

An Aquatic Multiscale Assessment and Planning Framework Approach—Forest Plan Revision Case Study

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Abstract

The Aquatic Multiscale Assessment and Planning Framework is a Web-based decision-support tool developed to assist aquatic practitioners in managing fisheries and watershed information. This tool, or framework, was designed to assist resource assessments and planning efforts from the broad scale to the fine scale, to document procedures, and to link directly to relevant research. The framework is a hierarchical, hyperlinked template that is readily updateable. For aquatic resources in a planning area, such as those occupied by salmonid fishes, the framework produces tabular and spatial displays of (1) current habitat conditions and distributions, (2) desired future conditions, (3) risks and threats to the species concerned, (4) analysis approaches, (5) a conservation and restoration strategy, and (6) a monitoring, inventory, and research strategy. The framework also provides a logical system for developing, tracking, and documenting aquatic information at various spatial scales (subwatershed to basin) and can hyperlink management questions and data to best available science and procedures. For example, different analysis approaches (e.g., extinction risk matrices, influence diagrams, probabilistic networks) along with supporting science or case studies are directly linked and downloadable from the framework. The framework helps define and display information assumptions and gaps and is transparent and defensible.

Keywords: Aquatic population information, cutthroat trout, decision-support tool, multiscale assessments, multiscale planning, salmonid fish extinction risks, watershed information.

Introduction

The Aquatic Multiscale Assessment and Planning framework is a Web-based decision-support tool developed to facilitate conservation and restoration planning for aquatic species influenced by national forest management: (http://www.fs.fed.us/rm/boise/research/techtrans/projects/multiscale_home.shtml). This tool, or framework, was designed to support resource assessments and planning efforts from the broad scale to the fine scale, to document procedures, and to hyperlink directly to relevant research. The framework was originally developed in collaboration between U.S. Forest Service Northern (R1) and Intermountain (R4) Regions and the Rocky Mountain Research Station (Boise, ID) to help aquatic biologists organize data and prioritize management actions for the restoration of native trout populations. Though not specifically designed for national forest plan revision, the framework lends itself well to this purpose, and forest planners have used all or parts of the framework to craft various planning components (e.g., species viability assessments, desired conditions, aquatic conservation strategies) required under the 1982 Planning Rule or the new 2005 Planning Rule (36CFR219, <http://www.fs.fed.us/emc/nfma/index.htm>).

The framework provides a logical template for developing, tracking, and documenting aquatic population and watershed information. It summarizes data at various spatial scales, distinguishes quantitative from qualitative data, and is transparent and defensible. The framework hyperlinks data and management options to procedures, best available science, and case studies and spotlights assumptions made in the analysis process, as well as data gaps.

The framework template follows modern principles of conservation and restoration for aquatic ecosystems, addressing (1) ecological patterns and processes that contribute to persistence of aquatic ecosystems and species (Naiman and others 2000, Rieman and others 2006, Thurow and others 1997), (2) natural variability, ecosystem and species diversity, and population resilience and resistance

to disturbance (Angermeier 1997, Rieman and others 2006), (3) habitats needed for all life stages of aquatic species (McElhany and others 2000); (4) genetic diversity of populations (Allendorf and Leary 1988, Likens and Graham 1988, Rieman and others 1993, Soule 1987); and (5) habitat connectivity for dispersal and migration (Dunham and Rieman 1999, McElhany and others 2000, Rieman and Dunham 2000, Rieman and others 1993, Sheldon 1998).

The framework is designed to support U.S. Forest Service regional species status overviews, subbasin assessments, watershed analyses, cumulative effects assessments, National Environmental Policy Act analyses, and consultation. Spatially explicit outputs are used to define and display risks and threats associated with fish, fish habitats, and watershed conditions. Broad-scale summaries provide context for fine-scale projects to help prioritize management actions for addressing risks and threats. The transparent design helps step down data and priorities for field unit verification and implementation.

The framework provides a hierarchical approach for summarizing available fisheries information at various spatial and watershed scales. All the geographic scales of a drainage system function together to create and maintain aquatic habitats (Wissmar 1997). The subwatershed (6th field Hydrologic Unit Code [HUC], sensu Maxwell and others 1994) is often synonymous with local fish populations or their life stages, risks and threats, or project-level management action assessments or all. Subwatersheds that support self-sustaining populations, i.e., strongholds, act as sources for populations that bolster weaker populations or recolonize vacant habitats. Aquatic data used for national forest land management plans are usually summarized at the subwatershed scale.

In order to determine how habitat conditions are distributed across a larger geographic area, subwatershed information is aggregated up to the subbasin scale (4th field HUC). The subbasin is the primary broad-scale summary unit for addressing salmonid fish extinction risks. The subbasin acts as a terminal aquatic environment and is the spatial scale where metapopulations, or interacting groups

of two or more local populations, operate as a hedge against extinction (Lee and others 1997, Rieman and others 1993). Thus, a multiscale approach allows for broader interpretations of current conditions in terms of salmonid population dynamics. In addition, aggregating data up to larger scales such as the basin (3rd field HUC) provides context for sub-basin assessments and national forest plans.

The Six-Step Framework Template

The framework process is organized into six steps (Figure 1). For aquatic resources in the planning area, following these steps produces tabular and spatial displays of (1) current conditions and distributions of populations or habitats, (2) desired future conditions, (3) risks and threats to the species concerned, (4) analysis approaches, (5) a conservation and restoration strategy, and (6) a monitoring, inventory, and research strategy.

The steps are in a logical order of priority for completing habitat and population assessments and providing base data for strategic planning. Framework steps 1 through 3 can be worked on concurrently but should be completed prior to moving onto step 4. Information needed for each step is gleaned from numerous sources, including published research, broad-scale assessments, and conservation strategies (e.g., FEMAT 1993, Pacific Anadromous Fish Strategy [PACFISH] 1995, Inland Fish Strategy [INFISH] 1995, Lee and others 1997), and forest-level inventory and monitoring. Information used can be a combination of quantitative and qualitative data. For each step, the Web-based framework provides hyperlinks to data-collection protocols used, relevant research and case studies, assessment data, and planning products.

The following is a case study from the Bridger-Teton National Forest in Wyoming, which used the framework and its six steps to structure a conservation and restoration strategy for Bonneville cutthroat trout (*Oncorhynchus clarki utah*) as a part of the forest plan revision process. The forest used the framework to assemble data on the cutthroat, its habitat, stream-riparian ecosystems, and watersheds (Figure 1), with a focus on the Central Bear River subbasin.

Step 1—Current Condition, Status, and Distribution of Native Trout Populations and Associated Stream-Riparian Habitats

Step 1 (Figure 1) provides the environmental baseline or current condition for cutthroat trout in the Central Bear River subbasin and is assumed to reflect natural disturbances and the effectiveness of the Forest's current land use plan direction and past management actions.

Step 1(A) displays the current distribution of cutthroat trout populations across their assumed historical distribution in Central Bear River subbasin. This information was based on stream survey data collected by aquatic researchers as well as State, tribal, and forest biologists and compiled at the subwatershed level.

The status of the trout population in each subwatershed was coded as strong, depressed, or absent (includes extirpated) based on criteria developed for assessing interior Columbia River basin fish populations (Lee and others 1997). For example, subwatersheds were coded as having strong populations if the subwatershed had all the following conditions:

- Fish presence had been verified within the last 10 years using standard sampling methods.
- Major life history stages (e.g., resident, migratory) that historically occurred in the subwatershed were still present.
- Fish numbers were stable or increasing, and the population was no less than half of its historical size or density.
- The population or metapopulation was at least 5,000 individuals or 500 adults; if the population size was based on a population that extended outside the subwatershed, the subwatershed was an important core area for this larger population.

In addition, current conditions of stream-riparian habitats were evaluated for each subwatershed. Qualitative approximations of subwatershed conditions were obtained from Inland West Water Initiative (IWWI) assessments (on file with Rocky Mountain Research Station, Boise Aquatic Sciences Lab, Idaho Water Center, Suite 401, 322 East Front St., Boise, Idaho 83702) and plotted in step 1(B). The Bridger-Teton National Forest chose to display water quality

integrity, but other indicators of watershed condition could have been used.

Data for populations and subwatershed conditions were organized in standardized Excel format. The data were readily displayed and reviewed by creating geographic information system (GIS) spatial data layers both by subwatershed and subbasin and creating maps using ArcGIS[®] tools.

In forest plan revisions, information developed in step 1 could be incorporated into the comprehensive evaluation report (CER), a constituent of the planning set of documents, which provides current conditions and analyses for the Forest Plan.

Step 2—Desired Future Condition of Native Trout Populations and Associated Stream-Riparian Habitats

Desired future conditions for fish populations and watershed conditions were generated by forest biologists familiar with the subbasin. They used the Conservation Rules of Thumb summarized in earlier broad-scale aquatic assessments (FEMAT 1993, INFISH 1995, Lee and others 1997, PACFISH 1995):

- The greater the population size, the greater the chance of persistence.
- Population recovery potential is greater the closer you are to a source or strong population.
- Preserving genetic and phenotypic diversity requires maintaining populations throughout a wide geographic range in a variety of habitats.
- Project assessments and planning will have to address habitat disruption and population responses at both the local and regional scales.

In addition, the biologists considered key aquatic habitat characteristics, such as water quality/quantity, channel integrity, and riparian vegetation, and visualized those future states that would allow persistence and sustainability of aquatic populations. They recognized that ecologically healthy watersheds are maintained by natural disturbances (e.g., fire, landslides, and debris torrents, channel migration) that create spatial heterogeneity and temporal variability to the physical components of the system (Naiman 1992) and

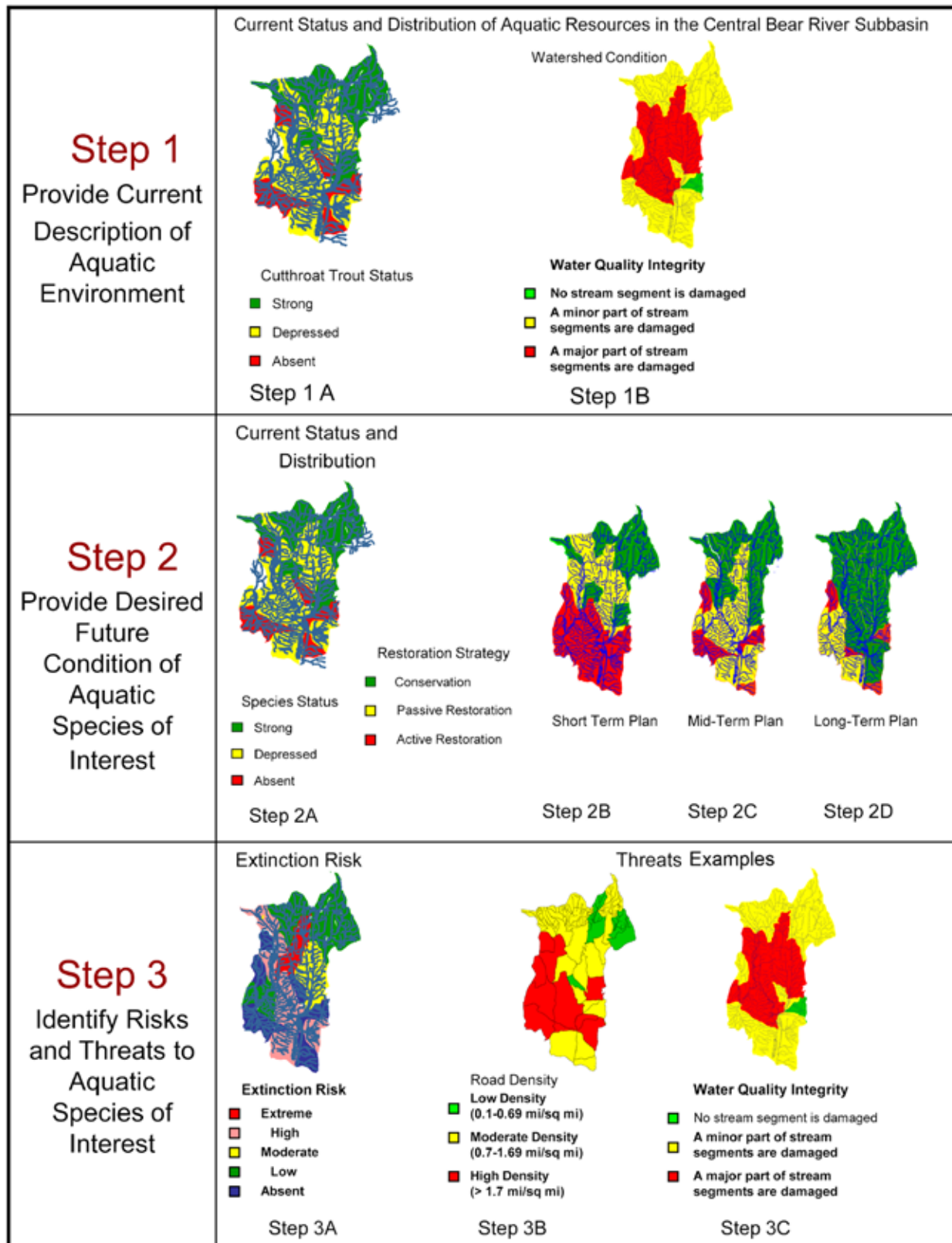
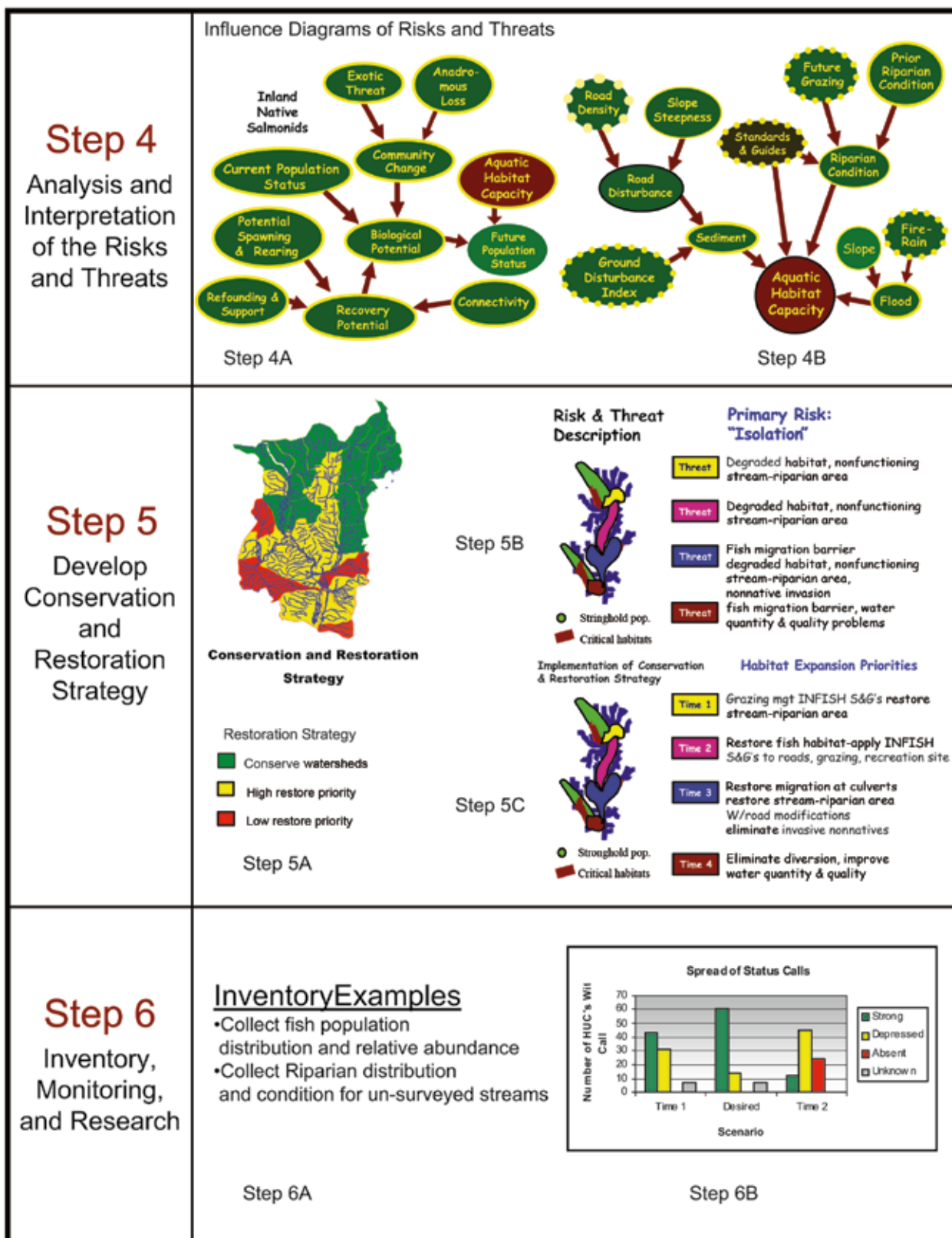


Figure 1—The multiscale framework steps and example products. The schematic displays example outputs specific to the individual steps (six) within the framework tied to the document step-by-step description.



that management consistent with natural variation should lead to more diverse, resilient, and productive biological systems (Rieman and others 2006).

Step 2 (B-D) displays desired future conditions over a period of time for cutthroat trout in the subbasin, showing fish population status and distribution at short-, mid- and long-term intervals. The long-term desired condition (Step 2(D)) would be expected to represent a healthy, self-sustaining metapopulation occupying ≥ 50 percent of its historical range along with strong population characteristics and high-quality habitats (FEMAT 1993, Lee and others 1997).

Outputs from Step 2 would be consistent with the desired condition component of the plan in the forest plan revision process, which is to describe how management activities will cause desired natural resource conditions to be obtained.

Step 3—Risks and Threats to Native Trout Populations and Associated Stream-Riparian Habitats

Extinction risks for salmonids are influenced by complex and interacting factors that are often difficult, if not impossible, to identify and measure. Despite this difficulty, understanding the nature of the extinction process and the characteristics of local fish populations and habitats can lead to management prescriptions that minimize risks. Relative extinction risks include deterministic, stochastic, and genetic factors at several spatial and temporal scales (Rieman and others 1993). The risk portion of step 3(A-C) was generated for cutthroat trout by agency biologists through application of an extinction risks matrix (Rieman and others 1993) that matched population characteristics, such as size, isolation, and survival rates, with a variety of environmental and demographic parameters. The outcome was an estimate of relative risk of extinction (low to extreme) for trout in a given reach, subwatershed, or across a subbasin. For the Central Bear River subbasin, step 3(A) maps extinction risks in subwatersheds based on trout population size and isolation.

The persistence of trout populations in a subwatershed can be threatened by land use practices such as grazing, fire suppression, mining operations, recreational activities, road

construction, dams and water diversions, and introduction of invasive species. Threats to fish populations or their habitat may be direct, as in the alteration of riparian and channel structure by overgrazing, or indirect, such as when high road density in the uplands impacts water quality and timing of flows. For the Central Bear River subbasin, biologists spatially displayed possible threats to cutthroat populations by mapping road densities (step 3(B)), and water quality integrity (step 3(C)). Aquatic specialists then evaluated the threats and identified those that Forest Service management or cooperative partnership actions could influence.

In the national forest plan revision process, risks and threats to native fish species on the subwatershed level would be included in the CER.

Step 4—Analysis and Interpretation of the Risks and Threats That Influence Native Trout Populations and Associated Stream-Riparian Habitats

In step 4, national forest biologists analyzed risks and threats to populations and their habitats at the subwatershed level, identifying those risks and threats most urgently to be considered and addressed by management. Influence diagrams, or cause-and-effect diagrams (step 4 (A, B)) were used to display the analysis thought process. These unambiguous diagrams helped biologists, managers, scientists, and interested publics visualize, discuss, and review all the factors and pathways that potentially impacted population and watershed condition. Forest biologists created an influence diagram for risks and threats to trout population persistence (step 4 (A)) and a separate influence diagram for risks and threats to habitat (step 4 (B)). The step 4 (A) diagram included elements such as migration barriers and presence of invasive species. To predict the future status of cutthroat trout populations in the subbasin, both influence diagrams were incorporated into a probabilistic network (in this case, a Bayesian belief network [Lee and Rieman 1997, Rieman and others 2001]) and run under different management scenarios. For example, the biologists found that if riparian road densities were high in a subwatershed where invasive species (brook trout *Salvelinus fontinalis*) were present, the future population status for cutthroat

was depressed. In this way, the forests could test different management alternatives and predict their impacts on trout population status at both the subwatershed and the subbasin scale (step 4(C)).

The framework facilitates risks and threats analysis by providing hyperlinks to potential analysis tools and current conservation literature. For example, links connect the user to the trout extinction risk matrix (Rieman and others 1993), effects of Federal land management alternatives on population trends (Rieman and others 2001), population viability assessment of salmonids using probabilistic networks (Lee and Rieman 1997), and conservation assessments for various fish species.

For forest plan revision, step 4 risks and threats analyses can be incorporated into the CER and thereafter provide background information for crafting the desired conditions and objective components of the plan. Step 4 is useful in the planning process in that it provides a transparent view of the spatial and temporal interaction of biological, physical, chemical, and social processes at work in the planning area. Implications of these interactions are used as the basis for development of the conservation and restoration strategies outlined in the next step of the framework, below.

Step 5—Conservation and Restoration Strategies to Address Risks and Threats to Native Fish Populations and Associated Stream-Riparian Habitats

In step 5, the forests used information gained in steps 1 through 4 to design a conservation and restoration strategy that could maintain and restore aquatic ecosystems at subwatershed through subbasin scales. A network of subwatersheds (green polygons in step 5(A)) was selected to serve as strongholds to conserve cutthroat trout or high-quality habitat or both. These conservation watersheds were intended to provide refugia across the landscape, areas where management focuses on protection and maintenance of quality aquatic habitat and strong native fish populations. Habitats that support the most productive, diverse, and otherwise critical populations provide the best opportunities for ensuring short-term persistence and provide an essential

nucleus for rehabilitating more complete networks in the future (Rieman and others 2000).

In addition, restored watersheds, with assigned priorities of low to high, were essential to delineate because protection of fish strongholds alone would not be sufficient to sustain populations (Franklin 1993). By restoring watershed processes that create and maintain habitats across stream networks, the long-term productivity of aquatic and riparian ecosystems can be ensured (Rieman and others 2000, Thurow and others 1997). Prioritizing the restoration in subwatersheds considers the extent of habitat degradation and how much natural diversity and ecological functioning still exists. For example, high-priority watersheds for restoration are those with limited loss of function and condition and that will likely serve as the next generation of strongholds for fish and water quality. Once the watersheds are prioritized for restoration, the type of restoration action implemented can be active (fence construction, bank stabilization, willow planting) or passive. Passive restoration relies on the implementation of guidelines, design criteria (i.e., Forest Service Manual and Handbook direction) and best management practices to maintain watershed processes and habitat conditions. Because passive restoration primarily maintains current conditions, active restoration is often needed to move a degraded system toward recovery.

Planning out the timing and sequence of restoration actions is aided by using displays generated by the framework. Step 5(B, C) illustrates the conservation and restoration strategy development process used by the Central Bear subbasin forests for a hypothetical watershed. This watershed has two subwatersheds with stronghold populations of cutthroat trout (step 5(A)). The primary risk to these two populations is isolation caused by threats such as degraded riparian areas and fish migration barriers. Through risk and threat analysis in step 4, the biologists determine the relative importance of the threats to population persistence and prioritize the timing and spatial sequence of restoration actions. The restoration strategy for the watershed can then be mapped (step 5(C)).

In the forest plan revision process, step 5 conservation and restoration strategies could be incorporated into various plan components. Conservation and restoration strategies

could appear in “Guidelines and Special Areas” within the forest plan components and could be used as a foundation of the monitoring program in the plan set of documents.

Step 6—Inventory, Monitoring, and Research Strategies

Inventory and research strategies fill data gaps and validate assumptions. If information required for the framework (e.g., population status, habitat condition) is incomplete or outdated, inventories or research may be needed to obtain the data (step 6(A)). Monitoring strategies are used to track the progress of conservation and restoration actions. Three types of monitoring generally apply to species assessments and forest planning: implementation, effectiveness, and validation. Implementation or compliance monitoring ensures that management actions were implemented as planned, such as moving livestock before utilization exceeds a critical level. Effectiveness monitoring assesses the progress of management actions in attainment of desired conditions. Validation monitoring corroborates the assumptions made during evaluation and analysis and is important for determining if restoration activities result in desired population and habitat conditions.

Forest biologists in the Upper Salmon subbasin chose the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (Kershner and others 2004) to measure and evaluate the effectiveness of their actions and best management practices in restoring and maintaining the structure and function of trout habitats at multiple landscape scales. In addition, periodic fish sampling surveys in specific subwatersheds monitored population responses to restoration activities, and results were aggregated across the subbasin to ascertain trends toward or away from desired condition for the planning area (step 6(B)). In our example, step 6(B) shows a movement away from the desired condition (Time 1) toward a less desired condition (Time 2). Research needs that emerged from the framework process included developing a decision-support strategy for barrier removal and brook trout control.

For national forest plan revision, the framework’s inventory, monitoring, and research strategies would slip

seamlessly into the monitoring program portion of the planning set of documents.

Conclusions

The Aquatic Multiscale Assessment and Planning Framework, as a Web-based decision-support tool, will facilitate conservation and restoration planning for aquatic species and watersheds influenced by national forest management. Through a six-step process that organizes information into tabular and spatial (GIS) formats, the framework helps aquatic practitioners visualize and analyze complex fisheries and watershed data, from the site-specific project level up through national forest and regional spatial scales. The framework provides a one-stop shopping site for maintaining and updating data and analysis procedures.

For aquatic resources, such as cutthroat trout populations and their habitat in a particular planning area, the framework produces tabular and spatial displays of (1) current status and distribution of populations or habitats, (2) desired future conditions, (3) risks and threats to the species concerned, (4) analysis approaches, (5) a conservation and restoration strategy, and (6) a monitoring, inventory, and research strategy. The framework also provides a logical system for developing, tracking, and documenting aquatic information. It summarizes available information at various spatial scales (subwatershed to basin) and can hyperlink the user to best available science resources and supporting information. For example, different analysis approaches (e.g., extinction risk matrices, influence diagrams, probabilistic networks) along with scientific papers or case studies are directly linked and downloadable from the framework. The framework helps define and display information assumptions and gaps and is transparent and defensible.

This transparent and defensible design will assist in clarifying decision outcomes and the elements and pathways used to support them. The ability to clearly track the background data and thought processes that go into controversial land use planning and decision documents may reduce misunderstandings and mistrust in stakeholders and enable timely and effective restorative actions that will benefit fishes and other aquatic organisms.

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