Watershed Program Strategic Research Plan
2003/2004

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Executive Summary

The following plan summarizes the research approach and direction of the Watershed Program. The mission of the Watershed Program is to conduct research on physical and biological processes that influence aquatic ecosystems in the Pacific Northwest, effects of land management on those ecosystems, and ensuing effects on the health and productivity of anadromous fish populations and their habitats. We provide technical support to NOAA Fisheries policy makers and regulatory staff, and collaborate with other agencies, tribes, and educational institutions on research and education related to the management of Pacific salmon. The Watershed Program focuses on four primary research themes: 1) landscape analyses and assessments to assist with recovery planning for listed species, 2) fish responses to changes in habitat, watershed or ecosystem conditions, 3) effects of natural or human disturbance on watershed processes and habitat conditions, and 4) effectiveness of various habitat and watershed restoration strategies or techniques. Examples of priority areas for continuing and new research over the next 3 to 5 years include: habitat-based salmon life-cycle models; urban stream and lowland river ecology; and evaluation of dam removal, watershed and floodplain restoration. We will update this plan and research priorities on an annual basis.

Introduction and Background

The listing of multiple species of Pacific salmon (*Oncorhynchus* spp.) as threatened or endangered has rapidly increased the demand for science to inform challenging management questions related to restoration and protection of salmon and their habitat. While salmonids are one of the most thoroughly studied fish species in North America, we still have a poor understanding of the fundamental relationships between habitat and salmon fitness, survival and production. This is a particularly important issue for the NOAA Fisheries, which is charged with management of salmon and other marine and anadromous fishes under the Endangered Species Act (ESA) and the Magnuson-Stevens Fisheries Conservation and Management Act.

The Northwest Fisheries Science Center (NWFSC) Salmon Research Plan outlines 10 key questions, several of which relate directly to watershed ecology and salmon habitat. Our research directly addresses several of these key questions including:

- Can we establish explicit links between salmon productivity and habitat attributes that can be protected or restored via management actions?
- Do exotic species substantially inhibit salmon recovery?
- Is there a way of making the ideal of "ecosystem and multispecies management" operational for salmon?
- Global climate change is upon us. Should our strategies for salmon recovery take this climate change (as it alters ocean conditions, the terrestrial environment, and fundamental physical processes) into explicit consideration?

However, these are fairly broad questions about aquatic habitats and fish production, and a more detailed and strategic plan is needed to guide the research efforts of the Watershed Program.

In the following plan we outline a strategy for watershed and habitat research, and identify specific research themes and questions. Our objectives are to describe 1) our scientific approach to address pressing watershed research needs, 2) our current and short-term research priorities (1-3 years), and 3) our long-term research plans (3-10 years). In doing so, we strive to provide a document that will assist in coordination and tracking of our research both within and outside the Center and Agency.

Program Mission and Expertise

The mission of the Watershed Program is to conduct research on physical and biological processes that influence aquatic ecosystems in the Pacific Northwest, effects of land management on those ecosystems, and ensuing effects on the health and productivity of anadromous fish populations and their habitats. Program scientists provide technical support to NOAA Fisheries policy makers and regulatory staff, and collaborate with other agencies, tribes, and educational institutions on research and education related to the management of Pacific salmon.

We are an interdisciplinary team of scientists with skills in fish biology, geomorphology, hydrology, chemistry, spatial analysis, statistics, and aquatic, riparian and landscape ecology. Our research focuses on natural processes that form and maintain aquatic ecosystems and on land uses and restoration actions that can alter these ecosystems and affect salmon populations. We link land uses to habitat conditions by examining the processes that form and sustain riparian, riverine, and estuarine environments, including such processes as the routing of sediment, water, and organic material from hillslopes and riparian areas to streams. Our research is ultimately related to the health and productivity of anadromous fish populations, as we seek to understand how watershed condition affects aquatic ecosystems, habitat conditions, and fish communities.

Our research findings are used by NOAA Fisheries and other natural resource managers to protect and recover aquatic ecosystems and salmon populations. The Watershed Program also provides NOAA Fisheries policy makers and regulatory staff with scientific information, and assists in evaluating the consequences of proposed management actions. In addition to conducting scientific research, Watershed Program scientists work on interagency technical teams and hold affiliate faculty positions at University of Washington (UW), University of British Columbia, and Seattle University. Watershed Program scientists also hold positions on the UW Center for Water and Watershed Studies (formerly Center for Streamside Studies) advisory board.

Scientific Approach and Research Themes

The Watershed Program focuses on four primary research themes:

1) landscape analyses and assessments to assist with recovery planning for listed species,
2) fish responses to changes in habitat, watershed or ecosystem conditions,
3) effects of natural or human disturbance on watershed processes and habitat conditions, and

4) effectiveness of various habitat and watershed restoration strategies or techniques.

The first theme addresses a variety of large-scale analyses important to salmon recovery planning, as well as scientific evaluation of habitat-related policy and management tools. The second theme responds to the lack of comprehensive habitat-based production models for most salmonids. Without such models we cannot predict population responses to watershed or habitat changes (including restoration actions). The third theme addresses the continuing need to quantify how land uses affect watershed processes and aquatic habitats, and ultimately alter salmonid production. Similarly, the effectiveness of various restoration strategies and techniques (the fourth theme) must be evaluated to understand how each approach affects watershed processes, aquatic habitat, and salmonid abundance and survival.

Watershed Program research is organized around a conceptual model of watershed function (Figure 1). In this model, habitat conditions in streams and estuaries link landscape and land use characteristics to fish abundance and survival. We distinguish between research on habitat-forming processes and habitat-based fish production models so that we can study habitat processes that influence riverine and estuarine ecosystems independent from the species that use those habitats. We can then relate abundance, growth, fitness, and survival of any species to this single suite of habitat or ecosystem metrics. Program research often spans all segments of the conceptual model, and this larger picture clarifies relationships between our various research activities.

Landscape and ecosystem processes operate at a wide variety of space and time scales (Figure 2). Therefore, we recognize that spatial and temporal scales of assessment vary depending on the relationships under study. For example, we might use coarse resolution remote sensing data to investigate broad regional patterns in relationships among geologic or climatic variables and ecosystem conditions or salmon populations. By contrast, we use detailed field data to investigate how different riparian buffer treatments affect productivity and biota in specific stream reaches. As a general rule, insights gained from larger scale assessments lead to investigation of specific cause and effect linkages at smaller spatial scales.

With this research structure the Watershed Program can strategically address research topics that are important in the near term, and initiate key in-depth studies that will provide answers to difficult questions in the long term. By maintaining process-based linkages between research elements, we can more cost-effectively integrate results into a comprehensive understanding of watershed and ecosystem function, which ultimately will allow NOAA Fisheries to better administer habitat protection under the ESA and the essential fish habitat (EFH) component of the Magnuson-Stevens Fishery Conservation and Management Act. For near-term ESA recovery planning (e.g., Technical Recovery Teams), we also use this conceptual model to help identify appropriate simplifying assumptions that can answer management needs sooner. Simpler models such as the salmonid watershed analysis model (SWAM) allow us to estimate answers to specific management questions quicker than through the more detailed studies in our research plan.

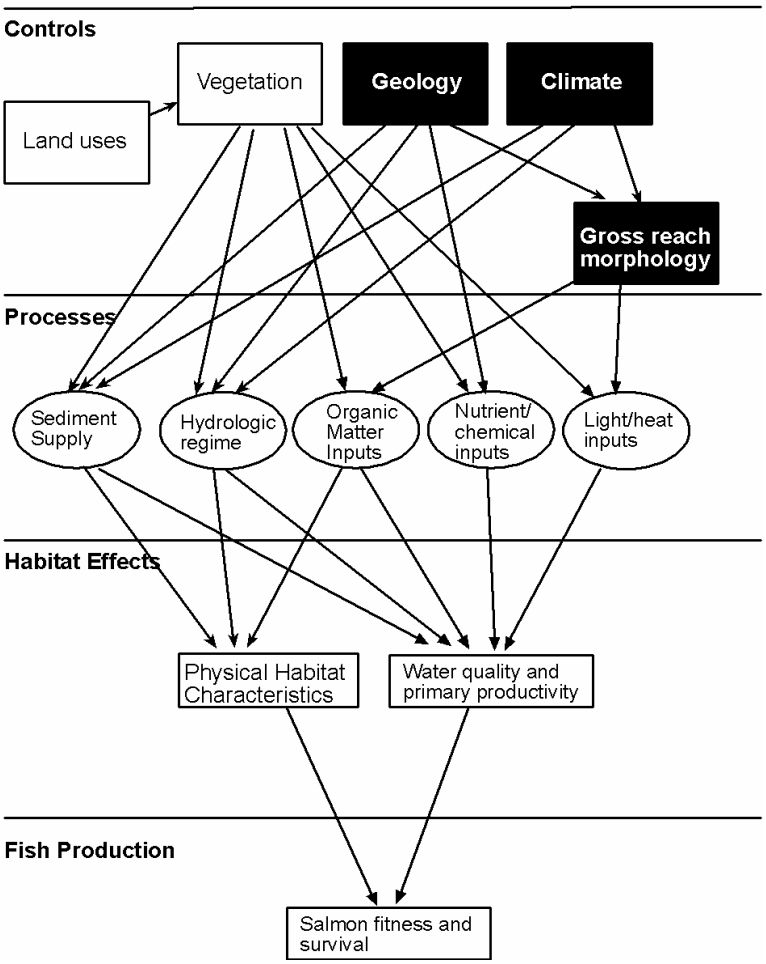

Figure 1. Schematic diagram of relationships between landscape and land use controls on habitat characteristics (via habitat forming processes), and between habitat characteristics and salmon fitness and survival.

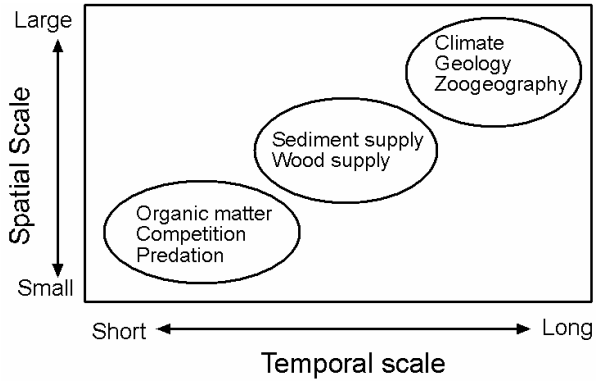

Figure 2. Spatial and temporal scales of factors that control habitat conditions and fish production in streams (adapted from Naiman et al. 1992).

Research Theme 1: Landscape assessments, synthesis, and watershed recovery science.
Landscape assessments at provincial, ESU, and basin levels are needed to assist in the massive efforts underway to recover ESA-listed anadromous fishes. We are developing landscape-scale fish production models to meet a range of management needs such as broad relationships among landscape characteristics, land use, and salmon abundance. Such models can assist managers in locating areas with relatively high potential abundance and areas with relatively high restoration potential, assist in recovery planning, and evaluating various recovery options and tools. These broad-scale studies also identify poorly understood mechanistic relationships among land uses and performance of fish populations, which helps focus our process-based research in the three other themes.

Research Theme 2: Fish responses to changes in watershed, habitat, or ecosystem conditions.
In order to predict responses of fish populations to watershed and habitat changes (ultimately what NOAA Fisheries needs to conserve and recover salmon populations), we must understand how fishes utilize stream and estuary habitats and construct life-stage and habitat specific life history models. There are relatively few studies that quantify abundance, survival, and fitness of salmonids in these habitats (coho salmon *O. kisutch* are a well-studied exception), especially in large rivers where chinook salmon (*O. tshawystcha*) and steelhead trout (*O. mykiss*) are dominant species. Without such studies we are unable to develop life-stage models to help evaluate potential effects of freshwater and estuarine habitat changes on most fish populations. Our research plan includes formalizing the structure of life-stage models for salmon, as well as collecting critical field and experimental data required to parameterize and run the models. Developing models based on empirical data will allow us to estimate responses of salmon populations to changes in watershed or ecosystem conditions.

Research Theme 3: Effects of natural and human disturbance on watershed processes and habitat conditions.
Critical to the restoration and recovery of freshwater and estuarine habitat is an understanding of how natural and human disturbances affect habitat and biotic productivity. Immutable landscape variables (e.g., geology, valley form, and drainage network configuration) are unaffected by land use practices, and determine the range of potential habitat conditions that a specific site can exhibit. Mutable landscape and land use variables (e.g., riparian forest condition, increased landsliding) then influence the habitat characteristics expressed at a site at any point in time. Understanding these hierarchical relationships is a critical step in identifying areas where habitat protection or restoration is most likely to provide significant benefits for salmon production. At the river basin scale ($\geq 10^3$ km^2) we rely primarily on analysis of relationships among underlying landscape characteristics, existing management regimes (e.g., agriculture, grazing, urban) and habitat conditions. At the reach scale we require field data in order to accurately assess influences of such factors as valley form, channel morphology, riparian management regime, and water quality on physical and biological processes, and habitat characteristics. Manipulative experiments isolate effects of individual landscape or land use characteristics on specific aspects of stream habitat or productivity (e.g., effects of agricultural runoff on fine sediment, nutrients, and primary and secondary productivity). These experiments will help resolve ambiguities emerging from our analyses at the river basin scale.

Research Theme 4: Effectiveness of watershed and habitat restoration strategies and techniques. Many approaches and techniques for restoring salmon habitats are used in watershed management plans or as components of a salmon recovery strategy. However, few watershed and stream habitat restoration techniques (e.g., instream structure placement, riparian planting, road restoration, reconnection of isolated habitats, etc.) have been adequately evaluated, and it is often unclear how watershed-level or site-specific restoration actions might contribute to recovery of salmon stocks. We will continue to work collaboratively with other agencies to evaluate the effectiveness of techniques for restoring habitat conditions, water quality, or fish populations.
Results of these studies will help identify:

1) which types of restoration actions are effective at restoring salmon habitats and contributing to recovery of salmon populations, and
2) where restoration actions will have the greatest long-term benefits for salmon populations.

The information gained in understanding salmonid responses to restoration actions will also assist with the previous two research themes. That is, restoration actions can be treated as experimental manipulations of land uses or habitat characteristics, which can improve our understanding of the linkages among watershed process, aquatic ecosystem conditions, and salmon abundance and survival.

Program Organization

The Watershed Program organizational structure (Figure 3) is consistent with the four themes outlined above. Thus we have four teams that are each responsible for addressing a key research theme:

1) Landscape Ecology and Recovery Science
2) Fish-Habitat Relationships
3) Natural Processes and Human Disturbance
4) Restoration

All of four of these research themes are interdisciplinary, interrelated, and require coordination among teams. Moreover, interdisciplinary and broad-scale research of this nature cannot be conducted without cooperation and collaboration from other divisions within the Center and other agencies and organizations throughout the region. Thus, we have one senior scientist designated as the Science Coordinator to assure that we are collaborating within and outside the agency, conducting cutting edge research, and not duplicating research being conducted by other organizations. A lead scientist is designated for each team (research theme) to assure that we meet science, technical support, and outreach needs. The Program organization also provides the structure necessary to conduct research efficiently and provides for continued Program evolution or expansion.

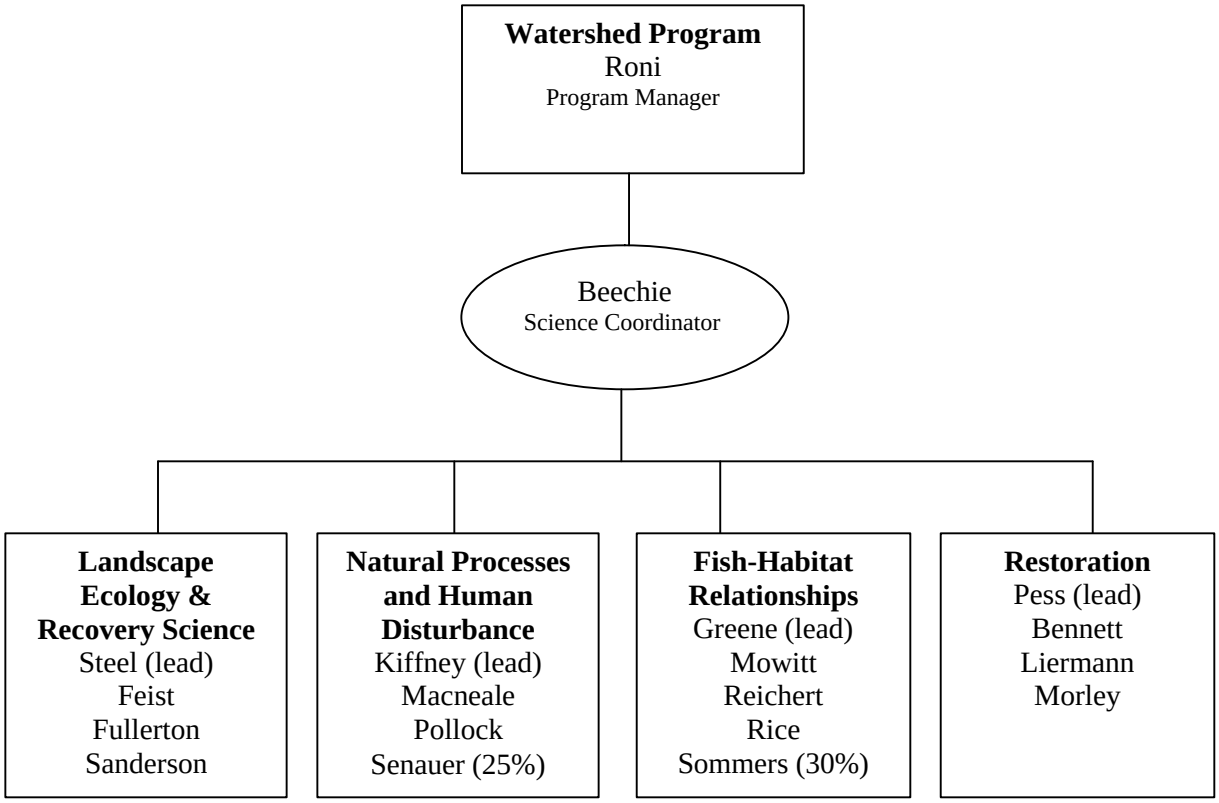

Figure 3. Organizational structure of the Watershed Program. This includes only the government employees. In addition, the Program includes approximately 15 non-government employees (contractors, graduate students, and interns) who are instrumental in conducting our research and day-to-day business.

Prioritizing Research and Allocating Resources

The prioritization of key research needs and questions under each of the four research themes and teams requires periodic meetings with both regulators and scientists within and outside the agency. We have gone through an extensive planning and development effort to define pressing research needs including meeting with NOAA Fisheries regulatory staff and with stakeholders to define our research direction over the next several years. This has also included an annual or biennial "Open House" to update constituents on our research, meeting regularly with the Regional office to discuss research priorities, a Cooperative Research Symposium to develop collaborative partnerships with constituents, and attending key workshops and professional meetings to report and promote our scientific research. Moreover, we continue to meet with the Regional office and our constituents to update our short-term research plans and objectives and to assure that we are focusing our efforts on the most pressing applied research questions.

Based on these periodic meetings, we prioritized our current and proposed future research in one of three categories:

- High (Priority 1), the most pressing needs for NOAA Fisheries science in the next 3 to 5 years

- Medium (Priority 2), important needs for which some information exists, or where we can leverage funds from other agencies
- Low (Priority 3), those needs for which some information currently exists but additional information is required to reduce uncertainty.

Below we briefly summarize high priority research direction of each team over the next 3 to 5 years.

Landscape Ecology and Recovery Science Team—

- Broad-scale relationships among land uses and fish populations
- Appropriate uses of remotely sensed and modeled data
- Impacts of non-indigenous species on salmon recovery

Fish-Habitat Relationships Team—

- Development of habitat-based salmon life-cycle models
- Quantifying stage-to-stage survivals for salmonids in freshwater and estuaries
- Influences of spatial structure (habitat and population) on population responses to habitat change
- Effects of changes in habitat quality on salmonid abundance and survival

- Natural Processes and Human Disturbance Team—
- Effects of urban and agricultural development on stream ecosystems
- Lowland river ecology: effects of dams, land use, and channel controls on large river ecosystems and salmon populations
- Watershed-scale management practices and cumulative effects
- Effects of watershed processes and land uses on biological diversity
- Influence of nutrients and light on stream ecosystems

Restoration Team—

- Restoration of large rivers: influence of engineered logjams in large rivers on primary production and fish response
- Floodplain restoration: comparison of natural to constructed floodplain channels
- Dam removal: effects of changing sediment supply on habitat and biota
- Small stream restoration: effects of wood and boulder placement on habitat and biota
- Effects of restoration at a watershed scale

These research needs (priorities) are likely to change over time, but we feel they represent our priorities for the next 3 to 5 years given our current expertise and level of funding. These will be refined on an annual basis to reflect changing needs and funding. Longer-term research is also needed in a number of key areas such as impacts of climate change on freshwater habitat, and long-term effects of other human activities. Many of the above priorities are incorporated into our existing projects. To assist with planning and project tracking, we schedule the start and end of each project and other long-term projects in Table 1. This provides an estimate of when projects will be initiated and completed over the next 10 years. It also provides a schedule that can be modified should funding or priorities change.

Table 1. Draft timeline for initiation and completion of Watershed Program major research areas and projects. Priorities 1, 2, and 3 are high, medium, and low, respectively. Dark gray shading indicates fully funded projects and light gray partially funded projects. Asterisks indicate research area or projects that are a priority in the next 3-5 years.

Team/Research Area/Project	Research Priority	Fiscal Year 3	4	5	6	7	8	9	10	11	12
Landscape Ecology and Recovery Science Team											
Landscape habitat assessments (SWAM)	1*										
Salmon Habitat Recovery Planning Guidance (ShaRP)	1*										
Willamette Lower Columbia											
Upper Willamette Temperatures	1*										
Isolated habitat	1*										
Lewis River Case Study	1*										
Puget Sound											
Skagit/Stilly Capacity	1										
Hydrologic regimes & life history	1										
ESU-wide habitat loss	1										
Sediment reduction prioritization	1										
Interior Columbia											
Salmon River life cycle model	1*										
John Day River life cycle model	1*										
Coastal Oregon	2										
Fish-Habitat Relationships Team											
Life-history models											
Multispecies modeling	1*										
Chinook	1*										
Steelhead	1*										
Chum/Pink	1*										
Estuary habitat use in Puget Sound											
Skagit Bay townetting	1										
Natural and Human Disturbance Team											
Natural processes	2										
Alder study	2										
Floodplain dynamics	1*										
Headwater sediment storage	2										
Beaver ponds in floodplains	2										
Cumulative effects											
Tributary influences/junctions	1*										

Team/Research Area/Project	Research Priority	Fiscal Year 3	4	5	6	7	8	9	10	11	12
Land Use Impacts											
Forest buffers (logging impacts)	2										
Channel incision (grazing impacts)*	1*										
Puget Sound Ag. land buffers*	1*										
Nearshore/estuarine impacts*	1*										
Urbanization- prespawn mortality*	1*										
Mining	3										
Effects of water withdrawal	1										
Climate change/variability	2										
Restoration Team											
Off-channel and floodplain restoration	1*										
In-stream restoration											
Stilly/Elwha logjams*	1*										
Coos Bay Boulder weirs*	1*										
Estuarine restoration											
Commencement Bay	1*										
Urban stream restoration	1*										
Watershed restoration	1*										
Riparian Restoration	2										
Carcass/nutrient enhancement	2										
Salmon River nutrients project	1*										
Dam Removal											
Elwha	1*										
Cedar River	2										
Road restoration	3										
Monitoring guidance/methods	1										
DNR in-channel monitoring design	2										
Tech. Support (all teams)											
Technical Review	1*										
Outreach	1*										
Total (thousands $'s)											