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An Ecosystem Approach to the Conservation and Management of Freshwater Habitat for Anadromous Salmonids in the Pacific Northwest

Gordon H. Reeves and **James R. Sedell**
USDA Forest Service
Pacific Northwest Research Station
Corvallis, Oregon

Introduction

Many stocks of wild anadromous salmonids (*Oncorhynchus* spp.) are presently in precarious condition. (A stock is a locally adapted population of fish that are reproductively isolated to a large degree from other stocks [Ricker 1972]). Nehlsen et al. (1991) identified 214 stocks in Idaho, Washington, Oregon and California that are in immediate need of special management considerations because of low or declining numbers. In addition, 106 major stocks were believed to be already extinct. Factors responsible for the demise of these fish include: (1) habitat degradation and loss from urbanization, agriculture, livestock grazing, mining, timber harvest and dams; (2) over exploitation in sport and commercial fisheries; (3) migratory impediments, such as dams; and (4) loss of genetic integrity due to influence of hatchery practices and introduction of non-local stocks. These factors do not operate in isolation from each other; the cumulative effects of two or more of these factors acting on a stock may exacerbate or magnify effects of individual factors (*see* Cederholm et al. 1981, Salo and Cederholm 1981).

The state of anadromous salmonid stocks in the Pacific Northwest is reflective of the general condition of fish throughout North America. Concern about biodiversity has focused on the tropics, but the loss of temperate species is equal to the loss in tropical areas. This is particularly true for fish in western North America (Allendorf 1988). Williams et al. (1989) listed 364 species and subspecies of fish in North America that are in need of special management considerations because of low numbers. This is an increase of 139 taxa since 1979. Moyle and Williams (1990) found that 57 percent of the freshwater native fishes of California were extinct or in need of immediate attention. The demise of these fish is attributable to factors similar to those responsible for the condition of anadromous salmonid stocks (Williams et al. 1989, Moyle and Williams 1990).

Habitat loss is the most frequent factor responsible for the decline of anadromous salmonid stocks (Nehlsen et al. 1991). This includes decreases in the quantity and quality of available habitat and the fragmentation of habitat into isolated patches. In the Pacific Northwest, effects from forest management activities have degraded the freshwater habitat of many anadromous salmonid stocks (*see* Hicks et al. 1991). However, quantitative relationships between long-term trends in fish abundance and effects of forest management practices have been difficult to establish (Bisson et al. 1992).

Hicks et al. (1991) and Bisson et al. (1992) concluded that, despite the lack of strong quantitative relationships between forest management activities (and other land-management activities as well), a primary consequence of these activities has been the simplification of fish habitat. Simplification includes a decrease in the range and variety of hydraulic conditions (Kaufmann 1987), reductions in amount of large wood and other structural elements (Bisson et al. 1987, Bilby and Ward 1991), and a decrease in the frequency and diversity of habitat units and substrate types (Sullivan et al. 1987). Salo and Cundy (1987) and Meehan (1991) contain several additional references detailing the link between effects of land-management activities and the condition of fish habitat.

The purpose of this paper is to describe a plan for managing habitat on federal lands in parts of the Pacific Northwest (northern California and western Oregon and Washington) for anadromous salmonids. This plan was initially developed as part of an effort that was requested by the Agriculture Committee and the Merchant Marine and Fisheries Committee of the United States House of Representatives to develop alternatives for managing old-growth ecosystems (Johnson et al. 1991). Here we describe the components of the report that dealt with the management of fish habitat, referred to as the Watershed/Fish Emphasis (WFE) in Johnson et al. (1991). These were designed as part of an integrated package for managing late-successional and old-growth ecosystems, and were not meant to stand on their own.

Components of the Watershed/Fish Element

The WFE is designed to address one factor, habitat degradation, that is responsible for the demise of anadromous salmonids. By itself, the WFE will not lead to the recovery of stocks that are in trouble. As mentioned previously, a suite of factors is responsible for the current status of these fish. The WFE represents actions we believe are necessary to prevent further deterioration and loss of freshwater habitat on federal lands, and to initiate the recovery of degraded habitats. It also is designed to maintain and restore ecological function and processes that influence fish and fish habitat.

Elements of the WFE are designed to protect habitat that is currently in good condition, minimizing probability of disturbance from future land-management activities in all areas, and initiating actions that restore ecological functions and processes influencing fish and fish habitat. The primary elements are: (1) key watersheds located throughout the area covered by Johnson et al. (1991); (2) expansion of riparian management areas throughout the area covered by Johnson et al. (1991); and (3) initiation of watershed restoration programs. Additional elements are listed in Johnson et al. (1991). Each element addresses a critical aspect for maintaining and restoring fish habitat and ecological functions in streams. They were developed as a package and were not designed to be implemented alone or in some limited combination.

Watersheds

Conservation efforts designed to aid threatened fish should be focused at the watershed scale (Sheldon 1988, Williams et al. 1989). We identified 137 watersheds as the nuclei of a broad-scale habitat protection and restoration program. Criteria for selection of these watersheds were: (1) they were greater than six square miles (15 km^2) and had relatively high quality water and fish habitat, or had the potential of providing high quality habitat with the implementation of restoration efforts; and (2) contained habitat for potentially threatened stock of anadromous salmonids or other potentially threatened fish species. Figure 1 shows watersheds in Oregon and

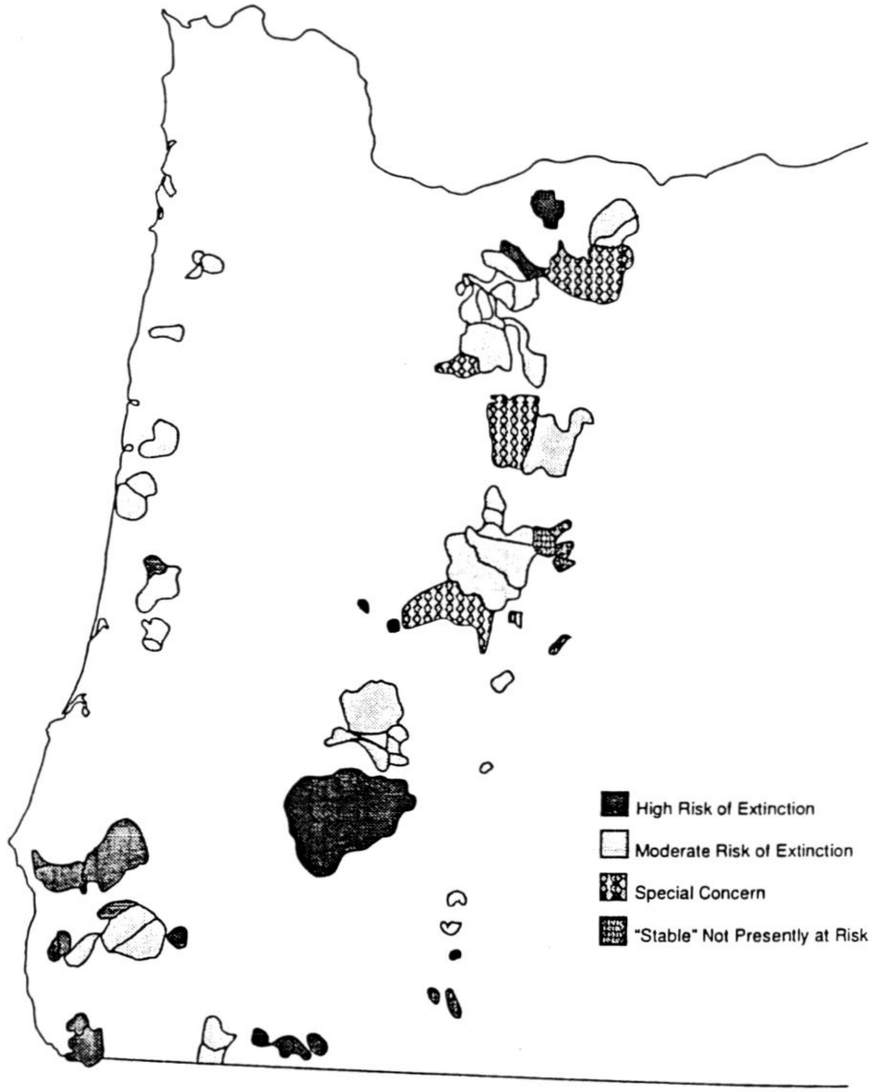

Figure 1. Location of key watersheds in Oregon and status of anadromous salmonid stocks (as determined by Nehlsen et al. 1991) within them.

the status of the stocks within the (*see* Johnson et al. 1991) for a complete list and maps of all watersheds). These watersheds will function as freshwater refugia for species or stocks that are currently at low population levels and also will be source areas of individuals to recolonize streams that may develop more favorable conditions.

Land-management activities within these watersheds will be restricted. Reserve areas for the northern spotted owl (*Strix occidentalis caurina*) and late-successional/old-growth ecosystems within these watersheds will be managed under guidelines established by Johnson et al. (1991). Timber harvest and other land-management activities would be curtailed in owl and old-growth reserves, at least in the short term (i.e., 3–4 years). All of the watershed outside of these reserves and other Congressionally established reserves (e.g., wilderness areas, national parks, etc.) would be managed for timber harvest on a 180-year rotation. One to two entries for silvicultural objectives will be allowed over a rotation. A primary benefit to fish and fish habitat from the reserves and long rotations is decreased probability of disturbance from land-management activities, both in frequency and magnitude. In addition, there will be increased time for recovery from anthropogenic, as well as natural, disturbance.

Ninety stocks of anadromous salmonids listed by Nehlsen et al. (1991) are found in the watersheds identified by this proposal (Table 1). An additional 85 stocks were found in watersheds within the area covered by Johnson et al. (1991). However, fish habitat in such watersheds was primarily affected by activities not occuring on federal lands, such as water withdrawal, agricultural practices and private forest management. Such activities were outside the scope of Johnson et al. (1991) and these watersheds were excluded from our proposal. In addition, four species of potentially threatened fish, bull trout (*Salvelinus confluentus*), redband trout (*O. mykiss gibbsi*), Oregon chub (*Oregonichthys crameri*) and the Olympic mudminnow (*Novumbra hubbsi*) (Williams et al. 1989) were found in these watersheds.

Riparian Management Zones

Fish habitat and ecological functions in streams are influenced by riparian zone characteristics (Gregory et al. 1991). The width of the riparian zone and the strength of its influence on the stream are related to stream size and local topography (Gregory

Table 1. Stocks of anadromous salmonids covered under the Watershed/Fish Emphasis (WFE) and those listed by Nehlsen et al. (1991).

Species	Number in WFE	Number in Nehlsen et al. (1991)
Cutthroat trout (*O. clarkii clarkii*)	4	13
Steelhead trout (*O. mykiss*)	32	75
Chinook salmon (*O. tshawystcha*)	28	64
Coho salmon (*O. kisutch*)	17	35
Sockeye salmon (*O. nerka*)	2	6
Chum salmon (*O. keta*)	6	17
Pink salmon (*O. gorbuscha*)	1	4
Total	90	214

et al. 1991). Riparian areas provide sources of large wood, food resources and nutrients, and influence water temperature. An ecologically functional riparian zone is an essential component of a productive aquatic ecosystem.

Under the WFE, we recommended expansion of riparian management areas on all federal lands covered by Johnson et al. (1991). The focus was on streams in watersheds smaller than 30 square miles (47,400 ha). In fish bearing streams in these watersheds, riparian management areas would extend 300 feet (91 m) on each side of the stream. In nonfish-bearing but perennially flowing streams, the riparian management area is 150 feet (45.5 m) on each side of the stream. The riparian management area in intermittent streams in moderate to highly unstable areas would have riparian management areas of 50 feet (15.2 m) on each side. In larger streams draining watersheds greater than 30 square miles (47,400 ha), the riparian management zone would be ⅛ mile (200 m) on each side of the stream or the 100-year flood zone, whichever is larger. To maintain the greatest potential for recruitment of large trees to these streams, no scheduled timber harvest would be allowed in any riparian zone. Silvicultural management may be required, in some areas, to facilitate the recovery of desired vegetation and conditions, however.

Expanded riparian management zones along all stream classes and elimination of scheduled timber harvest within them is necessary to create conditions more favorable to fish and other aquatic and terrestrial organisms associated with riparian zones. Streams within basins that have been managed for timber harvest generally have reduced levels of large wood compared to streams in basins with little or no timber harvest (Bisson et al. 1987, Bilby and Ward 1991). In fish-bearing streams, the increased riparian management areas will insure that all trees capable of falling into the stream will have the potential of being recruited to the stream. It also will protect trees in the riparian zone against blowdown. Third, it will protect cold water seeps and springs that deliver cold subsurface water to streams. In nonfish-bearing streams, wood creates areas for the storage and processing energy sources that are used in larger streams, stores sediments, and collects smaller material that filter and trap suspended sediments (Gregory et al. 1991). Many amphibians are found in these streams and are strongly associated with wood-formed habitat (Bury et al. 1991).

Expansion of riparian management zones will confer benefits to aquatic organisms other than fish and to terrestrial organisms associated with riparian zones. It will increase habitat for organisms that are dependent on the transition zone between upslope and riparian areas. Improved travel and dispersal corridors for numerous terrestrial animals and plants, and a greater connectivity of the watershed also will result from expansion of riparian management zone boundaries (Gregory et al. 1991).

Riparian zones that provide the full spectrum of structures and functions are necessary for maintaining and restoring productive aquatic ecosystems. Stipulated boundaries of riparian management areas and the accompanying restrictions on commodity production in the WFE will maintain currently functioning riparian zones in all parts of the watershed. Also, riparian zones that presently do not function optimally should improve as a consequence of these actions.

Watershed Restoration

Streams throughout the area covered by this proposal are in poor condition and will require active programs to restore their fish-producing potential. A major focus of such efforts will be on an examination of existing roads and drainage networks on federal lands.

Forest roads may have strong negative impacts on streams and fish habitat (*see* Furniss et al. 1991, Hicks et al. 1991). They are major sources of excess sediment and water. Many roads also disconnect streams from adjacent riparian areas. A comprehensive review of road networks and implementation of an improvement program is necessary to reduce the impacts of forest roads. Removal, relocation and realignment of roads will be required to restore fish habitat and steam ecosystems on a watershed scale.

Reduction of the miles of forest roads is an important component of watershed restoration. In Region 6 (Oregon and Washington) of the USDA Forest Service, road mileage has risen from 22,000–24,000 miles (33,850–36,900 km) in 1962 to over 90,000 miles (138,460 km) in 1990. This is important because there is a legacy of roads built without adequate consideration of requirements for drainage or placement necessary to maintain fisheries and other aquatic values. Higher road densities may result in increased frequency of debris avalanches, which can cause massive sediment entry into fish bearing streams. Many miles of road must be "put to bed," by pulling culverts, resloping road beds, pulling fill and replanting. Roads should be relocated out of floodplains where feasible. Road mileage for new harvest units should be minimized; roadless areas should remain roadless and should be harvested by other means where possible.

Improving the road drainage network also will be required as part of the watershed restoration effort. Removing unnecessary culverts can reduce impacts associated with culvert blockage and failure (Furniss et al. 1991). Increasing the size of other culverts is necessary to reduce risks to streams from floods. Replacement of culverts with hardened stream fords also can reduce risks to streams during storm events.

Other components of the watershed restoration effort include stabilization of hillslopes, which may be sources of sediment to channels, and placement of instream structures that create fish habitat. Together, these activities will facilitate the recovery of fish habitat and stream ecosystems.

Conclusions

We reiterate that the WFE will not, by itself, prevent the demise of potential threatened fish stocks. Decline of freshwater habitat and disruption of ecological processes and functions are only one of the factors responsible for the decline of fish stocks. This program, in conjunction with that proposed by Johnson et al. (1991) for the northern spotted owl and late-successional and old-growth ecosystems, represents a set of actions that we believe are necessary to ensure a moderate probability of maintaining freshwater habitat on federal lands into the foreseeable future.

Some of the Pacific Northwest's most valuable aquatic resources are in serious jeopardy and decisive action is needed to prevent their demise. Past and present approaches to management have been based more on mitigating losses than on protecting or restoring natural processes that have created and maintained diverse and productive stream habitat. Mitigation, while well intentioned, has not been effective as witnessed by the current situation. The WFE protects and restores the processes necessary for productive stream ecosystems. Some benefits will accrue immediately, such as preservation of high quality areas. Restoration and recovery of degraded habitats may require an extended period, but it is, nonetheless, important for the future. We believe that the WFE, in combination with other aspects of Johnson et al. (1991), will accommodate the naturally dynamic nature of stream systems in the Pacific Northwest, facilitate the recovery of degraded systems to more productive states, maintain options for future management, and sustain fish habitat and ecologically necessary functions until additional knowledge allows us to implement new management measures.

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