GRANDE RONDE MODEL WATERSHED ECOSYSTEM DIAGNOSIS AND TREATMENT:

TEMPLATE FOR PLANNING STATUS REPORT FOR GRANDE RONDE MODEL WATERSHED PROJECT AND PROGRESS REPORT ON THE APPLICATION OF AN ECOSYSTEM ANALYSIS METHOD TO THE GRANDE RONDE WATERSHED USING SPRING CHINOOK SALMON AS A DIAGNOSTIC SPECIES

Final Report

Prepared by:

L. Mobrand, L. Lestelle, L. Gilbertson,
and
R. Browning, D. Bryson, R. Carmichael, E. Claire, B. Hadden, C. Huntington, L. Kuchenbecker, M. Shaw

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number 94-030
Contract Number 94AC1033 1,94AM33243

July 1995

EXECUTIVE SUMMARY

for the

Grande Ronde Model Watershed
Ecosystem Diagnosis and Treatment Project Reports

July 1995

Prepared by

L. Mobrand, L. Lestelle, L. Gilbertson,
and
R. Browning, D. Bryson, R. Carmichael, E. Claire, B. Hadden,
C. Huntington, L. Kuchenbecker, M. Shaw

For

Bonneville Power Administration
Under
Contract #94 AC 1033 1
Contract #94 AM 33243

BACKGROUND

In the spring of 1994 a technical planning support project was initiated by the Grande Ronde Model Watershed Board of Directors (Board) with funding from the Bonneville Power Administration. The project was motivated by a need for a science based method for prioritizing restoration actions in the basin that would promote effectiveness and accountability. This report is a summary of the results of that project. In the following we will recall the project goals and objectives, outline the approach used, and summarize progress to date.

PROJECT GOALS AND OBJECTIVES

The purpose of the Grande Ronde Ecosystem Diagnosis and Treatment Project (Project) was to provide technical assistance to the Board in their effort to plan and implement watershed recovery projects.

Specific Project objectives were to develop and describe:

1) a science-based planning process that effectively incorporates local values and objectives

2) scientifically sound methods for:

   a) identifying factors that inhibit achievement of sustainable watershed recovery objectives
   b) prescribing potential recovery *actions*
   c) *prioritizing* actions
   d) analyzing *trade-offs* between actions
   e) *monitoring* and *evaluation* to manage risks and improve future plans

The project plan called for these methods to be captured in two reports-one was referred to as a Planning document, the other a Recommendations Document.

PROJECT APPROACH AND PHILOSOPHY

Our approach to the project is premised upon a set of concepts and principles. The concepts are by no means independent of one another. They are stated here to clarify the approach and philosophy of the project. They describe our perceptions and interpretations of the purpose of the model watershed program in general and of the Grande Ronde Model Watershed in particular.

Concepts

Ecosystem strategy - Watershed planning should employ a holistic approach that incorporates human economies and values, while being consistent with ecological principles that promote sustainability. The strategy should incorporate the broad range of values and objectives held by stakeholders in the Grande Ronde Basin. Although many of the initial actions may target spring chinook salmon, the scope of watershed planning is much broader. The salmon should be seen as an indicator, or diagnostic species, of the general condition of the watershed to sustain a diversity of values and objectives.

Sustainability - Communities generally desire that resource-based values and objectives associated with the water and land of a watershed be sustainable. These communities embrace basic land and water ethics that recognize the need for sustainability within the context of a watershed that has undergone major changes to accommodate human needs. Therefore, land and water processes of a watershed should continue to function in a manner that can sustain both human and natural resources If such processes are rapidly changed without regard to consequences, those resources may not be sustainable. Species like salmon that are dependent on the relative stability of those processes over a wide expanse of the watershed can therefore help us diagnose conditions for sustainability.

Scientific method - Current understanding of how to achieve resource sustainability is limited and inadequate to meet the challenges of growing communities and their associated needs for natural resources. Therefore, a necessary part of watershed management should be the use of the scientific method to improve understanding over time. Fundamental to this method of learning is the use of an explicit conceptual framework within which information about the system of interest is gathered, analyzed and organized. A logical linkage between actions and events within the watershed and their effect on values and objectives must be presumed and explicitly addressed. The scientific method promotes learning and assures accountability.

Decision process - Watershed management should be driven by a decision process that is based upon learning by doing, often referred to as adaptive management. This approach to decision making allows action in the face of scientific uncertainty. It serves two important functions: it provides assurance that watershed management is progressive--those actions that are effective are continued and those proven ineffective or damaging are discontinued; and it also provides the means for an open decision making process where the public has the opportunity to remain informed and participate effectively. Both scientific information and stakeholder values must be effectively incorporated into the decision process.

Principles

Also a part of the premise for the Project are the principles that:

1) Planning and decision making occur on a regular cycle for both decision makers and their technical support.

2) Goals and objectives are well defined.
3) Information and knowledge are pursued in a scientific and objective manner.
4) All reasonable treatment (action) alternatives are evaluated and prioritized.
5) Selected treatment recommendations are implemented as prescribed.
6) Results are evaluated scientifically
7) Treatment objectives and procedures are refined based on the feedback from monitoring and evaluation.

Benefits

The approach described above is intended to help the Board plan and implement the Grande Ronde Model Watershed Program in several important ways. Specifically, the approach:

1) facilitates the achievement of the goals established by the Board
2) empowers local communities to identify their own problems and select appropriate solutions within the larger context of what is beneficial for the watershed as whole and to other linked watersheds
3) avoids inappropriate regulations
4) employs state of the art science to identify the high priority objectives and develops practical strategies to address them
5) builds structures for evaluating current actions and applying new knowledge to the planning of future actions
6) safeguards the long term sustainability of natural resources
7) allows targeted objectives, such as spring chinook salmon recovery, to be pursued while integrating other potentially competing interests
8) broadens our perspective to include all of the influences which contribute to ecosystem decline and salmon mortality
9) bridges gaps between and among institutions and constituencies, detecting opportunities for synergistic solutions and emphasizing cooperation in addressing common problems

THE SOLUTION

The work products of the Project were developed through a series of workshops that were conducted between May and December of 1994 in La Grande. At these workshops concepts and approaches were formulated and debated; existing data and information were gathered; and, with the help of technical experts familiar with the Grande Ronde Basin, a set of technical procedures were adapted to the Grande Ronde Model Watershed Program.

The results of the first year of the Project was the development of a conceptual framework, a set of tools, and a process intended to assist the Board in the planning and implementation of restoration actions. These results are reported in three documents. The methodology recommendations (framework, tools and process) are contained in a report entitled "Recommendations". The second document is a Progress Report on the technical analyses (using the tools) that were conducted during the initial year of the project; it covers information about portions of the Upper Grande Ronde basin. A suggested approach for incorporating the approach into the Grande Ronde Model Watershed plans is contained in the "Draft Template for Project Planning Status Report for the Grande Ronde Model Watershed".

A Conceptual Framework

A science based conceptual framework for linking restoration actions to resulting benefits was developed. This framework is depicted in Figure 1. Actions and natural events affect attributes (temperature, flow, etc.) of the environment, and these attributes in turn affect the biological functions (performance) within the watershed (fish populations, cattle, vegetation, etc.) which determine the outcome of events and actions in terms of values and objectives. The scientific framework consists of these four items (actions - attributes - performance - objectives) and the relationships between them. When we describe these four items through time and space, we describe the watershed in terms of our conceptual framework. Within this framework we can incorporate facts and assumptions and state and test hypotheses--in other words, we have the foundation for the deployment of the scientific method. Much of the effort at our workshops was devoted to describing the Upper Grande Ronde Basin in terms of this framework. The results of this work is captured in the Progress Report mentioned above.

A Set of Tools

The framework defines the terms and concepts we use to describe the watershed. In order to translate existing data, information and knowledge into the language of the framework, a set of tools are needed. These tools consist of procedures for capturing data (data base systems), for analyzing information (models and analytical tools), and for displaying results (graphics and reports). A family of such tools have been developed. Examples of their use are contained in the Progress Report.

A Planning Process

Concepts, frameworks and tools are of little value unless there exists a context within which they may be used constructively. A key component of the solution is the integration of a sequence of procedural steps into the existing Grande Ronde Model Watershed processes. The six steps in this sequence are to:

1. solicit input from stakeholders about their values and objectives.
2. describe the watershed in framework terms.
3. diagnose the condition of the watershed. We may analyze an indicator species, such as spring chinook (or elk, or cattle), to determine what factors prevent stakeholder objectives from being met.
4. identify action alternatives. Based upon the diagnosis and known opportunities, potential action alternatives are identified and described.

5. analyze and prioritize action alternatives. This step has both technical and policy elements. A technical analysis of the trade-offs (relative risks and benefits) among the alternative actions (the no-action alternative must always be included) is performed. This analysis is used by the Board in making the key policy decision of selecting actions for implementation.
6. implement selected actions and monitor them. A procedure for prioritizing monitoring activities has been developed and is described in the Operations Manual.

In conclusion, this summary report is intended to provide a general overview of the Project and its results. Detailed discussions are available in the reports cited above. The Project work team is prepared to, and would welcome, the opportunity to provide additional information and more specific recommendations.

RECOMMENDATIONS

for

Application of the Ecosystem Diagnosis and Treatment Method to the Grande Ronde Model Watershed Project

July 1995

Prepared by

L. Mobrand, L. Lestelle, L. Gilbertson,
and
R. Browning, D. Bryson, R. Carmichael, E. Claire, B. Hadden,
C. Huntington, L. Kuchenbecker, M. Shaw

For

Bonneville Power Administration
Under
Contract #94 AC 1033 1
Contract #94 AM 33243

PURPOSE

The purpose of this document is to present a set of recommendations to the Grande Ronde Model Watershed Board (Board) for implementing a watershed planning process that incorporates a science-based framework to help guide decision making. This process is intended to assist the Board in its effort to plan and implement watershed improvement measures. The process will also assist the Board in coordinating its efforts with other entities in the region who are implementing forms of watershed management.

The planning process is based on an approach for developing an ecosystem management strategy referred to as the Ecosystem Diagnosis and Treatment (EDT) method.[1] The process involves an on-going planning cycle that incorporates a step in which a diagnosis is made of the condition of the watershed for sustaining its resources and related societal values. The diagnosis helps guide the development of actions aimed at improving the condition of the watershed for achieving long-term objectives.

The planning cycle calls for routinely reviewing, and updating as necessary, the basis of the diagnosis and other related analyses used by the Board in adopting actions for implementation. Our recommendations address this need for periodically incorporating new and updated information into the planning process.

This paper is the first in a set of three documents that summarize results from the first year of activities of the Grande Ronde EDT Project. The second document, entitled "Progress Report on the Application of an Ecosystem Analysis Method," presents results of a technical analysis that illustrate how the EDT approach can be applied to the Grande Ronde watershed. The third document, entitled "Draft Template for Project Planning Status Report," shows how an annual planning report is structured.

PREMISES

Our recommendations are based upon the following set of premises drawn from the purpose of the model watershed program in general and the Grande Ronde Model Watershed in particular:

> *Ecosystem strategy* - Watershed planning should employ a holistic approach that incorporates human economies and values, while being consistent with ecological principles that promote sustainability. The strategy should incorporate the broad range of

[1]/This planning approach is described in a paper entitled "An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems" by J. Lichatowich, L. Mobrand, L. Lestelle, and T. Vogel, published in *Fisheries 20:* 10-18.

values and objectives held by stakeholders in the Grande Ronde Basin. Although many of the initial actions may target spring chinook salmon, the scope of watershed planning is much broader. The salmon should be seen as an indicator, or diagnostic species, of the general condition of the watershed to sustain a diversity of values and objectives.

Sustainability - Communities generally desire that resource-based values and objectives associated with the water and land of a watershed be sustainable. These communities embrace basic land and water ethics that recognize the need for sustainability within the context of a watershed that has undergone major changes to accommodate human needs. 'Therefore, land and water processes of a watershed should continue to function in a manner that can sustain both human and natural resources. If such processes are rapidly changed without regard to consequences, those resources may not be sustainable. Species like salmon that are dependent on the relative stability of those processes over a wide expanse of the watershed can therefore help us diagnose conditions for sustainability.

Scientific method - Current understanding of how to achieve resource sustainability is limited and inadequate to meet the challenges of growing communities and their associated needs for natural resources. Therefore, a necessary part of watershed management should be the use of the scientific method to improve understanding over time. Fundamental to this method of learning is the use of an explicit conceptual framework within which information about the system of interest is gathered, analyzed and organized. A logical linkage between actions and events within the watershed and their effect on values and objectives must be presumed and explicitly addressed. The scientific method promotes learning and assures accountability.

Decision process - Watershed management should be driven by a decision process that is based upon learning by doing, often referred to as adaptive management. This approach to decision making allows action in the face of scientific uncertainty. It serves two important functions: it provides assurance that watershed management is progressive--those actions that are effective are continued and those proven ineffective or damaging are discontinued; and it also provides the means for an open decision making process where the public has the opportunity to remain informed and participate effectively. Both scientific information and stakeholder values must be effectively incorporated into the decision process.

RECOMMENDATIONS

We offer the following four recommendations:

1. *We recommend that the Board organize its planning process so that both policy and technical roles are clearly identified and supported.*

   The watershed management process consists of both policy and technical related components (Fig. 1). The Board is responsible for policy related elements, including such items as identification of objectives, selection of actions for implementation, scheduling, and review of program performance.

Technical support information is needed by the Board in fulfilling its functions (Fig. 1). This information needs to be organized and understood through a science-based framework. The information should be supplied to the Board by individuals qualified to perform necessary analyses and to communicate the results.

We assume that the technical aspects of the program are to be handled by existing staff of the Grande Ronde Model Watershed Program at least in the short-term. In the future, the Board may want to consider other options for handling technical needs, such as drawing on the expertise of other governmental agencies in the region or hiring its own specialists as may be necessary.

2. *We recommend that the Boardformalize an annualplanning cycle, through which the Board would review the progress of the program, consider proposed actions, and adopt appropriate actions for implementation.*

Such an annual planning cycle would revolve around the Board's responsibilities for considering proposed actions and for adopting and implementing those that are selected (Fig. 2). Technical staff would supply information to the Board consistent with the annual cycle.

The planning cycle would set a schedule for accomplishing the following each year:

- Produce an annual planning report (Planning Status Report or PSR)
- Review a range of candidate actions for the upcoming year
- Prioritize candidate actions on the basis of how consistent they are with program strategies and for their expected results
- Adopt actions for implementation
- Perform an annual review of the performance of the program

3. *We recommend that the Board modify its existing technical support activities so that staff support would include the following, consistent with the annual cycle:*

- Prepare a set of proposed actions that are developed consistent with the watershed diagnosis
- Prepare a technical analysis (including trade-offs) of all candidate actions (i.e., proposed actions based on the diagnosis and all others that may be submitted from various sources)
- Prepare drafts of the annual Planning Status Report (see Fig. 2)
- Coordinate the annual performance review
- Update analytical tools as required

4. *We recommend that a standard set of analytical tools be used in generating technical support information for the Board.*

We describe these tools in the technical progress report for the analysis of the upper Grande Ronde Basin. The tools include the following items:

- Data base of information used in diagnosing watershed conditions
- Analytical model for computing productivity and capacity indices of spring chinook in the basin
- Series of graphical displays to assist in performing analyses and communicating results
- Watershed strategy and guidelines for development of actions that complement one another

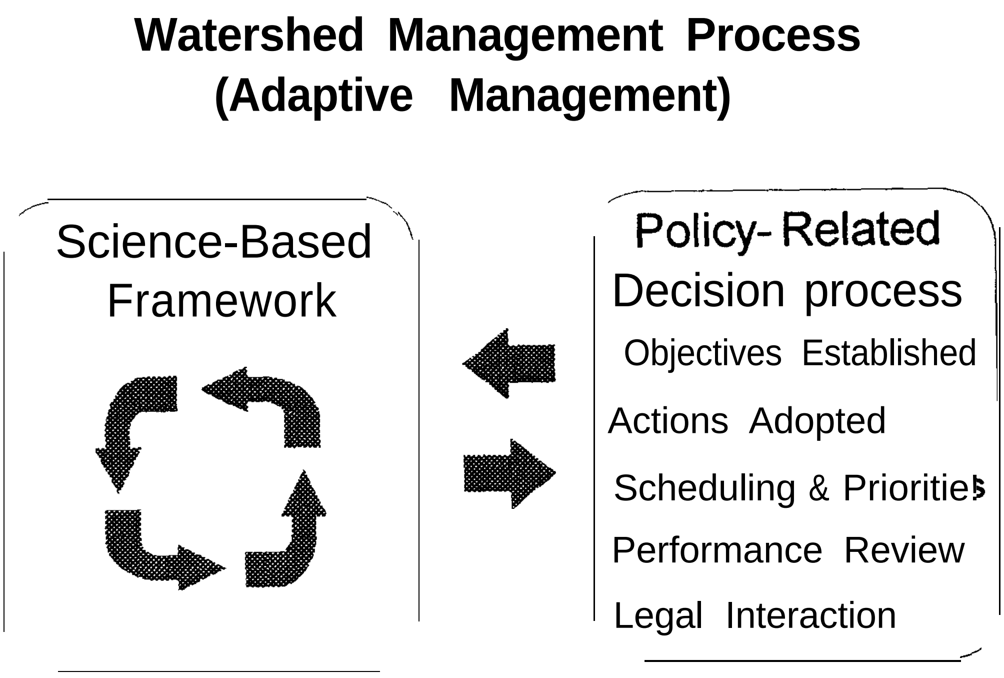


Fig. 1. **Technical and policy related components of Watershed Management Process.**

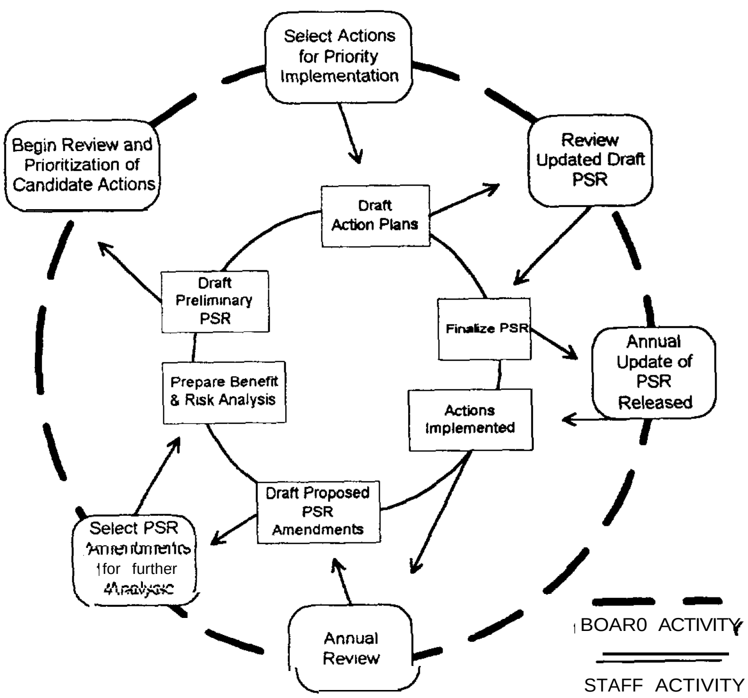


Fig. 2. **Annual planning and decision making cycle.**

TEMPLATE
FOR
PLANNING STATUS REPORT

for the
Grande Ronde Model Watershed Project

July 1995

Prepared by

L. Mobrand, L. Lestelle, L. Gilbertson,
and
R. Browning, D. Bryson, R. Carmichael, E. Claire, B. Hadden,
C. Huntington, L. Kuchenbecker, M. Shaw

For

Bonneville Power Administration
Under
Contract #94 AC 1033 1
Contract #94 AM 33243

ACKNOWLEDGMENTS

The authors would like to thank the following individuals for their vigorous, constructive and informed contributions at numerous workshops and data gathering sessions held throughout the course of the project: -Bob Horton, Jerry Gildemeister, Kim Jones, Mark Lacy and Lew Wallenmeyer . We would also like to thank Patty Perry of the Grande Ronde Model Watershed Project office for her administrative help and our hosts at the Fire Center at La Grande Airport for their hospitality in providing workshop facilities. We wish to thank the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe and the U.S. Forest Service for their involvement in this project and the Bonneville Power Administration for their support.

TABLE OF CONTENTS

PREFACE

This document is an example of how the Ecosystem Diagnosis and Treatment method might be folded into the Grande Ronde Model Watershed action planning documentation. It is a suggested template for an annual Planning Status Report. Most sections of the document consist of place holders for information yet to be assembled by the Board and its staff.

This is a report from the Grande Ronde Model Watershed Board describing the current status of ongoing and planned restoration activities in the Grande Ronde watershed. It is intended to inform the interested public about the general background of the GRMWP and the processes used to plan, amend, and implement restoration strategies and actions. The rationale for the selection of specific actions is provided in the form of analyses of the expected benefits and inherent risks and uncertainties of those actions. The purpose of this report is to offer accountability to investors in the restoration program and stakeholders in the basin and to encourage informed debate.

INTRODUCTION

The Grande Ronde Model Watershed Program (GRMWP) was established in 1992 to facilitate and coordinate public and private actions designed to improve conditions within the watershed. The Grande Ronde Basin was selected by the Oregon Strategic Water Management Group and certified by the Office of the Governor, as the Oregon model watershed. Local communities, including the Nez Perce Tribe and Confederated Tribes of the Umatilla Indian Reservation, supported the selection; and the GRMWP has been confirmed by the Union County and Wallowa County courts. The Program has received local endorsement as an approach for integrating diverse local actions to respond to both immediate challenges, such as recent listings of Snake River spring/summer and fall chinook under the Endangered Species Act (ESA), and to more general concerns regarding management of the entire watershed to sustain desirable conditions into the future.

The GRMWP is recognized as the central coordinating entity for long-term planning and management of restoration activities within the watershed. The Program's purpose is to coordinate stakeholder goals and objectives and to develop a comprehensive approach toward watershed management that will facilitate wise, beneficial use of natural, human, and fiscal resources. The Program also serves to represent the Grande Ronde Basin to local, state, and federal agencies and to other public and private interests.

The Program is organized and directed by a locally appointed Board of Directors (Board). Technical support is provided by the Pacific Northwest Region of the U.S. Forest Service, the Pacific Northwest Region of the Bureau of Reclamation, The Oregon Department of Fish and Wildlife, the Oregon Department of Environmental Quality, The Soil Conservation Service, The Oregon Water Resources Department, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and Oregon state universities. Program operations and staff are managed by an Executive Director, and the Program is administered by the Blue Mountains Natural Resources Institute under a Memorandum of Understanding and Cooperative Agreement with the Board.

The Board's stated mission is, . . . "*to develop and oversee the implementation, maintenance, and monitoring of coordinated resource management that will enhance the natural resources of the Grande Ronde River basin.*" In the spirit of this mission, the Board has developed a framework for planning and implementing watershed management activities that will serve both public and private interests and involve local stakeholders in the processes that affect their communities, cultures, and economies.

The GRMWP has established an approach for coordination and management of watershed activities that is based on an annual process of evaluation and planning. The entire array of implemented actions and their supporting rationale are evaluated and revised based on information acquired since the last review. This adaptive approach keeps program priorities and activities consistent with existing watershed conditions and more responsive to changes in stakeholder values and objectives. The purpose of this document (the Planning Status Report or PSR) is to describe the annual planning process of the Board and capture objectives, priorities and results of ongoing watershed management activities in sufficient detail for public review and involvement. The scope and level of detail contained in this document are intended to encourage full participation by the interested public.

The approach to watershed management implemented by the Board establishes stakeholder values as the source of objectives for actions implemented under the Program and as the focus for evaluation criteria and procedures. The success of this approach depends largely on the level of public participation achieved and the degree to which the stakeholder-values are correctly perceived and incorporated. This document is intended to provide stakeholders with program information they can use to evaluate contemporary management objectives and results and thereby improve their planning of future directions and activities.

This PSR is organized into sections corresponding to major topics of interest and to steps in the planning process. The order of presentation generally corresponds to the usual chronology of planning activities that set annual management directions. The document organization presented in the following annotated list of major report sections is meant to assist the reader in finding specific information and to provide perspective regarding the overall content and scope of the planning process.

Section 1. Process Summary - The annual process that generates an updated version of this document is described.

Section 2. General Approach of the Model Watershed Program - This section contains a brief description of the major elements of the Ecosystem Diagnosis and Treatment approach used to guide the adaptive management process for the GRMWP, consistent with the principles of ecosystem health.

Section 3. Background - The background section presents a general description of watershed conditions with historical perspectives of the human activities and natural processes that produced them. This section also discusses the contemporary issues that affect priorities in the Program. A general description of Program objectives and projects is also presented.

Section 4. Annual Review of Program Performance - This section presents results of Program operations and project implementation since the last annual review. Management performance is described and assessed in order to improve progress toward objectives. Projects are described and evaluated. Contributions of the projects to Program understanding and the achievement of stakeholder objectives are presented.

Section 5. Current Objectives - This section will document program objectives and provide clear explanations for their derivation, starting from their roots in the values and expectations of stakeholders. Stakeholder values will be discussed and transformed into objectives defined in qualitative and quantitative terms. This process changes the form, not the content, of the stakeholder values. It attempts to make them more explicit in scope, scale and location.

Section 6. Candidate Actions - Candidate actions selected by the Board for further evaluation are described and discussed in this section. Details regarding the source and rationale for each proposed action are presented along with a prognosis of results.

Section 7. Action Specific Assumptions - Assumptions are logical statements about presumed relationships and conditions of the ecosystem and its function. This section lists all assumptions associated with each action and the corresponding objectives.

Section 8. Benefit-Risk Analysis - This section analyzes the candidate actions in terms of expected benefits and risks. An approach to developing this information is outlined. This information is a substantial part of the justification for the selection and prioritization of actions to be implemented.

Section 9. Action Plan - The full set of actions planned for the next annual cycle are described. The source -of actions include those implemented during previous cycles that were chosen to be continued and new actions selected after evaluation of their benefits and risks.

Section 10. Monitoring Plan - Monitoring and evaluation activities needed to resolve uncertainties and contain risks are described in sufficient detail for implementation.

Section 11. Program Priorities and Schedule - A set of criteria for establishing action priorities is discussed. Actions selected for implementation are given priority rankings, and effects of priority-limited implementation are discussed. Detailed schedules for each selected actions are displayed and discussed.

Section 12. Public Information and Process Compliance - Regulatory processes and permit requirements are discussed for each action selected by the Board for implementation.

1. PROCESS SUMMARY

Critical to the success of any restoration effort is a well organized structure for planning, decision making and execution of actions. Figure 1 outlines the general responsibilities of a policy team and of its technical support staff. The importance of an organization that is cognizant of, and tailored to, the needs of adaptive management cannot be overemphasized.

> *This section would describe the organization of the GRMWP in detail. The organization would reflect the policy and technical responsibilities outlined in Figure 1.*

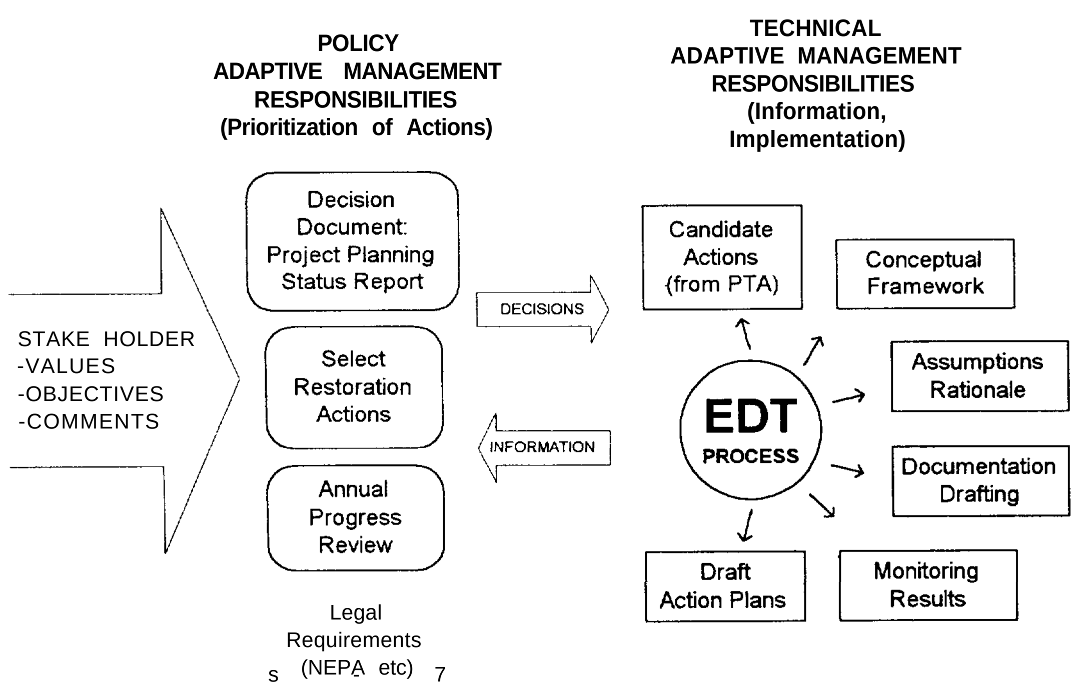


Fig. 1. Outline of roles and responsibilities for the Grande Ronde Model Watershed program.

The EDT method (Lichatowich et al. 1995) which forms the basis for the planning approach used in this document is designed as an adaptive management process. Adaptive management is based on the conclusion that uncertainty, variability and change are inevitable parts of resource management. The procedures described here are designed to make change and adaptation the routine rather than the exception. This is necessary to avoid the risks which are associated with uncertainty and incomplete information and to assure responsiveness to changing values and a changing environment.

Figure 2 is an adaptation of a process originally developed for the Yakima Fisheries Project (YFP 1994 PSR). The procedure revolves around an annual cycle of updating this PSR. It captures both long term and short term goals and objectives (Section 5) and describes the actions contemplated to meet those objectives and their rationale (Section 6).

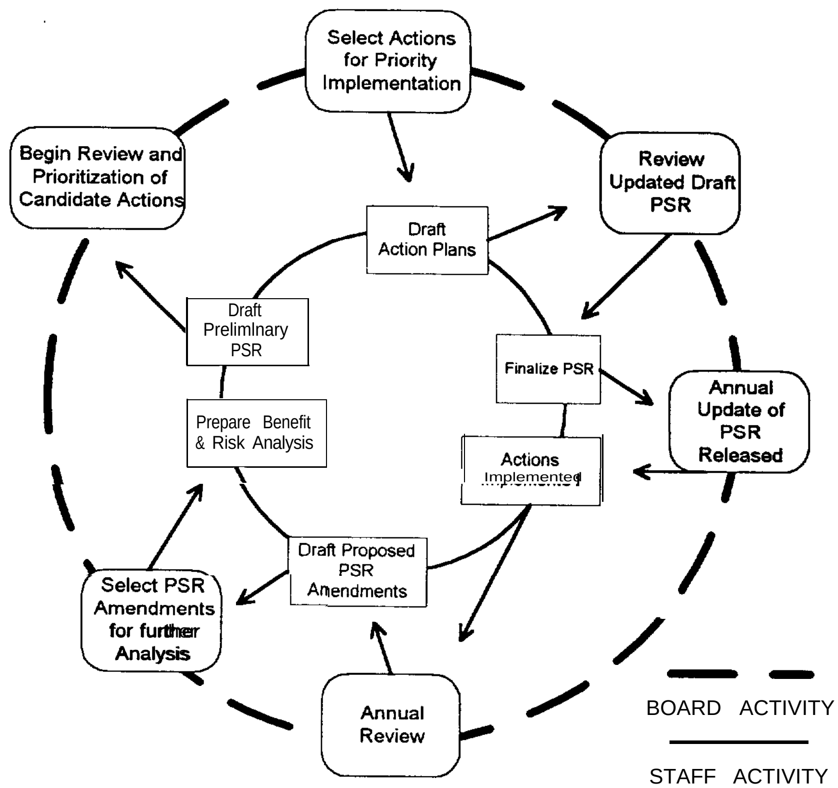


Fig. 2. **Annual planning and decision making cycle.**

The cycle illustrated in Figure 2 revolves clockwise - the inner circle represents staff activities throughout the year; the outer circle, the activities and decision points of the Board.

Following here is a brief discussion of each activity depicted in Figure 2. The starting point is the box labeled "Annual Update of the PSR Released" at the 3 o'clock coordinate. Each activity is categorized as either a Board activity or a staff activity.

Dates and durations for the activities would be added to Figure 2 and discussed further in this section.

Annual Update of PSR Released (BOARD ACTIVITY). Current action plans and other documents that identify the Grande Ronde Model Watershed goals and objectives constitute the Planning Status Report (PSR). This document will be updated annually and expanded to include the information described herein.

Actions Implemented (Staff Activity). This PSR represents the Board's blueprint for implementation of actions according to a specified schedule. Implementation activities incorporate monitoring and evaluation, documentation and progress reporting. Actions scheduled for implementation will be initiated throughout the year, with progress reports submitted periodically.

Annual Review (BOARD ACTIVITY). Once each year the Board conducts an annual review meeting where staff presents reports on monitoring and evaluation results, progress and completion reports, etc. At this meeting the Board also invites both staff and the community to propose amendments to the PSR. Specifically, the Board solicits proposals for new candidate actions. Actions proposed by staff would be based upon the EDT method (see Section 2 of this report and also the 1995 Progress Report on the Application of an Ecosystem Analysis Method to the Grande Ronde Watershed).

Draft Proposed PSR Amendments (Staff Activity). Based on instructions from the Board following the Annual Review, staff prepares a draft, "long list" of proposed PSR amendments. This list becomes the first redraft of Section 6. Staff also prepares a first redraft of Section 4 at this time.

The "long list" of amendments is narrowed down to a shorter list of proposals which the Board decides merit

are accepted or rejected.

Prepare Benefit and Risk Analysis (Staff Activity).
subjected to a benefit-risk or trade-off analysis (see Section 8). The results of this analysis are captured in updated versions of Section 7 and 8.

Draft Preliminary PSR (Staff Activity). Remaining amendments and their associated benefit-risk analyses are incorporated into a preliminary update of the PSR. This draft will constitute the basis for the Board's decisions regarding the priority of candidate actions.

Begin Review and Prioritization of Candidate Actions (BOARD ACTIVITY). The Board reviews the candidate actions described and evaluated in the preliminary PSR.

Select Actions for Priority Implementation (BOARD ACTIVITY). The Board completes its review of the preliminary PSR and selects actions for which detailed action plans will be developed.

Draft Action Plans (Staff Activity). Detailed action plans including schedules, monitoring programs, etc., are drafted and incorporated into the Action Plans section of the PSR. Sections 9, 10 and 11 are updated.

Review Updated Draft PSR (BOARD ACTIVITY). The Board reviews action plans and the draft PSR as a whole and instructs staff to make appropriate revisions.

Finalize PSR (Staff Activity). A final draft of the PSR for the following year is completed and submitted to the Board. Note that the PSR will still include all action plans from prior editions of the PSR, unless they have been explicitly revised or terminated by the Board.

Annual Update of PSR Released (BOARD ACTIVITY). The Board adopts the PSR, and it is released to the public. Staff is instructed to move forward with new or revised implementation activities.

2. GENERAL APPROACH OF THE MODEL WATERSHED PROGRAM

Watershed management is a complex endeavor that must match potential and candidate actions with local and regional priorities and attempt to achieve objectives within the limitations of available resources. The overall goal of watershed management is to establish and maintain a level of watershed health sufficient to provide conditions that will support local economic and cultural objectives on a sustainable basis. The sustainability of these interactions depends ultimately on the state of physical and biological processes within the watershed and upon the nature of stakeholder objectives. Some objectives may not be sustainable in the present environment or in any potential set of environmental conditions. Evaluation of these circumstances and the establishment of a rational management scheme require some understanding of the watershed and its ecosystem processes, as well as the system of human values and objectives that affect them.

Our understanding of ecosystem processes and their interactions with economic and cultural values is incomplete. Recognition of this incomplete knowledge is important in planning a project approach for watershed management. The proposed approach allows this management process to move forward in the face of uncertainty and complexity.

The approach is based upon the following set of premises drawn from the purpose of the model watershed program in general and the Grande Ronde Model Watershed in particular:

Ecosvstem strategy - Watershed planning should employ a holistic approach that incorporates human economies and values, while being consistent with ecological principles that promote sustainability. The strategy should incorporate the broad range of values and objectives held by stakeholders in the Grande Ronde Basin. Although many of the initial actions may target spring chinook salmon, the scope of watershed planning is much broader. The salmon should be seen as an indicator, or diagnostic species, of the general condition of the watershed to sustain a diversity of values and objectives.

Sustainability - Communities generally desire that resource-based values and objectives associated with the water and land of a watershed be sustainable. These communities embrace basic land and water ethics that recognize the need for sustainability within the context of a watershed that has undergone major changes to accommodate human needs. Therefore, land and water processes of a watershed should continue to function in a manner that can sustain both human and natural resources. If such processes are rapidly changed without regard to consequences, those resources may not be sustainable. Species like salmon that are dependent on the relative stability of those processes over a wide expanse of the watershed can therefore help us diagnose conditions for sustainability.

Scientific method - Current understanding of how to achieve resource sustainability is limited and inadequate to meet the challenges of growing communities and their associated needs for ‘natural resources. Therefore, a necessary part of watershed management should be the use of the scientific method to improve understanding over time. Fundamental to this method of learning is the use of an explicit conceptual framework within which information about the system of interest is gathered, analyzed and organized. **A** logical linkage between actions and events within the watershed and their effect on values and objectives must be presumed and explicitly addressed. The scientific method promotes learning and assures accountability.

Decision process - Watershed management should be driven by a decision process that is based upon learning by doing, often referred to as adaptive management. This approach to decision making allows action in the face of scientific uncertainty. It serves two important functions: it provides assurance that watershed management is progressive--those actions that are effective are continued and those proven ineffective or damaging are discontinued; and it also provides the means for an open decision making process where the public has the opportunity to remain informed and participate effectively. Both scientific information and stakeholder values must be effectively incorporated into the decision process.

A generalized approach which is based on these premises--the Ecosystem Diagnosis and Treatment (EDT) method (Lichatowich et al. 1995)--will be used as a framework for watershed planning and management. This approach partitions project management activities into an iterative, sequential cycle of planning, implementing, and learning. It can be modified to fit specific applications, but the general sequence is described in the following sections.

Step 1 - Identify Project Objectives

There is a broad array of human values that affect perspectives and decisions regarding the Grande Ronde watershed and its natural ecosystem components. A guiding principle of the GRMWP is that stakeholders desire conditions that lead to sustained achievement of their objectives, and sustainability of these valued conditions depends on the health and stability of ecosystem processes within the watershed. Stakeholder expectations regarding the sustainability of valued conditions will give rise to general program directions.

General program directions are used for focus and scale to derive an array of related objectives drawn from the sets of human values or other acceptable sources. Other sources could include agency documents, projects and goals, as well as previous actions of the Board. These more specific objectives are used to bound and direct the planning process in the succeeding steps. The objectives can be general, but attempts should be made to understand and describe their entire dimensions. For example, are the stakeholder concerns and objectives related to particular places and times, or should they be applied to the entire watershed with emphasis on sustainability? Are the objectives related only to quantity aspects, or is quality also important? What are the key ecosystem processes that affect these objectives, and how do they interact?

Step 2 - Perform Analysis and Diagnosis

The process of transforming general directions and objectives into a format organized for analysis and diagnosis begins with the formulation of conceptual models or frameworks that reasonably represent the dynamics of factors that affect or determine the objective conditions. The analytical tools can take many forms depending on the particular details of each situation. However, they must be organized and designed to compare existing and desired conditions using components and functions that are understandable, and the analysis results must be interpretable for use in designing treatment actions. A generalized approach for comparing existing and desired conditions is called the Patient-Template Analysis (PTA) (Lichatowich et al. 1995). This approach uses medical analogies to compare existing conditions of the target populations and their habitats (Patient) with hypothetical healthy conditions (Template) to form a diagnosis of the subject's status and arrive at a set of prescribed treatments.

The Template describes healthy, sustainable conditions. Representative, healthy systems that can be used as models for comparisons are not easy to find, although they do exist for some applications. Literature regarding other populations in similar watersheds can be very helpful. Perhaps the most fruitful approach is to infer the Template by reconstructing a representation of historic conditions of the subject populations and their habitats. The Template should not be confused with objectives. While the Template represents historic, pristine or relatively undeveloped conditions; the objectives represents desired future conditions, which usually differ significantly from the past.

The Patient describes existing conditions in the same scales of place, season, and life history that were used to describe the Template. The diagnosis is performed by comparing the Patient and Template to help understand the factors or functions that may prevent the realization of objectives. The diagnosis can be qualitative or quantitative, depending on the type and quality of the information used to describe the Patient and Template. Regardless, the diagnosis should identify potential actions that can be taken to correct or circumvent limitations on specific, defined life history-habitat relationships for the subject populations.

The diagnosis is usually aided and focused by the use of indicators or diagnostic species. A strong case can be made, for example, to use salmon as an indicator - the diagnosis of watershed health would be based on its suitability to sustain salmon production. Where possible more than one indicator should be used. Elk, bird species, and cattle are examples of indicators that might provide insights into the ability of the watershed to deliver and sustain desired values.

Step 3 - Select Proposed Action (Treatment) Alternatives

Treatments are specific actions suggested by the diagnosis that can be taken to reduce or eliminate constraints identified in the PTA and to achieve quality and quantity targets contained in the objectives. An array of reasonable alternative actions should be identified, along with a clear rationale for each.

Step 4 - Describe Benefits and Risks

Conceptualization of biological attributes and functions, design of representative analytical tools, and selection of alternative treatments will require recognition, description, and management of uncertainty. All uncertainties in watershed management are resolved, temporarily at least, through assumptions that are either stated as part of planning or implied in the recommended actions. Risk is a direct function of the cumulative effects of critical uncertainties associated with a recommended treatment. Risk analysis is the evaluation of strengths and weaknesses of those assumptions.

Incorporating risk into the decision process requires two steps: scientific inquiry and social evaluation. The level of risk can be determined through scientific evaluation of the uncertainties and assumptions. However, deciding how much risk to accept is a social evaluation.

Step 5 - Refine Project Objectives

The project oriented objectives selected in Step 1 should be evaluated based on the diagnosis and benefit-risk analysis. This evaluation can assess the likelihood of achieving the objectives, and the risks and costs of doing so. Evaluation of these factors, and resolution of apparent conflicts among competing values and objectives, can lead to revised project objectives or suggestions for specific alternative treatments.

Revised objectives and proposed alternative treatments should be analyzed using the tools developed in Step 2, and the benefit-risk should be described. Completion of this step will produce one, or a set of, alternative treatment(s) designed to achieve the project objectives, along with statements of likely benefits and risks associated with each alternative treatment.

Step 6 - Treatment' Application, Monitoring, and Evaluation

The diagnostic, analytical, and refinement steps may produce several alternative strategies and treatments (or actions), all of which could achieve the desired conditions. The selection of specific strategies and actions for implementation will occur in an open public process. The results of the analysis of benefits and risks associated with both accepted and rejected actions will be available for public scrutiny in this GRMWP Planning Status Report.

'The terms 'treatment' and 'action' are used interchangeably in this document. A strategy is defined as a suite of actions or treatments with a common, or integrated, purpose.

Project monitoring and evaluation along with public comment will generally be the sources for

3. BACKGROUND

The Grande Ronde Watershed

The Grande Ronde watershed is an assemblage of waterways and diverse land-patches defined by histories of natural processes and land use. The patches were once integrated by physical and biological interactions into a complex system that supported a varied and productive biota. The system also sustained local bands and tribes of Native Americans and early communities of new residents who settled into the area (e.g., Gildemeister, 1992). This integrated landscape has been changed through local economic and cultural developments during the past century.

Alteration of the watershed started soon after settlement in the 1860's. Agricultural development, timber harvest, mining, and ranching were among the land use practices that stimulated early development and supported the growth of local communities. These activities gradually changed the natural landscape and altered the physical and biological processes that characterized the system.

A complete description of wutershed development and landscape changes should be presented in this section. The approach should be non-judgmental. The purpose of this section is to document and churucterize general changes in the watershed landscape and ecosystem processes to help conceptualize management schemes and analytical tools and to assist in the diagnosis of wutershed heulth und ecosystem function. A general understanding of the wutershed history, including changes due to natural processes (e.g., climate putterns), would ussist in the plunning and design of treatment actions. Changes outside the watershed that affected the landscape and ecosystem processes within the Grande Ronde basin should also be documented. Recognition of these factors facilitate diagnosis, benefit-risk analysis and treatment planning.

The description of wutershed history contained in this section should focus on salient characteristics thut affect stakeholder interests and watershed health. The presentation should be summary *in nature and reference program documents that contain detailed information and analyses.*

Contemporary Issues

This section should explain contemporary issues from the perspective of the GRMWP. A general description of current watershed health should be presented. The known history of watershed changes described in the previous section would serve as a basis on which to begin a discussion of the state of present conditions. Results of the PTA analyses described in the General Approach section would also provide numerous insights regarding the present watershed conditions relative to desired conditions.

Documented indicators of watershed health should be discussed. These might include insect infestation in upland forest stands, excessive accumulation of woody debris in upland areas (fire damage potential), excessive sediment build-up in some waterways and loss of diversity in some aquatic communities. These indicators and others should be evaluated and placed within an overall perspective of watershed health as tempered by the values and objectives of the stakeholders involved. A rule for the overall restoration approach, and the EDT framework described above, is that watershed health is defined by the values of the stakeholders and the expectation that those values be sustainable.

Spring chinook salmon in the Grande Ronde watershed are part of a larger aggregate of populations that spawn and rear in the Snake River basin and that have been identified through regulatory and scientific deliberations as an endangered species. Formal listing as endangered under the provisions of the Endangered Species Act causes restructuring of local priorities and incentives regarding watershed activities. The listing of Snake River spring chinook has placed actions to protect and restore productivity of the Grande Ronde stock into categories of high priority for management and planning by the Board. Although the Board will focus planning and coordination on the problems of spring chinook, these actions will be taken within the context of a more general scheme for watershed management. Maintenance, enhancement and/or restoration of habitats and ecosystem processes for spring chinook will benefit the broader ecosystem. Spring chinook were historically widespread throughout the watershed and utilized essentially the entire system during their life history. Watershed management projects designed to benefit natural production of spring chinook will, by their nature, improve overall environmental health. Restoration of spring chinook natural production will require repair and reconnection of some of the basic processes and habitat conditions of the watershed. Spring chinook is arguably a useful indicator or diagnostic species for general ecosystem health.

4. ANNUAL REVIEW OF PROGRAM PERFORMANCE

Institutional Review

This section should contain annual program reviews. The institutional review is an internal audit performed by the Board and staff. The purpose of the audit is not to find fault for project failure, but to explore management and implementation processes to improve program performance. The audits should seek to further program objectives and reduce program risks. These annual audits, while promoting accountability, should be constructive and not discourage innovation and creativity. The audit focus is on the remedy, not on the complaint.

Project Review

The project review will describe actions taken and/or continued as a result of the last annual review, present results of the project monitoring, and document assessment conclusions. These presentations should be concise but must include full disclosure of project objectives, rationale, benefits and risks. Program technical and management documents that underlie this section should be cited so the public can pursue topics of interest. The assessment section should emphasize each specific project contribution to the Program's understanding of watershed problems and their remedies. This step should be focused on the planning criteria of learning and improving (i.e., reducing uncertainty and risk) with each annual iteration of the Program.

The annual project review should also be a forum for comments and ideas from the public, and these comments should be included in this section

Recommendations And Amendments

This section should present recommendations for the next annual cycle, based on the institutional and project reviews. The recommendations can be to continue, terminate, or amend projects. The presentations should include justification/rationale for each recommendation.

5. CURRENT OBJECTIVES

The Board has established general, operational goals that provide overall direction and perspective for the Program. The Board's primary goal is to enhance and maintain a healthy Grande Ronde watershed. This goal will be achieved through an ecosystems approach to watershed management.

The following are additional goals developed by the Board:

- Provide habitat for restoration and enhancement of anadromous salmonids in the Grande Ronde basin.

- Provide recommendations for the management of the basin resources which will enhance the quality and quantity of river flow.

- Develop recommendations for management and utilization of water by agriculture and other industries in the basin which require water for their economic viability.

- Conduct a public involvement program to address the concerns of landowners, land managers, and resource users in the Grande Ronde basin.

- Assure that watershed management activities implemented in the Grande Ronde basin are adequately monitored and evaluated on a coordinated basis.

- Protect the customs, culture, and economic stability of the Grande Ronde basin to provide for the welfare of the citizens in the basin, the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation, and the citizens of the United States of America.

- Recommend coordinated resource management and research and information activities within the basin which meet the mission statement of the Board.

- Promote the mission, goals, and objectives of the GRMWP to regional, state, and national entities.

The mission and goals of the Board provide direction and structure for planning and implementing watershed management actions. The planning framework and management initiatives described in this document serve these goals and will facilitate coordinated and cooperative watershed management. A hierarchy of objectives is one of the results of the planning process described in this document. Nested within the Board's general goals are objectives related to more specific sets of values expressed by stakeholders in the watershed; and, continuing the hierarchy, these objectives give rise to more specific objectives down to the individual project level. The hierarchical nature of the objectives provides organization and connects specific project objectives to the values of stakeholders and to the general goals of the Board.

Stakeholder Values And Objectives

This section should contain a compilation of stakeholder values and the watershed objectives to which they lead. A documented process should be used to compile statements of values and objectives. The list should be long and diverse to capture a fill array of perspectives on conditions that stakeholders value and expect. Clarity and precision are important. The more carefully stated and detailed the values and objectives are, the more precise the benefit-risk analysis can be. The objectives must eventually be expressed in terms that define success both qualitatively and quantitatively. The process of discussing, describing, analyzing, and refining the values is not an attempt to modify their content or intent. The purpose is to learn as much as possible about the values and how they relate to both the cultural and natural systems. This process should also provide valuable insights for structuring conceptual models of watershed function and health.

A combination of national, regional. and local stakeholders, supported by legal mandates of the Endangered Species Act (ESA), have elevated restoration (initially protection) of native Grande Ronde spring chinook salmon production to a level of highest priority. The National Marine Fisheries Service (NMFS) has recently determined to reclassify Snake River chinook salmon from threatened to endangered (Federal Register 59(248): 66784-66787, 12/28/94) which adds importance to a recognized problem. Since native spring chinook in the Grande Ronde system are part of a population classified as endangered, program objectives related to their protection and recovery will receive renewed emphasis. However, the objectives related to spring chinook are still placed within the hierarchical organization of objectives, values and goals. They will be approached within a watershed and ecosystem context. In addition, spring chinook in the Grande Ronde system is highly suited as a diagnostic species (i.e. as an indicator of general ecosystem health) for the following reasons:

1. As an aquatic species, spring chinook depend on streams for their existence, and streams are generally regarded as a good reflection of overall watershed condition; water drains downhill, bringing with it characteristics shaped by conditions upstream. Spring chinook are sensitive to these characteristics of the stream environment.

2. Spring chinook utilize a very large portion of the watershed during their freshwater life--from the river's mouth to the headwaters of many of its connected waterways.

3. Spring chinook are not stationary--they are highly migratory. Each fish that completes its life cycle experiences the conditions of the river from the spawning grounds, usually located high in the watershed, to the river's mouth. Hence the completion of the life cycle of these fish depends upon the connectivity of the stream network.

4. The life history of spring chinook within freshwater can be divided into seven more or less distinct life stages--each with different habitat requirements. Hence completion of the life cycle is dependent upon the existence of diverse habitats.

5. Spring chinook can exhibit a wide variety of life histories, or "pathways" in space and time taken in completing their life cycle if conditions along those pathways are suitable for survival. Populations exhibiting diverse life histories are more likely to sustain themselves in the face of environmental change and diverse mortality pressures.

6. The migration path of spring chinook connects the Grande Ronde watershed to larger watersheds and ecosystems--the Snake and Columbia Rivers and the Pacific Ocean. Ecosystem management recognizes that watersheds (or ecosystems) are not isolated; conditions in one can have profound implications for the sustainability of resources in another. The salmon life cycle connects these environments. Moreover, salmon are one of the few species that cycle nutrients between all of these environments.

7. Salmon are integral to the heritage and present-day values of people throughout the Pacific Northwest; they symbolize the vitality of the region.

GRMWP Objectives

This section should contain objectives selected for immediate program processing. These objectives are tied explicitly to those discussed in the previous section. The rationale for selecting the objectives listed here, and their associations with the values and objectives listed in the previous section, should be included. If this description is to voluminous for full disclosure here, the essential qualities can be presented with reference to supporting documents. The objectives listed in this section guide the diagnosis and selection of candidate actions that will be further processed through the EDT planning steps.

The need for attention to spring chinook production in the watershed suggests two general objectives:

- Maintain existing populations of spring chinook, and the associated natural productivity of utilized habitats.

- Improve the natural productivity of the watershed for spring chinook.

A more complete compilation of stakeholder values and objectives in the preceding section would lead to a more complete set of objectives in this section. A more complete set of objectives should include expectations for a broad array of watershed and ecosystem junctions that are related to stakeholder values concerning many levels ofpersonal, cultural, and economic interests. For example, these objectives could focus on forest health, patterns or strategies for sustainable livestock grazing, water quality, recreational opportunity, employment stability, populations of endemic species, habitat for migratory birds, water distributions for irrigation, and many other topics or targets of interest.

The more complete the compilation of values and associated objectives becomes, the broader will be the scope of interactions that must be considered and evaluated for conceptualization of the watershed and its ecosystem processes. In addition, the benefit-risk analysis will be more comprehensive and informative.

6. CANDIDATE ACTIONS

This section should present a comprehensive list of potential actions selected by the Board for further development and evaluation. Each potential action would be described in sufficient detail to be informative and support the succeeding sections of this document. Descriptions of the candidate actions would provide a concise explanation of why the action should be taken, including identification of the value-based objectives that suggested them and the rationale that led to their selection for further evaluation. The rationale should include a prognosis regarding probable results of implementing each action. The presentation for each treatment should follow this format:

- *Name of Candidate Action*
- *Description - description of the treatment action(s), including as much detail as possible regarding locations and times.*
- *Purpose - which specific objectives are addressed with this action?*
- *Rationale - brief explanation of how the candidate action will address the identified objective. The EDT approach (see I995 Progress Report) provides specific guidelines for this step.*

Enough information must be included regarding application locations, times, and affected populations that a benefit-risk analysis can be accomplished. The descriptions should reference supporting documents so interested parties can have access to more complete details.

Table 1 shows an example of how candidate actions are described. The example shows a list of actions selected for implementation in the Catherine Creek drainage. It is not a complete list of actions scheduled to be implemented. The example is presented as it applies to spring chinook only; other purposes (besides restoration of spring chinook) are intended in some cases and are noted. One of the actions on this list (Catherine Creek Sediment Reduction) is also used as an example in the next section of this report).

Table 1. Listing of Candidate Actions

Name of Action	Description: ,	Purpose:	Preliminary rationale:
Catherine Creek Fish Passage	Add step pools below diversion dams in Catherine Creek located in the town of Union to improve passage of adult spring chinook.	To improve the sustainability and production of Catherine Creek spring chinook.	Water diversion structures in the town of Union can inhibit passage of migrant adult spring chinook under certain flow conditions. This action is aimed at improving passage. This action is intended to improve the quality of habitat for both primary and secondary life history patterns of spring chinook (strategic priorities two and four).
Catherine Creek State Park	Improve education by placing informational signs in around state park and adjacent to Catherine Creek.	To maintain the sustainability and production of Catherine Creek spring chinook.	The state park has high recreational use and offers a point of access to river; adult spring chinook are known to use the river at this location for migration and spawning and are thus vulnerable to harassment and being hooked by fishermen; rearing juveniles are subject to hooking loss. This action is intended to maintain the quality of habitat for both primary and secondary life history patterns of spring chinook (strategic priorities one and three).
Catherine Creek Sediment Reduction	Closure (15 1 miles) and obliteration (16 miles) of 167 miles of road within National Forest lands in the North Fork, South Fork, Little Catherine Creek, and Mill Creek drainages (all tributary to Catherine Creek); 36 miles **of** the total will be closed within riparian corridors within the North Fork and South Fork drainages; closures and obliteration will provide for culvert removal and possibility that springs will be put back into original courses; currently open roads in these drainages will be reduced by about ½.	To maintain and improve the sustainability and production of Catherine Creek spring chinook.	Road closures and obliteration would likely reduce sedimentation and may improve water temperatures in stream reaches used by spring chinook. This action is intended to maintain and improve the quality of habitat for both primary and secondary life history patterns of spring chinook (strategic priorities one through four).

Table 1. (continued)

Name of Action	Description:	Purpose:	Preliminary rationale:
Catherine Creek Pasture Fence	Fence to be constructed within a grazing allotment in National Forest approx. 2 miles downstream of Catherine Creek forks; fence will be on hillside and is not a riparian fence; changes in grazing management of this allotment to change accordingly by shifting usage by animals in time-no change to occur in total AUMs; grazing in the vicinity of approx. 7 miles of Catherine Creek to be affected.	To maintain sustainability and production of Catherine Creek spring chinook.	Some grazing related impacts to spring chinook may be occurring in this area; this action could potentially reduce these impacts. This action is intended to maintain the quality of habitat for both primary and secondary life history patterns of spring chinook (strategic priorities one and three).
North Fork Catherine Creek Meadow Fencing	Fence approx. 2 acres of high meadow and prevent grazing; located within North Fork drainage; not located near streams.	Not related to spring chinook.	Not related to spring chinook. Not relevant to strategic priorities.
Catherine Summit Sediment Reduction	Stabilization of area subject to producing sediment into small drainage that enters Catherine Creek immediately upstream of Little Catherine Creek; this is a highway widening and straightening project.	To improve the sustainability and production of Catherine Creek spring chinook.	Reduction of sedimentation entering Catherine Creek tributaries would improve habitat quality downstream of that site and improve conditions for spring chinook. This action is intended to improve the quality of habitat for both primary and secondary life history patterns of spring chinook (strategic priorities two and four).

7. ACTION SPECIFIC ASSUMPTIONS

Assumptions are logical statements about presumed relationships and conditions of the ecosystem and its function. They are always present in the management of natural resources because knowledge is imperfect. Often, however, they are not stated explicitly enough to enable those engaged in the management process, or the general public, to consider them and use them as a basis for learning and improving future decision making. They also need to be explicitly disclosed to enable questioning, for example: Are the assumptions reasonable, i.e. are they consistent with existing information? Do the assumptions pose significant risk? Can the assumptions be tested?

One important purpose for identifying assumptions is to analyze the potential benefits and risks associated with candidate actions that are being proposed. The GRMWP planning process requires that all assumptions be identified and disclosed for each candidate action. This helps ensure that the process is accountable to itself and to the public in considering potential benefits and risks of those proposed actions.

There are five categories of assumptions identified in the planning process. These categories are:

1. *Actions to environmental conditions:* These assumptions refer to the relationship between restoration actions and their impact on environmental conditions or attributes.

2. *Environmental conditions to performance:* These assumptions involve the effects of environmental conditions on the performance of the biological system, such as is expressed by a survival rate or abundance of an animal population.

3. *Performance to objectives:* These assumptions refer to the relationship between biological performance and stakeholder values or program objectives. For example, what does spring chinook performance in the Grande Ronde basin suggest about other values and objectives.

4. *Conceptual frumework:* These assumptions pertain to the conceptual or theoretical basis for understanding the nature of the ecosystem and its processes, i.e. the terms we use to explain how the system functions.

5. *Monitoring and evaluation* (M&E): These assumptions involve our ability to monitor and evaluate changes in the ecosystem; i.e., the feasibility to make observations from which conclusions can be drawn about the validity of the other categories of assumptions.

The planning process requires the identification of all of the assumptions that are made in these five categories. It is therefore unavoidable that the lists of these assumptions will be long. Once these lists are initially completed, then they need to checked against one another to ensure that they do not conflict. If one set of assumptions is used to rationalize one suite of actions, and a conflicting set of alternative assumptions used for another suite, the program is internally inconsistent and obviously cannot succeed.

A list of assumptions associated with one candidate action is provided here to illustrate the nature of these assumptions (Table 2). One of the actions described under "Candidate Actions" is used: Catherine Creek Sediment Reduction. Only the assumptions pertaining to spring chinook are presented. This format would be followed in assembling all assumptions for candidate actions. Some of the assumptions refer to ratings of environmental attributes as those attributes relate to the survival (productivity) of spring chinook. The numeric ratings are used here as a way of shortening the descriptions. The ratings refer to the contribution that a particular attribute makes toward mortality of the animal (here spring chinook). The ratings are as follows: 0 = no effect on mortality; 1 = low effect on mortality, 2 = moderate effect on mortality, 3 = high effect on mortality, 4 = lethal effect.

Table 2. Example of list of assumptions made in considering the effects of candidate actions on spring chinook.

Candidate action	Program objective involved	Assumption category	Assumption
Catherine Creek Sediment Reduction	Improve the sustainability and production of Catherine Creek spring chinook.	Action to attributes	Sediment inputs to Cath. Cr. and both forks will be reduced compared to current levels.
			Seeps and springs at road cuts and crossings will largely be returned to original courses; there are l-2 (on average) such seeps/springs per mile of road in this area; this will result in some. improvement to water temperatures during summer and early fall, at least in the vicinity of points of entry to Cath. Creek or forks.
			Some changes in flow patterns, though minor, will occur.
			Some changes in riparian conditions, though minor, will occur along the forks.
			Some changes to habitat diversity within the forks, though minor, will occur along the forks.
			No other changes to environmental attributes within the riparian corridor will occur.
		Attributes to performance	Contributions of sediment to spr. chin. mortality in Cath. Cr. drainage are now rated to be in the range O-2.

Table 2. (continued)

Candidate action	Program objective involved	Assumption category	Assumption
			Changes in sediment inputs due to action will have some positive effect on survival but not enough to change current ratings of contribution to mortality.
			Contributions of high water temperature to spr. chin. mortality in Cath. Cr. drainage are now rated to be in the range 1-4; contributions are highest below Union (3-4), intermediate between Union and Little Cath. Cr. (2-3), and lowest above Little Cath. Cr. (l-2).
			Changes in water temperature due to action will result in some ratings of contribution to mortality to be changed: Union to Little Cath. Cr. (l-3) and above Little Cath. Cr., including forks (O-2); no changes in ratings will occur below Union.
			Contributions of other attributes to spr. chin. mortality in Cath. Cr. drainage are now rated to be in the range O-3, depending on life stage and reach.
			Changes in flow patterns, riparian conditions, and habitat diversity due to action will have some positive effect on survival but not enough to change current ratings of contribution to mortality.

Table 2. (continued)

Candidate action	Program objective involved	Assumption category	Assumption
			Changes in contributions of temperature to mortality of spr. chin. in Cath. Cr. drainage will have a negligible positive effect on productivity and abundance of the population.
			Cumulative effects of changes to all attributes will have a negligible Positive effect on productivity and abundance of the population.
		Performance to objectives.	Action will have a negligible effect on objectives for spring chinook.
		Framework	Framework concepts are adequate to guide analysis and decision making.
		M&E	Implementation of actions can be determined.
			Changes in site specific water temperature conditions due to action can be assessed.
			Changes in site specific riparian conditions and habitat diversity due to action can be assessed.
			Changes in performance due to action cannot be measured.
			Benefits accrued to meeting objectives for spring chinook can not be measured as a result of action.

8. BENEFIT-RISK ANALYSIS

The purpose of this section is to analyze the candidate actions in terms of expected benefits and risks. An approach to developing this information is outlined. This information is a substantial part of the justification for the selection and prioritization of actions to be implemented.

Risk here refers to the possible outcomes of the candidate actions (note that risks of no action should always be included) in terms of stakeholder values and objectives. We are concerned with both the possibility of increased values (benefits) and reduced values (i.e. the event where values/objectives are not fully met). The nature and extent of these potential consequences and the likelihood of their occurrence are implied when we talk about risk in this context.

A key to understanding risk is the implied cause and effect relationship between actions and stakeholder values. This relationship is made explicit when the specific assumptions in this linkage are stated. The very first step in the benefit-risk analysis is an analysis of the uncertainties associated with all the assumptions needed to form the logical conclusion that the action will lead to achievement of a specified set of objectives without adverse impact on other values.

Classification of Uncertainties

The key to the benefit-risk analysis is an understanding of the uncertainties of the stated assumptions and the implications of false assumptions. The following classification of uncertainties is useful in that it provides some organization to what might otherwise appear as a tangled web. It is based on three qualities of uncertainty: degree of uncertainty, consequences of error, and resolvability.

An uncertainty is classified as ACCEPTED when either the probability or the consequences of error are insignificant (Fig. 3). All others are labeled CRITICAL. CRITICAL uncertainties in turn may be RESOLVABLE or UNRESOLVABLE.

Resolution of uncertainties may be through literature review, studies outside the GRMWP, or studies that are a part of the GRMWP. The monitoring and evaluation section below describes different ways in which uncertainties may be addressed within the GRMWP.

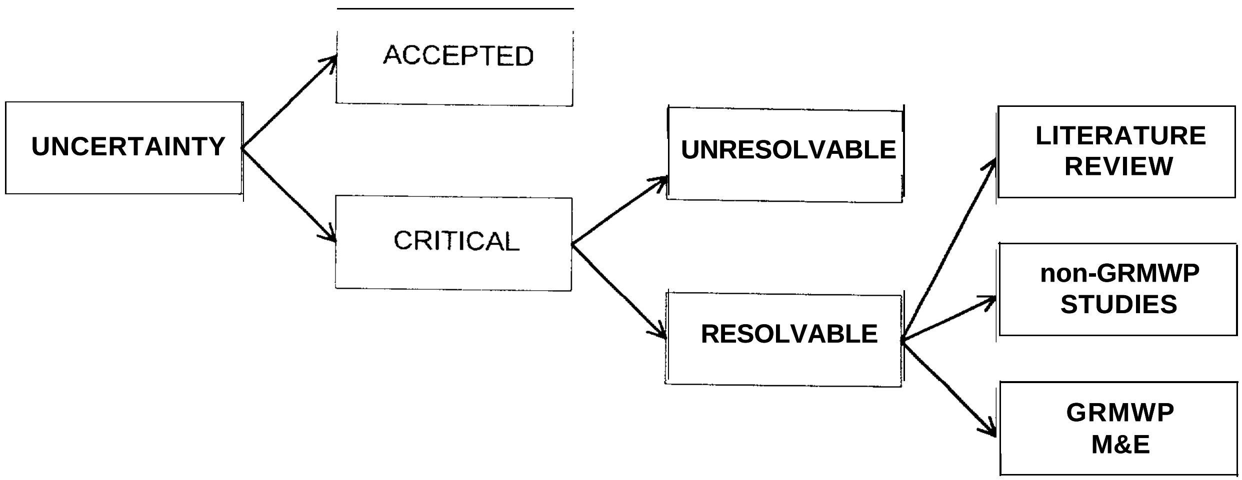


Fig. 3. Uncertainty classification.

Risk Analysis

The risk analysis is reported by value category and by objective. Using the list of assumptions and the associated uncertainty classifications, conclusions are stated regarding the risks to each objective in the Plan. This step is accomplished using a workshop format. The list of assumptions and their uncertainty classifications is distributed to a group of individuals knowledgeable about a set of subjects that cover the range of values/objectives of concern to the GRMWP Board. They are asked to review the list from the perspective of their field of expertise and to attend a facilitated workshop prepared to answer three questions: 1) What are the risks [to objectives related to your expertise] associated with uncertainty?, 2) Are there alternative actions available to achieve the same objectives? and 3) To what extent is it feasible to contain or resolve risks through monitoring? The purpose of the workshop is to discuss and record conclusions to these questions. The purpose of the workshop is not to seek agreement on risk, but rather to capture a range of viewpoints in a clear and consistent manner.

A summary of the benefit-risk analysis would be inserted here, with reference to a more detailed technical benefit-risk report.

9. ACTION PLAN

This section should present a complete list of treatment actions which the Board has selected for implementation in the next annual cycle. The treatments should include ongoing projects reviewed in the Annual Review of Program Performance and new projects recently processed through the EDT planning framework. Each selected treatment (action) will be discussed and described, including the rationale supporting the selection, and a brief description of the benefit-risk analysis. Emphasis will be given to details of actual application design--including project objectives, general methods, locations, and monitoring criteria.

There will be a subsection for each selected treatment action. Descriptions of the treatment actions and supporting rationale will be in greater detail than in Section 6 of this document and will follow this format (or include this information):

- *Action name - this name should be unique and should be identical to the name used for the same action as a candidate action.*
- *Purpose and justtfication - specific stukeholder values and objectives that motivate the action and secondary objectives or benefits expected from the action.*
- *Scope - description of the project design, as presently conceived, including identtjication of locations and times that the treatments will be applied.*
- *Prognosis - the anticipated results, expressed in terminology and/or units that will be used to monitor and evaluate the treatment.*
- *Monitoring opportunities - brief summary of potential monitoring opportunities associated with this action. The monitoring plan (Section 10) for the GRMWP will include details for an integrated M&E program that incorporate the needs of this particular action.*
- *Pre-implementation milestones and schedule - description of the detailed design, logistic preparations, and contracting steps that must be completed prior to implementation, and the regulatory/permitting steps that will be required. Schedules of milestones and critical path analyses will be shown in Section 11 below.*

10. MONITORING PLAN

After the preceding sections of this plan are drafted, a monitoring program can be designed. Monitoring and evaluation activities should be described with as much detail as other action plan items. The monitoring program itself should be subjected to quality assurance standards and review procedures.

The sections that follow are the preamble to the future monitoring program.

The purpose of the Monitoring and Evaluation (M&E) program is to guide decision making toward implementation of measures and actions that effectively contribute to Grande Ronde Model Watershed goals while containing risk. It is a cornerstone of adaptive management, which is the imperative safety net of watershed stewardship in the face of uncertainty. Five levels of M&E (see also Mobrand and Lichatowich[2], and Yakima Fisheries Project, 1994 Planning Status Report) are described corresponding to five questions shown in Figure 4.

Level 1 M&E addresses the question of quality control. Its purpose is to determine if indeed the action was implemented as designed. Was the work done in the right place, using the specified materials and methods? Quality assurance can and should accompany all implemented actions. This is important to assure effectiveness of the action and also to validate conclusions based on the assumption that it was indeed implemented as designed. Without quality control we have little confidence in any inferences drawn from our monitoring results. Most important in quality assurance is that the people performing the restoration work understand its intent and purpose. Quality control standards and procedures should be specified in the action plans and in contracts to perform the work.

The second level of M&E asks whether the actions were effective in altering the environmental attributes. As Figure 4 illustrates, actions are taken with the intent to modify (improve) a specified set of environmental attributes at given times and locations, these modifications in turn are expected to improve the performance of the biological system, which then leads to progress toward the goal of enhancing values (e.g. more spring chinook). Environmental attributes are notoriously variable; and therefore, monitoring plans must be statistically well designed to account for variation due to causes other than the restoration action.

‘Draft report titled “Fish and Wildlife Program Monitoring and Evaluation Plan,” available from Mobrand Biometrics Inc.

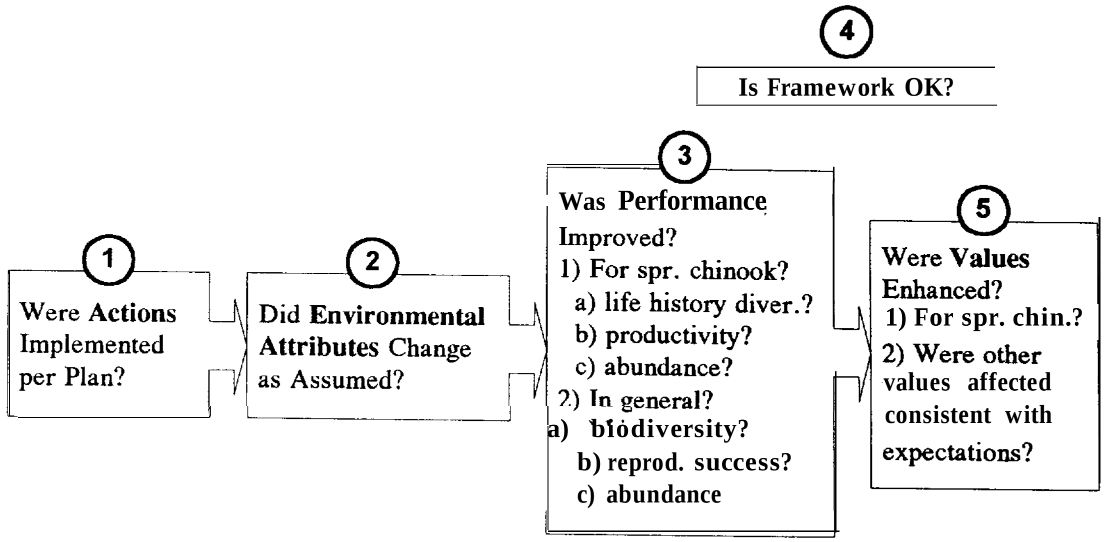


Fig. 4. Monitoring levels.

Biological performance is generally difficult to observe directly. Level 3 M&E typically would consist of experimental testing of hypotheses regarding the response of populations to environmental factors. The rationale for a certain action may include assumptions about, for example, both current and future life history patterns of an affected population - this suggests a hypothesis that fish are present in certain places at specific times, which can often be tested through observations. Hypotheses stated or implicit in the framework that form the rationale for the contemplated action should all be examined from the point of view of: a) what would the consequences of the action be if the assumption is false? b) how uncertain is the assumption? and c) can the assumption be resolved through a feasible experiment? This examination is a part of the benefit-risk analysis step in the planning process. The benefit-risk analysis, along with an assessment of the monitoring feasibility and cost, should form the basis for prioritizing the research that would be undertaken. It should be noted also that some of the critical hypotheses may allow broad inferences, with the implication that the research may have more global value and/or that it might be more appropriately conducted elsewhere.

Fundamental to the evaluation of restoration actions is the validity of the conceptual framework which forms the basis for interpreting all our observations. Both general and specific aspects of this framework should be subject to review and testing. Level 4 M&E is intended to capture the need to continually and progressively improve the theories that guide our decision making. Time and effort should be set aside for review of current literature on related subjects, thinking and creative exploration of new ideas, discussion and exchange of ideas, and active pursuit of critique and ideas from a broad range of interests and expertise. This level of monitoring may involve no direct' fieldwork. It is important to keep in mind that monitoring at level 4 should also address the assumptions or conceptual framework regarding impacts on stakeholder values other than those that primarily motivated the contemplated action.

Level 5 M&E includes, for example, monitoring of stock status (run size, spawning escapement, etc.), which provides information essential to tracking the condition of the populations over time. While erratic and imprecise as short term indicators (less than 30 years), trends in stock status are invaluable for assessing long term prognoses for stocks and their environment. Level 5 monitoring would also deal with observations of other affected objectives and stakeholder values. The maintenance of a sense of history, in terms of conditions that reflect values and benefits to the community, is important as a long term guide for setting public policy and to detect and respond to more gradual and insidious changes in the watershed. Level 5 monitoring provides a record for this broader, bird's eye view.

As stated above, monitoring and evaluation needs are determined by three factors: implication of error, uncertainty, and feasibility. The benefit-risk analysis examines the assumptions used in rationalizing actions, it identifies assumptions which if erroneous will render the action ineffective or even harmful, and it judges the degree of uncertainty about such assumptions. The development of M&E plans needs to be closely tied to the benefit-risk analysis. M&E is an important means for managing risk, and the ability to monitor may be a critical condition for proceeding with promising but uncertain actions.

The detuiled description of monitoring and evaluation activities would begin here.

11. PROGRAM PRIORITIES AND SCHEDULE

Priorities

This section should present the treatment actions selected by the Board for implementation in an ordered sequence based on assigned priorities. The rationale for setting priorities would be explained as a general procedure, and also specifically for each selected treatment. The Board's system for setting priorities would likely include parameters such as total anticipated cost, scope of the treatment effects (comprehensive ecosystem effects or narrow, isolated effects), benefits/cost analysis results, regulatory/legal incentives and constraints, and many other factors. This section should also characterize, at least in general terms, the effect of not implementing treatments with various levels ofpriority.

Schedules

Schedules for design, preparation (including regulatory/permitting processes), and implementation of each treatment should be presented. A project management, critical path software can be used to facilitate planning of treatment projects and for preparing displays for this section. The total set of activities for each treatment should be included in this presentation. Milestones for the treatment itself and for associated monitoring, evaluation, and review would be included in the schedule text and figures.

12. PUBLIC INFORMATION AND PROCESS COMPLIANCE

Regulatory Compliance

Implementation of the treatment actions selected by the Board would require regulatory review and permit processes. Federal, state, and local agencies would be involved. This section should review all of the program activities in these processes during the past annual cycle and describe anticipated activities during the next cycle. Activities should be described for each treatment action implemented or selected for implementation. In addition, this section should discuss any problems encountered with spectfic processes and recommend improvements.

Information and Education

Public awareness and open discussion of issues and actions in the exercise of watershed management are important elements for progressive programs like the GRMWP. Accountability to the public in general, and to stakeholders in particular, is an important aspect of guiding and coordinating management and restoration actions in an arena where people's basic values are involved. This section should review public involvement and public information/education efforts by the Board and cooperating local entities during the past year. The level of success achieved by these activities should be measured in terms of how the information and involvement help to move the Program toward watershed objectives.

A central purpose of this document is disclosure to the interested public regarding the programs and activities of the Board. This section should discuss the level of public involvement that the plan document and other Board initiatives have produced in the past year. This section should also encourage public involvement and solicit comments regarding Board initiatives in general, and this plan document in particular, as to their utility for public disclosure and encouraging public involvement.

LITERATURE CITED

Gildemeister, Jerry. 1992. Bull trout, walking grouse and buffalo bones. Oregon Department of Fish and Wildlife. 64pp.

Lichatowich, J., L. Mobrand, L. Lestelle and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries (Bethesda) 20(1): 10-18.

Progress Report
on the

Application of an Ecosystem Analysis Method to the Grande Ronde Watershed

Using Spring Chinook Salmon as a Diagnostic Species

July 1995

Prepared by

Lawrence C. Lestelle
Lars E. Mobrand

For

Bonneville Power Administration
Under
Contract # 94 AM33243

Acknowledgement

This project is very much a group effort. The (valid) information and the (good) ideas contained in this progress report are credited to the team of Ralph Browning, Don Bryson, Rich Carmichael, Errol Claire, Boyd Hadden, Chuck Huntington, Larry Gilbertson, Lyle Kuchenbecker, and Mark Shaw.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Purpose

This progress report presents initial results of a technical analysis undertaken to provide assistance in the formulation of actions aimed at improving the sustainability of natural resources and related benefits within the Grande Ronde watershed. The analysis was performed using a methodology referred to as Ecosystem Diagnosis and Treatment (EDT) (Lichatowich et al. 1995) which was adapted for specific application to the Grande Ronde Basin. Results reported herein primarily pertain to the Upper Grande Ronde system (upstream of Wallowa River).

The analysis focuses on spring chinook salmon, which serves as a diagnostic species in the assessment of the condition of the watershed for sustainability of its resources and related societal values. This study assumes that humans and their values are integral parts of an ecosystem and that human communities within the Grande Ronde Basin desire a healthy watershed--one that can sustain natural resources as well as economic and social values for future generations.

The EDT methodology requires that a clear diagnosis be formulated based on existing knowledge. The diagnosis is used to guide the development of rational actions, which can take many forms, such as habitat improvement projects, modifying land and water use activities, and intervention using artificial production techniques (i.e., supplementation). The major intent of this report is to illustrate how this diagnosis is formed for the Upper Grande Ronde system

The Grande Ronde EDT Project was initiated to provide technical assistance to the Grande Ronde Model Watershed Board of Directors (Board) in its effort to plan and implement watershed improvement measures. Other entities in the region are currently implementing forms of ecosystem management, and products resulting from this project will help the Board coordinate more effectively with these groups. Federal agencies, for example, have initiated efforts to improve understanding of ecosystem conditions on a watershed scale and to manage their lands accordingly (FEMAT 1993)--their process, referred to as watershed analysis, has a purpose similar to that of the Grande Ronde EDT Project.

This progress report is one of three documents that present results from the first year of the Project. The first document, entitled “Recommendations,” provides a set of operational recommendations to the Board. The second report, entitled “Draft Template for Project Planning Status Report for the Grande Ronde Model Watershed,” describes how the planning and decision making process might be documented. This third document reports progress to date in the development of analytical tools for identifying and evaluating recovery actions.

A full description of these tools and associated data bases will be prepared after data from the entire Grande Ronde Basin has been assembled and analyzed.

No attempt is made here to incorporate a thorough synthesis and interpretation of results; this will be done for the entire watershed after completion of the analysis for the remainder of the system. Some general assumptions about objectives or desired future conditions have been made for the sake of illustration--the companion documents in this series describe a process for addressing objectives.

1.2 Project Approach

The project approach is based upon the following set of premises drawn from the purpose of the model watershed program in general and the Grande Ronde Model Watershed in particular:

> *Ecosystem straegy* - Watershed planning should employ a holistic approach that incorporates human economies and values, while being consistent with ecological principles that promote sustainability. The strategy should incorporate the broad range of values and objectives held by stakeholders in the Grande Ronde Basin. Although many of the initial actions may target spring chinook salmon, the scope of watershed planning is much broader. The salmon should be seen as an indicator, or diagnostic species, of the general condition of the watershed to sustain a diversity of values and objectives.
>
> *Sustainability* - Communities generally desire that resource-based values and objectives associated with the water and land of a watershed be sustainable. These communities embrace basic land and water ethics that recognize the need for sustainability within the context of a watershed that has undergone major changes to accommodate human needs. Therefore, land and water processes of a watershed should continue to function in a manner that can sustain both human and natural resources. If such processes are rapidly changed without regard to consequences, those resources may not be sustainable. Species like salmon that are dependent on the relative stability of those processes over a wide expanse of the watershed can therefore help us diagnose conditions for sustainability.
>
> *Scientific method* - Current understanding of how to achieve resource sustainability is limited and inadequate to meet the challenges of growing communities and their associated needs for natural resources. Therefore, a necessary part of watershed management should be the use of the scientific method to improve understanding over time. Fundamental to this method of learning is the use of an explicit conceptual framework within which information about the system of interest is gathered, analyzed and organized. A logical linkage between actions and events within the watershed and their effect on values and objectives must be presumed and explicitly addressed. The scientific method promotes learning and assures accountability.
>
> *Decision* process - Watershed management should be driven by a decision process that is based upon learning by doing, often referred to as adaptive management. This approach to decision making allows action in the face of scientific uncertainty. It serves two important functions: it provides assurance that watershed management is progressive--those actions that are effective are continued and those proven ineffective or damaging are discontinued;

and it also provides the means for an open decision making process where the public has the opportunity to remain informed and participate effectively. Both scientific information and stakeholder values must be effectively incorporated into the decision process.

The use of a “diagnostic species” brings focus to the analysis. Implicit in the notion of a diagnostic species is the assumption that a species which is sensitive to a wide variety of ecosystem conditions can be used as a pulse on the system. Indicator species have a long tradition of use in the assessment of environmental conditions (Leppakoski 1975; Karr 1992; Rapport 1992). Although there has been some feeling in recent years that their use may disproportionately favor certain species groups, these indicator species are considered necessary in moving an analysis from general ecological concepts to the level of specificity needed to assess benefits and risks of human actions (Rapport 1992; Lichatowich et al. 1995). The term “diagnostic species” is used in this study to emphasize that it is a device to aid in diagnosing watershed conditions.

The analysis currently utilizes spring chinook salmon as the diagnostic species. Others could, and eventually should, be used to gain a broader perspective of ecosystem condition within the Grande Ronde watershed. However, listing of spring chinook salmon by the Endangered Species Act has given it priority in the watershed, making it a natural choice for a test indicator species in the analysis. In addition, spring chinook in the Grande Ronde system is highly suited as a diagnostic species for the following reasons:

1. As an aquatic species, spring chinook depend on streams for their existence, and streams are generally regarded as a good reflection of overall watershed condition; water drains downhill, bringing with it characteristics shaped by conditions upstream. Spring chinook are sensitive to these characteristics of the stream environment.

2. Spring chinook utilize a very large portion of the watershed during their freshwater life--from the river’s mouth to the headwaters of many of its connected waterways.

3. Spring chinook are not stationary--they are highly migratory. Each fish that completes its life cycle experiences the conditions of the river from the spawning grounds, usually located high in the watershed, to the river’s mouth. Hence the completion of the life cycle of these fish depends upon the connectivity of the stream network.

4. The life history of spring chinook within freshwater can be divided into seven more or less distinct life stages--each with different habitat requirements. Hence completion of the life cycle is dependent upon the existence of diverse habitats.

5. Spring chinook can exhibit a wide variety of life histories, or “pathways” in space and time taken in completing their life cycle if conditions along those pathways are suitable for survival. Populations exhibiting diverse life histories are more likely to sustain themselves in the face of environmental change and diverse mortality pressures.

6. The migration path of spring chinook connects the Grande Ronde watershed to larger watersheds and ecosystems--the Snake and Columbia Rivers and the Pacific Ocean. Ecosystem management recognizes that watersheds (or ecosystems) are not isolated; conditions in one can have profound implications for the sustainability of resources in another. The salmon life cycle connects these environments. Moreover, salmon are one of the few species that cycle nutrients between all of these environments.

7. Salmon are integral to the heritage and present-day values of people throughout the Pacific Northwest; they symbolize the vitality of the region.

1.3 Scope

The scope of this progress report is limited to the analysis performed in conjunction with a series of work sessions held in La Grande in 1994. It covers the Upper Grande Ronde Basin, from the river's confluence with the Wallowa River upstream to its headwaters, as well as the remainder of the lower mainstem river to its union with the Snake River. Work is planned for 1995 to complete the analysis for the remainder of the watershed.

The analysis was aimed primarily at understanding the impact of environmental quality conditions on the health of the diagnostic species. The abundance of spring chinook in the Grande Ronde Basin is currently so low that it is unlikely that habitat quantity has much effect on survival. In such situations, attributes of environmental quality are assumed to be the dominant factors affecting survival (Buell 1986; Lestelle et al. 1995). While analysis of habitat quantity may be deferred, it should not be omitted.

The analysis covered in this progress report is limited to conditions within the Grande Ronde Basin. The health of the Grande Ronde ecosystem in general, and of spring chinook populations specifically, depends upon conditions in the broader Columbia region. The diagnosis is not complete until the analysis is expanded to include the full life cycle of spring chinook. This analysis covers a single diagnostic species, spring chinook; additional species or economies would improve the diagnosis.

2. GENERAL DESCRIPTION OF WATERSHED AND DIAGNOSTIC SPECIES

2.1 Watershed

The Grande Ronde Basin is located in northeastern Oregon and southeast Washington (Fig. 1). The basin drains an area of approximately 4,000 square miles and connects to the Snake River 169 miles upstream of its mouth. The confluence of the Snake and Grande Ronde rivers is located 493 miles upstream of the mouth of the Columbia River.

The basin is characterized by rugged mountains and two major river valleys, the Grande Ronde and Wallowa valleys. The Blue Mountains and the Wallowa Mountains rise to 7,700 and 10,000 feet respectively.

The basin has a semi-arid climate. Temperatures and precipitation vary with elevation. Average annual rainfall in the valleys ranges from 12 inches to 23 inches, while at higher elevation it can exceed 50 inches. The valleys tend to have warm, dry summers and cold, moist winters (NPPC 1990).

Approximately 45 percent of the basin is public land managed by the U.S. Forest Service (NPPC 1990). Privately owned land is located primarily at lower elevations along streams and on the valley floors. Primary land uses in the basin are forest, range, and cropland.

The Grande Ronde Basin contains aquatic resources of considerable importance to local, regional, and national interests. These include approximately 2,300 miles of salmonid streams (Huntington 1994). The majority of these miles support anadromous salmonids.

Alterations of the watershed started soon after settlement in the 1860s. Agricultural development, timber harvest and mining were among the land use practices that stimulated early development and supported the growth of local communities. These activities have gradually changed the natural landscape and altered the physical and biological processes that characterized the system.

Reviews of changes that have occurred to the basin’s stream system are given in West and Zakel (1993) Smith and Knox (1993) and McIntosh (1992).

2.2 Spring Chinook Salmon

The Grande Ronde Basin historically produced large runs of spring chinook salmon. Fisheries managers estimated that 12,200 spring chinook entered the river in 1957 (NPPC 1990). Run sizes were estimated to be about 8,400 fish in the early 1970s (Smith 1975). Prior to all dam construction and alteration of the watershed, run sizes were likely much larger than these levels (based on inferences in Lichatowich and Mobrand 1995).

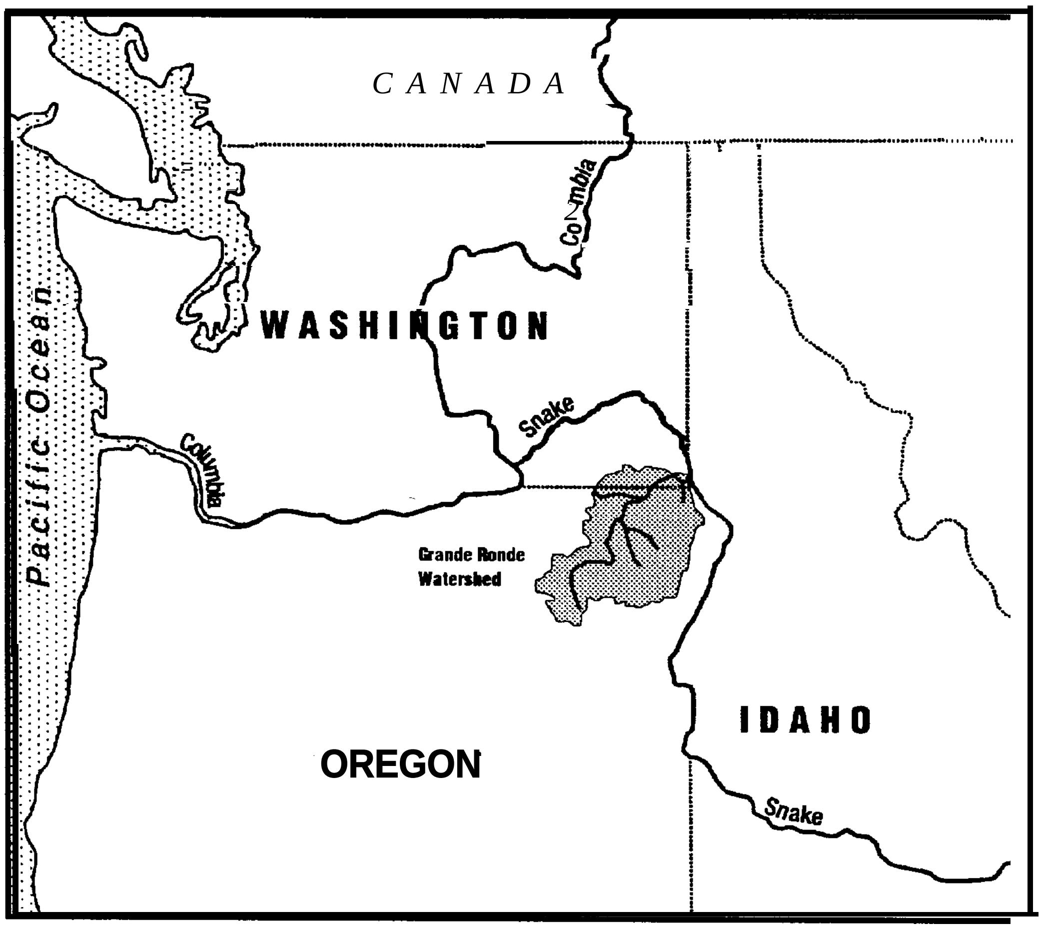


Fig. 1. Location of the Grande Ronde Basin.

Spring chinook are widely distributed in the basin. Twenty-one streams historically supported spawning. The Wenaha River, Catherine Creek, Minam River, Lookingglass Creek, Lostine River, and the Upper Grande Ronde River were considered highly productive for these fish (NPPC 1990).

Redd counts made in the basin indicate that spawner abundance remained relatively high until the early 1970s. A sharp decline has occurred since then. Run sizes in some recent years have numbered several hundred fish.

Outplanting (supplementation) of spring chinook has occurred in the basin in recent years in attempting to bolster the run. See NPPC (1990) for a more complete description.

3. CONCEPTUAL APPROACH TO ANALYSIS

This section presents the conceptual approach for diagnosing watershed conditions, developing action alternatives, and assessing possible outcomes of implementing those actions. Related diagnostic approaches are reviewed, a conceptual framework is described, and the application of this approach to the Grande Ronde watershed is presented.

3.1 Relation to Other Diagnostic Approaches

To understand the relevance of concepts incorporated into the EDT approach, it is helpful to first review two related diagnostic approaches: limiting factors analysis and watershed analysis.

The most widely used approach for assessing the effect of environmental factors on salmon populations involves what is loosely referred to as limiting factors analysis. This approach is based on a concept that considers factors affecting a population as a “bottleneck” to abundance. It is widely cited as a way of conceptualizing the relative importance of factors that regulate the abundance of fish populations (Hall and Field-Dodgson 198 1; Nickelson 1986; Hunter 1991; Reeves et al. 1991; Nickelson et al. 1993).

The premise of the limiting factors concept is that the upper limit to population size is determined by the resource in least supply (Ricklefs 1973; Begon and Mortimer 1986). If the supply of that resource is increased, the population can theoretically grow until constrained by the next most limiting resource. Competition for food or space resources in the most constricting life stage is seen as the “bottleneck” to population size. This view has led to the popular idea among biologists that stream populations are limited in size by one life stage or another, such as by summer habitat or overwintering habitat (Reeves et al. 1989; Hunter 1991).

This notion of a limitation in one stage or another has been extended by many biologists to cover a broader range of factors affecting population abundance over an animal’s life cycle, resulting in an extremely simplified diagnosis of population health. Fish biologists have extended the concept to include, for example, mortality from fishing and passage over dams. Hence Huppert and Fight (1991) concluded that “some stocks are habitat-limited while others are limited by fishing mortality.” Using similar logic, Reeves et al. (1989) concluded the following in considering the value of habitat improvement actions:

> *“If optimum (spawning) escapement is not expected within 5 years because of overharvest or downstream mortality (for example, dams), it is difficult to justify habitat improvement projects."*

This concept of limiting factors has resulted in a view held by many that an improvement in the condition of animal populations like salmon first requires that the “most limiting factor” be addressed before improvements in other mortality factors can be beneficial. Thus improvements in habitat condition are seen as being of little or no value if freshwater habitat is "underseeded" by natural spawners (e.g., Reeves et al. 1989; Huppert and Fight 1991). The solution in that case, by such reasoning, is to increase the number of spawners by reducing fishing or dam passage mortalities that occur downstream.

These concepts explain why the region has been locked in debate over *which* of several possible problems is *the* principal problem with salmon natural production.

Such thinking has actually contributed to the current plight of salmon populations. It has led to attempts to solve ecological problems without seeing, or addressing, the real issue causing salmon declines: the cumulative effect of many mortality factors operating throughout the salmon life cycle. Limiting factors analysis largely ignores this fact by taking an oversimplified view of how mortality occurs and the role of life history diversity.

Another related diagnostic approach is watershed analysis'-- part of a recent initiative to implement ecosystem management concepts on federal lands (FEAT 1993). The approach is aimed at development of a scientifically based understanding of the major ecological processes and interactions occurring within watersheds. The intended use of the analysis is to help guide management actions. The goal of watershed analysis is very similar, if not identical, to the purpose of the Grande Ronde EDT Project.

While watershed analysis is described as a "set of technically rigorous and defensible procedures" (FEAT 1993, V-55), which includes "limiting factors analysis for key species," it is probably better described as a set of general guidelines for considering how watershed processes occur. It is primarily aimed at physical environmental processes. No attempt has been made to incorporate a theoretical basis for analyzing how these processes affect populations such as salmon. A conceptual bridge is needed to link environmental factors to the biology of populations. Without such a bridge, or framework, resulting analyses are merely descriptive and lack a clear rationale for linking actions and expected outcomes,

The existing theoretical basis for performing diagnostic analyses of watersheds and their populations is not adequate to meet the needs of the Grande Ronde Model Watershed Project. A conceptual framework is needed to provide a basis for analyzing the relationship between environmental factors, resource sustainability, and societal values.

'/The term "watershed analysis" is being revised within the federal planning process to "ecosystem analysis at the watershed scale" to emphasize its role in moving toward ecosystem management (REO 1995).

3.2 Conceptual Framework

Ecosystem (or watershed) management has a logical requirement--that one be able to see the ecosystem as a whole in some fashion (Franklin 1992; Lee 1993). The conceptual framework of the EDT approach was formulated to help gain such perspective.

Terms and concepts have been incorporated to facilitate analyses that are consistent and transferable across spatial and temporal scales of ecosystems. This recognizes the hierarchical nature of watersheds and ecosystems (O'Neill et al. 1986). Hence analyses made at different scales--from the smaller watersheds (e.g., Meadow Creek) to successively larger watersheds (e.g., Upper Grande Ronde to entire Grande Ronde to Columbia Basin)--can be related and linked. Ultimately, conditions within these watersheds can be linked to those within the north Pacific Ocean. This feature of the conceptual framework enables consideration of conditions for sustainability that link all components of an extensive and complex life history, such as that exhibited by salmon, over successively larger spatial scales.

3.2.1 Framework for Linking Actions to Outcomes

In its simplest form, the conceptual framework shows a pathway for linking potential management actions (or natural events) to outcomes that may be relevant to society's objectives (Fig. 2). This framework provides a system of logic (rationale) that explains how actions are transferred into desired outcomes.

The framework consists of a sequence of relationships. The flow of logic proceeds as follows: 1) any action taken by humans (or a natural event) within the ecosystem has some effect on attributes, or conditions, of the environment; these attributes may be abiotic (such as sediment loading or water temperature) or biotic (such as increases in abundance of a particular species by hatchery outplanting); 2) in turn, these changes in environmental attributes affect how populations within the ecosystem perform (i.e., survive and function); and 3) the resulting performance of populations creates an outcome that has direct relevance to societal objectives.

Biological performance can be assessed for one or more populations. Entirely natural populations can be examined, or domestic populations, such as cattle, can be considered. Actions intended to have some effect on one population, like salmon, may also affect a different population, like cattle. The framework provides a system of logic for addressing such interactions.

The framework explains possible consequences in a manner consistent with existing knowledge and information, and it requires that all assumptions necessary to watershed planning are identified. It is a tool for learning and communicating.

In this progress report, the analysis is focused on one part of the framework - the relationship between environmental attributes and population performance.

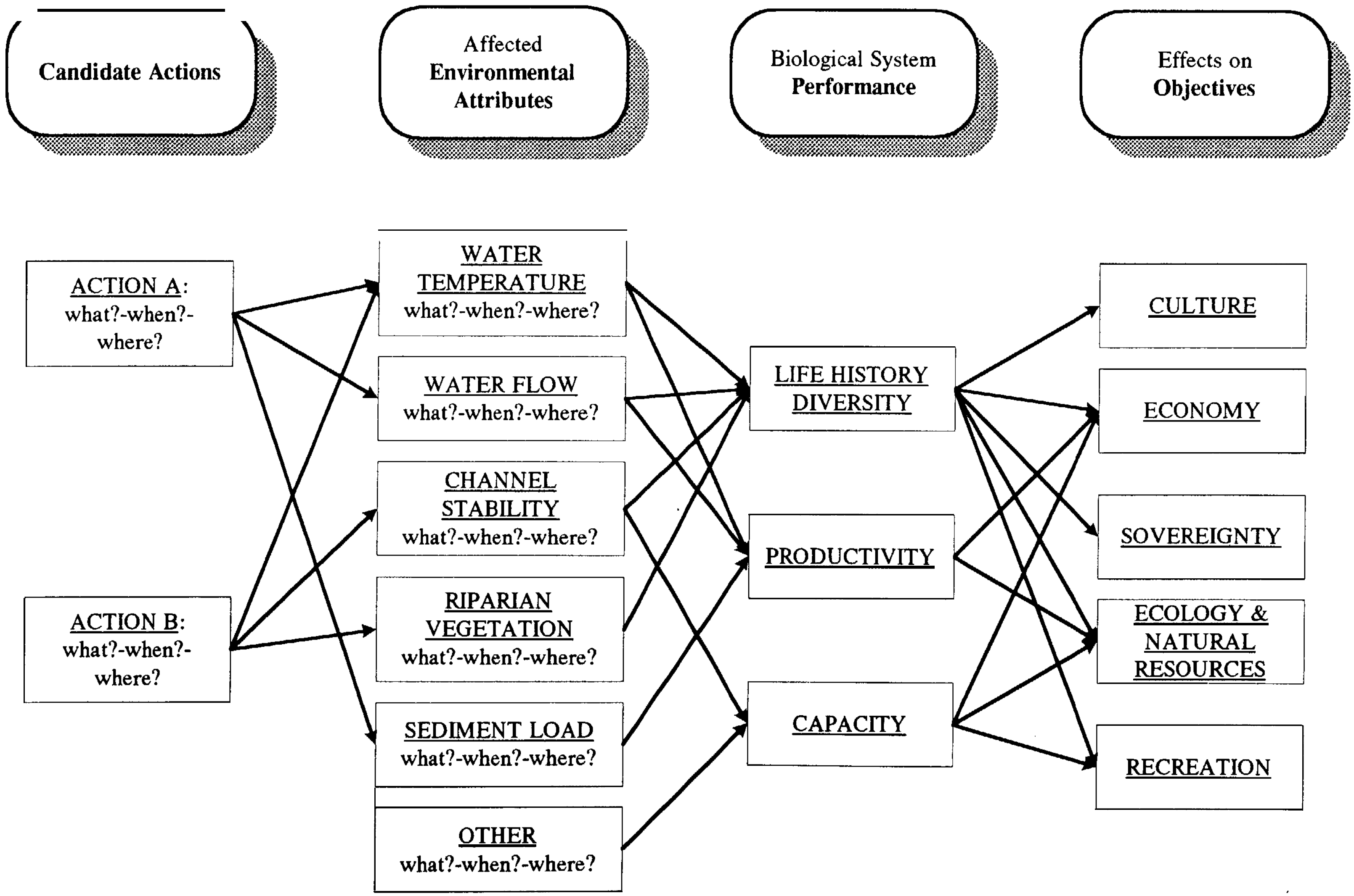


Fig. 2. Framework for linking actions to outcomes.

3.2.2 Elements of Biological Performance

Biological performance is described in terms of three elements: life history diversity, productivity, and capacity (Fig. 3). These elements represent the processes of mortality and behavior and the results of those processes on life history or species diversity.

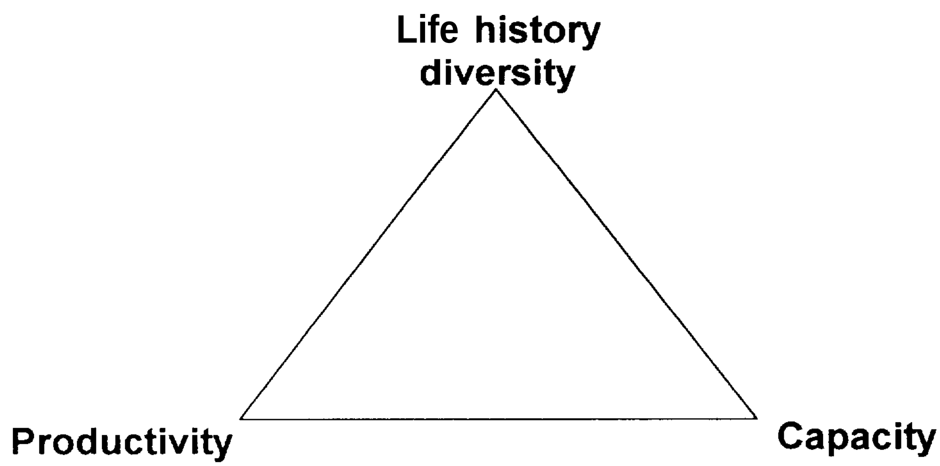


Fig. 3. Conceptual elements of biological performance.

because each is influenced differently by environmental conditions. A major problem with limiting factors analysis is its failure to recognize this distinction.

A density-independent process is one in which the *rate* of response is not affected by population density (Begon and Mortimer 1986). In contrast, a density-dependent process is one in which the *rate* of response varies according to population density due to competition for limited food and space resources. The combination of these two processes results in the total mortality rate of a population. The effect of density-dependent mortality is low at low population densities, whereas density-independent mortality operates more or less consistently across all population densities.

The identification of these two distinct processes is useful in explaining how different kinds of environmental conditions can affect populations. Habitat or environmental *quality* tends to affect density-independent processes. A deterioration in habitat quality will increase density-independent loss. Habitat *quantity* tends to affect density-dependent processes, and thus its effect on total mortality is minor at low densities, The amount of habitat available becomes increasingly important as population densities increase (i.e., as competition for resources increases).

Structure is needed in order to apply the principles of science in the quest for understanding. The aim here is to understand how the environment affects spring chinook performance. Existing theory links each of these elements to environmental conditions. Structuring or defining performance in terms of the elements of life history diversity, productivity and capacity facilitates the pursuit of conclusions about environmental effects in a rational (scientific) manner.

The first element, life *history diversity,* is the multitude of pathways through time and space available to, and used by, the species in completing its life cycle. Diverse life history patterns are the result of adaptation to a variable environment. Loss of diversity in life history patterns is an indication of declining health in animal populations; diversity dampens the effects of a fluctuating and variable environment. Life history diversity of spring chinook in the Grande Ronde Basin is measured by the range of distributions and pathways being used successfully by the population, Hence it reflects the extent to which members of the population can survive and complete their life cycles over a range of possible distributions within the watershed.

The second element, *productivity,* is a measure of density-independent survival.* It reflects the ability of fish to survive under a set of environmental qualities, not affected by the relative abundance of other members of the same species that may be present (Hilborn and Walters 1992). The productivities of all life stages are multiplicative, meaning that they can simply be multiplied together to compute an overall productivity value for the entirety of freshwater life, as well as for the entire life cycle. Hence the productivity of the full life cycle is an indicator of reproductive success beginning with egg fertilization and ending with egg fertilization of the next generation. If productivity of a life history pattern drops too low due to environmental effects, then the pattern is not self-sustaining.

The third element, *capacity,* is a measure of the number (or biomass) of animals that can be supported within a certain geographic area for a given time period. It regulates the extent to which the density-dependent mortality process operates on a population at a given location and life stage based on the relative density of the population present. Habitat quantity is a primary determinant of capacity, though it can be modified by quality attributes (Hilborn and Walters 1992). Limiting factors analysis is appropriate when studying this element of spring chinook performance.

The framework enables computation of indices of productivity and capacity, which together reveal life history diversity.

3.2.3 System Organization

Ecological processes occur in geographic space and time. The scale used for these dimensions is chosen to match the distribution and life stage requirements of the diagnostic species, spring

---

*/The term "productivity" refers here to population dynamics (see Hilborn and Walters 1992, pages 284-285); the meaning here differs from the more classical ecological usage referring to the rate at which energy or nutrients are assimilated by an organism or population.

chinook. This time/space organization defines the “landscape” within which the processes shown in Fig. 2 occur.

Within the overall project boundaries of the Grande Ronde watershed, the system is spatially organized according to sub-drainages defined by their ridge lines--as a connected patchwork of watersheds. The time scale is chosen to be consistent with the occurrence and duration of the distinct life stages of the diagnostic species, spring chinook.

3.3 Patient-Template Analysis and Diagnosis

The diagnosis of watershed conditions begins by performing what has been called Patient-Template Analysis (PTA) (Lichatowich et al. 1995)--an approach employing medical analogies to compare existing conditions of the diagnostic species and its habitat (Patient) with conditions considered representative of health (Template). Results of the analysis are used to formulate the diagnosis.

The Patient and Template are described through the conceptual framework in terms that define population performance within the spatial and temporal scales used in organizing the system. Template conditions are inferred by reconstructing a historic representation of the diagnostic species and its habitat--assuming healthy, sustainable conditions. The conditions that prevailed prior to about 1880 in the Grande Ronde Basin serve as the Template for the study. The assessment of the Patient is based on available information about current environmental conditions within the watershed and what is known or inferred about the effect of these conditions on survival and distribution.

The diagnosis is a determination, based on deductive analysis, of the general condition of the diagnostic species to sustain itself and related societal values given past and present modes of resource use and environmental change. It includes an assessment of the relative contributions of the various factors affecting the condition of the diagnostic species.

The diagnosis is aided by comparing the Patient and Template to identify potential causes for changes in performance of spring chinook. The Template should not be confused with objectives. If the Template represents historic, pristine or relatively undeveloped conditions, the objectives may only require partial restoration of certain watershed components or functions. Thus the purpose of describing the Template is twofold. It helps in formulating the diagnosis, and it should also help identify a range of possibilities achievable in the future.

3.4 Formulation of Treatment Alternatives

Guided by the diagnosis, an array of reasonable alternative actions is identified. Actions are intended to affect the performance of the diagnostic species and thereby aid in the achievement of objectives. Therefore, actions should address one or more of the environmental attributes diagnosed as affecting performance (Fig. 2).

In order to integrate actions effectively, they must be directed by, and consistent with, overall strategies for the watershed that are based on a system-wide diagnosis. Strategies concern comprehensive, large-scale marshaling and allocation of resources, whereas actions (or tactics) concern local, immediate and short-term activities. A strategy is based on an understanding of the bigger picture.

Without a clear, rational set of strategies to guide action selection, actions loose their effectiveness to complement one another. The sheer magnitude of some of the conditions addressed within the watershed makes it imperative that actions be coordinated by a consistent strategy to have a reasonable chance of program success.

A diagnosis that incorporates all of the elements of the conceptual framework provides a basis for visualizing the whole system, thus revealing patterns, Seeing these patterns and understanding their relation to the life histories of the diagnostic species is the basis for formulating cohesive system-wide strategies. Actions can then be identified that are consistent with these strategies.

3.5 Trade-off Analysis

Based on the diagnosis and descriptions of candidate actions, the trade-offs (benefits and risks) associated with actions, or suites of actions, can be derived. The approach requires that such an analysis be performed to provide policy-decision makers with technical information to aid them in adopting actions to be implemented.

This analysis is performed within the confines of the conceptual framework. Its purpose is to help decision-makers weigh the trade-offs associated with different candidate actions. The result of this analysis is a listing of action alternatives described in terms of expected trade-offs.

4. ANALYTICAL METHODS

The framework divides the relationship between actions and objectives into three parts: actions to environmental attributes, attributes to biological performance, and performance to objectives (Fig. 2). This report focuses primarily on the effects of environmental attributes on population *productivity* and life *history diversity.*

4.1 Patient-Template Analysis

The PTA procedures are described in the following sequence of steps: system organization, assessment measures, summarization and analysis, and graphical display.

4.1.1 System Organization

All of the information used in or produced from the PTA needs to be considered within spatial-temporal scales consistent with the range of possible life histories of the diagnostic species. This requires that spatial-temporal scales be defined accordingly.

The Grande Ronde watershed is divided into separate units on the basis of the natural stream drainage system, as illustrated in the schematic shown in Fig. 4. The schematic shows the drainage system broken into tributary and mainstem units used in the analysis. The units are not equal in size. Units are delineated by the connectivity of the drainage along stream channels using the EPA's stream reach numbering system as expanded by the Northwest Power Planning Council. For example, the sub-drainage of the Grande Ronde River upstream of Clear Creek is one unit. It includes the entire catchment of that area. Clear Creek is another unit and includes its entire catchment. The Grande Ronde River reach between Clear Creek and downstream to its confluence with LimberJim Creek defines another unit, which is treated as a separate catchment encompassing the drainage area surrounding this reach. This unit can be considered alone, but in combination with the two units upstream it defines a higher hierarchical level.

Unit delineation in Fig. 4 shows the level of spatial organization selected for analyzing spring chinook. Other scales may be required for other diagnostic species.

Time is delineated within a calendar year by statistical week (Table 1), forming the basic and smallest scale for defining time over the life cycle of spring chinook within the watershed. This scale is well suited to defining time periods associated with different life stages of many species over their life cycle; it works particularly well for freshwater life stages of aquatic species.

Seven life stages were defined for spring chinook salmon within the Grande Ronde Basin (Table 2). Approximate time periods associated with each stage are shown in the table, though these periods vary somewhat for some stages in different areas of the river system.

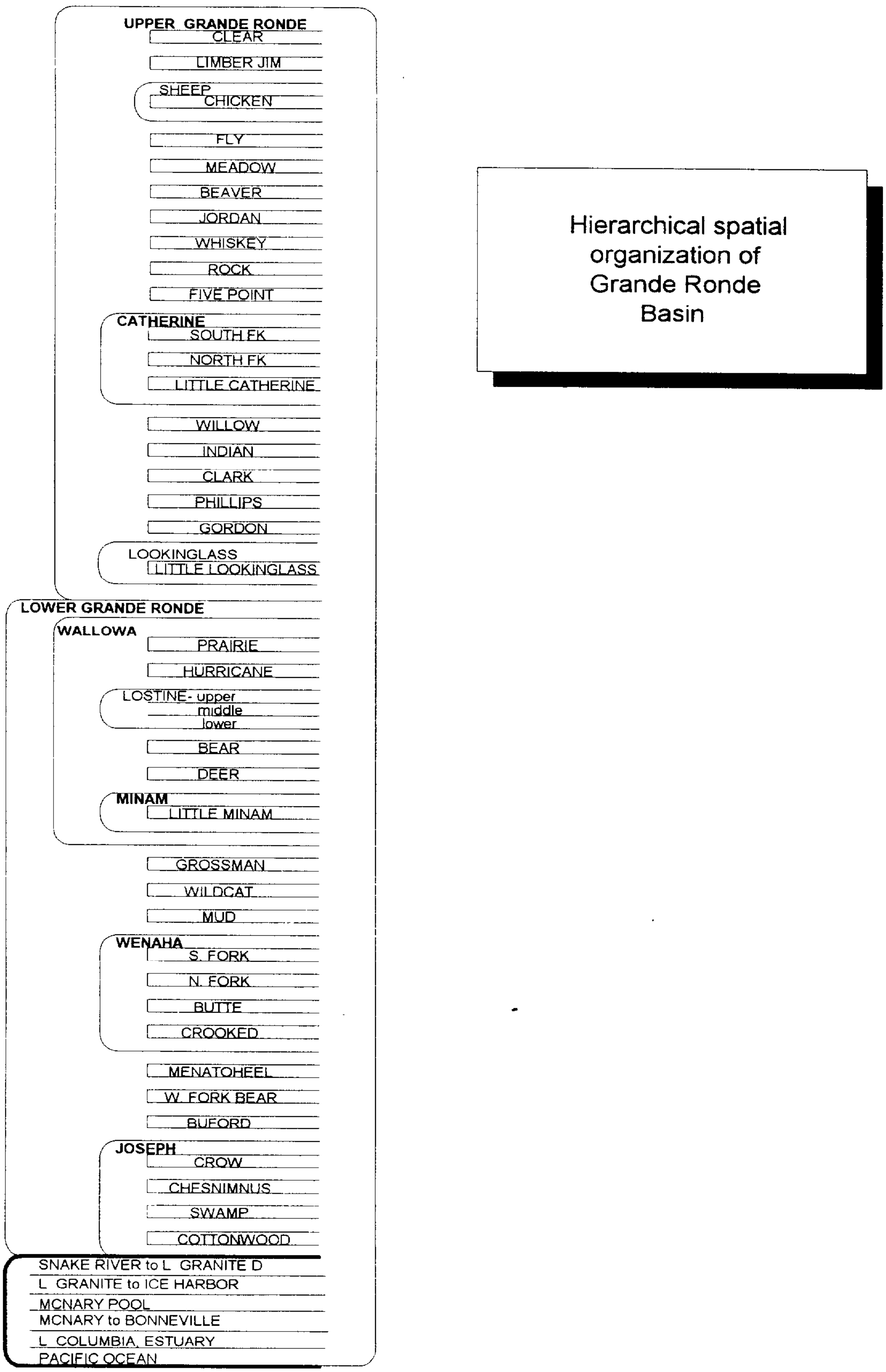


Fig. 4. Spatial scale used for the Grande Ronde Basin framework.

Table 1. Dates associated with statistical weeks within one calendar year.

Statistical week	Beginning day	Ending day	Statistical week	Beginning day	Ending day
1	l-Jan	7-Jan	27	2-Jul	8-Jul
2	8-Jan	14-Jan	28	9-Jul	15-Jul
3	15-Jan	21-Jan	29	16-Jul	22-Jul
4	22-Jan	28-Jan	30	23-Jul	29-Jul
5	29-Jan	4-Feb	31	30-Jul	5-Aug
6	5-Feb	11 -Feb	32	6-Aug	12-Aug
7	12-Feb	18-Feb	33	13-Aug	19-Aug
8	19-Feb	25-Feb	34	20-Aug	26-Aug
9	26-Feb	4-Mar	35	27-Aug	2-Sep
10	5-Mar	1 l-Mar	36	**3-Sep**	9-Sep
11	12-Mar	18-Mar	37	**1 0-Sep**	16-Sep
12	19-Mar	25-Mar	38	17-Sep	23-Sep
13	26-Mar	1-Apr	39	24-Sep	30-Sep
14	2-Apr	8-Apr	40	1-Ott	7-Oct
15	9-Apr	15-Apr	41	8-Ott	14-Oct
16	16-Apr	22-Apr	42	15-Oct	2 1-Oct
17	23-Apr	29-Apr	43	22-Oct	**28-Oct**
18	30-Apr	6-May	44	29-Oct	4-Nov
19	7-May	13-May	45	5-Nov	11-Nov
20	14-May	20-May	46	12-Nov	18-Nov
21	21-May	27-May	47	19-Nov	25-Nov
22	28-May	3-Jun	48	26-Nov	2-Dec
23	4-Jun	1 0-Jun	49	3-Dec	9-Dec
24	11-Jun	17-Jun	50	1 0-Dee	16-Dec
25	18-Jun	24-Jun	51	17-Dec	23-Dec
826	25-Jun	1-Jul	52	24-Dec	31-Dec

Table 2. Definition of spring chinook life stages within the Grande Ronde Basin.

Stage	Description	Months	Statistical weeks
Adult	Upstream adult migration and holding prior to spawning.	April-August	15-33
Spawning	Spawning period, including establishment and defense of redd sites.	August-September	33-38
Incubation	Egg deposition to fry emergence.	August-April	33-70
Fry Colonization	Fry emergence until establishment of summer rearing locations.	April-June	61-71
Summer Rearing	After colonization ceases when fish are largely stationary and activities are mainly directed at feeding and growth (large fish may outmigrate near end of period).	June-September	71-95
Fall Redistribution and Over-wintering	Beginning with drop in temperature in early fall until the onset of yearling smolt migration at the end of winter.	September-March	96-114
Smolt to Smolt	Onset of seaward migration to departure from the Grande Ronde Basin.	April-June	114-125

Our system of numbering statistical weeks begins with the entry of prespawner adults into the river system in spring, i.e.-, in week 15 of that calendar year, then continues over a period of approximately two years until their progeny, as smolts, migrate from the river system in their second year of life (Table 2). The week beginning the second calendar year, which occurs during egg incubation, is numbered week 53 Similarly, the week beginning the third calendar year, which occurs during the overwintering stage for fingerling fish, is numbered week 105. Smolts in their second year of life begin emigrating from the basin generally in about statistical week 115.

Much of the information used in formulating the diagnosis is displayed in a format that captures both the space and time dimensions, as shown in Fig. 5 for the mainstem Grande Ronde. The figure illustrates format only and contains no information. This format is used as a device to help visualize patterns of survival and the relative strengths of mortality factors operating on the population in time and space. This format is particularly effective at showing how conditions that affect the sustainability of a population can vary dramatically within these dimensions.

4.1.2 Assessment Measures

Four measures are employed to assess the effects of environmental attributes on population performance:

- Relative productivity (or survival)
- Relative effect of environmental quality on productivity
- Total quantity of habitat
- Relative quantity of key habitat (or proportion of total)

The combination and interaction of these measures describe population performance in relation to the unique set of environmental quality and quantity attributes of a watershed.

Each measure, except one, is assessed in a relative manner; i.e., as an index rather than absolute estimate. This simplifies the analysis. All measures are assessed for each life stage of the diagnostic species within each geographic unit.

The assessment is made through work sessions involving a team of individuals knowledgeable about the diagnostic species or about pertinent watershed conditions. To maintain consistency throughout the process, each work session is facilitated by an individual thoroughly familiar with the conceptual framework and its component pieces.

The assessment follows a set of consistent procedures for identifying and interpreting information relevant to each measure, leading session participants to make inferences about the condition, or level, of each measure. Inferences are based on existing studies in the Grande Ronde Basin, personal observations of work session participants, or extrapolation from other studies outside the basin. The inferences are assumptions that are necessary for assessing performance. The power of this type of analysis is the requirement to explicitly consider, identify, and document all assumptions, Forms used to perform the assessment are provided in Appendix A.

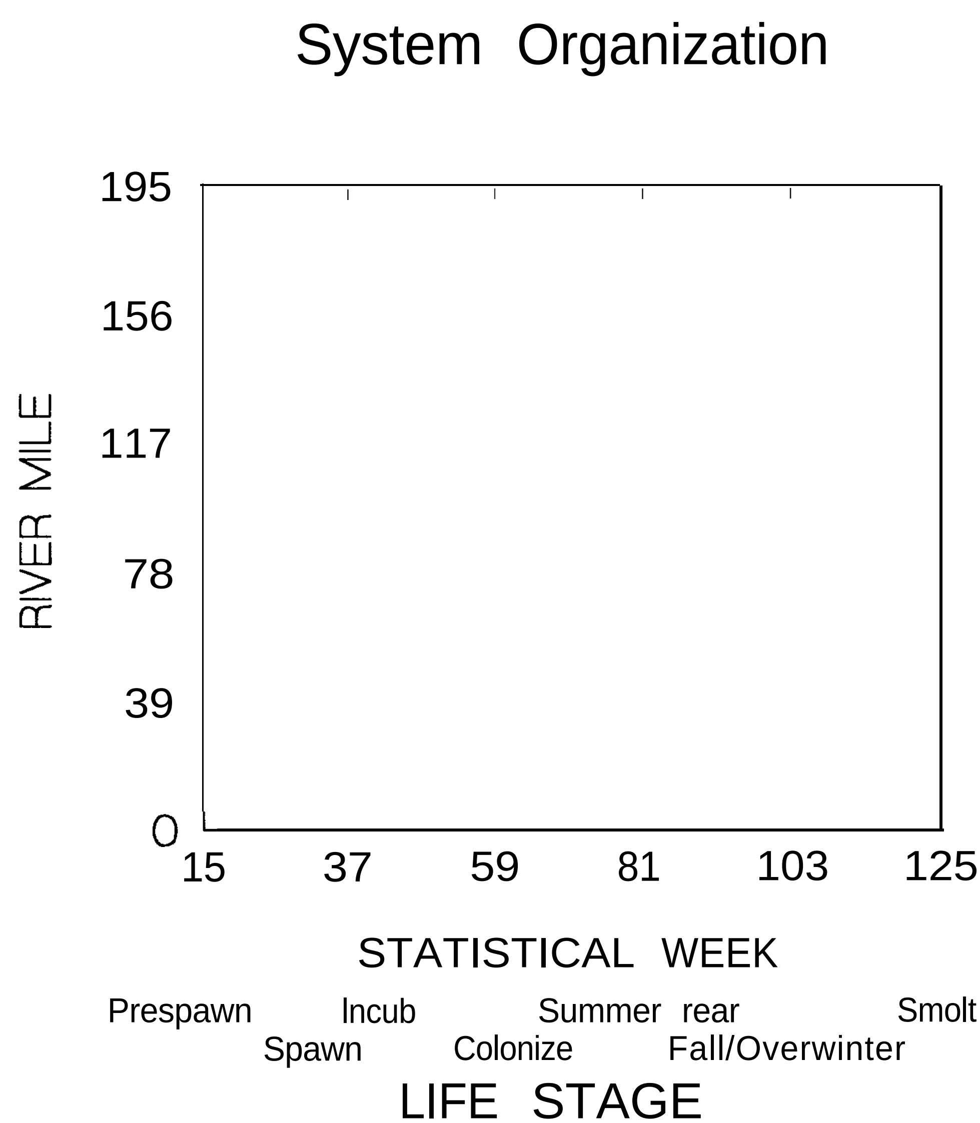


Fig. 5. Spatial-temporal format for displaying information for spring chinook along the mainstem Grande Ronde River.

Relative Productivity. This measure describes that element of performance referred to as productivity. It addresses mortality or losses due strictly to density-independent processes. Participants at the working session assess spring chinook productivity based on their knowledge of the environmental requirements considered optimal for .the species and of conditions within the geographic units.

The measure is scored on a scale of O-l, where a value of 0 represents no survival and 1 represents optimal survival conditions (ignoring density effects) for the diagnostic species. If, for example, a river reach is given a value of 1 for one life stage, say egg incubation, this would mean that conditions in that reach are considered optimal for egg survival. Therefore, survival in the absence of density effects would be the highest possible for this life stage under natural conditions. If the reach is given a score of 0.5, then survival is expected to be equivalent to 50% of the highest possible under natural conditions. If a score of 0 is given, then no survival is expected for the stage.

Participants at the working session also assess how the survival component varies, on the average, over the time period associated with each life stage. This is done for monthly intervals within the life stage. Each month is scored separately by assuming that survival conditions of that month are the worst for the entire life stage, This procedure allows estimation of when, and for what length of time, survival is affected.

Subsequent to the working session, the data are used to compute weekly relative survival rates for the duration of each life stage, using the monthly values to determine how survivals vary over the stage. Weekly survivals are assumed to be constant within months. Because survival rates are multiplicative, all weekly values for a life stage multiplied together equal the life stage productivity.

Relative Quality of Environmental Attributes. This measure explains, or justifies, the productivity scores by identifying the relative contributions of a range of environmental quality attributes to

environmental quality conditions within each geographic unit on life stage productivity.

Fourteen descriptive attributes of environmental quality for spring chinook were employed (Table

or more of the life stages in freshwater. Three of these attributes (competitors, predators, and pathogens) are biotic factors representing non-diagnostic species and their effects on the

The environmental quality attributes describe conditions within the stream environment or in its immediate vicinity (riparian condition). Many of the attributes also reflect conditions in the

on other diagnostic species, particularly terrestrial species, may need to include other attributes.

Table 3.

spring chinook salmon in the Grande Ronde Basin.

Attribute	
Channel Stability	Stability of the reach with respect to its streambed, banks, and its channel shape and location.
Flow	Pattern and extent of flow fluctuations within the stream reach.
Habitat Type Diversity	The extent of habitat complexity within a stream reach. Complexity is the opposite of uniformity; greater complexity increases density-independent survival; woody debris, brush, and other structure add complexity.
Sediment Load	The amount of sediment present in, or passing through, the stream reach. Sediment may be suspended (turbidity), moving along the substrate (bedload), or within the substrate (percent fine particles).
Temperature	Water temperature in the stream reach. Density-independent survival is affected by rapid fluctuations, or by conditions near the extremes of tolerance.
Riparian Condition	The state of the vegetation component of the narrow strip of land bordering the stream where vegetation species occur that are dependent on the stream or its adjacent water table.
Predators	The relative abundance of predators that feed upon the target species.
Chemicals	Concentrations of toxic chemicals from point and non-point sources.
Competitors	The relative abundance of other species in the stream reach that compete with the target species for food or space.
Obstructions	Physical structures that impede the use of a stream reach, such as dams, weirs, or waterfalls.
Withdrawals	Water withdrawals from the stream reach.
Nutrient Load	The concentration of dissolved nutrients due to natural or man-induced causes. Nutrients may be deleterious or may enrich the available food supply.
Oxygen	Mean concentration of dissolved oxygen in the stream reach.
Pathogens	The abundance, concentration, or effect of pathogens in the stream reach. For example, the presence of a fish hatchery or large numbers of livestock along the reach could cause unusually high concentrations of pathogens.
Other	Any other attribute unique to the stream reach that may affect survival.

Participants at the working session score each quality attribute by identifying its relative contribution to the productivity scores given. Attributes are scored on a scale of O-4, where 0 indicates no contribution to downgrading survival (from optimal) and a 4 indicates a lethal effect (Table 4). For example, if relative productivity was scored a value of 1, indicating optimal conditions for survival are present, then all quality attributes would be scored 0 (i.e., no deleterious attribute effects). If relative productivity had been scored 0.5, indicating less than optimal conditions are present, then at least one or more attributes would likely have been scored a 2 or 3 indicating a moderate or high effect on survival. If productivity had been scored 0, indicating no survival is expected, then at least one attribute would have to be scored a 4 for a lethal effect.

Table 4. **Numeric scores used in describing the relative effects of the quality of environmental attributes on the survival of spring chinook.**

Relative quality	Score
Lethal effect	4
High effect	3
Moderate effect	2
Low effect	1
No effect	0

This procedure for identifying and scoring environmental quality conditions, while based on judgement, is a way of profiling the entire watershed using a systematic and consistent approach. It is particularly useful for diagnosis because it links environmental attributes directly to survival (productivity) values, facilitating identification of the specific attributes that need to be targeted if survival conditions are to be changed at specific locations and times.

Ouantitv of Habitat. This measure quantifies the total amount of habitat available to be used by the diagnostic species within each geographic unit in each life stage, including areas that may not be highly preferred or utilized. For spring chinook, total available habitat would consist of the total amount of stream area available to be used in each geographic unit and life stage. Stream area is computed as the product of stream length and average width (wetted area) by time period. The data needed for these computations are obtained from stream habitat databases.

This measure is used in conjunction with the relative quantity of key habitat (see next section) to analyze the distribution of habitat capacity, one of the three performance elements.

Relative Ouantity of Key Habitat. This measure quantifies the amount of key habitat relative to the total amount available within each geographic unit in each life stage. Habitat requirements and preferences differ by species and often by life stage for those species. The key habitat measure is used as a way of examining habitat capacity in the diagnosis.

Key habitat is that component of the total habitat available to a species that is strongly preferred, or needed, during a life stage (shown for spring chinook in Table 5). For example, salmon require a stream to live in but they also require riffles containing a certain sized substrate for spawning and reproduction. These spawning riffles are referred to as "key habitat" during both the spawning and egg incubation life stages. In this example, the measure would indicate the percentage of stream environment within a geographic unit that consists of spawning riffles suitable for chinook salmon at the appropriate time. The measure says nothing, however, about the relative quality of spawning riffles for egg survival; that is described through the productivity measure.

The relative amounts of key habitat are determined according to five categories of availability using scores of O-4 (shown for spring chinook in Table 6). Here, a score of 0 indicates that no key habitat is present, whereas a value of 4 indicates that it is superabundant relative to total habitat present. Use of categories of availability in this manner facilitates acquisition of information.

4.1.3 Summarization and Analysis

All relevant quantitative information is stored in a computerized database (MS Access 2.0). Related descriptive comments obtained through the work sessions are placed in the same database.

The database also serves as the primary device for documenting assumptions, thereby creating a permanent record of the analytical process to be used in tracking the logic through the project, formulating hypotheses, and identifying monitoring needs.

The data are formatted into the appropriate spatial and temporal scales using a set of analytical steps coded in MS Excel 5.0. These steps are used to build data lists for use with SYSTAT software, required for producing many of the graphical displays.

4.1.4 Graphical Displav

Visual displays of information are the primary means of comparing conditions between Patient and Template for the diagnostic species. They provide visualization of patterns in space and time dimensions that are relevant to the overall condition of the resource under inspection. A set of standard formats, such as that depicted in Fig. 5, facilitate visualization and subsequent analysis.

All graphical displays are produced with SYSTAT 5 .O and Excel 5.0. Charts plotting information in space and time are made using a set of routines designed in SYSTAT using contour and 3-D surface plotting functions.

Table 5. Description of key habitat used by spring chinook by life stage within the Grande Ronde Basin.

Life stage	Key habitat
4dult	Large, deep pools with sufficient connecting flow for adult migration.
Spawning	Riffles containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity.
Incubation	Riffles as described for spawning with sufficient flow for egg and alevin development.
Fry colonization	Shallow and relatively slow velocity areas within stream channel, often associated with stream margins and in relatively low gradient reaches.
Summer rearing	Pool type habitat associated with relatively low gradient stream channel reaches (usually not in backwaters nor slow eddies).
Fall redistribution/over-wintering	Areas containing structural complexity (wood matrices, brush, or large cobbles) within flowing channel, not usually in swift or higher gradient reaches; off-channel areas (ponds, oxbows, etc).
Smolt to smolt	Sufficient flow for free movement of smolts downstream.

4.2 Diagnosis

The diagnosis is a determination of the general condition of the diagnostic species to sustain itself and related societal values, given past and present resource uses and environmental change. The diagnosis is made by viewing and analyzing the information assembled in the PTA from a life history perspective.

4.2.1 Life Historv Trajectories

In performing the diagnosis, consideration is given to the likelihood that conditions for sustainability may vary greatly within the watershed, both in geographic space and time. This poses an analytical challenge because there are a myriad of possible sets of conditions that different members of a population like salmon can experience throughout a watershed. Habitat

Table 6. Relative quantity of key habitat for spring chinook within stream reaches of the Grande Ronde Basin.

Relative quantity of key habitat	Score	All stages except smolt to smolt[1]	Smolt to smolt life stage
Exceptionally high	4	>50% of stream area	Superabundance of needed flow
High	3	>25% and <50% of stream area	Migration may be affected slightly
Low	2	>5% and <25% of stream area	Migration affected noticeably by reduced flow
Scarce	1	>O% and ~5% of stream area	Migration very diffkult due to low flow
None	0	0% of stream area	Channel is dry

[1] Stream area being referred to during fry colonization is the area along stream margins,

conditions for species as migratory as salmon are likely to be highly heterogenous within a geographic area the size of the Grande Ronde watershed.

This challenge is addressed by defining sample pathways, or trajectories, that members of the diagnostic species can follow through the watershed, both in space and time. This procedure, or analytical probe, is a way of sampling the possible sets of conditions that animals can encounter in completing their life cycles.

An example trajectory is illustrated in Fig. 6, where one possible path of a spawner and its progeny is traced in space and time within the watershed. The path begins in the lower right corner of the chart with the entry of an adult migrant salmon into the Grande Ronde River from the Snake River. In this case the fish enters in statistical week 16, or about mid April. The path continues upstream, charting the progress of the migrant adult to the spawning grounds in the Upper Grande Ronde River. At spawning, the path then represents progeny of the spawner, beginning as eggs and continuing through subsequent life stages until seaward migration as smolts.

A single trajectory can be defined in this manner such that it is consistent with a known life history pattern. Many trajectories differing only slightly from the one, could potentially be defined, so that the entire bundle of pathways would be representative of the life history pattern. A different life history pattern would be characterized by a different set of trajectories.

Series of trajectories can be defined in this manner, consistent with known life history patterns for the diagnostic species, facilitating analysis and comparison of the unique combinations of conditions and associated performance characteristics along each defined path. The conditions associated with major and minor life history patterns can thereby be characterized and compared.

This analytical device is one of the most significant aspects of this diagnostic approach. It facilitates analysis of performance across the watershed and provides the means for linking all other life stages that occur outside the drainage. In doing so, a comparison can be made of the sustainability of complete life cycles. Factors affecting mortality along the full life cycle can then be identified and analyzed.

4.2.2 Productivity Index

An index of productivity is computed as a way of analytically comparing the composite productivity between sample life history trajectories. The composite productivity (after Moussalli and Hilborn 1986 and Hilbom and Walters 1992) is the overall productivity for an entire life history trajectory. Productivity can be expressed as a density-independent survival rate; hence composite productivity can be expressed as a survival rate that encompasses all life stages traversed by a life history trajectory. The values of relative productivity described earlier in deriving the index are used here.

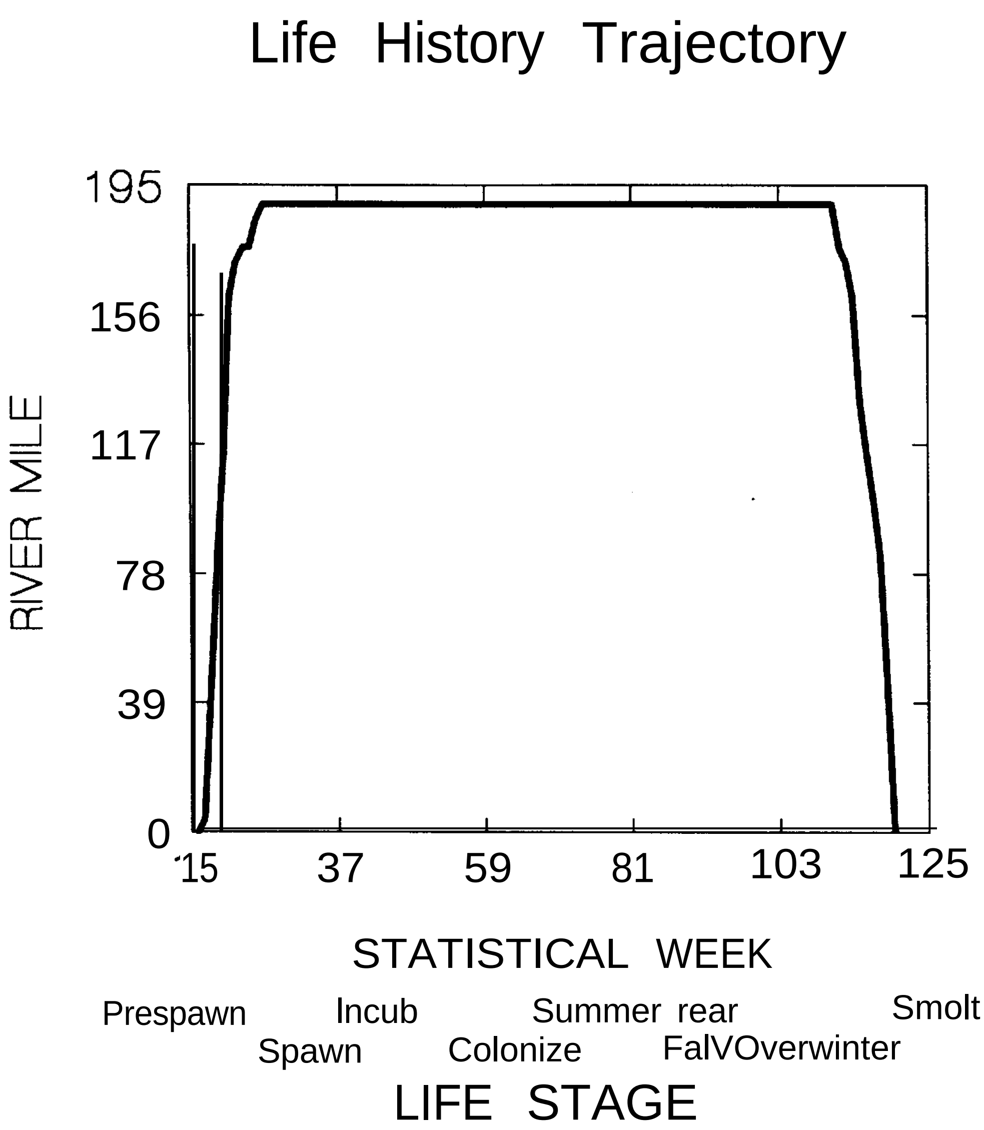


Fig. 6. Example life history trajectory illustrating a general pathway in space and time followed by spring chinook in the Grande Ronde Basin.

To compute the index, a profile of productivity for a hypothetical population existing under optimal environmental conditions at all life stages is first described. Productivity, or density-independent survival, would be the highest that could be theoretically attained in each life stage.

These values of productivity would be approximately equivalent to real survival rates for a population living in optimal habitat conditions at very low population densities, where density-dependent losses would be negligible.

A set of values for spring chinook productivity under optimal conditions was obtained through consultation with Dr. Ted Bjornn and review of pertinent literature. Selected values by life stage are listed below:

Life Stage	Productivity (as a survival rate)
Adult migration/holding	0.95
Spawning	0.95
Incubation	*0.70*
Fry colonization	*0.80*
Summer rearing	*0.70*
Fall redistributionloverwintering	*0.70*
Smolt to smolt	*0.95*

The composite productivity across all these life stages is simply all life-stage rates multiplied together (see Hilborn and Walters 1992, page 285):

$$P_n = \prod_{i=1}^{n} p_i$$

where P_n is the composite of productivities through the nth life stage and p_i is the productivity in stage I expressed as the density-independent survival rate for that stage.

Therefore, our estimate of a productivity standard across all seven stages under optimal conditions is 0.25.

As a survival rate that encompasses all of the life stages shown above, this can be thought of as the proportion of eggs per adult entering the river that eventually survive to depart the river as smolt.

The productivity value, or survival rate, can also be expressed in terms of the number of progeny, or smolts, produced per adult salmon entering the river. It is assumed, for the purpose of computing index, that an adult spring chinook salmon in the Grande Ronde River has, on the average, 2,700 eggs. It is also assumed that the sex ratio averages 1: 1 and that these values are representative of both Template and Patient characteristics.

The productivity profile is then converted to a weekly time scale to enable us to define p values along the trajectory pathway. This is done by taking the mth root of p_i:

$$p_w = \sqrt[m]{p_i}$$

wherep, is the productivity in week w, and m is the number of weeks defining the time period associated with that life stage.

The Productivity Index (PI), expressed as a rate, for n life stages is then calculated:

$$PI_n = \prod_w Rp_{r,w} \cdot p_w$$

where PI_n is calculated as the product of the productivities for all reach r and week w units traversed by the trajectory and $Rp_{r,w}$ is the relative productivity associated with stream reach r and week w (as described earlier).

The Productivity Index can also be expressed as a number of smolts per prespawning adult by multiplying the rate by the number of eggs per adult entering the river. Results here are presented using this form of the index.

The Productivity Index values are then used to compare the health, i.e. sustainability, of different life history trajectories and the patterns they represent. Values are applied in two ways. First, the index values indicate relative differences in the sustainability of various life history patterns. The values show how much variability in productivity exists within life history patterns (between trajectories) and between life history patterns. Productivity indices for similar trajectories in the Patient and Template are also compared.

Second, values are used in conjunction with information on smolt to adult survival rates as a measure of the composite productivity for the full life cycle. For example, if within basin productivity for a trajectory is 100 smolts per adult and smolt to adult survival is 2%, then the composite productivity for the entire life cycle would be 2 returning adults per parent spawner. In the absence of population density effects or environmental fluctuations, a life history with this level of productivity would be sustained. In contrast, if within basin productivity is 40 smolts per adult, then the composite productivity for the life cycle would be 0.8 returning adults per parent spawner. In this case, the fish following this life history path would be a drain to sustainability.

This procedure is meant to help reveal general patterns of condition and their relative importance to one another. The computed indices can provide insights about the magnitude and extent of conditions affecting sustainability. Differences between Patient and Template conditions suggest historic changes in productivity. Results should not be used for predictive purposes. Ecological processes are too variable and our understanding about them is too limited for that purpose.

4.2.3 Summary Determination

The final step in the diagnosis consists of a summary determination of the general condition of the diagnostic species and the relative contributions of factors affecting the species. The determination is made within the context of program objectives. Large amounts of information must first be viewed--at small scales defined by individual trajectories and at much larger scales that show broad patterns across the landscape.

The summary determination is where the scientists doing the analysis integrate all of the information across these scales into clear concise statements that summarize the diagnosis. The determination needs to be supported by and consistent with the analytical results. These summary statements combined with key visual displays, are the basis of communicating the diagnosis to decision makers.

It may be useful, even necessary, to formulate more than one plausible diagnosis to help identify information needs for future work.

4.3 Treatment Identification

The purpose of the treatment identification step in the planning process is to assemble a collection of candidate actions. Proposed actions can come from many sources, from individuals, organizations, and agencies. The treatment identification procedure should assure that among the collection of alternatives are some that are based upon the diagnosis.

The procedure for identifying actions consistent with the diagnosis involves first formulating one or more basin-wide strategies. A strategy sets an overall direction to guide the development of watershed improvement actions. Basin-wide strategies should be framed upon principles of watershed dynamics, ecosystem function, and conservation biology. These principles can be simply captured in one general principle using a life history perspective for the diagnostic species.

In simplest terms, the principle calls for setting the following priorities: first, maintaining; second, improving; and third, restoring. The conditions (or health) of existing life history patterns for the diagnostic species are the criteria for establishing strategic priorities. The rationale for this principle is that it is more prudent to maintain and make secure existing life history patterns before attempting to restore or recover patterns that have been disrupted through past changes to the watershed. At existing levels of production of Grande Ronde spring chinook, it is reasonable to apply this principle solely to the productivity of existing life history patterns.

The principle places highest priority *on maintaining* the existing quality of habitat associated with the primary, or most productive, life history patterns remaining today (Table 7). These life history

[3]/ Production levels are currently so low for this species that the effects of the density-dependent mortality associated with habitat capacity is considered less significant.

patterns are the dominant pathways in space and time still being used, and therefore, provide the most resilience to the population to protect it from mortality pressures anywhere in the life cycle. Maintenance of these life history patterns is vital to safeguard the population from further decline.

Table 7. Strategic priorities for watershed improvement actions based on a life history perspective for diagnostic species.

Priority	Description
1	Maintain habitat quality associated with the primary, or most productive, life history patterns, including migration corridors.
2	Improve habitat quality associated with the primary life history patterns, including migration corridors.
3	Maintain habitat quality associated with secondary life history patterns, including migration corridors.
4	Improve habitat quality associated with secondary life history patterns, including migration corridors.
5	Improve habitat quality in other areas to begin restoring other life history patterns.
6	Reconnect habitat segments to restore connectivity for other life history patterns.

The second priority reinforces the first; it calls for *improving* the quality of habitat associated with the primary life history patterns remaining today (Table 7). In doing so, the productivity of these patterns can be increased. Resilience of these patterns would thereby be strengthened, improving the chances that they can be sustained under today's prevailing environmental conditions. Particular attention should be given to areas that are used for longer portions of the life history; improvements in survival through these areas will result in the largest overall improvement in life cycle productivity.

Priorities three and four are similar to the first two, except that secondary life history patterns are targeted for attention (Table 7). Secondary patterns are those that are still utilized by the population but where survival conditions along the pathways are marginal. These strategic priorities would maintain, then improve, conditions for productivity along the space-time corridors associated with these patterns.

Priorities five and six call for *efforts* to *begin restoring* life history patterns that have been lost to the population (Table 7). Historically, spring chinook populations expressed many life history patterns (Lichatowich and Mobrand 1995). Such diversity helped ensure that a population was sustained through variable and fluctuating environmental conditions over time.

These strategic priorities are arranged to focus efforts where they are likely to achieve the most benefit. The priorities recognize, however, that watershed improvement efforts need a long-term vision. Success at all six priority levels may be required to achieve sustainable goals for the watershed over a long time period. The priorities should not be viewed rigidly--the first priority need not be achieved before progressing to the next. Opportunities, for example, may become available to improve conditions associated with a secondary life stage that would require little expenditure of resources. Cost of actions is clearly a necessary consideration.

The strategic priorities provide a basis for establishing guidelines to identify effective actions. These guidelines are formed by following the steps outlined in Table 8. In considering a possible action, careful consideration should be given to response time of the action, technical feasibility, and whether it can be implemented without inadvertently causing other negative effects.

Table 8. Procedures for developing actions consistent with strategic priorities.

Step	Procedure
1	Identify primary and secondary life history patterns (based on the life history analysis).
2	Identify where and when productivity can potentially be improved, giving particular attention to areas used for longer time periods (based on life history analysis and Productivity Index).
3	Identify environmental quality attributes that need to be addressed to improve productivity along the corresponding pathways.
4	Identify actions that would be required to change the appropriate environmental attributes (from preceding step) to a desired level.

4.4 Trade-off Analysis

Following identification of candidate actions, an analysis of trade-offs is performed to compare expected benefits and risks of individual or suites of actions. This progress report gives only a very brief summary of procedures for the sake of completeness.[4] The analysis requires descriptions of values and objectives for the watershed that are as yet incomplete. Greater attention to this aspect will be given in the next phase of the project.

The analysis is performed in terms consistent with the conceptual framework (Fig. 2). The result of the analysis is a listing, or menu, of action alternatives described in terms of benefits and risks,

---

[4]/ A more complete description of procedures will be included in the project completion report.

5. RESULTS AND DISCUSSION

The initial results for the Upper Grande Ronde watershed are presented in the following four sections: 1) Patient-Template Analysis; 2) Diagnosis; and 3) Treatment Identification.

5.1 Patient-Template Analysis

The PTA for the Upper Grande Ronde system is based on an assessment of conditions in the entire drainage upstream of Wallowa River at RM (River Mile) 80 and for the mainstem Grande Ronde River from the Wallowa River to the Snake River. Inclusion of the entire mainstem river enables us to consider all life stages for the diagnostic species within the entire Grande Ronde watershed. Spring chinook salmon produced upstream of Wallowa River are dependent on the lower river to complete their life cycles.

Results of the analysis are presented as a series of graphical comparisons.

5.1.1 Relative Productivity

Relative productivity is a measure of density-independent survival, where a value of 1 is equivalent to the highest possible survival rate under optimal conditions in nature. As a relative measure, it does not in itself identify what actual survival rates (ignoring density effects) would be.

Two types of graphics are provided to facilitate detection of spatial-temporal patterns across the watershed. The first type shows relative productivity within the two-dimensional display of geographic space and time of life. Values of relative survival are shown in black and white shading. The second type adds a three-dimensional surface, a "productivity landscape," of the same data above the 2-D display to enhance visualization of patterns that exist.

We found that major changes have likely occurred in spring chinook productivity within the Grande Ronde watershed between historic and current conditions. Along the mainstem Grande Ronde River, from its mouth to the headwater reach near RM 195, productivity appears to have declined substantially for portions or all of each life stage that occurs in these waters (Figs. 7 and 8). Similar patterns are evident when the geographic space scale (Y-axis) is modified to include Catherine Creek, from its mouth to its headwaters within one fork (Figs. 9 and 10). In this case, Catherine Creek begins at RM 114 (on the Y-axis) and continues upstream for 51 miles to RM 165.

While relative productivity for the historic template appears comparatively consistent across the space and time landscape, it varies dramatically under current conditions (Figs. 7 to 10).

Grande Ronde River

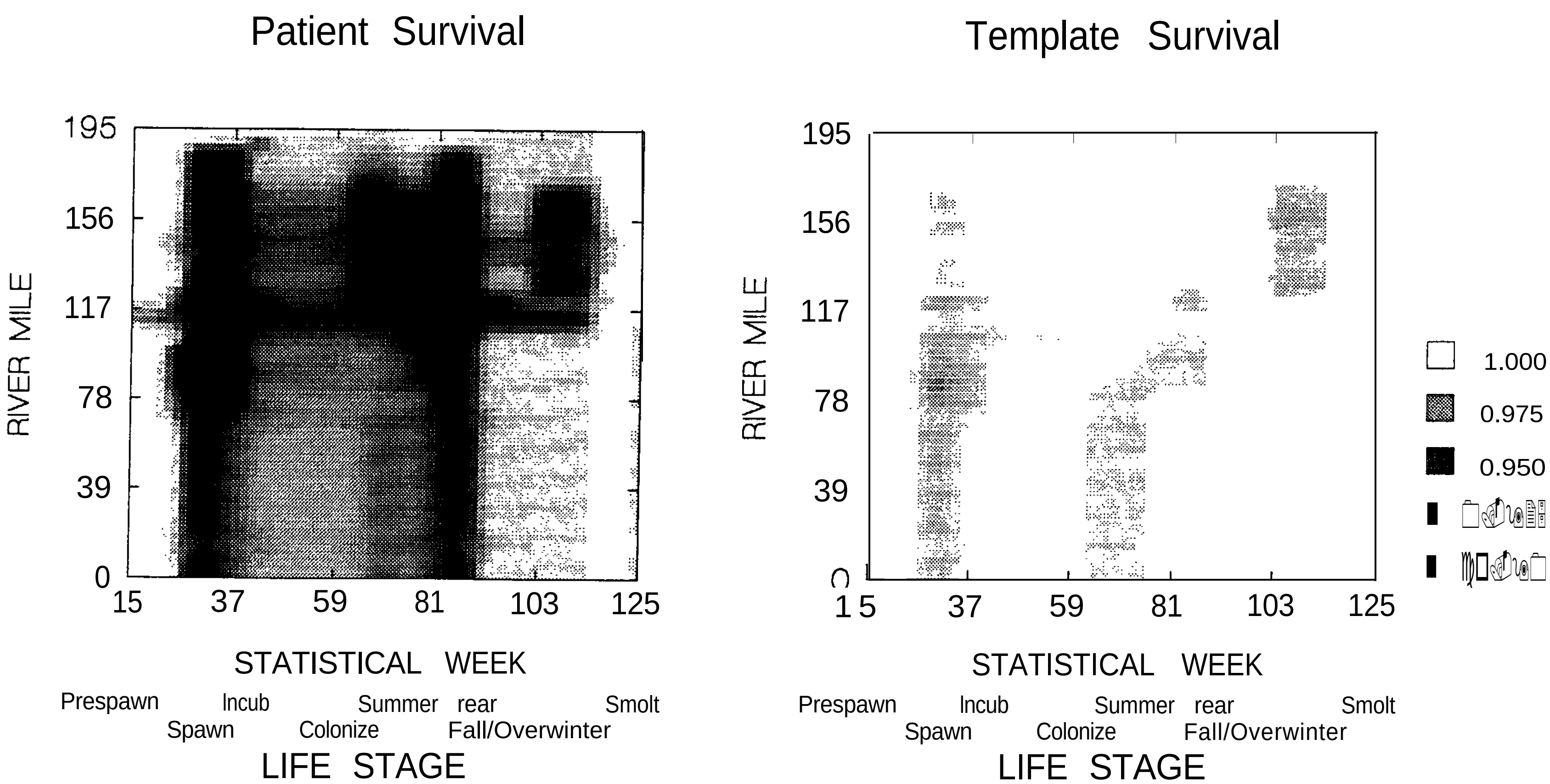


Fig. 7. Relative productivity (as a measure of density-independent survival) of spring chinook across space and time in the mainstem Grande Ronde River. Weekly values are shown. See text for explanation of terms.

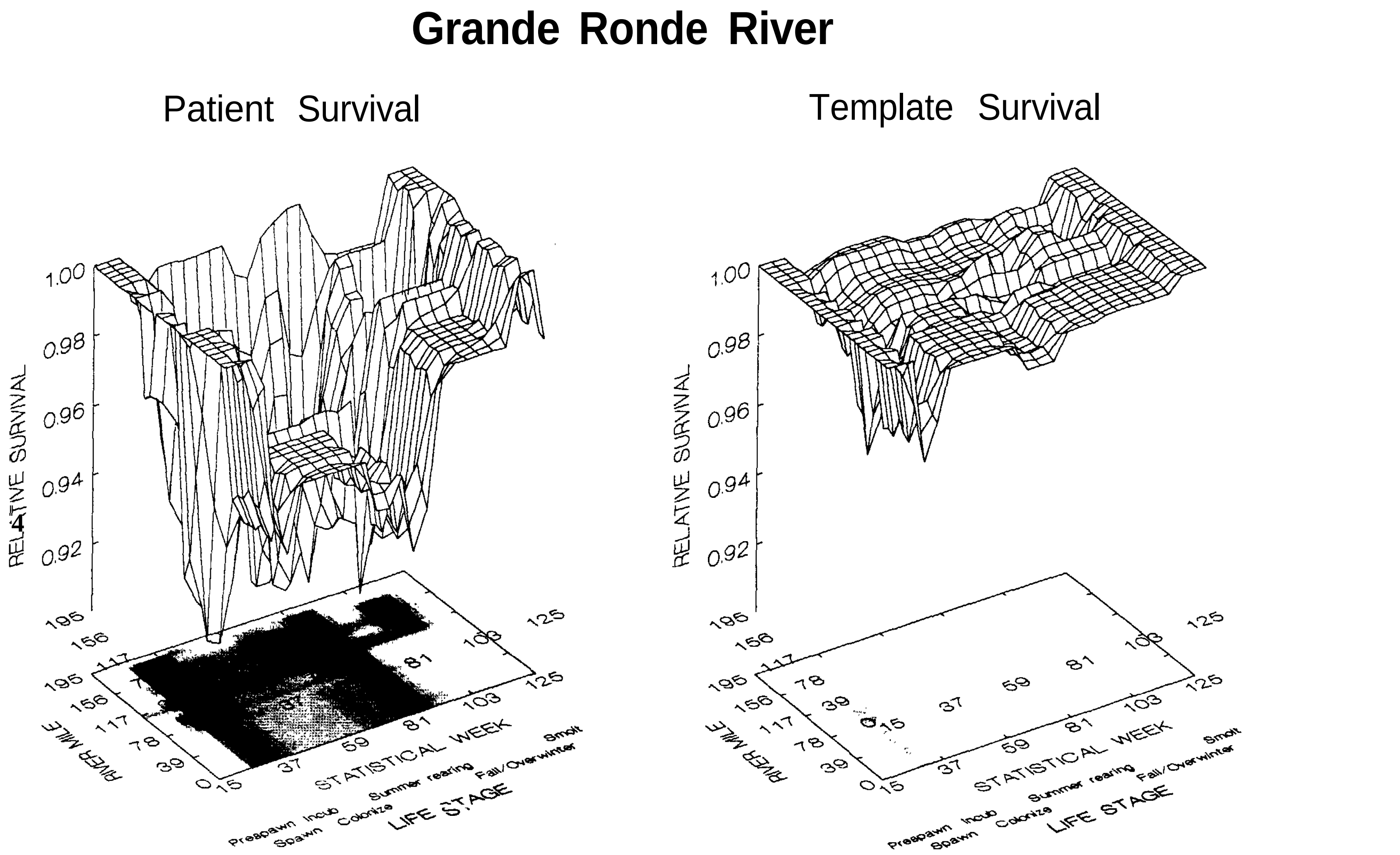


Fig. 8. Relative productivity displayed as three-dimensional landscapes in space and time for spring chinook in the mainstem Grande Ronde River. Data sets represented are identical to those used in Fig. 7.

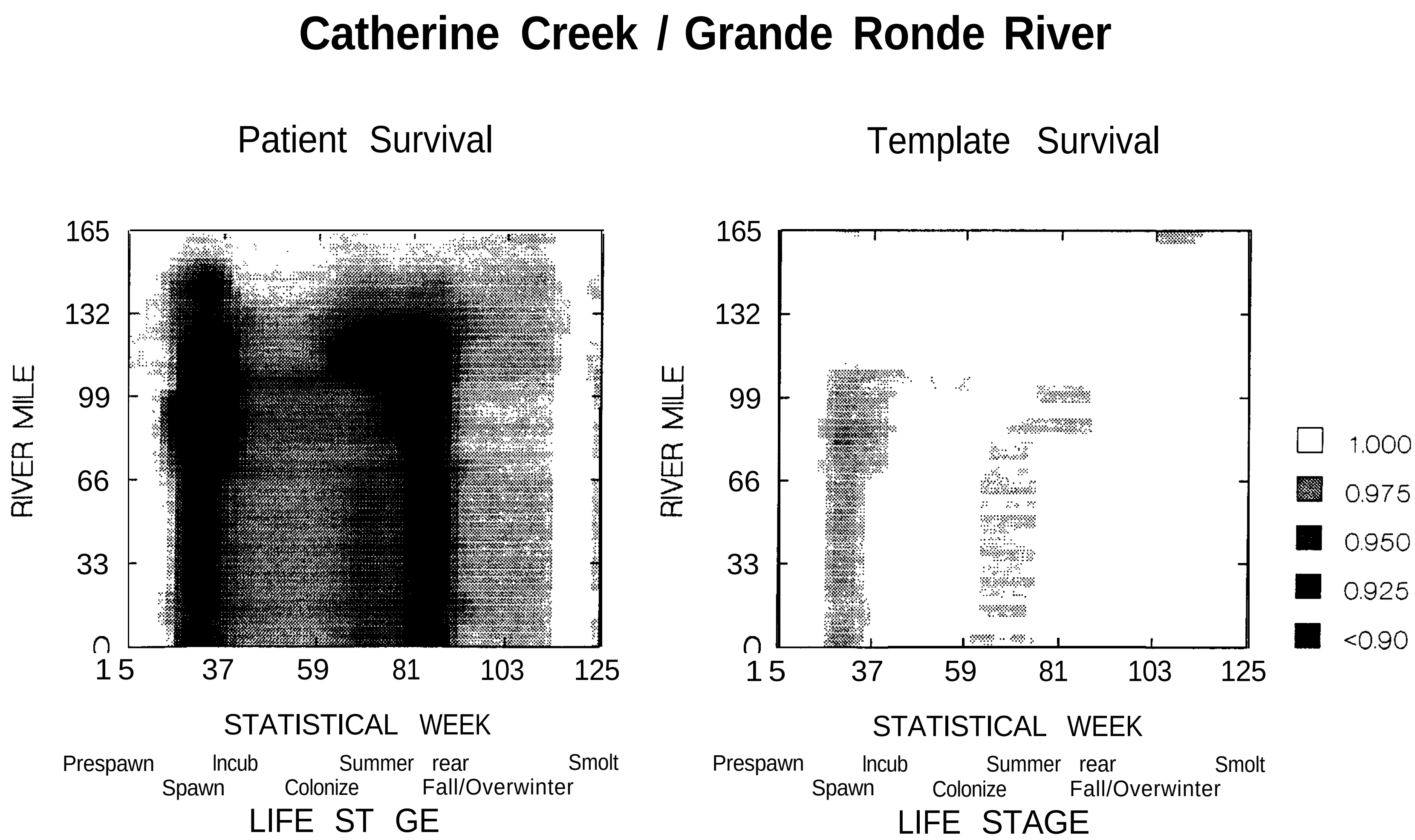


Fig. 9. **Relative productivity (as a measure of density-independent survival) of spring chinook across space and time in Catherine Creek and downstream in the Grande Ronde River. Catherine Creek enters the Grande Ronde River at RM 114. Weekly values are shown. See text for explanation of terms.**

Catherine Creek / Grande Ronde River

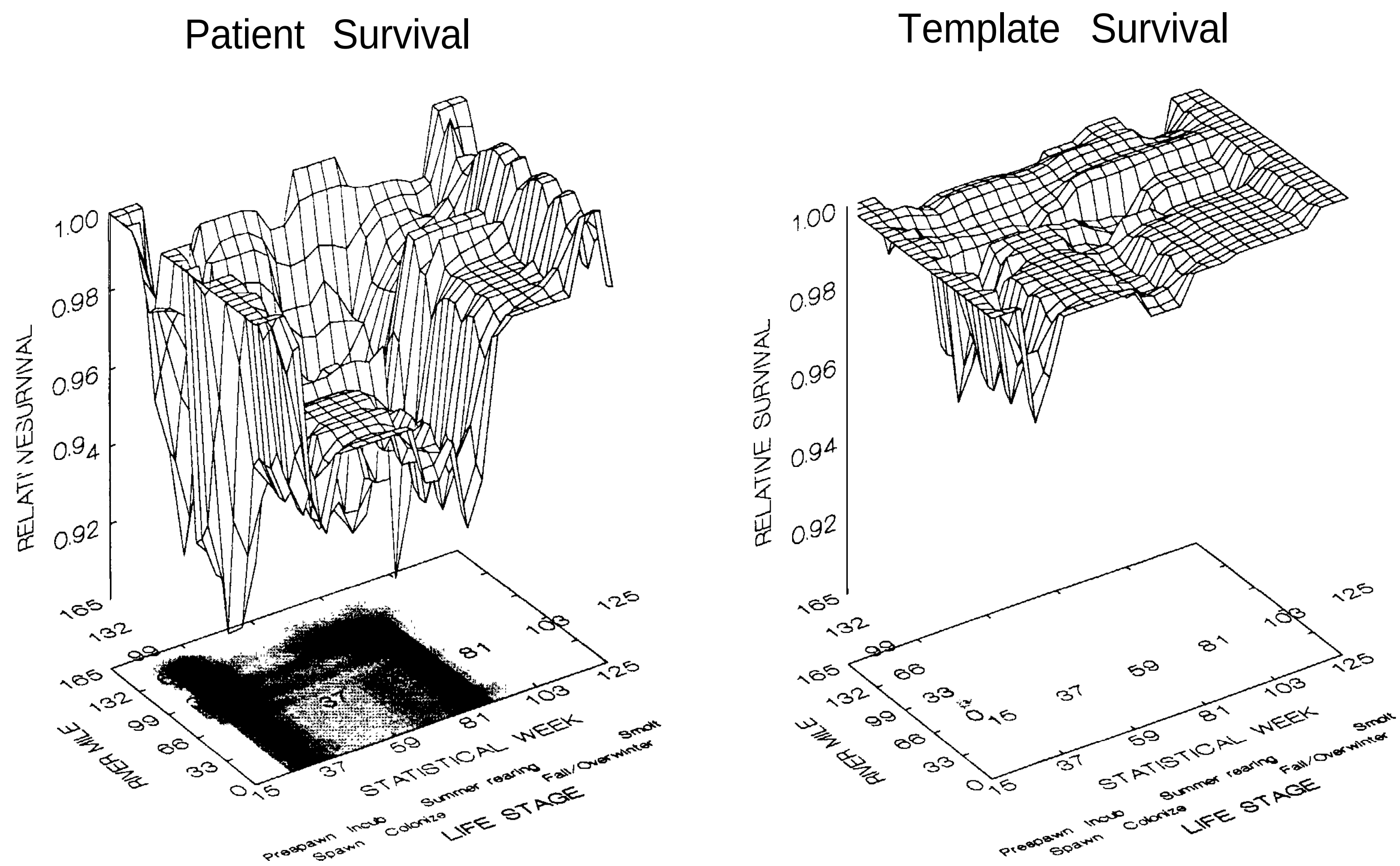


Fig. 10. **Relative productivity displayed as three-dimensional landscapes in space and time for spring chinook in Catherine Creek and downstream in the Grande Ronde River. Catherine Creek begins at RM 114. Data sets represented are identical to those used in Fig. 9.**

In general, relative productivity appears to be highest today for adult migrants moving through the system early, i.e, in April and May, and for smolts departing the system in spring of their second year of life. Relative productivity appears to be particularly low for fry colonization, summer rearing, and over-wintering in large segments of the mainstem Grande Ronde River and Catherine Creek today.

It should be noted that the values are expressed as weekly rates of relative survival. Low values approach 0.9, which may not seem particularly low at first consideration. These values are multiplicative, however, meaning that the relative survival for all life stages combined is the product of an entire string of weekly rates. For example, a weekly rate of 0.95 across 52 weeks results in a composite rate for the period of 0.07 (i.e., 0.95^{52}).

5.1.2 Environmental Qualitv Attributes

The productivity, or density-independent survival, of a population is a function of environmental quality. Two types of graphics display the relative contributions of 14 attributes of environmental quality to productivity within the watershed. The first type employs the same spatial-temporal format for the 2-D displays of relative productivity. This format is used to compare broad patterns for the 14 attributes together, all displayed on one page to facilitate comparison. It should be noted that attributes were scored for an entire life stage; no attempt is made to distinguish how these values might vary within a life stage. Therefore, the graphics should not be used to discern differences in attribute effects at a particular location within a life stage.

The second type of graphic uses a “consumer’s report style” format for comparing the relative importance of different attributes between geographic units. This format is used for comparing conditions between mainstem river geographic units and also between tributary sub-drainages.

Major changes have apparently occurred for most environmental quality attributes affecting spring chinook productivity within large segments of the watershed (Figs. 11 to 13). Of the 14 attributes, we judged the effects of channel stability, flow, habitat type diversity, sediment load, temperature, riparian condition, and predators to have generally increased the most. Effects of these changes have not occurred uniformly throughout the watershed nor across the life stages of spring chinook.

Overall, changes in water temperature between historic and existing conditions appear to have had the greatest contribution in reducing spring chinook productivity. Changes in this attribute have likely affected all life stages of spring chinook within the watershed. Within the mainstem Grande Ronde River, for example, increased water temperatures have likely occurred during late spring, summer, and early fall months, increasing mortality during adult migration and holding, spawning, egg incubation (during initial weeks), and summer rearing life stages. In addition, temperatures have apparently decreased in some river reaches during winter, thereby increasing mortality during egg incubation and overwintering life stages in those areas. These changes in temperature

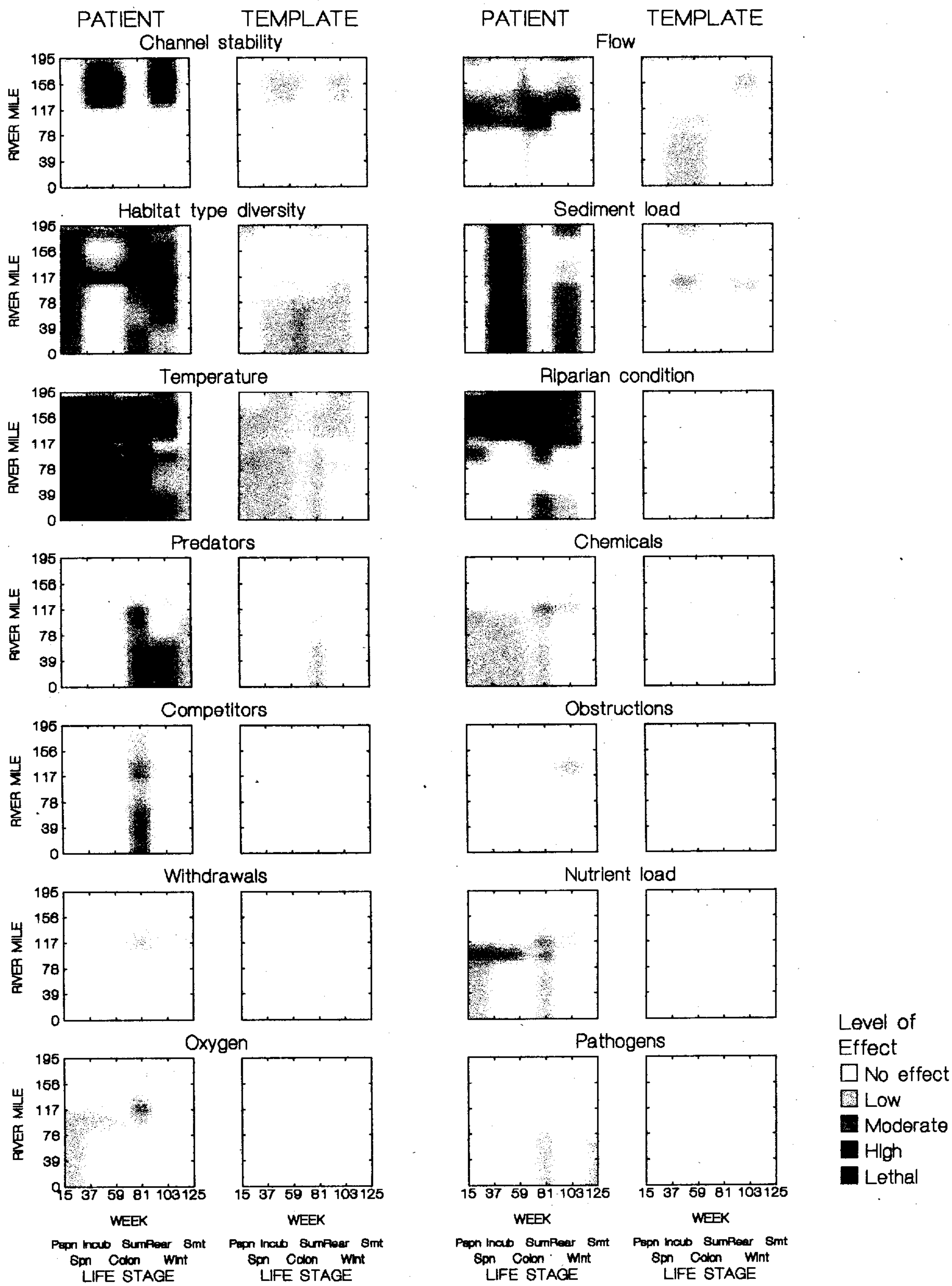


Fig. 11. **Relative effects of environmental quality attributes on spring chinook productivity (survival) in the mainstem Grande Ronde River.**

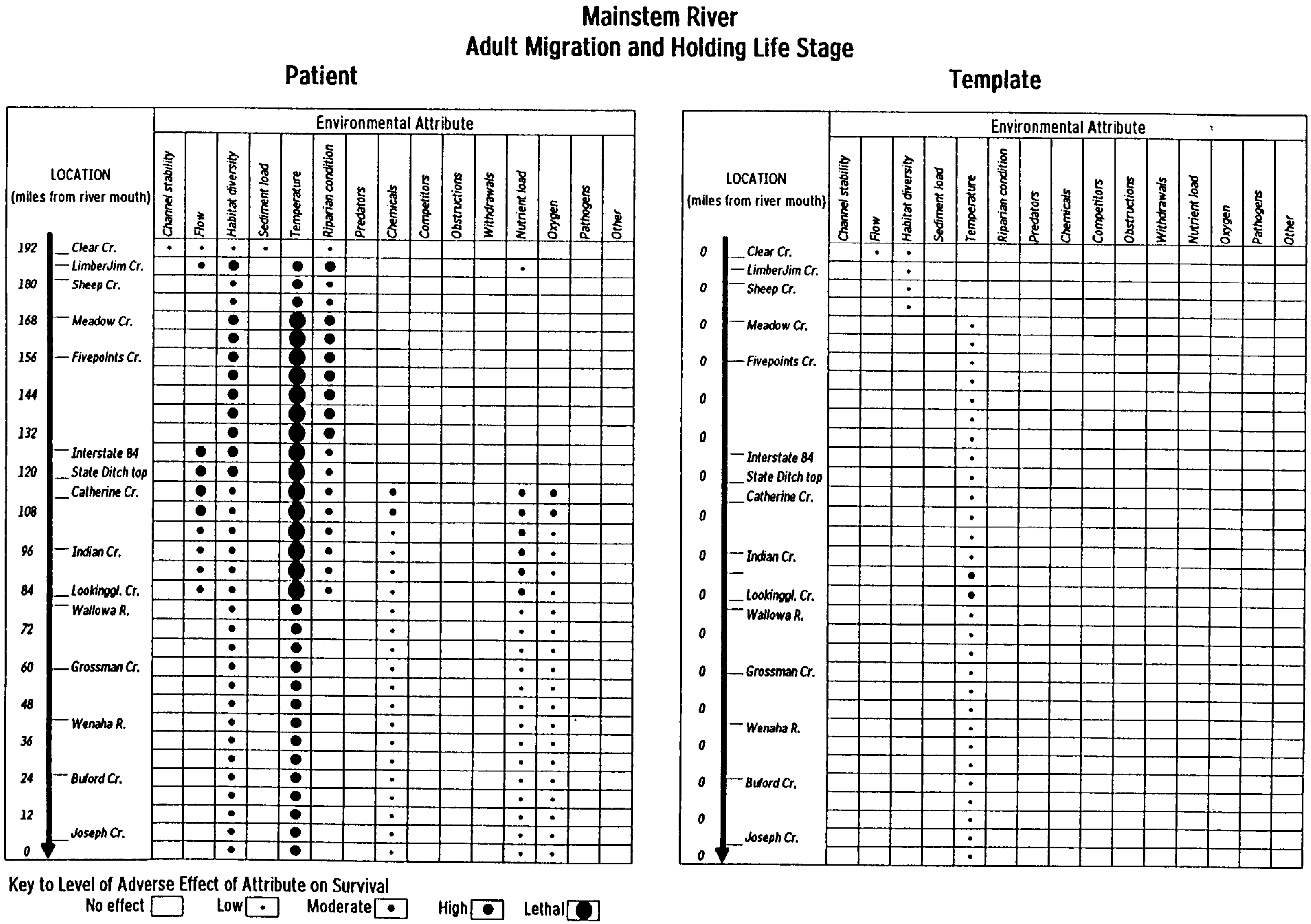


Fig. 12. Life-stage specific summaries in the mainstem Grande Ronde River of relative effects of environmental quality attributes on spring chinook productivity (survival); adult migration stage.

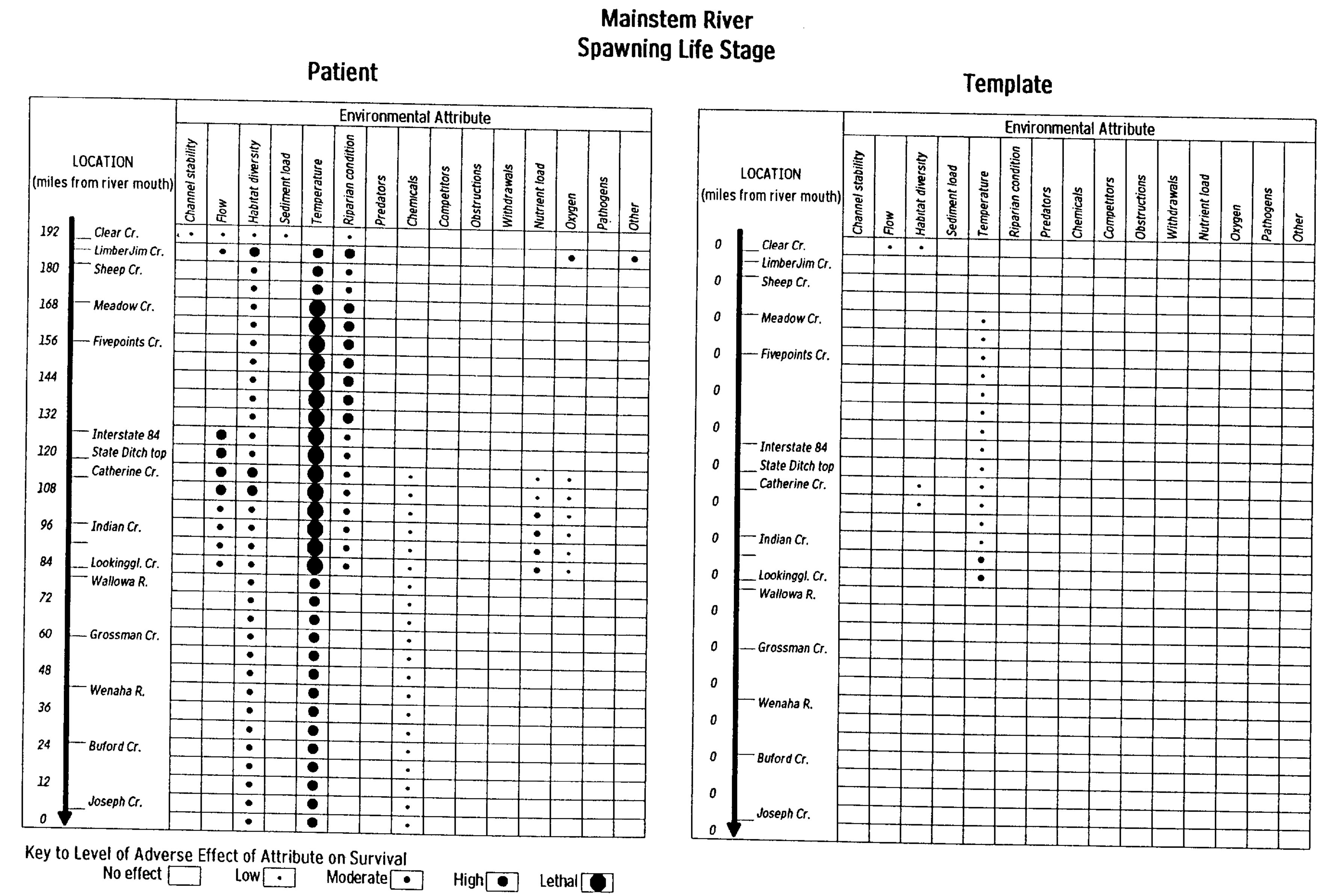


Fig. 12. **Continued; spawning life stage.**

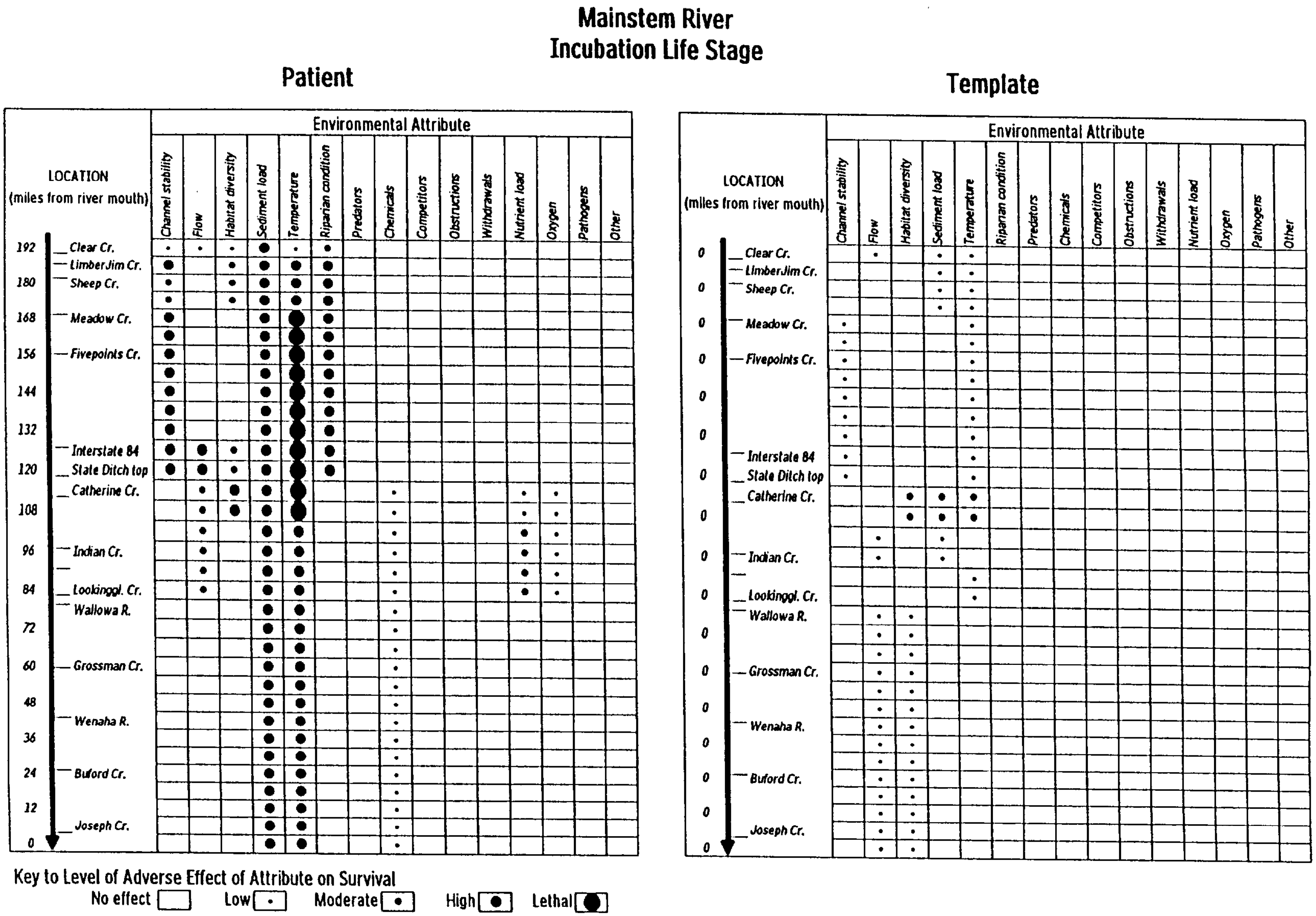


Fig. 12. **Continued; incubation life stage.**

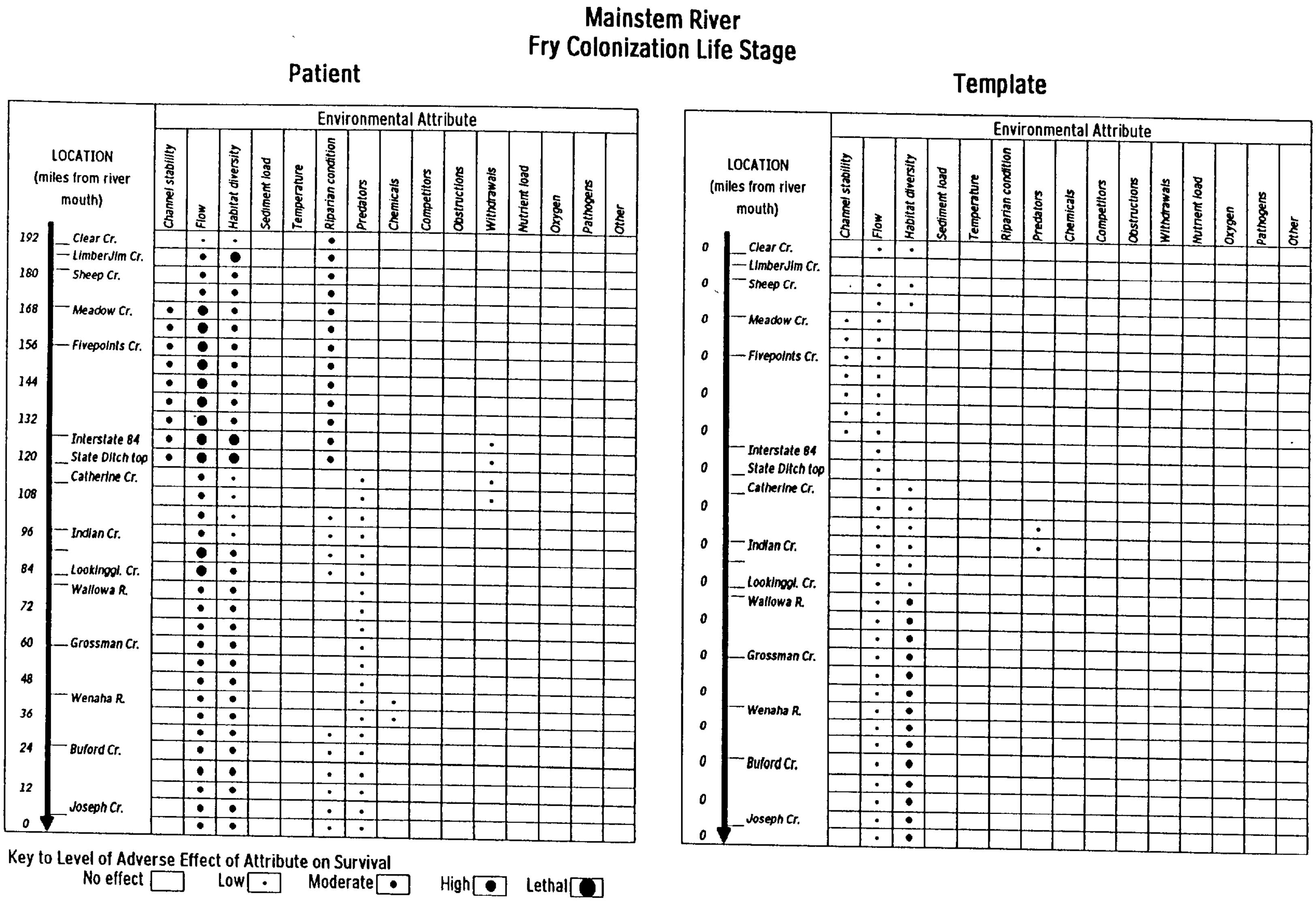


Fig. 12. Continued; fry colonization life stage.

Mainstem River
Summer Rearing Life Stage

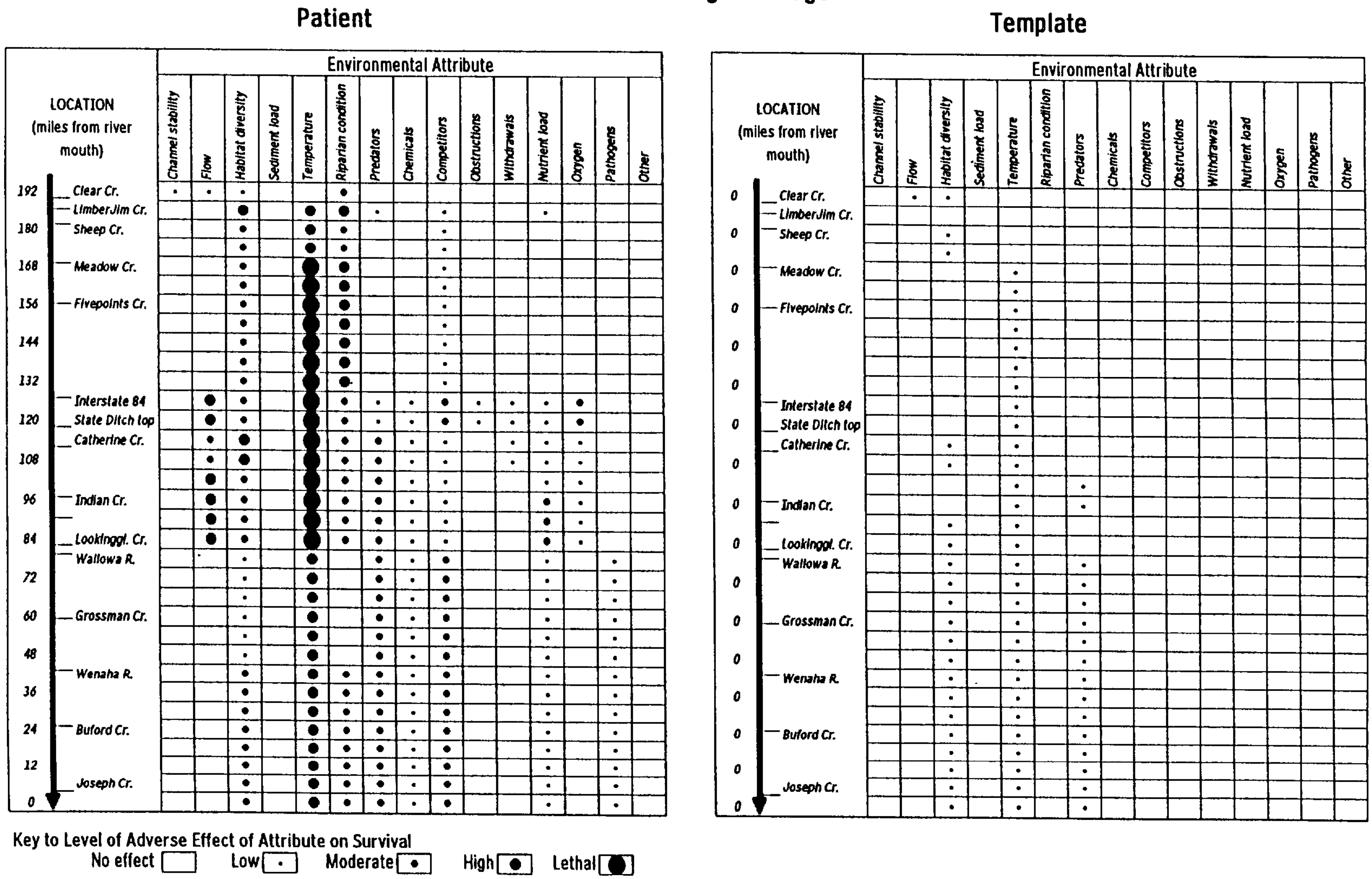


Fig. 12. **Continued; summer rearing life stage.**

Mainstem River
Fall/Overwintering Life Stage

Patient

LOCATION (miles from river mouth)		Environmental Attribute														
Miles	Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
192	Clear Cr.	Moderate	Moderate	Low	Moderate	Moderate	Moderate									
	LimberJim Cr.	Moderate		Moderate	Moderate	Low	Moderate									
180	Sheep Cr.	Moderate		Low	Moderate	Moderate	Moderate									
		Moderate		Low	Moderate	Moderate	Moderate									
168	Meadow Cr.	High		Moderate		High	Moderate									
		High		Moderate		High	Moderate									
156	Fivepoints Cr.	High		Moderate		High	Moderate									
		High		Moderate		High	Moderate									
144		High		Moderate		High	Moderate									
		High		Moderate		High	Moderate									
132		High		Moderate		High	Moderate									
	Interstate 84	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Moderate	Low	Low			
120	State Ditch top	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Moderate	Low	Low			
	Catherine Cr.			High	Low		Low		Low			Low	Low			
108				High	Low		Low		Low			Low	Low			
				Moderate	Moderate	Moderate										
96	Indian Cr.			Moderate	Moderate	Moderate										
			Low	Moderate	Moderate	Moderate										
84	Lookinggl. Cr.		Low	Moderate	Moderate	Moderate										
	Wallowa R.			Moderate	Moderate	Low		Moderate								
72				Moderate	Moderate	Low		Moderate								
				Moderate	Moderate	Low		Moderate								
60	Grossman Cr.			Moderate	Moderate	Low		Moderate								
				Moderate	Moderate	Low		Moderate								
48				Moderate	Moderate	Low		Moderate								
	Wenaha R.			Low	Moderate	Moderate	Low	Moderate								
36				Low	Moderate	Moderate	Low	Moderate								
				Low	Moderate	Moderate	Low	Moderate								
24	Buford Cr.			Low	Moderate	Moderate	Low	Moderate								
				Low	Moderate	Moderate	Low	Moderate								
12				Low	Moderate	Moderate	Low	Moderate								
	Joseph Cr.			Low	Moderate	Moderate	Low	Moderate								
0				Low	Moderate	Moderate	Low	Moderate								

Key to Level of Adverse Effect of Attribute on Survival
No effect [ ] Low [·] Moderate [•] High [●] Lethal [⬤]

Template

LOCATION (miles from river mouth)		Environmental Attribute														
Miles	Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
0	Clear Cr.	Low				Low										
	LimberJim Cr.				Low	Low										
0	Sheep Cr.			Low		Low										
				Low		Low										
0	Meadow Cr.	Low	Low			Low										
		Low	Low			Low										
0	Fivepoints Cr.	Low	Low			Low										
		Low	Low			Low										
0		Low	Low			Low										
		Low	Low			Low										
0		Low	Low			Low										
	Interstate 84	Low				Low										
0	State Ditch top	Low				Low										
	Catherine Cr.			Low	Low											
0				Low	Low											
				Low	Low											
0	Indian Cr.			Low	Low											
				Low		Low										
0	Lookinggl. Cr.			Low		Low										
	Wallowa R.			Low												
0				Low												
				Low												
0	Grossman Cr.			Low												
				Low												
0				Low												
	Wenaha R.			Low												
0				Low												
				Low												
0	Buford Cr.			Low												
				Low												
0				Low												
	Joseph Cr.			Low												
0				Low												

Fig. 12. **Continued; fall/overwintering life stage.**

Mainstem River
Smolt Life Stage

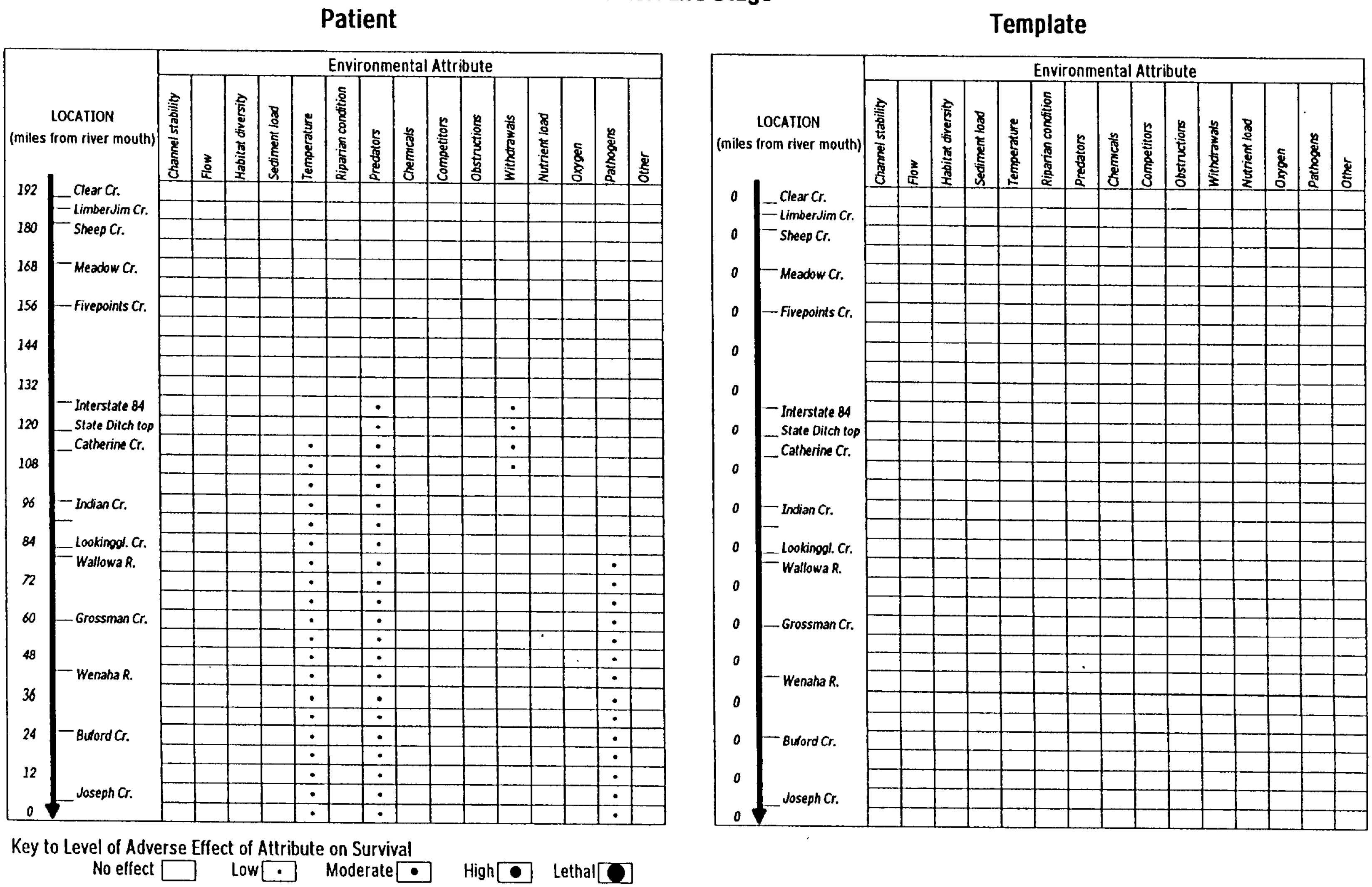


Fig. 12. Continued; smolt (yearling) life stage.

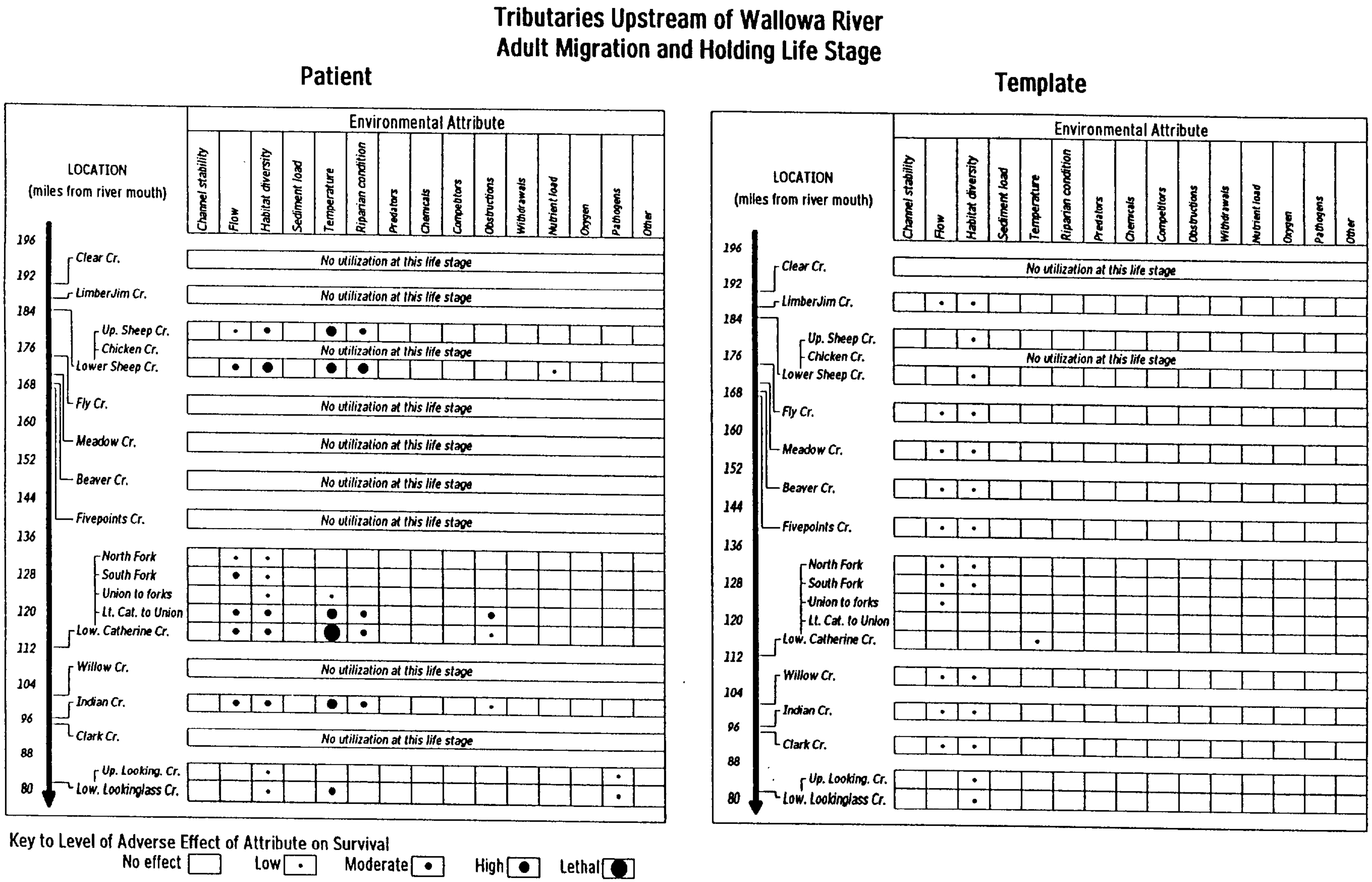


Fig. 13. Life-stage specific summaries for tributaries upstream of Wallowa River of relative effects of environmental quality attributes on spring chinook productivity (survival); adult migration stage.

Tributaries Upstream of Wallowa River
Spawning Life Stage

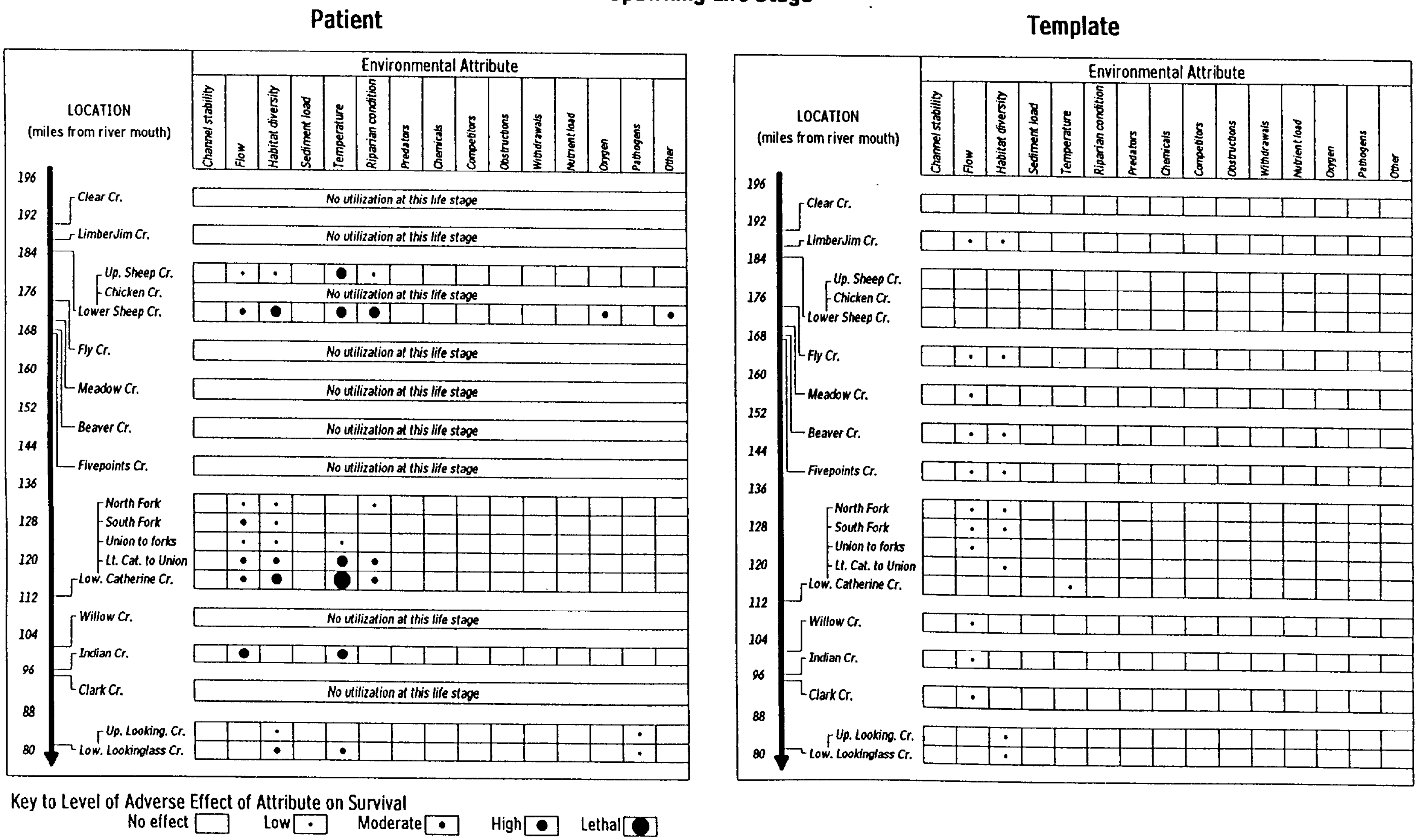


Fig. 13. **Continued; spawning life stage.**

Tributaries Upstream of Wallowa River
Incubation Life Stage

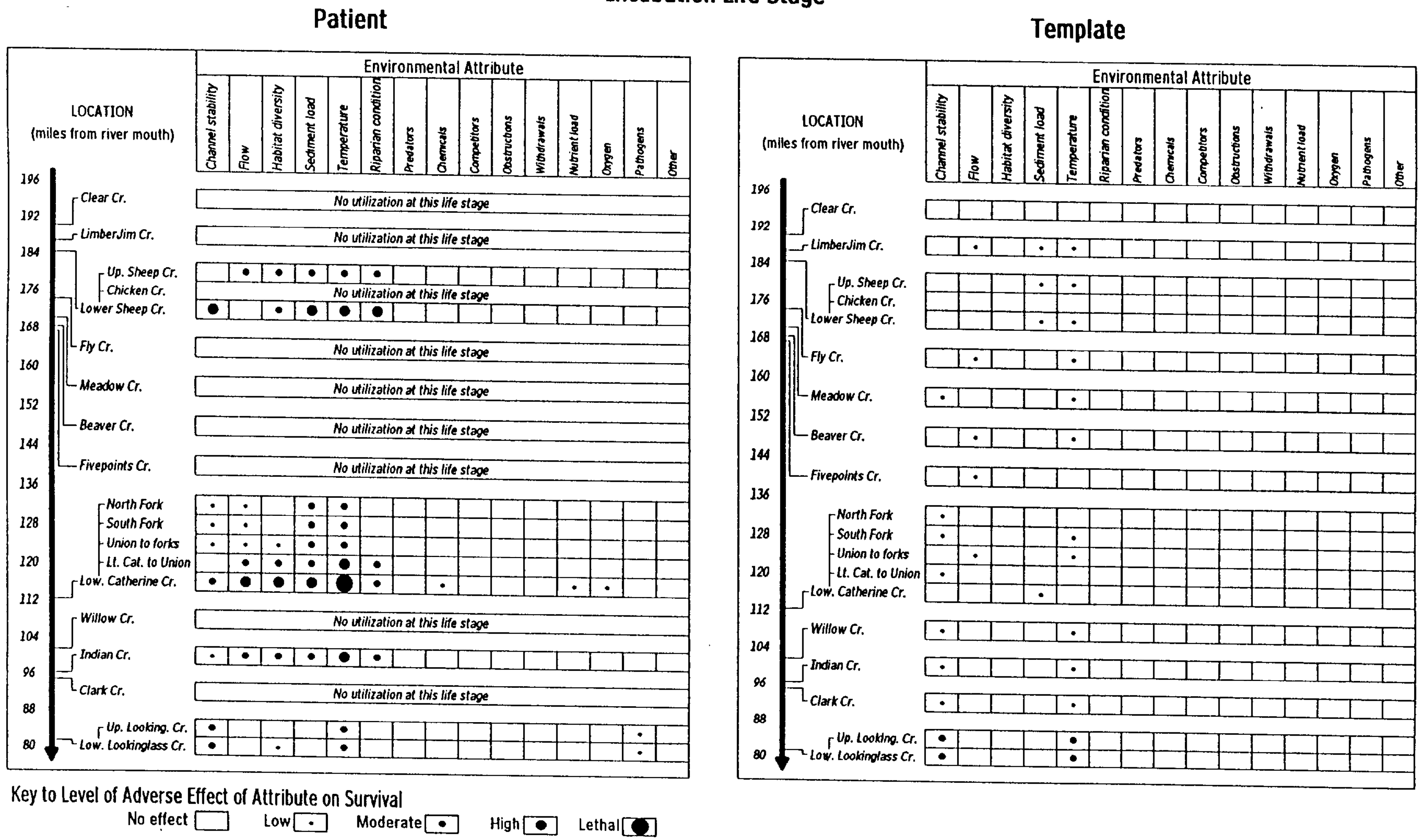


Fig. 13. Continued; incubation life stage.

Tributaries Upstream of Wallowa River
Fry Colonization Life Stage

Patient

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.	No utilization at this life stage														
LimberJim Cr.	No utilization at this life stage														
Up. Sheep Cr.		Low	Moderate			Moderate									
Chicken Cr.	No utilization at this life stage														
Lower Sheep Cr.		Moderate	High			Moderate									
Fly Cr.	No utilization at this life stage														
Meadow Cr.	No utilization at this life stage														
Beaver Cr.	No utilization at this life stage														
Fivepoints Cr.	No utilization at this life stage														
North Fork	Low	Moderate	Low		Low										
South Fork	Low	Moderate	Low		Low										
Union to forks	Low	Low	Low		Low										
Lt. Cat. to Union	Moderate	Moderate	Moderate			Moderate					Low				
Low. Catherine Cr.		High	High			Moderate	Low				Low				
Willow Cr.	No utilization at this life stage														
Indian Cr.	Moderate	Lethal	Moderate		Lethal	Moderate									
Clark Cr.	No utilization at this life stage														
Up. Looking. Cr.	Low	Moderate	Moderate		Moderate									Low	
Low. Lookinglass Cr.	Low	Moderate	Moderate		Moderate									Low	

Template

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.															
LimberJim Cr.		Low	Low												
Up. Sheep Cr.		Low	Low												
Chicken Cr.															
Lower Sheep Cr.															
Fly Cr.		Low													
Meadow Cr.		Low													
Beaver Cr.		Low													
Fivepoints Cr.		Low	Low												
North Fork		Low	Low												
South Fork		Low	Low												
Union to forks		Low													
Lt. Cat. to Union		Low													
Low. Catherine Cr.															
Willow Cr.		Low													
Indian Cr.		Low													
Clark Cr.		Low													
Up. Looking. Cr.	Low	Low	Moderate		Low										
Low. Lookinglass Cr.	Low	Low	Moderate		Low										

Key to Level of Adverse Effect of Attribute on Survival
No effect [ ] Low [•] Moderate [•] High [●] Lethal [⬤]

Fig. 13. **Continued; fry colonization life stage.**

Tributaries Upstream of Wallowa River
Summer Rearing Life Stage

Patient

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

LOCATION	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.		Low	Low			Low									
LimberJim Cr.		Moderate	Low		High	Moderate									
Up. Sheep Cr.		Moderate	Low		High	Moderate									
Chicken Cr.		Moderate	Moderate		High	Moderate									
Lower Sheep Cr.			High		High	High	Low		Low			Low			
Fly Cr.		High	Moderate		High	Moderate			Low						
Meadow Cr.		High	Moderate		High	Moderate			Low						
Beaver Cr.	No utilization at this life stage														
Fivepoints Cr.	No utilization at this life stage														
North Fork		Low	Low			Low									
South Fork		Low	Low												
Union to forks		Low	Low		Moderate	Low									
Lt. Cat. to Union		Moderate	Moderate		High	Moderate			Low		Moderate				
Low. Catherine Cr.		High	High		Lethal	Moderate	Low		Low		Low	Low			
Willow Cr.	No utilization at this life stage														
Indian Cr.		Moderate	Moderate		High	Moderate			Low		Low	Low	Low		
Clark Cr.		Moderate	Moderate		High	Moderate			Low		Low	Low	Low		
Up. Looking. Cr.			Moderate											Low	
Low. Lookinglass Cr.			Moderate		Low									Low	

Template

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

LOCATION	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.		Low													
LimberJim Cr.		Low													
Up. Sheep Cr.															
Chicken Cr.															
Lower Sheep Cr.															
Fly Cr.			Low												
Meadow Cr.			Low												
Beaver Cr.			Low												
Fivepoints Cr.		Low	Low												
North Fork			Low												
South Fork			Low												
Union to forks			Low												
Lt. Cat. to Union															
Low. Catherine Cr.															
Willow Cr.			Low												
Indian Cr.			Low												
Clark Cr.			Low												
Up. Looking. Cr.			Low												
Low. Lookinglass Cr.			Low												

Key to Level of Adverse Effect of Attribute on Survival: No effect (empty box), Low (small dot), Moderate (medium dot), High (large dot), Lethal (very large dot)

Fig. 13. Continued; summer rearing life stage.

Tributaries Upstream of Wallowa River
Fall/Overwintering Life Stage

Patient

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.		Moderate	Low	Moderate	Moderate										
LimberJim Cr.		Moderate		High	High	Moderate									
Up. Sheep Cr.		Moderate	Moderate	Moderate	Moderate	Moderate									
Chicken Cr.		Moderate	High	Moderate	Moderate	Moderate									
Lower Sheep Cr.			Moderate	Moderate	Low	Moderate									
Fly Cr.	Moderate	High	High	Moderate	High	Moderate									
Meadow Cr.	Moderate	Moderate	High	Moderate	High	Moderate									
Beaver Cr.	No utilization at this life stage														
Fivepoints Cr.	No utilization at this life stage														
North Fork	Moderate	Low	Low	Moderate	Moderate										
South Fork	Moderate	Low	Low	Moderate	Moderate										
Union to forks	Low		Moderate	Moderate	Low										
Lt. Cat. to Union	Moderate		Moderate	Moderate	Moderate	Moderate					Moderate				
Low. Catherine Cr.		Moderate	High	High	High	Moderate	Low		Low	Low	Low				
Willow Cr.	No utilization at this life stage														
Indian Cr.	Low	Lethal	Moderate	Moderate	Lethal	Moderate			Low		Low		Low		
Clark Cr.	Low	Lethal	Moderate	Moderate	Lethal	Moderate			Low		Low		Low		
Up. Looking. Cr.	Moderate		Low		High									Low	
Low. Lookinglass Cr.	Moderate		Moderate		High									Low	

Template

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.		Low			Low										
LimberJim Cr.		Low			Low										
Up. Sheep Cr.				Low	Low										
Chicken Cr.		Moderate			Moderate										
Lower Sheep Cr.				Low	Low										
Fly Cr.	Low				Low										
Meadow Cr.			Low		Low										
Beaver Cr.	Low				Low										
Fivepoints Cr.		Low	Low		Low										
North Fork	Low				Low										
South Fork	Low				Low										
Union to forks		Low			Low										
Lt. Cat. to Union															
Low. Catherine Cr.															
Willow Cr.			Low		Low										
Indian Cr.			Low		Low										
Clark Cr.			Low		Low										
Up. Looking. Cr.	Low		Low		Moderate										
Low. Lookinglass Cr.	Low		Low		Moderate										

Key to Level of Adverse Effect of Attribute on Survival
No effect [ ] Low [•] Moderate [•] High [●] Lethal [⬤]

Fig. 13. **Continued; fall/overwintering life stage.**

Tributaries Upstream of Wallowa River
Smolt Life Stage

Patient

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.															
LimberJim Cr.															
Up. Sheep Cr.															
Chicken Cr.															
Lower Sheep Cr.															
Fly Cr.															
Meadow Cr.															
Beaver Cr.	No utilization at this life stage														
Fivepoints Cr.	No utilization at this life stage														
North Fork															
South Fork															
Union to forks															
Lt. Cat. to Union											•				
Low. Catherine Cr.							•			•	•				
Willow Cr.	No utilization at this life stage														
Indian Cr.											•				
Clark Cr.											•				
Up. Looking. Cr.														•	
Low. Lookinglass Cr.										•	•			•	

Key to Level of Adverse Effect of Attribute on Survival
No effect [ ] Low [•] Moderate [•] High [●] Lethal [⬤]

Template

LOCATION (miles from river mouth): 196, 192, 184, 176, 168, 160, 152, 144, 136, 128, 120, 112, 104, 96, 88, 80

Location	Channel stability	Flow	Habitat diversity	Sediment load	Temperature	Riparian condition	Predators	Chemicals	Competitors	Obstructions	Withdrawals	Nutrient load	Oxygen	Pathogens	Other
Clear Cr.															
LimberJim Cr.															
Up. Sheep Cr.															
Chicken Cr.															
Lower Sheep Cr.															
Fly Cr.															
Meadow Cr.															
Beaver Cr.															
Fivepoints Cr.															
North Fork															
South Fork															
Union to forks															
Lt. Cat. to Union															
Low. Catherine Cr.															
Willow Cr.															
Indian Cr.															
Clark Cr.															
Up. Looking. Cr.															
Low. Lookinglass Cr.															

Fig. 13. **Continued; smolt (yearling) life stage.**

are assumed to have occurred as a result of widespread alterations in riparian conditions within the upper watershed and its tributary sub-drainages and due to changes in snow and ground water retention in the uplands of certain sub-drainages. Similar changes appear to have occurred in the temperature regimes of many other watersheds inhabited by spring chinook east of the Cascade crest (e.g., Lichatowich and Mobrand 1995).

Changes in the diversity of in-stream habitat appear to have been extensive throughout the areas examined. Effects of changes in this attribute are likely widespread along the mainstem river during the adult migration, fry colonization, summer rearing, and overwinter stages. These changes are largely explained by major alterations that have occurred in in-stream structure (e.g., large wood), channel morphometry, and the riparian corridor (see, e.g., McIntosh 1992, Huntington 1994, and McIntosh et al. 1994).

Alterations in the sediment load of the mainstem river appear to have reduced productivity of spring chinook throughout the length of the river. The effect was judged to be strongest during the egg incubation stage, followed by juvenile overwintering. Sources of sediment in the upper basin appear to be scattered, due to extensive land use activities that have occurred through time (McIntosh 1992). One recent event, a “one-two” punch consisting of a large fire followed by a major flood, occurred in 1989 (USFS 1994). That event appears to have resulted in a major recruitment of sediment to the upper river.

5.2 Diagnosis

The diagnosis is a determination, based on deductive analysis, of the general condition of the diagnostic species to sustain itself and related societal values as a result of past and present modes of resource use and environmental change. It includes an assessment of the relative contributions of the various factors affecting the condition of the diagnostic species. To complete the diagnosis, we examined the information presented thus far from a life history perspective. This perspective includes both the diversity of possible life histories and the necessity to view life history over the full life cycle. The four patterns are described in Table 9.

5.2.1 Life History Trajectories

Four generalized life history patterns were selected to sample the range of Productivity Index values in the upper basin. Each pattern is represented by one trajectory (or pathway) in Fig. 14. The patterns were identified based on field studies in the watershed (R. Carmichael, ODFW) or were assumed to have been present historically (Lichatowich and Mobrand 1995).

Pattern 1 is the primary life history pattern existing within the upper basin today. Most fish that spawn in Catherine Creek today follow a similar pattern. Studies indicate that approximately 80% of the existing smolt production in the upper basin follow this pattern.

Pattern 2 characterizes a secondary life history pattern, which comprises the remaining *20%* of the existing smolt production. A similar pattern exists for Catherine Creek fish.

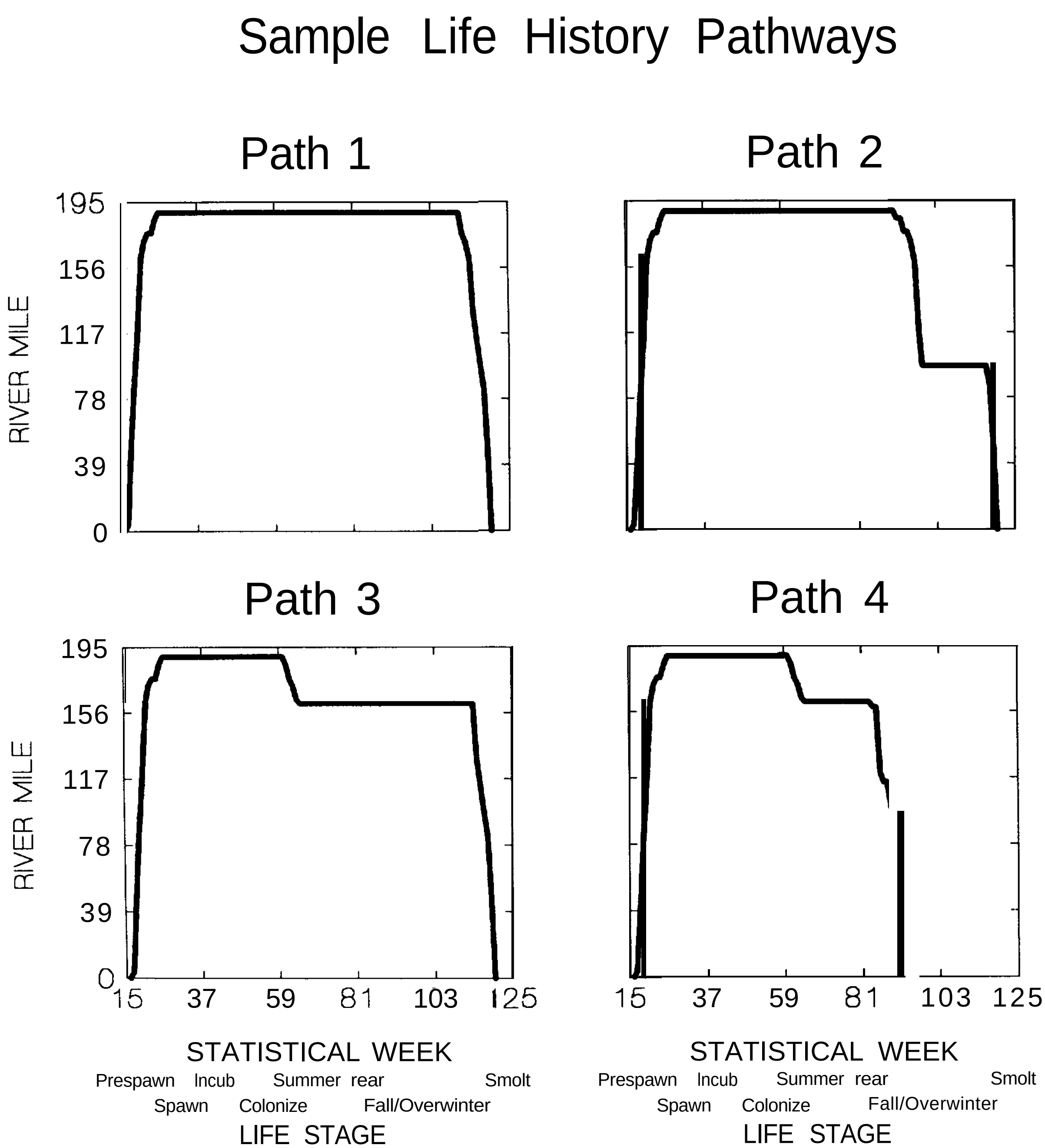


Fig. 14. **Four general life history patterns of spring chinook in the Grande Ronde River, each represented by a single trajectory (pathway). See Table 9 for descriptions.**

Table 9. Description of four generalized life history patterns of spring chinook in the Upper Grande Ronde Basin and associated sample trajectories.

Pattern	Pattern description	Trajectory description
1	Adults enter river early, move quickly to mainstem headwaters; progeny rear and over-winter in that vicinity, then emigrate seaward as yearling smolts	Spawn, rear, and over-winter in the mainstem near Clear Creek
2	Identical to pattern 1 but progeny emigrate to the Grande Ronde valley for over-wintering, then emigrate seaward as yearling smolts	Over-wintering occurs in the mainstem downstream of Catherine Creek
3	Identical to pattern 1 until fry colonization, when fry move downstream to above La Grande for rearing and overwintering, then emigrate seaward as yearling smolts	Rear and overwinter in the mainstem near Five Points Creek
4	Identical to pattern 3 until late summer when juveniles emigrate seaward as subyearling smolts	Rear in mainstem near Five Points Creek until late summer migration

5.2.2 Productivity Indices

The index suggests that productivity has declined sharply over the past century. Index values expressed as smolts per spawner for the four sample life history trajectories ranged between O-185 and 502-682 for Patient and Template, respectively (Fig. 15). The plots shown compare patterns of relative productivity through time for the four trajectories.

Under existing conditions, productivity values associated with the four patterns differ dramatically. Productivity of the primary life history pattern (Table 9, #l) is highest, followed by the value for the secondary pattern. The values for the other trajectories show these patterns as drains to population productivity.

The index suggests that the most productive pattern under Template conditions was number four. By migrating seaward before winter, survival from egg to smolt would have been higher relative to the other patterns.

Productivity also appears to vary substantially within these generalized life history patterns (Table 10). Trajectories following somewhat different paths through space and time, but maintaining the same basic patterns, show widely varied productivities. Table 10 compares multiple trajectories for the primary and secondary life history patterns for the upper mainstem Grande Ronde River and Catherine Creek.

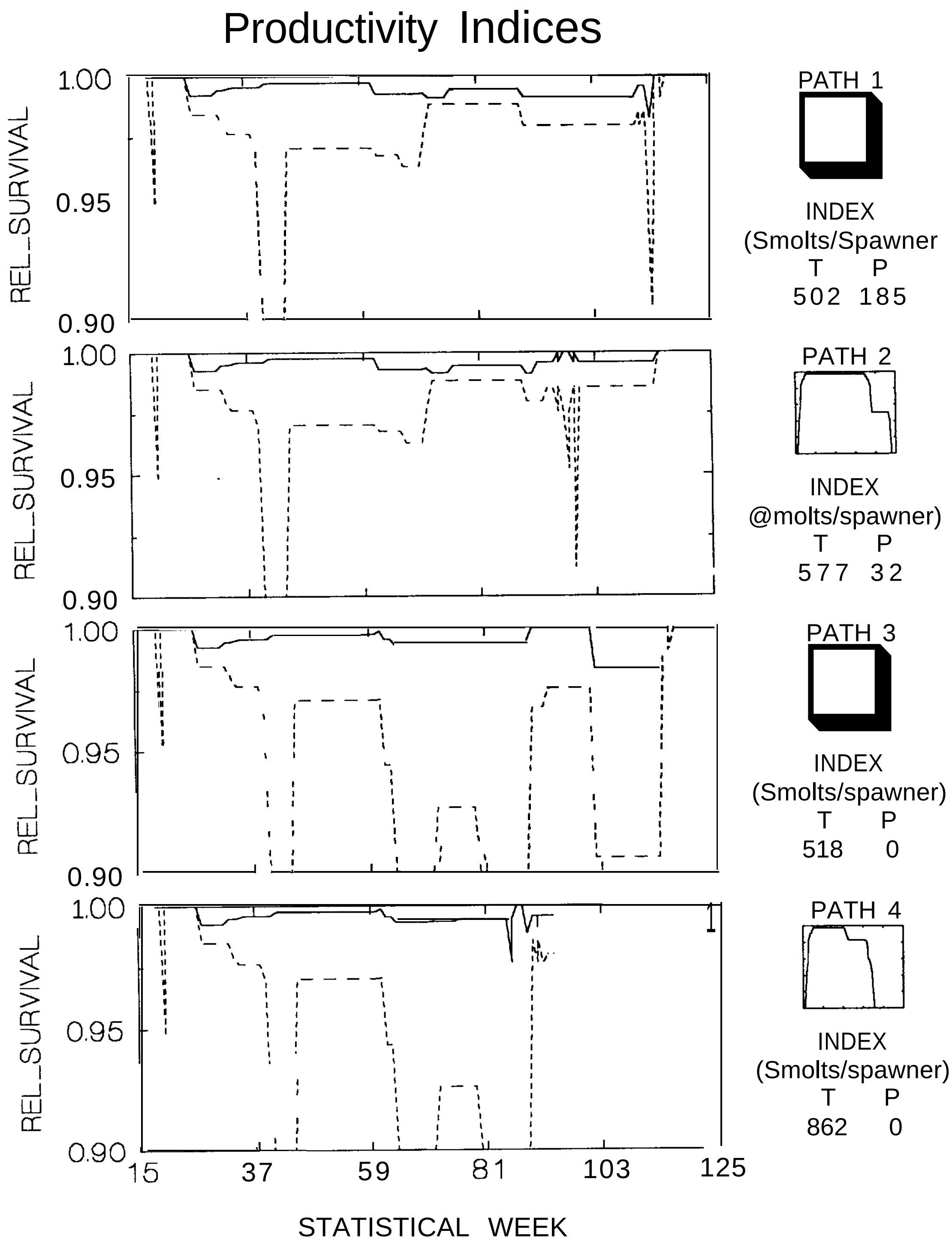


Fig. 15. **Relative productivities through time (by week) for four life history trajectories (see Fig. 14) and associated Productivity Index values (smolts per spawner).**

Table 10. **Productivity Index values (in smolts per spawner) for different trajectories within the primary and secondary life history patterns of spring chinook in the Upper Grande Ronde mainstem and in Catherine Creek.**

Life history pattern	Trajectory description	Productivity (smolts/spawners
Upper Grande Ronde - Primary	Spawns upstream of Clear Cr.	185
(spawn, rear and over-winter)	Spawns upstream of LimberJim Cr.	28
	Spawns upstream of Sheep Cr.	6
	Spawns below Sheep Cr.	5
Upper Grande Ronde - Secondary	Spawns upstream of Clear Cr.	208
(spawn, rear; over-winter in valley)	Spawns upstream of Limberjim Cr.	32
	Spawns upstream of Sheep Cr.	6
	Spawns below Sheep Cr.	5
Upper Catherine Creek - Primary	Spawns in fork	166
(spawn, rear and over-winter)	Spawns upstream of L. Catherine Cr.	214
	Spawns upstream of Union	37
Upper Catherine Creek - Secondary	Spawns in fork	200
(spawn, rear; overwinter in valley)	Spawns upstream of L. Catherine Cr.	209
	Spawns upstream of Union	43

Productivity index values for different life histories within the watershed can be combined with smolt to adult survival rates to assess productivity across the entire life cycle. The analysis of survival rates outside the basin is incomplete; hence results presented here are for illustrative purposes. Smolt to adult survival rates generally vary from less than 0.5% to 2% (Cramer and Neeley 1993).

Fig. 16 portrays the relationship between productivities within and outside the Grande Ronde Basin for spring chinook. Productivity values for each area are shown along the Y and X axes, respectively. The curved line passing through the figure can be thought of as the margin of sustainability for any given life history pattern (or trajectory). The line represents a progeny per parent ratio (adult returns per spawner) of 1; i.e., where the number of parent spawners is exactly replaced by its returning progeny. Values above the curve show combinations of productivities that will sustain a life history; those below the curve lead to extinction.

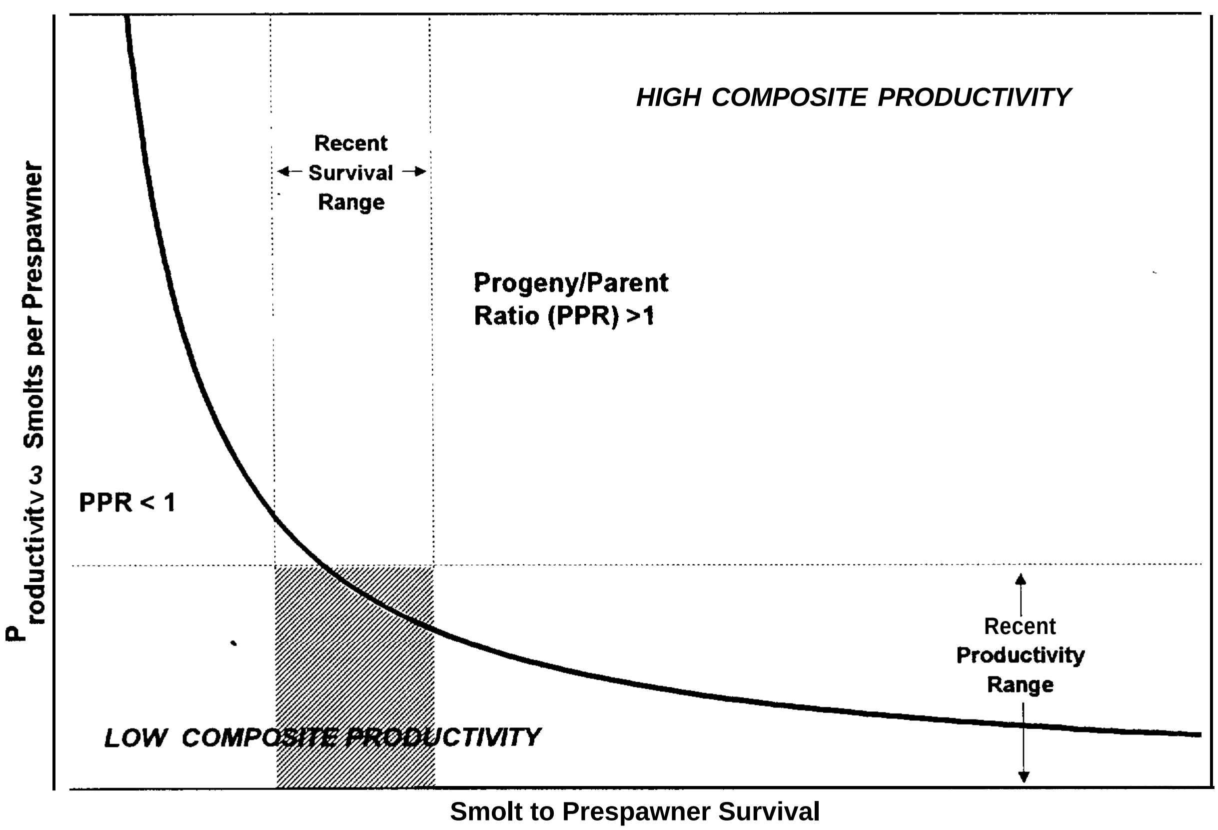


Fig. 16. **Representation of the relationship between productivities within the Grande Ronde Basin and outside the basin. Composite productivity must exceed one adult progeny per parent (PPR) to sustain a life history pattern. Present day productivities (combined, shown within intersecting dashed lines) are much reduced from historic levels, resulting in a number of adult progeny per spawner often less than a value of one.**

Present day productivities and smolt to adult survival rates are depicted; both ranges are much reduced from historic levels (Fig. 16). These reductions combine such that composite productivity across the entire life cycle is often less than one returning adult per parent spawner. Only those life histories with the highest productivities within the watershed appear to be sustainable, and then only at the higher end of the range for smolt to adult survival.

5.2.3 Summary Determination

Spring chinook abundance has declined sharply in the Grande Ronde Basin over the past century. Relatively small numbers persist, mainly produced from spawners that utilize the upper reaches of the mainstem river and its major tributaries.

The cause of the decline is a severe reduction from historic levels in the composite productivity of the population across its entire life cycle. Productivities (survival rates) have declined both within and outside the watershed (Fig. 16). Reduced productivities have occurred for most or all life history patterns, resulting in the complete loss of some. Lichatowich and Mobrand (1995) reached the same conclusion for other chinook populations in the region.

Outside the basin, factors affecting survival consist of passage-related problems associated with the hydroelectric system, harvest, interactions with hatchery fish, and a decline in natural marine survival (Lichatowich and Mobrand 1995; NMFS 1995).

Within the Upper Grande Ronde Basin, loss of productivity appears to have been widespread. Life history patterns that persist in this area of the basin appear to be almost entirely dependent on conditions in the extreme upper reaches of the river. A similar situation exists for fish produced in Catherine Creek. Therefore, the continued sustainability of these life history patterns appears at the present time to depend on maintaining productivity as high as possible within these headwater reaches.

Loss of productivity within the watershed can be linked to past alterations of habitat quality. These changes have affected survival of most life stages of spring chinook in the upper basin.

Habitat quality upon which this species depends falls off sharply as one moves away from the headwater reaches (Fig. 8). The attributes of habitat quality that have contributed the most to loss of productivity in the upper basin are water temperature, habitat diversity, riparian condition, sediment load, and channel stability, though other attributes have also contributed (Fig. 11).

The composite productivity, hence sustainability, of the population can be improved by increasing productivity within the basin, outside the basin, or both (Fig. 16). A prudent approach should involve measures both outside and inside the basin.

Table 11 illustrates the scale of improvements that may be needed within the basin to increase productivities to various levels. In general, a minimum productivity of 100 smolts per spawner

Table Il. **Scale of improvement needed (as multipliers) to increase spring chinook productivity (as smolts per spawner) to levels shown for primary and secondary life history patters in the Upper Grande Ronde Basin.**

Life history pattern	Trajectory description	Productivity (smolts/spawner)	Scaling Factors needed ta increase productivity to 50	100	150	200
Upper Grande Ronde - Primary	Spawns upstream of Clear Cr.	185				1.1
(spawn, rear and over-winter)	Spawns upstream of LimberJim Cr.	28	1.8	3.6	5.4	7.1
	Spawns upstream of Sheep Cr.	6	8.3	16.7	25.0	33.3
	Spawns below Sheep Cr.	5	10.0	20.0	30.0	40.0
Upper Grande Ronde - Secondary	Spawns upstream of Clear Cr.	208				
(spawn, rear; over-winter in valley)	Spawns upstream of LimberJim Cr.	32	1.6	3.1	4.7	6.3
	Spawns upstream of Sheep Cr.	6	8.3	16.7	25.0	33.3
	Spawns below Sheep Cr.	5	10.0	20.0	30.0	40.0
Upper Catherine Creek - Primary	Spawns in fork	166				1.2
(spawn, rear and over-winter)	Spawns upstream of L. Catherine Cr.	214				
	Spawns upstream of Union	37	1.4	2.7	4.1	5.4
Upper Catherine Creek - Secondary	Spawns in fork	200				
(spawn, rear; over-winter in valley)	Spawns upstream of L. Catherine Cr.	209				1.0
	Spawns upstream of Union	43	1.2	2.3	3.5	4.7

would be needed to sustain a single life history trajectory if smolt to adult survival is 1%. However, the progeny of a group of spawners that utilize a single river reach will ultimately follow many trajectories as they grow and disperse, as well as several life history patterns. Some of those patterns will be a productivity drain to this sub-population; therefore some patterns need a productivity much greater than 100 to replace the parent spawners. The table should be used only as a very rough guide for considering the magnitude of improvements that may be required.

5.3 Treatment Identification

A proposed strategy for guiding the development of watershed improvement actions was formulated based on the diagnosis and the strategic set of priorities (see Section 4.3). It is specific to the area of the watershed covered by this report. The strategy is portrayed visually in Fig. 17 for the area encompassing the mainstem Grande Ronde River.

Actions can be developed following the steps outlined in Table 8, using information presented in Figs. 12 - 15.

5.4 Trade-off Analysis

The trade off analysis will be a part of the next phase of the project.

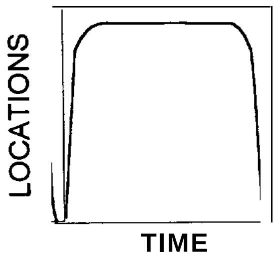
5.5 Future Direction

Future work is planned for items 1 and 2 below and item 3 is recommended to complete a comprehensive analysis:

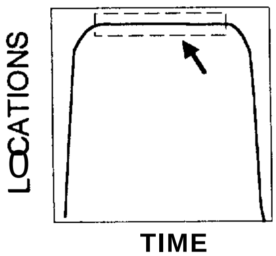
1. Perform a diagnostic analysis of spring chinook productivity for that portion of the watershed not covered by this report.

2. Integrate the analyses for all portions of the watershed and formulate a watershed wide strategy and appropriate guidelines for developing actions.

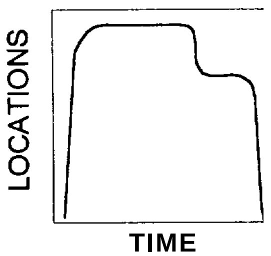
3. Integrate the watershed analysis with a productivity analysis for areas outside the basin to compare the relative contributions of actions in both areas to overall performance.



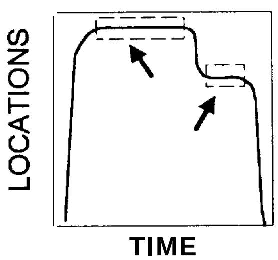
PRIORITY ONE
Maintain the quality of habitat associated with the **primary life history** pattern, including migration corridors.



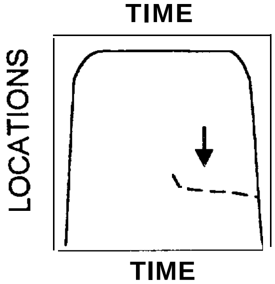
PRIORITY TWO
Improve the quality of habitat associated with the **primary life history** pattern, with particular attention to areas used for longer portions of the life history.



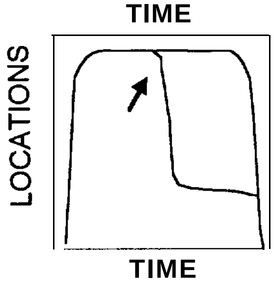
PRIORITY THREE
Maintain the quality of habitat associated with the **secondary life history** pattern, including migration corridors.



PRIORITY FOUR
Improve the quality of habitat associated with the secondary life history pattern, with particular attention to areas used for longer portions of the life history.



PRIORITY FIVE
Improve habitat quality in other areas to begin restoring additional life history patterns.



PRIORITY SIX
Reconnect habitat segments to restore additional life history patterns.

Fig. 17 **Strategic priorities for restoration of spring chinook in the Upper Grande Ronde River system. Corresponding life history patterns are shown.**

LITERATURE CITED

Begon, M., and M. Mortimer. 1986. Population ecology: A unified study of animals and plants. Second edition. Blackwell Scientific Publications, Oxford, England.

Buell, J.W. 1986. Stream habitat enhancement evaluation workshop: a synthesis of views. Level I workshop. Bonneville Power Administration, Portland, OR.

Cramer, S.P., and D. Neeley. 1993. Evaluation of de-listing criteria and rebuilding schedules for Snake River spring/summer chinook, fall chinook, and sockeye salmon. Recovery measures for Threatened and Endangered Snake River Salmon: Technical Report 10 of 11. S.P. Cramer and Associates, under contract DE-AM79- 93BP99654, Bonneville Power Administration, Portland, OR.

Forest Ecosystem Management Assessment Team. 1993. Forest Ecosystem Management: An ecological, economic, and social assessment. U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Bureau of Land Management, Environmental Protection Agency, Washington, D.C.

Franklin, J.F. 1992. Scientific basis for new perspectives in forests and streams. *In* R. Naiman, Editor. Watershed management: Balancing sustainability and environmental change. Springer-Verlag, New York.

Hall, J.D., and M.S. Field-Dodgson. 1981. Improvement of spawning and rearing habitat for salmon. Pages 21-28 *in* C.L. Hopkins, Compiler. Proceedings of the salmon symposium. New Zealand Ministry of Agriculture and Fisheries, Fisheries Research Division, Occasional Publ. 30, Wellington.

Hilborn, R., and Walters, C. 1992. Quantitative fisheries stock assessment: Choice, dynamics & uncertainty. Chapman and Hall, New York.

Hunter, C.J. 1991. Better trout habitat, a guide to stream restoration and management. Island Press, Washington, DC and Covelo, CA.

Huntington, C.W. 1994. Stream and riparian conditions in the Grande Ronde Basin 1993. Final report. Prepared for the Grande Ronde Model Watershed Board, La Grande, OR.

Huppert, D.D., and R.D. Fight. 1991. Economic considerations in managing salmonid habitats. Pages 599-606 *in* W.R. Meehan, Editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, MD.

Karr, J.R. 1992. Ecological integrity: Protecting earth's life support systems. *In* R. Costanza, B. G. Norton, and B.D. Haskell, Editors. Ecosystem health: New goals for environmental management. Island Press, Covelo, CA.

Lee, K. N. 1993. Compass and gyroscope: Integrating science and politics for the environment. Island Press, Washington, D.C.

Leppakoski, E. 1975. Assessment of degree of pollution on the basis of macrozoobenthos in marine and brackish water. Acta Acadmise Aboensis (Abo Akademi), Series B, Volume 35, No. 3.

Lestelle, L.C., L.E. Mobrand, M.L. Rowse, and C. Weller. 1995. Concepts and tools for planning natural coho salmon enhancement measures. A Planning Guide. Point No Point Treaty Council, Kingston, WA.

Lichatowich, J.A., and L.E. Mobrand. 1995. Analysis of chinook salmon in the Columbia River from an ecosystem perspective. Final Report, Contract No. DE-AM79-92BP25 105. Bonneville Power Administration, Portland, OR.

Lichatowich, James, L. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries (Bethesda) 20(l): 10-18.

McIntosh, B.A. 1992. Historical changes in anadromous fish habitat in the upper Grande Ronde River, Oregon, 194 l- 1990. Masters thesis. Oregon State University, Corvallis, OR.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wismar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Management history of eastside ecosystems: Changes in fish habitat over 50 years, 193 5 to 1992. General Technical Report, PNW-GTR-32 1. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Moussalli, E., and R. Hilborn. 1986. Optimal stock size and harvest rate in multistage life history models. Canadian Journal of Fisheries and Aquatic Sciences 43(l): 135-141.

National Marine Fisheries Service. 1995. Proposed recovery plan for Snake River salmon. Main report. US Department of Commerce, National Oceanic and Atmospheric Administration, Seattle, WA.

Nickelson, T.E. 1986. A model for determining factors limiting abundance, and thereby estimating carrying capacity of fishes in stream systems. *Unpublished manuscript,* Oregon Department of Fish and Wildlife, Corvallis. Appendix B *in* J. W. Buell, 1986. Stream habitat enhancement evaluation workshop: A synthesis of views. Proj. No. 86-107. US Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, OR.

Nickelson, T. E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1993. An approach to determining stream carrying capacity and limiting habitat for coho salmon *(Oncorhynchus kisutch).* Pages 251-260 *In* L. Berg and P.W. Delaney, Editors. Proceedings of the coho workshop. May 26-28, 1992, British Columbia Department of Fisheries and Oceans, Vancouver, BC.

Northwest Power Planning Council. 1990. Grande Ronde River Subbasin salmon and steelhead production plan. Columbia Basin system planning. Published by the Northwest Power Planning Council, and the Agencies and Indian Tribes of the Columbia Basin Fish and Wildlife Authority, Portland, OR.

O'Neill, R. V., D.L. DeAngelis, J.B. Waide, and T.F.H. Allen. 1986. A hierarchical concept of ecosystems. Princeton University Press: Princeton, NJ.

Rapport, D.J. 1992. What is clinical ecology? *In* R. Costanza, B. G. Norton, and B.D. Haskell, Editors, Ecosystem health: New goals for environmental management. Island Press, Covelo, CA.

Reeves, G. H., F.H. Everest, and T.E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. General technical report PNW-GTR-245. U.S. Forest Service, Corvallis, OR.

Reeves, G. H.; Hall, J. D.; Roelofs, T. D.; Hickman, T. L., and Baker, C. 0. 1991. Rehabilitating and modifying stream habitats. *In* W.R. Meehan, Editor. Influences of forest and rangeland management on salmonid fishes and their habitats, American Fisheries Society Special Publication 19: 5 19-557. American Fisheries Society, Bethesda, MD.

Regional Ecosystem Office. 1995. A federal agency guide for pilot watershed analysis. Portland, OR.

Ricklefs, R.E. 1973. Ecology. Chiron Press: Newton, MA.

Smith, A.K. 1975. Fish and wildlife resources of the Grande Ronde Basin, Oregon, and their water requirements, Federal Aid to Fish Restoration Project Completion Report. Oregon Department of Fish and Wildlife, Portland, OR.

Smith, B., and B.U. Knox. 1993. Wallowa District 1993 stock status review. Oregon Department of Fish and Wildlife, March, 1993.

U.S. Forest Service. 1994. Biological assessment: Upper Grande Ronde River (section 7). Final report. Wallowa-Whitman National Forest - La Grande Ranger District, Umatilla National Forest - North Fork John Day Ranger District.

West, D., and J. Zakel. 1993. La Grande Fish District annual report. Oregon Department of Fish and Wildlife, March 1993.

APPENDIX A

Forms Used in Assessment Procedures for Patient-Template Analysis

Appendix Table A-l. **Form used to assemble steam reach information for Patient-Template Analysis for spring chinook in the Grande Ronde Basin.**

PATIENT

Reach name:			
Reach Location:			
Upstream reach 1:		**Downstream reach 1:**	
Upstream reach 2:		**Downstream reach 2:**	
Reach length:		**Gradient (%):** **(SCHIN section)**	

Estimated stream width during average year											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

Source:
Comment :

TEMPLATE

Reach name:			
Reach Location:			
Upstream reach 1:		**Downstream reach 1:**	
Upstream reach 2:		**Downstream reach 2:**	
Reach length:		**Gradient (%):** **(SCHIN section)**	

Estimated stream width during average year											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

Source:
Comment:

Appendix Table A-2. Form used to assemble survival and environmental attribute information for Patient-Template Analysis for spring chinook in the Grande Ronde Basin.

Reach name:		Patient/Template:	
Utilization (Y or N):		Miles utilized:”	
Life stage:			
Wks of usage - Begin:		Wks of usage - End:	
Relative quantity of key habitat per unit area:			

Relative survival associated with habitat quality by month:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Attribute	**Rating**	**Source:**	**Comment:**
Channel stability			
Flow			
Habitat type diversity			
Sediment load			
Water temperature			
Riparian condition			
Predators			
Chemicals			
Competitors			
Obstructions			
Water withdrawals			
Nutrient load			
Oxygen			
Pathogens			
Other			

General Comment

l/Maximum miles for any life stage.