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Habitat Policy for Salmon in the Pacific Northwest

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Abstract

Earlier in the 20th century, habitat decisions were based on a belief that aquatic habitats could be manipulated with technology to benefit salmon, especially in terms of fish passage. The importance of riparian zones and biophysical watershed processes to salmon productivity was poorly appreciated. Recent events, coupled with an awareness of widespread habitat simplification, have changed this perspective. Spurred by passage of state forest practices acts, federal clean air and clean water acts, and the Boldt tribal fishing rights decisions in the 1970s, federal and state agencies recognized the importance of riparian zones as critical links between aquatic and terrestrial ecosystems. The listing of the northern spotted owl and several stocks of salmon (*Oncorhynchus* spp.) under the federal Endangered Species Act in the early 1990s prompted a team of scientists under a mandate from US President Clinton to suggest an ecosystem-based approach to habitat management that relied less on engineered habitat substitution and more on streamside buffers that preserved land-water interactions. This approach constituted a landscape-scale application of the principles of adaptive management in which conservative interim buffer guidelines (i.e., large buffers) could be adjusted if watershed analysis showed that smaller buffers would not be likely to harm aquatic resources.

While federal forest lands are expected to anchor the recovery of some salmon stocks in the future, the location of these lands regionally and within river basins prevents them from serving as refugia for many stocks that inhabit coastal lowlands containing urban, agricultural, and non-federal forests. Comprehensive, region-wide improvement in aquatic ecosystems can only occur when habitat policy decisions are shared among affected natural resource users and when watershed-scale strategies are implemented that identify and protect remaining nodes of productive habitat and seek to restore riparian corridors and greenway systems which reduce habitat fragmentation are implemented.

Looking Backward

The decision-making process for managing habitat has evolved from being a marginal issue in salmon restoration to being a major factor in recovery plans for salmon (*Oncorhynchus* spp.) in the Pacific Northwest. It has been a mixture of good and bad logic and serendipitous politics; it involves relationships between land-use activities and issues of watershed health and resource sustainability (Naiman et al. 1992). In order to understand how this mixture came about, we must retrace the history of habitat management in the Pacific Northwest. In this way, we can see how decisions were made in the past and better understand the basis for how current decisions are being made. Most of the examples we cite are related to forestry activities, but other land and water uses have had histories of similar decisions. We conclude our review with a discussion of how recent developments in forest planning are evolving into a general set of regional protocols for addressing the very complex habitat problems related to salmon and their ecosystems in Pacific Northwest watersheds.

Habitat loss has always been a concern of salmon conservation. Even in the 19th century there were papers in the fisheries journals, often anecdotal, suggesting that habitat was being lost at an alarming rate (Stone 1892). The earliest known stock extinction (a sockeye salmon population in the Puget Sound area) related to post-settlement land development was caused by a farmer building a dam across a spawning stream (Nehlsen et al. 1991). Before the turn of the 20th century, the notion of a salmon reserve, a large area where habitat would forever be protected from human development, had been put forward (Stone 1892). Although hatcheries figured prominently in the fisheries management programs of federal and state agencies even in the early part of the 20th century, the extent of habitat loss and knowledge that large hydroelectric dams were about to be built led to some of the first stream surveys in the 1920s and 1930s (Craig and Hacker 1940, Rich 1948). These surveys constitute important historical benchmarks against which current conditions can be measured.

After World War II and the Korean War, there were infusions of surplus heavy equipment that fisheries agencies used to modify stream channels in an attempt to improve habitat. The perception that drove these activities was that migrating salmon were often blocked by log jams and waterfalls; these and other obstructions were the principal culprits in habitat loss. Agency policies viewed impediments to the upstream migration of adult salmon as sources of mortality or reproductive failure (Evermann and Meek 1898, Gharrett and Hodges 1950, McKernan et al. 1950). In addition, fish biologists worked with the United States (US) Army Corps of Engineers to straighten and smooth stream channels so that fish would not be stranded with the rise and fall of the hydrograph. Stream cleaning was believed to benefit navigation and efficient log transport, as well as reduce the risk of fish becoming stranded (Sedell and Luchessa 1982).

The very large flood of late 1964 caused widespread habitat changes in many coastal watersheds of Oregon and Washington, including the creation of many log jams. Repairing the effects of this 100-year event dominated state and federal fish habitat restoration programs for 15 years. Many of these programs involved using heavy equipment or hand cleaning methods to remove log jams. Thus, there was much enthusiasm for engineered habitat solutions that began in the post-war years. The period from 1950 to the mid-1970s also witnessed the construction of many of the region's salmon hatcheries and other large-scale enhancement facilities such as rearing ponds and spawning channels (Hilborn and Winton 1993). Most projects were directed toward increasing the production of one or two species and did not closely resemble the complexity of natural stream environments (Bisson et al. 1992). This was consistent with management's philosophy for a commodity-production orientation towards other natural resources in the region. Protection of ecological processes and conservation of entire aquatic communities were not high priorities.

The impact of the federal court decisions in the mid-1970s on fisheries management in the Pacific Northwest cannot be overestimated (Lee 1993). By affirming the Native American treaty tribes' rights to half of the available salmon harvest in Boldt Decision Phase I and to protection of habitat in which salmon were produced in Boldt Phase II, the courts put fisheries agencies, fishers, and land owners on notice that the tribes would be co-managers of the resource and that harvest and habitat management would have to be linked together more effectively than in the past. The 1970s were also a time when the federal government enacted the Clean Water Act, Clean Air Act, and Endangered Species Act, and many western states were passing the first forest practices acts for state and private forests. Although somewhat cursory, the new laws included requirements to protect streams and riparian zones.

In combination, the Native American fishing rights decisions and new environmental laws moved salmon management organizations to take habitat issues much more seriously in the 1970s and 1980s. Natural resource agencies and timber companies formed fish-forestry groups, the US Congress created the Northwest Power Planning Council whose charter included a mandate to restore salmon runs in the Columbia River basin (Lee 1993), universities held symposia devoted to habitat problems (Krygier and Hall 1971, Salo and Cundy 1987), and stream habitat protection assumed greater importance in land-use plans.

The late 1980s and early 1990s produced a final development that set the stage for the current habitat crisis. The decision of the US Fish and Wildlife Service to list the northern spotted owl and of the National Marine Fisheries Service to list Sacramento River winter chinook (*Oncorhynchus tshawytscha*) and Snake River sockeye (*O. nerka*) and chinook salmon under the Endangered Species Act (ESA) had profound implications for the region's economic underpinnings. Following the spotted owl listing, the Seattle Chapter of the Audubon Society successfully petitioned the courts to halt logging on federal lands until the government could come up with a plan having a reasonable certainty of protecting fish and wildlife. In directing the USDA Forest Service (Forest Service) to solve the problem of managing multiple threatened and endangered species on federal lands, the US Congress demanded that a plan be prepared to provide sustainable fish, wildlife, and timber resources. A small team of Forest Service and university scientists was charged by a congressional subcommittee chairman with solving the timber, old-growth forest, and owl problems, and to include fish because of their critical importance to the region.

FEMAT and Habitat Decisions

The administrative gridlock accompanying the 1991 and 1992 injunctions against logging federal timber in the range of the spotted owl prompted the first visit by a US President and most of his domestic cabinet members to the Pacific Northwest expressly to help solve a natural resource problem. When President Clinton came to Portland, Oregon, in 1993, it was telling that he rarely mentioned owls but he mentioned fish a number of times. One of the main outcomes of the President's Forest Conference was the formation of an interdisciplinary scientific group, the Forest Ecosystem Management Assessment Team (FEMAT), whose charge was to consider both the long-term health of Pacific Northwest ecosystems and human socio-economic systems while developing plans that were scientifically sound, ecologically credible, and legally responsible (FEMAT 1993). The charge of legal responsibility was particularly important because court decisions indicated that federal agencies had not adhered to the principles of the National Forest Management Act (NFMA) in the preceding decade, and it was clear that future logging on federal lands could not take place without legal endorsement.

The FEMAT was asked to produce a plan that yielded a predictable and sustainable timber harvest and that incorporated fish habitat protection as a major component. All federal agencies were directed to cooperate. To protect salmon, the plan had to include the variability and availability of both freshwater and marine environments and develop alternatives employing an ecosystem-based approach. However, the plan was to minimize, to the extent possible, the economic impact of listed organisms on non-federal lands. Large patches of habitat for threatened and endangered organisms (Fig. 1) were set aside in federal forest lands so that the burden of conserving these species would be reduced for states or private land owners. Balancing this objective with the legal requirements of the ESA and the NFMA challenged team members because they were scientists, not lawyers, and little case law pertaining to similar situations existed that could help guide them. The NFMA required that forests be managed for "viable populations, well distributed across the landscape," but FEMAT understood that human presence in watersheds would obviate this goal in some instances by creating significant gaps in species' distributions.

The FEMAT also understood that whatever forest management option was finally adopted could not guarantee protection sufficient to prevent future salmon listings under ESA because federal forest lands supported only a portion of the life cycles of anadromous species (FEMAT 1993). Factors operating outside federal forests influenced the abundance of different stocks. On a region-wide basis, federal forest lands made up only about one-third the total land area within the range of the northern spotted owl. However, the position was taken that the Forest Service and USDI Bureau of Land Management (BLM) had an obligation to manage watersheds in such a way that productive fish habitat would be maintained regardless of the abundance of particular fish populations. Additionally, management plans had to account for uncertainty in such a way that forestry and related activities would not harm streams and riparian zones even when unforeseen natural disturbances occurred.

What finally emerged was an aquatic conservation strategy (Sedell et al. 1994) that included riparian reserves, watershed analysis, habitat restoration, and monitoring built around a system of drainages called "key watersheds" (Fig. 1). These were 4th- to 6th-order watersheds that possessed aquatic habitat considered to be in good condition and to have known populations of potentially at-risk anadromous or resident salmonids. It was assumed that fish from these productive watersheds would eventually be available to colonize surrounding areas as habitat in other watersheds of a basin improved over a period of 1 to 2 centuries. Key watersheds were relatively large (15–1,000 km^2), and the riparian buffer requirements within them (100–140 m wide, each side of the stream) were quite stringent. However, the aquatic conservation strategy specified that riparian reserves could be changed if a detailed watershed analysis had been conducted and a valid ecological rationale for redefining the boundaries existed. Thus, in a very real sense, the strategy utilized principles of adaptive learning (Walters and Holling 1990, Lee 1993) but began with a conservative protection approach that would be likely to cause minimal harm to important aquatic resources. The burden of proof for being allowed to alter riparian buffers so that more timber could be harvested from watersheds was on land managers, who were required to conduct a detailed analysis to justify proposed changes. This strategy of adaptive management became a central theme in President Clinton's Forest Plan (FEMAT 1993). The FEMAT report also recognized that most watersheds would benefit from some sort of restoration, and that watershed analysis would be quite helpful in identifying restoration priorities.

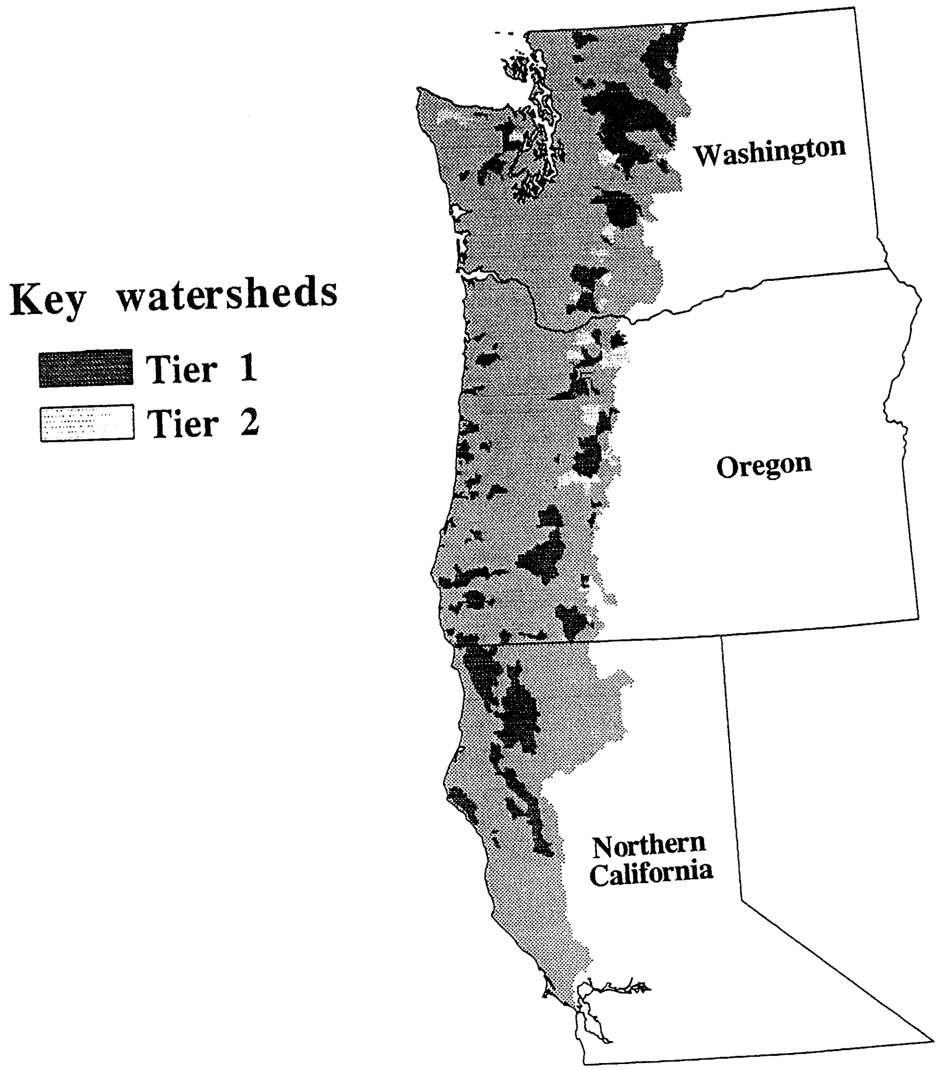

Figure 1. Distribution of key watersheds within the range of the northern spotted owl. Tier 1 watersheds contain at-risk anadromous or resident salmonids (bull trout, *Salvelinus confluentus*). Tier 2 watersheds are important water sources for drainages containing at-risk stocks. Source: Forest Ecosystem Management Assessment Team (1993).

The distribution of key watersheds and wilderness reserves throughout the range of the northern spotted owl was not uniform (Fig. 1). Some regions were fairly well covered while others had few key watersheds in which fish habitat protection and restoration would become a high priority. Large reserves were located along the central axis of the Cascade Mountains, in Washington's Olympic Peninsula, and in the Siskiyou Mountains of southern Oregon and northern California. Other regions such as southwest Washington, western and central Oregon, and many coastal lowlands, had fewer key watersheds. Absence of an extensive network of key watersheds in these regions resulted from the majority of these lands belonging to state and private ownership.

Key watersheds were not meant to be areas where all land uses, including timber harvest, were prohibited. Rather, they were meant to be drainages in which protection of aquatic habitat was given the primary emphasis as other management activities took place. In an idealized watershed, FEMAT requirements provided 100-m buffers for permanently flowing streams, wetlands, and hillslopes with highly unstable soil (Fig. 2). While buffers are present on all permanently flowing streams, many of the ephemeral streams do not have wide buffer zones. Although there may be certain ecological gains from maintaining late-successional buffers along ephemeral streams, there may be even greater benefits (e.g., reduced forest fragmentation) to integrating riparian management objectives of these numerous small drainages with those of adjacent hillslopes. Protection measures around these small streams will still be necessary during logging, but watershed analysis may indicate that some ephemeral streams may not require wide buffers in order for adequate ecological interactions to occur.

Designation of riparian reserves for permanently flowing and ephemeral small streams, as well as unstable hillslopes, distinguished the interim guidelines of the FEMAT from existing forest management plans (Table 1). At the time of the legal injunction against logging late-successional and old-growth federal forests within the range of the northern spotted owl, standard BLM riparian prescriptions in a drainage the size of Augusta Creek, an 11,200-ha watershed in the McKenzie River system of western Oregon, would have accounted for about 8% of the total watershed area. The riparian management guidelines of the Willamette National Forest of Oregon were somewhat more conservative and would have encumbered ~14% of the drainage area (Table 1).

The FEMAT concluded that neither of these riparian reserve systems would have been sufficient to prevent continued degradation of aquatic habitat over a century or more (FEMAT 1993). Application of interim buffer guidelines (100–140 m) for fish-bearing streams and smaller buffers (50 m) for non-fish bearing streams to watersheds such as Augusta Creek would have maintained ~30–40% of the landscape in riparian reserves—several times the amount of land existing forest plans had required. Augusta Creek drained the west slope of the Cascade Mountains and had a moderate drainage density—about 4 km of stream length per km^2 watershed area. However, some streams in the Coast Range of Oregon and Washington had drainage densities of about 6–8 km of stream length per km^2 watershed area. Application of interim FEMAT buffers to these watersheds would have placed ~65–80% of the total area in riparian reserves, a very large and politically unpopular increase over existing protection standards. But the intent of President Clinton's Forest Plan was that, given the precarious status of many stocks of Pacific salmon, a stringent set of protection guidelines should be followed until a thorough analysis indicated that buffer requirements could be relaxed in some parts of the drainage (Sedell et al. 1994). The really significant change was that the FEMAT proposal placed the burden of proof on watershed analysis to show where timber harvest in riparian areas could occur without the likelihood of significant damage to aquatic communities over time.

The other factor that prompted FEMAT to suggest wide vegetative buffers was the knowledge that a number of other, less well-known plant and animal species spent most or all of their lives in riparian zones (FEMAT 1993). Most of the ecological functions affecting aquatic species (Fig. 3, top) were believed to be achieved within a distance from the edge of the channel equal

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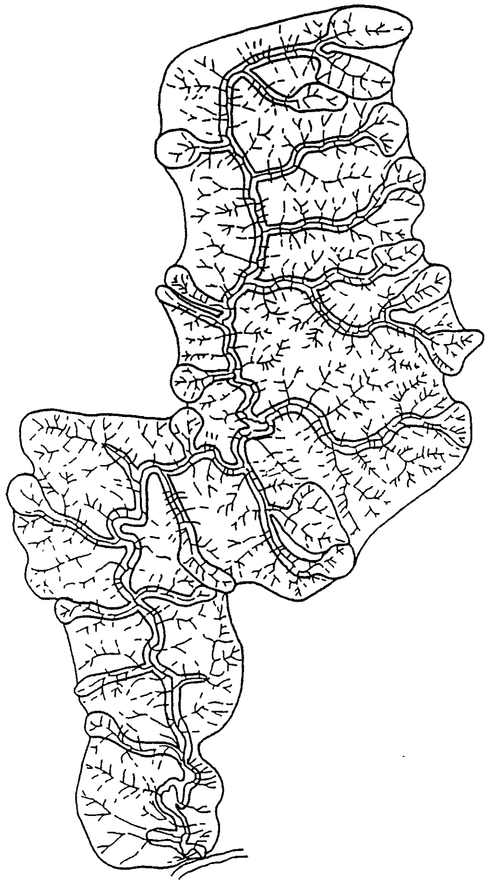

Figure 2. Schematic diagram of how riparian reserves might be arrayed after modification by watershed analysis. The channel network is depicted as follows: —— = permanently flowing streams; ---- = ephemeral streams.

to the height of a mature tree at that site (one "site-index" tree height), a width of ~45–75 m. However, a buffer this wide would be insufficient to protect all aspects of the interior microclimate associated with riparian zones in old-growth forests (Chen 1991). Interim buffer guidelines for permanently flowing streams were therefore extended to the width of two site-index tree heights (90–150 m), which FEMAT (1993) concluded would have a greater likelihood of producing microclimate conditions similar to what would be found in unmanaged forests (Fig. 3, bottom). Additionally, the wider buffers would provide a margin for error owing to scientific uncertainty or to the occurrence of infrequent large, natural disturbances. The overall impact of applying the riparian reserve guidelines to federal forest lands would lead to a significant reduction in watershed area available for timber harvest. The FEMAT believed this reduction alone would promote the recovery of ecological processes in watersheds where habitat had been damaged, as well as protect those functions in watersheds where habitat existed in a natural condition.

Table 1. Riparian reserve widths (one side of stream). Percent of total drainage area in riparian reserves are from Augusta Creek, Oregon, an 11,200-ha watershed. Modified from Thomas et al. (1993).

	Approximate widths (m) of riparian reserves and riparian management areas			
Stream category	Bureau of Land Management	Willamette National Forest	Reserves in non-key watersheds	Reserves in key watersheds
High value, permanently flowing, fish bearing	75	65	110	110
Lower value, permanently flowing, fish bearing	50	30	110	110
Permanently flowing, non-fish bearing	30	30	55	55
Intermittent	0	8	28	55
Area in riparian reserves	8.5%	14%	36%	53%

Habitat Policy in Non-Federal Lands

State and privately owned forest lands in the Pacific Northwest have been regulated by state forest practices rules since the 1970s, whereas until recently federal forests have been regulated through regional forest plans. The approximate percent of key ecological functions included in streamside management zones of different widths can be assessed by comparing the width of the riparian corridor needed for complete functioning, based on available scientific information, with the width of the buffer prescribed by rules and regulations (Fig. 3). Most state forest practices rules prescribe buffers that provide less than complete protection for some riparian functions. For fish-bearing streams, state rules prescribe buffers up to ~30 m, or ~20–30% of a dominant site-index tree height.

Compared with state rules, the interim guidelines recommended by FEMAT provide a much higher level of protection. Therefore, habitat protection policies for federal forests specify a very low risk approach while state policies apply an approach that accepts a greater risk of long-term habitat alteration. It is possible to get a general idea of how effectively state forest practices rules protect aquatic resources using approximate indicators of the completeness of ecological processes as a function of riparian width. For example, if microclimate functions important to riparian-associated wildlife species such as certain amphibians, birds, or bats are considered, we can examine cumulative effectiveness curves for soil moisture, temperature, etc., to suggest riparian management widths needed to protect these species (Fig. 3). More importantly, the curves provide a basis for predicting how reductions in buffer widths are likely to affect different ecological characteristics.

Habitat management policies in the past decade have benefited from information on the location of high-quality habitats and from scientific data suggesting incremental gains or losses associated with varying riparian management zones. Along with this new information has come the political will to protect and restore riparian zones as an important component of the restoration of at-risk salmonids. It is generally acknowledged that state and privately owned lands will not be held to the same low risk standard as that which will be applied to federal forests, but how much risk is acceptable on these lands has not yet been resolved.

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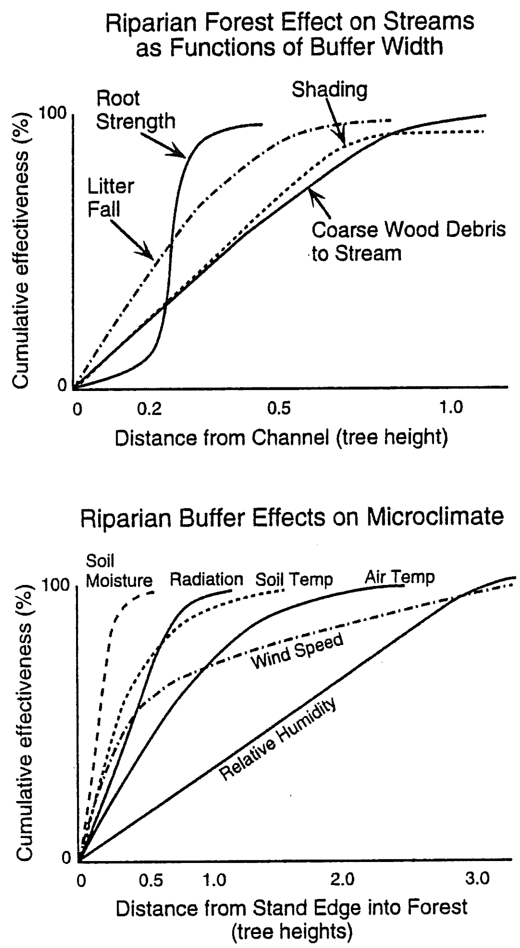

Figure 3. Top: generalized curves indicating percent of certain functions or processes affecting interactions between streams and adjacent riparian zones achieved within varying distances (as indexed to the height of a dominant tree) from the edge of the stream channel. Bottom: generalized curves indicating percent of microclimatic attributes achieved within varying distances from the edge of a riparian forest stand. Source: FEMAT (1993), based in part on Chen (1991).

Looking Forward

The overall effect of the President's Forest Plan and subsequent Record of Decision, if ultimately upheld in court, will be to remove a substantial portion of federal forest lands from the annual timber harvest base. Volumes of timber available for harvest that are believed to be sustainable over time while protecting fish and wildlife habitat are likely to be as little as 10–30% of the timber volumes logged annually during the 1980s. Federal forests and wilderness areas will, in effect, become the mainstays of a refuge system for salmon and other forestdependent species at risk of extinction in the Pacific Northwest. The policy decision to set aside significant lands for habitat conservation, whether driven by the ESA or other laws and treaties, will be very costly for the region.

Will this be sufficient to prevent at-risk salmon populations from becoming extinct? We believe in some instances it will not. Key watersheds in some federal forests are located around high-elevation montane environments with much of their land above those parts of river basins that support anadromous salmonids. State and privately owned forests in the Pacific Northwest tend to be located at lower elevations, which are more heavily utilized by salmon. Drainages with the greatest potential use by all species of salmon often occur in coastal lowlands and broad river valleys between the Coast Range and Cascade Mountains, areas usually dominated by agricultural and urban land uses. While having improved substantially over the last decade, habitat protection guidelines for state and privately owned forests in California, Oregon, and Washington are still less restrictive than those proposed by FEMAT (FEMAT 1993), and at present none of the Pacific Northwest states have an agricultural practices act that explicitly recognizes and protects riparian functions. In the absence of sweeping reforms of land-use laws to provide more even protection along all watercourses, continued degradation of aquatic habitat on non-federal lands remains likely.

Growth of major urban centers in the Pacific Northwest illustrates the dynamic population increases that have occurred in the region after 1950. Similar increases are seen in the number of automobile registrations, kilometers of roads, fishing license sales, and national forest recreational use (Fig. 4). Pressures on the productive capabilities of the region's natural resources have reached all-time high levels, along with the virtual certainty that they will further increase with continued immigration to the area. Given the inevitability of additional population growth and economic expansion, what can be done to help protect habitat currently in good condition and to rehabilitate habitat that is degraded?

A key to designing and implementing effective habitat conservation programs at the local level (i.e., the scale of individual watersheds or sub-basins) is to involve potentially affected

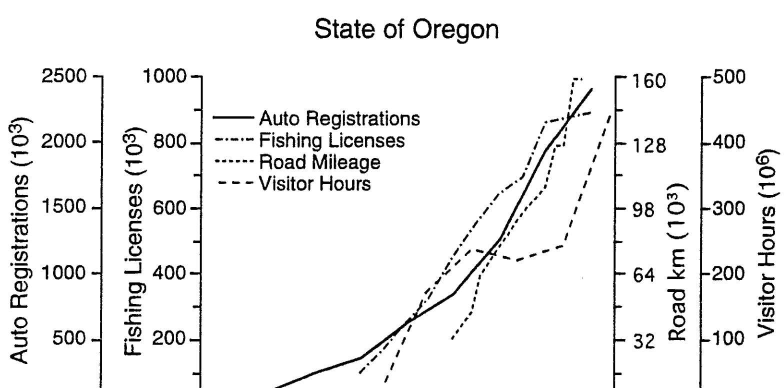

Figure 4. Trends in the number of automobile registrations, kilometers of roads, fishing license sales, and national forest recreational use during the 20th century.

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natural resource agencies, land owners, tribes, local governments, and environmental interest groups in policy decisions. For the most part, previous attempts to bring diverse interests to the table have failed (e.g., the "salmon summit" of the early 1990s that attempted, unsuccessfully, to forge a consensus agreement to resolve the crisis of declining Columbia River salmon). Whether more widespread salmon listings, or the threat of listings, under the ESA will be sufficient to catalyze successful co-management agreements remains to be seen, but unless the political will is present to develop consensus programs that have sound ecological underpinnings (Volkman and Lee 1994), prospects for non-litigated solutions seem remote.

Urban and industrial sites, highways, and other permanent structures will prevent restoration of riparian zones in heavily developed areas and some agricultural lands. In those areas, buffers along major river systems will not be continuous and riparian corridors will remain fragmented. Habitat improvement plans will need to identify locations of healthy riparian zones and opportunities for reestablishing corridors of riparian vegetation between them where possible. However, productivity will be lost where development prevents interactions between streams and riparian zones from occurring. Such losses may be unavoidable, but it will be important to locate remaining nodes of good-quality habitat so that they can be managed in a way consistent with the habitat needs of salmon and other aquatic resources.

Watershed analysis procedures for federal, state, and private forest lands are currently being refined; however, the analytical tools should be applicable to agricultural and urban lands as well as commercial forests and should assist in locating nodes of remaining good-quality habitat as well as identifying land-use activities that could cause habitat degradation. Although the stringent standards being applied to watersheds in federal forests will probably not be applied to non-federal land owners, it is essential that habitat management planning take place jointly. This will allow for identifying clear habitat goals, locating remaining productive habitats, and implementing reasonable conservation measures throughout the watershed. A basic premise is that habitat requirements should be met as salmon move through different parts of the river basin across different ownerships, and small, fragmented populations should receive the protection necessary to conserve genetic diversity wherever possible (Reeves et al. 1996).

We believe a sound technical underpinning based on ecological processes has now been established for managing the freshwater habitat of Pacific salmon. We now need better integration of habitat policy with regional policies affecting the harvest and propagation of salmon and other aquatic resources. Management policies involving resident and anadromous fishes are not always complementary. For example, a decision to enhance exotic game fishes or non-native salmonid stocks may affect both the habitat and genetic integrity of native salmonid populations. Harvest rates of commercially and recreationally important salmon may be so great as to deprive streams of the fish needed to occupy available habitats, and the loss of salmon carcasses may itself degrade the productivity of aquatic ecosystems (Bilby et al. 1996).

The future of habitat policy will also involve better coordination between publicly and privately owned land, a coordination enhanced by watershed-based planning groups in which all interested organizations are represented. We cannot return to completely pristine river systems; the Pacific Northwest landscape will consist of permanently degraded as well as productive habitats. Our ability to maintain and strengthen healthy salmon populations in high quality environments in spite of permanent habitat losses in some areas will depend on our ability to work together and to develop systems of practical incentives for land and water managers to increase environmental stewardship across all land uses. The extent to which such cooperative efforts succeed in improving habitat for salmon will depend largely on a willingness to change, a commitment to research and monitoring, and an ability to learn from past mistakes.

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