitigate impacts on-site and contribute to restoration elsewhere in the watershed.
- California, Oregon and Washington have wetlands mitigation banking programs to offset losses of wetlands to development.
- The West Eugene Wetlands Plan required that wetlands be designated for protection, restoration or development, created a wetland bank and acquired 2200 acres of wetlands for preservation.
- California has gone beyond wetland mitigation to a general habitat banking program.

Unfinished business

- Most mitigation occurs on a project-by-project basis which fails to account for cumulative impacts.
- Lack of detailed knowledge about salmon-habitat relationships limits managers' ability to assess the impacts of projects in sensitive areas and design appropriate mitigation.

Opportunities

- Performance zoning (such as requiring that new development not increase impervious surface) can limit the effects of land use changes.
- Pollution trading, water marketing and habitat banking can encourage more effective mitigation projects.

Challenge 3: Preserve high-quality habitat

Progress

- The Federal government, States, NWPPC [h] (through the Fish and Wildlife Program) and local governments have active habitat acquisition programs that combine land purchases with easements. The NWPPC has acquired 225,000 acres of habitat since 1978 [41]. King County (which includes metropolitan Seattle) has spent over $270 million in local funds since 1970 to acquire 29,000 acres of land; a recently-approved Transfer of Development Rights program promises to protect additional open space in this rapidly-developing area [42].
- Oregon, Washington and California have each experimented with tax breaks for riparian easements, though with mixed success. Scaling tax incentives to ecological benefits rather than enrolled acreage is essential; otherwise the tax benefits are too small to provide much incentive.
- A science-based framework to guide acquisition is slowly being developed. California (through its Biodiversity Council) and Oregon (through the Biodiversity Project) have both completed draft mapping of acquisition targets, though their focus is multi-species and at-risk species rather than endangered salmon.
- Oregon (through the Oregon Plan), Ecotrust and the American Fisheries Society have each identified core aquatic areas and connecting corridors that merit protection. The Trust for Public Land recently made detailed acquisition recommendations for the Puget Sound area [43].
- The Aquatic Conservation Strategy will protect key watersheds on Federal lands covered by the Interior Columbia Basin Ecosystem Management Plan and the Northwest Forest Plan.

Unfinished Business

- One of the largest sources of funding for land habitat preservation, the Land and Water Conservation Fund, has been raided for other purposes: since its inception, $11 billion has been diverted to other purposes.
- A related funding source, the Farmland Protection Program, suffers a severe shortage of funding, with a funding backlog (property offered for easement but for which funds were unavailable) of $48 million in California alone [44].

[h] Northwest Power Planning Council

- The lack of a statewide watershed analysis program in California has hindered the process of identifying target acquisition areas there.
- Although Oregon reports overall wetland acreage holding steady, that measure of success masks continued losses in some areas and of some types of wetlands. Recent court decisions may accelerate the loss of isolated freshwater wetlands, which are important in sustaining groundwater flows to headwater streams.
- Much of the habitat under Federal protection is in forested headwaters which tend to be less productive of salmon and which are often blocked to salmon access by unfavorable conditions downstream. Less effort has been placed on identifying and protecting the few remaining refugia in low-elevation river valleys and estuaries.

Opportunities

- Funding for the Land and Water Conservation Fund, the Farmland Protection Program and Forest Legacy was expanded in FY '01; pending legislation (the Conservation and Reinvestment Act [H.R. 701]) seeks to both expand and stabilize funding for these programs.
- Estate tax reform and other tax initiatives at Federal and State level can be structured to benefit habitat protection.
- The "Working Lands Stewardship Act" (H.R. 2375), introduced in the 107th Congress, would include funding incentives for landowners who forego development opportunities on farmland and forestland.
- Expanded use of TDR (transfer of development rights) programs can help preserve open space.

Challenge 4: Restore water quality

Progress

- The "Forests and Fish" agreement in Washington State will protect 60,000 miles of salmon streams on forested lands [45].
- In the Yakima Basin, irrigators reduced sediment pollution by 25% [46].
- TMDLs which will guide restoration of water quality have been completed across the region: 33 in California, 40 in Idaho, 64 in Oregon and 211 in Washington [47].
- In Oregon, 64% of streams showed improving water quality in 1999 [48].

Unfinished business

- Many miles of streams are listed as impaired: 25,716 in California, 7,935 in Idaho, 14,534 in Oregon and 922 in Washington [49].
- Although non-point pollution is responsible for more than 60% of water quality impairments nationwide, Federal assistance for nonpoint pollution control has lagged far behind assistance for point source control.
- 70% of farmers and ranchers seeking Federal assistance for conservation programs that would improve water quality are rejected because of inadequate funding [50].

- Nutrient management for livestock operations is a particular challenge: EQIP (the Environmental Quality Incentives Program) which funds nutrient management is under-funded, with demand exceeding supply in each of the four states: by $34 million in California, $21 Million in Idaho, $28 million in Oregon and $29 million in Washington [51].
- Recent court decisions limit States' ability to protect headwater wetlands which are vital to maintaining water quality in first and second-order streams.

Opportunities

- Conservation payments such as described under Challenge 1 can encourage landowners to adopt pollution-reducing Best Management Practices.
- Further incentive to adopt Best Management Practices can be provided by offering risk insurance to guard against reduced crop yields.
- Pollution trading can maximize pollution reductions for a given investment, or encourage additional pollution reductions
- Because control of nonpoint pollution is the responsibility of the States, additional funding must be found for State activities such as wetlands programs, Clean Water Act section 319 programs and Coastal Zone Management programs
- The proposed Conservation and Reinvestment Act (H.R. 701) could be structured to allow land acquisition for water quality protection purposes.
- Funding for EQIP and other conservation programs should be increased in the next Farm Bill.

Challenge 5: Restore flows

Progress

- Groups such as Oregon Water Trust and the Deschutes Resources Conservancy have demonstrated the value of water rights purchases and leases in restoring instream flows for fish.
- The Watershed Planning Act provides State grants to communities in Washington for assessment of water resources and planning for future water management.
- In 1999, Oregon reported that 94% of streams met flow targets for 9 months out of each year, and 65% of streams met flow targets year-round.

Unfinished business

- In Washington State, 25% of basins are over-appropriated.
- In Oregon, 40 rivers are threatened by low flow conditions [52].
- There is a lack of data on long-term flows, groundwater levels, water usage and consumptive use; this data is needed for water resources planning.
- State water laws contain disincentives for enhancing instream flows: instream flow is often not recognized as a beneficial use; increasing water use efficiency provides no benefit to the water right holder or instream flows but rather to the next junior appropriator; "use it or lose it" discourages even temporary transfers of unused water to instream flows.
- Water rights allocations are decoupled from seasonal or annual flow variations, causing problems in drought years.
- Small groundwater withdrawals are exempt from permitting requirements, yet the cumulative effect of many wells can be to deplete instream flows.

Opportunities

- State water laws should be revised to encourage conservation and enhanced instream flows
- Federal and State funding can be provided for water conservation practices, and conditioned on donating a % of saved water to instream flows. A study by Seattle PUD indicated that the city could conserve 31 million gallons per day by expanding the use of low-flow toilets and showerheads [53]
- Water conservation projects which provide water quality benefits should be eligible for funding under the Clean Water State Revolving Fund, as was proposed in the "Water Conservation and Quality Incentives Act" (S. 188) introduced in the106th Congress.
- Additional funding should be provided through the U.S. Geological Survey streamgaging program for water resources data collection.
- Water marketing can stimulate conservation and transfers.
- Funding should be provided through the Bureau of Reclamation and State agencies for pilot projects to demonstrate the value of water reuse and conjunctive use.
- Issuance of new water rights, and approval of new water delivery infrastructure, should be linked to development of salmonshed-level salmon restoration plans.
- State and local governments should develop drought preparedness plans; these should include proactive measures to mitigate future drought impacts, as well as emergency management plans. The Interim National Drought Council may provide a venue for identifying assistance for planning and projects.

Challenge 6: Restore instream habitat

Progress

- Funding for restoration projects, including instream habitat restoration, has been provided by the Pacific Coastal Salmon Recovery Fund ($110 million in FY 2002).
- In 1999, citizen-sponsored fish passage projects opened up 180 miles of streams in Washington [54].
- The "Irrigation Mitigation and Restoration Partnership Act" (H.R. 1444) approved in the 106th Congress will provide $25 million per year to screen irrigation diversions.

Unfinished business

- In the Oregon Coast Range, only 20% of streams have an adequate supply of woody debris.
- In Washington, 3 out of 4 culverts on forested lands block fish passage.
- Multiple Federal and State regulatory requirements for instream work deter watershed groups from undertaking restoration projects.

Opportunities

- Providing authority to the Bureau of Reclamation for instream work at non-Bureau projects would allow the Bureau's technical expertise to be used in addressing fish passage needs.
- Additional flexibility under the Transportation Equity Act for the 21st Century (TEA-21) would allow additional funds to be used to improve fish passage associated with Department of Transportation projects.
- Permit streamlining such as being undertaken by Oregon's Department of State Lands and Washington's Department of Transportation (both described in Part 4) would enable restoration projects to proceed more efficiently.

Challenge 7: Restore riparian buffers

Progress

- The Conservation Reserve Enhancement Program (CREP) has restored 600 miles of riparian habitat in Washington [55].
- In Oregon, watershed councils have improved riparian condition along 1,000 miles of stream [56].

Unfinished business

- The Wildlife Habitat Improvement Program (WHIP), which pays landowners for improvements such as restoring riparian buffers, is under-funded and over-subscribed.
- Scientists estimate that 12 - 16 million miles of riparian buffers are needed nationally to meet water quality goals, yet only 3 million miles of buffers have been created in the past 20 years [57].
- Landowner enrollment in CREP is limited by program inflexibility (e.g. limitations on acceptable plantings) and inadequate technical assistance.

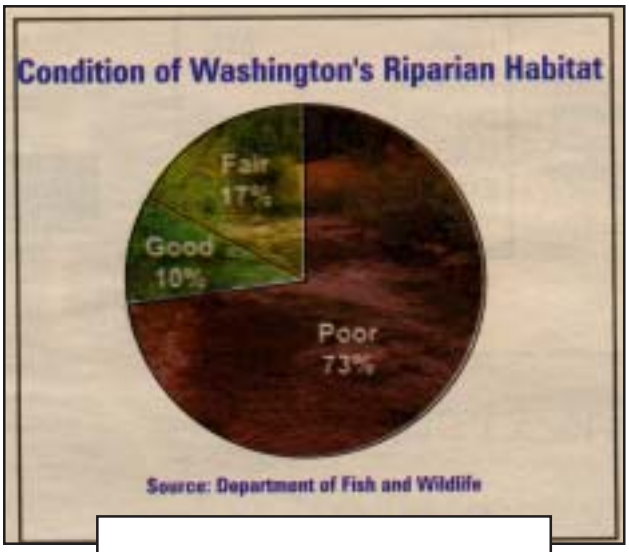


Figure 4. Condition of Riparian Habitat in in Washington.

- Throughout the region, grazing has damaged 80% of riparian ecosystems [58], yet few incentives are available to improve grazing management.
- 73% of Washington's riparian habitat is listed in "poor" condition [59] (Figure 4).
- Forest Practices laws protect riparian conditions on forested lands but less protection exists for riparian buffers in urban areas, cropland and rangeland.

Opportunities

- Reauthorization of the Farm Bill provides an opportunity to increase acreage limits, funding levels and flexibility of the Conservation Reserve Program, CREP and WHIP.
- Eligibility for these programs should be expanded to include rangelands and fruit and vegetable growers.
- The WHIP program can be targeted to priority conservation areas to increase environmental benefits, as was done for the Conservation Reserve Program.
- Providing incentives for carbon sequestration, such as the "Forest Resources for the Environment and the Economy Act" (S. 820) introduced in the 107th Congress, would encourage reforestation of buffers.
- Habitat banking could target mitigation of forest harvest to buffer areas.
- Landowners making habitat improvements should be provided "Safe Harbor" under the Endangered Species Act.

Challenge 8: Restore connections to wetlands and floodplains

Progress

- Existing regulatory programs have slowed the rates of wetland loss. In Oregon, wetland acreage is holding steady at 1990 levels and 98% of estuary wetlands are now protected under local zoning regulations [60].
- Water Resources Development Act section 206 (Environmental Restoration) and 1135 (Project Modification) programs provide authority for the Army Corps of Engineers to reconnect rivers, wetlands and floodplains.
- TEA-21 provides funding for highway improvements that can improve connectivity.
- The Northwest Coastal Estuary Program and Puget Sound Initiative, both authorized in FY2001, provide authority and funding for estuary restoration.

Unfinished business

- Although rates of wetland loss have declined, the Willamette Valley continues to lose 500 acres of wetland per year [61].

- Consumptive demand for water has reduced freshwater flows into estuaries, changing their salinity and hence functioning.
- Wetland regulations emphasize protection of acreage, rather than functions and benefits.
- Wetland regulations address project-by-project rather than cumulative impacts.
- The Wetlands Reserve Program, which pays landowners to protect and restore wetlands, is over-enrolled and under-funded.

Opportunities

- Wetland restoration can be integrated with flood protection, as has been done on the Mississippi River.
- Farm Bill reauthorization should increase acreage caps and funding for the Wetlands Reserve Program.
- FEMA should be authorized to reform flood insurance programs and funded to purchase buy-backs of structures in floodplains.
- Funding should be expanded for the Army Corps' section 206 and 1135 programs.

Challenge 9: Repair "legacy" conditions (abandoned logging roads, stabilize deforested slopes, degraded mine sites etc.)

Progress

- In Oregon, 2,000 miles of forest roads have been vacated, relocated or closed and another 2,000 miles have been improved [62].
- BLM and other Federal agencies have undertaken cleanup programs at several abandoned mine sites.

Unfinished Business

- While an aerial overview shows tens of thousands of acres of historic clearcuts, and thousands of miles of abandoned logging roads across the region, exact data on the extent of "legacy" conditions are unknown.
- A Seattle Post-Intelligencer Special Report depicts hundreds of abandoned mines, and hundreds of miles of streams polluted by wastes from these mines [63].

Opportunities

- "Good Samaritan" legislation proposed in the 106th Congress would encourage cleanup of abandoned mine sites without increasing liability.

- Incentives for carbon sequestration which emphasize reducing soil erosion and reforestation would help restore degraded watersheds.
- Incentives for reducing the impact of current land use and improving water quality, described under Challenges 1 and 4, could be expanded to address "legacy" conditions.

9. Science needs for a habitat strategy

Basics: understanding salmon-habitat relationships

Broader scientific involvement

Understanding the connection between ecosystem processes and salmon survival will be best advanced by expanding the range of scientific disciplines involved in the effort. Much salmon science is currently performed by fish biologists. A focus on ecosystems in general, and habitat in particular, will benefit from the involvement of ecologists, soil scientists, geologists, foresters, geochemists and others.

Additional research

Most studies of salmon habitat have focused on salmon needs for spawning habitat in the tributaries. The habitat conditions needed to support salmon spawning, rearing and migration in the mainstem of large rivers, estuaries and near-shore environments are less understood. Even in the tributaries, where there is general agreement on what constitutes "good" habitat, quantitative relationships between habitat conditions and salmon productivity (measured as egg-to-smolt survival) are lacking. These relationships must be known in order to turn fish recovery goals into habitat objectives, to identify promising areas for restoration, and to enable policymakers to understand how particular actions will contribute to salmon decline or restoration. These studies will provide the scientific foundation for choosing particular restoration options.

Strategic needs: setting goals

Fish goals

Setting fish recovery goals, although the highest priority, is ultimately a policy decision balancing the mandates of ESA, tribal treaty commitments, the needs of commercial and sportsfishermen, and the desires of the region's citizens. The scientist's role is to advise policymakers whether particular goals are ecologically feasible.

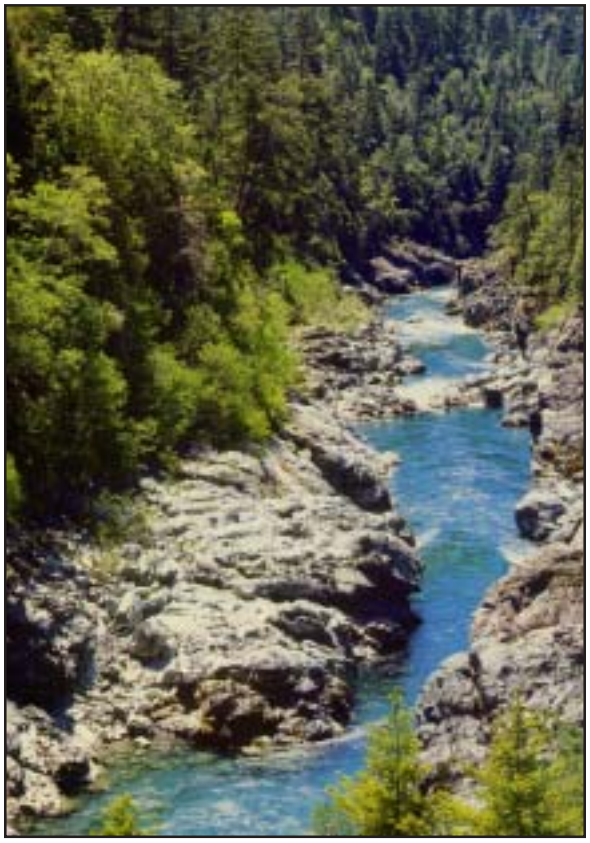
Habitat goals

The real challenge will be turning fish goals into habitat goals. Little work has been done on this beyond NMFS' use of a semi-quantitative screen, Properly Functioning Condition, to assess the condition of salmon habitat. Unfortunately while this tool is quite detailed for assessing existing conditions of in-river habitat at the scale of a stream reach, it is much less useful for predicting habitat requirements at the watershed scale where most goal-setting will be done.

One model which might be useful for this is SWAM (Salmonid Watershed Analysis Model) which statistically correlates salmon productivity and watershed conditions. As with all empirical models, it needs to be validated over a wide range of conditions and scales (stream reach, watershed, sub-basin).

Models will be needed to relate salmon productivity and survival to, among other factors, water quality, channel structure, extent of riparian buffers, and wetland type and distribution. Some models exist for some habitat components, but they need calibration and refinement. For example, the model most widely used to estimate needed instream flows (Instream Flow Incremental Methodology) has been widely criticized for being applied outside its intended geographic range. Empirical models based on real field data will be less subject to dispute than conceptual models built on theoretical ideas of ecosystem processes.

Once habitat goals are established, they will profoundly influence land and water use, and are therefore likely to be contested. Competing models will be used to advance political agendas, so it will be very important for scientists not only to identify where their models agree but also to explain why they disagree in terms that non-scientists can understand.



Necessary tools

Habitat assessment techniques

Habitat is not static; population growth and economic shifts will drive land use changes. Land use planners can mitigate the impact of development on salmon by identifying priority areas for protection. Key to this will be developing functional assessment tools for a range of habitat types. These tools measure a particular area's ability to provide "ecosystem services" such as nutrient uptake or groundwater recharge. Functional assessment schemes have been developed for wetlands, and have been critical in allowing the development of wetland mitigation banks. Should the region choose to develop broader habitat banks to offset the impacts of development – as has already been done in California, and will be discussed further in Part 4 – then functional assessment tools will be needed for forests, riparian buffers and tidal shorelines, amongst others.

Diagnosing problems: watershed analysis

Watershed analysis assesses current environmental conditions, determines how those conditions affect salmon and identifies sources of human disturbance which could be modified to benefit salmon. Oregon, Washington and the Northwest Power Planning Council all use some form of watershed analysis, though the emphasis tends to be on

inventorying conditions rather than analyzing ecological functions: in effect, describing symptoms but not diagnosing the underlying causes. "Limiting factor analysis" assesses habitat deficiencies, and provides small-scale and short-term prescriptions to remedy them, but the effectiveness of the resulting projects can be undermined without a focus on restoring the health of the whole watershed by restoring ecosystem processes. The Forestry Module produced by Washington's Department of Natural Resources which focuses on ecological processes, though on relatively small geographic scales, is an example of the type of analysis which should be developed for other ecoregions and land uses.

Understanding options: measures of BMP effectiveness

Much of what we need to do in order to halt salmon declines involves adopting more "salmon-friendly" land and water use practices. In many cases a variety of alternative Best Management practices (BMPs) are available to reduce the impacts of existing land uses. In order to understand the contribution that a particular BMP might make to salmon recovery we need to know its effectiveness in removing pollutants, conserving water, and so on. The effectiveness of stormwater BMPs in removing specific pollutants has been well-studied, but there is less detailed knowledge of the effectiveness of many agricultural BMPs. This information will be particularly important if pollutant trading programs are implemented, as suggested in Part 4. In addition, studies are needed to examine the feasibility of using BMPs: for example, many urban areas lack suitable sites for retrofitting.

Understanding options: decision support models

Decision-support models build on our knowledge of salmon-habitat relationships. They allow decision-makers to predict the effects of management actions on salmon populations, and thereby compare the biological effectiveness of proposed alternative actions. The most widely used model is the Ecosystem Diagnosis and Treatment (EDT) model developed by the NWPPC and used extensively in watershed planning. EDT is a conceptual model – it depends upon understanding the functional relationships between watershed condition and salmon biology (relationships which, as noted above, are not well understood for certain habitats). EDT needs extensive field testing of its assumptions. It also needs to be expanded to represent how changes in one habitat component can influence another and in turn how these interactions affect salmon populations.

Measuring success

Environmental indicators

One of the biggest challenges for a habitat strategy will be developing indicators to measure its success. A successful habitat strategy should improve landscape condition (the amount and quality of particular habitat types such as backwater areas) and water quality. However, changes in each of these will be difficult to measure and/or relate to management actions. For example, while it relatively straightforward to measure water quality at a site, that water quality is the integrated result of processes occurring throughout a watershed, and may vary regardless of local changes in land use management. Scientific uncertainty, natural environmental variability and the time lags expected

between onset of certain activities (such as planting riparian buffers) and expected environmental responses (lowered stream temperature) will greatly complicate efforts to connect "results" to actions.

Assessments of landscape condition will need to be both structural (amount, geographic distribution and condition of habitat) and functional (what natural processes are supported?). The region should take advantage of the work done by the states of Oregon and Washington, through the Oregon Progress Board and Salmon Recovery Scorecard respectively. Both of these have developed useful environmental indicators such as % of stream miles restored for salmon, % of stream sites meeting instream flow requirements 9 months of the year and wetland acreage as a % of 1985 acreage. Other useful indicators would measure the number of stream miles open to fish, the numbers of diversions adequately screened, and the acreage of habitat protected.

While it may seem intuitively obvious that we need to measure salmon populations, the complex lifecycle of salmon makes it hard to relate salmon numbers to local management actions. Aquatic insects and other organisms which are fixed in place, are functionally connected to salmon, and respond to local environmental changes may be more useful guides to a river's ability to support salmon.

Monitoring

An enormous amount of data will be needed to properly evaluate a habitat-based strategy. Data must be collected on past, present and future habitat conditions such as water quality and the distribution of riparian buffers. It must be collected on the past, present and future status of human and natural factors such as land use and precipitation which may affect habitat conditions. All of this data needs to be collected over very variable scales of time (weeks, months, years) and space (reach, watershed, sub-basin, region). The resource challenge is enormous.

One possible solution to address this resource challenge is to expand the role of citizen monitoring. The past decade has seen an increase in both the number of citizen groups conducting monitoring and the sophistication of volunteer monitoring techniques. Agencies sometimes express concern about the quality of citizen-collected data, but review shows that it can be as good as that collected professionally. This is particularly true for biological monitoring such as sampling of aquatic insects.

A critical need is for development of a standard data collection protocol so that data can be shared among different agencies and organizations. Agreement needs to be reached on data collection methods, and on the frequency and spatial extent of monitoring as well as on the division of this responsibility among organizations. An information management system must also be developed to make this data accessible as needed, so that it can be used in adaptive management. Streamnet [64] is a useful model of how data can be networked and made available over the Internet.

10. Meeting future habitat challenges

One of the few things we can be sure of is that future population growth, economic change and climate change will increase the stresses on salmon and their habitat, and that a habitat strategy must build in ways to address these stresses.

Population growth

Population in the Pacific Northwest doubled since 1960 [65]. The population of Washington State has been growing by 100,000 per year, and the Census Bureau predicts that 2.7 million more people - the equivalent of 5 Seattles - will live in Washington by 2020, as shown in Figure 5. A habitat strategy should encourage communities to adopt "Smart Growth" strategies that can accommodate population increases, create livable communities and minimize stress on ecosystems. All four States in the region have developed some variant of "Smart Growth" legislation.

However, translating "Smart Growth" concepts into on-the-ground projects will require planners and managers to make tradeoffs. For example, urban shorelines are often armored and "hard" to contain contaminated sediments and protect private property against flood damage, yet salmon and other aquatic species would benefit from a "soft" shoreline management approach relying on wetlands and other buffers. Likewise, the regional need to preserve open space favors maximizing development within urban growth boundaries, yet the attractiveness and livability of urban areas depends on foregoing some infill development to retain open space within cities. Planners and managers will need to develop an accounting system to compare the social, economic and environmental benefits of various alternatives at local and regional scales. The Willamette Valley Alternative Futures Project is a coarse-scale example of this, showing distribution of forest, farmland and urban development under two alternative scenarios and comparing the consequences for forest and farm production and for the cost of urban services.

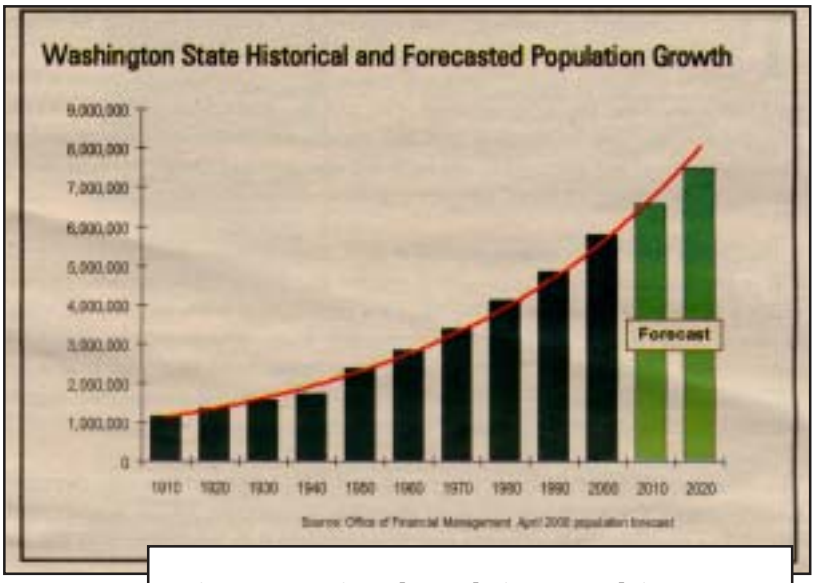


Figure 5. Projected Population Growth in Washington

Economic change

The economy of the Pacific Northwest has undergone a shift, from a primarily resource-dependent economy in the 1960s to a service- and information-oriented economy today. This economic shift has deepened the economic and cultural divide between urban and rural areas. "Working landscapes" are in decline and suburban sprawl is consuming former agricultural areas. Since 1970, 500 sawmills have closed and 15,000 farms have gone out of business[66] . The concentration of wealth in urban areas, and corresponding economic decline in many rural areas, creates obvious social problems but also poses a challenge to the funding of salmon recovery: how should the costs of salmon recovery be apportioned in a watershed or salmonshed that contains urban and rural areas? Will urban areas be willing to fund projects located in rural areas if these provide greater benefit to salmon? Balancing strategic investments and political realities will be discussed further in Parts 4 and 5.

Perhaps the greatest economic challenge arises from the fact that salmon restoration requires a commitment to long-term actions that is currently unmatched by a long-term commitment to fund those actions. The dangers of relying on annual or biennial appropriations were illustrated in 2001, when Federal and State budgets went from surplus to deficit in the course of a few weeks or months. Should ecosystem restoration be dependent on annual budget processes, or should it have dedicated funding through a trust fund mechanism as used for highway infrastructure? Theses issues will be explored further in Part 5.

Climate change

The drought of 2001 may be a harbinger of future difficulties for the salmon and people of the Pacific Northwest. Climate change predictions call for the Pacific Northwest to become warmer, with the result that much of the precipitation that now falls as snow will instead fall as rain. This will change the timing and amount of spring runoff, and will reduce summer streamflows. Consequently, it will become even more difficult to balance the water needs of agriculture, municipalities and salmon. Planning must begin now to meet the water needs of the future, which include not only current uses but also meeting instream flow requirements for fish and the needs of growing communities. Such planning must examine all options: increased conservation, water reuse, buybacks of water rights, and increased storage.

11. Conclusions

Although salmon habitat in the Pacific Northwest has been dramatically impacted by human activities in the past 150 years, local efforts have been successful in restoring habitat and bringing back salmon populations. Restoring watersheds benefits not only fish, but also the people who share those same watersheds.

Restoration needs to be guided by science, and considerable research is needed to better understand salmon-habitat relationships and to model the effects of habitat management actions. Restoration will be ineffective unless the causes of habitat degradation are addressed, and in many cases this will mean changing current land and water use practices to become more "salmon-friendly". In addition to restoration (rebuilding habitat) and conservation (improving land and water use), a habitat strategy must also include preservation of existing refugia, from which existing salmon populations can re-colonize restored habitat.

In short, salmon need "CPR": conservation, preservation and restoration. Performing "CPR" is not solely the work of the government, because much salmon habitat is on private land. Nor can we rely on the regulatory system to restore salmon and their watersheds; a complementary performance-based system which provides regulatory and financial incentives to those who commit to undertaking activities which benefit salmon may prove a useful complement to regulation.

Some aspects of "CPR" are being addressed by existing Federal and State programs. However, many programs are underfunded or in need of revision to maximize their effectiveness, and some habitat needs are not currently being addressed. Detailed recommendations for implementing a habitat strategy – who will do it, how it will be done and how it will be financed – will be described in Parts 3 through 6 of this series.

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