Ecosystem Analysis at the Watershed Scale

Federal Guide for Watershed Analysis

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Part 1: Process Overview

Introduction

Watershed analysis is a procedure used to characterize the human, aquatic, riparian, and terrestrial features, conditions, processes, and interactions (collectively referred to as “ecosystem elements”) within a watershed. It provides a systematic way to understand and organize ecosystem information. In so doing, watershed analysis enhances our ability to estimate direct, indirect, and cumulative effects of our management activities and guide the general type, location, and sequence of appropriate management activities within a watershed.

Watershed analysis is essentially *ecosystem analysis at the watershed scale*. As one of the principal analyses for implementing the Aquatic Conservation Strategy (ACS) set forth in the Northwest Forest Plan (*Record of Decision* (ROD) *for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl* (USDA, USDI 1994)) it provides the watershed context for fishery protection, restoration, and enhancement efforts. The understanding gained through watershed analysis is critical to sustaining the health and productivity of natural resources. Healthy ecological functions are essential to maintain and create current and future social and economic opportunities.

Federal agencies are conducting watershed analyses to shift their focus from species and sites to the ecosystems that support them in order to understand the consequences of management actions *before* implementation. The watershed scale was selected because every watershed is a well-defined land area having a set of unique features, a system of recurring processes, and a collection of dependent plants and animals.

Watershed analyses are conducted by teams of journey-level specialists who follow a standard, interagency six-step process. The process is *issue-driven*. Rather than attempting to identify and address everything in the ecosystem, teams focus on seven core analysis topics along with watershed-specific problems or concerns. These problems or concerns may be known or suspected before undertaking the analysis or may be discovered during the analysis. Analysis teams identify and describe ecological processes of greatest concern, establish how well or poorly those processes are functioning, and determine the conditions under which management activities, including restoration, should and should not take place. The process is also *incremental*. New information from surveys and inventories, monitoring reports, or other analyses can be added at any time.

Watershed analysis is not a decisionmaking process. Rather it is a *stage-setting* process. The results of watershed analyses establish the context for subsequent decisionmaking processes, including planning, project development, and regulatory compliance.

The results of watershed analysis can be used to:

- Assist in developing ecologically sustainable programs to produce water, timber, recreation, and other commodities.
- Facilitate program and budget development by identifying and setting priorities for social, economic, and ecological needs within and among watersheds.
- Establish a consistent, watershed-wide context for project-level National Environmental Policy Act (NEPA) analyses.
- Establish a watershed context for evaluating management activity and project consistency given existing plan objectives (e.g., ACS objectives).
- Establish a consistent, watershed-wide context for implementing the Endangered Species Act, including conferencing and consulting under Section 7.
- Establish a consistent, watershed-wide context for local government water quality efforts and for the protection of beneficial uses identified by the states and tribes in their water quality standards under the Federal Clean Water Act.

Organization of This Guide

This federal guide is organized in two parts.

Part 1 is an overview of the analysis process and includes an introduction; a summary of the six analysis steps; important process considerations; technical considerations; relationships to other laws, regulations, processes, and lands; monitoring; and a summary of the core topics and questions to be addressed in watershed analysis.

Part 2 includes the detailed description of each of the six steps for conducting ecosystem analysis at the watershed scale. The six steps guide analysis teams through a series of questions to characterize the watershed, focus the analysis on essential issues, describe and understand current and historical conditions and processes, interpret the results, and develop recommendations for subsequent action by responsible officials.

Teams planning to conduct watershed analysis should first review both parts of this federal guide. The process is intended to be flexible and adaptable but still follow a consistent overall approach. Teams can be most efficient by developing an understanding of the entire six-step process, anticipating information and analysis needs, and planning for ways to synthesize the analysis at each step along the way.

Future Additions to the Federal Guide

Section II of the Federal Guide will serve as a technical supplement or "tool box" of analytical methods and techniques designed to help address various aspects of watershed analysis and the Section I "core" topics. The goals of Section II are to meet Northwest Forest Plan goals, ensure scientific credibility, provide "methods and techniques," and provide for cooperation and coordination with other watershed analysis processes.

Summary of the Six-Step Process

The process for conducting ecosystem analysis at the watershed scale has six steps:

1. *Characterization of the watershed*
The purpose of step 1 is to identify the dominant physical, biological, and human processes or features of the watershed that affect ecosystem functions or conditions. The relationship between these ecosystem elements and those occurring in the river basin or province is established. When characterizing the watershed, teams identify the most important land allocations, plan objectives, and regulatory constraints that influence resource management in the watershed. The watershed context is used to identify the primary ecosystem elements needing more detailed analysis in subsequent steps.

2. *Identification of issues and key questions*
The purpose of step 2 is to focus the analysis on the key elements of the ecosystem that are most relevant to the management questions and objectives, human values, or resource conditions within the watershed. The applicability of the core questions and level of detail needed to address applicable core questions is determined. Rationale for determining that a core question is not applicable are documented. Additional topics and questions are identified based on issues relevant to the watershed. Key analysis questions are formulated from indicators commonly used to measure or interpret the key ecosystem elements.

3. *Description of current conditions*
The purpose of this step is to develop information (more detailed than the characterization in step 1) relevant to the issues and key questions identified in step 2. The current range, distribution, and condition of the relevant ecosystem elements are documented.

4. *Description of reference conditions*
The purpose of step 4 is to explain how ecological conditions have changed over time as a result of human influence and natural disturbances. A reference is developed for later comparison with current conditions over the period that the system evolved and with key management plan objectives.

5. *Synthesis and interpretation of information*
The purpose of step 5 is to compare existing and reference conditions of specific ecosystem elements and to explain significant differences, similarities, or trends and their causes. The capability of the system to achieve key management plan objectives is also evaluated.

6. *Recommendations*
The purpose of this step is to bring the results of the previous steps to conclusion, focusing on management recommendations that are responsive to watershed processes identified in the analysis. By documenting logical flow through the analysis, issues and key questions (from step 2) are linked with the step 5 synthesis and interpretation of ecosystem understandings (from steps 1, 3, and 4). Monitoring activities are identified that are responsive to the issues and key questions. Data gaps and limitations of the analysis are also documented.

For each of the six steps, Part 2 of this document generally describes the purpose of the step, core analysis topics and questions, summary or over-view questions, information sources, techniques that might prove helpful, products the analysis team would expect to generate in this step (but not necessarily include in the final document), and a general discussion of the step. The relative duration of each step is shown in figure 1.

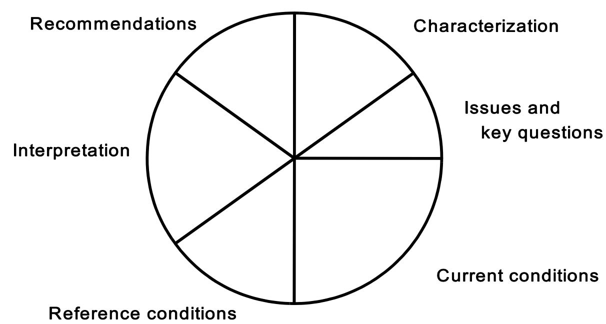

Figure 1. Relative duration of analysis steps.

Process Considerations

Participation in Watershed Analysis

Use a Qualified Interagency and Interdisciplinary Team
Teams conducting watershed analysis should include interagency and interdisciplinary resource specialists appropriate to the issues, ownerships, and respective jurisdictions within the watershed. Team members should be professionally qualified to assess and interpret the structure, composition, and functions of watershed-level ecosystems. Professional skills should

include those appropriate to analyze the core topics and other issues significant to the watershed. Involving other Federal agencies, especially early in the analysis, helps teams identify the full range of management issues and resource concerns in the watershed.

Involve Tribes

Tribes should be consulted and involved throughout the watershed analysis process, as appropriate, (1) to assist in the early identification of treaty rights, treaty protected resources, tribal trust resources, and other tribal concerns; and (2) to incorporate tribal data and resource knowledge into the analysis. Analysis reports should identify tribal trust resources that occur in the watershed and identify possible conflicts between potential Federal actions and management of the trust resources, treaty rights, tribal plans, and policies.

Involve State and Local Government

State and local governments play an essential role in determining ecosystem health at the watershed scale, both as land managers and regulators. State and local government participation will enable Federal land managers to consider all relevant issues in specific watershed analyses. Early and frequent interaction with state and local government partners also can help identify opportunities for cooperative efforts.

Involve the Public

Early, open, and frequent participation in the process by public stakeholders is encouraged. Public participants can provide important information about current and historical uses of the watershed, past disturbances, and location of unique and sensitive resources. Participation by public entities can help identify opportunities for public and private cooperation in watershed analysis, restoration, and other management activities. Among the many possible ways to involve publics are providing advanced notice of the intent to conduct an analysis, public meetings to solicit information useful in the analysis, providing opportunities for direct involvement in the analysis, and dissemination of analysis results.

Issues Define Scope and Priority of Analyses

Depth of Analysis

Even though all watershed analyses will follow the structure outlined in this guide and address core topics, the scope, intensity, and depth of analyses will depend on the important management and resource issues in the watershed. “Issues” can be triggering events that prompted the agency to initiate the analysis. In this context, issues include management programs, priorities, and potential projects; regulatory requirements; concerns people have about the watershed; or, other factors. Issues can also be resource problems or concerns in the watershed. In this context, issues include resource problems, concerns or other factors highlighted in the characterization of the watershed or in other steps.

This approach provides the flexibility for both triggering events and watershed specific resource problems and concerns to focus the analysis as appropriate. Responsible officials guiding the analysis will have to balance the number and scope of issues addressed in a given iteration of the analysis with available staffing and funding.

Priority Setting

The priorities for selecting watersheds to analyze reflect regional management priorities. Watersheds may be selected for analysis in response to anticipated resource and community needs, project opportunities, and existing issues that require immediate resolution.

Analysis Guides Project Development

Although known program needs, issues, and opportunities may initially target watersheds for analysis, the analysis will influence the determination of appropriateness and resulting character of projects. New program planning and resource management projects should be developed in conjunction with and incorporate the results of watershed analysis.

Incorporate Analysis Information From Other Sources

In most cases, analysis teams will have the benefit of other completed resource analyses. Forest-wide or District-wide analyses and plans, resource management plans, regional analyses, and species recovery plans will provide a wealth of information and analyses for the given watershed. Teams can interpret existing analyses as they relate to a particular watershed to speed their analyses without sacrificing scientific credibility. By incorporating the results of other analyses, teams may be able to reduce the size of their watershed reports. This method may not be appropriate for all resource issues, but teams should use the technique wherever possible to increase efficiency of team efforts.

Incremental Approach

Federal agencies will conduct multiple analysis iterations of watersheds as new information becomes available, or as ecological conditions, management needs, or social issues change. The time between iterations will depend on factors such as major disturbance events, monitoring or research results, new management objectives, and different regulatory requirements. Subsequent analysis iterations may be triggered when existing analyses do not adequately support informed decisionmaking for particular issues or projects. Future iterations also may be necessary to fill critical data gaps identified during earlier analyses. As subsequent analyses are conducted, new information will be added to that created in previous analyses.

Accountability

Peer Review
Watershed analysis teams are encouraged to review each others' approaches and reports. Agencies or administrative units should establish peer review procedures to evaluate all or a sample of watershed analyses conducted within their jurisdiction. The Research and Monitoring Committee, with concurrence by the Intergovernmental Advisory Committee, will develop a scientific peer review process to evaluate the scientific credibility and adequacy of watershed analyses. Such reviews could provide important feedback on whether analyses were based on sound scientific information, provided useful recommendations to managers, and met the requirements of existing plans and direction.

Responsible Official
The success of a watershed analysis will depend on how useful it is to decision makers and resource specialists applying the results. The ultimate adequacy of the analysis will, in large part, lie in the responsible official's ability to understand and apply the results to document a consistency of logic in reaching subsequent management decisions that meet the objectives of the Northwest Forest Plan (NFP) and other relevant land use plans.

Technical Considerations

Watershed Scales and Hierarchy

Definition of "Watershed"
"Watershed" refers to any area of land that drains to a common point. Unfortunately, the size of the area that one person associates with "watershed" may be quite a bit larger or smaller than the area another person has in mind when they say "watershed." To some, a watershed may be as large as the area that drains to the Columbia River. To others, it may be much smaller--maybe the area above a favorite fishing hole or hot springs. Both are technically correct. Before analysis at the watershed scale can begin, a consistent vision of the size of the area involved is needed.

Watersheds are hierarchical--little ones nest within larger ones. A set of commonly used terms that describe relative sizes of geographic areas is shown below and in figure 2. "Watershed" refers to one level in the progression of geographic sizes. A watershed is smaller than a river basin or subbasin, but it is larger than a drainage or site.

Hierarchy terms	Examples
Region	Pacific Northwest
Subregion	Middle Columbia
River Basin	Willamette River
Subbasin	Middle Fork Willamette
Watershed	M.F. Willamette downstream tributaries
Subwatershed	Hills Creek
Drainage	Packard Creek arm
Site	Hills Creek Dam

Because watersheds are hierarchical, smaller areas are described by subdividing larger areas. The U.S. Geological Survey completed mapping of the first four hierarchical levels of the United States in 1987. Across the United States, subdivision of fourth-level subbasins has been sporadically approached based on agency needs and available resources.

Watershed is a useful term to associate with all areas resulting from the first subdivision of a subbasin. The watershed, then, is the fifth largest level in the hierarchy and is often referred to as a "fifth-field watershed." With the increased emphasis on ecosystem-based management, the development of criteria for delineating the watershed and subwatershed levels is being given greater priority by Federal, state, local, and tribal governments.

The procedure for subdividing a subbasin into a collection of watersheds is highly debated. Regardless of the process used, subdivision of a subbasin yields two categories of watersheds: (1) true watersheds in which all water flows to a common point (figure 3, areas 1-7), and (2) areas formed as residuals or byproducts of delineating true watersheds (figure 3, areas 8 and 9). These residual areas may be referred to as composite watersheds, interfluvial areas, or facial areas. Both categories, being roughly the same size, fit within the watershed level of the geographic size hierarchy.

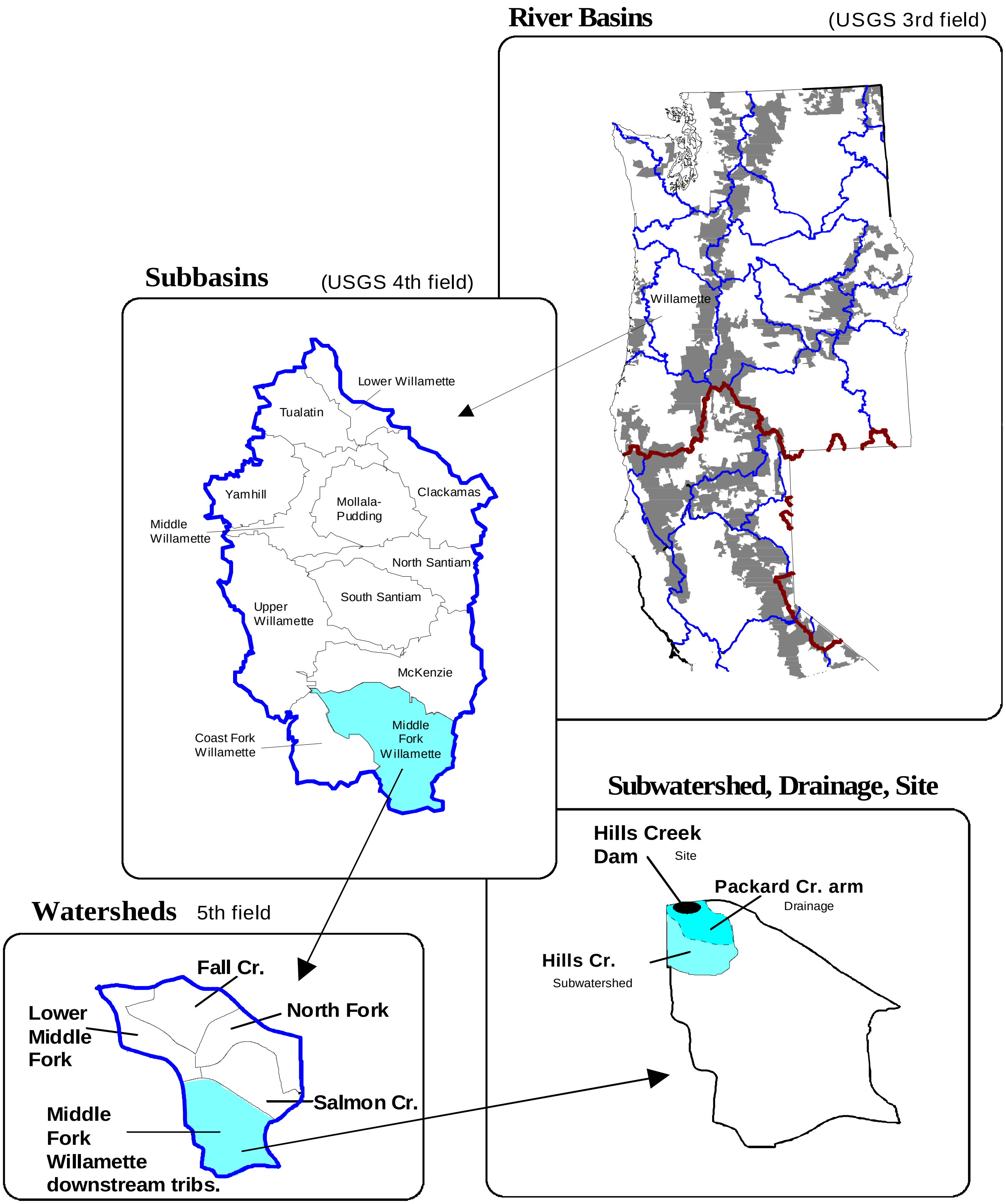

Figure 2. Hierarchy of watersheds.

Scales of Analysis

Any size land area can be selected for analysis. At the broadest scales, analyses provide the context for policy formulation and laws; e.g., regional-scale analyses from the Forest Ecosystem Management Assessment Team (FEMAT 1993) report resulted in a network of Late Successional Reserves (LSR) and other policies of the NFP. At finer scales, analyses provide the context for projects and are used to evaluate site-specific impacts or effects. Midscale analyses, at the watershed scale, provide the context for management through the description and understanding of specific ecosystem conditions and capabilities. Midscale analysis does not work well for all ecosystem components. Some components of ecosystems are best analyzed at larger scales (e.g., wildlife or fish populations, social interactions). Broad pattern recognition, process identification, and priorities for subsequent analysis over extended periods can be effectively completed at the river basin or subbasin scale.

Other ecosystem components may be analyzed best at smaller scales (e.g., some rare, threatened, or endangered plants). Analyses done at the drainage or site scale tend to be highly quantitative and appropriate for shorter time scales. Those issues possibly requiring areas smaller than the watershed for analysis can be addressed by further stratifying the land during analysis. There may be good reasons to resort to a subwatershed scale for some analyses. Analyses at the subwatershed level will tend to be more targeted at determination of potential effects of management activities rather than processes or functions of ecosystems.

Characterization and analysis of any ecosystem component need to be done at the scale appropriate for that component. The watershed becomes an identifiable analysis unit useful for reporting the results, conclusions, and recommendations in sufficient detail to provide the context for management decisions. Regardless of the physical area selected, one analysis will draw context from larger-scale analyses and provide the context for analyses at smaller scales.

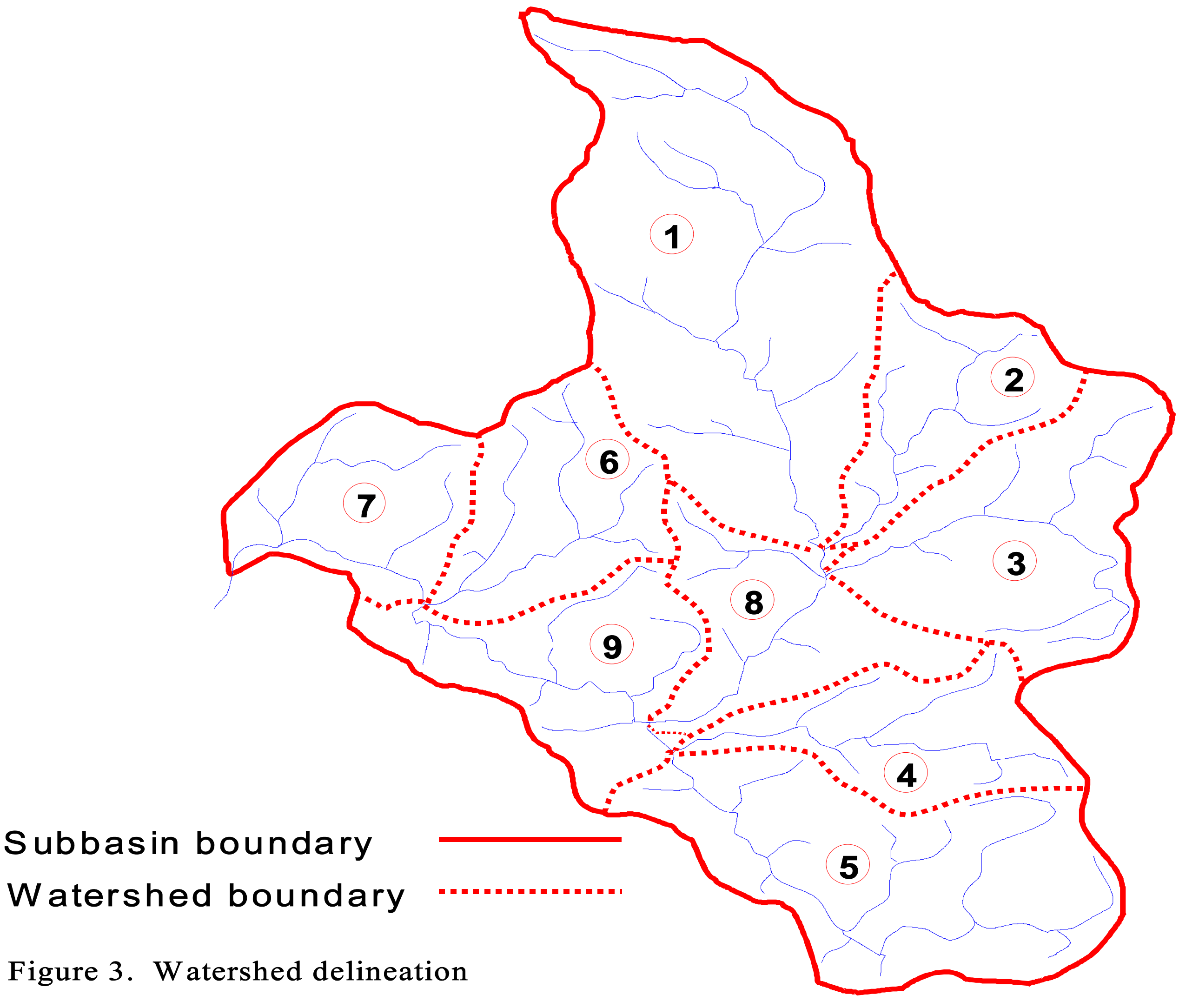

Figure 3. Watershed delineation

The size of the area chosen for analysis depends on the purpose of the analysis, the topics to be analyzed, and the physical, biological, and social complexity of the area. With watershed analysis, the challenge is to select an area such that the data and information are useful for deciding what management activities are compatible with ecosystem goals--not so broad that conclusions are not directly helpful to managers and not so refined or detailed that the information does not show broader ecosystem needs. The watershed provides an intermediate scale that satisfies many needs and offers a consistent format for reporting results of an analysis.

The analysis process described in this guide is designed for application at the watershed or subwatershed level. The guide does not address procedures for drainage or site-specific assessments that may be required under NEPA processes before project implementation. Similarly, the guide does not address consolidation of watershed analyses to assist in broad pattern recognition or process identification at the river basin or subbasin scales. Assessments of these larger scales are provided, for example, in the "Effectiveness Monitoring" section of the ROD (E-7). Specific methods for evaluating the success of the NFP in meeting the goals of biodiversity and late successional old-growth ecosystems are under development by the Research and Monitoring Committee.

Scale, Resolution, Utility, and Efficiency
Watershed-scale analysis guides site-level project planning and decisionmaking by providing the watershed context. As watershed size increases, it becomes more difficult to provide meaningful information for this use. As watershed size decreases, the larger scale context may be lost, and the analysis may begin to duplicate site-level or project-level assessments.

When planning a watershed analysis, teams should consider the size of the watershed relative to data needs, data availability, resolution, and time and resource requirements, as well as the issues to be addressed. Teams generally should avoid analyzing watersheds significantly smaller than 20 square miles or larger than 200 square miles.

Synthesis

Synthesis, the integration of separate ecosystem elements to understand the whole system, is a primary goal of watershed analysis. Teams can promote synthesis by looking for connections and relations between the major ecological features and processes in the watershed. For example, stream channel classification may be needed to understand fisheries use, and also to understand sediment transport processes and how they influence fish habitat. Synthesis depends heavily on close interdisciplinary work.

By developing the ability to integrate and synthesize the understanding of individuals and disciplines, teams can increase the scientific credibility and management utility of analysis results. Team understanding of the systems being analyzed allows more definite and accurate interpretations of conditions, causes, and trends. Team discussions early in the process (starting with step 1) can lead to a much clearer understanding of the processes and linkages between resources.

Data may be assembled, collected, or interpreted to serve a variety of purposes. As the team assembles information, it should anticipate the eventual uses of the data and analyses. Identifying common data and analysis needs early in the process and agreeing to common methods, to the extent possible, will contribute greatly to synthesis.

Tiered Key Questions

By developing tiers of hierarchical questions, teams can promote synthesis and develop consistent logic through the analysis. Broad questions addressing connections and relations can be progressively refined into more detailed or focused questions. For example:

> What human elements influence the condition of aquatic and terrestrial ecosystem elements?
>
> > How have human activities changed the landscape pattern of plant communities from the range of natural conditions in the watershed?
> >
> > > How have these changes in landscape patterns affected erosion processes, hydrology, channel form, water quality, distribution of species, and habitat quality?

Logic Tracking

A major objective for analysis reports is documenting the logic followed in the analysis process from planning the analysis through development of recommendations. Logic tracking is essential for the credibility and utility of the analysis. Because the results of each step can contribute greatly to the content of the final report, team members should also clearly document the work done in each progressive step.

Iterative Analysis Steps

Teams should generally conduct the six analysis steps in sequence. In some cases, information and understanding developed in one step may result in cycling back to previous steps to further refine the process or products, or both.

Data Gaps, Assumptions, and Level of Confidence

Teams may discover they lack, and cannot acquire, essential information about ecological processes and conditions in the watershed. When this happens, teams should describe in their report:
- Missing data needs
- Implications of data deficiencies and risks of proceeding given the quality of currently available data
- Recommendations for prioritizing data collection
- Assumptions used in the absence of data

This description is important to relate the level of confidence a team will have in their recommendations to the responsible official.

Possible strategies for addressing data gaps include:
- Attain complete data coverage of an area at a lower level of resolution than is ordinarily desired
- Attain complete data coverage of an area for a subset of the usual attributes
- Extrapolate data from representative subareas or substrata
- Stop analysis and collect data

Relation to Other Laws, Regulations, Processes, and Lands

Federal Laws and Regulation

Watershed analysis provides understanding of the watershed context that is essential to guide project planning and decisionmaking. Watershed analysis is not a decisionmaking process, and a watershed analysis report is not a decision document, a planning document requiring NEPA review, or a regulatory, prescriptive document. Watershed analysis contributes, however, to efficiently meeting land management and regulatory requirements at the watershed scale as the following examples show.

National Forest Management Act (NFMA), Federal Land Policy and Management Act (FLPMA), Oregon and California Lands Act (O&C Act)

Results from watershed analyses can assist in the development of ecologically sustainable commodity production programs (e.g., water, timber, recreation) by defining the context necessary to protect ecosystem functions. Analyses also can aid planning by stratifying areas of the watershed by inherent capability, sensitivity to disturbance, and suitability to sustain public use. Information should be presented in a manner that facilitates the location and timing of compatible projects; interpretation of applicable standards and guidelines with existing and possible future conditions; and assessments of habitat and population viability trends. The results of watershed analyses can facilitate program and budget development by identifying and setting priorities for social, economic, and ecological needs and capabilities within and among watersheds. Analyses also can assist in establishing a context for identifying and prioritizing watershed restoration needs. Analyses can support planning processes, including plan amendments if conflicts between plan features and ecosystem capabilities and protection needs are identified.

National Environmental Policy Act (NEPA)
Results of watershed analyses establish a consistent, watershed-wide context for project-level NEPA documents. Information from analyses should be used to enhance the quality of project or action-specific NEPA documents. Watershed analyses can form a strong basis for NEPA cumulative effects analysis by describing the current environment at the watershed level, past and present management activities and their influences on the watershed, and the likely historical conditions. In turn, project-level NEPA documents should augment watershed analyses with site-specific data and analyses. In reaching subsequent decisions through the NEPA process, responsible officials should document a consistency of logic with watershed analysis results.

Endangered Species Act (ESA)
Results of watershed analyses establish a consistent, watershed-wide context for Section 7 conferencing and consulting pursuant to the ESA. Analysis reports include information applicable to many projects and activities. Information on existing population status, species distribution, and habitat conditions presented in analyses can subsequently be used to evaluate the effects of proposed actions, assist in determining measures to avoid jeopardy and adverse modification of critical habitat, and reverse declining habitat and population trends. Information should be presented in

a manner that enables project-level consultation documents to directly reference or incorporate pertinent sections of analysis reports. Watershed analyses may also contribute information to support Section 4 and 7 (listing, recovery, and consultation) and Section 10 (permits and habitat conservation planning) activities.

Clean Water Act (CWA)
Results of watershed analyses establish a consistent watershed-wide context for water quality efforts by local governments and for protection of beneficial uses identified by the states and tribes in their water quality standards under the Federal Clean Water Act. Results of watershed analyses may sub-sequently be used to develop or update state, local, or tribal water quality management plans. Watershed analysis establishes a context for identifying resource protection and monitoring needs and restoration opportunities that are responsive to water quality issues described in the analysis.

Federal Trust Responsibilities to Indian Tribes
Watershed analyses establish the watershed context for early identification of treaty rights, treaty protected resources, and other tribal concerns. The results of watershed analyses will assist the Bureau of Land Management (BLM) and Forest Service (FS) in complying with policies and laws relating to tribal trust resources. Analysis reports should identify tribal trust resources that occur in the watershed and identify possible conflicts between potential Federal actions and management of the trust resources, treaty rights, tribal plans, and policies. Subsequent decisions concerning identified conflicts will be reached outside the watershed analysis framework, in ways consistent with the Federal government's trust responsibilities.

Other Analysis Processes and Plans

There are a variety of other analysis processes that are relevant at the watershed scale. Some examples are described below. Federal analysis teams should contact state, local, and tribal governments to determine if other analyses have been completed, are underway, or are planned in, or adjacent to, watersheds proposed for Federal analysis. Federal analysis teams should strive to conduct analyses in a manner consistent with this federal guide, but compatible with other relevant analysis processes. Teams should take advantage of opportunities for coordinated and cooperative analysis efforts, including data sharing, developing common data sets, agreeing to common analysis methods (modules), and defining compatible analysis boundaries.

State Water Quality Management Plans
Each state has the authority and responsibility to certify that Federal land management agency programs will meet water quality standards. Watershed analysis can be used to provide a basis for management prescriptions in both project and planning decisions. Where watershed analysis is being used to address Clean Water Act issues on both Federal and non-Federal land, there should be comparability and compatibility between analyses that cross geographic or jurisdictional boundaries.

Washington State Analysis Process
The Washington State watershed analysis process, developed by the Washington Forest Practices Board, is a principal tool for addressing cumulative effects of forest management on stream conditions. The Washington method includes modules for assessing elements of the watershed and synthesizing this information. While Washington modules describe a minimum protocol for conducting the analysis, the process allows for modifying the modules if the analysis team wishes to use equal or better methods. The analysis process results in a set of prescriptions for the watershed that are subjected to State review, then adopted as requirements for future forest management in that watershed.

Washington has delineated watershed analysis units that predefine the geographic scope of analyses conducted under state regulation. These watershed analysis units have been prioritized based on criteria reflecting need for cumulative effects analysis when conducted by the State. Analyses may be initiated by the Department of Natural Resources or by landowners within the watershed.

Local Watershed Efforts
Analyses at the watershed scale may be ongoing, planned, or have been completed by local watershed councils, model watershed groups, bioregional councils, conservation districts, or other local action groups. Analyses by these groups in cooperation with Natural Resources Conservation Service and other agencies may include inventory and assessment phases of watershed health activities, watershed planning, river basin studies, and Coordinated Resource Management Planning (CRMP). These volunteer private landowner processes may be relevant within a given watershed. Teams should identify and pursue opportunities for coordinated and cooperative analyses with these local efforts.

Habitat Conservation Plans on Non-Federal Lands
Both Federal and state watershed analyses offer interdisciplinary and cooperative processes that can provide information and establish a watershed-scale

context for habitat conservation plans developed for private lands under Section 10 of the Endangered Species Act.

Federal Watershed Analysis and Non-Federal Lands

Even though the Federal watershed analysis process is in no way intended to regulate non-Federal lands, analysis teams, as guided by responsible officials, will consider the interactions of various land ownerships in the watershed. Federal land management decisions based on the results of watershed analysis need to consider conditions and activities on adjacent non-Federal lands, especially to evaluate cumulative effects, as they affect public lands, pursuant to NFMA, NEPA, ESA, CWA, O&C Act, and other pertinent statutes. Consideration of these interactions is important to an overall understanding of ecological functions and processes.

Cooperative approaches to watershed analyses that cross jurisdictional and ownership boundaries are encouraged. Analysis teams, as guided by responsible officials, are encouraged to contact non-Federal landowners in the watershed and to foster voluntary participation in all stages of the analysis. Voluntary participation by non-Federal landowners will enhance each team's ability to share data and better understand the interactions of various land ownerships in the watershed. Teams should recognize that even with voluntary landowner participation, there may be concerns regarding proprietary data and public access to sensitive information.

In those instances where landowners do not voluntarily choose to participate, publicly available information should be used in the analysis. Publicly available information about topography, soils, geology, hydrology, transportation systems, and vegetation may be available, for example, through aerial photos, or state and local government records. Although this type of information will usually be available at a coarser level of resolution than information obtained through cooperative land- owner participation, it may be acceptable for developing a general understanding of the conditions and processes interacting with adjacent Federal lands.

Monitoring

Information from watershed analysis can be used to develop monitoring strategies and objectives for the watershed. Analyses provide information about patterns and processes within watersheds that can be used to:

- Reveal the most useful indicators for monitoring environmental change
- Detect magnitude and duration of changes in conditions
- Formulate and test hypotheses about the causes of the changes
- Understand these causes and predict impacts
- Manage the ecosystem for desired outcomes

Watershed analysis results assist in developing monitoring plans by revealing the most useful indicators for monitoring environmental changes within each watershed. Characteristics of good monitoring indicators, in addition to those described by MacDonald et al. (1991), include those that:

- Are sensitive and responsive to management actions
- Have low spatial and temporal variability
- Are easy to measure (accurate and precise)
- Relate directly to beneficial uses of the watershed
- Are early warning indicators
- Represent broader or more complex ecological processes or subsystem

When making recommendations for monitoring, teams should consider both the monitoring needs of the watershed and the role of the watershed in existing Forest, District, regional or other broader-scale monitoring plans. Monitoring plans developed at broader scales may require sample points within the watershed. Results of watershed analyses provide information for determining where such monitoring points should be located.

Core Topics

Every watershed analysis will be different, depending on the reasons for conducting the analysis and the resource concerns unique to the watershed, even though a common approach based on the six analysis steps will be followed. All watershed analyses should address the basic ecological conditions, processes, and interactions (elements) at work in the watershed. The following core topics are intended to provide the framework for focusing the basic analysis within the watershed. The appropriate level of detail needed to address each of the core topics should be determined by the responsible official, based on recommendations by the team and with consideration of the issues relevant to the analysis (triggering events or resource concerns).

The core topics represent the major and common ecological elements, and their relationships, in all watersheds. The topics are purposely broad and general, as they encourage a watershed-level perspective of the system as opposed to a site or project-level perspective. The purpose of the core topics is to ensure that responsible officials and their teams adequately address the major elements and their relationships in the watershed. The core analysis topics help ensure that analyses are sufficiently comprehensive to develop a basic understanding of the watershed. The analysis team should demonstrate understanding and knowledge of the basic ecological conditions, processes, and interactions in the watershed by addressing the following core topics through the six-step process:

- Erosion processes
- Hydrology
- Vegetation
- Stream channel
- Water quality
- Species and habitats
- Human uses

Core Questions

Core questions are designed to guide teams through the six-step process. The core questions are intended to focus the team's thinking on the core topics, not to set a minimum level of analysis needed to address each core topic. They are designed to help teams show a basic level of knowledge regarding the watershed through documentation of the findings and logic trail. The level of detail may range from professional knowledge and judgment to in-depth analysis, depending on the issues relevant to the analysis. The rationale for determining that a core question is not applicable will be documented.

The core questions are intended to be general in nature to allow the watershed team flexibility in determining the appropriate level of analysis, as judged by the responsible official, for each core topic. The analytical progression of the core questions for each topic generally parallels the analysis steps, with the first questions aimed at characterization and the last questions addressing integration and interpretation. Teams can apply this pattern of questions to other topics identified for analysis in a particular watershed. The following core questions are listed by core topic. These questions are repeated in Part 2 under the detailed descriptions of pertinent process steps.

Erosion Processes

Step 1: What erosion processes are dominant within the watershed (e.g., surface erosion processes, mass wasting)? Where have they occurred or are they likely to occur?

Step 2: Core questions not addressed.

Step 3: What are the current conditions and trends of the dominant erosion processes prevalent in the watershed?

Step 4: What are the historical erosion processes within the watershed (e.g., surface erosion processes, mass wasting)? Where have they occurred?

Step 5: What are the natural and human causes of changes between historical and current erosion processes in the watershed? What are the influences and relationships between erosion processes and other ecosystem processes (e.g., vegetation, woody debris recruitment)?

Step 6: Core questions not addressed.

Hydrology

Step 1: What are the dominant hydrologic characteristics (e.g., total discharge, peak flows, minimum flows) and other notable hydrologic features and processes in the watershed (e.g., cold water seeps, groundwater recharge areas)?

Step 2: Core questions not addressed.

Step 3: What are the current conditions and trends of the dominant hydrologic characteristics and features prevalent in the watershed?

Step 4: What are the historical hydrologic characteristics (e.g., total discharge, peak flows, minimum flows) and features (e.g., cold water seeps, groundwater recharge areas) in the watershed?

Step 5: What are the natural and human causes of change between historical and current hydrologic conditions? What are the influences and relationships between hydrologic processes and other ecosystem processes (e.g., sediment delivery, fish migration)?

Step 6: Core questions not addressed.

Vegetation

Step 1: What is the array and landscape pattern of plant communities and seral stages in the watershed (riparian and nonriparian)? What processes caused these patterns (e.g., fire, wind, mass wasting)?

Step 2: Core questions not addressed.

Step 3: What are the current conditions and trends of the prevalent plant communities and seral stages in the watershed (riparian and nonriparian)?

Step 4: What is the historical array and landscape pattern of plant communities and seral stages in the watershed (riparian and non-riparian)? What processes caused these patterns (e.g., fire, wind, mass wasting)?

Step 5: What are the natural and human causes of change between historical and current vegetative conditions? What are the influences and relationships between vegetation and seral patterns and other ecosystem processes in the watershed (e.g., hydrologic maturity, channel stability, shade, disturbance, species movements, soil and erosion processes)?

Step 6: Core questions not addressed.

Stream Channel

Step 1: What are the basic morphological characteristics of stream valleys or segments and the general sediment transport and deposition processes in the watershed (e.g., stratification using accepted classification systems)?

Step 2: Core questions not addressed.

Step 3: What are the current conditions and trends of stream channel types and sediment transport and deposition processes prevalent in the watershed?

Step 4: What were the historical morphological characteristics of stream valleys and general sediment transport and deposition processes in the watershed?

Step 5: What are the natural and human causes of change between historical and current channel conditions? What are the influences and relationships between channel conditions and other ecosystem processes in the watershed (e.g., inchannel habitat for fish and other aquatic species, water quality)?

Step 6: Core questions not addressed.

Water Quality

Step 1: What beneficial uses dependent on aquatic resources occur in the watershed? Which water quality parameters are critical to these uses?

Step 2: Core questions not addressed
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Step 3: What are the current conditions and trends of beneficial uses and associated water quality parameters?

Step 4: What were the historical water quality characteristics of the watershed?

Step 5: What are the natural and human causes of change between historical and current water quality conditions? What are the influences and relationships between water quality and other ecosystem processes in the watershed (e.g., mass wasting, fish habitat, stream reach vulnerability)?

Step 6: Core questions not addressed.

Species and Habitats

Step 1: What is the relative abundance and distribution of species of concern that are important in the watershed (e.g., threatened or endangered species, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?

Step 2: Core questions not addressed.

Step 3: What are the current habitat conditions and trends for the species of concern identified in steps 1 and 2?

Step 4: What was the historical relative abundance and distribution of species of concern and the condition and distribution of their habitats in the watershed?

Step 5: What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern in the watershed? What are the influences and relationships of species and their habitats with other ecosystem processes in the watershed?

Step 6: Core questions not addressed.

Human Uses

Step 1: What are the major human uses, including tribal uses and treaty rights? Where do they generally occur in the watershed (e.g., map the location of important human uses such as cultural sites, recreation developments, infrastructure)?

Step 2: Core questions not addressed.

Step 3: What are the current conditions and trends of the relevant human uses in the watershed?

Step 4: What are the major historical human uses in the watershed, including tribal and other cultural uses?

Step 5: What are the causes of change between historical and current human uses? What are the influences and relationships between human uses and other ecosystem processes in the watershed?

Step 6: Core questions not addressed.

Part 2: Process

Step 1: Characterization

Purpose

- To identify the dominant physical, biological, and human processes and features of the watershed that affect ecosystem function or condition.
- To relate these features and processes with those occurring in the river basin or province.
- To provide the watershed context for identifying elements that need to be addressed in the analysis.
- To identify, map, and describe the most important land allocations, plan objectives, and regulatory constraints (e.g., 303(d) stream reaches, critical habitat) that influence resource management in the watershed.

Core Topics and Questions

Erosion Processes
- What erosion processes are dominant within the watershed (e.g., surface erosion processes, mass wasting)? Where have they occurred or are they likely to occur?

Hydrology
- What are the dominant hydrologic characteristics (e.g., total discharge, peak flows, minimum flows) and other notable hydrologic features and processes in the watershed (e.g., cold water seeps, ground-water recharge areas)?

Vegetation
- What is the array and landscape pattern of plant communities and seral stages in the watershed (riparian and nonriparian)? What processes cause these patterns (e.g., fire, wind, mass wasting)?

Stream Channel
- What are the basic morphological characteristics of stream valleys and segments and the general sediment transport and deposition processes in the watershed (e.g., stratification using accepted classification systems)?

Water Quality
- What beneficial uses dependent on aquatic resources occur in the watershed? Which water quality parameters are critical to these uses?

Species and Habitats
- What is the relative abundance and distribution of species of concern that are important in the watershed (e.g., threatened or endangered species, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?

Human Uses
- What are the major human uses, including tribal uses and treaty rights? Where do they generally occur in the watershed (e.g., map the location of important human uses such as cultural sites, recreation developments, infrastructure)?

Summary Questions

1. Where is this watershed located in relation to the river basin?
2. What are the distinguishing physical, biological, and human features of the watershed?
3. What are the most important land allocations and management plan objectives that influence the watershed?
4. Do the characteristics of this watershed differ from neighboring watersheds or the river basin in which the watershed is located? Are they unique?
5. What are the ownership and land use patterns in the watershed?
6. What makes this watershed important to people?

Information Resources

- Existing maps or data.
- Existing resource information and land allocations from planning documents.
- Available literature.

Techniques

- Review large-scale plans, research, and other analyses for information specific to the river basin or watershed.
- Work in an integrated, interdisciplinary fashion to leverage the value of each individual's knowledge.
- Develop essential knowledge about the core topics and others through team teaching exercises (e.g., interdisciplinary team members present information to other team members).
- Based on current knowledge, discuss initial stratification of the watershed to organize the team's subsequent work. This stratification may be based on either process or condition information (e.g., subwatersheds, response units, geomorphology, fish production units).

Products

- Description (including maps) of the dominant features and processes, including the core topics, that characterize the watershed.
- Vicinity map showing the location of the watershed with respect to political, geographic or ecological boundaries and human population centers.
- Maps showing ownership patterns.
- Maps and descriptions of the most important land allocations, plan objectives, and regulatory constraints (e.g., 303(d) stream reaches, critical habitat) that influence resource management in the watershed.

Discussion

The objectives of step 1 are to identify the dominant physical, biological, and human processes or features of the watershed that regulate ecosystem function or condition and to relate these features and processes with those occurring in the river basin. Characterization establishes the relative importance of each of the core topics, as well as other analysis topics unique or relevant to the watershed. This step provides a broad watershed context useful in subsequent steps to identify the primary ecosystem elements that should be carried into the analysis.

Many physical, biological, and human processes or features span areas much larger than a watershed. To appropriately characterize and analyze specific aspects of the watershed, the watershed needs to be placed in its logical setting with respect to these larger scales. The basin perspective allows analysis teams to identify important characteristics or contributions of the watershed to issues or systems operating at larger scales. Examples are the identification of a watershed as an important habitat for a fish stock at risk and the watershed's role in species distribution and viability.

Characterization uses known information about the watershed to provide new information for the analysis through synthesis of the core topics. Teams may find that they need to return to step 1 and update the watershed characterization after completing subsequent steps of the analysis.

Step 2: Issues and Key Questions

Purpose

- To focus the analysis on the key elements of the ecosystem that are most relevant to the management questions, human values, or resource conditions within the watershed.
- To determine which core questions are applicable, establish the level of detail needed to address applicable core questions, and to document rationale for determining that a core question is not applicable.
- To identify additional relevant topics and questions based on issues in the watershed.
- To formulate key analysis questions for the watershed based on indicators commonly used to measure or interpret the key ecosystem elements.

Overview Questions

1. What are the resource concerns or problems that are unique or relevant to the watershed (including those identified for the core topics in step 1)?
2. What are the relevant management programs, priorities, needs, and projects of importance in this watershed (what triggered the need for this analysis)?
3. What do people care about in this watershed?
4. Are there obvious differences between the characteristics described in step 1 and those objectives or standards and guidelines documented in existing higher order plans (Forest and District plans) and regulations (ESA, NFMA, CWA, etc.)?
5. Based on the relative importance of the issues identified above in questions 1 through 4, which issues will be addressed in this iteration of the analysis?
6. What conditions and processes in the watershed (in addition to the core topics) are relevant in describing the issues?
7. Which ecosystem indicators are most useful to measure or interpret these conditions and processes?
8. Based on these indicators for each issue to be addressed, what are the key questions to be answered in this analysis iteration?

Information Resources

The process of identifying issues should lead the analysis team through a series of questions: What are the topics of concern in larger scale analyses or plans (basin or province) that are of importance in this watershed? Which of these issues are appropriate to address at the watershed scale? What triggered the need for this watershed analysis? What do managers need from this analysis to make better decisions, implement resource programs, or design projects? These types of questions help the team understand the context and importance of the watershed within the broader landscape. Additionally, the questions will help the team identify issues that cross watershed boundaries and that may be more appropriately analyzed at a broader scale. It is important to frame issues based on the entire watershed, regardless of land ownership.

Sources of issues include:
- Watershed characterization from step 1.
- Information from existing basin and higher order plans or assessments (e.g., Forest Land Management Plans, Bureau of Land Management Resource Management Plans, regional analyses, river basin analyses, monitoring plans, and state water quality assessments).
- Information from site-specific planning and analyses previously accomplished in the watershed (e.g., NEPA documents).
- Discussions with state, county, and tribal governments, and other Federal agencies.
- State and tribal water quality standards.
- Results of public involvement in either the watershed analysis or previous NEPA analyses.
- Interviews with local people and resource users.

Techniques

Prioritizing Issues
Once a list of issues is compiled, teams should make a preliminary assessment of priorities. For example, by designating each issue as high, moderate, or low priority, the team will be able to evaluate the necessity and probability for resolving each issue in a particular iteration of watershed analysis.

Prioritize issues to identify those needing investigation in this iteration of watershed analysis. In setting priorities, consider the following:
- Reasons for doing this watershed analysis (triggering events)
- Presence of critical stocks or populations
- Presence of threatened and endangered species
- Water-quality impaired stream reaches
- Anticipation of land management decisions or projects
- Resolution process for issues deferred from prior planning efforts
- Do not give all issues the same weight or the same urgency for resolution
- Document criteria used to prioritize the issues
- Reevaluate priorities for addressing an issue during the analysis as more information becomes available

Formulating Key Questions for the Watershed
- Identify indicators most useful in measuring or interpreting conditions of the core analysis topics.
- Based on the indicators, develop key questions, recognizing that each issue may have several key questions.
- Develop a series of questions that become progressively more refined
- Design key questions that:
  - Address the issues,
  - Focus on ecosystem elements that influence, and are influenced by, potential management actions and that can be measured at the watershed scale,
  - Promote synthesis among the core topics, and
  - Are expected to be answered by the analysis

Products

- List of issues that were reviewed and evaluated.
- Brief description of how the dominant ecosystem elements (including the core topics) from step 1 relate to the identified issues.
- List and briefly discuss the issues that the team decided to pursue at this time and an explanation for their specific selection.
- Description of the process the team used to identify and prioritize issues and to formulate key questions. (This will allow subsequent users of the analysis to understand the genesis and limitations of the analysis.)
- A set of key questions to be answered or addressed in the analysis.

Discussion

Watershed analyses assemble, organize, interpret, and present information needed to guide future resource management decisions. To meet this intent, step 2 has four phases: (1) identification of issues in the watershed; (2) prioritization of issues to identify the most important or relevant for anticipated management activities within the watershed; (3) identification of indicators most likely to reveal conditions of the core analysis topics; and (4) formulation of key questions about specific processes or conditions based on the issues and indicators. It is important to involve tribes, the public, state and county agencies, and other Federal agencies in step 2 of the analysis.

Step 3: Current Conditions

Purpose

- To develop information relevant to the issues and key questions from step 2 that is more detailed than information from the characterization in step 1.
- To document the current range, distribution, and condition of the core topics and other relevant ecosystem elements.

Core Topics and Questions

Erosion Processes
- What are the current conditions and trends of the dominant erosion processes prevalent in the watershed?

Hydrology
- What are the current conditions and trends of the dominant hydrologic characteristics and features prevalent in the watershed?

Vegetation
- What are the current conditions and trends of the prevalent plant communities and seral stages in the watershed (riparian and nonriparian)?

Stream Channel
- What are the current conditions and trends of stream channel types, and sediment transport and deposition processes prevalent in the watershed?

Water Quality
- What are the current conditions and trends of beneficial uses and associated water quality parameters?

Species and Habitats
- What are the current habitat conditions and trends for the species of concern identified in steps 1 and 2?

Human Uses
- What are the current conditions and trends of the prevalent human uses in the watershed?

Summary Question

- What are the current conditions and trends of the physical, biological, and human ecosystem elements, including the core topics?

Information Resources

- Information gathered from steps 1 and 2
- Results of existing surveys and inventories
- Maps
- Aerial photographs and other remote-sensing data
- Narratives
- Reports
- Records
- Anecdotal information
- Photographs
- Previous analyses
- Relevant research reports
- Results of modules

Techniques

- Interpret, evaluate, and summarize data.
- Establish methods and models.
- Stratify resources or their use within the watershed.

Products

- Maps, tables, text, charts, etc., that describe current conditions.
- Detailed descriptions of current conditions.
- Stratification maps, tables, and descriptions.

Discussion

In step 3, more detailed analyses will be completed for those core topics and other ecosystem elements identified in step 1 that are relevant to the issues and key questions identified in step 2. The analysis of current conditions in step 3 will develop additional detail over the characterization in step 1, as determined by the analysis team, to answer the key questions. Information germane to these key questions are collected and assembled in the analysis.

The watershed may be stratified, as needed, to accurately describe local conditions and processes. Data should be reported at a scale and resolution commensurate with the scale of the features and processes within the watershed. If conditions or values are averaged over an entire watershed, then data quality and utility may be affected.

Step 4: Reference Conditions

Purpose

- To explain how ecological conditions have changed over time as the result of human influence and natural disturbances.
- To develop a reference for comparison with current conditions and with key management plan objectives.

Core Topics and Questions

Erosion Processes
- What are the historical erosion processes within the watershed (e.g., surface erosion processes, mass wasting)? Where have they occurred?

Hydrology
- What are the historic hydrologic characteristics (e.g., total discharge, peak flows, minimum flows) and features (e.g., cold water seeps, groundwater recharge areas) in the watershed?

Vegetation
- What is the historic array and landscape pattern of plant communities and seral stages in the watershed (riparian and nonriparian) and what processes caused these patterns (e.g., fire, wind, mass wasting)?

Stream Channel
- What were the historic morphological characteristics of stream valleys and the general sediment transport and deposition processes in the watershed?

Water Quality
- What were the historic water-quality characteristics of the watershed?

Species and Habitats
- What was the historic relative abundance and distribution of species of concern and the condition and distribution of their habitats in the watershed?

Human Uses
- What were the major historical human uses in the watershed, including tribal and other cultural uses?

Summary Questions

1. What are the historical conditions of physical, biological and human ecosystem elements?
2. What has been the range, frequency, and distributions of ecosystem conditions during the current climatic period?
3. Have there been any fundamental changes to the system due to natural or human-caused disturbances?

Information Resources

- Historical information
- Available research reports
- Knowledge of basic ecological processes of the watershed
- Natural constraints and influences on ecological processes within the watershed
- Modeling results, if available
- Maps of potential vegetation
- Professional judgment

Techniques

- Comparison with "natural" areas
- Classification systems for various resource elements
- Condition ratings
- Watershed stratification
- Models and theories of ecological processes
- Literature reviews

Products

Maps, tables, charts, and text that describe (both qualitatively and quantitatively) the range, frequency, and distributions of ecosystem element conditions during the current major climatic period, stratified as appropriate.

Discussion

The intent of step 4 is to describe the known or inferred history of the landscape so that teams understand what existed in the past and what changes have occurred that may affect current capabilities. The reference condition step is based on the premise that ecosystems adapted over extended time periods and that the greatest probability for maintaining future sustainability is through management designed to maintain or reproduce natural components, structures, and processes.

Reference conditions can be used to help define goals or objectives established in management plans. For example, the ACS contains the objective of managing for maintenance of natural sediment regimes.

Sediment regimes differ between and within watersheds. Step 4 in watershed analysis can help define what is natural for any specific area or watershed.

The results of step 4 are not goals or desired future conditions (DFCs), but rather clues as to the function of ecological processes over the system's evolution period. No judgment is made on the optimal condition or value of elements. Teams document the range, frequency, and distributions of ecosystem element conditions and processes during the time span for which data are available for comparison with existing conditions and key management plan objectives. The significance of reference conditions with respect to issues from step 2 will be evaluated in step 5 (interpretation).

The conditions and values of ecosystem elements are dynamic in both space and time. The distribution of data values for ecosystem elements over a selected period of time may be termed the "reference variability." Distributions may differ spatially between different landscapes within the watershed, as well as temporally on a given landscape. This reference variability is similar to the concepts of "the natural range of variability" and "the historical range of variability." Because reference variability encompasses the full range of ecosystem conditions, processes, and values within the current climatic period, it includes both presettlement and historical epochs, as well as current conditions.

The time span for which data may be available will differ with ecosystem (e.g., grassland vs. riparian), ecosystem element (e.g., erosion processes vs. water quality), and geographic area (e.g., areas where only current and historical data are available versus those where paleoecosystems have been reconstructed). In many instances, data will not be available and the range and distribution of ecosystem conditions must be constructed from multiple sources, inference, and professional judgment.

Potential sources of historical information about the watershed include agency and landowners' inventories and records, early General Land Office and territorial surveys, settlers' and explorers' journals, ethnographic data on Native American uses, and other historical records that provide data relevant to the ecosystem elements being addressed. Anecdotal information sources may include oral histories, local knowledge, experiences of former employees and retirees, resource users, and stakeholders.

Step 5: Synthesis and Interpretation

Purpose

- To compare existing and reference conditions of specific ecosystem elements.
- To explain significant differences, similarities, or trends and their causes.
- To identify the capability of the system to achieve key management plan objectives.

Core Topics and Questions

Erosion Processes
- What are the natural and human causes of change between historical and current erosion processes in the watershed?
- What are the influences and relationships between erosion processes and other ecosystem processes (e.g., vegetation, woody debris recruitment, etc.)?

Hydrology
- What are the natural and human causes of change between historical and current hydrologic conditions?
- What are the influences and relationships between hydrological processes and other ecosystem processes (e.g., sediment delivery, fish migration)?

Vegetation
- What are the natural and human causes of change between historical and current vegetative conditions?
- What are the influences and relationships between vegetation and seral patterns and other ecosystem processes in the watershed (e.g., hydrologic maturity, channel stability, shade, disturbance, species movements, soil and erosion processes)?

Stream Channel
- What are the natural and human causes of change between historical and current channel conditions?
- What are the influences and relationships between channel conditions and other ecosystem processes in the watershed (e.g., sediment transport and deposition processes)?

Water Quality
- What are the natural and human causes of change between historical and current water-quality conditions?
- What are the influences and relationships between water quality and other ecosystem processes in the watershed (e.g., mass wasting, fish habitat, stream reaches vulnerability)?

Species and Habitats
- What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern in the watershed?
- What are the influences and relationships of species and their habitats with other ecosystem processes in the watershed?

Human Uses
- What are the causes of change between historical and current human uses?
- What are the influences and relationships between human uses and other ecosystem processes in the watershed?

Summary Questions

1. Are there obvious differences between existing and reference conditions of the core analysis topics? Of other relevant topics?
2. Are there trends in any of the physical, biological, and human elements? If so, what are the rates and magnitudes of change?
3. Which processes or causal mechanisms are most likely responsible for similarities, differences, and trends?
4. Have there been major natural and human-related disturbances or activities that have fundamentally altered the system and which would affect the ability of the system to achieve conditions as described in step 4, or management objectives from previously identified plans?
5. What are the implications of the changes and trends, including the capability of the watershed to achieve objectives from existing plans; e.g., attainment of ACS objectives?

Information Resources

- Watershed characterization from step 1
- Key issues and questions, including relevant management plans and laws that establish management objectives for the watershed, from step 2
- Data and descriptions from steps 3 and 4

Techniques

There are several techniques for comparing current conditions with historical and reference conditions. The techniques that can be used in watershed analysis will differ by resource, data availability, data format (e.g., survey data, maps, photos), data resolution, and desired products from the analysis. Techniques include:

- Condition ratings
- Map overlays
- Statistical comparisons
- Scientific method
- Models
- Logic tracking
- Classification systems
- Systems diagrams
- Stratification
- Synthesis

Products

- Description and explanation of trends for the core topics and others.
- Discussion and display of the dominant processes and causal mechanisms that explain the relationship between current and historical conditions (steps 1, 3, and 4) with the issues and key questions from step 2.
- Discussion of major natural and human-related changes in the system that have fundamentally altered the capability to achieve conditions as described in step 4 or key management plan objectives.
- Description of the discrepancies between the current resource conditions and relevant management objectives.
- Discussion of anticipated social or demographic changes or trends that could have ecosystem management implications.

Discussion

Step 5 is the place to synthesize and interpret information from the previous four steps. The spatial and temporal interaction of biological, physical, and social processes at work in the watershed are explained here. The implications of these interactions for attainment of management plan objectives identified in step 2 will be identified to provide a basis for management recommendations in step 6.

Differences in the range, frequency, and distribution of relevant historical, current, and natural conditions should be explained. Ecosystem processes and causal mechanisms that best explain the differences and how these factors affect the watershed's capability to achieve management objectives also should be identified. Discrepancies among watershed conditions, capabilities, and relevant management plan objectives should be identified. These will enable the team to make general recommendations in step 6 to correct and rectify inconsistencies between resource conditions and management objectives.

Data gathered and analyzed by using the modules or similar techniques should be quantitatively and qualitatively compared. Such comparisons will help the team arrive at conclusions regarding dominant changes that have occurred, processes and mechanisms responsible for the changes, natural or human-related causes of these changes, and effects on resources and issues of interest.

In step 5, the team should revisit and answer, to the extent possible, the key analysis questions developed in step 2. Questions that cannot be answered to the satisfaction of the team may need further analysis then or in the future. The final watershed analysis report should include a description of those questions answered and explain if and why any questions were deferred.

Logic tracking and documentation are critical in step 5. In reaching conclusions regarding core topics and others, the team should use the weight of evidence to reach and support their conclusions. The team should also review and revise system diagrams, or other logic documentation methods, and identify dominant processes and relationships.

Step 6: Recommendations

Purpose

- To bring the results of the previous steps to conclusion by focusing on management recommendations that are responsive to watershed processes identified in the analysis.
- To document logic flow through the analysis, linking issues and key questions from step 2 with the step 5 interpretation of ecosystem understandings (from steps 1, 3, and 4).
- To identify monitoring and research activities that are responsive to the issues and key questions.
- To identify data gaps and limitations of the analysis.

Questions

1. Which of the changes in ecosystem condition and function revealed in step 5 (including the core topics) require management action (restoration, maintenance, protection, alteration) to achieve management objectives identified in step 2?
2. What is the relative sequence of recommended management actions, based on resource risk and legal requirements?
3. How will the indicators identified in step 2 respond to the recommended management activities and over what duration? What level of certainty is involved?
4. What are the recommended monitoring and research actions and relative priorities for the above indicators?

Information Resources

- Products from the previous steps

Techniques

- Mapping
- Matrices
- Synthesis

Products

- Management recommendations (e.g., restoration, monitoring, protection of sensitive areas, and resources), based on the interpretation from step 5, that are responsive to the issues and key questions from step 2.
- Recommended timing, sequencing, and general location for each management recommendation.
- Anticipated rates and time frames for achieving the management objectives for each management recommendation.
- Recommended monitoring and research activities.
- Discussion of the limitations of the analysis, confidence in the analysis, data gaps, and implications of these limitations for management. If cross-boundary issues are identified, include a discussion of their extent and how they were resolved. (Refer to the cross-boundary discussion in step 2.)
- Maps and tables necessary for presentation.
- Summary tables or other clear presentation of logic tracking from step 1 through 6.

Discussion

The purpose of step 6 is to bring the results of the previous steps to conclusion and to focus on recommendations, not outputs. Completion of step 6 should enable the team to provide the logic flow from step 1 to step 6 and also make the task of documenting the process relatively simple.

Recommendations should address efficient ways to meet management objectives identified in steps 1 and 2; e.g., restoration activities, adjusting interim riparian reserve boundaries, and changing land allocation boundaries (through plan amendments) to resolve inconsistencies between objectives and resource capabilities.

The products of step 6 should be synthesized from the work of all involved disciplines. The recommendations are intended to be general in nature, address the conditions and processes in the watershed, and provide guidance for types of activities rather than site-specific recommendations. This does not imply that site-specific recommendations are never appropriate, but rather that recommendations should be commensurate with the scale of information in the analysis.

Teams should identify monitoring and research activities that address the issues and key questions (including requirements from higher-order monitoring plans), while focusing on watershed processes, trends, and data gaps.

Teams should address the expected effectiveness and relative risk associated with each recommended restoration activity and should document how these factors were considered when priorities were assigned to the recommendations.

Teams may prioritize areas of the watershed by importance in meeting management objectives. For example, for each stratum or area identified in step 3, identify the types of management activities expected to restore, maintain, enhance, or impede ecosystem functions.

In addition to recommendations, management actions that have the potential to cause undesirable trends or conditions (e.g., road building across the toe of a known landslide) also should be identified in the analysis report.

Watershed Analysis Report

Watershed analyses are documented in a report. This report is the communication of scientific information in terms useful to managers and resource specialists. The report should allow readers to easily follow the logic of the analysis, from characterization of watershed to the final recommendations and conclusions.

Suggested Format for Watershed Analysis Report

Executive Summary

Briefly describe the watershed context, highlights of the six steps, summary of findings, conclusions, and recommendations.

Step 1: Characterize the watershed
Characterize and highlight the dominant features and processes (ecological elements) of the watershed, including the core topics. Establish watershed context within the river basin.

Step 2: Identify issues and key questions
Identify issues (factors that triggered the analysis and resource concerns specific to the watershed) and key questions to focus the analysis.

Step 3: Describe current conditions
For the analysis topics relevant to the issues and key questions identified in step 2, provide a more detailed analysis than the characterization in step 1.

Step 4: Describe reference conditions
Explain how ecological conditions have changed as the result of human influence and natural disturbances for comparison with relevant management plan objectives.

Step 5: Synthesize and interpret results
Explain the changes in ecosystem conditions and their probable causes, including implications for watershed management objectives.

Step 6: Develop recommendations
Applying the results of steps 1 through 5, develop recommendations for management activities that are responsive to the issues and key questions from step 2; e.g., restoration, monitoring, and protection of sensitive areas and resources.

Suggested Appendices
A--Glossary
B--References
C--Maps

Glossary

Causal mechanism--Processes and related causes of change to conditions.

Component--Physical or biological features ("pieces") of an ecosystem (e.g., water, plant species, soils, and people).

Condition--The state of historical, current, or potential elements. May be a quantitative or qualitative descriptor.

Domain--(a) Subset of the elements of an ecosystem with scope or boundaries determined by links between ecosystem elements related to a particular issue or set of issues in a watershed. (b) A tool for organizing and focusing the analysis into issues regarding terrestrial, aquatic, and socio-economic resources.

Dominant--(a) Exercising the most influence or control. (b) Most prominent, as in position; ascendant. (c) Of, relating to, or being a species that is most characteristic of an ecological community and usually determining the presence, abundance, and type of other species.

Ecological process--(a) The actions or events that link organisms (including humans) and their environment, such as disturbance, successional development, nutrient cycling, carbon sequestration, productivity, and decay. (b) Flow or cycling of energy, materials, and nutrients through space and time (e.g., waters flow, photosynthesis, large woody debris recruitment, erosion)

Ecosystem--An ecological system, consisting of living organisms and nonliving components, as well as, flows and other processes, and the links and interrelationships among them from which "systems" properties, such as resilience and ecosystem function, emerge. While an ecosystem can occur on any scale, it is often convenient (for analysis, management, or other purposes) to delineate it as a geographic area, with its boundaries demarcating an area where links within the system are stronger than links with adjacent systems.

Ecosystem element--An identifiable component, process, or condition of an ecosystem.

Ecosystem function--(a) The process through which the constituent living and nonliving elements of ecosystems change and interact, including biogeochemical processes and succession. (b) A role of an ecosystem that is of value to society.

Indicators--Commonly used metrics for description or analysis of ecosystem elements. Example: If fire is an ecosystem component, severity, size, frequency, or seasonality are common metrics (indicators) of fire. Example: Vegetative age, size, and composition can serve as a surrogate, or indicator, of woody debris recruitment processes.

Integrate--(a) To make into a whole by bringing all parts together; unify. (b) To join with something else; unite. (c) To make part of a larger unit: integrated the new procedures into the work routine.

Issue--Issues can be triggering events that prompt an agency to initiate watershed analysis, including management programs, priorities, and potential projects; regulatory requirements; and, concerns people have about the watershed. Issues also can be resource problems, concerns, or other factors highlighted in the characterization of the watershed or in other steps of the analysis. The scope, intensity, and depth of watershed analyses depend on the important management and resource issues in the watershed.

Logic tracking--In watershed analysis, documenting a consistent flow of logic through the analysis steps, from step 1 (characterization) to step 6 (recommendations).

Potential--(a) Capable of being, but not yet in existence; latent. (b) The ecological community that would be established if all successional sequences of its ecosystem were completed without additional human-caused disturbance under present environmental conditions; often referred to as "potential natural community."

Reference conditions--Conditions characterizing ecosystem composition, structure, and function, and their variability.

Reference variability--Distribution of data values for ecosystem elements over a selected period. These data points include infrequent and extreme events over the length of record. Also applies to sociocultural elements. The timeframes selected for analysis of reference variabilities must be appropriate for the element considered.

Scientific method--Principles and empirical processes of discovery and demonstration considered characteristic of, or necessary for, scientific investigation, generally involving the observation of phenomena, the formulation of a hypothesis concerning the phenomena, experimentation to demonstrate the truth or falseness of the hypothesis, and a conclusion that validates or modifies the hypothesis.

Stratification--Process of categorizing different areas of the watershed that are similar in ecological function or response.

Structure--The spatial arrangement of the living and nonliving elements of an ecosystem.

Sustainability--The ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time.

Synthesis--The integration of separate ecosystem elements to understand the whole system; a primary goal of watershed analysis.

Systems diagrams--A graphic representation of a system. In watershed analysis, a diagram that identifies key resources, ecosystem processes and mechanisms, and interrelationships.

Triggering--To set off; initiate. An event that precipitates the conduct of a watershed analysis. One aspect of "issues" that influence the scope, intensity, and level of detail of a watershed analysis.

Values--Principles or qualities that are held in high esteem.

Watershed--Any area of land that drains to a common point. A watershed is smaller than a river basin or subbasin, but it is larger than a drainage or site. The term generally describes areas that result from the first subdivision of a subbasin, often referred to as a "fifth-field watershed" (see page 5).

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