Guidelines for Management of Wildland Watershed Projects
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Executive Summary

Literally hundreds of projects have endeavored to improve watershed situations on western rangelands and forestlands. Experience gained from these wildland watershed projects can be beneficial to people who are responsible for current or new projects.

The Wildland Resources Center—supported by a gift from the Pacific Gas and Electric Company, a private utility that manages watersheds—recently published 30 case studies on management of wildland watershed projects and held a Workshop on Management of Watershed Projects. There the case studies and management of projects were discussed by 43 watershed and fishery specialists. This report presents their findings and recommendations on management of projects.

Escalating Number of Projects

Nearly every state and province in the West has experienced a dramatic increase in the number of watershed projects during the past decade. An inventory by the Wildland Resources Center identified 330 wildland watershed projects that were started during the period 1906 to the present. Very few projects were started before World War II. Starts of new projects jumped upward and held steady during the 1950s, 1960s, and 1970s. A dramatic threefold increase in frequency of new projects occurred in 1980 and was sustained throughout the 1980s. The likelihood is that the pace of new projects being started will be sustained and may accelerate even more in the future.

Many agencies of government and innumerable private organizations are involved in these watershed and fishery projects. The guidelines and recommendations on management presented in this report are intended to be useful to people in these organizations involved with a current or new watershed project on western wildlands.

Benefiting from Past Experience

The Canadian Hydrology Symposium in 1988 pointed to some of the problems frequently encountered in research projects on forested watersheds. Key managerial problems revolved around adequacy and duration of funding, deficiencies in planning and leadership, and lack of long-term commitment by sponsors.

The Workshop on Management of Watershed Projects in 1990 used 30 case studies to examine what transpired in the management of selected projects. Difficulties that were encountered revolved around inadequate or unrealistic definitions of goals and objectives, inadequate planning and funding, lagging interest of sponsors during necessarily long-term undertakings, and technologies being applied that were inadequate or inappropriate for the situation.

Management Concepts

Some of the concepts, practices, and terms of management applicable to wildland watershed projects were presented and discussed at the workshop to give all participants a common footing.

The introduction to managerial concepts started with definitions provided in a glossary. Then it turned to the four dimensions of management: managerial functions, resources to be managed, capabilities of managers, and managerial roles. The four functions of management—planning, organizing, controlling, and evaluating—were quickly presented. Then the discussion turned to the five resources to be managed: people, money, physical resources, scientific and technical information, and time. The knowledge, skills, and abilities of effective managers were described as were the roles managers play in producing, implementing, innovating, overcoming obstacles, and integrating all activities.

Special attention was given to the resemblance of every organization to a social system having four interactive subsystems that must be managed. Features of the internal and external environments of a wildland watershed project were described.

At the conclusion of the presentation and discussion of this topic, participants decided how they wanted to structure their guidelines and recommendations for management of wildland watershed projects. They divided into five teams to focus on each of four phases of any project—problem identification, problem analysis, project implementation, and project evaluation—and a special topic, use of findings.

Problem Identification

The first phase of any project, problem identification, should begin with the recognition of a social or technical problem. This phase involves simultaneous clarification of the problem and negotiations among stakeholders. It ends with a commitment by one or more organizations to proceed to the following phase.

Participants at the workshop during their discussions of case studies identified 15 illustrative examples of difficulties encountered during problem identification.

The workshop team responsible for this topic emphasized that problem identification has two interacting dimensions: one associated with the problem or opportunity; the other associated with the stakeholders.

During this phase the problem or opportunity must be clearly and succinctly defined. Boundaries must be drawn realistically to limit the scope of what is to be analyzed and planned. The seriousness of the situation must be determined. Work on the problem dimension should only go so far as to show possibilities and limits or constraints.

The stakeholder dimension involves identifying and attempting to involve the individuals and organizations that are, or should be, concerned about the situation. Stakeholders for wildland watersheds include owners or managers of affected lands; organizations positioned to solve the problem, correct the situation, or capitalize on the opportunity; and special-interest groups.

During and at the conclusion of this phase the two dimensions merge. The stakeholders learn more about the problem or opportunity and what might be done about it. After discussions and negotiations, they reach a consensus on a final statement of the problem or opportunity and set a goal to be achieved.

Problem Analysis

The second phase of any wildland watershed project begins with an inquiry into the situation and ends with a plan for action. This phase features formation of a planning team, gathering and analysis of information, and production of a project plan. Like the preceding phase, problem analysis has two dimensions: one related to the problem or opportunity; the other related to the stakeholders.
Participants at the workshop produced long lists of positive and negative situations encountered in 30 wildland watershed projects. Some general managerial problems experienced were: failure to establish roles and contributions of stakeholders; failure to establish tight, achievable objectives for the project; and reliance on a multidisciplinary, rather than a unidisciplinary, approach. Problems with scheduling and financing included: failure to provide a realistic time frame and schedule; gross underestimation of costs for equipment and staff; and failure to budget for overtime work during storms. Problems related to technical considerations included: calling for instrumentation that was antiquated and inadequate; failure to estimate accurately the magnitude of streamflows and of debris transported during severe weather events; and prescribing the wrong technical solution.

The technical field of management can provide much help to people involved with analyzing problems and producing a plan of work. The technologies related to planning and finances are highly developed, and their application to wildland watershed projects is elucidated.

Recommendations by the workshop team responsible for this phase stressed that problem analysis starts with the goal and stakeholders emerging from problem identification and ends with a completed plan for action plus binding agreements. The agreements commit signatory stakeholders to support the plan of action that is to follow. The team provided an outline of 16 points to be covered during problem analysis. Their list provoked a long discussion that brought out many additional points to be considered during this important phase of gathering and analyzing information and deciding what should be done to improve the situation.

Project Implementation

This third phase of any wildland watershed project involves the execution of planned activities. Managerial functions exercised during this phase include organizing, controlling, and monitoring of the five available resources.

Here again, discussions of the case studies pointed to some characteristic situations that were encountered. Bureaucratic problems within and among governmental agencies resulted in inefficient work and inappropriate demands on the staff. The long-term commitments required for most projects led to difficulties resulting from turnover of personnel and dwindling interest by financial sponsors. Conflicts resulted from unclear and inadequate delegations of authority and responsibilities to project leaders.

Presence at the workshop of people who were knowledgeable about nine wildland projects that measured water yields provided a unique opportunity to show the time required for project implementation. Planning most frequently required 2 years. Start up required from 1 to 9 years, with 2 years being the modal time. Calibration before treatments ranged from 2 to 10 years; the mean was 6.2 years. Treatment periods required from 1 to 10 years and averaged 3.8 years. Measuring effects of treatments ranged from 0 to 100 years, but most were allowed only 2 to 7 years. However, the majority of projects needed more than 30 years to determine effects.

People involved with project implementation can benefit from the technical field of management. Technologies related to organizing, controlling and monitoring are explained.

The workshop team responsible for recommendations on project implementation organized their findings under eight headings: absolute commitment of resources, collecting quality data; depreciating resources; scheduling work; adding objectives; obtaining funding; focusing on objectives; and building feedback loops.

Project Evaluation

Management, activities, and accomplishments of a project should be evaluated frequently during the life of a wildland watershed project.

During discussions of case studies at the workshop, participants noted that most projects lacked a process for evaluation. Evaluations that were made tended to be done by a supervisor, a team from within the project, or some group having a special interest in the project. Such evaluations suffered from bias and narrow viewpoints. Only rarely were evaluations done as a basis for making decisions about the accomplishments and status of the project.

Evaluation is a field of management about which much is known. Great benefits can be realized from applying the technology of evaluation to wildland watershed projects. An outline of some technology related to evaluation is provided as a starting point for people responsible for planning, managing, and overseeing watershed projects.

The team at the workshop responsible for this topic emphasized two primary questions to be answered in the evaluation of any project. To what extent were planned objectives achieved, and did the project adhere to its schedule and budget? Extenuating circumstances contributing to delays or unexpected costs should be examined. Evaluation must be planned for and scheduled from the outset of a project, and it needs to be recurring in its frequency.

Use of Findings

Information flows from every wildland watershed project. It may be information about how to solve a practical problem. It may be an innovative new technology. Sometimes the information may have a negative twist, as when something failed to work or gave other than expected results. The staff of a project should be held responsible for spreading appropriate information to people in the project’s audience.

Notes made by participants during discussion of case studies at the workshop illustrated some problems and successes associated with dissemination of information from wildland watershed projects. Problems stemmed from: inadequacies of human and financial resources provided for technology transfer; expecting scientists to perform technology transfer without recognizing that they generally lack the knowledge, skills, and abilities to be transfer agents; and local people not accepting information that was not to their liking. Successes in dissemination were attributed to: projects using a variety of media, tours, and open houses to spread the word about what was being done and learned; employing specialists to transfer technology; and including cooperative extension from the project’s inception.

Application of technology is a subject about which much has been learned in recent years. Some important knowledge and methods applicable to wildland watershed projects are highlighted.

The workshop team responsible for this topic emphasized that technology needs to be both transferred, meaning handed off, and applied, meaning put into use. Each wildland watershed project should have a specific objective related to technology transfer, and the project should provide both mechanisms and an environment favoring transfer and application of technology. A list of 13 points considered to be important to the processes of transfer and application of information flowing from a project is provided.
Introduction

Experience from hundreds of watershed projects on western forestlands and rangelands, henceforth called wildlands, provides a wealth of knowledge about how such projects should be managed. Recently the Wildland Resources Center published a catalog describing 330 wildland watershed projects and case studies on management of 30 of these projects (Callaham 1990). All projects were located in the two western provinces of Canada, southeastern Alaska, and the 11 coterminous western states. Each case study briefly reviewed the
- background of the project
- problems encountered
- strengths and weaknesses of what was done
- how things might have been done better
- what was accomplished.

Authors of case studies and other watershed and fishery specialists participated in a Workshop on Management of Watershed Projects at Oakland, California, March 6-8, 1990 (Appendix A). The workshop enabled 43 specialists to critique the case studies, examine factors contributing to success and failure of watershed projects, and suggest how watershed projects should be managed.

This report summarizes their discussions and conclusions. Provided here are findings and recommendations on management of wildland watershed projects presented in four sections parallel to the four essential phases of any project:
- problem identification
- problem analysis
- project implementation
- project evaluation

plus a special section on
• use of findings

Each of these sections covers examples of actual situations encountered by workshop participants; applicable principles and practices from the general field of management; and recommendations and guidelines from a team of workshop participants. A special section of the report, that follows this introduction, provides an overview of concepts of management that are applicable to wildland watershed projects.

Hopefully the guidelines contained in this report will be useful to organizations and individuals undertaking watershed projects or seeking to improve management of projects already underway.

Escalation in Number of Projects

Management of wildland watershed projects is of much interest as indicated by the recent dramatic increase in the number of such projects (figure 1). From the center's recent inventory we were able to estimate starting dates for 196 wildland watershed projects across the West.

The earliest project reported to the center started in 1906 on the Snake River in Wyoming. Two more projects were started during the following decade. During the 1930s scattered experimental watersheds on forestlands and rangelands were established by USDA Forest Service.

Approximately equal numbers of projects—29, 26, and 29—were established during each of three decades—1950s, 1960s, and 1970s. These projects sought to

reduce downstream flooding and sedimentation from rangelands and forestlands

determine effects of harvesting timber and building roads on yield and quality of water and on habitats for fish

rehabilitate rangelands

understand hydrology

Several projects underway or started during the 1960s received impetus from the International Biological Program and the International Hydrological Decade.

During the 1980s the number of new wildland watershed projects more than tripled, to 9.2 per year as compared with 2.8 per year during the previous 30 years. Continuation of this pace into the 1990s was supported by our inventory finding nine new projects be started in 1990. These new and recently started projects seek to

• restore riparian habitats, depleted fisheries, and upland watersheds

• improve water quality

• understand cumulative effects

• rehabilitate urban creeks

• mitigate lost or damaged habitats for wildlife and fish

• determine impacts of atmospheric deposition

That the pace of establishment of wildland watersheds accelerated dramatically during the 1980s is illustrated by these programs conducted by governmental agencies and professional societies.

• Dozens, perhaps hundreds, of coordinated resource management and planning (CRMP) programs have been activated in western states. These programs are created by local initiative to guide actions in management of resources. They are based on resource boundaries and are not limited by individual, agency, or political constraints.

• British Columbia, in conjunction with federal Canadian agencies, started in 1980 a Stream Enhancement Program. The goal is restoration of populations of anadromous fish to historic levels.

• California's Department of Water Resources started in 1985 an Urban Streams Restoration Program that has funded more than 100 projects.

• Oregon's Watershed Enhancement Program provides technical assistance and grant funds for projects that improve or enhance riparian areas and associated uplands.

1Terms used in this report, both managerial and technical, are defined in Appendix B, Glossary of Terms Pertaining to Management of Watershed Projects.

Figure 1. Number of inventoried western projects started in each decade since 1900.
The program is managed by the Governor's Watershed Enhancement Board and became effective in 1987.

- USDA Forest Service declared a policy to establish riparian demonstration areas on each of its districts across the West. Best management practices are being applied in order to demonstrate the agency's intent and capability to restore degraded watersheds.

- A mini-competition has ensued between and within these two federal agencies to win awards for "Excellence in Riparian Habitat Management" given by the Western Division of the American Fisheries Society.

- The Oregon Chapter of the American Fisheries Society has repeatedly offered training in stream rehabilitation from design through evaluation. This training, emphasizing practical methods that are field tested and proven, enables the trainee to carry out a successful stream rehabilitation project.

Considering the incentives from inside and outside government agencies and the growing environmental consciousness of the public, we foresee dramatic increases in the number of wildland watershed projects during the 1990s. New projects will respond to the population's growing demand for quality water by expanding populations concern for the environment desire to rectify past abuses of natural resources alarm about global warming

Benefiting from Past Experience

Much has been learned from past projects that can be useful to people concerned about management of new or existing wildland watershed projects.

Experience from Canadian research. The Canadian Hydrology Symposium held at Banff, Alberta in May, 1988, provided a forum for discussion of some research projects on forested watersheds. The proceeding of that symposium (National Research Council of Canada, Associate Committee on Hydrology 1988) is the only previous publication dealing into managerial aspects of wildland watershed projects. The opening paper in the proceedings included brief statements on problems that were frequently encountered in the projects under consideration (Swanson et al., 1988).

Key problems related to financing and leadership were:
- lack of sufficient funds
- lack of commitment for on-going funding
- lack of awareness of real costs and time to obtain results
- too little time allowed for a study
- waste of time and energy striving for additional funding
- lack of a full-time coordinator (deemed in hindsight to be a necessity)

The Canadian research watershed projects encountered several other managerial problems:
- lack of a focused yet flexible long-range plan (leading to a lack of direction, collection of unusable or unneeded data, and failure to collect necessary data)
- lack of on-going commitment by agencies to the project and their shifting priorities (affecting allocation and commitment of funds and personnel)
- lack of on-going coordination (turnover of staff lead to a lack of continuity and commitment)
- lack of awareness of issues being addressed and problems being encountered

Swanson and his coauthors made three points on scientific problems related to project management:
- Results were not communicated in ways that received attention of managers.
- Research was done primarily in response to scientific curiosity rather than to a hydrologic problem (implying that wrong objectives had been established for the project in the beginning or that, if the objectives had been appropriate, they had not contributed to solving a problem).
- Research efforts were stifled by preconceived and unrealistic time tables.

Swanson and his coauthors added these points:
- Public involvement and high visibility—attained through demonstrations and workshops—should raise the awareness and the profile of the work that is being done, maximize information exchange, and increase the likelihood of findings being used.
- Management and operation should include a cooperative and highly involved team.
- If several agencies are involved, financial and jurisdictional commitments must be clarified and agreed to at the outset, a lead agency must be identified, and a full-time coordinator must be appointed.
- A permanent and secure field camp should be established.

Experience from case studies. The first inquiry in the United States into management of wildland watershed projects was at the workshop in 1990. It brought together specialists knowledgeable about hydrology and fisheries. They quickly wrote case studies describing what went on—both good and bad—in management of their projects. They explained conditions or factors that caused the project to be undertaken, named the stakeholders involved in the project, described the environment surrounding decisions to proceed, listed goals and objectives, described by whom and when planning was done, noted strengths and weaknesses of the plan, described problems that arose during implementation of the plan of work, discussed managerial and technical complications and contributing factors, described how and when the project was evaluated, described use of the project for educational purposes and to inform people about the outcome or findings.

These wildland watershed projects were managed by individuals or groups of people whose experience in management of project work ranged from considerable to none. Naturally the conditions encountered—technical, economic, social, and, political—made every project unique. As a result, each project had its own set of problems to be solved. These difficulties included:
- inadequate or unrealistic definition of goals and objectives
- inadequate funding, especially long-term
- vast planning with only half-vast resources
- unrealistic expectations about capabilities to perform needed work
- lagging of interest and financial support during long-term undertakings
- available technologies proved to be inadequate or inappropriate for practical application

Specific problems encountered during each phase of the management of a project will be listed and discussed in following sections of this report.
Concepts of Management Applied To Watershed Projects

Participants at the workshop were introduced to concepts of management applicable to watershed projects. This gave them a common understanding of terms used in management and some of the principles and practices basic to management.

A draft glossary of terms commonly used in management and in reference to watershed projects was introduced. Several participants served on a committee that contributed additional terms and definitions to the glossary for this report (Appendix B).

By the conclusion of the presentation and discussion of concepts of management, participants decided how they wanted to structure their guidelines and recommendations for management of watershed projects.

Managerial Concepts

The discussion of managerial concepts during the workshop started with definitions of management and then turned to a four-dimensional view of management (Table 1):

- Functions of management
- Resources to be managed
- Capabilities of managers
- Roles of managers

Participants briefly reviewed and generally accepted the definitions of terms related to management in the glossary in Appendix A:

- Management is getting things done through people under conditions of uncertainty and partial control.
- The responsibility of a manager is not to do things but rather to cause things to happen.

Managerial functions. The four functions of management—planning, organizing, controlling, and evaluating—were quickly outlined.

- Planning is thinking and deciding before acting.
- Organizing is gathering, structuring and coordinating the staff of the project and their relations to cooperators and collaborators, and the external cooperators.
- Controlling is assuring that everything is carried out in accordance with the plan, monitoring to acquire necessary information, and taking remedial actions. Controlling is the function that guides an action program toward its targets and measures progress.
- Evaluating inquires into what has been done, what has been accomplished. Its output is information about expenditures of resources, accomplishments, resulting benefits, and needs for remedial actions or activities.

Five resources to be managed. Managerial use of five available resources has a major impact on the success of any project.

- People—the human resource—are the most critical and essential resource. Without the intellectual and technical knowledge, skills, and abilities resident in its staff, no project could succeed.
- Scientific and technical Information is the often overlooked fourth resource. It is requisite for any project to succeed. The staff of any project must have access to appropriate information to fulfill their responsibilities. Time is often forgotten as a resource that must be managed. Whereas other resources—notably personnel and funds—can be added or withdrawn to change the pace of a project, time is fixed and limited. The time required to calibrate a watershed, before treatments can begin, is difficult to determine and can not be administratively fixed. Realistic expectations about the time required to accomplish objectives must be established at the outset of a project.

Managerial capabilities. The manager must have requisite knowledge, skills, abilities, and understanding to carry out an effective project. Knowledge includes not just technical subject matter, but also knowledge of management per se and of the internal and external environmental factors affecting a project. The manager must have skills and abilities to communicate, to negotiate, to convince, and to otherwise accomplish what is needed for the project.

Managerial roles. The manager must:

- produce, in the sense of accomplishing
- implement what is planned
- innovate, in the sense of doing things in new, novel, or different ways
- overcome obstacles or become more cost-effective
- integrate all of the functions, resources, and roles to achieve a desirable outcome for the project

Interactions between managerial roles and the resources and functions to be managed are easily illustrated. Consider the managerial roles related to management of financial resources. Leadership involves anticipating the needs and opportunities ahead; proposing and justifying budgets; lobbying to obtain funds; seeking grants and contracts; and involving cooperators to share costs. The role of delegating involves the manager in giving—to persons at the lowest appropriate levels in the organization—responsibilities and commensurate authorities for obligating and expending funds to meet the project’s financial obligations.

Money—the financial resource—obviously is critical to the success of any project. Probably more project failures and problems during the life of projects result from inadequate or delayed funding than from any other sources.

Physical resources—facilities, structures, equipment, and the watershed itself—are essential for any watershed project. Included, of course, are waterbodies, adjacent terrain, vegetation, wildlife, and dependent livestock. All are part of the complex facility that must be managed in a watershed project.

Managerial definitions. The manager must have appropriate responsibilities and commensurate authorities for managing the project and the watershed itself—essential for any watershed project. Included, of course, are waterbodies, adjacent terrain, vegetation, wildlife, and dependent livestock. All are part of the complex facility that must be managed in a watershed project.

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Organizations as Social Systems

Hershey & Blanchard (1982) have stressed that four managerial roles relate to four interactive subsystems to be managed. These roles and related subsystems are:

- implementing\(\rightarrow\)administrative/structural
- producing\(\rightarrow\)economic/technological
- innovating\(\rightarrow\)information/decision-making
- integrating\(\rightarrow\)human/social

The role of implementing involves the manager in the administrative and structural subsystem where he or she works on staffing, organizing, budgeting, reporting, and delegating authority.

Producing involves the manager in the economic and technological subsystem. The manager must utilize available resources to achieve programmatic objectives.

Innovating involves the manager in the third subsystem of information and decision making. In this subsystem information flows into and out of the project, and decisions are made based upon available information. The decision-making process has its own steps and procedures which must be followed if success is to be achieved.

Integrating, probably the most difficult role for the manager, involves the human and social subsystem. Included here are not only the human resources available to the project but also the social environment in which it must perform and accomplish its objectives. Included in integration is the bringing together of cooperating and collaborating organizations to plan for and participate in the project.

Internal and External Environments of a Project

The managerial environment of a watershed project has both internal and external dimensions.

**Internal environment for management.** The environment within a project is influenced by the:
- watershed situation
- ownerships involved
- motivation of management
- availability of resources

The situation of the particular watershed in which the project is being undertaken may range from one with little degree of risk to a great degree of risk. The watershed might simply have been available and appropriate for purposes of the project. On the other extreme, it might have been subject to abusive actions that contributed to a great alarm in the public arena. A flood downstream, the loss of a fishery, or some other calamity may have caused the situation in the watershed to appear as a crisis.

The number of landowners within the watershed can severely influence a project's complexity. If only one or a few landowners are involved, then decisions and actions may be taken more easily. If landowners share common values and viewpoints, then the project may proceed easily. If the landowners have divergent, strongly held viewpoints, then the project can expect to experience difficulties.

Management's motivation is an important internal environmental factor. It may positively or negatively affect the pursuit and outcome of a watershed project.

Managers responsible for a project at its outset may feel strongly about the importance of the water resource, but they may turn away from water and give other resources greater value as time passes. Watershed projects usually require a long period of investment and activity. If top management becomes fickle towards water, a project can suffer substantially.

Management, either because of the individuals involved or the environment in which they must work, may lack willingness either to undertake new initiatives or to assume risks associated with a project.

Management that is reluctant to delegate fully the authorities and responsibilities required to conduct a project may hamper its implementation.

Availability of resources to carry out a project may constitute the most constraining internal environmental factor.
- A qualified project leader must be available and willing to fulfill responsibilities of the position.
- Human resources—often involving multiple disciplines and having requisite technical knowledge, skills, and abilities—must be available to work in the project.
- Funds must be adequate and available, either from new sources or by redirection from existing sources, and predictable for long-term planning.
- Facilities—such things as, field camps, roads, trails, installations for data collection, and capabilities for data reduction and analysis—required to conduct the project must be either available or installed promptly and within budgetary constraints.
- Technology needed to carry out the project must be both adequate and available. If means of gathering data to answer technical questions are inadequate, then a project can expect to exceed schedules and budgets.
- Time, the finite resource, is a severe constraint in the internal environment of a project. Too often have wildland watershed projects lost support or been terminated before objectives were achieved.

**External environment for management.** A project is influenced by many factors in its surroundings:
- availability of suitable technology
- economic climate
- availability and status of cooperators and collaborators
- laws, regulations, and regulatory agencies
- adjacent landowners
- rights and demands of downstream water users
- public attitudes and awareness
- politics and politicians

The most important and critical factor for any watershed project is that there be available adequate and suitable technology to achieve the desired objectives. If technology is inadequate or untested, then serious contingencies must be planned for in any so-affected watershed project.

The second most important external environmental factor influencing a watershed project is the economic climate in which it occurs. Watershed projects require considerable financial and human resources. These resources must be sustained for a comparatively long time.

Some might regard a project's cooperators and collaborators as part of its internal environment. Actually they are external to the project, for they independently make their own decisions. Each one follows its self-determined course of action. Wooing, winning, and maintaining good relations with cooperators and collaborators are important tasks for the manager of any watershed project.
Laws and regulations affect uses of land and activities upon it. Regulatory agencies and the regulations that they promulgate and enforce may strongly influence a project. Conversely, if a project is primarily for purposes of research and development, then it may strongly influence current and future regulations.

Adjacent and local land owners are an obvious part of the external environment of a project. They require courteous attention to assure that they are aware of the project and its development and that it does not impact them negatively. Including their leadership in the project will foster their cooperation and help and their acceptance of findings.

Downstream from every wildland watershed project are many water users. Their rights to water may be affected by a watershed project. These users need to be informed about and involved in any watershed project that would affect their water rights and supply.

Many sectors of the public are parts of the audience for a project. Some sectors will have an active interest in a project, and their interest may warrant them being given a participatory role—serving on advisory boards, involvement in technology transfer, and perhaps even lobbying for financial support. Other sectors of the public, having only a passive interest in a project, need only to be informed about a project’s objectives and status.

All of these internal and external factors of the project’s environment affect the functions of management, resources to be managed, and role of the manager. They must be melded together as the project moves through its four phases:
- problem identification
- problem analysis
- project implementation
- project evaluation

Problem Identification

Each project should start with a problem. The problem should be couched in terms of something that needs to be fixed or something unknown that needs to be elucidated. Unfortunately, many past projects resulted from someone capturing an opportunity to carry out research on a pet topic, with the result that many important watershed management problems have not been addressed. All too often, past projects have strived to “solve” local problems for which a reasonably well defined solution already existed.

Watershed management problems are not all that easy to identify and define. The stakeholders may not be aware that a problem exists. In some cases, the real problem may not be the obvious technical one, but rather one of creating an awareness of a situation that may have serious repercussions at some future time or place. This is often the case with projects where the water users, who ultimately are affected by management in the headwaters, being unaware of linkages between activities on the watershed and effects on downstream water quality and streamflow regime.

Problem identification begins when an individual, a special-interest group, or a governmental agency, recognizes a situation having the possibility of creating current or future difficulties. The problem identification phase proceeds through a series of steps to its outcome—commitment by one or more organizations to proceed to the next phase.

This first phase of any project involves identification and clarification of a problem or opportunity and a decision or agreement to proceed to the next phase. During problem identification the stakeholders—those who have some part in the action or who are concerned about a solution to a problem—are identified. Negotiations among the stakeholders are undertaken to avoid addressing conflicting objectives and to gain a consensus that a problem or opportunity exists and that a project should be undertaken. When the consensus is reached, this phase ends, and the following phase, problem analysis, begins.

Situations Encountered

Unusual circumstances or serendipitous funding often leads to creation of a watershed project, but neither should be the principal reason for that project. For example, wildfires have led to projects in British Columbia, Montana, and Oregon. Flooding in Wyoming, Colorado, Utah, Idaho, New Mexico, and other states lead to public clamor that resulted in some of the earliest watershed projects. Drought, a recurring problem across the West, creates a demand for projects to augment the flow of water to meet the needs of communities and agriculture. Available money often provides unique opportunities for a watershed project. Examples are the many projects conducted as mitigation for lost habitats for fish or wildlife. Many of these projects resulted in improved management and provided useful findings for others to use, but many of them simply faded from view without publication or application of their findings.

Increasing pressure on owners and managers of forestlands and rangelands are being exerted as a result of federal, provincial, and state laws and related regulations. Impacts of these laws and regulations are such that the technology utilized in traditional practices of managing land and resources must be replaced or refined. But unfortunately, new technological innovations, the primary purpose for a watershed project, often are not realized because of poor communications between researchers and land managers.

Notes made by individual participants during discussions of case studies at the workshop illustrate some of the difficulties encountered and things to consider during problem identification.
- The process must be proactive not reactive.
- Focus on what causes the problem, not its features.
- Do not make anyone wrong in the process of problem identification.
- Resolve conflicting objectives of stakeholders.
- Move stakeholders to recognize and accept that a problem exists.
- Stakeholders should begin to recognize needs for changes in behavior and problem perception.
- Avoid or overcome emotional and political pressures that cloud the problem identification process.
- Resist political pressures that would incorrectly define the problem or its parameters.
- Resist pressure to retain the status quo.
- Require identification of a desired end product or result.
- Set goals in specific terms with sideboards to help avoid add ons.
- Resist stakeholders adding on their problem or subproblems that can detract from a sharp focus on the primary problem and add considerable complexity.
- Recognize that education and training with respect to anything new that comes out of the project would be an essential part of the project itself, that is, the project should cause new technology to be transferred and accepted.
- Require an interdisciplinary team.
- Most often this is a top -> down rather than a bottom -> up process.
What Management Would Suggest

Guidance in how to proceed with problem identification is diffused within the literature on management. Specific guidance on problem identification in contexts close to those of a watershed project is available. In California, 14 state and federal agencies have joined together in a Coordinated Resource Management and Planning Technical Advisory Council (CRMP). This council produced a handbook for those involved in the CRMP process (Anonymous 1990). The handbook describes 12 steps in the combined phases of problem identification and problem analysis. Appendices provide a "List of Planning Considerations", "Suggested Outline for a Coordinated Resource Management Plan", and pertinent "References".

Recommendations

The first phase of any watershed project has two important dimensions—the problem and the stakeholders. The problem dimension refers to enunciation and recognition of a social or technological situation causing difficulties or concerns for a significant sector of our society. The stakeholder dimension refers to the individuals, groups, and organizations, both public and private, involved with or impacted by the problem or situation. Stakeholders have a vested interest, either positive or negative, in the problem's solution.

Problems result when someone needs information, data, or the ability to cope with a technical or social situation. The first step is to define the problem clearly and succinctly with its scope and boundaries defined. The next step is to learn who is concerned about this problem.

Obvious stakeholders in most watershed situations are owners or managers of affected forestlands or rangelands. Other stakeholders include those who are clients for technology or who would be affected by a technical or social solution to the problem. Still other stakeholders, include those who may have legal, regulatory, or political concerns. These would include downstream users, governmental agencies, and special-interest groups in the private sector.

The primary stakeholders are those who are or would be positioned to solve the problem, correct the situation, or capitalize on the opportunity. Very often these primary stakeholders are the landowner and the landowners assignees—permittees, concessionaires, or contractors. If the problem requires new or modified technology, then governmental research agencies and universities may be primary stakeholders.

Identification of the many stakeholders involved in each problem or situation is an iterative process. At the beginning a few stakeholders are forthcoming or obvious. As the problem definition improves, other stakeholders may be identified and involved. Individuals and organizations affected by the problem should be contacted. Thus, development of the problem dimension influences development of the stakeholder dimension, and vice versa.

Each new stakeholder brought into the action will have different perspectives on the nature and seriousness of the problem and acceptability of alternatives for solving the problem. Some stakeholders who should be involved may decline to be involved. Some stakeholders who should be in a position to solve the problem may be unwilling either to recognize that a problem exists or to accept recommended solutions.

After the problem is recognized and the primary stakeholders are involved, efforts should be made to determine the seriousness of the problem and its consequences. Very often the seriousness of the problem can be interpreted in terms of what will happen if the problem is left unattended. Consequences of enduring the status quo or of correcting the problem should be estimated.

Continuing with the problem dimension, the problem needs to be diagnosed. Criteria need to be developed for use in expressing the seriousness of the problem. Effort should be directed at determining possibilities for solving the problem under existing laws, regulations, and policies and with existing resources and technology. In the same vein, effort should be directed at showing what is impossible today because of social or technological limitations. Work during this phase should only go so far as to show possibilities and limits or constraints. Detailed exploration along these lines is done during the next phase, problem analysis.

During the problem identification phase and at its conclusion the two dimensions merge. The stakeholders variously debate, negotiate, and learn about the problem or opportunity and what might be done about it. Ultimately they write a consensus statement about the real problem or opportunity and agree upon a goal to be achieved toward its solution. At this stage a consensus can be gained on the final statement of the problem.

Most stakeholders will accept that a problem exists, but there may not be total agreement on its expression or content. As this final statement of the problem is developed, care should be taken to involve key stakeholders who previously may not have been involved in this first phase of problem identification.

The final step of this first phase involves securing commitment by someone or some organization to undertake the problem analysis, the next phase. The handoff is made from the problem identification team to the team responsible for the problem analysis. There should be an ongoing interaction between these teams.

Problem Analysis

Analysis of components of the problem or situation begins with an inquiry and ends with a plan—a recommended action program. All dimensions of the problem or situation are examined whether they are of a social, economic, or technical nature. Alternatives for actions are considered. Both the positive and negative consequences of alternatives for action are evaluated. Impacts of the problem on stakeholders are estimated, as are costs to solve the problem.

This phase like the first phase has two dimensions. The stakeholder dimension involves, not only those suffering from the problem, but also those who would be required to solve it if resources were provided. Stakeholders also include those who would benefit from the project, e.g., downstream users. The problem dimension involves sociological and technological inquiries leading to declaration of specific objectives, targets for accomplishments, schedules, and budgets for an action program or project. Culmination of this second phase brings the stakeholder and problem dimensions together in a consensus to proceed with the program or project.

2Available at a cost of $5.00 from Calif. Assn. of Resource Conservation Districts, 3830 U Street, Sacramento, CA 95817
Situations Encountered

During discussions of case studies at the workshop, participants made notes on situations encountered during problem analysis. Their comments related to project management, scheduling, financing, and technical considerations.

Management

- Needed to establish roles of participants including a lead agency and to specify the nature of each agency's contribution.
- Failed to assign responsibilities to each organization that was participating.
- Contacts were made with movers and shakers among the constituents.
- Many (202) landowners involved were grouped into 20 subunits or subbasins as a means of trying to bring them into the planning.
- Needed to identify the leader or coordinator responsible for the analysis and specify that person's authorities and responsibilities.
- Responsible persons lacked knowledge and experience to deal with the problem.
- Responsible individuals lacked required expertise; a technical advisory committee should have been appointed to provide requisite multidisciplinary knowledge, skills, and abilities.
- Failed to specify who would be responsible for reporting (frequency, distribution of copies, reviews, approvals, etc.)
- Failed to establish objectives that were specific, finite, attainable, and measurable.
- Tried to solve all the issues, not just the primary problem.
- Individual sponsors added their own objectives which detracted from achieving the primary objective.
- Outcome of the analysis was a multiagency agreement for approval and endorsement by all participants.
- Process provided education for the clients and participants to bring them up to a state of readiness to make decisions and to begin the project.
- Decision-makers required on-the-ground review to appreciate the nature and seriousness of the situations.
- Process promoted local involvement and included key leaders and their education to ensure on the ground participation and support.
- Higher managers failure to accept responsibilities for the project required bringing force down upon them from still higher authorities.
- Management interfered with the process and diluted the effort.
- Process evolved as information was acquired.
- Process required feedback from and from affected clients.
- An interdisciplinary approach would have reduced the confusion that resulted from the unidisciplinary approach that was taken.
- Failed to allow for turnover of personnel.

Scheduling

- Failed to provide a realistic time frame and schedule for the project.
- Failed to recognize need for 24-hour staffing during prolonged storm events.
- Too often the time required to achieve objectives was grossly underestimated.
- Should have provided buffer time for unforeseen circumstances.
- Participants should have reviewed schedule to ensure they could meet deadlines.
- Schedule should have been in written form.
- Failed to allow time for training.

Financing

- Recognized the existing political processes and funding sources and adapted to them.
- A steering committee that included the financial sponsors of the projects was helpful.
- Process sought out sources of funding for various phases of the project.
- Grossly underestimated costs for purchase, maintenance, and replacement of equipment and for staff to collect and analyze data.
- Needed better estimates of costs for road construction, drainage, removal of sediments from settling basins.
- Failed in estimating the commitment needed.
- Failed to estimate needed resources of manpower, funds, and equipment.
- Forgot to consider the extraordinary costs for overtime work to collect data during natural events (storms) that exceeded customary hours of work.
- Failed to provide for maintenance of installations, e.g., maintenance of a new system to supply water to livestock away from streams.

Technical considerations

- Called for instrumentation consistent with the sophistication of the writers and expected operators, but that level was inadequate to meet needs experienced later.
- Appropriate technology was available, so a project to transfer technology was needed and should have been planned.
- Considered alternative watersheds for locating the project and found those where objectives could be achieved at reasonable costs with expected resources.
- Failed to recognize problems in scaling up technology, that came from studies on plots or small watersheds, for widespread applications on a watershed. (Work to develop and apply technology was lacking or deficient.)
- Failed to estimate accurately the magnitude of streamflows and of debris transported during severe weather events.
- Failed to recognize that treating only a small fraction of the watershed would not result in a measurable effect.
- Failed to consider some effects of past abuse of the watershed, such as sedimentation.
- Prescribed the wrong solution (instream structures), so time and effort were wasted until the error was recognized and an appropriate solution was identified.

What Management Would Suggest

Planning for Projects. Planning is defined as thinking in advance of doing, that is, thought before action. It involves assessing the future and making provisions for it. Planning shapes tomorrow's actions.

Decisions are made during planning about objectives, targets, required resources, and a program of work. Planning considers all of the internal and external factors related to a project and establishes the importance of each factor and interrelationships among factors.

Planning requires multiple considerations. Some of the variables which must be considered in the development of any plan include:

- stakeholders (cooperators, clients, special-interest groups)
- means (scarce or limited resources)
- schedules (flow and sequence of actions)
• constraints (capabilities, limitations, requirements, safety)
• threats and vulnerability (political, technological, environmental)
• appropriate technologies (possible, workable)
• alternatives
• efficiency (costs and efforts)
• effectiveness (capability of accomplishment)
• expected result or output (desired future state)
• benefits to be realized (returns on investment, societal impacts)
• review by qualified and affected individuals

A good plan can be characterized as:
• comprehensive
• explicit
• systematic (= preplanning, systems approach, and reiterations)
• formal (= written)
• reviewed by peers, stakeholders, technically qualified individuals
• accepted or approved by sponsors or superiors
• adequate basis for implementation

During the process planners sequentially:
• identify the internal and external environments of the project
• identify stakeholders and their concerns
• involve all cooperators or collaborators
• specify and clarify problems to be solved or overcome
• review the state of knowledge and technologies appropriate to the situation
• decide objectives
• set targets
• specify required resources
• schedule events
• seek review of and comments upon the draft plan
• obtain approval of the final plan by all significant stakeholders

Some barriers to effective planning need to be recognized and overcome. Typical barriers that are encountered include:
• administrative problems
  - information flow (insufficient, lacking quality, inaccurate)
  - planning costs (requires money, time, and information; costs to acquire, store, and retrieve data; recruiting and training of planners)
• reluctance to establish goals and objectives (unable or unwilling to engage in meaningful goals)
  - fear of failure
  - lack of organizational knowledge
  - lack of knowledge of the environment surrounding the problem
• human factors
  - psychological (too much attention to the present rather than to the future)
  - resistance to change (planning involves change, and human nature is to resist change)
  - lack of commitment to planning (planning regarded as an intellectual, passive exercise and not favored by managers prone to action)

The dimensions of tactical and operational planning, both applicable to watershed projects, are well known (Table 2). Tactical plans propose what might be done, suggest schedules, and estimate the consequences and impacts. They specify objectives and required resources. Tactical plans are useful in building support for a program or project. Operational plans are more detailed. Based on available or expected resources, they specify targets, commit resources, schedule work, and provide for the health and safety of workers.

### Table 2. Levels and features of planning applicable to watershed projects

<table>
<thead>
<tr>
<th>Question</th>
<th>Tactical</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Done by?</td>
<td>Programs; projects; basic org. unit</td>
<td>Individual; small team</td>
</tr>
<tr>
<td>What is it?</td>
<td>Problem analysis</td>
<td>Study plan; work plan</td>
</tr>
<tr>
<td>Why is it done?</td>
<td>Outline elements, objectives, and targets of work during 3-5 years</td>
<td>Provide a specific plan for action</td>
</tr>
<tr>
<td>Who participates?</td>
<td>Team comprised of leader + scientists + specialists</td>
<td>Scientists or specialists; reviewed by peers</td>
</tr>
<tr>
<td>When is it done?</td>
<td>Before program is proposed and at 3-5-year intervals</td>
<td>Before work starts and at times of major change of direction</td>
</tr>
<tr>
<td>How is it done?</td>
<td>Identify potential problems and stakeholders; assign priorities for work; estimate required resources; lay out timeline</td>
<td>Specify and clarify problems; review state of knowledge; establish specific objectives with targets; identify stakeholders; specify required resources; schedule events</td>
</tr>
</tbody>
</table>

Planning at the operational level has a number of definable attributes. It is:
• done by individuals or small teams
• provides a specific plan for action
• calls for finite resources
• involves specialists, scientists and cooperators
• done before work starts
• done at times of major changes of direction

### Steps in financing projects

Work to finance a project starts with the identification of sources of funds and the qualifications and processes required to obtain funds from each source. While this is going on, every effort should be made to develop realistic estimates of the funds that will be required during each phase of the project. Included is the funding required for:
• planning
• start up costs (including initial road and trail construction and installation of data collection facilities)
• annual costs of operation
  - during the phase-in
  - routine operations
  - anticipated effects of inflation
  - during the close-out (when routine annual expenditures decrease but unusual expenditures for wrap-up activities necessarily increase)
• technology transfer

Care should be taken to include some estimate of costs for technology transfer or other use of the findings that will come from the project after the project is terminated. If technology transfer is a part of the project then it needs to be included in the budget. If it is to be separated from the project, then costs should be estimated so they will not be overlooked by organizations responsible for using findings from the project.
Usually the individual or team responsible for the problem analysis is not responsible for lobbying to secure funds, but the need for this activity should be recognized and met. Leaders need to anticipate and foresee the needs ahead, propose and justify budgets, lobby to obtain funds, seek grants and contracts, and seek and involve cooperators or collaborators to share the costs.

General problems experienced in financing watershed projects revolve around:
- substantial initial outlays for treatments and for measuring effects
- long time required for calibration (of water yield and quality)
- long time required for monitoring to determine effects of treatments
- long time required to show benefits in relation to costs
- low value (sometimes unrealistically low) placed upon water vis-a-vis other resources and land uses
- lack of a "market" return from investments to produce more or better water or more fish
- disassociation of those who receive benefits downstream from those who incur upstream costs of production
- competition for discretionary funds in bureaucracies
- inflation and shrinking budgets in the public and private sectors
- legal limits placed on federal spending (Gramm-Rudman) and spending by some states (California's Proposition 9, the Gann Spending Limit)

Recommendations

The workshop team responsible for this phase provided an outline of steps in the problem analysis for any watershed project (figure 2). It should start from the group of clients and potential financial sponsors involved in problem identification. It should end upon completion of a plan for the project and signing of formal agreements or contracts. These should bind sponsors and participants together in the project that will follow.

An outline of the process. The small team working on this topic at the workshop provided a detailed outline of 16 points to be covered during problem analysis and related decisions that should precede starting of work on any watershed project.

1. Recognize that analysis is an evolving process based on acquisition of knowledge and that it requires feedback from affected clientele
2. Associate problems or opportunities with relevant political and socioeconomic issues important to client groups
   a. Determine level of resolution
      1) How good is "good enough"?
      2) Estimate costs
   b. Define relevant issues in terms sufficiently broad to accommodate changes over time
   c. Estimate economic impacts
      1) Experienced in the past
      2) Anticipated in the future
   d. What will be the costs of taking no action? Is this an alternative?
   a. Explore issues
      1) Erosion and sedimentation
      2) Water quality and quantity
      3) Fire protection and control
      4) Biological status
         a) Aquatic life and habitats
         b) Terrestrial life and habitats
         c) Vegetation management
      f. Identify patterns of land ownership

3. Determine how decisions will be made
   a. By consensus
   b. By represented constituencies as defined by
      1) Expertise
      2) Agency
      3) Funding source
      4) Interest groups
      5) Landowners or managers
      6) Other
   c. Recognize that constituencies represented may change as the analysis matures

4. Name a leader or coordinator to manage the process of the analysis
   a. Establish objectives and priorities
   b. Acquire needed resources
   c. Establish and adhere to a schedule of work

5. Identify human resources and expertise needed for the analysis

6. Develop a procedure for insuring continuity of program and leadership

7. Develop a procedure to insure all appropriate stakeholders are included in the analytical process

8. Recognize legal and regulatory parameters
   a. Water quality standards
   b. Biological thresholds and objectives
      1) Fisheries
      2) Wildlife
      3) Special-status species

9. Identify what will not be included
   a. Exclude issues that can not be resolved
      1) Established constraints on water quality

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Figure 2. Steps and participants in problem analysis for a watershed project.

<table>
<thead>
<tr>
<th>Problem Identification Phase</th>
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</thead>
<tbody>
<tr>
<td>Problem Analysis Phase</td>
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<tr>
<td>Stakeholders</td>
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<tr>
<td>Sponsors, clients, special-interest groups</td>
</tr>
<tr>
<td>Planning Team</td>
</tr>
<tr>
<td>Coordinator/leader, technical experts, representatives of stakeholders, consultants</td>
</tr>
<tr>
<td>Information Gathering</td>
</tr>
<tr>
<td>Social situations, laws and regulations, scientific and technical documents, environmental studies and reports, public meetings</td>
</tr>
<tr>
<td>Project Planning</td>
</tr>
<tr>
<td>Objectives and scope, plan of work, tasks, costs and schedules</td>
</tr>
<tr>
<td>Approval to Proceed</td>
</tr>
<tr>
<td>Signing of agreements among stakeholders, negotiations for funding</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Project Implementation Phase</th>
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</thead>
<tbody>
<tr>
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<td>3. Determine how decisions will be made</td>
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<td>c. Establish and adhere to a schedule of work</td>
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<td>3) Special-status species</td>
</tr>
<tr>
<td>9. Identify what will not be included</td>
</tr>
<tr>
<td>a. Exclude issues that can not be resolved</td>
</tr>
<tr>
<td>1) Established constraints on water quality</td>
</tr>
</tbody>
</table>

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10. Determine the amount of time necessary or available for analysis
   a. Consider constraints imposed by other scheduled activities
   b. Deterioration of the situation may require haste
   c. Synchronize with funding cycles
   d. Recognize seasonal constraints
   e. Look for windows of opportunity
11. Identify project "stoppers"
   a. Environmental impact statements or reports
   b. Policy constraints, as on use of toxicants
   c. Administrative constraints (tim ing)
   d. Operational constraints (ti ming)
   e. Data collection and management
   f. Cultural resource problems
      1) Archaeological sites
      2) Rights of Native Americans
   g. Assigned land uses and implied limitations
      1) Gravel harvest
      2) Quarry sites
   h. Lack of geomorphological information
   i. Financial support
      1) For analysis
      2) For project
12. Establish project priorities
13. Assure change within context of objectives as project matures
   a. Anticipate emergence of new interest and pressure this may generate
   b. Be opportunistic; be ready to take advantage of unscheduled opportunities to enrich data collection
14. Estimate costs appropriate to the project
15. Include a plan for technology transfer
16. Signatures of all participants should be in the resulting project plan
   a. Identifies a "buy in"
   b. Represents a proprietary interest
   c. Establishes commitments

Expansion on the outline. Open discussion of this outline by all participants brought out many interesting points about the problem analysis phase.

- The job of planning is to anticipate contingencies and to foresee the unforeseeable.
- Analysis and planning have costs and needs that must be met. Provision must be made by sponsors of the project or others to pay these costs.
- The problem analysis requires a leader, coordinator, or facilitator whose job it is to oversee the processes of analysis and planning. The individual in this position needs to have responsibility and authorities to establish the approach, set priorities, and establish targets for the analysis and planning phase. Further, the individual should have authority to gather required resources and to deal with groups of people who need to be informed and involved.
- The basis for and process of making decisions about the course of the project needs to be agreed to very early in the planning process. Delegations of authority and responsibilities for decisions by the project leader need to be spelled out. Decisions that the project leader must make to higher authorities need to be described, and the individual responsible for those decisions needs to be designated.
- Recruiting and filling the job of project leader with a strong individual is a key to future survival and longevity of the project.
- Elements for the job description of the project leader should be listed by the planning team. The position should require technical capability, commitment, ability to work with others, and ability to stand up for and represent the project. The chosen individual should be released from all other responsibilities in order to be free for full-time work as project leader.
- A technical panel of consultants should be involved in or available to the planners for a project in order to provide needed multidisciplinary expertise and advice from people who have carried out comparable projects.
- The staff persons involved in analysis and planning require access to data and to scientific and technical information.
- The analysis and planning process needs to involve downstream stakeholders who would benefit from the project. It needs to involve those who would sanction it or finance it. It needs to involve those who would observe or react to it critically.
- Special-interest groups, which may or may not have not entered during the problem identification phase, need to be involved so as to avoid the project receiving unanticipated criticism from its blind side during implementation.
- Watch out for organizations signing on with hidden agendas so as to block or hinder the project.
- Provision should be made in the analysis and planning for what can be done with existing or anticipated resources. Existing resources should be defined. Further, the analysis or plan should show what could be done if additional resources could be provided, in case sponsors for this additional work can be found.
- The project plan must provide accurate estimates of costs for staff, travel, living expenses, equipment and field facilities, for collecting and analyzing data, and for reporting and disseminating findings.
- Costs can be estimated accurately only after
  - objectives have been specified
  - required data and information have been gathered
  - the required sensitivity has been specified
  - costs have been estimated for facilities, hardware, software, and human resources to carry out the project
- Allowance must be made for inflation of costs during the rather long life of watershed projects which often exceeds 20 to 30 years.
- Recognize that opportunistic projects tend to be under-funded and difficult to finance. (They lack the crisis element that favors financial support.)
- Projects too often are adorned to look like Christmas trees. New sponsors or groups having special interests want to add their own ornaments. While some allowance must be made for additions to any project, an effort should be made to keep the project narrow and focused on its primary objective. If others want to augment and embellish it with their activities, then let them do so by their added efforts. No add-on should be allowed to detract from or compete with achievement of the primary objectives.
- The planning team must recognize a need for flexibility in what it proposes, but with side-bars to assure that something meaningful can and will be done in the life of the project.
- The analysis and plan needs to recognize constraints or stoppers on the proposed activities. These may be biological, physical, legal, or regulatory in nature.
- Project plans need to specify the kinds, quantities, and qualities of data to be collected, how data will be maintained, analyzed, and reported, and what facilities must be provided and maintained.
- The analysis and plan must specify the desired level of resolution of the information that will be obtained from the project.
• Unnecessary refinements in data collection and analysis should be avoided. Refinements to detect small differences from treatments on the watershed may not be economically feasible.

• Many past watershed projects could not make inferences from their data because of the lack of controls (data were lacking for untreated conditions). Therefore, all watershed projects should either provide for measurements during an untreated period prior to treatment or from paired watersheds in which one watershed is an untreated control.

• The wrong approach is to collect data with anticipation of analysis. The only acceptable approach is to specify objectives and required analyses and then to decide what data are required and how they will be collected. All of this should be done prior to decisions about kinds of equipment and installations that will be used for data collection and analysis.

• Larger and longer studies should use a phased plan that provides operational information for the start up and early phases of the project and provides a tactical plan for the remainder of the project. Detailed planning for later phases and the conclusion of the project should be done midway of the project's life. In the same way objectives should be subdivided to make smaller objectives that are attainable in each phase of the project.

• Planning must consider the likelihood of getting maximum and minimum occurrences of weather events during the calibration period and in determining the effects of these events.

• Beware of not allowing adequate time for calibration of watersheds before treatments begin.

• Identify safety and health hazards associated with the project and prescribe ways to deal with them. Assign to individuals their responsibilities for safety and health considerations.

• At the conclusion of the analysis and planning process, stakeholders desiring to continue must
- sign on to the project
- become committed to and own part of the project package
- ensure that signatures indicating acceptance are taken at all levels above the project within the host organization (to ensure that changes in positions of line managers two and three steps above the project leader will not adversely affect the project).

• Some of the individuals involved in problem analysis and planning should be involved in implementation of the project. Handoff of the plan to the project leader and staff must be skilfully and tactfully handled.

**Project Implementation**

The purpose of project implementation is "to take the dream to reality". This third phase of any watershed project involves the execution of work and activities that have been planned during the preceding phase. This phase requires line management of the project by a responsible leader. Managerial functions to be exercised include organizing, controlling, and monitoring of the five resources available to the project.

**Situations Encountered**

Notes made by workshop participants during discussions of case studies point to some of the situations that were encountered in a wide range of projects. A brief look at situations encountered in earlier projects may help leaders of existing and new projects to avoid some pitfalls. These notes are organized under headings that were used previously in this report—management, financing, and technical considerations.

**Management**

- Success drove the program and its modifications.
- Bureaucratic problems put a bind on the project and resulted in inefficiency of work and inappropriate demands on the staff.
- Stakeholders failed to recognize the considerable time required for water quality and yield to recover to preharvest conditions.
- Turnover of personnel caused serious problems in consistency of the program.
- Inconsistencies in the project staff created difficulties.
- The long-term commitment required for most projects conflicted with the family life, mobility, and career opportunities of the staff.
- Agency hierarchies and policies were not flexible enough to permit employing or retaining the right person as leader.
- The project leader should have reported to only one institution and one superior person.
- Conflicts arose because the project leader did not control affected resources—timber, water, or grazing.
- Authorities and responsibilities delegated to the project leader were not spelled out.
- The project leader was required to go to a superior for certain decisions, but those kinds of decisions were not specified and the position of the person responsible for making those decisions was not clearly defined.
- The project leader, not being strongly dedicated to the project, failed to meet his responsibilities.
- Weaknesses arose because the plan of work was inadequate or required changing due to unanticipated circumstances.
- Technology transfer was not provided for during the problem analysis phase, so a technology transfer plan had to be developed as the project generated information for transfer to others.
- Lacking a clear mandate, the project had difficulty with its sponsors, staff, and achievement of objectives.
- As situations and objectives changed during a long-term project then plans had to be amended considerably.
- Control and monitoring were facilitated by one agency and one person being responsible for these functions.
- Contracting, a significant part of the project, should have been managed by a single agency.

**Financing**

- Without long-term and secure funding, substantial investments for installations of equipment and extensive data gathering were not possible.
- Funding totally from one agency simplified budgeting and negotiating for adjustments in the budget.
- Funding from two or more sources enabled adjustments between the sources. When one had less capability to provide, the other fortunately was able to afford a larger share.
- Limitations on funding required that priorities be established for spending. Certain activities or work had to be deferred until funds became available.
- Financial support diminished or became less certain as projects were extended in time.
- Earmarked funding made it difficult to accomplish objectives.
- Costs escalated during storms, and adequate staff and fail-safe equipment were not available to collect vital data during peak events.
The project leader had to justify increased budgets to meet unforeseen contingencies and to optimize the effort.

A slush fund provided flexibility in handling add-ons and change-orders and in meeting unforeseen contingencies.

Technical considerations

Major climatic events due to storms or very low temperatures required considerable overtime work and dedication of staff, analogous to that of a fire fighting situation.

Unanticipated delays in treatments, such as harvesting timber or installing instream structures, caused the project to fail to meet its objectives or greatly prolonged the schedule of a project.

The critical data were not identified with the result that lots of convenient data were collected and important data were missed.

Difficulties in implementing the plan, e.g., difficulties in collecting data as specified, significantly delayed the project or caused it to fail.

Data collection was spotty and too meager to accomplish the purposes for which the project was established.

Time required for project implementation. During the workshop it became apparent that several participants had a clear picture of how long it takes to carry out a project designed to determine effects of land treatments on water yield. Within a few minutes data were obtained for nine projects on the years required for each part of the implementation phase (table 3).

Most frequently the planning phase required two years. In a couple of projects it required only one year, and in one project it required 12 years.

The start up phase ranged from 1 to 9 years with 2 years being the modal time. Start-up included opening up the watershed, installing stream-gaging stations and climatic station networks, and debugging the data collection system. Only when the start up was completed could calibration begin.

The calibration period ranged from 2 to 10 years, with a mean of 6.2 years.

Treatment periods were variable, as would be expected. The time depended upon whether treatments were simple or complex. Treatment period ranged from 1 to 10 years and averaged 3.8 years.

People knowledgeable about these projects had an interesting reaction when asked how long it took to measure effects of the treatments. Unexpectedly they responded with two numbers, the first being the amount of time they were allowed, and the second being the amount of time they desired to collect data. Most anticipated treatment effects to last a very long time. Times given for measuring effects of treatments ranged from 0 to 100 years, but most were allowed only 2 to 7 years. However, the times desired ranged from 5 to 120 years with the majority of projects needing more than 30 years to determine effects of treatments.

The prolonged period required for study of effects was exemplified by a report at the workshop on the situation at Fraser Experimental Forest in Colorado. The person responsible for work there, Charles A. Troendle, having studied watersheds treated 35 years ago expects that it will take 70 to 80 years for the treated watersheds to return to control conditions.

The elapsed time before projects were evaluated was highly variable. For the 6 of 9 projects that were evaluated, the first evaluation was sometime between the third and twelfth year. Only two projects had been evaluated a second time, and that occurred 8 to 18 years after the first evaluation.

What Management Would Suggest

The managerial functions of organizing, controlling, and monitoring are involved during project implementation. Much is known about these functions (table 4).

Organizing a project relates to the resources that are managed. The human resources require organization charts, writing of job descriptions, recruitment and training of staff, and establishment of committees, teams and other groups of people to accomplish purposes of the project. With respect to the financial resources, organizing refers to the allotments and allocations of funds to subprojects or even to individuals. With respect to facilities, the project leader must organize responsibilities for utilization of space and equipment. Arrangement must be made both for procurement to meet needs of the project and for maintenance of facilities and equipment to assure that what is acquired remains effective and operative.

The informational resources for a project must be organized.

<table>
<thead>
<tr>
<th>Watershed (location)</th>
<th>Planning</th>
<th>Implementation</th>
<th>Effects of Treatments</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Start up</td>
<td>Calibration</td>
<td>Treatments</td>
</tr>
<tr>
<td>Aisea Basin (OR)</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Carnation Creek (BC)</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Caspar Creek (CA)</td>
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<td>3</td>
</tr>
<tr>
<td>Coon Creek (WY)</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>2</td>
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<tr>
<td>Marmot Basin (Alb)</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Maybeso Creeks (AK)</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Tri-Creeks (Alb)</td>
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<td>2</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
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<td>1</td>
<td>7</td>
<td>3</td>
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<tr>
<td>Stillaguamish River (WA)</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>
to give staff members access to the scientific and technical information they need. Production and delivery of information flowing from the project to various audiences also must be organized.

Controlling can have several meanings in relation to a watershed project. Some of these are:

- "Seeing that everything is carried out in accordance with the plan." (Henri Fayol)
- Ensuring that particular channels or procedures are followed.
- Systematic effort to set performance standards, to compare actual with desired performance, to take corrective action.
- Authority to direct, regulate, hold back, restrain, curb (Webster)
- The activity that measures and guides actions toward some predetermined target.

When executing the controlling function, the project leader sets standards for performance, uses operating budgets, redirects funds, reschedules works, reallocates uses of facilities and equipment and requires reports of expenditures and accomplishments.

The process of controlling has four steps. The first is to establish a specific objective or target and expected standards for performance or accomplishment. Flexibility of standards is an important consideration for situations and circumstances do change; yet, standards should be clear and made known to all affected parties. They should be bent only rarely and then only after prior approval by the project leader.

The second step is to measure actual performance against the pronounced standards. Here personal observations, formal reports, charting, or plotting can be used to measure performance.

The third step is to identify deviation from expectations and then to take effective remedial actions.

The fourth step is to build feedback loops that give the leader information needed to decide when any of the first three steps needs further attention.

Monitoring is part of the second, third and fourth steps in controlling. Monitoring is based upon standards and procedures developed for controlling. It requires periodic observations, inventories, and reporting of uses of resources and consequent accomplishments. Monitoring is designed to provide information to decision makers. In this way monitoring provides part of the feedback process required for controlling project activities.

Effective controls are:
- accurate
- timely (to identify a problem quickly and enable corrections to minimize losses)
- objective (understandable, not subjective)
- comprehensive (understandable, not subjective)
- focused on strategic control points (where deviations are most likely, or where deviations would do greatest harm)
- economically realistic (costs should be less or no more than benefits realized)
- applicable, and acceptable in the organization
- flexible in application

Controls have behavioral implications. The people affected are an essential part of the control systems themselves. Properly designed control systems should and do reinforce positive behavior, not negative behavior. Constant pressure and negative implications can exert negative behavior. Some options for avoiding problems in this relationship are to automate operations so as to reduce tedium and wearisome tasks. Centralization of operations also removes pressure from individuals. Another possibility is to share risks with an outside body that might provide such options as insurance, security systems, or back-up resources to meet special needs of the project.

Recommendations

The workshop team responsible for developing recommendations on project implementation opened their report with four introductory statements.

| Table 4. Activities related to managerial functions and resources during project implementation |
|-------------------------------------------------|------------------|-------------------|-----------------|
| Managerial functions | People | Funds | Facilities & Programs | Information |
| Organizing | Create organization charts; designate line versus staff; limit span-of-control; write job descriptions; recruit to fill needs; decentralize; est. committees/teams | Allot and allocate funds | Assign responsibilities for utilization of space and equipment, field facilities, laboratories; arrange for procurement maintenance | Establish systems for disseminating, retrieving, and using managerial information; establish libraries and channels for obtaining sci-tech information; establish systems for outflow of information |
| Controlling | Establish policies and procedures | Use operating budgets; redirect funds | Reschedule or reallocate uses | Require reports of accomplishments |
| Monitoring | Review performance | Require periodic reports of obligations and expenditures | Inventory uses; monitor uses, conditions, and trends | Use blue-ribbon panels and expert consultants |
• Project implementation begins with the completed plan and the desire to do something. It ends with closure of the project and final reports.
• The purpose of a project is to provide a framework for establishing objectives and making sure the objectives are reached.
• It is best to work backwards from the desired endpoints or objectives through flow diagrams. These diagrams can reflect the sequence of detailed events and should reflect the realistic schedule that can be attained by the project.
• It is essential to recognize the time and effort required during project start up to gather the necessary resources, to train the staff, to acquire and install equipment, and to do all else required before calibration of watershed can actually start.

The team's recommendations for project implementation were organized under eight generic headings.

**Absolute commitment of resources**
1. Establish a policy or steering committee comprised of members representing the sponsors and other significant stakeholders who have sufficient rank and position to make commitments or to strongly influence top-level decisions by the group they represent.
2. Have the project leader or coordinator report to the chair of the policy or steering committee.
3. Establish a board comprised of technical specialists to whom the project leader or coordinator can turn for advice and consultation.
4. Establish an advisory board or committee on which all stakeholders are represented and to which the project leader or coordinator provides information about the status of the project on a regular basis.
5. Staff positions should be permanent, if possible, to assure job continuity and to reduce turnover of staff.

**Collecting quality data**
1. Assure that the objectives of the project are clear and that all members of the staff understand them in the same way.
2. Assure that the staff understands how and why data are collected and what uses are to be made of them.
3. Assure that the data collected are of the level of accuracy and commensurate with the achievements of the project.
4. Assure that the data collection process is checked for accuracy and completeness.
5. Assure that data after collection are archived to assure their safety.
6. Assure that data are analyzed in a timely fashion.
7. Document any changes in methods or procedures.

**Depreciating resources**
1. Realize at the beginning of the project the need to acquire and maintain staff and equipment sufficient to achieve the project's objectives.
2. Provide for turnover of personnel after reasonable tenure of service to the project.
3. Provide for training and professional development to build and maintain the staff's capabilities.
4. Realize that capital improvements will require maintenance and upgrading during the life of a project.

**Scheduling work**
1. Establish schedules for tasks, achieving targets, annual leave, etc.

2. Develop a contingency plan for unforeseen events such as floods or wildfires.
3. Secure commitments of others, who often are responsible for treatments of a watershed, to schedule and finance their events synchronous with the schedule of the project.

**Adding objectives**
1. Before accepting additions to the scope or objectives of a project, determine impacts of such an action on the existing project.
2. Accept added objectives only when a sponsor provides full funding for requisite resources and activities.

**Obtaining funding**
1. Present the objectives and needs of the project in positive ways to likely sponsors.
2. Secure funding that is needed from existing or new sponsors.
3. Design the program for the worst situation and establish a contingency fund.
4. Do not design the program for minimal funding levels.

**Focusing on objectives**
1. Keep the eye of the staff on accomplishment of the objectives.
2. Establish job descriptions and performance standards for each staff member.
3. Monitor performance of staff to assure adherence to planned work and to assess accomplishments.

**Building feedback loops**
1. Build an internal communication process and schedule.
2. Keep everybody informed.
3. Keep data out of the power structure.
4. Disseminate information promptly and according to a pre-arranged and agreed upon schedule.

**Project Evaluation**

The workshop team responsible for this topic came up with this definition: "evaluation is a process that should be used frequently for appraising accomplishments of a project."

The team pointed to four critical assumptions in the evaluation of any project. First, the project's design should lend itself to evaluation. Second, the objectives established for the project should be reasonable and achievable. Third, a project leader or manager should be responsible for programmatic accomplishments and continuity. Fourth, working groups and advisory committees should be used as needed to accomplish the objectives of the project.

The team noted that evaluation includes:
• identifying costs, benefits, and environmental changes associated with the project
• determining whether the project's objectives were achieved as planned
• determining whether the implementation phase of the project produced the desired results
• determining whether findings and interpretations of results of the project have been documented and distributed to stakeholders
• providing feedback to managers for their use to refine the project or to be applied to management of other projects
Informing stakeholders about the status of the project.

Situations Encountered

Individual participants at the workshop made these notes related to project evaluation as they discussed the case studies.

- Most projects lacked a set process for evaluation.
- Project needed to evaluate its process for monitoring its accomplishments.
- Primary sponsor reviewed the project according to its procedures for evaluation.
- Evaluation was conducted by a project team annually, but never by anyone from outside the project.
- Special-interest groups reviewed the project periodically, but only for information, not as a critique.
- Evaluation tended to be ad hoc with no one having primary responsibility or interest.
- Periodic visits to the project site by superiors tended to be for their information and not as evaluations of the project.
- Project was evaluated on the short-term basis to show progress relevant to decisions, usefulness of data and technology transfer.
- Evaluation should have focused on accomplishments of the project rather than on the happiness of the staff.
- Evaluations are biased, but cannot figure a way around this problem.
- Project is dynamic and never ends, but it will change!

What Management Would Suggest

Considerable is known about the evaluation of projects (Callaham 1988). Perhaps the most useful definition of evaluation as related to a project has been given by Salas and his coauthors (1980). They define evaluation as:

- collection and analysis of structured information in order to answer questions related to
  - decisions about duration and funding
  - changes to improve probability of success
  - altering policies or procedures
  - building support with policy makers and constituencies

Purposes of evaluation. Evaluation of any watershed project should be designed to:

- provide overviews for higher bodies
- benefit managers of the project
- improve allocations of its scarce resources
- inform and motivate performers within the project
- improve cooperation among participating organizations
- educate professionals and the public

An evaluation might specifically explore whether a project:

- efficiently expended its resources in relation to its outputs
- fulfilled its social contract
- achieved and was accountable
- provided adequate output to its clients
- produced technology that both was useful and was put into use
- had any impacts
- should be continued or changed in status

Audience for evaluation. Each of the foregoing purposes pertains to one or more sectors of the diversified audience for a watershed project. These sectors of the audience, the key people in each sector, and their special interests must be identified at the outset of an evaluation. These audience sectors include:

- higher authorities for policies, decisions, commitments
- those who manage director, project leader, 1st-line supervisors
- performers, workers
- outsiders having special interests stakeholders, special-interest groups

Levels for evaluation. An evaluation might focus on one or more hierarchical levels within a project:

- responsibilities of management adequacy and allocation of resources, delegating authorities and responsibilities adequacy and appropriateness of policies and directives team organization and coordination consideration for safety and health of workers morale training and advanced education for employees program planning relations with cooperating and collaborating organizations getting results to clients and users of technology
- responsibilities of specific groups or units kind and adequacy of outputs responsiveness to policies and directives efficiency of expenditures safety record impacts of achievements
- performance of individuals job assignments and descriptions of duties standards and processes for evaluating performance teamwork leadership output and achievements recognition personal satisfaction

Who should evaluate. For an evaluation to be objective and unbiased it should be conducted by people who work outside of the project. Evaluators should be knowledgeable about the kind of work being undertaken by the project. Three options, which may be used in combinations, are:

- “blue-ribbon” panels comprised of prominent individuals recognized as authoritative have access to highest levels recommendations tend to considerably influence decisionmakers
- panels of peers comprised of individuals respected by people in the project usually very knowledgeable technically may be biased toward the values and viewpoints of the people being evaluated recommendations may have less impact on decisionmakers
- internal teams intimately familiar with the project often biased toward maintaining the status quo may lack credibility with decisionmakers
Steps in evaluation. The process of evaluation has six steps:

1. Define the problems as perceived by affected decision-makers and identify their specific needs and questions: who wants to know what, why, when, where, and how
2. Determine the basis for comparisons and judgements to be made
3. Determine the scope of the evaluation
   - draw side boards
   - decide which users, clients, and special-interest groups will be included
4. Establish an independent team
   - independent of those asking for it
   - independent of the process or activity to be evaluated
5. Conduct the evaluation
   - involve the spectrum of stakeholders in briefings before, during, and after
   - proceed with dispatch
6. Report findings objectively and promptly
   - to decision makers
   - to affected participants
   - to special-interest groups

Recommendations

The team responsible for this topic pointed out that planning that proceeds from higher bureaucratic levels to lower bureaucratic levels (top→down) may result in objectives being unrealistic. This seemed to be the case in the barometer watershed program conducted by USDA Forest Service during the 1960s and 1970s. Other difficulties experienced with top→down planning are that directions may be too general or may be politically motivated.

The team further noted that planning that progresses in the opposite direction (bottom→up) also has faults. Too often such planning lacks a leader who can direct planning toward realistic objectives and who can secure needed funding. Problems then arise when such projects have unclear objectives or inadequate resources.

According to the team, projects are often designed for collecting data but not for providing information. Evaluation should be planned as an integral part of any project. A project's objectives should be clear and simple to facilitate evaluation. Evaluation is difficult or impossible if a project's objectives are not clear, precise, and measurable.

Some pitfalls in projects detected during evaluations were:
- do not try to make conclusions on insufficient data
- state assumptions on reliability of data
- avoid poorly designed projects
- do not extrapolate findings beyond the limits of the data
- do not report results as positive only
- report negative results

One primary question should be answered in the evaluation of any project: Was the project completed on time and within costs? If the project was delayed or over budget, then the extenuating circumstances contributing to these situations should be examined.

Evaluation must be planned for and scheduled from the outset of a project. It needs to be recurring in its frequency. The first evaluation should be made soon after start up of the project. A second evaluation should be made when the project is about half completed. A final evaluation should be undertaken during or immediately after the closeout of a project. Each of these evaluations should provide information for subsequent decisions related to the project's leadership, direction, and program of work.

Use of Findings

One output of every project is new information. It may be information about how to solve a problem. It may be an innovative new technology for improving the yield or quality of water or habitats for wildlife. Sometimes the information has a negative twist, when something failed to work or gave other than expected results. Whether information has positive or negative implications, it has utility to people associated with the project and to others not associated with the project.

Spreading this information to other people is called by a variety of terms. Included are
- extension
- technology transfer
- knowledge utilization
- diffusion of innovation
- applications of technology.

Whatever term is used, the purposes remains the same: to give people information they need and cause them to use that information to improve their situations.

Provision should be made for use of the findings from every project. If adequate attention is not given to use of the findings from the project, from the planning of the project through its termination, then it will not have the desired impact.

Situations Encountered

The following notes, made by participants during discussions of case studies at the workshop, illustrate some things that should be done and should not be done to improve dissemination of information generated from watershed projects.

- Technology transfer was not planned at the outset, and no one thought of it during the project.
- The project included cooperative extension from the beginning; therefore, the flow of information to a variety of audiences was very good.
- Information provided to the public caused them to be aware of the project and led to trespass and stealing of equipment.
- Emphasis in technology transfer should have been on the technology not the means by which it was acquired.
- Transferable information from the project was about understanding the processes that operated and not the specifics of what happened on the watershed, for rarely will another watershed behave in the same way.
- National review of the project resulted in a new system for classification based on the one developed for the project and turned around awareness of riparian problems and restoration.
- Findings from the project lead to the development of new standards and guidelines for use on several national forests.
- Local people did not accept the information that was generated from the project, for it was not to their liking.
- The project lead to a document used by several agencies for credibility in dealing with public groups.
- Information resulting from the project is not getting out to those who need it because of pressures on the responsible persons to do more research and teaching.
- Information is not getting out from the project because of inadequate funds.
- The project's value was restricted because of the very small plots that were involved.
- Researchers and scientists do not like technology transfer and are not good at it.
• The project should have hired an extension or technology transfer specialist to do a professional job on use of findings.
• The project focused on getting local leaders to apply the technology that came from the project as a way of getting other potential users to apply the technology.
• Projects reported variously using tours, publications, picnic days, open houses, and newspapers to spread the word about what was being done and findings from the projects.
• A video based on the project and aimed at funding sources helped to justify the project to the public and to the sponsors.

What Management Would Suggest

Application of technology resulting from research and developmental efforts is a subject about which much is known (Glazer 1977; Callaham 1984). The goal is to speed the process of putting knowledge and methods to work. Factors contributing to successes or failures in technology transfer have been identified (table 5).

A necessity for adoption of innovations is that the technology be adequate, credible, observable, and documented. Users, particularly managers, must feel the need for innovation or be committed to it. All parties must value, accept, and be compatible with the innovation and associated changes. Adequate resources, facilities, structural capacity, and training capabilities must be available.

Table 5. Some Important knowledge and methods related to use of findings from projects

Other names:
• extension
• technology transfer
• knowledge utilization

Definition:
• knowledge, acceptance, and use of new technology

Goals:
• reduce or eliminate delays in use of knowledge and methods
• create an awareness of and favorable regard for a project

Primary approaches:
• product marketing = supply-push
• responsive service = demand-pull

Factors Influencing acceptance:
• technology must be adequate, credible, documented, and demonstrated
• users must feel the need or be committed
• society must accept and value the innovation and associated changes
• resistance must be overcome skillfully
• laws and regulations must be favorable
• payoffs and rewards must be obvious

Success requires:
• direct contact between participants
• person-to-person communications
• risk-taking innovators and early adopters
• helpful linkers, liaison agents, change agents, and gatekeepers

Successful linkers show unusual characters:
• strong belief in own capabilities
• belong to several or many organizations
• naturally curious
• lack identification among peers

Special qualifications to be a "change agent":
• understand existing situation
• know and relate to the human situation
• able to work in organizations and political situations
• be a "linker"

Application requires specialists who understand:
• people
• communications
• societal organizations

Delegations of authority and responsibility for applications must be made:
• explicitly and firmly
• to qualified and capable people

Variables affecting rate of applications:
• awareness of potential gains or benefits
• requirements for changes in established values
• needs for money, people, and facilities
• availability of recognized sponsors or champions
• openness to change by the social structure
• centralization versus decentralization of power
• threats to security
• attributes of participants
• young people accept change quickly
• old people accept change almost as quickly
• middle-aged people most resist change
• affluence, higher rank, status, affiliation, and success all increase willingness to change

Application should proceed only if technology is:
• complete
• available
• suited for proposed audiences

Typical tasks in application:
• analyze practical situations to identify needs and opportunities
• identify technology suitable for application
• define and analyze sectors of the project's audience
• repackage or adapt technologies for selected audiences
• sell technology to innovators in selected audience sectors
• demonstrate how to apply technology
• motivate and train users
• estimate and publicize expected benefits
• use a variety of media effectively

Time and duration:
• requires long-term, continuous effort until acceptance or rejection is obvious

Rewards for accomplishments:
• recognition by people affected
• recognition of benefits created
• promotion, more salary bonuses
to carry out the innovation. Resistance to innovation and the sophistication and value systems of individuals and organizations must be dealt with skilfully and tactfully.

A climate of trust and willingness to accept challenge and risk must prevail. Demonstrations and other means are used to make managers and users of the technology appreciate the potentials for gain or loss by adoption of the innovation. Any circumstances in timing, including attitudes and moral of employees, and current laws or regulations, can strongly influence adoption of innovations. Prospects of payoff, reward, or advantage, or benefits anticipated comprise a final category of factors influencing adoption or adaptation of an innovation.

Transmission of new knowledge and methods is best done through direct contact between the participants. Therefore, person-to-person communications are most important. The people who bring ideas and potential users together are called linkers, innovators, liaison agents, or gatekeepers. Several scientific studies have clarified the linking relationship and have shown how it can be fostered.

Individuals successful in linking show unusual characteristics that set them apart from most scientists and managers. They strongly believe in their own capabilities. They have a natural curiosity about everything. They tend to be gadflies in their affiliation with organizations. They have a wide circle of friends and acquaintances, but they lack identification with peer groups. Managers must learn to tolerate their behavior which to some may seem odd. When present, linkers may not be used to good advantage, for their personal attributes are often troubling to managers. Linkers must not be over managed. Informality is one key to their success. Unusual activities by individuals, different from those found in either R&D organizations or in management of natural resources, are essential to success in applying new technology.

Approaches and strategies for change must be outlined by teams comprised of technical specialists, who know the subject matter, and applications specialists, who understand people, communications, and organizations. Thus, the application of knowledge and methods resembles a marketing endeavor or a public relations effort.

Recommendations

The workshop team responsible for this topic recognized that it is important both to transfer, put into use, and apply, the knowledge and methods that have resulted from the project. The objective is to provide a mechanism and environment by which the transfer and application can occur. Perhaps policies or regulations will have to be changed. They considered 13 points to be important in the process of transfer and application of information flowing from a project.

- Achieve a proper balance of outreach to different audiences. (Too often a permittee receives much attention, and other sectors of the public are ignored).
- Provide for technology transfer at the beginning, middle, and end of a project.
- Workshops and seminars often do not provide an environment to generate interest in results by many audiences.
- Coordinate efforts in technology transfer with that of other projects in the area, when it is appropriate to do so.
- Identify people who are effective at technology transfer and use them in the process.
- Motivate researchers to take part in technology transfer by developing a satisfying reward system.
- Train project staff, or at least one person, in effective use of media and other aspects of technology transfer.

Conclusions

The number of wildland watershed projects across the West is truly great and rapidly expanding. If successful, these projects have the potential to improve yields and quality of water and habitats for fish and wildlife and to provide technology—knowledge and methods—that can be exploited elsewhere. How each project is managed significantly influences whether its objectives will be achieved and whether the project's activities will be conducted in a cost-effective manner.

Experiences during past wildland watershed projects demonstrate how current and new projects should and should not be managed. Key managerial problems have related to planning, financing, and leadership. Based on what we have learned, a successful project must have a realistic statement of objectives, a plan of work that is based upon appropriate technology, financial support that is adequate and assured during the life of the project, firm and continuing support from several sponsors or stakeholders, and a capable and dedicated project leader and staff.

Principles of management are well developed and have been shown here to be pertinent and useful in management of wildland watershed projects. Leaders of watershed projects will profit from improving their knowledge and understanding of management and their skills and abilities as managers. They should pay particular attention to the essential managerial functions of planning, organizing, controlling, and evaluating. They need to understand, accept, and play their several managerial roles. As the managerial performance of the leader improves, the project can be expected to improve in achievement of objectives and in efficiency and effectiveness of its activities.

The problem identification phase of any project has two critical dimensions. One is the sorting out of achievable objectives for the project. The other is the gathering together of stakeholders concerned about achieving those objectives. Care must be taken to define clearly and precisely what is wanted in the way of achievements, the desired outcome. All organizations and individuals having a vested interest in the outcome or achievement of the objectives need to be informed about and involved in the decision to proceed with a project.

The next phase of any wildland watershed project, problem analysis, has the greatest potentials for difficulties. These difficulties occur both during the actual work of problem analysis and during subsequent work to implement the plan. This phase requires a planning team to gather information needed for decisions, to specify objectives and targets, to plan a program of work to achieve these objectives and targets, and
to estimate the required resources. This phase is complete only when an agreement to proceed has been signed by the stakeholders and negotiations have resulted in funds being provided for the project.

Project implementation can take a few months or a few decades depending upon the nature and scope of objectives. The world of management can provide much technology that is applicable during this period. The leader must deal with organizing resources and controlling activities to achieve targets and objectives. Start up of activities is a key period when resources are gathered and organized and the stage is set for data collection. Start up usually requires more resources, particularly money and time, can be provided, so compromises must be reached between what is wanted and what can be realized. Important to success during project implementation are absolute commitments of resources, a strong focus on objectives and collection of quality data, adherence to schedules of work, and communication networks that assure adequate flows of information.

Evaluation is undoubtedly the most overlooked and poorly handled phase in management of wildland watershed projects. The need for evaluation should be recognized during the problem analysis phase. The project’s plan of work should call for persons from outside the project to conduct evaluations soon after start up, at the project’s midpoint, and just before or after its closure. Facts and viewpoints gathered during evaluations should bear importantly on decisions about the project’s achievements, its continuance, needed adjustment of its objectives or working plans, or redirection of its resources.

Too often have wildland watershed projects failed to deliver information that was generated to audiences for the information. Transfer of the knowledge and methods that result from a project is a subject about which much is known, but technology transfer has been sadly neglected by leaders and staffs of many wildland watershed projects. Planning, including setting of special objectives, for technology transfer should be done as a part of the problem analysis. Project implementation should provide the necessary resources and incentives to assure prompt flow of information, specially packaged, to meet the needs of each sector of a project’s audience.

### Literature Cited


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Appendix B. Glossary of Terms Pertaining to Management of Watershed Projects

Compiled by R. Z. Callaham, with notable input from Douglas N. Swanston, USDA Forest Service, Juneau, AK

Managerial Terms

activity any specific action or pursuit (Webster)\(^1\); any process to achieve specific purposes of management

allocation or allotment proposing or providing resources for a particular organizational unit, activity, or other purpose

application results in acceptance and specific use of new technology; puts new technology, or technology used elsewhere, into use to solve problems or improve upon current practice; requires repackaging technology to appeal to various audiences, to foster understanding, and to fit it for practice; requires selecting and skillfully utilizing media for communication with identified audiences; uses either the product-marketing (supply-push) approach or the problem-solving (demand-pull) approach

budget a document displaying proposed, recommended, or approved allotments of funds for work according to activities, locations, or objectives

consensus an opinion held by all or most; general agreement, esp. in opinion (Webster); a situation when no one objects or stalls the activity or actions of the remainder

constraint a circumstance that confines, restricts, precludes, compels, or obliges certain actions, processes, or effects; usually includes laws, regulations, policies, codes, ethics, physical realities, time or other resources

cooperation joint operation, concurrent effort or labor, collective action in the pursuit of common well-being (Webster); pertains to individuals or organizations working together on the same or a related endeavor

Coordinated Resource Management and Planning (CRMP) a process pertaining to land and associated natural resources at the local level allowing direct participation of many individuals and organizations in discussion and decisions about alternative uses of resources, managerial problems, goals and objectives; strives to minimize conflicts and to reach agreements among participants

coordination a state of relation of being coordinate; bringing into proper order or relation; harmonious adjustment or action (Webster); pertains to individuals or organizations working separately but on the same or a related endeavor

development results in technology or knowledge that is usable or available; focuses on delivery of new products, processes, or systems; starts not with the unknown, as does research, but with the known and strives for practicality by adapting, testing, evaluating, and modifying; output from development is input to application and includes descriptive documents, operating systems and machines, hardware and software, and aids for training and instructing those who will apply the technology; clients of development are other developers, specialists responsible for extending technology into practice, and innovative practitioners

discipline a field of study or specialization (Webster)

dominant use a concept of classifying and managing land and water resources for one main type of use; other uses may or may not be excluded but are always of secondary importance to the optimum development for the dominant use (Scasso, et al. 1973)\(^2\); also see dominant use management

dominant use management management based on the idea that land, although potentially capable of many uses, will provide for one use better than any other; management for the single purpose of maximizing that use to the exclusion of other uses where conflicts exist; devoting each land unit to the use it best provides for is assumed to be the most efficient allocation of resources (this assumption has been shown to be erroneous by the science of operations research, among others); dominant use management is prohibited on the national forests under the Multiple Use-Sustained Yield Act (E.C.T.)\(^*\)

effect that which is directly produced by an action, process, or agent and is the exact correlation of cause (Webster)

evaluate to estimate, determine, or fix the value of, especially by careful appraisal and study and in relation to established systems (Webster)

expenditure actual or expected payment or transfer of funds in response to an obligation

extension as used by Cooperative Extension in the land-grant college system, refers to the gamut of work—applied research, development, applications of technology, training, and education—to solve practical problems; involves field trials, adaptations, evaluations, pilot tests, demonstrations, repackaging technology, and using a variety of media to communicate with selected audiences

goal the end, aim, or purpose to which an organization or unit aspires; a concise statement of an organization's central strategy in addressing a problem expressed in terms of a desired state or process that operating programs are designed to achieve; normally expressed as a broad, time-less, generalized statement; usually not well-defined, quantified, attainable in the short term, or expressed in operational terms; the principal statement from which objectives must be developed; e.g., create a watershed or riparian demonstration area

Implementation accomplishment, fulfilment, carrying out, completion (Webster)

Innovation introduction of something new; a new idea, method, or device; to innovate is either to introduce as new or to change to some new way or means (Webster)

Interdisciplinary involving, or joining, two or more branches of learning (Webster); joining talents of people having different intellectual backgrounds; contrasts with multidisciplinary

Interdisciplinary team a group of two or more individuals with different training assembled to solve a problem or perform a task; recognizes that no one scientific discipline is sufficiently broad to adequately solve the problem; proceeds to solution with frequent interaction by team members so each discipline may provide insights to any stage of the problem and disciplines may combine to provide new solutions; different from a multidisciplinary team, where

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\(^1\) Authorities for definitions are cited in "Sources" at the end of this appendix.

\(^2\) Authorities marked by an asterisk are as cited by Schwarz et al. 1976.
each specialist is assigned a portion of the problem and their partial solutions are linked together to provide the final solution; forming of the team, the data collection and analysis, team discussion, interactive evaluation, and joint resolution of the problem is the interdisciplinary process (USDA Forest Serv. 1979 Manage. Practice Documentation)*

location a site where programmatic tasks or activities are carried out

management the act or art of managing; conducting or supervising something; judicious use of resources to accomplish an end; executive skill; the collective body of those who manage or direct an enterprise (Webster)

manager one who conducts business affairs; a person who directs a team; a person responsible for resources and programs (Webster)

mission special purpose or reason for existence, phrased as very broad aspirations related to needs and values to be met by the organization; relates to the organization’s niche and expertise; characterizes an organizer’s role in problem solving; e.g., provide stewardship for water resources (after USDA Off. Manage. Finance 1974)*

mitigation abatement or diminution of anything harsh or severe, mollification, appeasement, lessening or diminishing impacts (Webster)

model a mathematical system, usually computerized, that seeks to emulate an existing system in nature, business, etc.; may feature means for varying the kinds, amounts, and treatments of resources input to the system, for estimating effects upon the system, and for estimating expected outputs from the system

monitor to watch, check, observe, control, or regulate, especially for quality or adequacy

multidisciplinary of or combining many different branches of learning (Webster); requiring coordinated attention by representatives of many disciplines; contrasts with inter-disciplinary

multidisciplinary team a joint effort by two or more people having different scientific training and/or backgrounds all assigned responsibilities in the same activity or effort; each specialist is assigned a portion of the problem, and their individual solutions are combined to provide the complete, final solution (after USDA Forest Serv. 1972B)*; different from an interdisciplinary team, which does not break the problem apart by disciplines but instead works with frequent interaction so each discipline may provide insights into any part of the problem and disciplines may combine to provide new solutions beyond the scope of any single discipline

multiple use 1. involves three somewhat different ideas: (a) different uses of adjacent subareas which together form a composite multiple-use area, (b) alternation through time of different uses on the same area, and (c) more than one use of an area at one time (after Rowe and Mccormack 1968)*; 2. a modern social concept whereby the consumer public demands a variety of values from a resource in ways that, to the single purpose resource user, may seem inefficient or economically ruinous; resource use is allocated to maximize the national well-being, promoting general social and economic prosperity; social needs are best served by maximizing the over-all mix of total national resource uses that brings greatest social and economic benefits (after Rowe and Mccormack 1968)*

multiple use management (Multiple Use-Sustained Yield Act usage) all renewable surface resources of national forests are utilized in combinations that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output. (Multiple Use-Sustained Yield Act)*

network a system of interconnected elements, individuals, or organizations linked to increase effectiveness and decrease costs via cooperation, coordination, communications, and shared activities

objective an aim or end of action; a point to be hit or reached (Webster); a specific, attainable end toward which concentrated effort is directed; when achieved represents significant and measurable progress toward attainment of a broader, longer-range goal, characteristically subordinate to a goal, narrower and shorter range in nature, having a reasonable probability of attainment within specified time periods and resources; that which is specific, definite, verifiable, attainable, or achievable; should include four essential elements: (1) desired outcome, what is to be accomplished, (2) time period within which the expected outcome is to be achieved, (3) measurement factors, such as quantity, quality, or cost, and (4) who is responsible for achieving the indicated results (USDA Off. Manage. and Finance 1974; USDA Forest Serv. 1972B)*; e.g., that which is to be attained or achieved by a watershed demonstration area

obligation act or intent to spend funds for a specific item; equals commitment, but not actual transfer, of funds.

output a broad term describing any result, product, or service from a process or activity (USDA Forest Serv. 1972B)*

Induced output the indirect result of system activities; generally the secondary outputs of another system; e.g., a specific timber harvest, primarily for wood production, induces improved wildlife habitat (USDA Forest Serv. 1974A)*

primary output the main goods, services, or environmental conditions of a resource system—the key indicator used to identify with meeting an objective; e.g., production of animal-unit-months of forage for livestock or board feet of timber harvested (USDA Forest Serv. 1974A)*

output from watershed demonstration areas new technology or methods that pushes back frontiers of knowledge or that solves problems and increases efficiency and effectiveness of practical programs.

Immediate output includes, but is not limited to, publications, reports, training materials, hardware and software, machines, models, and operating systems.

Intermediate output includes innovations, modifications to previous innovations, scientific findings, and scientific methods.

Ultimate output through applications enhances the quality of life, enhances decision-making, and improves social or economic conditions.

photo point an identified place where repetitive pictures are taken to record changing conditions; usually implies care being taken to assure that sequential pictures are comparable as to scale, composition, and exposure
process a particular method of doing something, generally involving a number of steps or operations (Webster); moving forward progressively from one point to another on the way to completion; continuous development from a beginning to a contemplated end; a succession of developmental stages, e.g., land use planning is a "process" rather than a single, finite, irreversible event in time or space (C.F.S.)

program the assemblage of diverse studies or other activities being conducted by an organizational unit at all of its locations

project an organized undertaking; a special unit of work; often includes parts of, or input from, two or more organizational units

research leads to discovery of new facts, and methods, rather than a single, finite, irreversible event in time or space (Webster); e.g., write a plan or report, install a demonstration of new technology, or gather and analyze information on a certain topic

technology applied science; application of knowledge and methods derived from science or experience to solve practical problems; the totality of means employed to provide for human sustenance and comfort (Webster)

technology transfer actions and processes aimed at putting into practical use technology that is either newly developed or used elsewhere; includes knowledge, methods, or both; involves active processes of identifying possible audiences, using a variety of communication techniques, and causing people to adopt new technology and to innovate so as to solve problems or improve their situation

Watershed Terms

aesthetics amenity values perceived and enjoyed from the visual and physical components found variably related with the landscape (Webster)

aggradation a geologic process by which stream beds, flood plains, and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas; the opposite of degradation (Amer. Fish. Soc. West. Div. 1985)

algal bloom a rapid growth of algae, often associated with warming temperatures or presence of added nutrients

alevin the newly hatched salmon when still attached to the yolk mass (Genrich 1976)

alluvial fan low, fan-shaped deposits of partially stratified, water transported silts, sands and gravels deposited where a steep-gradient tributary flows out onto the valley floor (Howell 1960)

alluvium soil, sand, gravel, or similar detrital material deposited by running water, esp. during recent geologic time; ordinarily local in occurrence on flood plains of streams, or, as alluvial fans or cones, at places where streams lose velocity and deposit their contained sediment (Webster)

armor the newly hatched salmon when still attached to the yolk mass (Sedgwick 1982)

base flow see flow

base flow see flow

baseline data information representative of a particular time period; normally means representative of the undisturbed or undeveloped state (USDA Forest Serv. 1979 Manage. Practice Documentation)

bass a mass of sand, gravel, or alluvium deposited on the bed of a river or stream (Howell 1960)

base flow see flow
bed-load discharge the quantity of bed load passing a given point in a unit of time, expressed as dry weight (Amer. Fish. Soc. West. Div. 1985); see also sediment discharge

benthic of, relating to, or occurring at the bottom of a body of water (Webster)

benthos organisms living on or within the substrate of a waterbody (Amer. Fish. Soc. West. Div. 1985)

berm a levee, shelf, ledge or bench along a stream bank that may extend laterally into the channel to partially obstruct the flow, or parallel to the flow to contain the flow within its stream banks; may be natural or man-made (Amer. Fish. Soc. West. Div. 1985)

best management practice a practice, or a combination of practices, that is determined by a state (or designated area-wide planning) agency after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with goals for water quality (USDA Forest Serv. 1979 Manage. Practice Documentation)

biomass 1. the weight of a taxon or taxa per unit of stream surface; 2. amount of substance in a population, expressed in material units, such as living or wet weight, dry weight, ash-free weight, nitrogen content, etc.; also called standing crop (Amer. Fish. Soc. West. Div. 1985)

BOD, biological or biochemical oxygen demand the amount of molecular oxygen required to stabilize decomposable matter by aerobic biochemical action (Amer. Fish. Soc. West. Div. 1985)

bog a wetland comprised of in-situ accumulations of poorly to moderately decomposed peats that are derived chiefly from sphagnum mosses; water is acidic (Amer. Fish. Soc. West. Div. 1985)

boulder a particle or rock larger than 256 mm in diameter (Amer. Fish. Soc. West. Div. 1985)

calibration period the time during which the flow of water is measured; usually pertains to the time when conditions are pristine or undisturbed and before treatments will be applied to the land

carrying capacity (holding capacity) all definitions of the concept must involve specification of some (1) level of use, (2) allowance for perpetual maintenance, (3) level of environmental quality, (4) managerial objective set with respect to the cost of maintaining resource quality, (5) level which will provide resource user satisfaction (after Schwarz, C.F.1976)*

ecological carrying capacity (Inherent capability, inherent carrying capacity, natural capability, natural carrying capacity, physical carrying capacity, resource bearing capacity, site capacity, biotic carrying capacity) 1. the number (or weight) of organisms of a given species and quality that can survive in, without causing deterioration of, a given ecosystem through the least favorable environmental conditions that occur within a stated interval of time (Ford-Robertson 1971)*; 2. the limit of a natural ecosystem's ability to sustain user impacts (after Conservation Foundation 1972)*; 3. strictly speaking, any level of use greater than zero always results in some alteration of natural environments, so ecological carrying capacity should not be defined in terms of "no change"; an acceptable amount of alteration of natural values must be determined before ecological carrying capacity can be used to set levels of use; 4. biotic carrying capacity used in a recreational context; that level of development and use beyond which the site's capacity to provide a sustained high level of satisfaction becomes impaired due to severe damage (La Page 1963)*; 5. physical carrying capacity considers effect of use on abiotic aspects of the habitat—e.g., ability of a particular terrain to resist trail erosion, but also the ability of the terrain to absorb trails, roads, and other man-made objects (Conserv. Found. 1972)*

grazing carrying capacity the maximum number of animals that produces the greatest return without damage to the physical resources and in concert with other values received from the land (Heady 1975)

wildlife carrying capacity 1. the number of animals of a given species that a habitat supports, measured at the low stage of any annual population cycle (after Allen)*; 2. the upper limit of population growth beyond which no major increase can occur (after Odum 1959)*; 3. the number of animals that a habitat can maintain in a healthy, vigorous condition (after Dasmann 1945)*; 4. the level at which a population is normally held by hunting and predation (after Errington 1945)*; 5. the level of population above which infraspecific tolerance permits no further increase (after Leopold 1933)*; six. constraints and circumstances that confine, restrict, preclude, compel, or oblige certain activities, processes, or effects, usually includes laws, regulations, policies, codes, ethics, physical realities, time, or other resources.

catchment area see drainage area (Amer. Fish. Soc. West. Div. 1985)

channel a natural or artificial waterway of perceptible extent that periodically or continuously contains moving water; has a definite bed and banks which serve to confine the water (Amer. Fish. Soc. West. Div. 1985)

channelization straightening of a stream or the dredging of a new channel to which the stream is diverted (Amer. Fish. Soc. West. Div. 1985)

channel stability a measure of the resistance of a stream to erosion that determines how well a stream will adjust to and recover from changes in flow or sediment transport (Amer. Fish. Soc. West. Div. 1985)

check dam a small concrete, gabion, or log dam designed to retard the flow of water and sediment in a channel; used especially for controlling soil erosion and limiting channel downcutting, reducing overall channel gradient, and collecting and trapping bedload sediment; frequently used to form the downstream end of a sediment basin; used in channels to divert intragravel water toward surface water for interchange of dissolved gases (Amer. Fish. Soc. West. Div. 1985; Howell 1960)

chute 1. a narrow, confined channel through which water flows rapidly; a rapid or quick descent in a stream, usually with a bedrock substrate; 2. a short straight channel which bypasses a long bend in a stream and is formed by the stream breaking through a narrow land area between two adjacent bends (Amer. Fish. Soc. West. Div. 1985)

cobble naturally rounded stone larger than a pebble; cobbled, abounding in, or covered or strewn with cobbles, cobbly or cobbly gravel, with cobbles between 64 and 256 mm in diameter; syn: rubble (Webster)

cohesive material material composed of soil particles with the capacity to stick or adhere together through capillary tension or weak electrical bonding of clay minerals (Sedgwick 1982)
cover anything that provides protection from predators or ameliorates adverse conditions of streamflow and/or seasonal changes in metabolic costs; may be instream cover, turbulence, and/or overhead cover; may be for purposes of escape, feeding, hiding, or resting (Amer. Fish. Soc. West. Div. 1985)

CPOM see organic materials, coarse particulate organic matter

cross-sectional area the area of a stream, channel, or waterway opening, usually taken perpendicular to the stream centerline (Amer. Fish. Soc. West. Div. 1985)
cutbank the concave wall of a meandering stream that is maintained as a steep or even overhanging bluff by the impinging of water at its base (Howell 1960)
debris material scattered about or accumulated by either natural processes or human influences (Amer. Fish. Soc. West. Div. 1985)
debris avalanche the sudden, rapid movement of the soil mantle on steep slopes (Swanston and Swanson 1976)
debris cone loose mixture of soil, rock, and organic debris deposited along the toe of steep mountain slopes as the result of debris avalanche and debris flow activity (Swanston and Swanson 1976)
debris flow a general designation for all types of rapid flowage involving water lubricated soil, rock, and organic debris. (Howell 1960)
debris jam log jam; accumulation of logs and other organic debris (Amer. Fish. Soc. West. Div. 1985)
debris loading the quantity of debris, due to natural processes or human activities, located within a specific reach of stream channel (Amer. Fish. Soc. West. Div. 1985)
debris torrent (debris flood) a large volume flow of debris charged water moving with great velocity and turbulence down a confining gully or canyon (Swanston and Swanson 1976)
deflection wall a berm, concrete wall, or other elongated retainer structure placed at an angle above downstream site or structures in order to reduce impact forces and deflect water and debris transported by debris torrents and floods (Howell 1960)
degradation the geologic process by which stream beds and flood plains are lowered in elevation by the removal of material; the opposite of aggradation (Amer. Fish. Soc. West. Div. 1985)
degraded watershed a catchment basin which has suffered environmental damage, either from natural or man-made causes, which is resulting in accelerated soil loss to the quantifiable detriment of other resources (USDA Forest Serv. 1979 Manage. Practice Documentation)
dendritic drainage irregular branching of tributaries from the main channel; implies horizontally bedded rock or surficial materials of uniform strength and texture (Howell 1960)
deposition the settlement or accumulation of material out of the water column and onto the stream bed; occurs when the energy of flowing water is unable to support the load of suspended sediment (Amer. Fish. Soc. West. Div. 1985); settlement or accumulation of wet or dry material from the atmosphere onto land, water bodies, and associated organisms

discharge volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as m$^3$/sec (Amer. Fish. Soc. West. Div. 1985)
dissolved oxygen the concentration of oxygen dissolved in water, expressed in mg/liter or a percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature (Amer. Fish. Soc. West. Div. 1985)
diversity index relationship of the number of taxa (richness) to the number of individuals per taxon (abundance) for a given community (Amer. Fish. Soc. West. Div. 1985)

DOC see organic materials, dissolved organic carbon

DOM see organic materials, dissolved organic matter
downcutting erosion of the soil, streambank, or streambed resulting in the surface level moving from a higher to a lower level

drainage area total land area draining to any point in a stream, as measured on a map, aerial photo or other horizontal plane; also called catchment area, watershed, and basin (Amer. Fish. Soc. West. Div. 1985)

dehflow slow downslope movement of weathered rock or soil either by a flowage mechanism or by gliding displacement of a series of blocks; many flows begin as a slump or series of slumps and develop broader earthflow characteristics downslope (Swanston and Swanson 1976)
eddy contrary or circular current, usually behind an obstruction (Webster)
enhancement improvement of conditions that provide for the betterment over natural conditions of aquatic, terrestrial, and recreational resources (Amer. Fish. Soc. West. Div. 1985)

ephemeral stream see stream, ephemeral

evapotranspiration that portion of precipitation intercepted by vegetation and returned to the air through direct evaporation or by transpiration of the vegetation (Huschke 1959)
exclusion a structure, usually some kind of fencing, to shut out, or at least hinder, access by animals that are already outside

fill 1. localized deposition of material eroded and transported from other areas, resulting in a change in bed elevation; opposite of scour; 2. deliberate placement of (generally) inorganic materials in a waterbody, usually along the bank (Amer. Fish. Soc. West. Div. 1985)

fish habitat aquatic environment and the immediately surrounding terrestrial environment that, combined, afford the necessary biological and physical support systems required during various life stages by fish species (Amer. Fish. Soc. West. Div. 1985)

flood any flow that exceeds the bankful capacity of a stream or channel and flows onto the flood plain; greater than bankful discharge (Amer. Fish. Soc. West. Div. 1985)

flash flood a condition created by precipitation of severe intensity causing a rapid rising of the stream level and usually brief in duration

flood plain any flat, or nearly flat lowland that borders a stream and is covered by its waters at flood stage; also floodplain, flood-plain (Amer. Fish. Soc. West. Div. 1985); includes debris cones and flood-prone areas of offshore islands including, at a minimum, that area subject to a 1 percent (100-year recurrence) or greater chance of flooding in any given year(USDA Forest Serv. 1979 Manage. Practice Documentation)

flow 1. movement of a stream of water and/or other mobile substances from place to place; 2. movement of water, and the moving water itself; 3. volume of water passing a given point per unit to time; syn: discharge (Amer. Fish. Soc. West. Div. 1985)
base flow the discharge entering stream channels from
ground water or other delayed sources. (Howell 1985)

Instream flow streamflow regime required to satisfy a
mixture of conjunctive demands being placed on water
while it is in the stream (Amer. Fish. Soc. West. Div.
1985)

Instream flow requirements amount of water flowing
through a stream course required to sustain instream
values at some ordained level

low flow lowest discharge recorded over a specified pe­
riod of time; also called minimum flow (Amer. Fish. Soc.
West. Div. 1985)

mean flow average discharge at a given stream location,
usually expressed in m^3/sec, computed for the period of
record by dividing the total volume of flow by the number
of days, months, or years in the specified period (Amer.
Fish. Soc. West. Div. 1985)

minimum flow 1. lowest discharge recorded over a
specified period of time (preferred definition) 2. negoti­
ated lowest flow, may vary seasonally, in a regulated
stream that will sustain an aquatic population at agreed
upon levels (this recently developed definition is in con­
flict with the older, preferred definition and to avoid
confusion should not be used; a suggested alternative
is to apply the second definition to the term least flow)
(Amer. Fish. Soc. West. Div. 1985)

optimum flow discharge regime that allows for the max­
imum expression of the carrying capacity of any specified
use in a stream; any flow above or below this flow be­
comes limiting to the use under consideration (Amer.
Fish. Soc. West. Div. 1985)

peak flow highest discharge recorded over a specified
period of time; often thought of in terms of spring
snowmelt or a particular rainy season; also called maxi­
mum flow (Amer. Fish. Soc. West. Div. 1985)

fluviial pertaining to streams or produced by stream action
(Amer. Fish. Soc. West. Div. 1985)

FPOM see organic materials, fine particulate organic matter
FR see total dissolved solids, filtrable residue
FTU see turbidity, formazin turbidity units
gabion wire basket filled with stones, used to stabilize banks
and for habitat enhancement (Amer. Fish. Soc. West. Div.
1985)

gaging station a permanent site with structures and
equipment to record the level of the water surface and to
calculate volume of stream discharge; may include a stilling
well or basin, a weir or flume, a transect of known
cross-sectional area, equipment to measure the level of the water
surface, and a rating equation to calculate stream discharge
glide wide, shallow pool in a stream flowing smoothly and
gently, with low to moderate velocity and little or no turbu­
ence. (Bisson et al. 1981)

gradient 1. general slope, or rate of change in vertical el­
evation per unit of horizontal distance, of the water surface
of a flowing stream; 2. rate of change of any characteristic
per unit of length (Amer. Fish. Soc. West. Div. 1985)

gentle gradient less than 1.5 percent; Rosgen's type C

moderate gradient 1.5 to 4 percent; Rosgen's type B

steep gradient greater than 4 percent; Rosgen's type A

gravel loose or unconsolidated material consisting of
rounded fragments of rock ranging in size from 2 mm to a
meter or more in diameter; material of finer particles is
classed as sand. (Webster)

groundwater flow that portion of precipitation which has
been absorbed by the ground and has become part of the
groundwater alternately being discharged as spring and
seepage water into the stream channels (Huschke 1959)
gully a small ravine; a hollow or channel carved in the earth by
running water (Howell 1960)
gully erosion (gullying) removal of soil along well defined
paths by running water produced by surface runoff, resulting
in formation of deep hollows and ravines; generally a product
of heavy overland flow and channelization of water by differ­
etial erosion. (Howell 1960)
gully plug a structure of wire, wood, or natural material in­
stalled at the top of a gully to reduce headcutting and
deepening

habitat place where a population lives and its surrounding,
both living and nonliving; includes provision of require­
ments for life, such as food and shelter (Amer. Fish. Soc.
West. Div. 1985)

headcutting headward erosion; wearing away of rock or soil
by erosive agents at the upper end of a channel; evidenced
by gullying, undermining by springs, and slumping.

hydrology the science treating of water, its properties,
phenomena, and distribution over the earth. The term is
used spec. by USDI Geological Survey to refer to under­
ground water sources, as distinguished from hydrography,
which is applied to surface water supplies and sources.
(Webster)

Ice, anchor water frozen below the surface of a stream, on
the stream bed or upon a submerged body or structure
(Amer. Fish. Soc. West. Div. 1985)

Ice cap 1. the layer of frozen water on the surface of a lake;
2. dome of frozen water covering a precipitation gage

Ice dam an accumulation of frozen water, often in chunks or
blocks, hindering the flow of water in a stream which may
cause flooding in unsuspected places

Ice, frazil fine spicules of ice formed in water too turbulent
for formation of sheet Ice; forms in supercooled water
when the air temperature is far below freezing (most often

Infiltration rate maximum rate at which soil can absorb rain or
shallow impounded water (Huschke 1959)

Instream flow requirements see flow, instream flow re­
quirements

Intermittent stream see stream

Intragravel flow flow within streambed gravels (Howell
1960)

JTU see turbidity, Jackson turbidity units

lodgement a generic term encompassing the sudden move­
ment of earth and rocks down a steep slope (Howell 1960)

large organic debris (LOD) any large piece of relatively
stable woody material having a least diameter greater than
10 cm and a length greater than 1 meter that intrudes into
the stream channel; syn: large woody debris, log (Amer.
Fish. Soc. West. Div. 1985); specific types include:

affixed logs single logs or groups of logs that are firmly
embedded, lodged or rooted in a stream channel (Amer.
Fish. Soc. West. Div. 1985)

bole term referring to the stem or trunk of the tree (Amer.
Fish. Soc. West. Div. 1985)
large bole 10 meter or more in length; often embedded, remain in the stream for extended periods (Amer. Fish. Soc. West. Div. 1985)
small bole less than 10 meters in length, usually sections of bole; seldom stable, usually move downstream on high flows (Amer. Fish. Soc. West. Div. 1985)
deadheads logs that are not embedded, lodged, or rooted in soil, but are submerged and close to the water surface (Amer. Fish. Soc. West. Div. 1985)
digger log log anchored to the stream banks and/or channel bottom in such a way that a scour pool is formed (Amer. Fish. Soc. West. Div. 1985)
free logs logs or groups of logs in water bodies that are not embedded, lodged, or rooted in soil or rock (Amer. Fish. Soc. West. Div. 1985)
rootwad root mass of the tree; synonym: butt ends (Amer. Fish. Soc. West. Div. 1985)
snag 1. standing dead tree; 2. sometimes a submerged fallen tree in large streams; top of the tree is exposed or only slightly submerged (Amer. Fish. Soc. West. Div. 1985)
sweeper log fallen tree whose bole or branches form an obstruction to floating objects (Amer. Fish. Soc. West. Div. 1985)
types of large organic debris accumulation:
clumps accumulations of debris at irregularly spaced intervals along the channel margin, not forming major impediments to flow (Amer. Fish. Soc. West. Div. 1985)
jams large accumulations of debris partially or completely blocking the stream channel, creating major obstructions to flow (Amer. Fish. Soc. West. Div. 1985)
scattered single pieces of debris at irregularly spaced intervals along the channel (Amer. Fish. Soc. West. Div. 1985)
large woody debris (LWD)-rootwads and tree stems which provide overhead cover and flow modifications for effective spawning and rearing habitat of anadromous and resident fishes. (Bisson et al. 1981)
macroinvertebrate an invertebrate animal (without backbone) large enough to be seen without magnification (Amer. Fish. Soc. West. Div. 1985)
marsh water-saturated, poorly drained wetland area, periodically or permanently inundated to a depth of up to 2 meters; supports an extensive cover of emergent, non-woody vegetation, essentially without peat-like accumulations found in bogs (Amer. Fish. Soc. West. Div. 1985)
meander a pattern present in the stream channel, angle between the channel and the general valley trend is less than 90°; if the angle is greater than 90°, it is called a tortuous meander (Amer. Fish. Soc. West. Div. 1985)

NTU see turbidity, nephelometric turbidity units
nutrient load concentration of minerals in water resulting from leaching, biological decomposition, and atmospheric deposition; commonly includes nitrates, nitrites, phosphates, and potassium compounds; high levels contribute to eutrophication, algal blooms and other phenomena
organic materials:
coarse particulate organic matter (CPOM) organic matter having a least dimension ranging from 1 mm to 10 cm; technically includes both living and dead material, but often used more specifically to refer to detritus (Amer. Fish. Soc. West. Div. 1985)
dissolved organic matter (DOM) or dissolved organic carbon (DOC) organic material having a least dimension smaller than 0.45 μm; passes through a 0.45 μm filter (Amer. Fish. Soc. West. Div. 1985)
fine particulate organic matter (FPOM) organic matter having a least dimension ranging from 0.45 μm to 1 mm (Amer. Fish. Soc. West. Div. 1985)
overhead cover material (organic or inorganic) that provides protection to fish or other aquatic animals from above; generally includes material overhanging the stream less than a particular distance above the water surface; values of less than 0.5 m and less than 1 m have been used (Amer. Fish. Soc. West. Div. 1985)
parr young salmon during the period they spend in fresh water (Sedgwick 1982)
pebble a small roundish stone, esp., one worn and rounded by action of water; pebble gravel, with pebbles between 4 and 64 mm in diameter; pebbly or pebbled, abounding in, or covered or strewn with pebbles (Webster)
perennial stream see stream
plowing depressions made in the soil surface to detain water and to reduce wind erosion by increasing roughness of the soil surface
point bar sediment deposited as a bar on the inside of a channel bend (Howell 1960)
pool a small, rather deep body of water in a stream; generally formed by turbulence associated with the presence of bedrock outcroppings, large rocks, or large tree stems and rootwads in the channel; for habitat element assessment, six types are generally recognized:
secondary channel pools formed outside the average wetted channel
backwater pool found along channel margins caused by eddies around obstructions such as boulders, rootwads, and large woody debris
trench pool generally long and deep in a stable substrate plunge pool formed where a stream passes over a complete channel obstruction and drops steeply onto the streambed below, scouring out a depression
lateral scour pool formed by scour generated by turbulence as flow impinges against the streambank or partial channel obstruction
dammed pool formed by water impounding behind a complete or nearly complete channel blockage (Bisson et al. 1981)
pool/riffle ratio the relation between surface area or length of pools to surface area or length of riffles in a given stream reach, frequently expressed as the relative percentage of each category (Amer. Fish. Soc. West. Div. 1985); an expression of potential habitat condition; higher ratios imply more pools and a better overall habitat condition (Bisson et al. 1981)
productivity 1. rate of new tissue formation or energy utilization by one or more organisms; 2. capacity or ability of an environmental unit to produce organic material; 3. ability of a population to recruit new members by reproduction (Amer. Fish. Soc. West. Div. 1985)
rain-on-snow event late winter or spring storm which adds large quantities of warm rain onto an existing snow pack, resulting in rapid runoff of high volume (Huschke 1959)
reach a straight portion of a stream or river (Howell 1960)
rearing habitat specific locations in the main channel and side channels where over-wintering parr can gain adequate cover and food (Sedgwick 1982)

redd a depression in the streambed created by a male salmonid and in which the female spawns

reforestation natural or, most commonly, artificial restocking of an area with forest trees (USDA Forest Serv. 1979 Manage. Practice Documentation)

revegetation replacement of depleted or lost vegetative cover; accomplished through planting of nursery stock, seeding, or natural processes (USDA Forest Serv. 1979 Manage. Practice Documentation)

revetment a lacing of stone, concrete, fascines, or any other material, to sustain an embankment; also, a retaining wall (Webster); see riprap

riffle a shallow extending across the bed of a stream; for habitat element assessment, three types are generally recognized:

  - low gradient riffles shallow reaches with swift flowing turbulent water and some partially exposed substrate, gradient >4%, substrate is cobble dominated
  - high gradient riffles steep reaches of moderately deep, swift, and very turbulent water, amount of exposed substrate is large; gradient is >4%, and substrate is boulder dominated

  - cascades the steepest riffle habitat, consisting of alternating small waterfalls and shallow pools, substrate is usually bedrock and boulders (McCain et al. 1985)

rill one of the first and smallest channels formed by surface runoff

riparian 1. in loose usage, referring to the land bordering a stream, lake, or tidewater (Hanson 1961)*; 2. of, pertaining to, or situated on the banks of a river (though by common usage extended to include any stream, irrespective of size) (Stamp 1961)*; pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water (Amer. Fish. Soc. West. Div. 1985)

riparian vegetation vegetation growing on or near the banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season (Amer. Fish. Soc. West. Div. 1985)


riparian area a geographically delineated area with distinctive resource values and characteristics that is comprised of the aquatic and riparian ecosystems (adopted by USDA Forest Serv. and USDI Bur. Land Management); a stream or other body of water and adjacent upland identified by soil characteristics and distinctive vegetation; includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation (Amer. Fish. Soc. West. Div. 1985)

rip rap a foundation or wall made of broken stones thrown together irregularly or loosely, as in water or on a soft bottom (Webster); layer of large, durable materials (usually rock but sometimes car bodies, broken concrete, etc.) used to protect a stream bank from erosion; may also refer to the materials themselves; syn: revetment (Amer. Fish. Soc. West. Div. 1985); a system of armoring, protective coverings, and structures used to displace the erosive force of water

riparian area boundaries aquatic ecosystem, floodplains, riparian ecosystems, wetlands, and the land and vegetation extending at least 100 feet, measured horizontally, from all perennial streams (CDF Forest Practice Rules)

riparian ecosystem the transition area between the aquatic ecosystem and terrestrial ecosystem, identified by soil characteristics and distinctive vegetation communities that require free or unbound water (adopted by USDA Forest Serv. and USDI Bur. Land Management)

riparian rights 1. rights of owners of lands on the banks of watercourses or bodies relating to the water, its use, ownership of soil under the stream, shoreline accretions, etc. (US Bur. Outdoor Recreation 1974)* 2. rights accruing to a landowner on the bank of a natural watercourse, lake, or ocean; these rights vary with state law; riparian rights cease at the water's edge and do not interfere with use of the water area by others offshore (after Abrams 1971)*

rock-fill dam dam composed of large, broken, and loosely placed or pervious rocks with either an impervious core or upstream facing, surface layer (Amer. Fish. Soc. West. Div. 1985)

rubble stream substrate particles between 64 and 256 mm in diameter; syn: cobble (Amer. Fish. Soc. West. Div. 1985)

run swiftly flowing stream reach with little surface agitation and no major flow obstructions (Bisson et al. 1981)

sag pond pool of water or swampy area occupying depressions caused by uneven settling of the ground due to slumping and earthflow activity (Howell 1960)

saturated flow flow of water through the soil within the zone of saturation, where all interstices are filled with water under pressure equal to or greater than atmospheric (Huschke 1959)

scour localized removal of material from the stream bed by flowing water; opposite of fill (Amer. Fish. Soc. West. Div. 1985)

sediment fragmented material that originates from weathering of rocks and decomposition of organic material that is transported by, suspended in, and eventually deposited by water or air, or is accumulated in beds by other natural phenomena (Amer. Fish. Soc. West. Div. 1985)

sediment basin a constructed basin at the mouth of a steep gradient channel for collecting and storing bedload sediment; used primarily to limit excessive sedimentation and impact forces generated by heavily laden storm flows on structures downstream (Howell 1960)

sediment discharge mass or volume of sediment (usually mass) passing a stream transect in a unit of time; term may be qualified, for example, as suspended-sediment discharge, bed-load discharge, or total-sediment discharge, usually expressed as tons per day (Amer. Fish. Soc. West. Div. 1985); see also bed-load discharge

sediment load refers to sediment moved by a stream, whether in suspension (suspended load) or at the bottom (bed load); not synonymous with either discharge or concentration; see bed load (Amer. Fish. Soc. West. Div. 1985)

sediment wedge a thick, wedge-shaped alluvial deposit of mixed soil, rock, and organic debris deposited in stream channels by debris avalanches and debris flows from adjacent hillslopes (Swanston in press)

sheet erosion initial erosion by surface runoff accomplished by sheets of running water as distinct from channelized erosion in rills and gullies (Huschke 1959)

sheet runoff water running off the surface equally in all directions as a continuous sheet of surface water (Huschke 1959)
side-channel rearing areas pools and secondary channel segments adjacent to the main channel which serve as rearing areas for salmon parr during their 1 to 2 year period in fresh water prior to migrating to the sea (Bisson et al. 1981)

significant disturbance man-created disturbance of surface resources, including soil, water and vegetation, which has the potential to generate degradation of water quality to the magnitude which would require corrective action (USDA Forest Serv. 1979 Manage. Practice Documentation)

sinuous refers to the configuration of a stream channel with slight curvature within a belt of less than approximately two channel widths (Amer. Fish. Soc. West. Div. 1985)

site preparation activity of preparing a site for revegetation; can be accomplished by either mechanical, chemical, or biological means, or by controlled fire (USDA Forest Serv. 1979 Manage. Practice Documentation)

site specific pertains to a discernible, definable area or point on the ground where a project or activity will (or is proposed to) occur (USDA Forest Serv. 1979 Manage. Practice Documentation)

slump the sudden downward movement of a block of bedrock or soil by backward rotation along a broadly concave slip surface (Swanson and Swanson 1976)

smolt young salmon when they are one to two years old, turn silvery, and are ready to migrate to the sea (Sedgwic 1982)

snow course a site on which long-term measurements are made at 10 points with a standardized tube for sampling the depth and density of snow

snow pack annual accumulation of snow at higher elevations (Huschke 1959)

spawning habitat specific locations within stream channels where redds are construction and eggs are laid during the salmon spawning cycle; typically includes pools, riffles, and glides in the mainstem channel (Bisson et al. 1981)

spring a location where an underground flow of water reaches the earth surface and appears as surface water

storm flow water flowing in a stream as the result of a specific precipitation event of "rain storm" (Huschke 1959)

stream or stream course a natural water course containing flowing water, at least part of the year, supporting a community of plants and animals within the stream channel and the riparian vegetation zone; streams in natural channels may be classified as follows: (Amer. Fish. Soc. West. Div. 1985)

1. relation to time:
   - ephemeral flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table
   - intermittent or seasonal in contact with the ground water table that flows only at certain times of the year as when the ground water table is high and/or when it receives water from springs or from some surface source such as melting snow in mountainous areas; ceases to flow above stream bed when losses from evaporation or seepage exceed available streamflow
   - perennial flows continuously throughout year; syn: permanent

2. relation to space
   - continuous does not have interruptions in space
   - interrupted contains alternating reaches that are either perennial, intermittent, or ephemeral

3. relation to ground water
   - insulated stream or reach of stream that neither contributes to nor receives water from zone of saturation;

   separated from zones of saturation by an impermeable bed
   - gaining stream or reach of stream that receives water from zone of saturation
   - losing stream or reach of stream that contributes water to zone of saturation
   - perched either a losing stream or an insulated stream that is separated from underlying groundwater by a zone of aeration

4. other
   - incised stream that has, through degradation, cut its channel into the bed of the valley

stream bank portion of the channel cross section that restricts lateral movement of water at normal water levels; bank often has a gradient steeper than 45° and exhibits a distinct break in slope from the stream bottom; an obvious change in substrate may be reliable delineation of the bank (Amer. Fish. Soc. West. Div. 1985); steeper sloped earth or rocks demarking the channel of a watercourse; may adjoin hills or valley walls or be separated from them by a floodplain; see undercut bank

streambank zone land adjacent to and water within any stream or streamcourse where human activities can have direct consequences on the quantity, quality, or timing of water flow or instream conditions.

stream bed the substrate plane, bounded by the stream banks, over which the water column moves; also called stream bottom (Amer. Fish. Soc. West. Div. 1985)

stream classification systems for grouping and identifying streams possessing similar features according to geomorphic structure (e.g., gradient), water source (e.g., spring creek), associated biota (e.g., trout zone) or other characteristics; usually hierarchal in structure; two concepts in use are (1) management use-related, based almost entirely on value to fish populations, (2) a geomorphic-habitat system developed by an interagency effort at Ft. Collins, CO (Amer. Fish. Soc. West. Div. 1985)

stream/estuary ecotone area near stream mouth extending from upper limit of tidal influence seaward to lower limit of marsh vegetation; size depends on stream gradient and range of tidal heights (Amer. Fish. Soc. West. Div. 1985)

stream/forest ecotone area of stream directly influenced by riparian vegetation, including stream bank and upland area adjacent to stream; size depends on stream width, type of vegetation, and physical characteristics of adjoining uplands (Amer. Fish. Soc. West. Div. 1985)

stream order arrangement of channel segments in a stream system; first-order streams are the smallest unbranched tributaries; second-order tributaries are initiated by the confluence of two first-order channels (Howell 1960); designation (1, 2, 3, etc.) of relative position of stream segments in a drainage basin network: smaller, unbranched, perennial tributaries, terminating at an outer point, are designated order 1; junction of two first-order streams produces a stream segment of order 2; junction of two second-order streams produces a stream segment of order 3, etc.; use of small-scale maps (<2 inches/mile) may cause smaller streams to be overlooked, leading to gross errors in designation; ideally designation should be determined on ground or from large-scale aerial photos (Amer. Fish. Soc. West. Div. 1985)

stream morphology description of the bed and bank of a stream in relation to the contained water

streamside edge of a stream as defined by a high-water line associated with bankful discharge of perennial streams. (USDA-Forest Service Manual, Chapter 2400)
streamside management zone a designated area along streams and wetlands where prescriptions are made that will minimize effects of nearby logging and related activities disturbing to land (USDA Forest Serv. 1979 Manage. Practice Documentation. Practice 1.8)

stream transect a corridor or line along which measurements are made of the depth and velocity of water and the configuration and materials of the stream bed

structure 1. any object, usually large, in stream channel that controls water movement; 2. diversity of physical habitat within a stream; 3. when applied to a biological community, the organization of taxa into various functional or trophic groups (Amer. Fish. Soc. West. Div. 1985)

suspended load portion of total sediment load that moves in suspension, free from contact with stream bed, and is made up of particles having such density or grain size as to permit movement disassociated from stream bed; density and grain size vary according to amount of turbulence; only unusually swift stream are turbulent enough to lift particles larger than medium-sized sand from their beds; see bed load (Amer. Fish. Soc. West. Div. 1985)

suspended sediment see suspended load

swamp tree or tall shrub dominated wetlands that are characterized by periodic flooding and nearly permanent subsurface water flow through mixtures of mineral sediments and organic materials, essentially without peatlike accumulation (Amer. Fish. Soc. West. Div. 1985)

TDS see total dissolved solids

talus (scree) a heap of coarse rock at the foot of a cliff, or a sheet of coarse rock covering a slope below a cliff (Howell 1980)

thalweg the line connecting or joining the lowest or deepest points along a stream bed (Amer. Fish. Soc. West. Div. 1985)

torrent temporary flow condition in streams created by heavy rainfall or rapid snowmelt; characterized by near bankful discharge, sizable increase in velocity, standing waves, and loss of typical stepped profile and hydraulic diversity of habitat (Amer. Fish. Soc. West. Div. 1985)

total dissolved solids (TDS) measure of inorganic and organic materials dissolved in water (passing through a 0.45μm filter); often referred to as filterable residue (FR) and expressed as mg/filter FR; sometimes considered similar to conductivity as an indicator of potential production in habitat quality indices (Amer. Fish. Soc. West. Div. 1985)

total suspended solids organic and inorganic material left on a standard glass fiber filter (0.45μm) after a water sample is filtered through it; often referred to as Non-Filterable (Amer. Fish. Soc. West. Div. 1985)Residue (N.F.R.)

trash catcher or rack a structure with a grid or fingers placed in front of pipe systems, culverts, etc. to detain larger organic material from entry

trellised drainage parallel branching of tributaries from the main channel; implies folded or faulted rock and significant structural control of drainage system (Howell 1960)

tributary stream feeding, joining, or flowing into a larger stream; syn: feeder stream, side stream; tributary types based on watershed geomorphology include: (Amer. Fish. Soc. West. Div. 1985)

lower-valley-wall tributaries characterized by moderately steep gradients and occur at slope break between valley wall and valley floor (Amer. Fish. Soc. West. Div. 1985)

terrace tributaries result from spring networks on valley floor, and from tributaries draining valley side slopes and continuing across terraces to main stream (Amer. Fish. Soc. West. Div. 1985)

upper-valley-wall tributaries possess very steep gradients, high velocities, and flow over a stepped profile of alternating pools and cascades (Amer. Fish. Soc. West. Div. 1985)

wall-based tributaries run along base of valley wall, parallel to main stream channel (Amer. Fish. Soc. West. Div. 1985)

turbidity 1. relative water clarity; 2. measure of extent to which light passing through water is reduced due to suspended materials; measured by several non-equivalent standards (e.g., Nephelometric Turbidity Units, NTU; Formazin Turbidity Units, FTU; Jackson Turbidity Units, JTU) (Amer. Fish. Soc. West. Div. 1985)

turbulence motion of water where local velocities fluctuate and direction of flow changes abruptly and frequently at any particular location, resulting in disruption of laminar flow; causes surface disturbance and uneven surface level, and often masks subsurface areas because air bubbles are entrained in water (Amer. Fish. Soc. West. Div. 1985)

undercut bank bank that has had its base cut away by water or has been man-made and overhangs part of stream (Amer. Fish. Soc. West. Div. 1985); unsaturated flow flow of water through the soil above the zone of saturation or water table, where voids are only partially filled with water (Huschke 1959)


v-notch 1. narrow, steep-sided ravine or valley with v-shaped cross section whose bottom usually contains a watercourse; 2. type of weir containing a v-shaped notch used for gauging discharge in small streams (Amer. Fish. Soc. West. Div. 1985)

wash load load that because of its fine size has such a small settling velocity that it would be held in suspension; essentially synonymous with suspended load (Amer. Fish. Soc. West. Div. 1985)

watercourse and lake protection zone (WLPZ) (In California) an area clearly identified on the ground with paint or flagging and given special consideration to ensure retention of canopy for shade or to filter and stop sedimentation; trees marked either to be retained or to be harvested; width of the WLPZ varies from 50 to 200 feet according to slope percent and class of watershed (CDF Guidebook to Board of Forestry Watercourse and Lake Protection Rules July 1983)

watershed see drainage area

water table the upper surface of the zone of saturation in the soil mantle (Huschke 1959)

water yield total outflow from all or part of a drainage basin through either surface channels or subsurface aquifers within a given time (i.e., a year) (Amer. Fish. Soc. West. Div. 1985)

wattle a woven wall or fence made of intertwined twigs or branches.

weir 1. notch or depression in a levee, dam, embankment, or other barrier across or bordering a stream, through which flow of water is measured or regulated; 2. barrier constructed across a stream to divert fish into a trap; 3. dam
(usually small) in a stream to raise water level or divert its
flow (Amer. Fish. Soc. West. Div. 1985)
wetland area subjected to periodic inundation, usually with
soil and vegetative characteristics that separate it from ad­
joining non-inundated areas (Amer. Fish. Soc. West. Div.
1985)
wetlands those areas that are inundated by surface or
groundwater with a frequency sufficient to support, and
under normal circumstances does or would support, a
prevalence of vegetation or aquatic life that requires satu­
rated or seasonally saturated soil conditions for growth and
reproduction; generally include swamps, marshes, bogs,
and similar areas such as sloughs, potholes, wet meadows,
river overflows, mud flats, and natural ponds. (USDA Forest
Serv. 1979 Manage. Practice Documentation)
wetted perimeter in a stream channel cross section, the
outline of the edge where water and channel meet
(Huschke 1959)
windthrow trees blown down singly or in groups by strong
winds (Swanson in press)
woody debris see large organic debris

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Appendix C. Selected References on Methods and Interpretations for Watershed Projects

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