NATIONAL COASTAL ECOSYSTEM

RESTORATION MANUAL

Sea Grant
Oregon

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Oregon Sea Grant
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Sea Grant is a unique partnership with public and private sectors, combining research, education, and technology transfer for the public service. This national network of universities meets the changing environmental and economic needs of people in our coastal, ocean, and Great Lakes regions.

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Contents

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Watershed Stewardship: A Learning Guide—Oregon State University Extension Miscellaneous 8714 (Oregon State University, Corvallis), new July 1998, revised January 2000 (revised January 2002), 485 pages, $42.00— was written "to help residents and volunteers be good stewards of their watershed." Its focus is on all salmonids west of the Cascades.

The *National Coastal Ecosystem Restoration Manual,* by contrast, is intended for a national audience and addresses a variety of species. Furthermore, it includes case studies of successful restoration projects from across the nation. We ask that the information in this book be used for noncommercial purposes.

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PART ONE

Communication

CHAPTER ONE

Creating Successful Partnerships

by Pat Corcoran

Watershed groups are voluntary organizations made up of people with a wide variety of backgrounds and interests. Whether your group is called a watershed council, an association, a coalition, or something else, members have a common interest in improving the ecological health of your watershed.

The open membership and voluntary nature of watershed groups make them less internally similar than other groups such as church groups, industry organizations, environmental groups, or service groups. A watershed group is a diverse collection of people with a particular interest *and* a common interest. This kind of group is described most accurately by the term *partnership*.

This chapter highlights some of the unique aspects of watershed groups and points out how they can be formed and sustained successfully. It will provide you with a basic understanding of partnerships.

In this chapter, I assume you are starting a partnership from scratch. In practice, however, most groups already are involved in some kind of partnership. If that's the case with your group, you'll still find lots of ideas here to help you.

Other chapters in this section build on this understanding of voluntary partnerships and are full of tips for increasing group effectiveness. Chapter 2, "Choosing Your Group's Structure, Mission, and Goals," provides more specifics on organizational structures that can be used for your group, the roles and responsibilities of members, and ways to establish group vision and goals. Chapter 3, "Effective Meetings Management," contains tips for managing meetings more effectively, while chapter 4 discusses decision making. Skills for improving communication are addressed in chapter 5. Common stumbling blocks to working together and possible solutions are identified in chapter 6, "Common Stumbling Blocks and How to Deal with Them."

In this chapter you'll learn

- What a partnership is and the value of working together
- Characteristics of successful, and less successful, partnerships
- Key elements to consider when forming and sustaining your partnership
- The importance of a shared vision and measurable goals

What Is a Partnership?

A partnership is a public agreement among a group of people to work together for a common interest. A partnership implies a willingness to collaborate with others to reach common goals without giving up your own identity or personal interests. For watershed groups, it means a good-faith attempt to work together to enhance and restore healthy watersheds. It means finding a way to tolerate people you might not like but agree to work with. It's an acknowledgment that cooperation may be the best strategy for getting things done.

If people are involved in selecting a project, they are more likely to have ownership of the project and are more likely to help implement it.

Partnership members agree to set and follow certain guidelines in order to work together successfully. All groups, especially diverse groups, experience a certain level of frustration. However, people who share an interest and goodwill—people in partnerships—spend less time and energy fighting each other and more time and energy tackling problems.

Why Work Together?

With something as complex as a watershed, nobody can know everything. Partnerships add value to watershed restoration efforts by drawing on the expertise of a variety of people who know the watershed in different ways. Partnerships operate with the understanding that everyone has a piece of the truth. It often takes awhile to find out what each person's piece of the truth is, but with effort the pieces fall into place. Involving a wide variety of people also multiplies the group's creativity because a wider variety of solutions can be generated.

The voluntary nature of these groups means people must *choose* to roll up their sleeves and implement projects. A key concept in the management of volunteers is that of *ownership*. If people are involved in selecting a project, they are more likely to have ownership of the project and are more likely to help implement it.

Furthermore, broad local involvement increases the likelihood that projects will be accepted and supported over the long haul. This support is critical, given the time needed to show the results of ecological enhancement. Skillfully maintained partnerships increase citizens' personal sense of responsibility, involvement, and commitment.

Characteristics of Successful Partnerships

Given the great variety of partnerships, it helps to know what distinguishes a successful partnership from an unsuccessful one. As you look at the following list, you might think, "Our group doesn't have these characteristics, so we can't be a successful partnership." Keep in mind, however, that we all operate under less-than-ideal circumstances. Your group can succeed as

long as you identify what you need to do to improve the partnership. It takes effort.

The following characteristics of successful partnerships are adapted from the *Partnership Handbook* (1995) by Ann Moote.

- *Broad membership*—A common guideline for partnerships is to involve everyone. Typical partners in watershed groups include government agencies, nonprofit organizations, professional societies, corporations, landowners, and private citizens.
- *Local knowledge*—Partnerships enhance stewardship and watershed health by drawing on the expertise of a wide range of individuals and groups who live in and intimately know the resource base and the local economy. No single individual, agency, or organization can do the job alone.
- *Effective communication*—Partnerships use communication to solve problems and reach agreements. Effective communication improves everyone's understanding of the issues and of each other's needs and concerns, thereby reducing conflict. See chapter 5, "Communication Skills," for hints on how to improve your group's communication.
- *Common vision*—By generating a commonly shared vision, partnerships build long-term support that can improve project implementation. For watershed groups, this vision relates to the future of natural resources and local communities. Chapter 2, "Choosing Your Group's Structure, Mission, and Goals," talks more about this topic.
- *Collaborative decision making*—Decisions usually are made by consensus to ensure that everyone's needs and concerns are addressed. In this way, partnership groups often come up with more creative and generally acceptable decisions than they would if only a few people were involved in making decisions. See chapter 4, "Decision Making," for more information on effective decision-making methods.
- *Pooled resources*—Partnerships improve on-the-ground management by pooling the resources of several organizations, agencies, and individuals. Pooling resources provides various benefits; for example, volunteer involvement may increase, and there may be a broader base of financial support.

Characteristics of Unsuccessful Partnerships

You also can learn from unsuccessful partnerships. Again, seeing characteristics of your group on this list doesn't mean you're doomed to failure. It does mean that you'll need to bring up these issues and address them openly and honestly in order to resolve them. (See chapter 5, "Communication Skills," and chapter 6, "Common Stumbling Blocks and How to Deal with Them.") Here are some characteristics of unsuccessful partnerships (also from the *Partnership Handbook*):

- Conflict among key interests remains unresolved.
- The group has no clear purpose.
- Goals or deadlines are unrealistic.

- Key interests or decision makers aren't included or refuse to participate.
- Not all participants stand to benefit from the partnership.
- Some members stand to benefit considerably more than others.
- Some members have more power than others.
- The partnership isn't needed because one entity could achieve the goals alone.
- Financial and time commitments outweigh potential benefits.
- Members are uncomfortable with the commitments required.
- Constitutional issues or legal precedents constrain the partnership.

Key Elements in Forming and Sustaining Successful Partnerships

Partnerships are relationships, and all relationships require effort to sustain openness and effective communication. Relationships don't just happen; you have to work at them.

Sustaining partnerships requires basic relationship skills and more. By looking at Moote's lists, we can conclude that successful partnerships have three key ingredients—*collective involvement, shared vision,* and *measurable goals.* Conversely, partnerships aren't successful when membership is rigged or one-sided, members don't actively seek common ground, or goals are fuzzy. Let's look at each of these factors more closely.

Collective Involvement

Watershed groups are primarily voluntary groups and therefore require voluntary involvement. People contributing their time and goodwill are rewarded when their contribution can be made with some choice and with varying levels of involvement. There is plenty of work for anyone interested, but it takes effort to synchronize each contribution in a way that supports the goals of the group.

There is a tendency to want to have a small group of decision makers tell a large group of workers what to do. This approach is efficient from a manager's perspective, but it seldom works with volunteers. You can't expect people to volunteer to implement ideas that they haven't been part of developing. In keeping with the adage "go slow to go fast," it's important to involve as many future implementers as possible right from the beginning.

If you're just starting a group, you will need to identify potential participants. In addition to the typical folks likely to be involved in your group, think about people who can interpret the various systems involved in the watershed (for example, ecological, economic, community, and political systems).

Also consider some important types of participants. They may be from any field but have certain characteristics that serve the group. Examples are champions, sponsors, catalysts, doers, and youth. *Champions* choose issues that are personally meaningful. They are willing to do battle for the collective interests of the group. *Sponsors*

provide direct support to the group. They advocate, promote, assist, and further the goals of the group in many ways. *Catalysts* are initiators and prodders. They make things happen by their energy, their integrity, and the force of their will. *Doers* get things done. They often work behind the scenes and are the backbone of any volunteer group.

Youth can be a phenomenal asset to your group. Young people have a fresh view of the world, lots of energy and ideas, and a huge stake in the outcomes of the group. Youth activities are a large component of family and community life. Youth involved in restoration work can extend commitment throughout the community.

At some point, you'll need to generate a list of all major groups, landowners, and other people interested in or affected by watershed issues in your area. Then consider the issues your group will address. Who could be affected (both positively and negatively) by stewardship decisions of the group? Add these names to your list. When contacting potential participants, ask them to identify other people they think should be invited to participate. It is often easier to get people involved when they know they've been referred by someone they trust.

The following list (from the *Partnership Handbook*) identifies some of the types of groups and individuals typically represented in watershed partnership groups:

- Landowners
- Community organizations, citizen groups, and informal community leaders
- Local elected officials, chambers of commerce, and elected civic representatives
- Representatives from state and federal environmental, natural resource, and land management agencies
- Local agencies such as municipal and county agencies, conservation districts, and planning commissions
- Native American tribes and communities
- Environmental and conservation groups (both local and national)
- Financial institutions, commercial agriculture, industry, and professional organizations
- Individual citizens
- Young citizens

Remember, stakeholders who are excluded from participation sometimes undermine the collective effort.

As your group develops, continuously monitor group participation. Ask yourselves which new groups or individuals might be recruited into the partnership. Remember, stakeholders who are excluded from participation sometimes undermine the collective effort.

Encouraging participation

Getting all potentially affected groups and individuals to participate requires more than simply announcing meetings. You'll need to use every form of communication

and education available. The following tips (from the *Partnership Handbook*) can help:

- Use the media both to announce ongoing events and to publicize special activities.
- Use peer-to-peer networking. Have members call or visit neighbors, colleagues, and others who may have an interest in or be affected by your group's activities.
- Use field or site visits to make the issues tangible and build enthusiasm.
- Use newsletters and brochures to advertise your partnership's efforts.
- Work through local schools to educate the public about partnership goals and activities.
- Consider innovative outreach methods such as photography, music, art, dance, and theater to publicize the partnership.

Rarely will all of the people your group needs step up and volunteer for your partnership. To encourage broad participation, try appealing to people's sense of stewardship, citizenship, and service. Demonstrate how the problem you're addressing affects different groups and how each person can make a unique contribution to the solution.

Maintaining participation

Participant burnout is a common problem in partnership groups. Use the following tips (from the *Partnership Handbook*) to motivate participants and maintain enthusiasm:

- Start with small, manageable projects that are likely to be successful.
- Document and celebrate success.
- Use on-the-ground projects to give participants a sense that they are making a difference.
- Use positive feedback, recognition, and rewards as incentives for continued participation.
- Maintain a stable structure to reassure members that the partnership is accountable to them and that something will get done.
- Offer opportunities to participate at different levels (regularly, occasionally, professionally, etc.).
- Build on sources of community pride.
- Make explicit what member organizations and individuals stand to gain; identify specific benefits.
- Demonstrate that these benefits will offset any loss of autonomy participants might experience.
- Continually revisit and stress successes and achievements.
- Make it fun—for example, provide refreshments at meetings or plan social events.

Economic incentives

Current land-use and management practices exist not only within a complex ecological web, but also within an equally complex web of economic practices and incentives. These economic factors include everything from the interests of global investors with a corporate presence in the watershed, to state tax incentives for

businesses and individuals, to local land-use ordinances and water and sewer prices.

When you think of economic incentives for changing practices, it's easy to focus quickly on the most visible symptom of the underlying condition. For example, you could rightly say that farmers, ranchers, and loggers should receive compensation for lost production that is due to changes in management practices. But someone else could rightly say, "What about fishers?" Another person might say, "What about the public, who is paying more for water treatment and receiving a lower quality of life in terms of clean water and healthy wildlife?" And an important question not often asked is, "What is the cost of doing nothing?"

A very complex web indeed. Nonetheless, if you want landowners to change their stewardship practices voluntarily, you must help philosophically willing landowners find economic incentives to do so. Short of that, at least try to find ways to offset the financial disincentives of good stewardship.

Watershed groups need to be creative in providing economic incentives to those who want to change their stewardship practices in ways the group supports. Time-tested methods include organizing work parties to do on-the-ground work and providing public recognition for voluntary efforts of landowners or managers. Larger-scale efforts might include providing specific technical expertise or helping people find available cost-share programs or appropriate tax incentives.

The most difficult economic issue may be making up lost income if production declines as a result of changes in management. One way to offset this loss is to increase the value of the remaining yield. Marketing the product as being produced in an "environmentally friendly" manner can appeal to customers.

Another way to level the playing field is for all producers to employ the preferred practices. Industry associations can play an important role in helping all producers be successful in a new stewardship model of production. Alternatively, citizens can lobby for economic incentives that support preferred practices across the board.

Contracting for services

Whereas watershed groups tend to be voluntary partnerships, project implementation might require outside help. Despite broad membership in your group, you might need to look for skilled labor, scientific expertise, or special equipment. Contracting for professional services can be an involved process. Important issues to consider are the legal responsibilities of entering a contract and liability for injury or property damage. Someone in the group might have experience in contracting, or you might find help by talking to other watershed groups or similar organizations.

Contracting for stewardship services can be an important way to help local residents build skills and earn income. Restoration work often employs traditional skills and technologies in a new way. The opportunity (and challenge) lies in matching local labor

with local restoration work. Sometimes the desire to implement projects quickly results in hiring nonlocal firms that have done this kind of work before. Although this gets the job done in the short term, it misses the opportunity to develop these skills locally and help people find new careers in this field.

Whether your contractor is local or not, the key is to find the right one for you, your project, and your budget. When investigating firms, ask how their prior experience relates to your specific project. A successful project in one ecosystem might not transfer to another. Ask to see sites where potential contractors have worked in the past. Show them your project site and ask how it is similar to and different from others on which they have worked. Follow up by calling prior customers to see how happy they were with the firm.

If you still feel comfortable with the firm, request a proposal that includes an outline of the work to be done, a schedule highlighting various phases of work, start and completion dates, and a detailed budget for personnel, equipment, and materials. Once a contractor is hired and the work begins, ask for regular status reports describing the work completed, current schedule, and costs to date. A project can be considered a success only when your needs and objectives are met.

A variety of local sources can help you with contracting. They include

- Other watershed groups who have used contractors before
- The small business development center at your local community college
- Your local natural resource conservation and development council
- The regional office of your state's employment services department
- The local provider for the federal Job Training Partnership Act program
- Your local soil and water conservation district

Shared Vision

The most important element of any partnership with diverse membership is its shared vision—the basic reason the group has formed. When times get frustrating, the vision serves as a positive affirmation of the group's hopes.

It's easy to forget the common vision during moments of controversy. During conflict, members often identify with the organization they represent rather than with the partnership. The vision can remind people of their common values and bring the conversation back to a more productive tone.

It's important for your group to revisit its vision during times of relative calm. Annual group exercises that restate common interests and update the group's vision statement are a good idea. Some groups find it useful to incorporate their vision statement into their letterhead and group mailings. See chapter 2, "Choosing Your Group's Structure, Mission, and Goals," for more on visioning.

Measurable Goals

Your partnership will need to document and communicate its progress. Establishing clear goals and objectives makes it easier to measure progress toward them. There are many ways to establish goals and objectives. The method discussed in chapter 2, "Choosing Your Group's Structure, Mission, and Goals," is one effective method of goal setting. Chapter 7, "Planning for Improved Watershed Health," presents a method for setting objectives.

Goal setting typically occurs after a group articulates its vision, which sets the context for subsequent goals and objectives. While there is one vision, there can be several goals, many objectives, and scores of tasks. The language used to identify goals, objectives, and tasks must be increasingly specific. The more specifically stated the objective, the easier it is to measure whether you're making progress toward it. See chapters 2 and 7 for more information.

Summary

Partnerships are a particular form of organization. Partners often have very different views of the problems in the watershed and the solutions required to address them. Partnership members need to keep focused on areas of agreement and build on those areas.

To be successful, members need to regularly reaffirm their common vision, interests, and goals. Additionally, successful partnerships require broad membership, ample local knowledge, effective means of communication, a collaborative process for making decisions, and a knack for pooling resources.

As with any voluntary organization, your group will need to pay special attention to encouraging and maintaining member participation. A variety of social and economic incentives, such as public recognition of good stewardship and innovative marketing of products, can help you maintain active volunteers. You might need to obtain special expertise by contracting with local workers.

Ultimately, the success of your watershed group will be determined by what happens on the ground. The real-world outcomes of the partnership will result from a compelling common vision, supported by clear, measurable steps that allow all the inhabitants of the watershed to contribute to the vision in the best way they can.

Resources

Training

Many land grant universities have excellent publications and training opportunities, often available free or for a nominal charge. Contact your county Extension Service for details.

Langevin Learning Services offers a variety of training programs on group process and organizational development. They can be contacted on the Web at www.langevin.com or by phone at 1-800-223-2209.

Information

Collaboration Framework (The National Network for Collaboration, Fargo, ND). Phone: 701-231-7259; e-mail: nncoinfo@mes.umn.edu; Web: http://crs.uvm.edu/nnco

Creating Community Anywhere, by C. R. Shaffer and K. Anundsen (New York: Jeremy Tarcher/Putnam Book, 1993).

"Long-term success begins with proper consultant selection," by L. Marrs. *Land and Water,* January/February 1998.

Partnership Handbook, by A. Moote (Tucson: Water Resources Research Center, College of Agriculture, University of Arizona, 1995). Web: http://ag.arizona.edu/partners/

The Salmon Safe program. Contact Dan Kent at the Pacific Rivers Council, 921 SW Morrison, Suite 531, Portland, OR 97205; phone: 503-294-0786.

The Conservation Technology Information Center (CTIC) materials

The Conservation Technology Information Center (CTIC) at Purdue University has a great selection of materials, which are listed below. Many of these materials can be reviewed on the Web at www.ctic.purdue.edu/Catalog/WatershedManagement.html#GUIDES

The address and phone number for ordering CTIC materials are:

The Conservation Technology Information Center
1220 Potter Drive, Rm. 170
West Lafayette, IN 47906
Phone: 317-494-9555; fax: 317-494-5969

- *Better Wetlands.* Full-color brochure that illustrates a dozen techniques for enhancing restored wetlands for wildlife, aesthetics, and personal enjoyment. Includes useful information on how to add food plots; goose, duck, and songbird nests; observation blinds; walkways; wildflower plantings; and more. Published by U.S. Department of Agriculture Natural Resources Conservation Service Iowa in cooperation with other state and federal agencies and associations. 20 pp. $2.
- *Building Local Partnerships: A Guide for Watershed Partnerships.* Booklet with good sections on identifying and involving partners, communication,

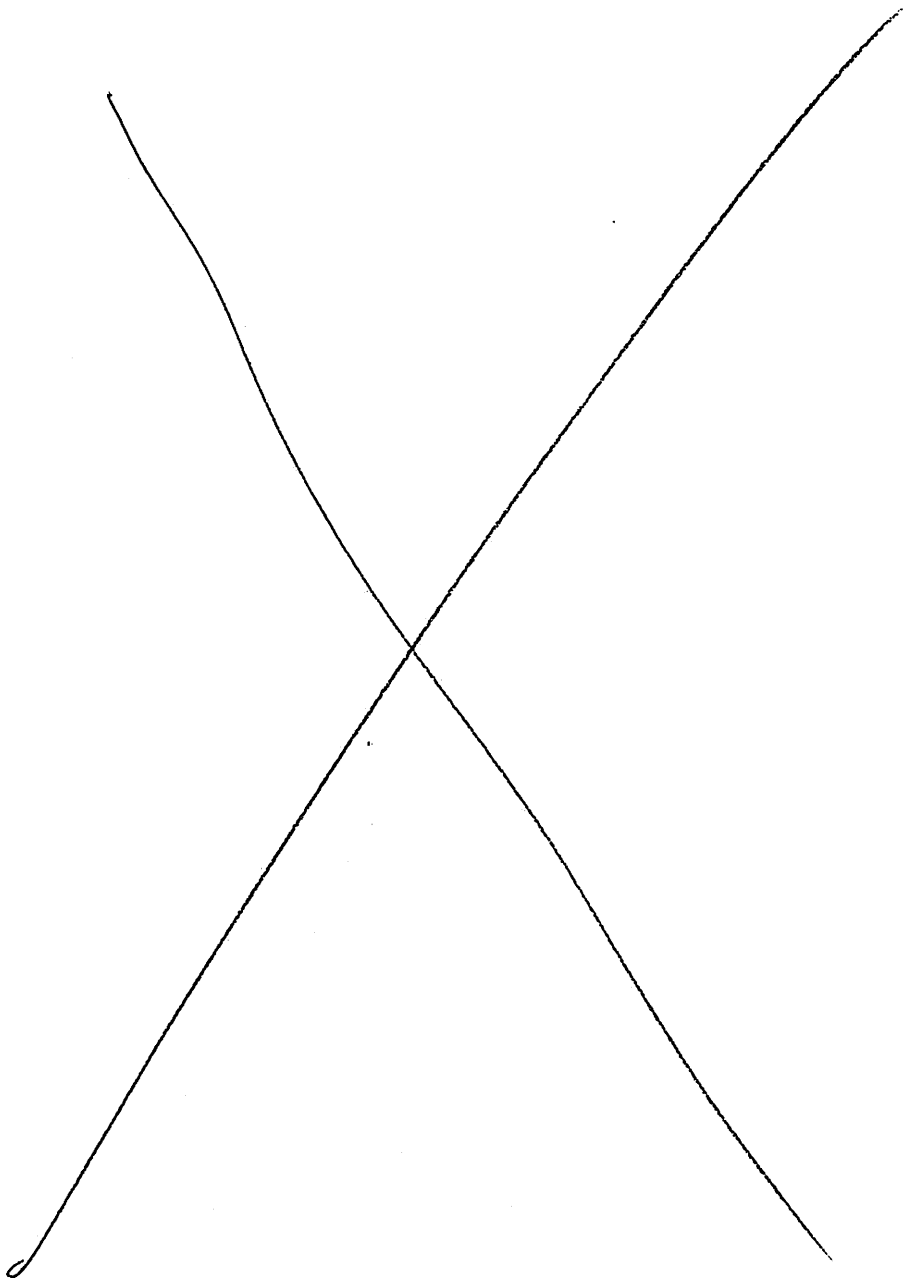
teamwork, and building consensus. 10 pp. $2.

- *Building Local Partnerships Guide.* Describes who should be involved and what they can bring to the group. 12 pp. $2.
- *Farmer-led Watershed Initiatives Conference Proceedings.* Manual includes case studies of five farmer-led watershed initiatives (Heron Lake, Minnesota; North Fork Ninnescah/Cheney Reservoir, Kansas; Embarras River Basin, Illinois; Otter Lake, Illinois; and Catskill-Delaware Watershed Complex, New York). Also includes brief descriptions of presentations on farming practices and innovative management practices. 32 pp. $5.
- *Farming for Maximum Efficiency (MAX) Kit.* MAX has been used successfully by farmers to evaluate return on their inputs (e.g., nutrients, tillage practices, and pesticides). Now CTIC and corporate sponsors Monsanto, Bayer, and Case are working with 13 watershed partnerships in five states to emphasize watershed issues and help farmers understand the economic benefits of conservation practices. No charge.
- *Geographic Information Systems (GIS): Introduction for Public Agencies Manual.* Provides decision makers with the essential background and tools to learn how to implement a geographic information system. Provides essential background. Four sections: overview of GIS, data quality, implementation, and water resource management. Originally developed for public agencies. Used by consultants, industry, watershed partnerships, and many others. $20.
- *Getting to Know Your Local Watershed: A Guide for Watershed Partnerships.* Booklet covering the range of biological, physical, social, and economic factors that need to be considered in watershed planning. 6 pp. $2.
- *Getting to Know Your Local Watershed Guide.* Describes what type of information is needed and where to get it to put together a successful watershed management plan. 8 pp. $2.
- *Groundwater and Surface Water: Understanding the Interaction Guide.* Describes the connection between groundwater and surface water. Discusses watershed management approaches that protect vulnerable groundwater uses. 16 pp. $2.
- *Leading and Communicating: A Guide for Watershed Partnerships.* Booklet covering listening, discussion, brainstorming, and other communication skills. 6 pp. $2.
- *Leading and Communicating Guide.* Describes the skills needed (and serves to refresh your skills) to facilitate a diverse partnership of stakeholders. 8 pp. $2.
- *Managing Conflict: A Guide for Watershed Partnerships.* Booklet describing general negotiation skills and a five-step process for managing conflict. 6 pp. $2.
- *Managing Conflict Guide.* Describes how you can turn conflict into a healthy discussion resulting in viable ideas. 8 pp. $2.
- *National Agricultural Ecosystem Management Conference Proceedings*

Manual. Leading experts address ecological principles of wetlands and watersheds. Includes sections on social, economic, biological, pest management, and partnership aspects of resource protection. 282 pp. $25.

- *National Watershed Library Directory.* This directory on computer disk includes more than 450 entries of brochures, manuals, fact sheets, extension publications, videos, and other materials concerning water quality. Disk works on any IBM-compatible computer with at least 640K of memory. $20.
- *National Watershed Network Directory.* A listing on computer disk of more than 700 local and state watershed groups nationwide. Each entry includes the group's name, location, size, and focus (such as pollution prevention). Disk works on any IBM-compatible computer with Windows 3.1 or Windows 95 and at least 640K of memory. $20.
- *No Matter Where You Live . . . You Live in a Watershed.* This introductory brochure shows and explains what a watershed is, how it affects water quality, how you make a difference, the watershed address system, and more. A self-test is included to highlight watershed-friendly actions. Ideal for local festivals, fairs, mall shows, etc. No charge.
- *Operation Greenstripe Kit.* This packet provides information on Operation Greenstripe, a program developed by Monsanto to provide monetary incentives for chapters of Future Farmers of America to work with landowners to plant filter strips (conservation buffers) in critical areas.
- *Partners for Watersheds.* Video that describes what a watershed is and how, by getting involved with a watershed partnership, everyone with a stake in it wins. 13 minutes. $8.50.
- *Putting Together a Watershed Management Plan Guide.* Describes the process of putting together a plan that all who have a stake in the watershed can agree to implement. 16 pp. $2.
- *Reflecting on Lakes Guide.* Watersheds that feed lakes differ dramatically from those that feed streams or rivers. This guide explains some of the differences. 12 pp. $2.
- *Riparian Area Management: A Citizens Guide.* Offers practical tips, definitions, and illustrations to help riparian landowners avoid the pitfalls of improper stream management. Includes components of management, methods, household guidelines, illustrated landscape tips, and more. From Lake County, Illinois Stormwater Management Commission. 6 pp. $2.
- *River Friendly Farmer Kit.* Originally developed for use in Minnesota by a consortium of agricultural organizations and companies, this kit is ideal for use by watershed partnerships. You set the criteria that farmers must meet to receive a sign at the end of their lane or be recognized in the press or at an award banquet. The program is very flexible to meet the unique needs of your watershed and the people who have a stake in it. $2.

- *1996/97 State and Regional Watershed Contacts: Nonpoint Source Directory.* Lists more than 375 resource people from state and federal agencies capable of answering your questions about nonpoint source water pollution. Agencies include state coastal zone, conservation, forestry, water quality, Cooperative Extension, Farm Service Agency, Natural Resources Conservation Service, fish and wildlife service, U.S. Geological Survey, U.S. Environmental Protection Agency regions, and National Estuary Program. 24 pp. $2.
- "Think Globally—Act Watershed" bumper sticker. Also provides a telephone number for obtaining information about watersheds. $2 for one sticker; $1 for each additional sticker.
- U.S. Watershed Map. This map shows the two-digit, four-digit, six-digit, and eight-digit watersheds using the U.S. Geological Survey numbering system. Originally printed by the USGS. $17.50.
- *Walk Your Watershed Festival Organizing Kit.* This kit outlines practical how-tos of getting started, choosing activities, finding volunteers, and securing financial support. Included within the kit are a suggested checklist to help plan an event, a model watershed festival program, a sample press release, survey, and a Walk Your Watershed logo. $2.
- *A Watershed Approach to Urban Runoff: Handbook for Decisionmakers Guide.* Outlines the process for understanding your watershed; describes the watershed management approach to assessing, planning, implementing, and evaluating; and gives an overview of assessment and management tools. Provides detailed insights into structural and nonstructural best management practices and sample site plans. Produced by the Terrene Institute in conjunction with the Environmental Protection Agency, Region 5. 115 pages. $27.45.
- *Watershed Management Starter Kit.* Want to start a watershed management partnership for your local watershed? This complete kit includes five guides *(Getting to Know Your Watershed, Building Local Partnerships, Putting Together a Watershed Management Plan, Managing Conflict,* and *Leading and Communicating),* a 13-minute video *(Partnerships for Watersheds),* 10 companion brochures, and an application to the National Watershed Network. In other words, it includes everything you need to get started. $18.00.
- *What is a Watershed Partnership?* Trifold brochure explains what a watershed is, how it works, similarities and differences between watersheds, and how our actions affect our watershed. No charge.



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CHAPTER TWO

Choosing Your Group's Structure, Mission, and Goals

by Viviane Simon-Brown

This chapter contains some of the best-kept secrets for creating and sustaining successful watershed groups. Being clear about your group's organizational structure, roles, responsibilities, mission, and goals can make a big difference in how successful your group is.

Organizational structure means the pattern of relationships within the group. It may include hierarchy (who's in charge) and roles and responsibilities (who does what), but it also incorporates people's attitudes and perceptions, the quality of what is produced, the way decisions are made, and hundreds of other factors. The most effective structures are built out of conscious choices. They frame how we do business.

Few citizen groups spend time on this subject at first. They're too busy working on their project and getting things organized. But sooner or later, the initial excitement wears off, and the bothersome little details take on immense importance.

If your watershed group is just starting, use this chapter and chapter 1, "Creating Successful Partnerships," to help you form its basic framework. If your group has been in existence for quite awhile, it's not too late to step back and reassess your structure and mission.

In this chapter you'll learn

- Why organizational structure is important
- The characteristics of six typical organizational structures in America (and why it's important to understand them)
- How to be clear about your group's vision, mission, and goals
- The roles and responsibilities of all the players in your watershed group
- What to do when things go wrong (or right)

Being clear about your mission is also important. Many groups have trouble identifying their mission. And if two of you from the same group don't say the same thing, the problem is even worse.

Why Is Organizational Structure Important?

Many organizational problems arise when (1) the group didn't choose an organizational structure in the first place, or (2) they mixed and matched components from different structures.

Designing a flexible, informal, matrix-type organization and then using *Robert's Rules of Order*, for example, creates confusion. It's like wearing a wool hat, mittens, and a down parka with shorts and sandals. They're all clothing and they all can be effective in the right season, but together they just don't do the job!

As you read about various types of organizational structure in this chapter, step back and look at your local watershed group. Which model does it fit? Many watershed groups use parts of model 4 (matrix), model 5 (project organization), and model 6 (organic). They also use *Robert's Rules of Order* and consensus decision making in the same meetings.

Acknowledging what you have now is the first step.

Acknowledging what you have now is the first step. The next, more important, step is to answer this question: "What would we like our organizational structure to be 18 months from now?" The third step is to identify what actions your group is willing to take to get there.

Ask yourselves this question: "Is our group a *governing* group, determining direction (goals), focusing on long-term outcomes, and legally responsible for its decisions? Or, is it *advisory*, meaning we can recommend, suggest, and advise, but have no legal authority?"

County commissions are examples of governing groups. Jack Ward Thomas' blue ribbon panel, which analyzed the spotted owl issue a few years ago, was an advisory committee. It gave its opinions to a decision-making body, which chose to implement most of the recommendations in the report.

If you aren't sure which category your group fits into, don't make another move until you talk it over. You may have major problems later if the group's intent isn't clear.

Types of Organizational Structures

Gareth Morgan, an authority on organizational theory, wrote, in his book *Creative Organizational Theory*, "An organization's structure strongly affects its ability to handle change. Though organizations can and do evolve, the transformation process is extremely difficult—and the required change is more than structural—it's cultural and political as well."

The following six models are typical organizational structures in the United States. Each works effectively in particular situations; each has disadvantages. It's easy to dismiss the more traditional structures as archaic. But when your house is on fire, you want a fire department with a clear chain of command and a plan for every contingency, not one trying to decide by consensus what to do next.

Model 1—The rigid organization

Fire departments and the military are obvious examples of rigid organizational structure. If you watch the *Star Trek* series,

you'll recognize the Klingons as consummate rigid organizationalists.

This structure is organized for stability, and its focus is on maintaining the system. Even the terminology comes from military culture—"battle readiness," "moving up through the ranks," "chain of command." Decisions generally are made by the top people, with rank-and-file members implementing rules, laws, and regulations that they don't have authority to change (figure 1).

This organizational structure depends on two factors for success—strict control and an environment that is ultrastable. Its nemesis is change. Contingencies are planned for; there are few, or preferably no, surprises. Moving quickly to handle never-before-encountered situations is almost impossible.

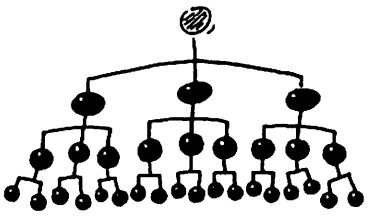

Figure 1. The rigid organization.

- Environment is ultrastable
- Organized for stability
- Focus is on maintaining systems
- Strict control
- Every contingency is planned for
- Slow and ineffective in dealing with change
- Either majority vote or no vote

Model 2—Senior management team

This model is similar to the first. It requires a stable environment. Standardization is important. In this kind of organization, you hear people say things such as, "Did you submit your request on an SF153-G form?"

This model does expand authority for policy decisions to a senior management team. If there is disagreement on an issue, the decision is put to a vote using *Robert's Rules of Order,* and the majority wins. In this kind of organization, everyone knows what his or her job is and isn't. Authority is clearly defined by a chain of command (figure 2).

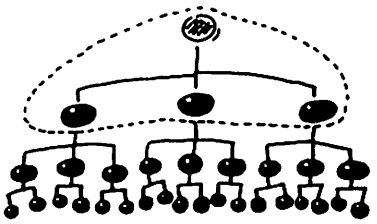

Figure 2. Senior management team.

- Environment is stable with some new problems
- Organized for stability
- Focus is on maintaining systems
- Management team makes all policy decisions
- Clearly defined authority
- Prefer standardization and key operating principles
- Majority vote

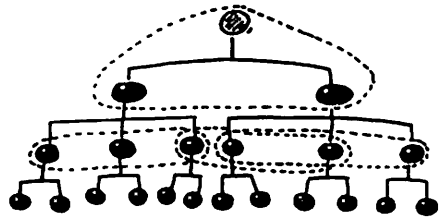

Figure 3. Project teams and task forces.

- Environment is changing rapidly
- Organized for handling specific problems
- Focus is on improving systems
- Uses interorganizational project teams and task forces
- Strong sense of traditional hierarchy
- Primary loyalty to own organization
- Problems are delegated upward
- Team members have little power
- Majority vote

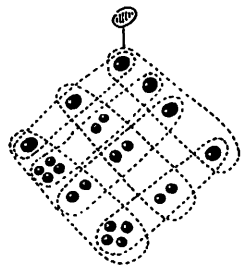

Figure 4. The matrix organization.

- Environment is changing rapidly
- Organized for flexibility and change
- Focus is on end product
- Meets the demands of special situations
- Encourages flexible, innovative, and adaptive behavior
- Diffuses influence and control
- Coordination is informal
- Decisions by consensus

The biggest corporate conglomerates of the 1950s and 1960s exemplified this model. Banks and some federal agencies still use it today. The major disadvantages are the inherent inability to change and the lack of recognition of the decision-making abilities of employees.

Model 3—Project teams and task forces

The project team and task force model was developed as a way to respond to major change. Its official beginning was the Manhattan Project, in which government and private industry scientists joined forces in the early 1940s to develop the atom bomb. The focus changed from maintaining existing systems to improving them to handle new and specific problems.

In this model, teams of people from different organizations work together toward a specific goal (figure 3). While the rules in *Robert's Rules of Order* are not as rigorously enforced as in the senior management team model, majority voting is the norm. Since this model derives from models 1 and 2, it carries their cultural values.

Although widely used today—United Way's Loaned Executive program is a prime example—this model has several disadvantages. Participants maintain their primary loyalty to their own sponsoring organizations. Because their paychecks still come from their employers, they know their priorities. Generally, the team members have a lot of expertise but little real power. Problems are delegated upward through the chain of command.

Model 4—The matrix organization

This model looks different! The matrix organizational model is organized for flexibility and change, and it acknowledges that the environment is changing rapidly. Its focus is on the end product (figure 4). This organizational structure encourages flexible, innovative, and adaptive behaviors. It diffuses influence and control, with an informal method of coordination. Most decision making is by consensus. Ted Gaebler, coauthor of *Reinventing Government*, states that most of America's companies will use this model by 2005.

The disadvantages are that the boundaries of responsibilities are less clear and there are more people to connect with. And achieving real consensus takes time.

Land's End catalog company is an excellent example of a matrix organization. Its employee teams determine direction and goals and have authority as well as responsibility to solve problems creatively.

Model 5—The project organization

When Boeing wanted to build the 777-model passenger jet, it selected a team, gave the team a budget and a nonnegotiable deadline, and said "make it so." The team's job was to create a prototype that flew, and they did. This was true outcome-based work.

In a project organizational structure, teams have free rein within clearly stated, agreed-upon parameters (figure 5). Allegiance is to the project, not necessarily

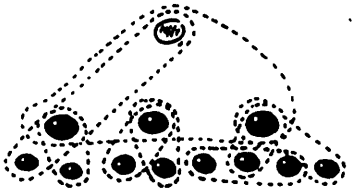

Figure 5. The project organization.

- Environment is changing rapidly
- Organized for flexibility and change
- Focus is on end product
- Coordination is informal
- Teams have free rein within agreed-upon parameters
- Frequent cross-fertilization of ideas
- Decisions by consensus

to the organization. All systems are designed to focus on the end product. Decisions are by consensus. Frequent cross-fertilization of ideas infuses the organization.

On the downside, there is more opportunity for miscommunication in this model simply because there's so much communication going on. It's harder to keep track of the process or to control its outcomes. If you're a control freak, this model might not be for you.

Model 6—Organic network

This model is more of an open-ended system of ideas and activities than an entity with a clear structure and definable boundary. A core group of members sets a strategic direction, provides operational support, and then steps out of the way as others take over the idea and move it forward (figure 6).

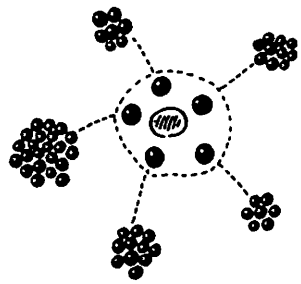

Figure 6. Organic network.
- Environment is rapidly changing
- Organized for flexibility and change
- Core members set a strategic direction and provide operational support
- An open-ended system of ideas and activities rather than an entity with a clear structure and definable boundary
- Consensus or total agreement

This model works in community action settings where the intent is to get people involved in making the community a better place to live. It provides the most flexibility and opportunity for spin-off organizations. The grassroots food co-ops of the 1960s epitomized this model.

Vision, Mission, and Goals

Quick, answer this question: "What is our group's mission?"

If it takes longer than 30 seconds to explain clearly what your group does, you've got a problem. And if two of you from the same group don't say the same thing, the problem is even worse. It's important to define your vision, mission, and goals *before* you get into the details of who does what. (We'll discuss roles and responsibilities later in this chapter.)

Many groups have trouble identifying their mission. Part of the problem is vocabulary. You probably hear the words "vision," "mission," and "goals" all the time. Are you ever confused about which is which, or wonder why it matters? This section will explain these terms.

Vision expresses the ideal future, what life would be like in the best of all possible worlds. Linda Marks, in *Living with Vision* (Toronto: Knowledge Systems, 1988), states, "Vision is the foundation on which we create what really matters for ourselves, for others and for humanity."

"A world without hunger" is a vision. It's powerful. You can see it. Is it attainable? Only if many people share the same vision. Is it worth working toward? Absolutely.

Using this definition, your watershed group's vision is the world you're striving for. Remember what you read in chapter 1: successful partnerships are supported by commonly shared vision.

Missions are much more practical than visions. What's the responsibility your organization is willing to shoulder to attain its vision? If a group's vision is a world without hunger, it has lots of choices for a mission. It could choose to provide healthy dinners for transients in the community, raise funds for overseas famine relief, or advocate for the preservation of family farms.

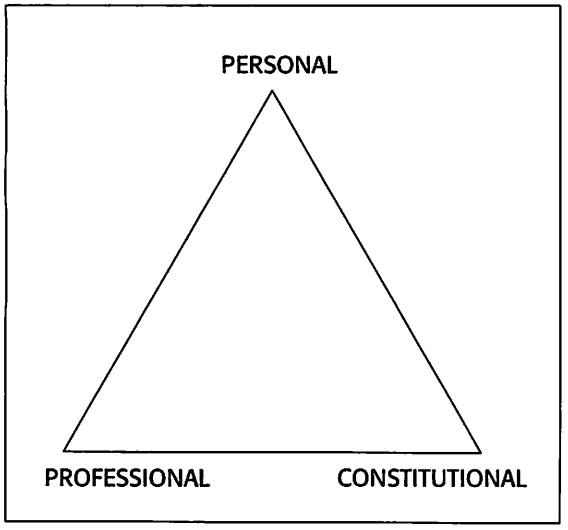

Figure 7. Our personal, professional, and constitutional values interact to define how we relate to the world.

The environmental, social, and economic issues we face are so overwhelming that most groups try to take on more than they can handle. Keep MinitLube's motto in mind: "Other companies want to change the world. All we want to do is change your oil." Take the time to narrow your focus. Your group will do a better job.

To be successful, all organizations need to articulate their *values* and *operating principles*. They are intertwined, underpinning everything we do (figure 7). They tell the world who we are and how we go about our business.

We have personal values, such as "I want to be healthy; therefore I choose to not smoke," "I value good education for my children, so I volunteer in their school," or "I have an obligation to help those less fortunate." In our work life, we live with a set of professional values. One of the best known is the physician's Hippocratic Oath (in part, "First, do no harm"), but the rest of us have values too. We also have constitutional values, for example, to obey our nation's laws and to pay taxes. (Values, like consciences, aren't always fun.)

Groups often get into trouble when individuals superimpose their personal values onto the values of the organization, another example of mixing and matching. No matter what your values are concerning abortion, gun control, old-growth forests, or the myriad other value-laden issues we face, you should be clear about the values you bring to the watershed group and recognize that your personal values are not the same as the group's values.

Because it's so easy to confuse personal values with group values, it's important to recognize diverse personal values and to agree on the values your group shares in working toward its mission.

The best organizations define their value systems. These values become the foundation upon which all of their resources are built. Peters and Waterman, in *Search for Excellence* (New York: Warner Books, 1982), say it best: "[W]e were asked for one all-purpose bit of advice for management, one truth that we were able to distill from the excellent companies' research. We might be tempted to reply, 'Figure out your value system. Decide what your company stands for. . . .'"

What does your group stand for? What kind of people are you? Continuing the food example, one value that would greatly affect how the group does business would be "We

believe that everyone deserves a good, hot meal in pleasant surroundings at least once a day."

Action plans are the goals, objectives, and benchmarks your organization pursues to achieve your mission. Planning must come before action. Consider Abraham Lincoln's words of wisdom, "If I had an hour to cut down a tree, I'd spend the first 45 minutes sharpening my ax."

Racing to action seems to be a national value. It's hard for groups to slow down enough to know where they're going. A good action plan helps you slow down and go in the right direction.

The hardest thing about goals is selecting which ones to go for first.

Goals are specific, straightforward statements of expectations. One goal of our food group might be to establish a permanent location for storing and preparing food and serving meals.

Goals can be relatively short-term, for example one year, or ongoing, depending on their complexity. The hardest thing about goals is selecting which ones to go for first. And remember, the greatest deterrent to meeting your goals is not having any.

Objectives are specific steps you'll take to achieve the goal. Sometimes they're even called actions, but objectives usually are broader than actions. The important thing is that they are tangible steps. To achieve the goal of a permanent location, the food group might agree to contact other providers to explore purchasing and renovating the old armory. This is a very focused, specific objective. Objectives often are described as being measurable.

Benchmarks or *outcomes* are measures of success. Our food group might choose the benchmark "have identified three to five potential partners." When they achieve that benchmark, they can celebrate, check it off the list, and move on to the next task.

Evaluations and *assessments* are ways to measure what your group has accomplished. Let's hope you have more to show for your efforts than attending meetings! As you evaluate your progress, benchmarks come in handy.

Of course, you'll ask people who are directly involved with your group to assess its efforts, but also make sure to ask people with no direct connection to your activities. For your efforts to succeed, as many people as possible need to support them. Here's one sure way to know you're on the right track: If people are clamoring to be on your committee, obviously you've got a winner!

Right now, you're either congratulating yourself for being part of an organization that has all of these components firmly in place, or. . . . Backtracking to fill in the gaps saves time and headaches in the future. "Go slow to go fast." (You'll learn more about this in chapter 3, "Effective Meetings Management.")

Roles and Responsibilities

Now that we've talked about organizational structure, mission, and goals, let's look at the responsibilities of watershed group members. Regardless of the organizational structure your group uses, each member has two distinct sets of roles and responsibilities—content and process. *Content* roles and responsibilities are what you do; *process* roles and responsibilities are how you do it.

The following is a general guide to the roles and responsibilities of the participants in watershed groups. After reading this section, you'll see that although roles and responsibilities are divided among group members for convenience, it is the whole group's responsibility to take care of the group. Chapter 3, "Effective Meetings Management," focuses on the process roles in more detail.

A watershed group member

- Advocates for the group's vision, mission, shared values, and goals *(content)*
- Maintains a holistic perspective (keeping long-range goals in mind while dealing with short-term tasks) to keep all members on track *(content* and *process)*
- Is a liaison between interested community citizens and group members *(content* and *process)*
- Helps create possible solutions *(content* and *process)*
- Arranges adequate time to carry out his or her group responsibilities *(process)*
- Listens to other group members and follows the rules of the group *(process)*
- Participates in group discussion and decision making *(content* and *process)*
- Serves on standing committees and appropriate ad hoc committees *(process)*

Your group may choose to have an executive committee, which

- Includes two or three group members who can devote additional time to the group's work *(process)*
- Is more oriented to the big picture *(content)*
- Reports back regularly to the full group *(content)*
- Suggests items for consideration by the full group *(content)*
- Ensures that it is not considered by outsiders as "THE group" *(content)*

Standing or long-term committee members

- Focus on the steps needed to achieve a specific goal *(content* and *process)*
- Become informed about the overall process and content concerns of the group *(content* and *process)*
- Advocate for the group's vision, mission, shared values, and goals *(content)*
- Maintain a holistic perspective to keep members on track *(content)*
- Share useful committee information with the full group *(process)*

Ad hoc or short-term committees

- Work on specific issues (ranging from one special event to setting up a complex collaboration with another group) *(content)*
- Include all affected constituencies *(process)*
- Have one member who acts as liaison to the full group *(process)*
- Are aware of what the whole group is trying to accomplish *(content)*

Staff

Some watershed groups are fortunate enough to have staff. Staff can do the following:

The peace of mind a facilitator can bring is worth the investment.

- Manage the day-to-day operations in such a way that the group's goals are achieved
- Perform all tasks delegated by the group
- Keep group members informed by
  - Prioritizing and highlighting important things to know
  - Providing background information as requested
  - Providing objective analysis and recommendations on issues
- Offer technical assistance and logistical support
- Keep in close contact with colleagues in other agencies and organizations
- Take the lead in monitoring programs to determine their effectiveness
- Work together in a supportive and professional environment

If your group doesn't have staff, these responsibilities are shared by group members, often at the executive committee level.

Who should not be in your group?

As you can see, every member of your group has important roles and responsibilities. Thus, a person who has no role to play shouldn't be a member of your group. Without a clearly defined role, a person isn't responsible for the success of the group. Neither do you want someone who is unwilling to play by the group's ground rules or who sabotages group decisions. (For more information on ground rules, read chapter 3, "Effective Meetings Management.")

When Things Go Wrong

Every group goes sideways. Although it would be nice to go from point A to point B in a straight line, that rarely happens. Generally, a mix of progress and detours can be expected. Consider how many times those "detours" actually get you to where you need to be.

The things that go wrong usually involve people problems or organizational difficulties. Chapter 6, "Common Stumbling Blocks and How to Deal with

Them," discusses hurdles that partnerships often face and suggests ways to avoid or overcome them. While the do-it-yourself approach works most of the time for community groups, when your group is in real crisis, it's time for an outside facilitator to help you refocus.

A group member could ask the same questions a facilitator would (What's our mission? What are our operating principles? What are the difficulties we face, and how can they be surmounted?), but an outsider is neutral, which makes all the difference in the world. The peace of mind a facilitator can bring is worth the investment. Sources for good facilitators are listed in the "Resources" section of this chapter.

When Things Go Right

It's so easy to focus on the negative that we have to make a conscious effort to celebrate the positive. People who have accomplished great things often say that at some point they were so discouraged they were ready to give up, when, all of a sudden, they experienced one small, positive result that encouraged them to continue their efforts. Your group needs the same incentives. Take time to notice and cheer!

Summary

The following checklist will remind you of the key points in this chapter and will help you see where your group might need to do some work on its organizational structure, mission, and goals.

- Do you know what your group's current organizational structure is?
- What would you like it to be 18 months from now?
- Is your watershed group governing or advisory? What entity makes the final decision on your recommendations?
- What is your group trying to accomplish? (All members should be able to answer this question in 30 seconds or less.)
- Are the definitions and differences between vision, mission, values and operating principles, goals, objectives, and benchmarks clear to you?
- Can you identify some of your group's values, some beliefs that everyone in your group would agree with?
- Do you know the role you play and your responsibilities in your watershed group?
- Does your group need an outside facilitator to help it move forward?
- Does your group celebrate its successes?

Resources

Training

The Family Community Leadership program sponsored by the Extension Service has excellent publications and training opportunities—often free or for a nominal charge. Contact your local county Extension office for details.

Information

The Art of the Long View, by P. Schwartz (Newbury Park, CA: SAGE Publications, 1996).

Creative Organizational Theory: A Resourcebook, by G. Morgan (Newbury Park, CA: SAGE Publications, 1989).

Images of Organization, by G. Morgan (Newbury Park, CA: SAGE Publications, 1986).

Reinventing Government: How the Entrepreneurial Spirit Is Transforming the Public Sector, by D. Osborne and T. Gaebler (Reading, MA: Addison-Wesley, 1992).

Starting Up: A Handbook for New River and Watershed Organizations (Portland, OR: River Network, no date). PO Box 8787, Portland, OR 97207; phone: 503-241-3506.

Case Study

The Citizen Review Board

The Citizen Review Board is responsible for monitoring the placement of children into foster care in Oregon. Changes within the volunteer community—more working women, less volunteer time, and the need for highly skilled volunteers—placed new demands on the existing system.

In 1994, through a facilitated, multimeeting process, the Citizen Review Board completely rebuilt its organization to accommodate the changing demographics of its volunteers and the changing needs of its clientele. Because the group's work is primarily within a nonflexible judicial system, the group consciously chose a senior management team organizational structure, thus providing stability and clearly defined authority.

To strengthen the legitimacy of the organization and to attract and retain top-quality volunteers, the Citizen Review Board established clear roles and responsibilities for all its staff—both paid and unpaid. It developed new training systems and working parameters. It clarified its mission and then discontinued projects outside the purview of its well-defined mission.

Today, the Citizen Review Board is a healthy organization that reviews 100 percent of the foster care placements in the state. Its volunteers are motivated, skilled, and respected within the court system. Volunteer training takes longer than it did in 1994, but the improved retention rate offsets the additional up-front time commitment. Most importantly, the Citizen Review Board successfully achieves its mission each year.

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CHAPTER THREE

Effective Meetings Management

by Viviane Simon-Brown

In 1992, the Oregon Business Council surveyed 1,361 Oregonians about what they valued most—and liked least—about living in Oregon. Of course, no surprise, they loved their tall trees, pristine beaches, and towering mountains. What did they dislike the most? Attending meetings, especially public meetings! We suspect that Oregonians aren't the only ones to feel that way.

Since meetings are a required part of our lives, let's see if we can make them better. Fortunately, meetings don't have to be bad. Bad meetings are nothing more than bad habits!

In this chapter you'll learn

- The fair-open-honest triangle
- Eleven easy ways to improve your meetings
- The roles and responsibilities for your group's meetings
- The importance of documenting your agreements

Fair, Open, Honest Meetings

For meetings to be effective, the process must be fair, open, and honest. Fair, open, and honest? It sounds like something from the book *Everything I Ever Needed to Know I Learned in Kindergarten.* But think about what those words really mean for your meetings.

Fair

Being fair means several things:

- Providing opportunities for people to participate in ways that work well for them. For instance, you can schedule meetings at convenient times, acknowledging that the high school playoffs might be more important than your meeting.
- Being prepared to apply ground rules without bias
- Accommodating special access needs
- Making room for different learning and communication styles so everyone has a chance to participate
- Making sure the people who are affected by your group's decisions help make those decisions

Open

Having open public meetings is the law. People need to be able to witness meetings,

but too often this law has meant that anyone who wants to sit through a laboriously dull meeting, can. Check to find out whether your watershed group is required to have open meetings.

The true spirit of open meetings is more, however. True openness means

- The process is straightforward, understandable, and explained, both verbally and in writing.
- The only agenda is the one hanging on the wall.
- Participants understand their roles in the process.
- There is a safe physical and intellectual environment for the exchange of ideas, with agreed-upon and enforced ground rules to protect people and ideas.

Honest

Honest means telling the truth. Here are some examples of honesty within the context of meetings:

- Posting desired meeting outcomes
- Eliminating hidden agendas; topics are addressed openly
- Taking everyone's input at face value
- Not trying to fool citizens by asking for input when decisions have already been made
- Acknowledging that some issues—for example, abortion, gun control, and spotted owls—are so value laden that you'll probably never reach common ground, so your group focuses its efforts on topics you can agree on

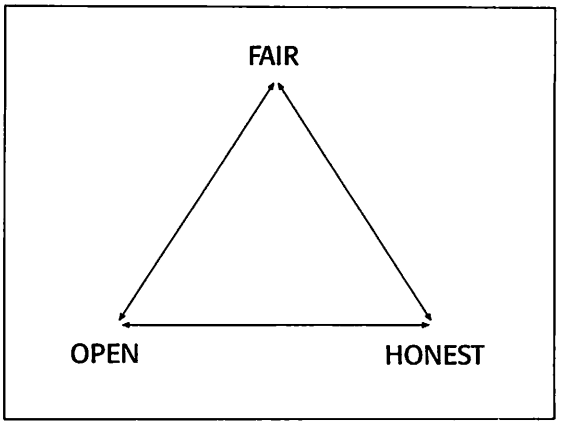

Figure 1. All three principles should be in place and in balance, something like an equilateral triangle.

- Not glossing over the amount of time people are expected to commit to the group's efforts
- Not promising what you can't deliver, whether it's a report or a legislative policy

Fair. Open. Honest. Can it really be that simple? Actually, no. The trick is to make sure all three principles are in place and in balance, something like an equilateral triangle (figure 1). If one side is missing, the process doesn't work. For example, you could say to a fellow group member, "Fred, I want to be totally honest with you. The fact that you're tall makes it impossible for me to work with you." It's honest. It's open, too. But fair? No way!

This fair-open-honest concept is easy to understand and takes a lifetime to implement. It's worth the effort.

Eleven Easy Ways to Improve Your Meetings

Although the fair-open-honest principle sounds great, most of us need more practical suggestions to make our meetings go more smoothly. Try the following 11 ways to improve your meetings.

1. Have an agenda and use it.

A written agenda can make a huge difference in the success of your meeting, especially if you use it. Here are some situations that highlight this point:

"So Jim, you've asked me to come to this meeting of yours on Friday. What is it you want to accomplish?" (Maybe this meeting isn't for you.)

"Denise, I'm sending you a memo about an upcoming meeting of our watershed coalition, but I wanted to talk to you first. I'd sure like to have you there. If all goes as planned, by the end of the meeting, we'll have identified the evaluation criteria for the grant proposal, and we'll have selected the people who'll present our information to the county commissioners." (Wouldn't you want to go to this meeting?)

"Carlos just brought up a really important issue. We don't have it on the agenda, but I think we have to address it before we can make a decision on the restoration project. Can we adjust the agenda?" (Agendas certainly can be rearranged to accommodate new issues and unforeseen discussions.)

2. Use a meeting manager.

You have several options here. The idea is to have people with good meeting management skills run your meetings. Meeting managers are like traffic cops. They guide the process, not the content. And like the police, often their very presence encourages good behavior. Here's an example of good meeting management:

"Wow, we're finishing right on time. All we have to do is confirm our next meeting time and place and build the agenda. Ginny mentioned earlier that we should discuss the Christmas party at our next meeting. What else needs to be on the agenda?" (Doesn't this sound like a great way to wind up a meeting?)

Here are some things your meeting manager can say to help the group along:

"We agreed to spend 10 minutes on this topic. We're running out of time. Can someone summarize the key points?"

"OK. Joe has stated the problem as he sees it. Let's go around the room and see if others see it the same way."

"Let's hear from the folks who haven't had a chance to say something yet."

For your regular meetings, try rotating the meeting manager role among group members who have these skills. It's amazing how courteous and effective groups become when members realize they're individually responsible for the success of the meeting. Rotating the meeting manager position also helps build group solidarity.

Having the chairperson "run" the meeting isn't necessarily a good idea. The chairperson is integrally involved in the "content" of the group—what you're trying to accomplish. Being simultaneously responsible for the "process" usually is more than he or she can handle.

You might consider using an outside facilitator as your meeting manager. Good outside facilitators are worth their weight in gold. You might be able to borrow one from a partner group, or you might choose to hire a professional.

A facilitator really comes in handy when bad habits threaten to overwhelm the group, when major differences of opinion arise, when an impasse is reached and the group needs a jump-start, or when you're actively involved in strategic planning. Be careful, however, not to come to depend on a facilitator for the success of your meetings—that's your responsibility.

3. Have agreed-upon ground rules for behavior—and use them.

You probably don't play a new game without learning the rules. To minimize hurt feelings, misunderstandings, and wasted time, decide up front what your group's operating principles will be. One quick way to get to the basics is to ask each member to finish this sentence, "At this meeting, all rules can be broken except this one. . . ." Post these rules at every meeting.

Here are some situations where rules come in handy:

"Hey, Jerry and Kim, we agreed to respect divergent opinions at this meeting. Please stop arguing."

"Hold on! We all agreed not to evaluate ideas at this time. Let's back up."

"We agreed to hold all calls for the next hour while we work on this problem" (while gazing at Bill, who has just picked up his cell phone).

4. Use wall notes for group memory.

Wall notes—chalkboards, butcher paper, flip charts—are great visual tools. They help group members focus more on the issues than on each other. People can keep on track. To make it easier to use wall notes, set up your meeting room in a "U" shape with the wall note space at the open end of the U.

Here are some ways wall notes can help your group:

"Shawna, can you summarize what you just said so we can put it on the chart?"

"Bob, didn't you already make that point? How is what you just said different from what's already on the chart?" (This technique can really cut down on "air time.")

"Yes, Alice, your comment has been recorded. It's right here" (pointing to chart). *"Did we get it right?"*

"Great! Derek just volunteered to call the governor's office. Put his name on the flip chart next to that task. Thanks!"

5. Accommodate different learning and communication styles.

People perceive and take in information in different ways. Some people process information verbally, and most meetings cater to these people.

Other people don't say a word at meetings. In the past, it was assumed that these people were shy or didn't have anything to contribute. Now we know this assumption is wrong. Approximately half of

the United States population is composed of people who process information internally, mulling it over before speaking.

With just minor changes to the meeting structure, you can create opportunities for everyone to participate. Try the following methods.

Try nonverbal communication.

"We've spent a lot of time talking around this issue. How about everybody taking five minutes to write down the situation as they see it."

"I know this sounds a bit weird, but we've been going around in circles on this issue for a long time. How about approaching it in a different way? Let's divide into groups and draw a picture of what a solution could look like."

Use small groups.

"We're ready to start strategizing solutions. Let's divide into small groups. Do you want to count off or just choose your own group?"

Allow time when possible for reflection.

"Now that we're clear about the problem, let's give ourselves some time to mull over some possible solutions. If everyone gets their ideas to me by Wednesday afternoon, I'll put them all together and get them to your office by the following Monday."

6. Start on time so you can finish on time.

7. Know how decisions will be made.

Chapter 4 focuses on decision making, but it's important enough to be mentioned more than once. Whatever your group's decision-making process, make sure everyone knows and understands it. Here are some examples of being clear about the decision-making process:

"OK, remember we agreed that since this is Orasa's project, she'll make the final decision."

"Our decision-making process is consensus minus one. Everyone except Bart is comfortable with the proposal. Using consensus minus one, we can go ahead with the project."

See chapter 4 for a detailed discussion of decision making.

8. Go slow to go fast.

Has the following situation ever happened in your group? You're brainstorming solutions when, all of a sudden, part of the group jumps on one idea, obviously deciding it's the one they want, effectively stopping the whole brainstorming process. We often race to a solution without being clear about what the problem really is.

Ernie McDonald, a respected meeting management consultant, coined the phrase, "Go slow to go fast." It's worth trying. Here are some ways to put this principle into practice:

Check understandings before moving on.

"I don't hear any complaints about Scott's suggestion, but just to be sure, does anyone have

serious problems with his suggestion? Great, let's move ahead."

Define the problem.

"Whoa! We're rushing to solve this 'problem,' but I'm not sure we understand what the 'problem' really is. Let's go around the room to hear everyone's 'read' on it."

Pay attention to the group's emotional level.

"Whoa! Let's cool down a bit. Let's take a 10-minute break."

Create time for rest and reflection.

"We seem to be floundering here. How about a 15-minute break? Then we can refocus our energy."

9. Make sure everything you do works directly toward your mission.

Unless your group structure is an organic network (see chapter 2, "Choosing Your Group's Structure, Mission, and Goals"), think twice before spinning off onto new projects and expanding your mission. Usually, volunteer committees barely have enough time to get the essentials done. Think about what you're supposed to be focusing your time and energy on.

Here are examples:

"You know, Billy Bob's just had a great idea. Since we agree it doesn't fit our mission, how about we share it with the Red Cross folks? I'll bet they'd love it!"

"What are we trying to accomplish here? Sure sounds like we're not clear about our mission. Let's back up a bit."

"Buying the old bowling alley sounds intriguing, Janey, but I don't get how it fits with our mission. Help me out."

10. Document your agreements.

Does this scenario sound familiar? You've been hashing out a complex situation for an inordinate amount of time, the meeting has gone on far too long, and everyone's worn down. Somebody jumps up and says, "Hey, all we need to do is. . . ." Everyone agrees it's a great idea, grabs their stuff, and dashes out of the room. Later, nobody can agree on what it was they agreed to. Taking time to "agree on what you're agreeing to" is worth it.

"Let's make sure we know what we're agreeing to. Can someone restate their understanding of the solution? Let's get that down on the flip chart. Wait, before you dash out, do we have it correctly written down?"

If it's a major decision, you might even want to go a step further:

"To ensure we've got the wording exactly right, please come up and put your initials on this."

11. Evaluate, evaluate, evaluate

Your watershed group regularly measures its progress in attaining its content goals. (See chapter 2, "Choosing Your Group's Structure, Mission, and Goals.") You also should evaluate your process, especially when you're changing to a new way of conducting meetings. After all, how will you know that the meeting's been successful? Here are three quick ways to evaluate how you're doing:

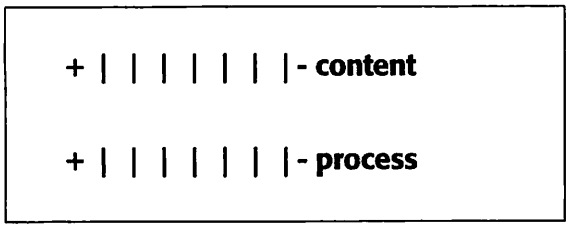

Figure 2. Have people mark on a line how successful the meeting was for them.

- *Three minutes*: One person volunteers to record. On a flip chart, record what the group liked about the meeting and what they would like to change. Draw a line down the middle of the sheet and draw a "+" on one side and a triangle on the other. (The triangle is scientific shorthand for change.) Then record people's comments in each column.
- *One minute*: Ask each member to do the same exercise individually. Have one person collect and tabulate results.
- *Three minutes*: Hang a flip chart at the exit of the room. As people leave, have them mark on a line how successful the meeting was for them (figure 2).

Roles and Responsibilities for Successful Meetings

Making your meetings successful is your responsibility. It is not the job of the chairperson or the highly paid outside facilitator; it's yours—the participants'. The days of sitting back and reading your mail while someone else runs the meeting and makes the decisions are over. Shared decision making means shared meeting obligations.

The process roles and responsibilities are straightforward (figure 3). None of the jobs is particularly difficult. Now imagine being in a meeting where everyone does his or her job. Doesn't that look good? It wouldn't take much to make it happen.

Group memory (wall notes)

- Helps group focus on task
- Depersonalizes ideas
- Is an instant record of the meeting's progress
- Minimizes repetition
- Encourages participation because it respects each idea
- Ensures that ideas are recorded accurately
- Helps problem solving by preserving information through different phases
- Helps latecomers catch up without interruption
- Improves accountability through recording who will do what and when
- Costs little; is easy to use; and is available to any group

Group members

- Use facilitative behavior
- Keep meeting manager (and recorder) neutral
- Ensure ideas are recorded accurately
- Focus their energy on the problem

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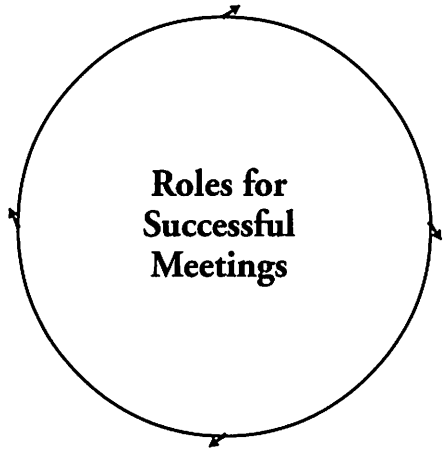
Recorder

- Remains neutral
- Uses the speaker's own words
- Captures ideas on wall notes
- May ask meeting manager for clarification



Meeting manager

- Remains neutral
- Focuses group energy
- Does not evaluate or contribute ideas
- Encourages everyone to participate
- Suggests alternative methods
- Helps group find agreement

Director and staff

- Listen more and talk less
- Use facilitative behaviors
- Maintain final decision responsibility
- Make sure that action is followed up

Figure 3. Meeting roles. (Adapted from Ernie McDonald of McDonald Communications.)

Recorder

- Remains neutral
- Uses the speaker's own words
- Captures ideas on wall notes
- May ask meeting manager for clarification

Meeting manager

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Director and staff

- Listen more and talk less
- Use facilitative behaviors
- Maintain final decision responsibility
- Make sure that action is followed up

Summary

The following lists summarize the key points in this chapter. You can use them to evaluate your group's meetings and to identify areas for improvement.

Are your meetings fair, open, and honest?

- Are your meetings scheduled at convenient times?
- Does your group accommodate special access needs?
- Do you involve the people who will be affected by your group's decisions?
- Do you offer a variety of formats—verbal and nonverbal—to ensure full participation?
- Is the meeting process straightforward and understandable to participants and observers?
- Is your group required to comply with your state's open meeting law?
- Do participants understand their role?
- Does the meeting feel like a safe place to exchange ideas?
- Does your group have ground rules for behavior—and use them?
- Are meeting agendas and expected outcomes posted so all can see them?
- Is everyone's input taken at face value (or are people trying to read more into it than was said)?
- Are people asked to give input, and is that input used?
- Are time commitments clear?
- Does your group deliver what it promises?

Ways to improve your meetings

- Does your group have a posted agenda? Do you use it?
- Do you use a meeting manager for your regular meetings? Do you rotate this responsibility?

- When your group has a crisis, do you bring in an outside facilitator to help you get back on track?
- Does your group have agreed-upon ground rules for behavior? Are they posted? Do you use them?
- Does your group consistently use wall notes (for example, flip charts or a chalkboard) that everyone can see?
- Does your group accommodate different learning and communication styles?
- Do you ever write out solutions rather than talk about them?
- Do you use small groups for brainstorming and problem solving?
- Does your group start its meetings on time?
- How does your group make decisions?
- How do you know that a decision has been made?
- Are your decisions written down where all can see them?
- Does your group sometimes rush to solve the problem before the problem is defined?
- Does your group call an unscheduled break to allow emotions to cool or time to think?
- Do all of your group's decisions move you closer to achieving your mission?
- How does your group evaluate the meeting process?

Roles and responsibilities

- Do you know what role you play in the meeting process?
- Do you contribute to the success of the meeting?
- What about the role of the meeting manager, or the decision maker?
- What steps are you going to recommend to your group to improve your meetings?

Resources

Training

The Family Community Leadership program of the Extension Service has excellent publications and training opportunities—often free or for a nominal fee. Check with your local county Extension office.

CISPUS Inter-Agency Public Meetings Training. If you work for a federal or state natural resource agency, call 503-231-6121 about the training schedule. Trainings are held annually in Randall, Washington.

Information

The Fifth Discipline, by P. Senge (New York: Doubleday, 1990).

The Fifth Discipline Fieldbook, by P. Senge (New York: Doubleday, 1994).

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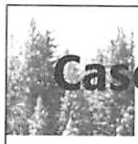
The Skilled Facilitator: Practical Wisdom for Developing Effective Groups, by R. M. Schwarz (San Francisco: Jossey-Bass Management, 1994).

We've Got to Start Meeting Like This! by R. K. Mosvick and R. B. Nelson (Glenview, IL: Scott, Foresman, 1987).



Case Study

Dealing with School Problems

Parents of middle school children in a rural school district were circulating a petition to move fifth graders out of the middle school and back into the elementary school, citing bullying and excessively long school bus routes as the main reasons for the change. This seemingly small issue polarized the community. The situation deteriorated to the point that police were called in to control the crowds and to prevent weapons from being brought in to the emergency public meeting.

In facilitating such a volatile public forum, it was vital to be fair, open, and honest with the audience and to let them know they were expected to behave the same way with each other. The agenda and ground rules were clearly highlighted, both verbally and on flip charts on the wall. The school board members and the facilitators listened carefully to the concerns of the parents—and the youth who were affected. Together, the audience and the school board developed a series of options for the steering committee to consider. All participants—including youth—were given the opportunity to vote for or against the options.

The overwhelming majority voted to retain the existing system. The situation was defused. The steering committee was given clear direction. Two hundred thirty citizens and youth actively and positively voiced their opinions on a range of education-related topics. Public input was valued. Best of all, when the meeting ended, everyone stood up, clapped, and cheered!

Case Study

Seafood Industry Workshop

In 1995, key leaders in the seafood industry and the Oregon Economic Development Department felt that better results could be achieved if all the groups focused on a limited number of high-priority projects. One hundred fifty trawlers, fishers, processors, advocacy groups, regulatory agencies, and Extension agents and specialists gathered at a workshop to create a shared vision for the future, to develop strategies to sustain harvests for all Oregon fisheries, and to strengthen and expand partnerships.

For this ambitious project to work, the facilitators had to develop processes which enabled the disparate groups that make up the seafood industry in Oregon to set aside their possibly conflicting positions and consider the benefits of joining forces. It was important to model effective processes throughout the workshop.

As a result, members of the Oregon seafood industry clarified positions, shared assumptions, demonstrated interrelationships of the different species strategies, and found common ground.

CHAPTER FOUR

Decision Making

by Pat Corcoran

Most of our daily decisions are pretty automatic. When we need to make a decision, we very quickly measure the choices against our internalized personal values and interests. Typically, we then see a fairly obvious range of acceptable alternatives. We choose one and move on. We alone enjoy the benefits (or suffer the costs) of the decision.

We give up some of this autonomy when we become part of a group. What we gain in return is an ability to influence and add value to something larger—something that we care about but can't fully control ourselves.

Organizations of similar people pursuing similar interests often struggle with making decisions. When diverse groups of people are involved, the challenge is even greater. Nonetheless, the quality of your partnership is reflected in the quality of your decision making. A decision-making process that is clear, open, and understood will lead to better decisions.

This chapter addresses several issues facing groups when making decisions.

The meetings management and communication skills discussed in chapters 3 and 5 also can help your group become more effective at decision making.

In this chapter you'll learn

- The importance of understanding your decision-making process
- Why it is critical to document and track decisions
- Different ways people and groups make decisions
- Using the consensus approach
- *Robert's Rules of Order* and consensus decision making
- The roles of the meeting manager and facilitator
- Two important tips for making better decisions
- A comprehensive framework for making big decisions
- Common pitfalls in decision making

The Importance of Understanding Your Decision-Making Process

It is critically important that your group agree on how it will make official decisions and that your bylaws specify how those decisions are to be made. If the decision-making process is unclear, different people

can leave a meeting with a different understanding of the decision. Conflicting pronouncements then are made, leading to confusion, mixed messages, and distrust among group members.

If your group comprises official and nonofficial members, then group bylaws and meeting protocols need to make that distinction clear. For example, some groups have an executive committee that has authority beyond that of the general membership. Similarly, technical teams may have the power to make decisions in their subgroup without endorsement by the general membership.

Member orientation packets (including bylaws, membership, officers, and vision statement) can make these roles clear. Additionally, a one-page, decision-making "flow chart" can be handed out at meetings to remind everyone how decisions are made. This reminder is especially useful for those who don't attend regularly.

Documenting and Tracking Decisions

A common problem in groups is "discussing a decision to death" but not making a definitive decision. Often, the group's energy wanes before a decision is reached, again leading people to different conclusions about the decision.

Whatever your decision-making process, you can manage this problem by using a flip chart dedicated to tracking decisions. When an issue comes up that warrants a formal decision, the meeting manager can instruct the recorder to write it on a flip chart visible to the group. The manager then determines whether the decision needs to be made immediately, deferred until later in the meeting, or saved for another meeting. Be sure to review decisions and nondecisions at the end of the meeting.

Include decisions and nondecisions in the minutes. The following is one possible ground rule: A decision isn't a decision until it is written down and entered into the minutes of the meeting. Make sure the entry in the minutes includes the following:

- The issue that needed to be decided
- Whether a decision was made at the meeting
- What the decision was
- Any necessary follow-up

When the meeting minutes are approved, documented decisions also are approved. Official documentation of decisions and leadership provides a way to track the implementation of decisions through time.

Different Ways Groups Make Decisions

There are many different ways individuals and groups make decisions. Most are appropriate for some decisions; none is appropriate for all decisions. It's important to select a decision-making process that is appropriate for the issue at hand. Listed below are six common ways groups make decisions and the limitations of each of these methods *(Rural Resource Management).*

Impulsive choices

Sometimes we make decisions based on whatever feels right at the moment. This method lacks any thoughtful consideration of how the choices relate to our key objectives and to other alternatives.

Yes/no choices

When we phrase a choice as a yes/no question, it implies a choice between change and no change. There is no third option. This approach doesn't consider how the choices might affect the things that are important to us. It also eliminates consideration of other alternatives.

Either/or choices

Either/or choices are similar to yes/no choices and have similar limitations. Also, we tend to structure either/or choices so that one alternative clearly is best. Then we collect information that supports that choice.

Automatic choices

Automatic choices are the crutches of noncritical thinkers. Examples include, "That's the way we've always done it," "Low bid wins," and "If it ain't broke, don't fix it." Such automatic behavior keeps us from looking at how the choices relate to what we value. They can keep us from making more appropriate choices.

"Objective" choices

"Letting the facts decide" gives more power to the people who collect the facts than to the people who have authority to make decisions. Unless the group's values are stated explicitly in the form of criteria for decision making, there is no guidance to the people who collect and interpret data. This approach also limits creativity and win/win alternatives and often leads to "analysis paralysis" because all of the data never are available.

Weighing pros and cons

Weighing the pros and cons is a more thoughtful approach, but still is overly simplistic and resembles yes/no and either/or choices. As in those approaches, the choices aren't weighed against values. This method implies that more than one alternative is being considered (which is good), but creative "new" choices are unlikely to emerge.

To this list of specific ways people make decisions, Mosvick and Nelson *(We've Got to Start Meeting Like This!)* add four general approaches to decision making: the authoritarian, majority, minority, and consensus approaches.

Authoritarian decisions

With the authoritarian method, a chairperson makes a final decision with minimal, if any, input from others. This method is fast, but rarely effective. It

excludes valuable input from the people who will have to implement the decision.

Majority decisions

Voting is democratic and participative, but votes are often framed as either/or choices that oversimplify the issues.

Minority decisions

In practice, majority rule is often distorted by two or three people who force a minority decision on the entire group. Persistent individuals can dominate the thinking of others and lobby for votes by appealing to factions in the group.

Deeper issues and fundamental interests emerge when people spend the time and effort trying to reach consensus.

Consensus decisions

Consensus decisions are the easiest to implement because everybody affected agrees not to block the decision. The disadvantage is that this method is very time-consuming and is vulnerable to sabotage by ill-intended members.

Using the Consensus Approach

Many groups strive for consensus in their decisions; some are required to use it. Consensus typically is described as an agreement that all members can live with and support—or at least not sabotage—even if it is not everyone's preferred decision. The protocols for coming to consensus vary widely. Consensus is an approach for working through issues and can be part of any decision-making method.

The purpose of raising the standard of decision making to consensus (instead of majority vote) is to encourage people to work *through* an issue rather than *around* it. It's easy to avoid thinking seriously about the concerns of a minority when all you have to do is outvote them. Majority voting systems often create factions within the group and lead to power plays outside of meetings.

Deeper issues and fundamental interests emerge when people spend the time and effort trying to reach consensus. The group is forced to explore the assumptions and motivations behind each position. The key question to ask is, "What line of reasoning led you to your position?" This question seeks to identify people's interests rather than their stated positions.

Groups are often surprised to find out how often supposedly opposite positions actually share many elements. Decisions

based on fundamental interests lead to solutions that everyone can support.

A potential pitfall in trying to achieve a consensus decision is that you might end up with a "lowest common denominator" decision. The challenge of consensus decision making is to make decisions that incorporate the fundamental interests of everyone but still are worthwhile.

Frustration with consensus can result in a desire to institute a voting procedure, usually a "super majority" vote of some high percentage. Although this method is efficient, it is not always effective. Reverting to a vote reduces the imperative to get to the bottom of important issues and undermines the spirit of coming to consensus. A better solution is to develop good facilitation skills for achieving consensus (see below).

Robert's Rules and Consensus Decision Making

Many groups use some form of *parliamentary procedure* to run their meetings. *Robert's Rules of Order* is the contemporary version of this ancient English tradition *(How to Run a Meeting).* The benefits of this method for managing meetings are its familiarity and use in many of the groups in which members are involved.

The down side to using *Robert's Rules of Order* in a consensus-based structure is its use of the majority vote for making decisions. Seeking consensus is the opposite of "voting." The point isn't to tabulate yeas and nays, but to establish a consensus position on a motion. An initial vote gives the group a sense of how close it is to consensus, but mixing and matching processes can be confusing. See chapter 2, "Changing Your Group's Structure, Mission, and Goals," for more information.

The following approach can be used if your group blends *Robert's Rules of Order* with consensus decision making. Follow *Robert's Rules* through the "motion" step. Then, instead of asking for a vote, ask "can any official member not support this motion as stated?" If nobody speaks out, you have consensus. If any official member cannot support the decision, the meeting manager needs to assess whether to proceed with seeking consensus right then, postpone the decision, or see whether there is consensus not to make the decision. Whatever the decision, it needs to be documented in the minutes of the meeting.

The Role of the Meeting Manager and Facilitator

The job of the meeting manager is to run the meeting and make sure decisions get made—that is, to get the group through the agenda in the time available. It is a full-time job. When the group needs additional help with an issue, a facilitator can be very valuable.

Facilitators can be useful when the group moves from reporting and conducting general business to a more task-oriented

situation such as decision making. These situations might include seeking consensus on a sticky topic, brainstorming lists of new ideas, prioritizing activities, mediating disputes among members, or going through a decision-making process.

The value of the facilitator is that he or she serves as the group disciplinarian. Once the group decides what they need to do and what the ground rules are for doing it, the facilitator holds them to it. It isn't always a popular job. Good facilitators develop skillful ways of helping groups be productive while maintaining civility and goodwill among members. See chapter 3 for a more detailed discussion of meetings management and facilitators.

Two Important Tips for Making Better Decisions

Many methods for problem solving and decision making are available to groups *(We've Got to Start Meeting Like This!)*. The book *Rural Resource Management* (Miller et al., 1994) offers a comprehensive framework and a clear process for making decisions. An important part of this method is that it checks the tendency to make hasty decisions.

> Criticizing ideas when they are offered stifles creativity and leads to "group think."

Two important principles in this approach are (1) separating *creative* thinking from *critical* thinking and (2) establishing specific *criteria* for a good decision before coming up with a decision. Both techniques require people to make thoughtful decisions, not quick ones.

Creative thinking is the generation of ideas and solutions free from constraints. It lets you explore potentially better ways of doing things. Critical thinking is the challenging of ideas based on known constraints. It tests your creative ideas against reality. Both are essential to effective decision making.

For example, when brainstorming a list of ideas, facilitators ask that people not criticize any idea until after the brainstorming session. After brainstorming, all of the ideas are evaluated critically. This separation of creative thinking from critical thinking increases the range of possible solutions and then helps the group select wisely from that list. Criticizing ideas when they are offered stifles creativity and leads to "group think."

Establishing clear criteria for determining what a good decision would look like *before* coming up with a decision is critical to making sound choices among alternatives. Criteria are essential elements that the group thinks need to be part of the final decision. Criteria are statements of values and key interests held by the group.

Identifying and refining criteria for decision making is similar to the consensus-building technique of focusing on people's interests instead of their positions. When making complex decisions, the point is to first identify the elements that members think any good final decision must have. Sound decisions then are crafted according to key criteria shared by the group.

If groups spend adequate time agreeing on their criteria, adopting the final alternative is easy. This step is especially useful for groups that must use consensus.

A Decision-Making Framework

The decision-making framework below is one model for making important decisions on complex issues. The "deciding" in these cases actually is an extended form of problem solving. Few groups will use such an elaborate model, but it is instructive to consider a thorough approach before choosing or modifying the method your group uses.

After generating a few alternative solutions, the group decides which one is best under the circumstances. As business consultant Peter Drucker says, "A decision is. . . a choice between alternatives. It is

A decision-making model

What is the decision to be made?

- State the decision clearly.
- State the group's long-term goals and short-term objectives.
- Limit the scope of the decision to its essentials.

On what criteria will the decision be based?

- List all of the criteria the group thinks are essential.
- Refine the criteria. Group similar criteria, restate others for clarity, etc.
- Rank the criteria in order of importance.

What alternative courses of action exist?

- List several alternatives but do not evaluate them.
- Refine the alternatives.
- Review the list of criteria and the proposed alternatives.

What is the expected effect of each alternative on each criterion?

- For each alternative, go through the list of criteria.
- Discuss the likely impact of each alternative on every criterion.
- Record your opinions.

Which is the best alternative for each criterion?

- List each criterion.
- Identify the preferred alternative from the perspective of each criterion.
- Record your conclusions.

Which is the best alternative overall?

- Does one alternative meet all of the criteria?
- Does one alternative meet the highest-ranked criterion?
- Is there a new alternative that can emerge from a short list of alternatives?

rarely a choice between right and wrong. It is at best a choice between 'almost right' and 'probably wrong.'"

The framework on the previous page incorporates a step-by-step process that guides the sequence of your questions and answers in a way that helps separate creative idea generation from critical evaluation. It also forces the group to fully develop decision-making criteria before selecting an alternative.

Following this framework will lead to more thoughtful decisions. Probably the most important points are to generate more than one alternative and to compare the impact of alternatives on each criterion. These steps counter the tendency to jump to decisions.

Common Pitfalls in Decision Making

The decision-making approach described above takes discipline to put into practice. Unfortunately, many groups (especially those without facilitators) abandon the structured sequence once fast-paced interaction and conflict begin. Here are some common pitfalls that groups encounter and some tips for avoiding them (for more information, see chapter 6, "Common Stumbling Blocks and How to Deal with Them"):

- *Ignoring a full definition of the problem and moving immediately to a discussion of solutions.* Make sure you spend plenty of time exploring and defining all aspects of the problem so you can understand all of the implications of the alternative solutions.
- *Ignoring systematic analysis of the problem and paying attention only to the most current, dramatic, and controversial aspects of the problem.* Develop sound critical thinking skills and devote more time to understanding what caused the problem.
- *Ignoring the need to establish criteria or standards by which solutions will be evaluated.* Establish these criteria early in your deliberations, before solutions are discussed, in order to focus the discussion on relevant topics.
- *Concentrating solely on the quality of the decision while ignoring the need to gain group acceptance of the decision.* There usually are several equally good options from which to choose. Spend enough time selecting the option most acceptable to the group. You'll find that this decision is also the one most likely to be implemented.

Summary

By now, you should have a better understanding of how groups can improve the quality of their decisions. Different groups have different needs for their decision-making structure. The most important thing is for your group to agree on a process, make sure everyone understands it, and stick to it. Also, as your group makes decisions, be sure to document them and enter them into the meeting minutes.

Consensus raises the standard for decision making. It offers the best chance of finding effective gain/gain solutions. It also is slower and less efficient in terms of time. The trade-off is effectiveness over efficiency. Coming to consensus usually requires a skilled meeting manager or facilitator.

Big decisions need a more sophisticated process than little ones. Whatever the framework, it is important to develop clear criteria about what a good decision would look like *before* making the decision. The generation of good alternatives is helped by thinking both creatively and critically.

Resources

Training

Many land grant universities have excellent publications and training opportunities available free or for a nominal charge. Contact your county Extension Service office for details.

Langevin Learning Services offers a variety of training programs on group process and organizational development. They can be contacted on the Web at www.langevin.com or by phone at 1-800-223-2209.

Information

How to Run a Meeting, by M. A. De Vries (New York: Plume/Penguin Books, 1994). $7.95.

Rural Resource Management, by S. E. Miller, C. W. Shinn, and W. R. Bentley (Ames: Iowa State University Press, 1994).

An excellent resource for problem solving and decision making in community groups. Chapters on facilitating decision making when no one is in charge are especially useful.

We've Got to Start Meeting Like This! by R. K. Mosvick and R. B. Nelson (Indianapolis: Park Avenue Productions, 1996).

A comprehensive treatment of how meetings are run and how they can be improved. Good chapter on decision making in groups.

The following Program for Community Problem Solving materials is directed at community collaboration for a broad range of purposes, including economic development, social programs, and land-use planning. All publications are available from Program for Community Problem Solving, 915 15th St. NW, Suite 601, Washington, DC 20005; phone: 202-783-2961; fax: 202-147-2161.

Involving Citizens in Community Decision Making, by J. L. Creighton. $30. Directed at government agencies, this manual covers the formation and development of public participation programs, how to prepare a public participation plan, and specific implementation techniques.

Pulling Together: A Land Use and Development Consensus Building Manual, by D. R. Godschalk et al. $30. A detailed and comprehensive "guidebook for community leaders," with sections on developing a game plan, getting all parties to participate, building consensus, improving meetings, and learning from others. Includes case studies and sample materials.

Solving Community Problems by Consensus, by S. Carpenter. $15. This guidebook, geared toward local government

managers and other community leaders, covers strategies and techniques for using participatory group processes to resolve community problems. It discusses instances when consensus programs are appropriate; the types of problems that lend themselves to the consensus approach; and the formats, phases, and considerations for running a consensus program. Includes case studies illustrating the techniques.

CHAPTER FIVE

Communication Skills

by Flaxen Conway

Communication—or knowing how to communicate—is a process that is simple yet complex, easy to do but easy to blunder. It can be the source of conflict and misunderstanding that torpedoes your group into a war zone; ironically, it's also the only thing that can get you back to peacetime.

As the renowned family therapist Virginia Satir said, "Communication is to relationships what breathing is to maintaining life." Communication is the sending, receiving, and assigning of meaning to verbal and nonverbal messages. It is political and, to some extent, persuasive. It takes at least two to communicate, and with each additional person it gets more complex and challenging. Unlike two individuals, groups are systems, and they develop communication patterns or styles based on their history, values, socioeconomic status, and external conditions.

Innovative communication between people or groups results when the participants succeed in helping each other become inventive (coming up with new ideas, products, or points of view). There are several strategies likely to improve intergroup or intercommunity communication, such as asking about roles, theirs and yours; observing verbal and nonverbal patterns; acknowledging politics and power issues; acknowledging history and its current effects; and being careful not to assume that your culture and identity are the standards by which others should be judged. The skills that improve communication include respect, empathy, tolerance of ambiguity and information-gathering skills, willingness to be open, and flexibility.

In this chapter you'll learn

- Why active listening is important and the key elements in doing it well
- How to express yourself directly
- How to express and receive anger
- What "dialogue" is and why it's important
- How effective internal communication protocols will improve communication within your watershed group
- How effective external communication protocols can help your group tell the world what it's doing
- Why it's important to follow these protocols

To look at communication as just techniques or tools is simplistic. One person communicates to another in his or her own personalized world. What causes the gap of misunderstanding or in some other way complicates communication is the challenge to communicate *meaning*. In fact, the work of communication is in knowing what meanings are stored up in the other person and how they can be used to construct an intended message.

The process of adding meaning to an incoming message is called *perception*. Perception is not always reality. This gap gets played out in the form of defensiveness, resistance to a change in (self) image, attempts to change how someone else looks at the situation, bypassing (the use of the same words, but with different meanings), allness (assuming you know *all* about something), polarization (failure to see the middle ground, alternatives, or graded variations), and stereotypes.

The listener has a responsibility to try to grasp the facts and feelings of the speaker.

Still, learning and using tools that improve communication can help your group and its members build trust and respect, foster learning, and accomplish goals. Written, oral, and body language can be important tools for sharing ideas, feelings, and commitment. Clear codes of communication behavior, or *protocols*, can help individuals and the group as a whole match expectations to reality.

The move to establish partnerships that work to restore, enhance, and manage watersheds is exciting. It must, however, coincide with an increase in effective communication between individuals and within the group. Your group is made up of people who share an interest and a commitment but see things from a variety of perspectives and positions. Good communication is the only way this diverse group of people will be able to understand watershed processes and make decisions for effective enhancement.

Active Listening

When asked to define "communication," most people describe the techniques used to express what they think, feel, want, and so on—namely talking, writing, or body language. However, when you confront difficult issues, listening is more important than speaking or any other form of expression.

Listening is not passive. Rather, the listener has a responsibility to try to grasp the facts and feelings of the speaker. Active listening can be an important way to bring about changes in people, in their attitudes about themselves and others, and in their basic values and personal philosophy. Listening conveys interest and respect, even if there is not agreement. And active listening is contagious. Improving listening could drastically change how groups interact and understand each other.

One of the first steps to improving communication is to recognize the importance of listening and to make listening a key part of your organization's culture. Active listening has several benefits:

- It saves time because you cut through people's defenses and get more information without having to repeat the same conversations over and over.
- It helps you assess a situation accurately.
- It helps speakers clarify what they're saying and feel that they're being heard.
- It reduces emotions that block clear thinking.

The good news is that *everyone* can learn the art of effective listening. There are several models you can follow. They all revolve around the need to stop talking and concentrate on what's being said. Stay an inch ahead of the speaker, not a mile. Don't jump to conclusions and solutions. You're not listening if you're busy thinking about a response. As a listener, try to be relaxed, maintain eye contact, and avoid interrupting the speaker.

Below is one five-step model of active listening (Mary Zinkin, Center for Conflict Studies, 1993). Remember, the key to listening effectively is *relaxed attention*—listen with your whole body by using verbal and nonverbal listening skills (face the person, maintain eye contact). Follow the steps in order.

Step 1. Acknowledge feelings first

Acknowledge the feelings the speaker may be trying to express. Note that you recognize and hear the feelings, and show your readiness to listen. Use nods, "uh-huhs," and comments that indicate you recognize the validity of the speaker's feelings. For example:

"It's been one frustration too many. You're wanting to give up."

or

"Sounds like you're really upset by this."

Step 2. Say it in different words

One of the most powerful and important components of active listening is reflection—otherwise known as *paraphrasing*. Paraphrasing lets the other person know you're trying to understand, clarifies the communication, and slows the pace of the interaction, thereby reducing intensity and eliciting more information.

To paraphrase, repeat what the speaker is saying, *in your own words*, without adding anything not there in the first place. For example:

"Sounds like you've tried everything, and you don't know where to go next, but you have to do something."

or

"If I'm following you, you're really wondering if this recent decision is going to affect your land or just the fed's."

Step 3. Ask open questions

Ask for help when you get lost in a conversation. Check out your interpretation of what the speaker is saying. But don't get hung up on being right or use defensive questions such as "why?" or "don't you think. . . ?" Instead, ask relevant, open-ended questions beginning with "what," "how," "please explain," or "describe." For example:

"How will that affect what will happen to your neighbors?"

or

"If this policy goes through, describe for me how it will affect your ability to do business."

Pitfalls in active listening

In active listening, as in everything in life, there are pitfalls to avoid:

- *Me-too-ism,* such as *"That's nothing, let me tell you what happened to me!"* These statements make the speaker feel you didn't really hear what he or she said.
- *Moralizing, preaching, being judgmental.* Suspend judgment. Recognize that the speaker might have said something to offend your value system, but set aside that judgment so you can listen. Put yourself in neutral.
- *Asking a direct question to satisfy your curiosity.* It's none of your business unless the speaker wants to divulge more information.
- *Giving advice*
- *Cheap consolation,* such as *"It's going to be all right."*
- *Arguing or disagreeing with the speaker*
- *Analyzing or interrupting*
- *Ignoring obvious heavy emotions.* Don't let speakers turn their emotions loose and then walk away, leaving them no way to resolve their feelings.

Step 4. Summarize and clarify

Now, pull together what you've heard. Getting clear will help you as a listener because it keeps you from falling into "selective perception" and operating in the problematic "as if" zone. You respond to the speaker in a certain way because you perceive that she is operating "as if" she is dealing with situation X when, in actuality, she is dealing with situation Y and is not operating "as if" at all. This scenario happens often despite the fact that it is not clear communication and unhelpful for the speaker and the listener.

In addition, getting clear can ultimately help the speaker by clarifying the possible choices. For example:

"You've mentioned moving or changing your business. I wonder if those are your only options."

or

"Sounds to me as though you see several options, although some are more appealing than others. Is there any way you can get clearer on which ones will be best for you?"

Step 5. Give an opinion

If you offer an opinion, *do it with great caution* and only *after* doing steps 1–4. And remember, sharing your opinion is most helpful if you have asked whether the speaker is willing or wants to hear your opinion. Below is one way to do this:

Pause for a moment.

Preface your opinion with a statement such as, *"Would you be open to hearing my opinion on this issue or situation?"*

If the person responds with "no," let it go. Maybe he just needed to talk and he'll figure it out on his own.

If he responds with "yes," then use the skills presented here and in the rest of this chapter to guide you through a helpful exchange of ideas and feelings.

Direct, Assertive Expression

If half of the equation in communication is active listening, the other half is expressing what you think, feel, or want *in a way that is clear, true, and not defensive.* Most of us don't have a good track record in this arena. Often intention does not equal impact. In fact, it generally takes a speaker 3 to 10 assertions to deliver a message that a listener will actually get. The key to success is to be clear about what you want and what you're willing to give.

The number one rule to follow when expressing yourself is to use "I" messages. Using I statements lets you share what you think or feel without sounding like you're blaming or attacking. I statements are important for communicating your preferences ("It would be helpful to me if . . .") and making your actions or intentions clear ("What I would like to accomplish is . . .").

It may not feel normal to use I statements at first because most of us have gotten really good at using "you" statements. It's worth breaking those bad habits, though, because if you do, you truly can turn around a problem communication.

For example, here are three ordinary and probably familiar comments you might say or hear. An I-statement alternative is given in italics below each one. You can see how the I statement would be much less threatening to the other person.

"You know that's not right."
"I see it differently than you."

"You are really irritating me."
"I'm feeling irritated right now."

"You're not listening to me."
"I don't feel listened to."

Another way to express yourself is to give feedback to someone who is open to receiving it. Feedback is a way for you to give someone information about his or her *behavior in a given situation.* By being open to receiving feedback, people can learn how their behavior affects themselves and others. Feedback helps people keep behavior appropriate and focused on intended goals. Ultimately, the person receiving feedback—*not* the person giving the feedback—can decide whether a change in her or his behavior at this time is desirable.

Feedback is useful *only* when it is

- Solicited and well-timed—*"Would you be interested in some feedback from me right now?"*
- Specific, descriptive, and accurate—*"I'm sensing that you are angry right now about (this situation) by the way you are raising your voice, and your face is red. Am I correct?"*
- A realistic request that is clearly communicated—*"I'm feeling concerned/ scared. I'm wondering if you'd be willing to take a short break—a couple of minutes to step back, breathe—and then continue with our conversation?"*

Through actively listening and clear, direct expression, two or more people in a conversation—when willing—can communicate their ideas and their feelings with each other in a way that builds understanding, safety, and trust.

Body Language

Remember, we communicate as much or more through body language as we do through words. Body language includes facial expressions, eye contact, and the stance or movements of your arms, hands, and legs.

Be aware of your body language and what it might communicate to others. A good way to become aware of your own body language is to become aware of it in others first. The next time you're involved in a group conversation or watching one on television, take a moment to watch the body language of one of the listeners and consider how it might affect the speaker. Check out the speaker's body language; does it tell the same story as his or her words?

Body language, and the thoughts and feelings it communicates, can be a really important tool to witness and use in groups. One time when it is especially important is during periods of group decision making. Are people saying yes with their words but no with their bodies? Chapter 4 in this section talks about the steps and strategies groups can use in decision making.

Anger—Expressing It and Receiving It

Anger probably is one of the least understood emotions. It's hard for some of us to express anger or feel good about how we express it. Others find it easier to express anger but often do so in an unhealthy and unhelpful way.

Anger itself is not bad. It can provide information and produce energy that can be used positively. And it's important to understand that other emotions, such as pain, fear, powerlessness, or hopelessness, often are hidden beneath anger.

Unless you live on a deserted island, you're bound to encounter conflicts, and feelings of anger won't be far behind. This is especially true as you work with others in a group setting. Here are some key things to remember when you're angry:

1. Remember rule of thumb #1: *Use I statements.*
2. Use the A, B, C formula:

1. *I feel A . . .*

   "I'm feeling really frustrated . . ."

2. *In situation B . . .*

   ". . . right now because there is so much going on and noise in the room. . ."

3. *When you do C . . .*

   ". . . and you keep talking to me but I can't hear everything you are saying."

3. By talking about yourself first, you avoid bringing out the listeners' need to defend themselves. By being descriptive, you let the listeners know exactly what situation you feel angry about.
4. Avoid judgment—good or bad. Using words such as "better," "worst," or "should" can make listeners really defensive. Similarly, exaggeration can cause them to argue against the exaggeration rather than against the real issue.

Receiving another person's anger also can be challenging, but there are ways to make it easier. For example

- Understand your own anger or emotions and how they might affect your response.
- Acknowledge the feelings of the other person. When you show interest, an angry person often calms down.
- Rephrase what you heard the person say. The angry person won't feel good or be receptive to your help until his or her feelings are communicated and understood.
- Get agreement on what the issue is.
- Invite the other person to join you in addressing the issue.
- Take action and follow up.

Dialogue—What It Means and How to Do It

What is dialogue? Mostly it is doing well what we've been talking about in this chapter: actively listening, increasing your inquiry skills, letting people finish thoughts before responding, noting your own internal responses, learning how to stay open in conversations even when unpleasant emotions arise, giving up blaming and judging, and so on.

When people talk about dialogue, Peter Senge's name inevitably comes up. In his books, Senge talks about how dialogue is a different and often unfamiliar way of communicating. Dialogue is more than talking. It is continued, thoughtful exchange about the things that matter most to us. In short, it's thoughtful conversation. In a sense, dialogue is nothing new. It's what some folks do around kitchen tables or during a long ride in the car—sitting together, talking as ideas come to them, without an agenda, time pressures, or the need to solve something.

Dialogue is continued, thoughtful exchange about the things that matter most to us.

Perhaps dialogue simply is a new way of looking at conversation or communication. If the goal in communication is to decide something, do something, or convince someone, then the goal of dialogue is to listen to understand.

Dialogue's purpose is as important as what is being discussed. In a sense, its purpose is to honor, at a deep level, the development of human beings, ideas, and organizations. And, at the risk of sounding too philosophical, we change the world by changing the way we perceive the world, the way we think about cause and effect, the way we conceptualize the relationship between things, and the meaning we ascribe to events in the world.

Thinking about communication in this sense is important as the members of your group work together and communicate with each other and the outside world about its benefits, challenges, successes, and failures.

Dialogue is a conversational practice. As with sports, exercising, or other practices, you build skills as you work at it. Some important dialogue skills to practice are

- Allowing others to finish their thoughts
- Respecting others' thoughts, feelings, views, and realities, even when they differ from your own
- Listening deeply without needing to fix, counter, argue, or resist

The best news is that to work on improving dialogue skills, you simply need to make a note to yourself to listen in a supportive way and see what happens.

Effective Communication Protocols

Chapters 2, 3, and 4 of this section talked about the importance of having a clear organizational structure for your group, roles for each member, and appropriate tools to ensure effective meetings and optimal decision making. This chapter takes those concepts a step further by focusing on communication within the group (internal) and with the outside world (external). To do so, we'll talk about *communication protocols*. Remember, communication can be either written or oral.

Communication protocols are codes of behavior or conduct that help an organization run smoothly. They are ways to interact and communicate that are well-known and documented. In effect, they help the group be clear about the what, when, who, and how of their internal and external communications. They help you avoid the ever present problem of mismatched expectations and reality.

Clear communication protocols can improve understanding among group members, raise trust, and make working together more fun and comfortable. All of these factors will improve the effectiveness of your group.

Each group will have its own communication protocols (how and when to get a topic on a meeting agenda, communicating with the media, and so on). Setting protocols might feel time-

consuming, tedious, and artificial at first. However, creating and following protocols are especially important for new groups. Even many well-established groups falter because of unclear communication protocols that erode trust and jeopardize the group's success. With practice, good, clear communication protocols eventually will become part of your group's culture—a safe, effective way to work on issues of mutual interest.

Communication protocols might need to change with time. Anticipate situations and set protocols. But when new situations come up, or the protocols aren't working as well as intended, take the time as a group to revise them and create new ones as needed.

Internal communication protocols

The key to good internal communication protocols is to make sure they're clear, documented, and understood by *all* members—post them on flip charts, have them in every group member's notebook, and so on. If they are available to everyone, all members of the group know what is expected of them and what they can expect from others.

Below are some questions that clear internal communication protocols address. There are many more, but these examples can start you thinking:

- When will meetings happen? How often? Who calls the meetings or is in charge of other duties requiring intergroup communication? Do these notices have to be in writing?
- Who is in the group? Who is on what subcommittees? Who needs to know what? Who gets notices about subcommittee work sessions, outcomes, and so forth?
- How will subcommittee actions be communicated to the rest of the group?
- If someone hears something outside the group that deals with the group, whom do they tell and when?
- How will agreements or decisions be communicated to all group members?

There are so many possibilities! Think up as many as you can; others will become evident as your group continues to work together. And remember, if a protocol is not working (too loose, too restrictive, not clear, and so on) don't resist a discussion to make the appropriate revisions.

External communication protocols

When you move from communicating within the group to communicating outside the group, the basic principles are the same. However, the risk of unmet expectations, miscommunication, and ruptured trust increases manyfold.

On the next page are three examples of actual external communication protocols that were developed by one group that I've been working with. It is a group made up of many different people, with diverse interests and perspectives, but a common mission. This group's organizational structure is that of a membership group with a board of directors. Your group's structure might be different. Your group's protocols should be

GROUP A's External Communication Protocols

Protocol 1: Communicating with the media via press releases

Step 1. When the need arises, one person writes a draft press release.

- If it's related to a subcommittee, that subcommittee or an agreed-upon representative writes it.

Step 2. Three members of the group's board of directors must review this draft press release.

- The author faxes it to these reviewers within 48 hours.
- The chair serves as a tie breaker or has the option to poll the entire board of directors
- If it goes no further than the board of directors, it gets shelved until the next membership meeting.

Step 3. *All* board of directors and members get final news releases.

- Each news release will have a contact person's name and phone number.

Protocol 2: Communicating with other groups

Group A developed a mutually agreed upon "canned general statement" about their group and its mission, goals, and so on. This protocol requires group members to use this statement when communicating with other groups.

Protocol 3: Sitting on some other group's board of directors or advisory committee

- If membership is free, any member may join.
- Who joins should be based on comfort, area of interest, geographic location, and so on.
- You must poll the board of directors before you commit.
- If it costs, poll the (Group A) board of directors and membership to see if it is worth it to join.
- If you sit on existing groups ("wear another hat"), please poll the (Group A) board of directors before you wear our (Group A's) hat.

suitable for its structure. See chapter 2 in this section about organizational structures and what makes them work. These are just some examples of external communication protocols that this group created to enhance their effectiveness and the trust and safety within the group.

Summary

Active listening is important because it allows the speaker to feel heard and gives the speaker the opportunity to clarify what's being said. It helps to accurately assess the situation. The key elements in listening well are acknowledging feelings first, reflecting what's being said, asking clarifying questions, and summarizing your understanding of the communication.

The key points in direct expression (including oral, written, and action) are being clear on what you want and what you're willing to give. The tools to use for this include using I statements, giving feedback appropriately, and being aware of your body language and what it might be communicating to others.

The key considerations for expressing and receiving anger are using I statements, using the A, B, C formula, talking about yourself first to avoid bringing out the listener's defensiveness, being descriptive, and avoiding judgment.

Dialogue is thoughtful communication. The goal of dialogue is listening to understand. Dialogue is a conversational practice that can be improved by the use of certain skills—for example, allowing for the time and space for others to finish a thought or learning to listen deeply without the need to fix, counter, argue, or resist.

Protocols are codes of behavior or conduct that help groups run smoothly. Internal communication protocols are ways to interact and communicate within the group, thereby helping to improve the understanding of the group, raise trust in working together, and make the group more effective. External communication protocols improve how the group shares with the world what the group is about and what it has accomplished. The key to communication protocols is that they be clear, documented, and in the hands of all group members.

Resources

Training

Many Extension programs in states across the country offer the Family Community Leadership program or some other type of leadership program. These programs have publications and training opportunities—often for free or a nominal charge. For more information, contact your state's Extension office or the Family Community Leadership office at Oregon State University, 541-737-7654.

Check your local phone directory for private consultants or trainers who offer educational materials or workshops on powerful, nondefensive communication and conflict management. For example, there is a company in Oregon that does workshops locally and nationwide: Glaser and Associates, Inc., communication educators and consultants, 541-343-7575.

River Network offers consultation, training, grants, electronic networking, and practical publications, many of which have to do with communicating and working together. River Network, 520 SW 6th Ave., # 1130, Portland, OR, 97204-1535, 503-241-3506, or http://www.rivernetwork.org.

Information

Communicating with a Group. Part of *On Common Ground: Skills for Discovering and Building Common Ground.* (Baltimore, MD: National 4-H Council, 1994).

The Communicator's Handbook: Tools, Techniques and Technology, ed. by Patricia Calvert, 4th ed. (Gainesville, FL: Maupin House, 2000). 1-800-524-0634.

The Conservation Technology Information Center offers several publications related to watersheds and working together. The excellent publications are *Building Local Partnerships* and *Managing Conflict.* You can print them off the following Web site: http://www.ctic.purdue.edu/KYW/NWE/NWE.html. You can also request a catalog by calling CTIC at 765-494-9555.

The Fifth Discipline (New York: Currency, Doubleday, 1990) and *The Fifth Discipline Fieldbook* (New York: Currency, Doubleday, 1994), by Peter Senge.

Getting Coverage: A Guide to Working With the News Media, by Betsy Kauffman (Portland, OR: For the Sake of the

Salmon, 1996). For the Sake of the Salmon, 319 SW Washington St., Suite 706, Portland, OR 97204. Available on the Web at http://www.4sos.org.

Getting to Yes: Negotiating Agreement without Giving In, R. Fisher and W. Ury, with B. Patton, ed., 2nd ed. (New York: Penguin, 1991). Also, *Getting Together: Building Relationships as We Negotiate,* by R. Fisher and S. Brown (New York: Penguin, 1989), and *Getting Past No: Negotiating Your Way from Confrontation to Cooperation,* by W. Ury (New York: Penguin, 1987).

Leading and Communicating: A Guide for Watershed Partnerships (West Lafayette, IN: Conservation Technology Information Center). Conservation Technology Information Center, 1220 Potter Drive, Rm 170, West Lafayette, IN 47906, 317-494-9555.

The Miracle at Bridge Creek (VHS), an award-winning video about the trials and tribulations of coalition building among groups at odds seeking common ground. Available for $30 from Oregon State University Extension and Experiment Station Communications, Kerr Ads 422, Corvallis, OR 97331, 541-737-2513; or view and order on the Web at http://eesc.orst.edu. Order video #VTP 013.

Partnership Handbook: A Resource and Guidebook for Local Groups Addressing Natural Resource, Land Use, Or Environmental Issues, by Ann Moote (Tucson, AZ: Water Resources Research Center, College of Agriculture, University of Arizona, 1997). Available on the Web at http://ag.arizona.edu/partners/.

People Skills, by Robert Bolton (Englewood Cliffs, NJ: Prentice-Hall, 1979).

Starting Up: A Handbook for New River and Watershed Organizations and *River Talk! Communicating a Watershed Message* (Portland, OR: River Network, 1996). River Network, 520 SW 6th Ave., # 1130, Portland, OR, 97204-1535, 503-241-3506, or http://www.rivernetwork.org.

Transitions: Making Sense of Life's Changes, by William Bridges (Reading, MA: Addison Wesley, 1980).

Case Study

Habitat Restoration Working Group of the Peconic Estuary Program

An excellent example of using protocols and other organizational and communication strategies to increase the efficiency and the effectiveness of a group and its outputs can be seen with the Habitat Restoration Working Group of the Peconic Estuary Program, which is part of the EPA National Estuary Program in New York State. One of the charges facing the Habitat Restoration Working Group was to identify sites in need of restoration. Here's how communication played a role in this successful effort.

First, they had effective meetings with agendas, ground rules, and a respectful, effective group process. They had two cochairs, who facilitated the meetings, took the minutes, and kept the ball rolling. Therefore, their process was fair, open, and honest.

Second, they knew they needed the input and support from the community at large, so they worked together to create an effective strategy to achieve this. They created a communication tool and a process to get input. They created a nomination form and mailed it to all local governments, community, and environmental groups in the watershed. They put a press release in the local papers about the nomination process and encouraged people to call for a nomination form. They also created a system for Habitat Restoration Working Group members to keep on track and do outreach to inform others of their progress. These took the form of fact sheets, write-ups of field reconnaissance observations and recommendations, status of activities write-ups, and so forth.

There is a lot more to this story. If you want to know more about how this group used communication not only to function better but also to accomplish their tasks, contact Chris Pickerell (516-852-8660) or Nancy Niedowski (518-473-8359).

CHAPTER SIX

Common Stumbling Blocks and How to Deal with Them

by Flaxen Conway

Americans are independent people. Those who live and work in communities that are focused on natural resources are among the most strongly independent. Yet at times we need to work together to find solutions to issues facing our communities. Working in a group might not feel natural at first. But when we realize a task is bigger than anyone can do alone, we join together to get the job done.

Keep in mind that although the members of your watershed group have a common interest and commitment, they see things from a variety of perspectives and positions. Your group is bound to stumble from time to time. All groups do; it's a normal part of the group development process.

Working together can be productive, creative, effective, and fun, despite the unnatural way it feels or the challenges that come up. The key is to realize that stumbling is normal and to not let the occasional stumbles derail your group's entire effort—the mission of understanding watersheds and making decisions for effective management and restoration.

In chapters 1–5, you learned about creating successful partnerships, choosing an organizational structure, holding effective meetings, making group decisions, and communicating effectively. In each chapter, some common perils were introduced.

In this chapter you'll learn

- Ten stumbling blocks common to many groups
- Key ways to overcome each of these stumbling blocks
- Why stumbling happens
- How to go with the flow and not give up

In this chapter, 10 of the most common stumbling blocks are described. If your group is running into problems, this chapter can help you identify exactly what the problem is and find solutions. In many cases, it refers you to another chapter for more information and specific strategies to deal with the stumbling block.

#1—Conflict

Watershed groups and other groups are made up of people with many different ideas and feelings. Wherever people live and work together, conflict exists. In fact, a good definition of conflict is "a natural tension that arises from differences."

One of the most common misperceptions or misunderstandings about conflict is that it is always a negative experience. In fact, conflict has at least three benefits: it produces energy, it can make you feel alive, and it can remind us of our interconnectedness. Ultimately, a conflict that is worked with and through can bring about very positive results.

The key to managing or transforming conflict is to understand and use three basic concepts.

1. The common causes of conflict are
   - Avoidance of conflict. Most people, out of fear or habit, tend to change to be like the other.
   - Unwillingness to express feelings and thoughts directly or clearly
   - The need to be right

When you're involved in a conflict, ask yourself these questions:

1. *Am I avoiding this conflict unnecessarily?* It might be easier in the long run to deal with the problem now, before it turns into something bigger.
2. *Am I directly expressing how I feel or think?* Take a minute to stop, collect your thoughts, and share them clearly and directly with the individual or the group.
3. *Is it really that important to me to be right?* Often we forget that both sides of a conflict might be right. A time of conflict is an important time to practice active listening and the principle "Everyone has a piece of the truth." By doing so, you may find out that the other person is as "right" in their truths as you are in yours.

2. Your personal history with conflict affects how you react to it. Successfully managing conflict requires moving beyond past emotional experiences with conflict and learning new skills to deal with it well. One way to do this is to recognize—first in yourself and then in others—the difference between positions and interests. Positions are often voiced in conflicts; people state their "stand" and then "dig in" on what appears to be two or more drastically opposing sides. Once a discussion or interaction gets stuck on positions, no deeper understanding or resolution occurs. Whereas, when interests—the myriad beliefs and values that underlie positions—are explored and communicated, similarities can be noticed and built on to acknowledge or create common ground.

3. Paradoxically, communication, or the lack of it, can get your group into conflicts, but it also is the only thing that can get you through conflict. You'll need strong communication skills to manage all types of conflicts. (See chapter 1–5 for specifics.)

Conflicts will come and go throughout the life of your group. Remembering the concepts above can change how you respond to a conflict situation.

The communication skills presented in chapter 5 will help you make it through most conflicts on your own. There are times, however, when a neutral third party can be really helpful. Don't hesitate to call in someone (for example, a mediator) to fill this role if and when you or your group feels it's necessary.

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black-and-white areas. Nor should it. Frankly, the grays, blacks, and whites are what make life interesting. This process will, however, help you interact with others in your group in ways that let you be true to yourself and clear about what you believe, value, know, and don't know.

#3—Resources/Barriers

When groups talk about resources as a stumbling block, they usually are talking about the lack of enough financial resources. There are a couple of key points to remember when dealing with this stumbling block, and they both have to do with "who" rather than "how much."

This process will help you interact with others in your group in ways that let you be true to yourself and clear about what you believe, value, know, and don't know.

For example, who is either in your watershed group or in some way a supporter of its mission? What are their resources? Don't think only of their financial resources, but also of their ability to access funds and other means of support. Do they have grant-writing or other fund-raising experience? Do they have experience in generating support for projects?

Don't get stuck on the concept of money; there also are other "currencies" that can be resources—for example, energy, time, tools, community contacts, political contacts, technical or administrative expertise, and so on. It might be worthwhile to do a brief assessment of your group members and ask these questions:

- What do we need?
- Who's here?
- Who's missing that could help?

Other barriers might be legal, social, economic, or technical. Once again, do a brief assessment. Using chapters 1–5 as guides, determine where the barrier is. Is it internal—in your organizational structure, how meetings are managed, how decisions are made (or not made), and so on? Is it external—are you communicating poorly with the public or with decision makers, violating laws or regulations, or in some other way not fully grasping the external factors affecting your group (for example, endangered species regulations)?

Systematically look at each level, identify your group's weaknesses and the threats facing you, and find ways to change as many as possible into strengths and opportunities. The idea is to exhaust every possibility for how to get through, over, under, or around—before you even consider stopping.

#4—Covert Agendas

Covert agendas usually come up if a group has stumbled during the development of their partnership or group structure or has a lack of clarity around group processes, meetings management, and communication protocols (see chapters 1–5). Sometimes people leave things muddled on purpose, and the lack of clarity and inclusiveness make it easier to carry out concealed, self-

serving plans. But most often unintentional confusion creates an atmosphere of paranoia in which people fear that some type of covert agenda is driving the process.

The keys to keeping either imaginary or real covert agendas from happening are in chapters 1–5. For example,

- Be deliberate about your partnership—take the time to get and keep the appropriate people involved.
- Learn about possible organizational structures and pick one that works for your group, given your members' geographic region, vision, mission, and goals.
- Keep the group's vision, mission, and goals visible, where the entire group can help guide activities toward them.
- Cultivate skilled participants and leaders.
- Build the decision-making and communication skills necessary to keep your group going along efficiently and effectively.

By cultivating an environment in which trust and respect can exist among different viewpoints and perspectives, you'll be able to overcome this stumbling block if and when it happens.

#5—Decision Making Outside of Meetings

It's especially easy to fall into this trap—making decisions outside the meetings—in the early stages of a group's life. During this time, trust has not developed, and protocols, structures, and agreements don't yet exist. Although it's usually not intentional, members talk outside of meetings and they forget they're not the only ones with opinions or perspectives. These "decisions" can be treated as if they were the result of the larger group, thereby leaving the others out. When this happens intentionally, it can splinter a group and damage relationships.

It's easy to paint a picture with only 3 or 4 colors, but it rarely has the depth or beauty that one with 20 colors might have. Typically, diverse members bring challenges to the group, but they also bring different skills and viewpoints that ultimately strengthen the group. Making decisions outside the group means some of these skills and viewpoints are left out.

The keys to preventing this problem are clearly defined in chapters 3 and 4. In the first meeting, raise this issue and make a temporary or permanent ground rule related to decision making. Then, as soon as possible, agree on a clear group decision-making process. Also refer to chapter 5 and the importance of clear internal and external communication protocols.

Make sure this problem isn't ignored. Talk about it openly. Remember, people are less likely to meet group expectations when they don't know what they are.

#6—Group Members Not Taking Ownership of the Group Process

Remember, although you might have a convener that calls meetings and a

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on an ecosystem basis are restricted by these aspects of federal law.

To deal with these and other legal constraints, rules, and regulations, do some research and read carefully any publications that address these issues. Your best chance at not stumbling, or recovering from a stumble, is to know what you face.

#10—If Not Your Group, Then Who?

The pitfall of trying to do it all yourself is ever present. If you've read and followed the principles in chapters 1–4 and you run into a task your group can't do or a problem you can't solve, ask yourselves, Who else can, could, or should be doing this?

There are many reasons some tasks might not be appropriate for your group to undertake. Maybe key research or technology doesn't exist yet or isn't available to your group. Maybe an activity would make local people uncomfortable. Maybe the problem needs to be looked at not just from an ecosystem perspective, but also from a community and workforce perspective. Saddling yourself with impossible tasks creates frustration—frustration that can be avoided.

Here's an example. Your group is laying out, or periodically revisiting, your watershed's master plan. As you focus on several watershed restoration projects, you notice that some parts of the projects require technical expertise that just doesn't exist in your cadre of volunteers, landowners, and so forth. You realize that you will have to contract out these parts of the projects, but to whom? Do you want to just design the project contract and award it to the lowest bidder, or do you want to set up clear design and contracting procedures that result in achieving good work and promote and sustain high-skill, high-wage work for your local workforce?

The key to avoiding this and other "if not us, who?" situations is to not get tunnel vision. Even if you've done a remarkable job at getting lots of different people involved in your watershed group, you're still only part of the world at large. Maybe a good part, but only one part. Take the time to look up and out the window every now and then. With careful and considerate thought, you can accomplish multiple objectives and achieve multiple rewards.

Summary

The fact is that stumbling happens and the best way to cope with it is to go with the flow and not give up. Listed below are some of the more common stumbling blocks that face groups and some key points to overcoming them.

1. Conflict

Conflict is a natural tension that arises from differences. The common causes of conflict are the need to be right, the lack of direct expression, and avoidance of conflict. Your personal history with conflict plays a part in how you cope with it now. Communication skills are needed to manage all types of conflicts.

2. Facts/myths/values/unknowns

Breaking down issues into bite-sized elements is helpful in confronting or understanding those issues. To do this, delineate and clarify facts, myths, values, and unknowns; destroy myths and replace them with facts or unknowns; anticipate and legitimize value differences; recognize your own values and articulate your own myths and unknowns about various aspects; and support the formulation of alternatives based on this new, clarified discussion of the issue.

3. Resources/barriers

Do brief assessments to get clear. Think of resources in terms of various currencies. Figure our where the barrier is—internal or external—systematically, at each level, and exhaust every possibility about how to get through, over, under, or around it.

4. Covert agendas

To keep covert agendas from developing, be deliberate about your partnership. Pick an organizational structure that works. Cultivate a skilled group of participants and leaders and the skills to keep the group going along effectively.

5. Decision making outside of meetings

Decision making outside of meetings occurs often in the early stages of a group's life span. Keep it from happening by making a temporary or permanent ground rule related to it, then come to a clear and agreed upon group decision-making process.

6. Group members not taking ownership of group process

The key to encouraging participants to take ownership of the group is knowing what makes good group members—with regard to both content and process.

7. Lack of clarity regarding decisions

Taking the time and energy to form, or reform, clear structure and protocols really alleviates the problem of unclear decisions. Having a clear organizational structure and effective meetings management is the beginning. Adding to that a clear understanding of how decisions will be made in your group, and why, will provide the framework to keep your group from stumbling over this one.

8. Politics and history of working together

Effective watershed groups are effective because they have members who represent all aspects of the watershed's interests. Successful groups are groups of people who have a common interest and commitment but from a variety of perspectives and positions.

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NWE/NWE.html. You can also request a catalog by calling CTIC at 765-494-9555.

Desmond Conner, Conner Development Services Ltd. Offers several educational materials related to constructive citizen participation. For more information, contact Development Press, 5096 Catalina Terrace, Victoria, BC, V8Y 2A5, 205-658-1323, or http://www.connor.bc.ca/connor.

Getting Past No: Negotiating Your Way from Confrontation to Cooperation, by W. Ury (New York: Penguin, 1993).

Getting to Yes: Negotiating Agreement without Giving In, R. Fisher and W. Ury, with B. Patton, ed., 2nd ed. (New York: Penguin, 1991).

Getting Together: Building Relationships as We Negotiate, by R. Fisher and S. Brown (New York: Penguin, 1989).

Guides for Watershed Partnerships, a series of guides from the Conservation Technology Information Center, 1220 Potter Drive, Rm 170, West Lafayette, IN 47906, 317-494-9555.

Keys to Successful Funding: A Small Community Guide to Federal and Foundation Resources (Washington, D.C.: National Center for Small Communities, 1997). Gives a clear presentation on keys to successful funding, the process, and tips for foundation funding. Contact NCSC at 444 N Capitol, NW, Suite 208, Washington, D.C. 20001, 202-624-3554.

The Miracle at Bridge Creek (VHS), an award-winning video about the trials and tribulations of coalition building among groups at odds seeking common ground. Available for $30 from Oregon State University Extension and Experiment Station Communications, Kerr Ads 422, Corvallis, OR 97331, 541-737-2513; or view and order on the Web at http://eesc.orst.edu. Order video #VTP 013.

Partnership Handbook: A Resource and Guidebook for Local Groups Addressing Natural Resource, Land Use, Or Environmental Issues, by Ann Moote (Tucson, AZ: Water Resources Research Center, College of Agriculture, University of Arizona, 1997). Available on the Web at http://ag.arizona.edu/partners/.

Policy Consensus Initiative works with states to promote use of the tools of conflict resolution to resolve policy disputes and negotiate change benefiting all citizens. Their publication *States Mediating Solutions to Environmental Disputes* presents five interesting, real-life case studies. Contact the group at 811 St. Michael's Drive, Suite 102, Santa Fe, NM 87505, 505-984-8211.

PART TWO

Watershed Ecosystems

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Bay, are among them, but many smaller estuaries are included as well. Local groups involved in these programs identify priority problems and develop and carry out strategies to address them.

Although voluntary groups form to solve a variety of environmental problems, many of the most successful citizen-led efforts today have one thing in common—they approach their problems from a *watershed* perspective. Whether dealing with fish habitat restoration, wetland or riparian protection or rehabilitation, or runoff pollution from urban or rural land uses, these groups view the watershed as the logical planning unit. The watershed approach has also won strong support from governmental agencies formally charged with maintaining the health of our nation's ecosystems and natural resources.

> "If you don't know where you're going, you're likely to end up somewhere else."
> – Lawrence J. Peters

The Watershed Approach

Albert Einstein once said, "The significant problems we face cannot be solved at the same level of thinking we were at when we created them." This is especially true today with environmental problems. There is a need for a new, more integrated way of thinking and acting that looks at whole systems, not isolated parts.

The watershed is emerging as one of these integrated frames of reference in which environmental problems will be addressed in the future. Why? Because ridgelines divide the landscape into geographic units within which many of our biggest environmental problems can be addressed effectively. Water is the critical factor—it circulates energy, chemical elements, soil, and pollutants through ecosystems. Streams and rivers connect headwaters with estuaries, the land with the water, surface waters with groundwater aquifers, and forests, farmlands, and cities with one another.

In addition to its ecological sensibility, a watershed approach to environmental problem solving makes sense from economic, social, and political perspectives. Economic uses of land and water upstream have impacts on downstream land and water users, affecting drinking water quality, flooding potential, sustainable resource use such as fishing, and other elements of quality of life. The watershed approach is also valuable because it brings together people from different walks of life—loggers and miners in headwaters, farmers and ranchers in rural valleys, recreational users, and business, industry, and urban water users in cities. To find common ground, individuals from all these groups must be involved—inclusiveness is thus the first step toward consensus. Because political boundaries are arbitrary and governmental agency missions narrow, the watershed approach also fosters needed intergovernmental cooperation. For these

What is a watershed?

In simple terms, a *watershed* is the land area that is drained by a river, stream, or creek (figure 1). Other terms used interchangeably with watershed include *drainage basin, river basin,* or *catchment basin.* Watersheds range in size from the Mississippi River basin (41 percent of the land area of the lower 48 states) to your local stream valley, which may be just a few hundred acres in size. Large watersheds are thus composed of many smaller watersheds associated with tributary streams (the Ohio River watershed is actually a subwatershed of the Mississippi, for example); and so it goes, on down to your small local watershed. Watersheds are ultimately defined by gravity.

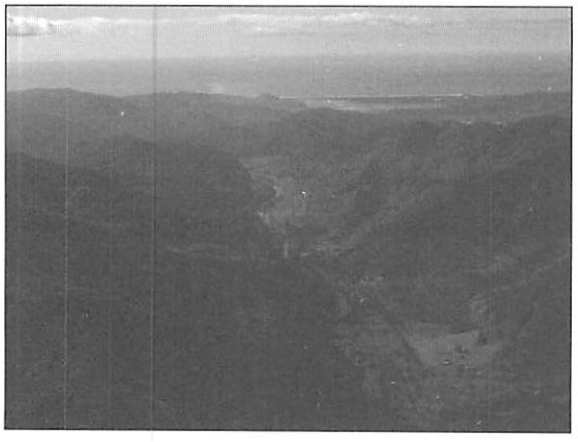

Figure 1. In mountainous coastal areas like this one in Oregon, watershed boundaries are easy to determine, but this may not be the case along the Atlantic and Gulf coasts, where topographic changes are subtle and barrier islands create large estuaries draining many river systems.

Try this simple exercise to define your watershed boundary. First, on a large-area topographic map (for example, a U.S. Geological Survey 1:62,500 scale map, or larger scale if your watershed is small), select the stream or river of interest. Then locate the ridgetops that surround the river or stream—a line traced along these ridgetops is your watershed boundary. Rainwater falling within this boundary (and not otherwise stored in groundwater aquifers or used by plants or animals) will eventually find its way into the river or stream and eventually to the estuary and ocean.

Watersheds, of course, are much more than this to people. They are places where we humans live, work, play, raise crops, harvest trees, and build our towns and cities. Watersheds and the habitat and resources they contain also provide goods and services we sometimes overlook. For example, watersheds provide natural flood control, clean water for drinking, pollutant removal or transformation, the oxygen we breathe, and inspiration in our daily lives.

Coastal watersheds and the estuaries and nearshore ocean waters they drain into are among the most productive ecosystems in the world. Whereas all watersheds provide essential habitat for plants and animals, coastal watersheds are vital to anadromous species such as salmon, shad, crab, shrimp, and numerous other species of commercial and recreational importance that require healthy estuaries and river channels for spawning and rearing.

Use consensus rather than adversarial approaches to make decisions. There has been a shift in recent years from contentious litigation to consensus building as an approach to environmental problem solving. This is particularly important in watersheds, where you are attempting to voluntarily change behavior patterns of landowners and local decision makers, based on principles of good land stewardship and ethics. Consensus decision making promotes real partnerships among potential adversaries, including businesses, developers, landowners, farmers, forest managers, environmentalists, and others, because the emphasis is on balancing interests and community and ecosystem sustainability.

No single cookie-cutter approach will work. There are real differences in the nature of watershed issues in different regions of the country and between urban and rural areas. Watershed activists must recognize and work with these differences and with different governmental situations (for example, state and local land-use regulations, growth-management strategies, or the lack thereof) as they design strategies and actions for their watersheds.

Get all the right people and interests involved. Include all stakeholders in the process of developing and carrying out your plan. Stakeholders include everyone who has a real stake in the long-term management of the watershed. Be inclusive, get all parties at the table, and recruit if necessary. It is wise to get key stakeholders at the very first meeting if possible.

Be creative about who foots the bill. Be innovative about who pays the costs of watershed conservation and restoration. Develop partnerships between the public and private sectors and with landowners. Promote self-reliance by relying less on tax-supported funding sources and regulatory approaches and more on local, voluntary, and in-kind contributions. Promote governmental incentives that will foster partnerships and desirable voluntary action.

Use the best scientific information available to make informed decisions, but don't expect it to ever be perfect. Decisions will always be made with some degree of uncertainty, but the use of sound science will increase the likelihood of success. It does not have to be perfect to be reliable.

Remember the need for watershed education. Most people have a limited understanding of how the natural world functions or of watersheds in particular. Watershed activists need to engage the public in a sustained educational program about the watershed—how it functions, what its value is, how actions affect its health, and what can be done to make things better at both the personal and community level.

Nurture watershed brokers and leaders. All successful watershed conservation efforts have an effective leader or group of leaders. Sometimes called "fixers," these individuals are adept at looking at problems from a broad perspective, helping groups reach decisions, figuring

out where the gaps are, and finding ways to solve problems. Leadership is a key ingredient in success.

Features of a Watershed Action Plan

What does a good watershed action plan include? That depends on your watershed and the unique set of issues you are trying to address, the people who are involved, and the resources that can be employed to help you address priority problems. Nevertheless, although plans will differ in emphasis, most watershed action plans have some common features:

1. A good base map of the watershed that can be used to add needed "layers" of information such as rivers and streams, lakes, wetlands, floodplains, transportation networks, political and land ownership boundaries, land use, and similar data
2. A well-documented list of priority issues—problems and opportunities, along with findings, and goals for addressing them
3. A professional-quality aquatic and terrestrial resource assessment of what natural and other resources exist within the watershed (from rare natural habitats to prime development sites)
4. Identification of major point sources of pollution coming from factories, sewage treatment plants, and other "point sources" (sewage and industrial pipelines, for example), along with actions that might be taken to minimize accidental spills and pollutant discharge that could harm human and ecosystem health
5. Identification of polluted runoff or nonpoint sources in the watershed (for example, urban streets and parking lots, residential lawns, timber-cutting areas, soil and fertilizer from farms), along with actions needed to minimize runoff pollution problems, such as working with communities, industry, and landowners to improve retention and treatment of polluted runoff
6. A program designed to protect and restore streams, rivers, lakes, wetlands, and native riparian vegetation that serve as habitat for fish and wildlife, filter out pollutants and sediment from runoff, and function as temporary water storage areas during floods and high water
7. A program to protect headwater areas and the very best areas of undisturbed, natural habitat throughout the watershed, thereby serving as refuges for rare, threatened, and endangered species and as an area of high biological diversity generally
8. A program to provide for adequate streamflows for fish and wildlife that corresponds as closely as possible to the natural hydrograph (flows and timing of flows). This may include increasing natural storage capacity through wetland restoration, water conservation programs for industry and urban areas, and other strategies.

9. A program that addresses the threat of nonindigenous species introduction and the need to control existing nuisance species

Steps in Developing a Watershed Action Plan

Although we cautioned earlier against a cookie-cutter approach for evaluating watershed health and developing an action

Watershed action planning steps

Step 1: Assess the condition and health of watershed ecosystems and resources.

- What were the historical extent, condition, and functions of watershed ecosystems and resources?
- What are the current extent, condition, and functions of watershed ecosystems and resources? How have things changed over time?
- What are the principal ecological problems and foreseeable threats and risks to watershed health?

Step 2: Set goals for watershed restoration, enhancement, and other issues.

- Considering current and historical conditions, present ecological problems, and threats, what are the long- and short-term watershed goals for protection, restoration, enhancement, management, research, monitoring, and public and decision-maker education?

Step 3: Identify potential watershed projects and actions.

- Considering the results from steps 1 and 2, what actions or projects will do the most to accomplish watershed goals? What actions or projects fit into short-term versus long-term priorities?

Step 4: Screen potential projects and actions for constraints and feasibility.

- Considering possible constraints, such as land-use conflicts, property ownership, willingness of landowners to participate, and public and private cost, what projects and actions are realistic, cost-effective, and achievable in the short and long term?

Step 5: Synthesize planning results, write an action plan, and implement.

- Set forth an overall vision for watershed protection, restoration, enhancement, management, research, monitoring, and public and decision-maker education.
- Commit the plan to writing and illustrate it clearly with maps and drawings, begin its implementation project by project, monitor progress; and periodically reevaluate priorities, recognizing that goals and constraints may change over time.

plan, it is useful to begin with a model process and adapt it to local conditions and needs. One such model, which is really a composite of watershed planning approaches used in Massachusetts, Washington, and elsewhere, is outlined in the sidebar below and explained in more detail in the following text. Reevaluate priorities, recognizing that goals and constraints may change over time.

The process in the sidebar sounds relatively simple—or does it? Successfully accomplishing this process, even for a relatively small watershed, is a significant undertaking. It requires detective work to track down useful information, an understanding of how the watershed functions, sensitivity to existing land uses and private property rights, inclusion of people who could be affected, and incorporation of local knowledge and values. A bottom-up, team approach is needed to pull together and analyze information, to go neighbor to neighbor with proposals, and to arrive at an acceptable watershed protection and restoration vision. Top-down help is needed as well to help locate and interpret information and to help access financial resources.

This process may take six months, a year, or more. However, it will be clear as you proceed that some projects are desirable and feasible from the start and address real problems that everyone agrees need to be addressed. Start working on these projects as soon as possible. *Early success in implementing actions or projects is critical to building and maintaining community support and interest.*

A well-reasoned plan is important and will help you get financial support, but we all know about plans gathering dust on the shelf. Your plan should include ways to monitor progress and publicize success stories and milestones. It also should include provisions for revising goals to address new problems, opportunities, or constraints.

Each step in this process is discussed below, with emphasis on the first—watershed assessment.

Step 1: Assess the condition and health of watershed ecosystems and resources.

- What were the historical extent, condition, and functions of watershed ecosystems and resources?
- What are the current extent, condition, and functions of watershed ecosystems and resources? How have things changed over time?
- What are the principal ecological problems and foreseeable threats and risks to watershed health?

A good information base is the first step in any planning process. To evaluate your watershed's health, you need a reference point. Typically, the condition of the watershed before it has undergone major physical alterations, such as dams or widespread land clearing or diking, is used as a starting point. From there, major changes can be tracked up to the present. The result is the *ecological history* of your watershed.

Current conditions would seem to be the easiest part of the assessment. We have maps of existing habitats, for example, plus detailed aerial photos and at least some water-quality data.

However, you will quickly find that little published information is available that explains how your particular watershed works at the scale you seek to understand. Thus it is useful to tap into the knowledge of local biologists, other professionals, and those who spend lots of time on the land and water.

Even more challenging is trying to predict future risks and threats. Present trends offer some clues, however. For many watersheds, threats such as runoff pollution and aquatic nuisance species need to be documented.

Each of the tasks that make up this first step is discussed in more detail below. Completing these tasks will leave you with an initial list of potential projects or actions to restore or enhance watersheds.

What were historical conditions in the watershed?

Because ecosystems are by nature dynamic and constantly changing in response to both natural and human influences, the first challenge for the ecosystem historian is to select a time frame for beginning his or her assessment. This decision should be made in light of the main purpose of researching the watershed's ecological history, namely to provide insight into how the watershed functioned in a comparatively healthy, self-sustaining condition.

Long before Euro-American settlement, Native Americans "managed" and changed the landscape in a variety of ways, clearing land for agriculture, burning large areas for game management, and harvesting wildlife. Although some of these practices may not have been ecologically benign, it is generally assumed that ecosystems as early Euro-American settlers found them were in relatively good condition. Euro-American settlement, however, resulted in dramatic and long-lasting changes to the landscape—land clearing for agriculture, draining of wetlands and swamps, channelization of streams and rivers, improvements for navigation, and harvesting of timbered riparian and upland areas. Consequently, the baseline selected for historical ecosystem analysis is generally as close as possible to the beginning of Euro-American settlement of a region. This is also when landscape changes began to be well documented and these records are still available to researchers.

It will be apparent that some physical changes that have damaged or degraded the watershed are reversible. Your task is to identify and describe opportunities to rehabilitate the watershed in ways that are consistent with present and projected economic uses *and* your goals for improving watershed health and functioning. For example, replacing an undersized road culvert that prevents fish passage with a larger culvert or small bridge would benefit the watershed without interrupting traffic flow. Restoring riparian vegetation along a stream, fencing out livestock, or removing dikes that prevent tidal exchange are other examples.

Other changes to the watershed clearly are not reversible. It is unlikely, for example, that jetties will be removed, navigation channels filled in, or cities and ports relocated. In any case, historical assessment is not undertaken as a basis for turning back the clock to recreate these conditions. Even if it were physically possible to recreate a pre-Euro-American settlement ecosystem (which it is not), it would not necessarily be ecologically desirable, nor would it be realistic from a modern-day community perspective.

Watershed groups can use a variety of resources to assess historical conditions and compare them to present conditions. Examples include

- *National Wetlands Inventory (NWI) maps*, which superimpose estuarine habitats (and most diked areas) on USGS quadrangle maps
- *County soil surveys* and maps, which show tideland and other hydric soil areas
- *U.S. Coast Survey charts* dating back to the mid-1800s, which show channels, bottom sediment types, marsh vegetation, forested swamps, and changes such as jetties, fills, and other development. Figure 2 is an example for Oyster Bay, located on the north shore of Long Island, New York.
- *Original public lands survey records* from the mid-1800s, which include maps and descriptions of forested and grassy areas, tidal creeks and streams, and other landscape features

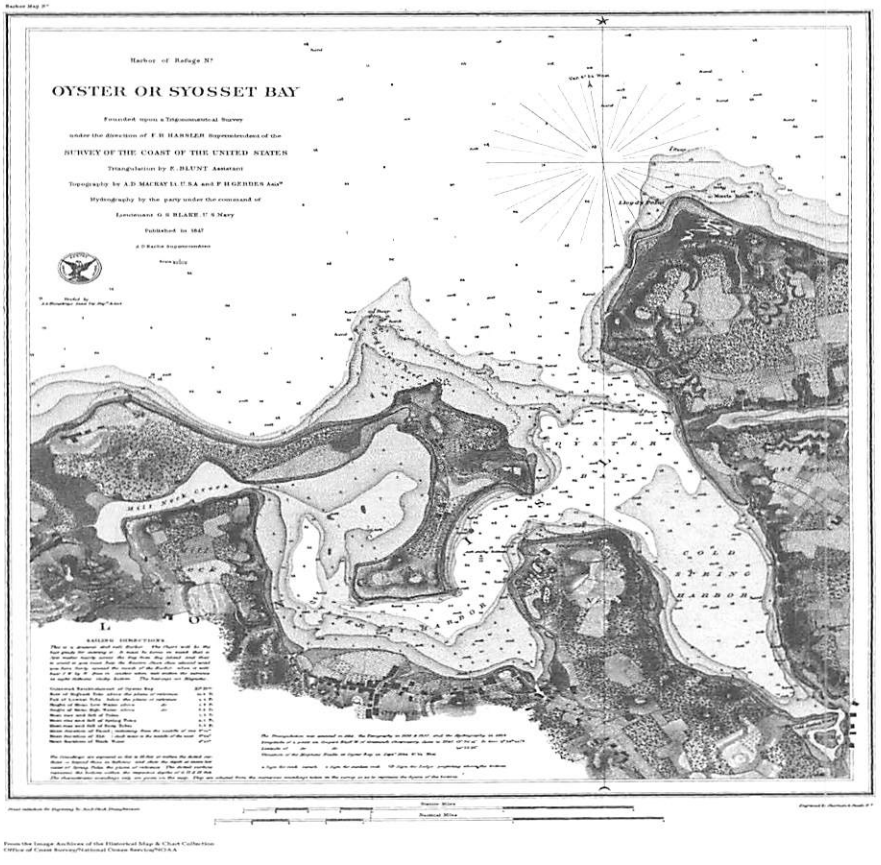

Figure 2. Historical nautical chart of Oyster Bay, New York, 1847. (Image from the archives of the historical map and chart collection, Office of Coast Survey, National Ocean Service, National Oceanic and Atmospheric Administration.)

- *U.S. Army Corps of Engineers navigation and snag removal records*
- *Hydrologic and water-quality records* from state and federal agencies
- *Fisheries statistics and records* that document fish runs and harvests
- *Historical ground photos and written accounts*
- *Local diking and drainage district records*

These data sources and how to acquire them are described in more detail in "Resources."

What are current watershed conditions and health?

A comparison of historical watershed conditions and current conditions is one indicator of watershed health. For example, changes in land cover and use can be used to estimate changes in the timing and quantity of streamflow. Changes in estuarine salt marshes and tidal creeks can be used to estimate an estuary's capacity to support salmon, shrimp, or crab. This information then may serve as a basis for watershed goal setting.

The extent to which remaining habitats are protected from future alterations is another important, if speculative, consideration. Generally, coastal habitats such as salt marshes and eelgrass beds are well protected. Freshwater wetlands and riparian areas, particularly in rural areas used for farming, are less well protected.

Habitat information

Among the best sources of relatively recent habitat information for rivers, streams, wetlands, and lakes are National Wetlands Inventory (NWI) maps, available from the U.S. Fish and Wildlife Service and state wetland management agencies.

Recent physical alterations

Corps of Engineers regulatory records for permitted dredge, fill, and in-water construction projects are one good source of data on recent physical alterations, although these data are sometimes difficult to access. States that operate similar regulatory programs may be another source of good data—New Jersey, for example, keeps a detailed database on freshwater wetland alterations.

Aquatic nuisance species

As noted earlier, some introduced species are welcome in coastal regions while others are not. The European green crab *(Carcinus maenas)* and saltmarsh cordgrass *(Spartina alterniflora),* for example, are problems in the Pacific Northwest, while the common reed *(Phragmites australis),* is invasive in East Coast salt marshes and the zebra mussel is a costly invasive pest species in the Great Lakes.

As part of your watershed assessment, collect information on what is known about aquatic nuisance species in your watershed—the severity of infestations, potential sources of introductions, and possible control strategies. Early detection of new aquatic nuisance species populations sometimes allows successful control or eradication. Watershed groups can play an important role in a statewide aquatic nuisance species detection network.

Nonpoint source or "runoff" pollution

Because excessive pollution can derail otherwise successful restoration and enhancement efforts, it is important to identify potential pollution sources. Gathering and making sense of pollution data can be complicated. State environmental protection agency staff may be able to provide technical assistance.

Pipeline-introduced pollution is strictly regulated by the state water quality agencies as part of the National Pollutant Discharge Elimination System permit program. Information on these discharges can be obtained from those agencies.

Information on broadly distributed runoff pollution from farms, forests and rural, and urban areas is much more difficult to obtain. How these pollutants affect estuarine health also is poorly understood. State water-quality agencies do have water-quality measurements for some rivers, lakes, and estuaries, but often the data have not been thoroughly analyzed. Bacterial contamination (for example, coliform counts) is also routinely monitored, especially in estuaries where shellfish are produced commercially. Recently, NOAA synthesized and published data on nutrient and other pollution for 138 estuaries around the United States—the *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries,* by S. Bricker et al. (1999).

Where dairy and other livestock operations are common, check with local farm organizations and local Extension Service agents about problems and for suggestions on how the watershed group can get involved in finding solutions.

Find out whether and how communities along watershed shorelines capture, treat, and discharge storm water and how they regulate and enforce sediment runoff controls at construction sites. Link up with local citizen monitoring efforts such as CoastNet, a program operated through high schools and middle schools in many states, or start a citizen monitoring program.

Controlling runoff pollution is a long-term proposition requiring training, monitoring, evaluation, and problem solving. See related chapters in this manual for more information on water quality, runoff pollution, and actions that may reduce pollution.

What are today's principal ecological problems and foreseeable threats and risks?

As you examine historical and current watershed conditions, ecological problems will be revealed—invasive pest species, pollution sources and hot spots, restricted tidal circulation, habitat degradation, and other conditions that diminish watershed health, functions, goods, and services. Restoration and enhancement activities and projects might help resolve these problems or at least make them less severe.

It is very important to make problem identification and goal setting a *community-based process.* You can use a combination of techniques to collect local viewpoints and, at the same time, present the watershed

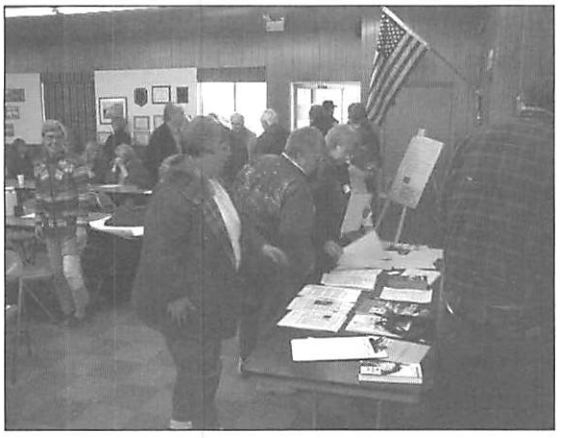

Figure 3. Watershed planning processes should be transparent. Public information meetings are a good way to spread the word and collect ideas from local residents.

assessment information being compiled. Examples include newspaper or mail surveys, educational programs at meetings of local organizations, coffee klatches, and door-to-door, neighbor-to-neighbor discussions (figure 3).

Step 2: Set restoration and enhancement goals.

Considering current and historical conditions, ecological problems, and threats, what are the goals for restoration, enhancement, protection, management, research, monitoring, and public and decision-maker education?

As problems are identified in the community-based process discussed above, consider goals for restoring and enhancing watershed health. In meetings with local organizations and the public, present findings of the watershed health assessment (step 1) and facilitate discussion to identify watershed problems, protection and restoration opportunities, and goals for improving the watershed.

Setting goals is relatively simple once there is a consensus about key problems. Simply turn problem statements from negative to positive to create a goal. Before finalizing goals, present them to the community and ask for feedback. This process takes time, but it is worthwhile in terms of building support and understanding in the community and among property owners.

Step 3. Identify potential restoration, enhancement, management, and educational projects and priorities.

On the basis of results from steps 1 and 2, what specific projects will do the most to accomplish each watershed goal?

The next step in developing a realistic watershed action plan is to screen protection, restoration, and enhancement opportunities identified in step 1 for their potential to help solve problems and achieve the goals identified in step 2. This process requires a careful, even tedious, examination of each project as it relates to each goal. It may be useful to create a large matrix of opportunities (project sites) versus goals. Give each site a rating of 1 to 5 (high to low) for its ability to meet each goal. Then add up all of the ratings for each site to establish site priorities (figure 4). Some goals may need to be weighted more heavily than

others, depending on their relative importance. This sort of process can be helpful but should be supplemented by common sense. See the sidebar on the following page for an alternative means of setting priorities.

Step 4: Screen potential projects and actions for constraints and feasibility.

Considering possible constraints, such as land-use conflicts, property ownership, willingness to participate, and public and private cost, which projects and actions are realistic and cost-effective?

One result of step 3 is a list of priority projects based on the match between identified restoration or enhancement opportunities and the goals your group has set forth. However, other constraints need to be factored in to set realistic priorities.

Figure 4. Small work groups using a variety of resources such as National Wetland Inventory maps are one good way to identify and rate potential restoration and enhancement projects.

To accomplish this, ask the following questions for each on-the-ground project or proposed action:

- Are there potential land-use conflicts?
- Who owns the property?
- Is the property owner willing to sell, donate, or allow restoration use of the property?
- How do neighbors feel about the project?
- How much will the project cost?
- Where will the money and labor come from to actually implement and monitor the project?

Answers to some of these questions may drop some actions, sites, or projects off the list immediately. Project feasibility might change over time; what is not feasible today might be feasible five years from now, for example, if land ownership changes or funding becomes available.

Some projects may involve working to get land-use or water-quality rules changed so that otherwise feasible on-the-ground projects can go forward. In Coos Bay, Oregon, for example, reservation of a diked wetland for use as future development mitigation made it ineligible for nonregulatory restoration, even though it was owned by the South Slough National Estuarine Research Reserve. After much discussion, the county changed the rule to allow habitat restoration for research purposes, but similar constraints exist in other areas.

Step 5: Synthesize results, write an action plan, and begin work.

What is the overall vision for watershed protection, restoration, enhancement, and management?

Commit the plan to writing, maps, and drawings; begin its implementation project by project; monitor progress toward its accomplishment; periodically reevaluate priorities, recognizing that goals and constraints may change over time.

Using specified criteria to set priorities

Many approaches to priority setting rely on comparing alternatives to a set of criteria and ranking them on how well they achieve each criterion. Examples of criteria include

- *Ability to achieve objectives.* You'll want to choose alternatives that clearly contribute to the achievement of your management objectives.
- *Ability to influence change.* Make sure the alternative is within your group's sphere of influence and your ability to influence change. For example, a particular large landowner may not want to cooperate with a watershed group in improving the riparian area along a particular stream reach. The group might not have the ability to influence change along this stream at present so it probably would be better off putting its efforts into other stream reaches.
- *Delay between actions and results.* Some alternatives lead to short-term changes, whereas others take a long time to show results. Your group needs to know what level of delay is acceptable. For example, planting conifers in a shrub-dominated riparian area will take a very long time (more than 100 years) to improve salmon rearing habitat by increasing the amount of large woody debris in the stream. Although this may be the best long-term solution, you also might need to choose other alternative ways to improve habitat in the short term.
- *Cost versus benefits.* Do the costs outweigh the benefits, or do the benefits outweigh the costs? It can be difficult to put a monetary value on the benefits of a project, but the costs usually can be readily calculated. One way to do a cost-benefit analysis is to compare the cost of alternative ways of achieving a given benefit.
- *Educational value*: Watershed groups need landowner cooperation, which can be improved through education. Projects that have value as demonstrations can help achieve this objective.

You may want to give the most important criteria the heaviest weights. Then you can rank alternatives by how well they achieve the criteria. Next, use budget information and other constraints to decide how many of the ranked alternatives your group can achieve in a given period of time.

The action plan developed to this point is a vision for improving a watershed's health and condition. Document your planning process and decisions with maps and text.

Restoring the Watershed—Project by Project

A watershed action plan developed using the process described above will yield specific, high-priority restoration and other projects to achieve watershed goals and will have the support of the community and property owners. The next step—actually carrying out and monitoring projects—is the rewarding part. But it is not so simple as planting trees or installing new culverts. Project by project, you must survey sites, set realistic goals, make drawings of present and projected conditions, secure funding and equipment, undertake construction, and begin monitoring. The needs associated with any given project will vary, but all require the same general steps.

There is a growing body of knowledge about how to best restore or enhance aquatic habitats and ecological functions. From these experiences, it is possible to derive a general process and set of principles for carrying out watershed restoration or enhancement projects. This process is outlined below as four steps:

1. Planning and design
2. Project construction
3. Monitoring
4. Practicing adaptive management

This kind of approach is often called *adaptive management*, meaning that we recognize our limited ability to predict outcomes and thus treat every project as an experiment.

Step 1: Project planning and design

Planning and design considerations for watershed restoration or enhancement projects vary by project type. However, some general aspects of project planning and design are similar for all projects. First, a thorough assessment of historical and current site conditions is needed. Next, clear goals and objects—consistent with site potential and expected restoration trajectory—must be set. Finally, a monitoring plan is needed for estimating progress toward goals and for identifying needed corrective actions.

Beyond these general considerations, each type of restoration project and each individual project will have unique design considerations. Establishment of salt marsh vegetation on a dredged material island, for example, will have different design specifications than an eelgrass planting, a clam bed restoration, a culvert replacement, or a riparian zone revegetation.

The project used here to illustrate design considerations is a *tidal marsh restoration*–a common opportunity in our nation's estuaries, given the extensive wetland diking, draining, and ditching that took place during and after Euro-American settlement. Many factors listed here are purely physical

considerations, reflecting the perspective that if you restore appropriate hydrology and landscape conditions, the biology will follow. But biological considerations also are important in planning.

On the basis of previous tidal marsh restoration experience in the United States, specialists recommend the following design principles and planning considerations. They can serve as a checklist for groups undertaking projects similar to those described. The guidelines can also be modified somewhat to apply to a variety of coastal habitat restoration and enhancement projects.

- *Watershed disturbances*—Consider existing or potential upland and upstream disturbances when designing restoration or enhancement projects.
- *Links to other projects*—Consider opportunities to simultaneously plan and construct estuarine, upstream, riparian, and upland enhancement projects to increase effectiveness and efficiency at the watershed level.
- *Ecological history*—Historical conditions at and surrounding the site may or may not be a good predictor of site restoration potential, given past alterations. However, understanding the use history of the site and its likely condition prior to physical alterations will provide clues that are useful in setting goals, designing the project, and understanding limitations.
- *Prerestoration survey*—A careful prerestoration survey of historical channels and creeks, present drainage patterns and hydrology, water quality, soil characteristics, and land elevations is important for setting realistic restoration goals and developing a monitoring program. Also survey nearby intact reference sites to serve as reference or control sites.
- *Hydrology*—Restoring prior hydrologic connections is critical to successful restoration. If possible, completely remove dikes. Open tidal creeks at their former locations and dredge them to ensure adequate tidal exchange.
- *Vegetation*—Vegetation reestablishment can be passive if there are nearby "seed bank" tidal marshes of the type expected to develop at the restoration site. Planting is expensive and usually unnecessary for tidal wetlands. If vegetation does need to be planted, use local plants or seed stock and pay careful attention to site elevations, slopes, energy regime, tidal influence, salinity regime, and freshwater input.
- *Buffers*—Minimize boundaries shared with developed areas that will disturb wildlife or interfere with desired functions or values. Where such boundaries are unavoidable, plan for adequate buffers between the restored area and adjacent development.
- *Size*—Large restoration and enhancement projects are, in general, preferred over small projects because of their potential for greater habitat and functional diversity and complexity.

- *Corridors*—Consider the need for water and vegetated corridors between separated habitat areas so wildlife and aquatic animals can move safely from one area to another.
- *Energy regime*—Carefully consider the site's energy regime. Particularly along bays and estuaries, exposure to excessive wind, waves, and tidal currents is the most frequent reason for failure of vegetation development.
- *Manipulation*—Minimize manipulation of the site. Work with the site to take advantage of its natural configuration, drainage, and other characteristics. Extensive manipulation is expensive and prone to failure.
- *Sustainability*—Plan for self-sustaining habitats, thus minimizing maintenance costs.
- *Subsidence*—Because diked, ditched, and drained wetlands may subside a foot or more and continue to exhibit unnatural drainage patterns after restoration, complete restoration to historical conditions is *not* a realistic goal. However, restoration to a well-functioning part of the watershed ecosystem *is* realistic.
- *Permit*—You will need permits from the U.S. Army Corps of Engineers, state regulatory agencies, and possibly local government bodies to construct your project. (See "Resources.") Involve them early. Specialists from these and other agencies, such as state fish and wildlife agencies, nongovernmental organizations, and universities can also be helpful.

Step 2: Project construction

After you complete the site assessment, planning, and design and secure funding, construction can begin. The following considerations and principles are important:

- *Follow construction plans*—Construction should follow the site plan exactly. Next to poor planning, construction that did not meet specifications is the most common cause of failed restoration and enhancement projects. Biologists and engineers who helped design the project should be on the site during construction to ensure plans are followed.
- *Salvage materials*—Construction should be phased to allow salvaging of vegetation and substrates of ecological value.
- *Timing*—Time construction to accommodate the tidal and other hydrologic cycles, and seasonal cycles of vegetation growth and fish and wildlife activities.

Step 3: Monitoring

The importance of monitoring a site after it has been manipulated for restoration or enhancement cannot be overemphasized. Every project should be monitored at some basic level (figure 5). Monitoring lets you know whether you are moving along the projected restoration trajectory and suggests ways of correcting problems that inevitably arise. Monitoring also can be used to set more realistic goals and improve the design of future projects.

Monitoring has both short- and long-term considerations. In the short term,

Figure 5. Monitoring restoration and enhancement projects is an essential component of project implementation, providing the information necessary to gauge success.

monitor drainage pattern development, sedimentation and erosion, fish and wildlife use, and vegetation establishment. In the long term, the concern is whether the estuarine habitat has become a well-functioning, integral part of the watershed ecosystem.

Plans for postrestoration monitoring vary, depending on the size, scope, and goals of the project; the purpose of monitoring; and the training, skills, and time available. *Basic monitoring,* which can be carried out by trained volunteers or watershed council members with engineering, map making, and other skills, may include the following:

- *General photo documentation*—Take photos from established locations before, during, and immediately after construction.
- *Construction assessment*—Create plan views, cross-section maps, and drawings to ensure that construction follows plans.
- *Physical site development*—Use periodic photo documentation and mapping to follow the evolution of creeks and other drainage patterns, hydrologic connections, undesirable ponding, and, if possible, sedimentation and changes in elevation (monthly at first, quarterly later).
- *Vegetation*–Continue photodocumentation, mapping, and description of vegetation development and succession, including percent cover, species composition, and distribution. If the information seems relevant, compare the success of planted areas with natural recruitment (quarterly).
- *Water quality*—Monitoring water quality requires specialized equipment and training, but your group can work with local schools or other groups involved in voluntary water-quality monitoring programs. (See "Resources.")
- *Aquatic life use*—Describe initial colonization, succession, and use of restored and created habitats by bottom-dwelling plants (for example, eelgrass and algae) and animals (amphipods, worms, clams, and fishes), land and aquatic mammals, and birds (seasonal for at least a day from dawn to dusk). Sediment cores and sieves, fish nets, traps, and visual inspection are useful techniques. Although the resulting data may not be statistically accurate, these methods can give a good overall view of changing site use by aquatic organisms.

- *Recreational use*—Evaluate the site for recreational use, including levels of disturbance and effectiveness of established buffers.

The above monitoring guidelines are ideal but are unrealistic for many projects because people, funds, or equipment may not be available. The extent of monitoring should be related to the level of investment in the project, its importance, and the risk of failure.

In some cases, even more in-depth monitoring may be desirable. In this case, professionals and scientists probably already are involved. In-depth *technical monitoring,* such as calculating sedimentation rates, analyzing sediment salinity, measuring plant biomass, quantifying the use of the site by endangered species, and evaluating food and habitat preferences, generally is carried out by professionals and scientists.

How long should monitoring continue? Research on watershed restoration and enhancement during the past 20 years suggests that determining "success" may require at least 10 years of postrestoration monitoring, both because sites take time to develop and because needed corrective actions may not be apparent over shorter time periods. Few watershed projects are monitored formally for this long. However, productive partnerships with schools, hunting or fishing groups, and others may allow longer-term tracking of project success.

Whatever the proposed level of monitoring, it is advisable to secure technical assistance before initiating monitoring. Resource specialists and scientists from agencies and universities can help design a monitoring program and train local volunteers.

Step 4: Practicing adaptive management

If monitoring shows that the project is not proceeding as planned, physical or other modifications may be needed. Alternatively, you may need to modify project goals to be more realistic and consistent with the site's actual potential to perform desired functions. Every project should be viewed as an experiment requiring adaptive management strategies.

Summary

A *watershed* is the land area that is drained by a river, stream, or creek. Other terms used interchangeably with watershed include *drainage basin, river basin,* or *catchment basin.* Watersheds provide a variety of valued goods and services—fish and wildlife habitat; food production that supports the estuarine food chain; water-quality maintenance; moderation of floodwater flows; shoreline stabilization; and a variety of economic, recreational, and educational benefits.

To maintain and increase the benefits watersheds provide to people and the environment, we need to

- Protect the critical remaining habitat
- Restore former or degraded habitat where feasible

- Link restoration actions to upland and upstream restoration and enhancement efforts in a whole-watershed approach
- Monitor water quality, clean up existing pollution problems, and prevent new pollution that cannot be readily assimilated
- Avoid inadvertent or intentional introduction of harmful, nonnative plants and animals
- Incorporate both local knowledge and the best available scientific information into our planning, decision making, and projects
- Support research to improve understanding of watershed ecosystems

Watershed planning to restore watershed ecosystem health involves five key steps:

1. Assessing historical conditions, current conditions, and present risks and threats
2. Setting restoration and enhancement goals
3. Identifying potential restoration, enhancement, management, or educational projects and setting priorities
4. Screening potential projects for constraints and feasibility
5. Synthesizing planning results, writing an action plan, and beginning work

The purpose of studying a watershed's ecological history is to understand how the watershed functioned in the past, how it has been changed, and how it might be rehabilitated to better serve economic and ecological functions.

Experience with watershed restoration and enhancement projects suggests that careful planning and design, clear goals, construction that follows plans exactly, follow-up monitoring, and adaptive management are keys to success.

Resources

Technical agencies, information sources, and Web sites

Office of Ocean and Coastal Resources Management
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, MD 20910
http://www.ocrm.nos.noaa.gov/

National Estuarine Research Reserve System
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, MD 20910
http://www.ocrm.nos.noaa.gov/nerr/programs.html

State Coastal Management Programs
http://www.ocrm.nos.noaa.gov/czm/czmsitelist.html

National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Community-based Restoration Program
http://www.nmfs.noaa.gov/habitat/restoration/community/index.html

U.S. Environmental Protection Agency
Office of Watersheds, Oceans, and Wetlands
http://www.epa.gov/OWOW/

U.S. Environmental Protection Agency
Watershed Information Network
http://www.epa.gov/win/

U.S. Fish and Wildlife Service Coastal Program
Division of Fish and Wildlife Management Assistance and Habitat Restoration
http://www.fws.gov/cep/cepcode.html

Publications

Restoring Wetlands at a River Basin Scale: A Guide for Washington's Puget Sound: Operational Draft. Publication No. 97-99 (Olympia, WA: Washington Department of Ecology, 1997). Available on the Web at http://www.ecy.wa.gov/biblio/97099.html

Putting Together a Watershed Management Plan: A Guide for Watershed Partnerships (West Lafayette, IN: Conservation Technology Information Center, 1997). Available from CTIC, 1220 Potter Drive, Rm. 170, West Lafayette, IN 47906; phone: 317-494-9555; fax: 317-494-5969.

Leadership in Watershed Management: The County Role, by James E. Kundell (Washington, D.C.: National Association of Counties, 1999). Available from

NACO, 440 First Street, Washington, DC 2000; phone: 202-393-6226.

Watershed Restoration: A Guide for Citizen Involvement in California, by Keir (William M.) Associates. NOAA Coastal Ocean Program Decision Analysis Series No. 8. (Silver Spring, MD: NOAA Coastal Ocean Program Office). Phone: 301-713-4044; http://www.ceres.ca.gov/watershed/restoration/Kier95.PDF

Web sites

http://www.mapping.usgs.gov
USGS digital orthophotos and other products

http://secchi.hmsc.orst.edu/coastnet/index.html
CoastNet, local schools water-quality monitoring program, some data for some estuaries

http://www.estuaries.org/
Restore America's Estuaries—working together to save our coastal heritage

http://www.abi.org
The Nature Conservancy's heritage sites

Sources of historical information about coastal ecosystems and resources

Aerial photos

USGS digital orthophotos and other products are available at http://www.mapping.usgs.gov. Black-and-white and color aerial photos of all coastal regions and watersheds are available from local sites, including government and private sources.

National Wetlands Inventory

NWI maps and data are available from the U.S. Fish and Wildlife Service and state wetlands agencies. Search the Web for "National Wetlands Inventory" or on your state wetland agency site. NWI maps provide a wealth of information, showing existing streams, rivers, lakes, freshwater wetlands, riparian wetlands, and estuarine wetlands. Selected physical alterations, such as dikes' preventing inundation of tidal wetlands, are also shown. Some of these alterations have significant restoration potential.

County soil surveys

Soil survey maps and soil descriptions help delineate the extent of former wetlands, and in tidally influenced areas, areas that might be subject to tidal inundation if dikes were removed or culverts installed or enlarged. These surveys are available from local soil and water conservation district offices or state Extension offices.

U.S. Coast Survey charts

Topographic surveys (T-sheets), hydrographic (bathymetric) surveys, and composite charts from the nineteenth and early twentieth centuries are available for some coastal areas. (Figure 2 is a sample for Oyster Bay, New York.) These maps, along with interpretation aids in government publications, provide surprisingly accurate geographic data showing pre-alteration conditions of tidal marshes, forested

swamps, and flats, as well as changes in channels and estuary volume caused by sedimentation.

Original Public Lands Survey records

In the nineteenth century, the General Land Office conducted a mile-by-mile public lands survey of much of the western United States, including coastal lowlands surrounding estuaries and upstream areas. These surveys used the familiar township-range system found on present USGS topographic maps. The old survey records are available from the Bureau of Land Management on microfiche. These records can be used to reconstruct habitats in and around estuaries and other areas. For restoration site planning, site-specific maps and survey notes can be quite useful in evaluating historical drainage patterns and vegetation.

U.S. Army Corps of Engineers navigation records

The Corps of Engineers has long been responsible for keeping estuaries and rivers navigable. They have dredged, built water-control structures, and cleared snags from river and estuary channels since the early 1800s. The Corps keeps excellent records, which have been used to help reconstruct former estuarine and river conditions. These records are generally available from the district headquarters of the Corps.

Hydrologic and water-quality records

A change in the amount or timing of freshwater inflow to estuaries changes the makeup of the stream, river, and estuarine ecosystem, altering physical characteristics and plant and animal communities. State water-resource agencies and the U.S. Geological Survey are good sources of hydrologic information, and most state water-quality agencies maintain good data on pollution of waterways. Only recent records are available, but they are important complements to historical habitat information from other sources.

Fisheries data and records

Compilations of fish catches and processing records are another useful source of data. Some data are available from the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries) and some from state fish and wildlife agencies. Still others are available in university libraries, where librarians can assist you.

Historical ground photos, written accounts, and local diking and drainage district records

Local records available from state and county historical societies are another good source of information. Local diking districts, map collections at university libraries, and local "oldtimers" are other useful sources.

CHAPTER EIGHT

Watershed Science

by Paul W. Adams and Derek Godwin

Watersheds are like a patchwork quilt over the landscape: they're made up of many pieces that fit together to make a whole. And because of their many connections, what happens on one patch can affect other pieces far away.

As your watershed group starts thinking about what it can do to effectively manage and restore portions of your watershed, don't bypass the important first step—understanding how watersheds work. Especially important are the watershed processes that affect how water, sediment, and other materials behave in an ever changing landscape.

A watershed provides a very useful setting for studying and understanding these processes. But what is a watershed and how is one identified? It's an area of land that collects rain and snow and discharges much of it to a stream, river, or other water body. The specific water body of concern is what defines the watershed. If the Columbia River is this water body, the watershed is an area of about 255,000 square miles, covering parts of seven states and two Canadian provinces.

Big watersheds such as the Columbia River basin are made up of lots of smaller watersheds. Some of these watersheds are near ridgetops and feed small streams that flow only part of the year. The ridgetop-to-riverbank perspective reminds us that almost any resource management practice or land use has the potential to affect water resources downstream. Likewise, the unique natural features (geology, soils, and so on) and processes of each watershed can directly influence water resources, as well as how human activities affect these resources.

Looking at both natural processes and human influences from a watershed perspective is vital for dealing with concerns such as declining fish stocks. Fish such as salmon and steelhead, for example, can be affected by ocean conditions, urbanization, agriculture, and forestry during their long, complex life cycle. Many different areas, landowners, and practices need to be involved to effectively manage such key resources. An understanding of watershed processes can help focus everyone's efforts.

In this chapter you'll learn

- The general pattern of water movement known as the hydrologic cycle
- Upland erosion
- Sediment transport and deposit in stream channels

Identifying Watersheds

In areas where bedrock is found within about 20 feet of the soil surface, visible terrain can be fairly reliable for identifying watershed boundaries. U.S. Geological Survey (USGS) *topographic maps* identify the ridges and other high points that separate one watershed from another. The map in figure 1 shows the boundary of a large watershed as well as the boundaries of some of the smaller tributary basins that make up the larger watershed.

USGS topographic maps are available for most areas in the U.S. You can get them from a variety of sources, including outdoor and sporting goods suppliers, bookstores, and college and university libraries. For mail orders, a catalog of USGS maps and information is available from

USGS Information Services
Box 25286, Federal Center
Denver, CO 80225
Phone: 1-800-USA-MAPS

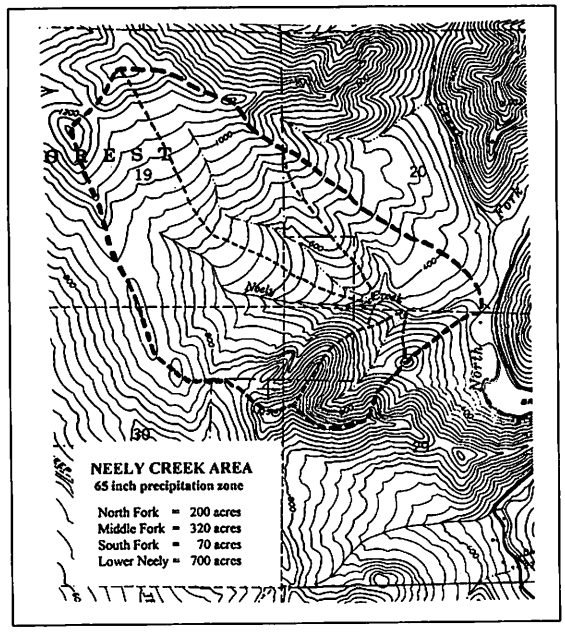

Figure 1. Precipitation zone map showing watershed boundaries (dashed lines).

The Hydrologic Cycle

To understand how watersheds behave, both naturally and under management, it's essential to understand the general pattern of water movement called the *hydrologic cycle*. Figure 2 highlights the key parts of the hydrologic cycle, which also are defined briefly below. Most are discussed in greater detail later in this chapter.

- *Precipitation*: Water from the atmosphere that reaches plants, the ground, or water bodies. Depending on local weather conditions, precipitation may be deposited in many forms, including rain, snow, sleet, hail, and condensation (dew, frost, etc.).

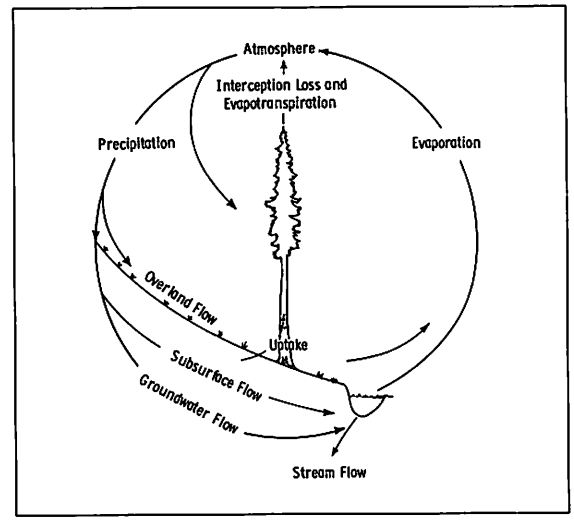

Figure 2. Forest hydrologic cycle. (Source: U.S. Forest Service)

- *Interception*: The action of plant surfaces catching precipitation that otherwise would reach the ground. Depending on local weather conditions and the plant canopy characteristics, intercepted precipitation may evaporate quickly, leaving less water to reach the ground and contribute to streamflow.
- *Overland flow* or *surface runoff*: Water from precipitation that moves over the ground surface.
- *Subsurface* and *groundwater flow*: Water that flows through the soil and underground rock crevices.
- *Transpiration*: The uptake of soil water by plants and its evaporation to the atmosphere through leaves and other plant surfaces.
- *Evapotranspiration*: The loss of water to the atmosphere by the combined effects of interception, transpiration, and direct evaporation from ground surfaces and water bodies.

Precipitation

Precipitation is the single most important influence on the flows in rural streams. The type and amount of precipitation in most areas vary widely by location, season, and year. In addition to rain and snow, "fog drip" from trees or other plants can contribute significant amounts of water to soils and streams in areas where heavy fog is common.

Precipitation usually is measured with a device called a *gauge* that has a funnel or other opening to collect water falling from the open sky. As precipitation accumulates in the gauge, its depth is measured in inches. Some mechanical or electronic gauges monitor precipitation continuously. Others use simple containers that a person checks manually at regular intervals, such as 24 hours or a week.

Although snow depths often are reported in inches, for hydrology it's more important to know the amount of water that will melt from the snow. The rule of thumb that one foot of snow contains one inch of water is a very rough average, and actual water amounts can be much more or less. The effort it takes to shovel snow by hand is good proof of how much the water content of snow can vary.

Newspapers and television often refer to "normal" or "average" precipitation levels. These reports can give the mistaken impression that it is unusual to see much more or less precipitation than "normal." Instead, we should expect precipitation to be significantly above or below normal every few years. For example, the long-term precipitation average for Estacada, Oregon, is 60 inches. Records show, however, that over a 10-year period we should expect at least 4 years with total annual precipitation at least 8 inches above or below average.

Within a given region or even an individual watershed, precipitation differences can be dramatic. One key factor is elevation. Generally, as elevation increases, so does the amount of rain or snow.

Another major influence is the local terrain as it relates to the direction that storms typically travel. In Oregon, storms

often move from west to east, and so more rain or snow usually falls on west-facing slopes.

An annual precipitation map for Oregon has been published by the office of the state climatologist at Oregon State University. Part of this map is reproduced in figure 3. Each line on the map intersects locations that are expected to have the same annual precipitation. Each adjacent line represents a five-inch increase or decrease in precipitation. The amount of precipitation for locations falling between two lines can be estimated as something between the amounts represented by the surrounding lines.

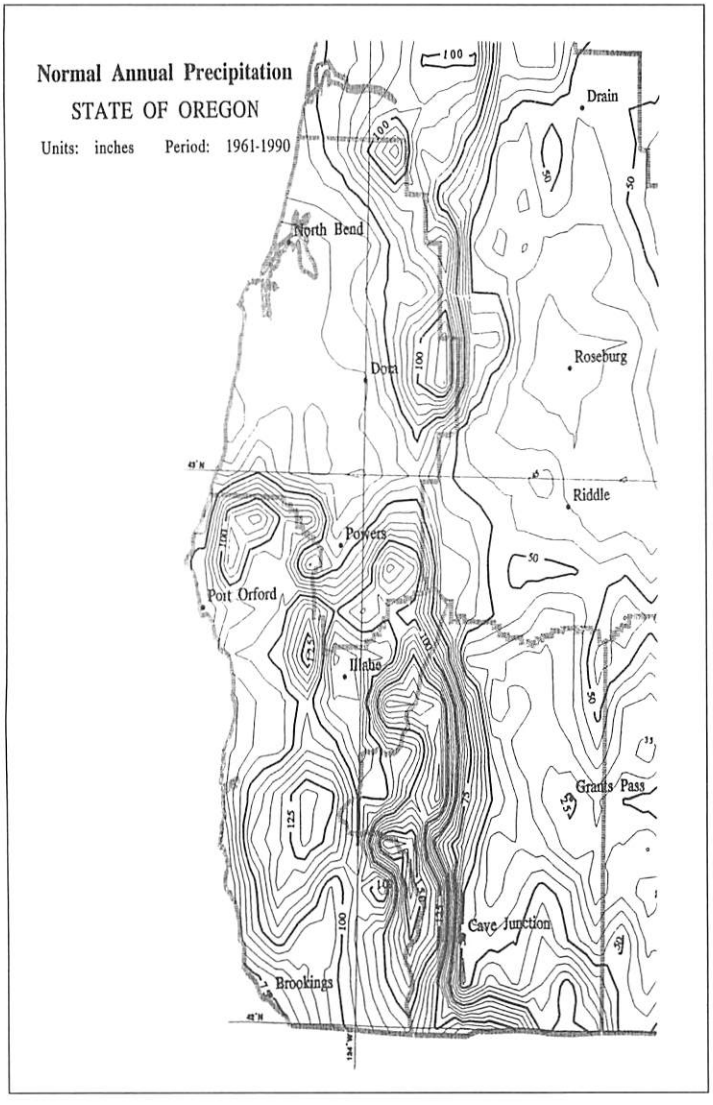

Figure 3. Normal annual precipitation for Oregon.

Precipitation records and maps typically are based on gauges located at low elevations near major communities. Although useful for general purposes, these records and maps may not provide a very accurate picture of precipitation in small, rural forest watersheds. With careful installation and monitoring, it's possible to collect local precipitation data to see how well they compare with records from nearby weather stations.

Vegetation, soils, and streamflows

Vegetation can have a strong effect on the amount of water available for streamflow. First, when rain or snow falls on the canopy of trees and other plants, some of this water is *intercepted* and evaporates before reaching the soil. Evaporation is especially likely when periods of light rain alternate with dry periods.

Second, water that does reach the soil can be taken up by plant roots before it has a chance to move to the deeper soil layers that contribute to streamflow. In this process, called *transpiration*, water moves from the roots to other plant tissues and eventually to the leaves, where it evaporates from small pores. The loss of water to the atmosphere by the combined effects of canopy interception, transpiration, and direct evaporation from soil surfaces and water bodies is called *evapotranspiration*.

This water loss can be considerable. For example, in western Oregon forests, evapotranspiration losses can equal about one-quarter to one-half the total annual precipitation. In an upland forested area where 56 inches of precipitation falls annually, about 20 inches of that water returns to the atmosphere before it reaches deep soil layers or adds to streamflow. Large amounts of deep storage are uncommon in upland terrain in Oregon, so it's reasonable to expect most of the remaining 36 inches to contribute to streamflow.

The calculations below for a 320-acre forest watershed (1 acre = 43,560 square feet) show the total and average streamflows expected from 36 inches of water over a year.

3 ft (36 inches) x 13,939,200 sq ft (320 acres) = 41,817,600 cu ft total annual flow

Average daily flow = 41,817,600 cu ft ÷ 365 days = 114,569 cu ft

Average instant flow = 114,569 cu ft ÷ 86,400 seconds per day = 1.33 cu ft per sec (cfs)

Ground surface and soil characteristics also play an important role in how precipitation affects streamflow. Surface conditions determine whether water moves into or over the ground. On most forest soils, even the water from very heavy storms is absorbed. However, where soils are exposed or compacted, or in lower areas with saturated soils, precipitation water may move over the ground as surface runoff that quickly adds to streamflow.

Soil depth and ability to store water also influence streamflow. Moisture storage in soil layers near the surface can affect how much precipitation water is lost by transpiration. Where soil water storage is limited by bedrock within 5 to 10 feet of the surface, precipitation water can move fairly quickly to streams. As a result, streamflows respond to individual storms in a "flashy" manner (rising and falling quickly). The stream *hydrograph* (a graph of changing streamflow over time) in figure 4 shows this type of response.

As an example, table 1 lists the soil types on the watershed that supplies much of the municipal water for Corvallis, Oregon, as well as soil characteristics that can affect water in this area. Note that most of the soils in this area are well drained and moderately deep, yet

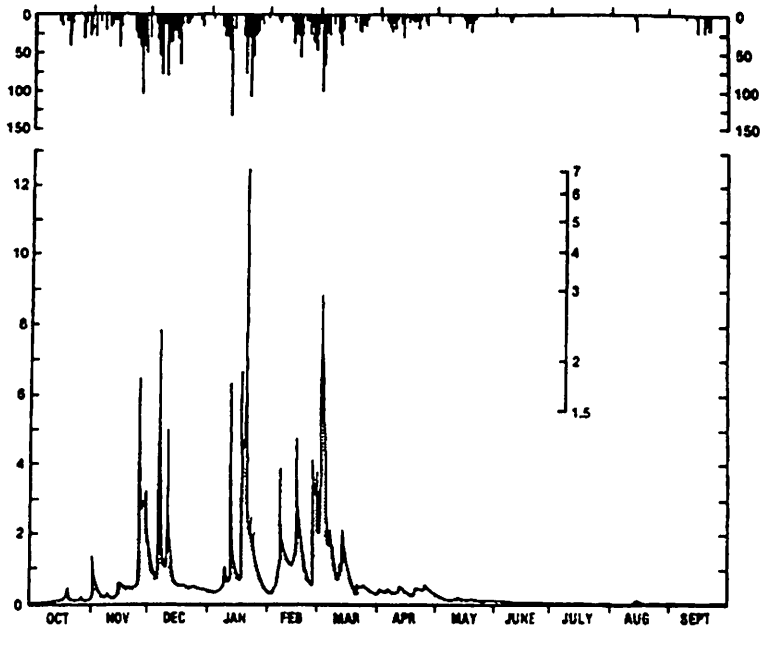

Figure 4. Hydrograph showing daily precipitation and instantaneous streamflow for a forested watershed in the Oregon Cascades, 1972 water year.

Table 1. Corvallis municipal watershed-Marys Peak area soil hydrology information (Benton County Soil Survey).

Soil type	Surface permeability (in/hr)	Depth to bedrock (in)	Depth to water table (in)	Runoff potential
Abiqua	0.6–2.0	>40	>40	high
Apt	0.6–2.0	>60	>60	high
Blachly	0.6–2.0	>60	>60	high
Bohannon	2.0–6.0	20–40	>60	high
Honeygrove	0.6–2.0	>60	>60	high
Jory	0.6–2.0	>40	>60	high
Kilchis	2.0–6.0	12–20	>60	very high
Klickitat	0.6–2.0	40–50	>60	high
Marty	0.2–0.6	>60	>60	moderate
Mulkey	2.0–6.0	20–40	>60	high
Ritner-Price	0.6–2.0	30–60	>60	high
Slickrock	0.6–2.0	>40	>60	moderate
Witham	0.06	40	12–30	very high

during wet weather they can generate considerable runoff. Note also that one soil (Witham) can be expected to have a shallow *water table* (a layer of saturated soil) during the winter and early spring. You can find similar information on soils in your area by checking your county soil survey, which often is available in local libraries or from the USDA Natural Resources Conservation Service.

Extreme events

Extreme events are periods of very high or very low precipitation or streamflow that may create problems for people, soil, and water. If you have some idea of the size and likelihood of extreme events that can occur in a watershed, you can take more effective steps to prevent or reduce the problems they might cause. For example, you could install a larger road culvert or put large rocks along part of a stream channel to prevent a washout or bank erosion.

One way to identify what might be expected in a given watershed is to look at past precipitation or flow records. Where long-term records are available, it's possible to estimate such events as the "50-year flow" or the "two-year, one-hour peak rainfall." The 50-year flow is the streamflow level that, on average, is likely to occur about once every 50 years. The two-year, one-hour peak rainfall is the maximum total rain for a one-hour period that is likely to fall once every two years.

Another way to look at an extreme event is the probability or likelihood that it will happen. In the case of a 25-year flow, there is a 1 in 25 (or 4 percent) chance that it will occur in any given year. However, it's important to know that for any given 25-year period, a 25-year event may occur once,

several times, or not at all. This is because these *return intervals* are simply averages. From year to year, large storms or droughts occur in a fairly random pattern, although some climate cycles (for example, El Niño) are becoming better understood and more predictable.

Table 2 shows the peak flow levels expected for several different return intervals for Flynn Creek, a small stream that drains a 500-acre forested watershed in the Oregon Coast Range. The flows are estimated from long-term streamflow records for Flynn Creek.

The streamflows in table 2 are shown in their most common measurement units—cubic feet per second, or *cfs*. Note that flow levels do not increase in direct proportion to the return interval. That is, the 10-year peak flow is not twice as large as the 5-year peak flow, and the 50-year peak flow is not five times as large as the 10-year peak flow.

Table 3 shows the estimated one-hour peak precipitation amounts for the Oregon Coast Range, based on historical records. By comparing these figures with the local *infiltration* characteristics of the soil (that is, the rate that a given volume of water can move into the soil surface), we can determine whether rain that falls during these heavy storms is likely to be absorbed by the soil or will become surface runoff. This distinction can be important because surface runoff can lead to erosion or add to peak streamflows.

Surface soil *permeability* represents how much water can be absorbed by the soil in an hour. The values in table 1, which are as low as 0.06 inches per hour, show how it's possible for peak rainfall to be greater than the rate the mineral soil can absorb. However, these values do not include the effect of the highly absorbent *duff layer* (accumulated organic debris such as fallen leaves) that usually is found on top of the mineral soil in forests. Thus, surface runoff is rare on these lands unless significant areas of mineral soil are exposed or compacted.

Table 2. Flynn Creek peak flows.

Return interval (years)	Stream flow (cu ft per sec)
2	73
5	111
10	153
25	234
50	321

Table 3. Peak precipitation, Oregon Coast Range.

Return interval (years)	1-hour maximum precipitation (in)
2	0.6
5	0.8
10	0.9
25	1.1

Upland Processes

Important links between uplands and streams can be found in every watershed. Stream hydrology and channel characteristics, for example, often reflect things that happen on the surrounding uplands. These upland processes and events may be obvious or subtle, but they can be very important to stream characteristics, both locally and a long way downstream. Chapter 10 discusses evaluation and enhancement of upland areas.

Erosion is one of the most important upland processes because it helps contour landscapes, determine how trees and plants grow, and shape streams. For example, the erosion of topsoil in mountain terrain can limit plant growth, but deposits of these rich sediments can make floodplains and other lowland locations among our most productive sites. Similarly, heavy erosion and sedimentation can harm fish, but spawning gravels originate from erosion, and seasonal increases in fine sediment in stream water help salmon determine when and where to spawn.

Erosion is a natural, ongoing process, but erosion types and rates vary widely with local climate, soils, terrain, and vegetation (figure 5). Erosion often increases during periods of unusually heavy rainfall or rapid snowmelt. Human activity can increase erosion to levels that cause problems for upland and aquatic systems, and controlling such erosion often is a primary objective of watershed management and restoration.

Surface erosion is the movement of individual soil particles, usually by water flowing over exposed soil surfaces. If rainfall or snowmelt exceeds the local soil infiltration rates, surface erosion can occur, especially on steep slopes where runoff water can develop more erosive energy.

Some soil types are more susceptible to surface erosion than others, usually because they have low infiltration rates or the individual soil particles are easily detached and moved. Most forest soils in the Pacific Northwest have fairly low surface-erosion rates, especially when the duff layer is maintained and infiltration remains high.

Mass movement refers to landslides and other types of downhill movement of large masses of soil and related material (for example, rocks and woody debris). Mass movement is a very important process in many areas of the Pacific Northwest, including the steep terrain of the Coast and Cascade Ranges. Mass movements can be

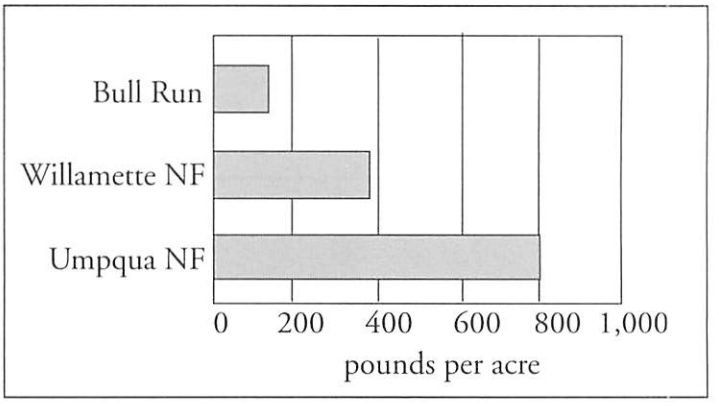

Figure 5. Average annual erosion, undisturbed forests.

rapid and dramatic or very slow and subtle (figure 6).

Debris avalanches, or *slides,* are shallow, rapid mass movements that are most common in steep, upland areas with thin soils over bedrock. If debris avalanches or slides reach a stream channel, they may become very fluid and change to a *debris flow* (sometimes also called a *debris torrent*). These flows can scour extensive lengths of stream channels, but they also can deposit a lot of sediment and other debris where they stop.

In areas of deep, fine-textured soils, large, slow, mass movements such as *slumps* and *earthflows* can occur. They may move only inches per year, and clues of movement may not be very obvious (for example, leaning trees or soil cracks). Like the other types of mass movements, they can be important sources of sediment and debris in streams.

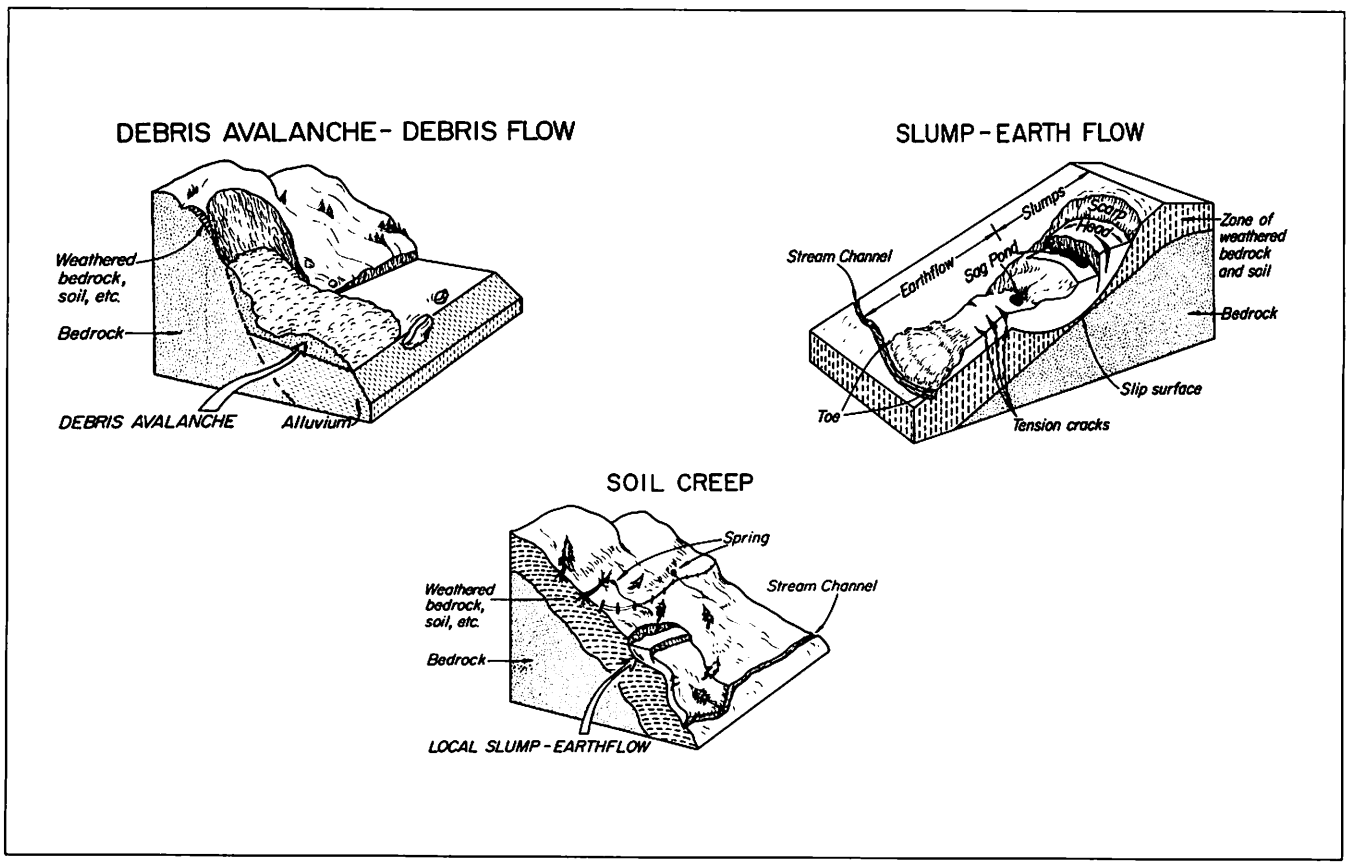

Figure 6. Types of mass movement.

Stream Channels

There are many different kinds of stream channels, and an understanding of their characteristics and behavior can be very useful in watershed management. For example, the kinds of stream restoration and enhancement needed can vary widely among different channel features and types. Channel processes are an especially important consideration, because many channels are active and changing. When enhancement practices and channel dynamics are not carefully matched, the result may be little or no benefit or even worsened conditions.

Stream order

Stream order is a useful way to classify streams because within a given climatic and geologic region, certain stream orders tend to share many features and processes. The most common stream order classification system is to call the initial channel where a small stream first appears a *first-order stream* and then to increase the order with each successive downstream junction with a stream of equal or higher order. Thus, small streams have low-order numbers, while large streams and rivers have high-order numbers (figure 7).

Major channel features and types

In low areas with little slope, where valleys have formed or broadened, both large and small streams may have *floodplains, levees,* and *terraces* that can interact with the stream (figure 8). These areas also have soil conditions, vegetation, and other important features that can be different from the nearby steeper uplands.

The shape and movement of a stream channel may be *confined* (the term

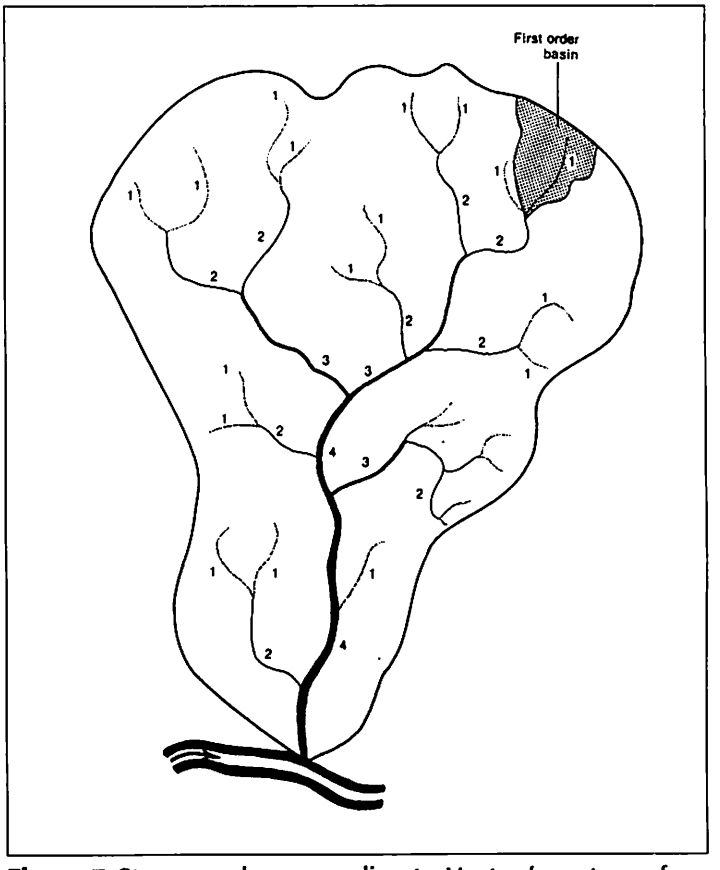

Figure 7. Stream orders according to Horton's system of classification. (Source: *Principles of Forest Hydrology,* J. D. Hewlett, 1982.) Reprinted by permission of the publisher.

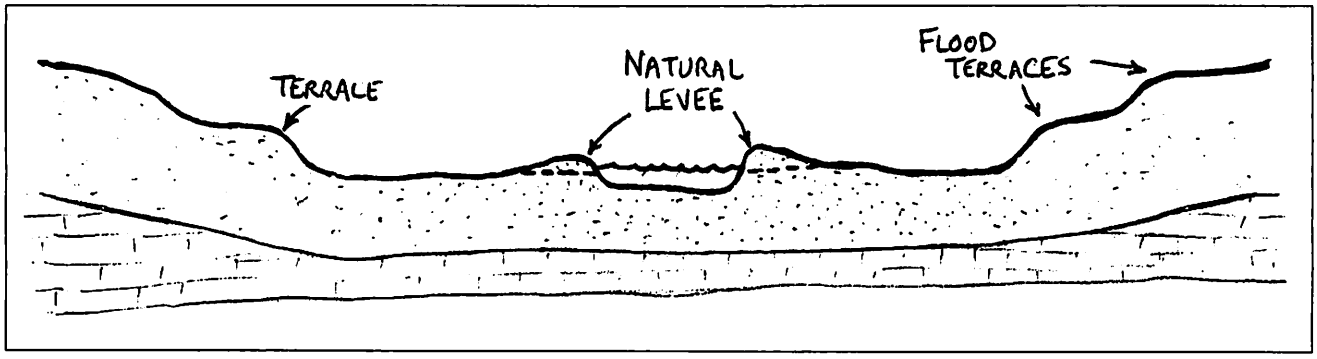

Figure 8. Terraces and levees.

constrained also is used) by resistant bedrock or large boulders. On the other hand, where streams are found in deep soils, gravels, and other easily moved material, channels may migrate or become *braided* (that is, form secondary or smaller side channels), especially as flows change. Stream migration in unconstrained settings also often results in greater stream *sinuosity*, which is the winding or snakelike pattern of a stream. Figure 9 illustrates different channel types.

Stream channel processes

Most streams, especially those in soil and other loose material, have areas of active *channel erosion* and *sediment deposition* (figure 10). The terms *degradation* and *aggradation* are also sometimes used to describe channel erosion and deposition processes. It's easy to see erosion on stream banks, especially during high flows. Erosion of stream bed materials also can be important but less obvious. Areas of sediment deposition are common in most

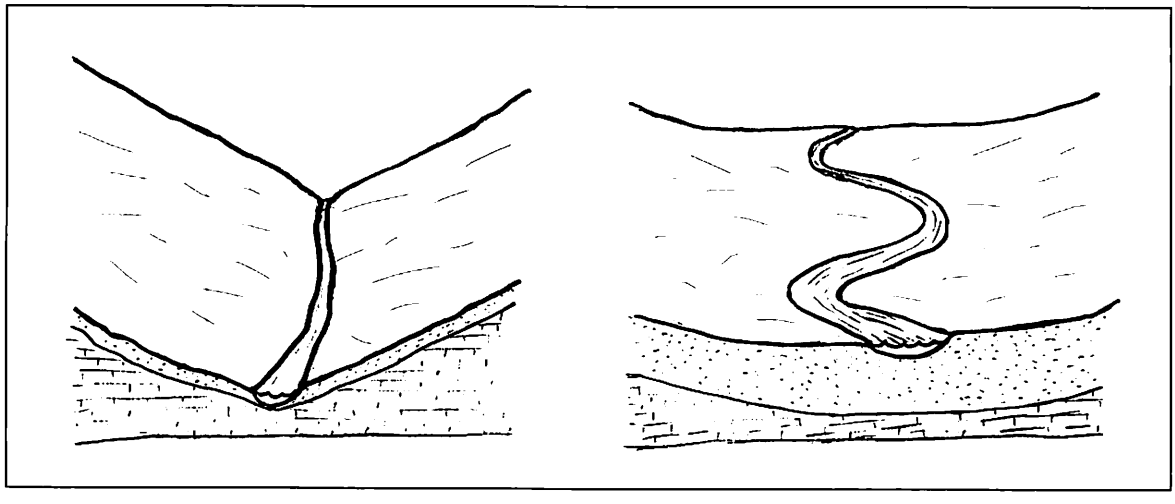

Figure 9. Channel types.

streams and may be found even near eroded areas.

Channel slope *steepness* (or *gradient*) and *sediment particle size* are important factors that can control erosion and deposition in streams. Fast-moving water in steep streams can promote channel erosion, whereas slow-moving water in more level areas can allow eroded sediments to be deposited.

Faster water also allows coarser channel materials to erode and move some distance. When fine sediments (for example, clays) erode, even slow-moving water can carry them long distances. Eroded sediments can be deposited in the stream channel wherever flows become slower, such as the inside of channel bends or where a stream becomes significantly wider (for example, unconfined by surrounding terrain) or less steep. Gravel or sand bars are a common type of such deposits.

Levees, terraces, and deltas often form near larger (high-order) streams and rivers in wide, level areas where water has deposited sediment during high flows. Their location and landform often lead to unique soil and vegetation conditions that may be important to consider in watershed restoration and enhancement projects.

The dynamic and interacting processes of channel erosion and deposition can extend over long distances and can be linked to the upland processes described earlier. The success of watershed restoration and enhancement projects may depend on your understanding of these processes and linkages.

Summary

Watersheds are very dynamic, and certain processes are particularly important in both the characteristics and management of watersheds. Several key processes and related

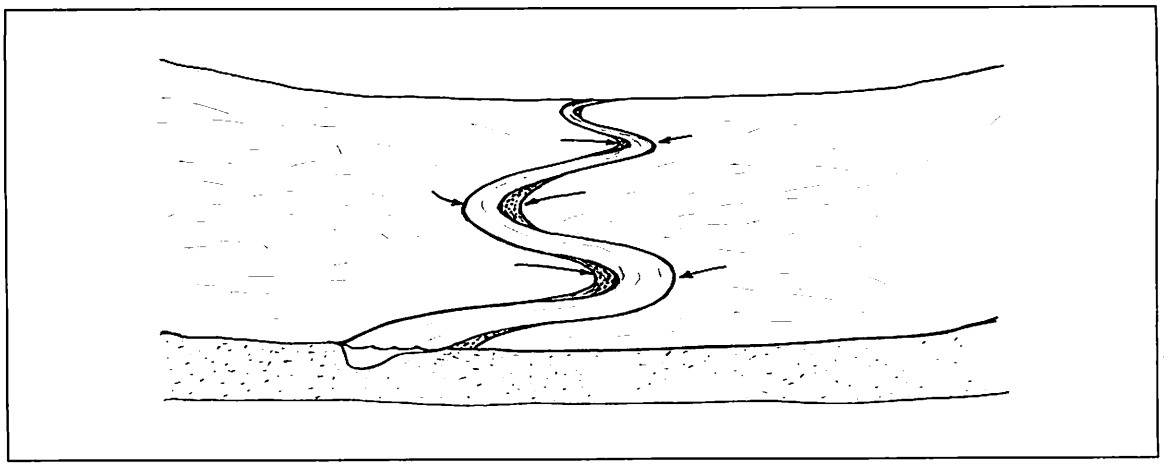

Figure 10. Examples of erosion and deposition.

concepts can help you better understand watershed features, behavior, and response to management practices:

- Location is the most fundamental watershed characteristic, and its identification is the first step to understanding key watershed features and behavior. Topographic maps provide a simple, useful tool for locating general watershed boundaries.
- Hydrologic cycle components such as precipitation (that is, type, amount, and distribution) have a major influence on important upland and stream characteristics. Soils and vegetation play a primary role in water storage, release, and evapotranspiration loss. Published precipitation, soil, and streamflow data are helpful resources, but you might need to collect local data to better understand your watershed.
- Most major natural and management-related watershed impacts occur during extreme events of precipitation and streamflow. Understanding and planning for such events are essential for effective watershed management and restoration.
- Upland processes of erosion are a key link between land and stream. Surface erosion and mass movements are especially important influences on sediment and debris in streams.

Stream channel features and processes vary widely within and among watersheds. Characteristics such as channel slope, confinement, and bed and bank materials can have strong effects on channel stability and responses to management.

Resources

Training

Regular public training specifically on watershed processes is not widely available outside of formal university classes, although some basics could be reviewed as part of short courses and seminars offered by various organizations. You can learn about available training opportunities by maintaining good communication with government agencies and other groups. In addition, many textbooks and other references are available (see list at the right) if you're interested in self instruction.

Information

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CHAPTER NINE

Assessment and Monitoring Decisions

by Paul W. Adams

"We should do some monitoring" is a common response when concerns are expressed about local watershed conditions or resources. But you need to consider many issues before acting on this idea. There's a long list of potentially useful watershed characteristics that can be assessed, and an even longer list of ways to assess them. Without some careful planning, you may waste a lot of time, energy, and money.

You can use monitoring both to identify watershed enhancement opportunities and to evaluate results of enhancement activities. Monitoring can be very challenging, however, because regardless of location within a watershed (stream, riparian area, wetland, or upland), there are many conditions that can be measured. Furthermore, these conditions vary a lot, depending on time, location, and management approaches.

Simply put, you may need to take many careful measurements to understand a situation. Usually, there are few shortcuts to a well-designed watershed evaluation or monitoring plan.

Many formal watershed assessments and resource monitoring programs have been or soon will be conducted under a variety of public and private initiatives. Detailed guidelines and technical assistance on these activities are available from many organizations, including state departments of fish and wildlife, state forestry departments, and the United States Department of Agriculture Forest Service.

This chapter simply provides a general overview of some important considerations when undertaking nearly any type of watershed evaluation or monitoring effort. It will serve as a foundation for your work with specific projects as discussed in other chapters in this section.

In this chapter you'll learn

- The need for clear objectives and terminology for evaluation and monitoring
- Why careful sampling and analysis are essential for accurate assessments
- Different approaches for comparing watershed practices and conditions
- The elements of a good watershed plan
- The steps in putting together and implementing a good watershed plan, project by project

Planning Assessment and Monitoring Projects

Perhaps the most important first step is to ask, "What's the objective of our evaluation or monitoring effort?" Often, the objective is to answer one or more basic questions about the condition of a watershed resource or the effects of a management activity or enhancement project.

The challenge is to ask a question that is broad enough to have a useful answer, yet specific enough to keep the time and expense of data collection and analysis reasonable. "Is the stream quality good?" is a question that is phrased much too simply to help direct an assessment project. The following questions, while still broad, get closer to striking the right balance between usefulness and feasibility:

- What is the current dissolved oxygen level of this stream?
- Do the temperature levels of this stream meet regulatory or other desired standards?
- Are levels of chemical contaminants in this stream declining or increasing over time?
- Does this new or different farm or forest practice reduce or prevent erosion or sedimentation?
- Has this stream restoration or enhancement practice produced better fish habitat?

Another useful step is to consider some of the major types of evaluation and monitoring projects. If you understand project types and use standard terminology to talk about them, you'll improve planning and eliminate confusion about the nature and objectives of your evaluation and monitoring projects.

The following list of monitoring categories was modified from a U.S. Environmental Protection Agency publication, *Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska.* (See the "Resources" section.)

- *Baseline* assessments establish a reference point for measured conditions. You then can compare this baseline measurement to measurements taken at different times or locations.
- *Trend* monitoring repeats measurements over time and compares them to a baseline measurement to see whether a pattern emerges (for example, an increase, a decrease, or a cycle).
- *Implementation* monitoring determines whether an activity such as a watershed enhancement project is being carried out as planned.
- *Effectiveness* monitoring often follows implementation monitoring to see whether an activity produces the desired results or benefits.
- *Compliance* monitoring is similar to implementation monitoring, but usually assesses whether an activity meets legal or other administrative requirements.
- *Impact* monitoring is similar to effectiveness monitoring but typically is used to determine whether a resource use or management activity has negative impacts.

- *Validation* monitoring usually refers to measurements that are designed to see whether a mathematical model or other prediction tool provides accurate results or should be improved or used differently.

Looking at this list, you can see that, in some cases, you may need to do more than one type of evaluation and monitoring to meet a general objective or information need.

Sampling and Statistical Considerations

It's impossible to evaluate and monitor everything everywhere in a watershed, so you'll need to decide what, how, when, where, and how often to take measurements. The following discussion of some of the issues involved with assessing suspended sediment levels in a stream will give you an idea of the complexity of these decisions. Similar concerns arise when you evaluate nearly any other watershed characteristic (for example, fish habitat, stream shading, or soil infiltration), especially when you want to determine how management activities might affect these factors.

For most evaluation or monitoring efforts, such as an assessment of suspended sediment levels, you'll need to meet the following general objectives:

- The samples or measurement points should accurately represent the larger area to be assessed (for example, a stream). In other words, you need *good sampling design and technique.*
- There should be no changes or confusion in the samples or measurement data that might affect the results. Thus, you need *proper sample and data handling.*
- The sample and data analyses should accurately assess the characteristic of interest, so you need *good analytical procedures and statistical methods.*

With these things in mind, how can you sample a stream for sediment? One common way is to take "grab" samples, that is, stand in the stream and collect a sample in a bottle or jar.

But how well does such a sample represent all of the sediment carried by the stream? Suspended sediment isn't carried uniformly across the width and depth of a stream. For example, coarse materials such as sand and gravel usually are carried closer to the stream bottom. Thus, samples taken only near the surface might not accurately represent total sediment levels. Specialized equipment is available for sampling coarser sediments, but such equipment adds to the cost of assessment.

Another issue is the number of samples needed. All watershed characteristics vary over space and time, some tremendously. How can you be sure you've taken enough samples to understand and account for this variability?

One approach is to take a preliminary set of samples and use a statistical analysis to see whether more samples are needed. Such a *pilot study* not only can help determine the number of samples needed, but also can identify other concerns, such as equipment needs, personnel needs, or limitations of the sample design (for example, specific locations or extremely high variability that requires more intensive sampling).

The following equation often is used to assess sample size in this approach:

$$n = \frac{t^2 s^2}{p^2}$$

The symbols in this equation mean the following:

- n is the number of samples needed to precisely estimate the mean value of a measurement with a desired level of confidence.
- t is the "student's t value" for the desired level of confidence (for example, a 95 percent probability of obtaining a precise estimate). This value is available in most statistics textbooks.
- s^2 is the variance of preliminary sample set or variance expected from other sampling experience.
- p is the desired precision of the estimate (how close you want your estimate to be to the true value—for example, +/-5 percent).

To use this procedure, it helps to have some familiarity with statistical analysis and a calculator with statistical functions. Even if you don't, however, it's important to appreciate that this type of analysis can show how difficult and costly it may be to provide clear and reliable answers to questions about watershed conditions and management effects.

For example, table 1 shows the results of an analysis to find out how many stream water samples are needed to accurately identify a 10 percent increase in sediment levels. The reason so many samples are needed is that sediment in individual samples varies a good deal with time and streamflows.

The effect of streamflow on suspended sediment, as well as on many other stream characteristics, often is substantial and complex. As a result, it may be difficult to sample a stream at the right time or often enough to accurately characterize its condition.

Table 1. Samples needed to detect 10% increase in sediment concentration (small forest stream—Oregon Coast Range).

Stream flows (cfs)	Samples required
0.0–1.5	7,968
1.5–2.2	1,947
2.2–5.0	3,253
5.0–25	3,493
>25	51

(Adapted from "Sampling water quality to determine the impact of land use on small streams," by R. M. Rice, R. Thomas, and G. Brown, unpublished paper, presented at ASCE Watershed Management Symposium, Utah State University, 1975.)

Figure 1 shows how suspended sediment levels in a stream in the Oregon Coast Range change as streamflow rises and falls in response to a winter storm. Note that for the same streamflows, suspended sediment level can vary a lot, depending on whether the stream is rising or falling.

This type of complex water-quality response to flow changes is why researchers sometimes use automated samplers to take many samples during storms. Not surprisingly, it can cost a lot to purchase and maintain this equipment.

Potential *errors* or *biases* in sampling or measurement methods are another vital concern in evaluation and monitoring. Such problems result in measurements that differ from the true values. These erroneous measurements in turn can yield unclear, exaggerated, or wrong observations or conclusions.

Using grab samples to assess water quality is an example of a method that can introduce errors. For example, the types or amounts of material collected by grab samples may not accurately represent the sediment that a stream actually carries.

A common source of sampling bias in natural resource measurements is the tendency for people to work in locations that are more accessible and easier to move around in. Carefully designed sampling schemes can reduce such bias, but they don't always overcome the physical challenges of working in difficult areas such as dense, rugged riparian zones or large, complex streams.

For example, a random number table can be used to identify numbered plots for *random* sampling; a grid with consistent, fixed distances between sample points can be used for *systematic* sampling; grouping sample plots in areas with similar conditions (for example, soil type, slope, cover, or habitat type) is an approach for *stratified* sampling. Keep in mind that if you can't achieve the fundamental assumptions on which statistical procedures are based (for example, use of truly random or systematic samples), your results or their interpretation may be invalidated or seriously questioned.

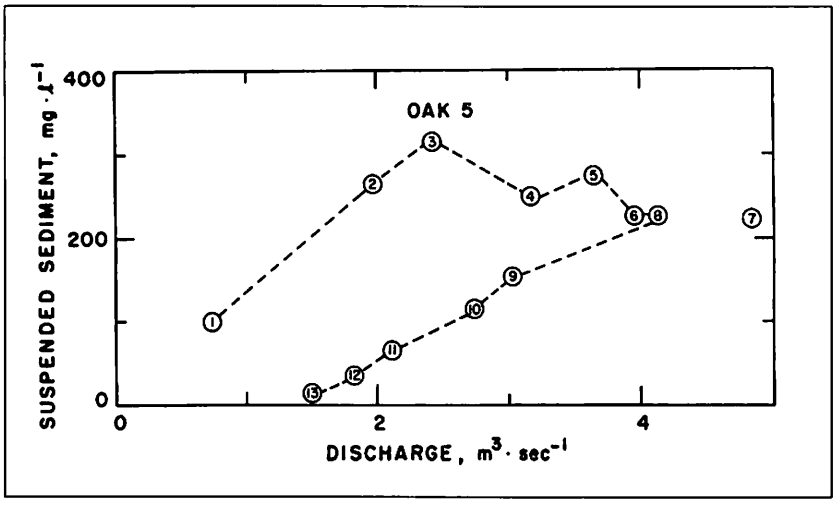

Figure 1. Suspended sediment levels and streamflows for a small Oregon Coast Range stream.

Equipment errors also are common in watershed measurements. The most reliable and accurate equipment can be very costly to purchase and maintain; thus, older or less expensive equipment is often used. Such equipment can provide useful data and information, but you may need to verify or calibrate these measurements against those taken with better equipment to ensure that your measurements are accurate and usable. *Calibration* often involves further calculations to carefully define the relationship between similar measurements collected with different equipment.

If you send samples to a laboratory for analysis, you may run into two additional kinds of errors—sample handling and storage errors, and lab measurement errors. To identify such problems, you can take additional test and control samples and handle and analyze them in the same or different ways.

Test samples are collected normally, but are used specifically to check handling and analytical procedures. *Control* samples contain known amounts of the material or other characteristic being evaluated (for example, a water sample that is "spiked" with a carefully measured amount of nitrate) and also are used to verify procedures.

If you use commercial laboratories, ask about quality-control procedures or professional certification. These labs can also provide information about expected measurement errors for their analytical procedures and equipment.

Comparison Studies

A common objective of evaluation or monitoring projects is to make a comparison. For example, you might want to identify the effects of different management practices or see whether resource characteristics change over time.

You can use several approaches to make such comparisons. Each method has advantages and disadvantages.

For example, you might want to evaluate changes or differences in water quality or fish habitat related to a management practice such as adding a riparian buffer next to a subdivision or agricultural field. To do so, you might make *upstream vs. downstream* comparisons. That is, you could compare measurements taken from stream locations immediately upstream and downstream of a stream reach where the particular practice is used (figure 2).

Another approach is the *paired watershed* comparison. This method compares conditions such as water quality or habitat features in two nearby watersheds (figure 3).

For either the upstream vs. downstream or paired watershed approach to provide accurate and useful comparisons, you need to be sure that site differences (other than the management practice of interest) between the compared areas have little or no effect on the conditions being studied. If they do have an effect, you need to be able to account for this effect and clearly separate it from the management effect.

It can be very difficult to distinguish between the effects of management and other factors because no two streams or

stream reaches are exactly alike. There are always differences in flow, gradient, substrate, or morphology, for example. One way to deal with differences between sites is to use *replicate* comparisons, which means to compare various locations to see whether any effects caused by management occur in a consistent pattern.

A third approach is the *before and after* comparison. This approach requires that site characteristics such as local climate patterns that might affect the condition being measured be very similar before and after the treatment or change of interest is implemented. Also, to use this method, you need to be sure to establish an accurate *baseline* condition to use in the comparison. As suggested by the discussion of suspended sediment measurements, it can be very challenging to identify what is "normal," given the degree to which measurements can vary as a result of changing background conditions such as streamflow.

Regardless of which comparison approach you use, consistent methods and good record keeping are essential. Different sampling procedures, tools, or field crews can produce different results that might render a comparison unclear, inaccurate, or invalid. Similar weaknesses can result from poor record keeping. Both of these requirements are especially important when you make the substantial investments needed for useful long-term comparisons.

Finally, keep in mind that although well-designed comparison studies can help identify management effects or resource trends, without further study it can be difficult to determine the specific cause of an observed difference or trend. And, without some caution, it can be easy to reach a wrong conclusion.

For example, if stream sediment or temperature varies between the upper and

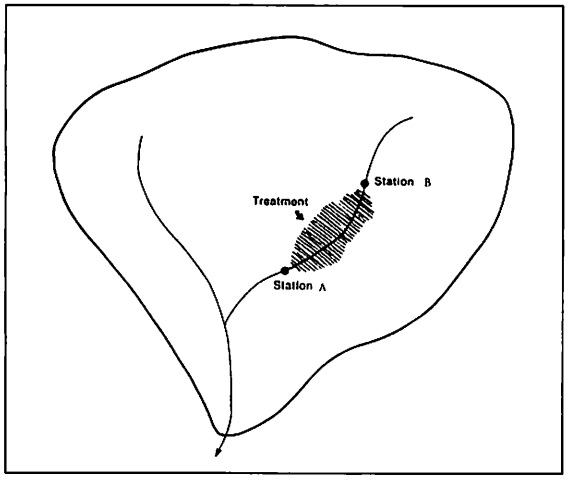

Figure 2. An upstream-downstream comparison looks at measurements taken from stream locations immediately upstream and downstream of a stream reach where a particular practice is used.

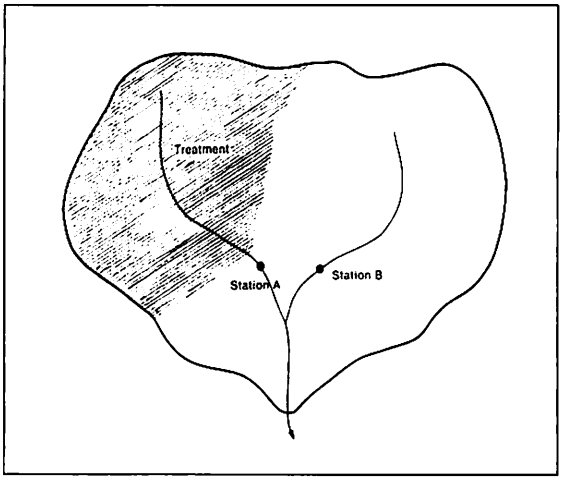

Figure 3. A paired watershed comparison looks at conditions in two nearby watersheds.

lower points of a stream reach where a land management enhancement practice occurs, it's tempting to credit the management practice with causing the difference. Until such key factors as local channel features or cool seepage are carefully accounted for, however, the influence of the activity remains uncertain. Thus, an important question to try to answer is, "Is this a case of cause and effect, or guilt by association?"

Summary

Watershed evaluation and monitoring can be very challenging because of the time and effort often needed to provide accurate and useful information for resource management. Careful project planning begins with defining the primary evaluation and monitoring objectives and approaches. Identifying procedures for effective sample and data collection, handling, and analysis is especially important. Giving close attention to these key considerations in watershed evaluation and monitoring can help ensure that your observations and conclusions are accurate and correct. Whenever possible, avoid taking shortcuts that can lead to poor information.

Resources

Training

Universities and government organizations occasionally offer short courses on topics related to watershed evaluation and monitoring. Training programs are also offered by various nonprofit and private organizations, including consultants. If you're interested in self instruction, consider the publications below.

Information

"How to study a stream," by N. D. Gordon et al. In *Stream Hydrology—An Introduction for Ecologists* (New York: John Wiley & Sons, 1992).

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, by L. H. MacDonald et al. EPA 910/9-91-001, (U.S. Environmental Protection Agency, 1991). Available from the U.S. EPA, Region 10, NPS Section, WD-139, 1200 Sixth Ave., Seattle, WA 98101. Also available on the Web at http://www.epa.gov/cincl/

Oregon Watershed Assessment Manual (Salem: Oregon Watershed Enhancement Board, 1998). Available from OWEB, 775 Summer St. NE, Suite 360, Salem, OR 97301-1290, or at http://www.watershednet.com/oweb.htm

"Reliability of water analysis kits," by C. E. Boyd. In *Transactions of the American Fisheries Society* 109:239–243 (1980).

Volunteer Water Monitoring: A Guide for State Managers. EPA 440/4-90-010 (U.S. Environmental Protection Agency, 1990). Available from U.S. EPA, Office of Water, Washington, D.C. Also available on the Web at http://www.epa.gov/cincl/

Water Quality Monitoring Programs, by S. L. Ponce. Technical Paper WSDG-TP-00002 (Fort Collins, CO: Watershed Systems Development Group, USDA Forest Service, 1980).

Wildland Water Quality Sampling and Analysis, by J. D. Stednick (San Diego: Academic Press, 1991).

Case Study

St. Joseph's Academy's Wetlands Stewardship Project at Alligator Bayou, Prairieville, Louisiana

by M. Liffmann and P. Blanchard

The Problem

Alligator Bayou, located in Prairieville, Louisiana, is a pristine wetland environment that epitomizes the typical Louisiana swamp. A part of the larger Spanish Lake watershed, Alligator Bayou boasts herons, cypress trees, tupelo gums, and of course, alligators. However, Alligator Bayou has recently had to face problems associated with suburban development. To the north and east of the bayou, new housing developments have resulted in an influx of sediment into the basin, increasing turbidity. Levees, put in place to reduce flooding in low-lying areas, have resulted in higher water levels being retained within the basin. High water levels within the Spanish Lake basin have halted the natural regeneration of cypress trees. All around its perimeter, faulty septic systems leak human waste into the waters. The proprietors of Alligator Bayou Tours, an ecotourism business, have made a concerted effort over the years to improve the environmental quality of the Spanish Lake watershed. In 1999, they partnered with St. Joseph's Academy and the Louisiana Sea Grant College Program to host an educational project aimed at teaching students about wetlands monitoring and restoration and to institute a water-quality monitoring program in the Spanish Lake watershed. This initial project was funded as part of a larger, national Sea Grant effort that also involved the Oregon and New York Sea Grant programs. Because Alligator Bayou and the Spanish Lake watershed are part of the Lake

St. Joseph's Academy students prepare to plant a cypress tree as part of the Wetlands Stewardship Project at Alligator Bayou, Prairieville, Louisiana.

Pontchartrain basin, student water-quality monitoring volunteers were eligible to join the Water Watch program hosted by the Lake Pontchartrain Basin Foundation.

What Was Done

As a part of this project, St. Joseph's Academy high school students received two types of wetland stewardship training. The first workshop focused on the concepts of stewardship and the areas of environmental concern—primarily coastal erosion and water quality—that face Louisiana's citizens today. The second workshop trained students in the proper use of standard water-quality testing equipment. Later on, students also began using CBL calculators and probes, in addition to the standard equipment, to collect data. Students have been collecting water quality information every other weekend since November 1999. They analyze the collected data to identify trends or disturbances. Data are also reported to the Lake Pontchartrain Basin Foundation as part of its River Watch program. St. Joseph's students returned to Alligator Bayou to plant more than 50 cypress seedlings in March 2000 along the levee that borders the Cypress Flats area. This planting is part of the ongoing restoration effort at Alligator Bayou and is an important part of the Wetlands Stewardship Project.

Outcomes

This project provided students with background information on wetlands management issues and trained them in basic water-quality monitoring methods. It provided students with hands-on experience in applied science that made a significant contribution to the community, as well as giving them the opportunity to participate in a restoration project related to the basin in which their water-monitoring program was happening. In addition, the Alligator Bayou owners gained valuable long-term monitoring of the Spanish Lake watershed, and this information has become one of the northernmost sites in the Lake Pontchartrain Foundation's Water Watch Database.

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CHAPTER TEN

Upland Evaluation and Enhancement

by Paul W. Adams and Derek Godwin

Because uplands usually represent the largest areas within a watershed, they can have important effects on streams and other water bodies. Upland management and enhancement activities focus on two things:

- Maintaining or improving conditions that promote the natural hydrologic functions discussed in chapter 8, "Watershed Science"
- Minimizing erosion and other problems resulting from extreme events such as floods or droughts

Soil that lets water infiltrate quickly can reduce erosion and promote natural groundwater storage and surface flows. Likewise, well-designed road surfaces and stream crossings can reduce erosion and fish passage problems, particularly on the unpaved roads that extend throughout many rural watersheds.

A number of checklists are included in this chapter to help you evaluate some important upland features and highlight opportunities for watershed enhancement. Other broader watershed assessments can complement these focused evaluations, including identifying key watershed features and processes that can favor or hinder the success of enhancement practices.

Other chapters that will help you plan evaluation and enhancement projects include chapters 7, "Planning for Improved Watershed Health," and 9, "Assessment and Monitoring Considerations."

In this chapter you'll learn

- Infiltration and drainage processes and ideas to improve hydrologic functions
- Ideas for evaluating and improving upland roads and stream crossings to minimize erosion
- Considerations in designing culverts for fish passage
- Clues for identifying and reducing landslide potential

Infiltration and Drainage of Rain and Snowmelt

Chapter 8, "Watershed Science," discussed important aspects of watershed *hydrology,* such as precipitation, surface flows, subsurface flows, and evapotranspiration. Soil plays a primary role in nearly all of these hydrologic functions.

Infiltration and *drainage* of rain and snowmelt refer to the movement of this water into and through the soil. Good infiltration and drainage mean that water is

less likely to run off the soil surface. As a result, groundwater recharge increases, and there is less chance that sediment and other contaminants will be carried to streams.

Soil porosity and compaction

An important factor in infiltration and drainage is the *porosity* of the soil, both the various sizes and the total volume of spaces in the soil. Highly porous soil allows water to infiltrate quickly.

Undisturbed soil often is porous and soft, and so traffic by animals, people, or farm or logging vehicles easily compacts it. *Compaction* can reduce the number of large soil pores and can inhibit plant root growth. If these changes occur over large areas, surface runoff and erosion may increase. Areas of potential concern include slopes with many heavily compacted logging skid trails, pastures subjected to heavy livestock grazing, and fields where intensive cropping has been practiced. Contrary to popular belief, wet soils are not necessarily more prone to compaction than drier soils, but rutting and other problems are more likely with traffic on wet soils.

You can evaluate soil porosity and compaction both visually and with specialized equipment. During periods of heavy rain or snowmelt, you can recognize low soil porosity by the presence of ponded water or surface runoff. Some soils have naturally slow drainage (for example, heavy clays in floodplains). Take care to distinguish this natural condition from slow drainage caused by human activities.

Poorly growing vegetation is another visual indicator of compaction and low porosity. When soil is compacted, it doesn't have much oxygen and it's difficult for plant roots to penetrate. Under these conditions, plants don't grow well.

Several kinds of equipment are used to evaluate and monitor soil porosity and compaction and water infiltration. Examples include ring infiltrometers, rainfall simulators, soil cores, and penetrometers.

Ring infiltrometers are open metal rings that are partially inserted into the surface soil. An observer adds a measured amount of water and notes how long it takes the water to drain. *Rainfall simulators* add a measured amount of water to the soil surface in drop form to more closely resemble real rain.

An increase in soil *bulk density* is a common measure of soil compaction. Bulk density is defined as the soil's dry weight per unit volume and can be determined by taking soil core samples.

Penetrometers measure the resistance of the soil to probing, which typically increases when soil is compacted. A spade or narrow metal rod can serve as a simple penetrometer for basic assessments. Specialized devices provide quantitative measurements. For example, probes are available that give values in pounds per square inch.

When you are assessing changes in soil porosity and compaction, it can be a challenge to identify relatively undisturbed soil as a baseline for comparison. This is especially true in agricultural and developed areas, but even forested areas may have old compacted trails that are difficult to see.

It's also a challenge to take enough samples to accurately assess soil conditions, especially if you want to determine whether soil changes are affecting watershed hydrology. To make such an assessment, you need an accurate estimate of where soils change and how widespread the changes are.

Enhancing infiltration and drainage

Deep tillage of heavily compacted areas can help restore infiltration and drainage, as well as promote better growing conditions for protective vegetation. Where topsoil has been lost or removed (for example, in heavily eroded areas or on abandoned roads), you may need to add fertilizer, organic amendments, or nitrogen-fixing plants (legumes) to further restore productivity. The publication *An Evaluation of Four Implements Used to Till Compacted Forest Soils in the Pacific Northwest* provides helpful information about soil tillage options. Tillage results from different types of equipment are shown in figure 1.

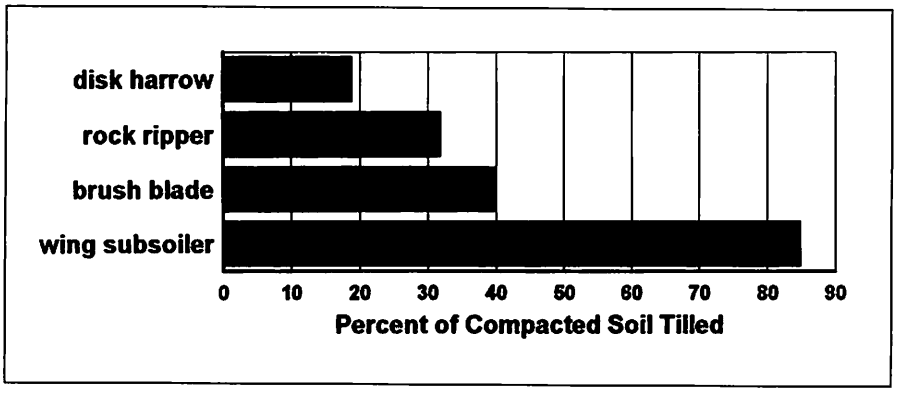


Figure 1. Tillage results from four different types of equipment.

There are several ways to reduce upland soil compaction and disturbance from agricultural and forest operations:

- *Low-till* and *no-till* cropping systems minimize machine traffic.
- *Fenced pastures* and *rotation grazing* systems (moving animals among pastures) can limit the intensity of livestock use.
- Upland locations for water troughs and salt licks can help keep livestock away from wet soils, streams, and small drainages. You usually need a permit to divert water from a stream, but permit fees are kept relatively low to encourage such improvements.
- A system of *designated skid trails* can control logging vehicle traffic and ground disturbance. This approach includes *felling to lead* (felling trees toward skid trails) and log winching to the trails to limit disturbance by heavy logging vehicles.

Infiltration also can be enhanced by measures to slow down surface water movement so that water has time to soak into the soil. One way to do this is to leave adequate surface *duff* (plant litter), logging *slash* (tree debris), and crop residues. Another approach is to add surface mulch.

Forest managers often use *slash treatment* or *scarification* to promote

reforestation success after logging. Slash treatment usually involves piling or burning, while scarification consists of mechanically disturbing the topsoil. Both techniques can enhance survival of tree seedlings. However, both expose more soil surface, which may increase the risk of surface runoff, especially on sloping terrain.

You can help reduce surface runoff problems by leaving some duff and by piling slash in windrows along slope contours. Try to manage slash to balance the needs of site preparation with those of watershed functions. If you do burn slash, schedule burns when weather conditions, slash, and other fuels are cool and moist enough to limit burn intensity.

Managing agricultural crop residues can follow similar principles.

Role of vegetation

Vegetation can enhance watershed processes such as water infiltration, which contributes to desirable moisture storage and release and also helps reduce excess erosion and sedimentation. Plants shield the soil from raindrops, which can break down soil clods and reduce large pores, resulting in surface runoff. In addition, plants, roots, and plant litter help slow runoff, hold soil in place, and promote soil porosity.

Watershed enhancement thus can include measures to improve vegetation cover. Such improvements are especially important in locations where plants are absent or sparse and increased runoff and erosion are evident. You might find these conditions around roadsides, ditches, construction areas, fields, or pastures.

Contact your local Extension Service or Natural Resources Conservation Service for information about suitable plant species and methods for establishing vegetation for erosion control along roads. As mentioned earlier, you may need to improve soil growing conditions through tillage, fertilization, or organic amendments to ensure that new plants thrive and cover the area well.

Keep in mind that tree planting or natural reforestation can significantly change a forest and have unintended effects on water resources. For example, where dense, vigorous alder stands grew after historical logging of riparian forests, reduced summer flows (probably from heavy water uptake) or water-quality effects (for example, increased color and dissolved organic matter) sometimes have been noted.

Reforestation of agricultural fields or other open lands also may reduce local streamflows because forests use more water than do crops and other plants. Figure 2 shows how streamflows in watersheds in other regions generally decreased when forest cover was increased. While streamside plantings often are desirable to provide shade, which helps maintain cooler water temperatures, you should carefully consider the trade-off with potential streamflow reductions.

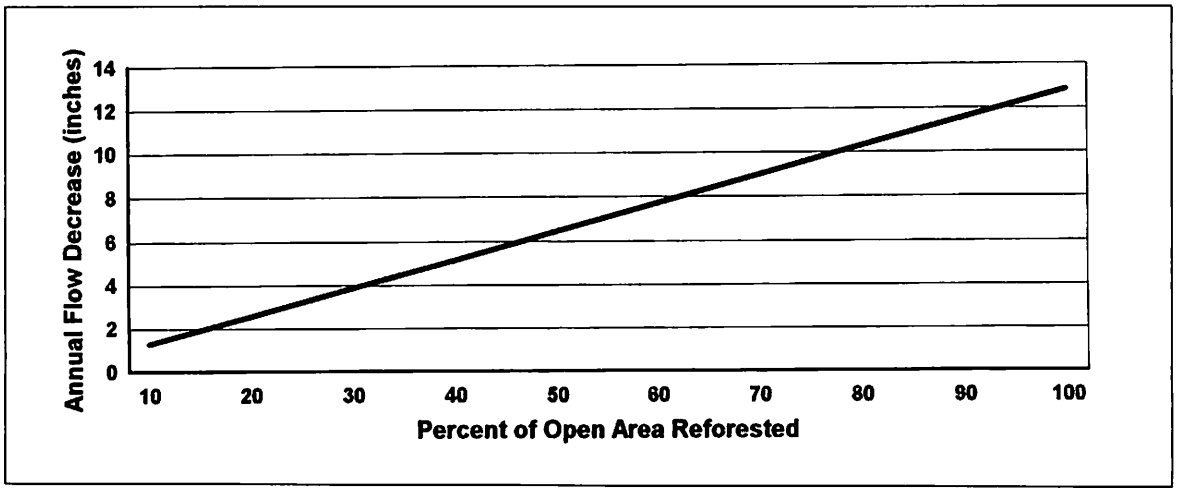


Figure 2. Relationship of streamflow to increasing forest cover.

Road Surface Drainage

Road use and maintenance

In most cases, landowners and managers rely heavily on existing roads for property access. How these roads are used and maintained should be a major part of your watershed evaluation and potential enhancement efforts.

For example, sediment losses from unpaved roads can increase if traffic is heavy or if travel occurs during wet weather. Thus, in areas where sedimentation is a major concern, it may be wise to reduce or suspend traffic on such roads during wet weather. Likewise, scheduling timber harvest and log hauling during drier periods may reduce sedimentation from forest roads.

Both routine and emergency road maintenance can be critical to preventing or reducing erosion and sedimentation problems. Ensuring that the road drainage system functions well is a major focus of both types of maintenance. Figure 3 shows some important differences between a well-maintained and a poorly maintained forest road. It's best to do routine road maintenance before the rainy season and before roads are used heavily (for example, for log hauling or crop harvest). Key maintenance activities include

- *Road grading* to smooth ruts and direct water off the road surface
- *Ditch and culvert cleaning* to efficiently move road drainage to stable areas
- *Adding* fresh *surface gravel* when earlier applications become worn by traffic

Emergency maintenance involves monitoring road conditions during large storms so that clogged ditches and culverts can be taken care of promptly to prevent serious problems such as gullies, washouts, or landslides.

To help you determine what kind of road maintenance is needed in your watershed,

see the "Checklist for Storm Proofing Rural Roads: Road Maintenance."

Drainage design

Road improvements to prevent or reduce watershed problems generally focus on drainage systems. Road surfaces usually are designed with a crown, inslope, or outslope to quickly move water off to a ditch or the roadside. Generally, these slopes should be 2 to 3 percent greater than the travel grade; otherwise, water will move down the road surface rather than off to the side.

Simple maintenance grading might be sufficient to provide surface drainage on many roads. In some cases, however, the road might need additional soil or rock to create an adequate slope.

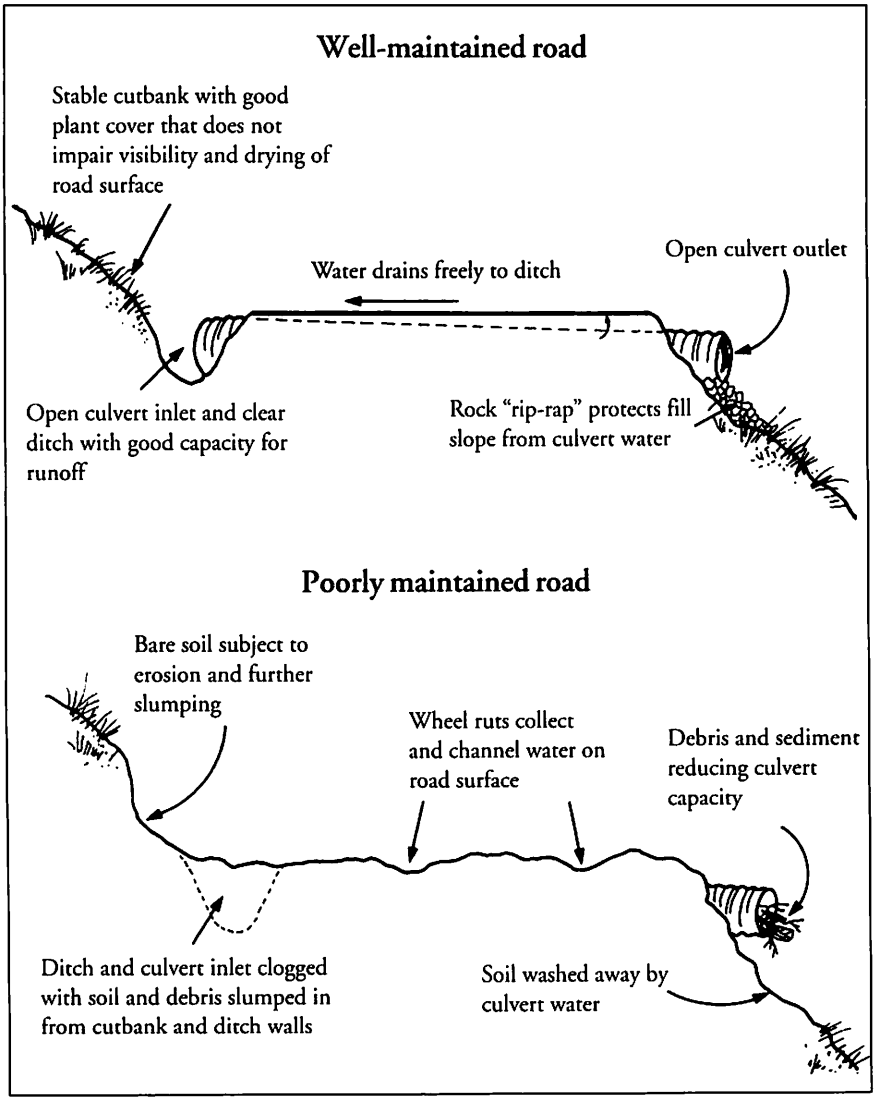


Figure 3. Examples of some important differences between well-maintained and poorly maintained woodland roads.

The Oregon State University Extension publication *Designing Woodland Roads* illustrates good road drainage design features. Another helpful tool for evaluating existing roads is the "Checklist for Storm Proofing Rural Roads: Road Drainage Design." Be aware that road design can be quite complex, and you may need to get help from a professional engineer or other specialist.

Where roads are cut into a slope, ditches and cross

Checklist for Storm Proofing Rural Roads
Road Maintenance

Road surface

- ❒ Rutting or uneven surface concentrates or sends water to wrong area
- ❒ Rock surfacing has deteriorated or migrated into subgrade
- ❒ Other risky situation or comments:

_____

_____

Drainage ditches and roadsides

- ❒ Eroding ditch material (gullies, etc.)
- ❒ Cutbank slumping or ravel blocking ditch flow
- ❒ Roadside berms concentrate or send water to wrong area
- ❒ Cracks in road fill, indicating soil instability
- ❒ Other risky situation or comments:

_____

_____

Cross drains

- ❒ Erosion at inlet or outlet
- ❒ Sediment or organic debris clogging pipe
- ❒ Denting from traffic or ditch maintenance
- ❒ Other risky situation or comments:

_____

_____

Other considerations

- ❒ Heavy traffic (e.g., farm vehicles or log trucks) expected
- ❒ Plans for emergency maintenance during storms
- ❒ Other:

_____

_____

Checklist for Storm Proofing Rural Roads
Road Drainage Design

Road location

- ❒ Intense storms locally common
- ❒ Erodible or unstable soils locally common
- ❒ Streamside location could be subject to washout
- ❒ Other risky characteristic: _____

Road grades

- ❒ Steep grades add to erosive power of runoff
- ❒ Low grades allow water to accumulate on surface
- ❒ Other risky feature: _____

Road bed and surface

- ❒ Soft road bed (e.g., weak or wet subgrade material)
- ❒ Erodible surface material (e.g., bare, fine-textured soil)
- ❒ Slope angles of road crown or sideslope inadequate for efficient flow
- ❒ Other risky feature: _____

Drainage ditches

- ❒ Erodible ditch material (e.g., bare, fine-textured soil)
- ❒ Cutbank seepage adds to ditch flows
- ❒ Low ditch grade accumulates water
- ❒ Other risky feature: _____

Cross drain size and spacing

- ❒ Small pipe could overflow or become easily clogged
- ❒ Wide spacing could cause ditch erosion or overflow at inlet
- ❒ Other risky feature: _____

Cross drain angle, grade, and installation

- ❒ Pipe may not efficiently move water and be self-cleaning of debris
- ❒ Fill too shallow or not well compacted (e.g., erosion or pipe bending)
- ❒ Other risky feature: _____

Cross drain inlets and outlets

- ❒ Inlet may not divert all ditch water into pipe
- ❒ Flow from outlet could cause erosion or instability
- ❒ Other risky feature: _____

drains usually are needed to direct water to stable locations. If road ditches are eroding or forming gullies, they might need to be stabilized with armor rock or vegetation, or they might need additional cross drains. Even where there are lots of cross drains, however, heavy storm flows may cause erosion problems at either the inlet or outlet of the drain.

Three types of cross drains commonly are used on simple rural roads—ditch-relief culverts, rolling dips, and water bars. Tables 1 and 2 summarize key features of each of these designs.

Ditch-relief culverts are the most common type of cross drain. Where costs or maintenance requirements make them impractical, however, consider options such as rolling dips and water bars.

Stream Crossings

Stream crossings are a point of direct contact between streams and roads. Thus, erosion and other problems at these locations can quickly have a substantial impact on water quality and fish habitat. Many older crossings have a limited capacity to handle storm flows. Some of them continue to add sediment to streams when high flows erode fill material around culverts or bridge abutments. Another

Table 1. Cross drainage on rural roads.

Ditch relief culverts—The 5 Ds

Divert	Culvert inlet should provide direct and unhindered diversion of ditch water (i.e., water should not bypass inlet). Angle culvert at least 30 degrees downslope from the road for efficient flow into and through the pipe.
Debris	Keep inlets cleaned of debris and sediment (e.g., watch for cutbank slumps and ravel, ditch erosion, and sedimentation). Slope the culvert at least 3 percent and at least 2 percent greater than the ditch slope to help keep it self-cleaning of sediment and debris. Where debris and sediment are a chronic problem, consider control measures such as catch basins, drop inlets, and recessed cutslopes.
Discharge	Culvert installation should have sufficient capacity to handle flows from very large storms; minimum 12-inch pipe size recommended. Consider local conditions (e.g., storm intensities, slope position, cutbank seepage) that may add to flows.
Distance	Carefully space culverts to prevent ditch erosion and to avoid large discharge flows onto steep or unstable slopes. Closer spacing is needed with steeper road grades, erodible soils, locally intense storms, etc.
Dissipate	Use riprap, downspouts, etc., at culvert outlets to dissipate erosive energy of discharge water, especially on steep or unstable slopes.

Source: "Considerations in placement of cross drain culverts," by R. L. Beschta. Short course notes. *Design and Maintenance of Forest Road Drainage* (Corvallis, OR: Oregon State University College of Forestry, 1991).

important concern with stream crossings is that some culverts are a barrier to migrating fish.

Crossing types

The most common stream crossings are culverts and bridges. Culverts generally are less costly than bridges for crossing small streams. However, they must be designed and installed carefully to provide for storm flows and fish passage. Design suggestions are discussed later in this section. Many older culvert crossings don't meet these standards and may be good candidates for enhancement projects.

Some relatively inexpensive bridge designs are available. Examples include log and rail car bridges and some newer, prefabricated, sectional designs.

Where traffic is very light, carefully designed fords or temporary crossings can be used. A *vented ford* crossing is a unique way to minimize the disturbance and expense of large road fills (for example, in floodplains) while maintaining clean water and adequate fish passage during times of low flow. These crossings combine a smaller culvert (that is, capacity for moderate storm flows) with heavily armored fill at or near the crossing to handle overflows during very heavy storms.

Flow capacity

It's critical that stream crossings have adequate flow capacity to prevent erosion or washouts during large storms. Each state has requirements or guidelines for designing culverts that have adequate flow capacity and that provide fish passage. Contact your state forestry or fish and wildlife department.

Table 2. Other cross drainage options.

Where costs or maintenance requirements make ditch relief culverts difficult to use, consider such options as rolling dips and water bars.

Rolling dips	Dips generally are suitable for road grades less than about 10 percent. Begin the dip cut a minimum of 50 feet upslope of the dip bottom, and extend it at least another 15 feet beyond the dip bottom.
	Cut the dip 1–2 feet into a firm roadbed, and angle it 45–60 degrees downslope from the road centerline. Increase the outslope cut of the dip uniformly from the upper inside start of the dip to the outlet.
	Use riprap or other outfall protection on steep or unstable slopes.
Water bars	Construct water bars at least 1 foot high, with a 30–60 degree angle from the road centerline, and a clear, stable outlet.
	Carefully space and locate bars, e.g., consider using ditch relief culvert spacing guidelines.
	Where significant traffic is expected, consider flexible water bars.

Because stream crossing issues are complex, you may need help from engineers and other technical specialists for successful evaluation and enhancement projects. Replacing or installing culverts larger than those shown in table 3 is one situation where special expertise probably is needed.

Fish passage

Fish passage at stream crossings is a major concern because barriers to passage can effectively eliminate many miles of valuable spawning or rearing habitat. For example, Oregon's Forest Practices Rules now require that new stream crossings provide for upstream and downstream passage of both adult and juvenile salmonids (salmon and trout). But older forest stream crossings and those on nonforest lands often were installed with little or no consideration for fish passage. Thus, upgrading crossings that restrict access to valuable habitat can represent an important watershed enhancement opportunity.

Fish passage problems occur most often with culvert crossings. Figure 4 illustrates some common situations:

- A steep slope or a small culvert results in water velocities that are too fast to allow upstream swimming.
- The culvert outlet is too high above the stream for fish to jump.
- There is no pool at the culvert outlet where fish can rest and gain velocity for upstream passage.
- Flows in or near the pipe are too shallow during low flows to allow passage.

The ability of fish to jump and swim against strong flows depends on their size and species, as well as on how long they have been migrating. Adult steelhead are known as the highest jumpers of the salmonids.

States have specific recommendations for designing culverts for fish passage. For example, the Oregon Department of Fish and Wildlife recommends less than a 12-inch jump to allow passage of juvenile salmonids. If resting pools are absent or shallow, a minimum pool depth of 1½ times the jump height is advised. If flows are too fast or steep for migration, a *fish ladder* or larger pipe with baffles can provide upstream access.

Table 4 shows the short-term burst speeds for some important species and recommended velocities for constructed crossings or channels.

Some stream crossings use oversized culverts or wide concrete fords to safely

Table 3. Flow capacities of round culverts.

Culvert capacity (inches)	Flow diameter (cfs)
24	5–11
30	12–20
36	21–31
42	32–46
48	47–64
54	65–87
60	88–113

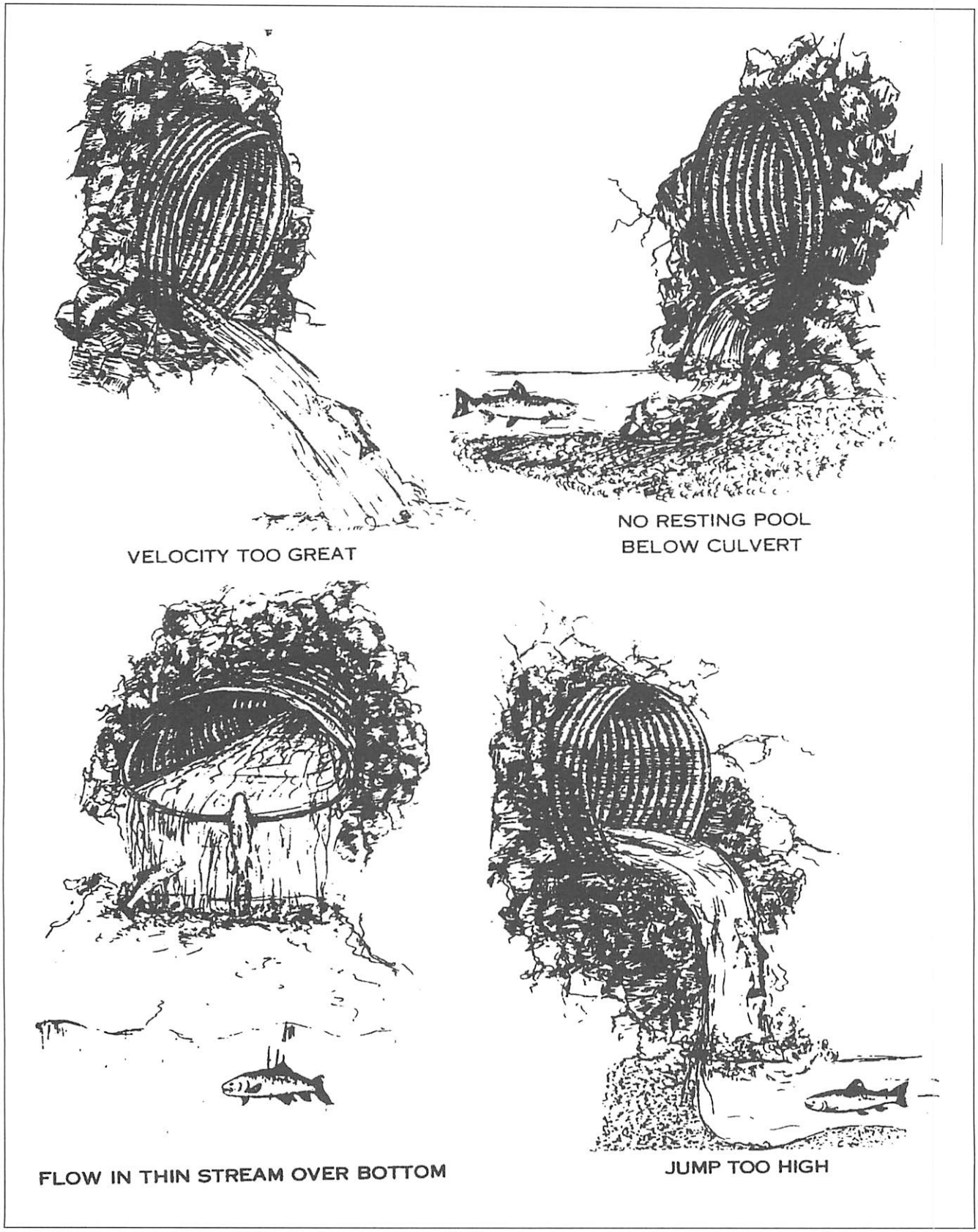


Figure 5. Culvert installations that block fish passage.

handle extreme flows. While these designs may avoid washouts, they also may create very shallow flows that large fish can't swim through. In such cases, you might be able to install a secondary pipe or side channel to provide a route with deeper flow.

One particularly useful reference for evaluating and designing stream crossings for adequate fish passage is the Oregon Department of Forestry advisory memo *Interim Fish Passage Guidance at Road Crossings.* The Oregon Department of Fish and Wildlife also has developed a basic form for evaluating existing crossings, the "ODFW Culvert Evaluation Form." See also "Checklist for Storm Proofing Rural Roads: Stream Crossings."

New Road Construction

Both watershed concerns and construction expense make it desirable to build as few new roads as possible. If new roads are needed primarily for logging activity, keep in mind that some logging systems require more roads than others.

Generally, ground-based logging requires the most roads. Systems that can carry logs over longer distances (for example, multispan cable skylines or helicopters) require the fewest roads. These methods tend to be more expensive, however, and are best suited to steep or less-accessible terrain.

Proper road location can prevent or reduce watershed impacts. Key principles include building roads far away from streams and other drainages, minimizing the number of crossings, and recognizing and avoiding potentially unstable areas.

In steep terrain, ridgetop roads can limit soil excavation and exposure. They also

Table 4. Short-term burst speeds of salmonids.

Species	Maximum capability (feet per second)[1]	Acceptable flow (feet per second)[1]
Juvenile salmon, trout, and steelhead		0–3 0–4
Adult cutthroat and age 1+ steelhead		0–3 0–4
Adult sea-run cutthroat trout	6.4–13.5 11.4	0–8
Adult coho salmon	12.2–17.5 10.6–21.5	3.4–10.6 0–8
Adult chinook salmon	14.5–22.1 10.8–22.4	3.4–10.8 0–8
Adult steelhead trout	12.0–26.8 13.7–26.8	4.6–13.7 0–8

[1]Multiple entries are observations by different authors.

ODFW Culvert Evaluation Form

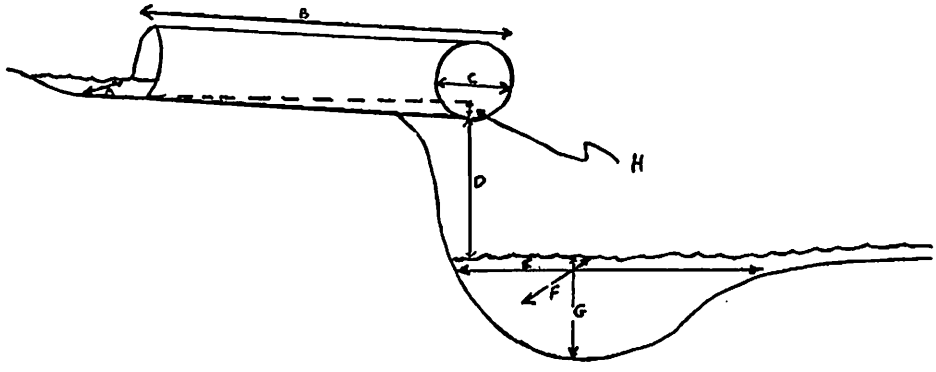
Evaluators:_____ Date:_____

Stream:_____

Subbasin or fork:_____ Basin:_____

Legal description: T._____ R._____ Sec._____

Road and crossing location:_____



Factor	Measurement	Record
A: Width of stream above culvert		Nearest foot
A: Estimated winter width of stream		Nearest foot
B: Length of culvert		Nearest foot
C: Diameter of culvert		Feet and inches
D: Height of culvert		Feet and inches
E: Pool length below culvert		Nearest foot
F: Pool width below culvert		Nearest foot
G: Pool depth below culvert		Nearest foot
H: Drop of culvert from horizontal		Inches

Answer questions on page 2 of the form.

ODFW Culvert Evaluation Form, page 2

Questions

What is the type of culvert?

❒ steel ❒ tarred steel ❒ aluminum ❒ concrete ❒ wood ❒ other

Who owns and maintains the culvert?

Is the culvert in good condition?

Is the culvert easily accessible from the road for fish-passage repair work?

What species and estimated size of fish are observed in the pool *below* the culvert?

What species and estimated size of fish are observed in the first pool *above* the culvert?

In your judgment, could adult fish pass upstream through the culvert in winter?
If not, why not? What would be needed to improve passage?

In your judgment, could juvenile fish pass upstream through the culvert in winter?
If not, why not? What would be needed to improve passage?

Do you have other comments about this culvert?

Checklist for Storm Proofing Rural Roads Stream Crossings

Culvert size or bridge clearance

- ❒ Insufficient capacity to pass 50-year storm flow
- ❒ Potential for clogging by woody debris, etc.
- ❒ Water diversion with excess flow or clogging creates other risks away from crossing
- ❒ Other risky situation or comments:

_____

_____

Pipe or bridge condition

- ❒ Evidence of deterioration (e.g., rust or rot), settling, etc.
- ❒ Other risky situation or comments:

_____

_____

Inflow and outflow area condition

- ❒ Evidence of or potential for erosion at high flows
- ❒ Other risky situation or comments:

_____

_____

Road fill height and condition

- ❒ Low fill height could be overtopped at high flows
- ❒ Evidence of poorly compacted fill (e.g., seepage, settling)
- ❒ Other risky situation or comments:

_____

_____

Road surface and ditches

- ❒ Road drainage contributes to flow at crossing
- ❒ Potential for direct sedimentation from road surface or ditch
- ❒ Other risky situation or comments:

_____

_____

reduce the amount of water that the road's drainage system must handle because there is less area upslope to add runoff.

New road construction provides an ideal opportunity to incorporate proven design features that help reduce or prevent watershed impacts. As mentioned earlier, most of these features focus on road drainage and stream crossings.

Subgrade preparation, or preparing the road for surfacing, is another important part of road design. In steep terrain, for example, *full-bench* and *end-haul* construction can reduce landslides and other erosion problems. In this approach, the entire road width is cut into the slope, and the excavated material is hauled to a stable location. This method contrasts with *cut and fill* construction, in which some of the excavated material is used to build up a portion of the road surface. In wet or weak soils, synthetic fabrics or other subgrade enhancements can improve the bearing strength of roads and reduce rutting and drainage problems.

Gravel surfacing is another proven way to reduce erosion and sedimentation from forest roads. The Oregon State University publication *Rocking Woodland Roads* provides further information on this topic.

Soils freshly exposed by construction can be especially prone to erosion, so you should time road building so soils have a chance to stabilize before the rainy season begins.

Unstable Terrain

Unstable terrain where landslides occur can be an important source of stream sediment and woody debris, both natural and the result of management practices. Identifying these areas can be very helpful in understanding current watershed conditions and in prescribing management activities.

Keep in mind that different types of slope instability can present different concerns for watershed management. Slow-moving earthflows, for example, may provide a chronic, natural source of stream sediment that can be difficult or impossible to control. On the other hand, landslide potential may be reduced locally by avoiding road construction along a slope that shows evidence of past debris avalanches.

It's not possible to identify the exact locations where landslides will occur, but broader areas of current and potential instability can be recognized. Expertise in geology, soils, hydrology, and geotechnical analysis is needed for the most reliable assessments, but preliminary surveys can be done using simple guidelines.

For example, basic clues for current or potential instability include

- Very steep slopes (for example, those greater than 65 percent)
- Slope depressions or other sites where water may concentrate
- Slopes with active seeps or springs. (Indicators include localized water-loving plants, and black or "mottled" soil.)

- Very uneven or hummocky slopes
- Very shallow soils over bedrock
- Deep, wet soils with high clay content
- Bulging stream banks with actively sloughing soil
- "Jackstrawed" trees (trees leaning in different directions) or trees with curved trunks
- Slopes with tension cracks or "cat steps" (soil slippage that forms small steps on a slope)
- Bedrock faults or rock beds parallel to the surface slope

Be aware that most topographic maps and aerial surveys provide only a rough picture of actual ground conditions that contribute to instability. For example, a recent study by the Oregon Department of Forestry showed that standard topographic maps poorly identified the exact locations of steep slopes. Likewise, aerial photos failed to show many existing landslides, especially where there was forest cover.

It's often very difficult or costly to improve slope stability in very unstable terrain through watershed enhancements. Simply put, it's hard to hold back naturally weak soil on a very steep slope when it's soaked by an unusually large storm. However, some practices can at least help maintain existing soil strength, and a few can increase it somewhat.

Some of the following practices have already been mentioned: directing road drainage away from unstable slopes and avoiding burning or chemical treatments that remove duff and vegetation. In addition, rock buttresses can be used along unstable road cutbanks, and tree planting on steep, grassy slopes may add some root strength. Experts familiar with slope stability problems and solutions can best assess such opportunities.

Tree removal to reduce landsliding is a method that has not been validated by research. Tree weight is insignificant compared to the weight of wet soil, and tree roots provide some soil strength. Most studies in very unstable terrain have shown some increase in landslides in the first decade after clear-cutting, but some locations and young forests have shown fewer landslides after such cutting.

Individual state forestry departments have guidance for forest operations in unstable terrain, and other new efforts to deal with landslide hazards are underway. However, it's essential to recognize that in unstable terrain, a significant landslide risk will exist whether or not management activities occur.

Summary

Uplands usually represent the largest areas within a watershed, so they can have important effects on streams and other water bodies. Upland management and enhancement activities focus on two things:

- Maintaining or improving conditions that promote natural hydrologic functions
- Minimizing erosion and other problems from extreme events such as floods or droughts

Infiltration and *drainage* of rain and snowmelt refer to the movement of water

into and through the soil. Good infiltration and drainage mean that water is less likely to run off the soil surface.

An important factor in infiltration and drainage is the *porosity* of the soil, both the various sizes and the total volume of spaces in the soil. Highly porous soil allows water to infiltrate quickly. *Compaction* can reduce the number of large soil pores and can inhibit plant root growth. If these changes occur over large areas, surface runoff and erosion may increase.

Deep tillage of heavily compacted areas can help restore infiltration and drainage, as well as promote better growing conditions for protective vegetation. Infiltration can also be enhanced by measures to slow down surface water movement so that water has time to soak into the soil.

Vegetation can enhance watershed processes such as water infiltration, which contributes to desirable moisture storage and release and also helps reduce excess erosion and sedimentation. Watershed enhancement thus can include measures to improve vegetation cover.

How roads are used and maintained should be a major part of your watershed evaluation and potential enhancement efforts. Both routine and emergency road maintenance can be critical to preventing or reducing erosion and sedimentation problems. Ensuring that the road drainage system functions well is a major focus of both types of maintenance.

Stream crossings are a point of direct contact between streams and roads. Thus, erosion and other problems at these locations can quickly have a substantial impact on water quality and fish habitat. It's critical that stream crossings have adequate flow capacity to prevent erosion or washouts during large storms.

Fish passage at stream crossings is a major concern because barriers to passage can effectively eliminate many miles of valuable spawning or rearing habitat. Older forest stream crossings and those on nonforest lands were often installed with little or no consideration for fish passage. Thus, upgrading crossings that restrict access to valuable habitat can represent an important watershed enhancement opportunity.

Proper road location can prevent or reduce watershed impacts. Key principles include building roads far away from streams and other drainages, minimizing the number of crossings, and recognizing and avoiding potentially unstable areas.

Unstable terrain where landslides can occur can be an important source of stream sediment and woody debris, both natural and the result of management practices. Identifying these areas can be very helpful in understanding current watershed conditions and in prescribing management activities.

Resources

Training

State universities (through the college of forestry, the Extension Service, and so on) and state departments of forestry occasionally offer public seminars, field trips, and short courses on topics related to upland watershed management and enhancement. Training programs may also be offered by various nonprofit and private organizations, including consultants. If you're interested in self instruction, consider the publications and audiovisual programs listed below.

Information

General practices

Environmental Impacts of Brush Control, slide-tape 705.6 (Corvallis, OR: Oregon State University Forestry Media Center).

Forest Operations: Part of the Solution, video 1071 (Corvallis, OR: Oregon State University Forestry Media Center).

Forest Practices and Surface Erosion, slide-tape 795 (Corvallis, OR: Oregon State University Forestry Media Center).

Healthy Watersheds (video), VTP-019 (Corvallis, OR: Oregon State University Extension Service, 1994).

The Miracle at Bridge Creek, Watershed Improvement (video), VTP-013 (Corvallis, OR: Oregon State University Extension Service, 1994).

Oregon Watershed Assessment Manual (available from the Governor's Watershed Enhancement Board, Salem).

Pesticides in Forestry: Behavior in the Forest Environment, video 911.2 (Corvallis, OR: Oregon State University Forestry Media Center).

Soil and Water Conservation: Introduction for Woodland Owners, EC 1143, by P. Adams (Corvallis, OR: Oregon State University Extension Service, reprinted 1997).

Timber Harvesting Options, EC 858, by J. Garland (Corvallis, OR: Oregon State University Extension Service, reprinted 1997).

Timber Harvesting Options, slide-tape 767 (Corvallis, OR: Oregon State University Forestry Media Center).

Water Quality and Our Forests: Western Oregon Research (video), VTP-014 (Corvallis, OR: Oregon State University Extension Service, 1993).

We All Live Downstream (video), VTP-021 (Corvallis, OR: Oregon State University Extension Service, 1995).

Soil infiltration

Designated Skid Trails, slide-tape/video 903 (Corvallis, OR: Oregon State University Forestry Media Center).

Designated Skid Trails Minimize Soil Compaction, EC 1110, by J. Garland

(Corvallis, OR: Oregon State University Extension Service, Corvallis, 1997).

An Evaluation of Four Implements Used to Till Compacted Forest Soils in the Pacific Northwest, FRL Bulletin 45 (Corvallis, OR: Oregon State University Forest Research Lab, 1983).

Recognizing and Managing Forest Soil Compaction, slide-tape/video 823 (Corvallis, OR: Oregon State University Forestry Media Center).

Soil Compaction on Forest Lands, film/video 850 (Corvallis, OR: Oregon State University Forestry Media Center).

Soil Compaction on Woodland Properties, EC 1109, by P. Adams (Corvallis, OR: Oregon State University Extension Service, 1998).

Tilling Compacted Forest Soils, slide-tape/video 876 (Corvallis, OR: Oregon State University Forestry Media Center).

Waterbars, ODF Forest Practice Note No. 1 (Salem, OR: Oregon Department of Forestry).

Roads

Designing Woodland Roads, EC 1137, by J. Garland (Corvallis, OR: Oregon State University Extension Service, 1993).

Logging Road Construction, slide-tape 909 (Corvallis, OR: Oregon State University Forestry Media Center).

Maintaining Woodland Roads, EC 1139, by P. Adams (Corvallis, OR: Oregon State University Extension Service, 1997).

Unstable terrain

Forest Practices and Mass Soil Movement, slide-tape 813 (Corvallis, OR: Oregon State University Forestry Media Center).

Landslides in Oregon (Salem, OR: Oregon Department of Forestry).

Slope Stability on Forest Lands, PNW 209, by R. Sidle (Corvallis, OR: Oregon State University Extension Service, 1980).

Ordering instructions

OSU Extension Service publications are available from county offices of the OSU Extension Service or from Extension and Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; fax: 541-737-0817; Web: eesc.orst.edu

OSU Extension Service videos are available for purchase from Extension and Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; fax: 541-737-0817; Web: eesc.orst.edu. (These programs also may be available for viewing or loan from county offices of the OSU Extension Service.)

OSU Forest Research Lab publications are available from OSU Forestry Publications Office, Forest Research Lab 227, Corvallis, OR 97331-7402; phone: 541-737-4271, fax: 541-737-3385; Web: www.cof.orst.edu/cof/pub/home/homepage.htm

OSU Forestry Media Center slide-tape, film, and video programs are available for purchase or rental from OSU Forestry

Media Center, 248 Peavy Hall, Corvallis, OR 97331-5702; phone: 541-737-4702; fax: 541-737-3759; e-mail: forestrm@ccmail.orst.edu; Web: www.orst.edu/Dept/fmc/

Oregon Department of Forestry publications are available from local ODF offices, or from Oregon Department of Forestry, 2600 State Street, Salem, OR 97310; phone: 503-945-7422, fax: 503-945-7212; Web: www.odf.state.or.us/default.htm

Case Study

Designing Culverts in Oregon for Adequate Flow Capacity

Oregon's Forest Practices Rules now require that crossings be designed to handle a 50-year storm flow. By using the following procedure to check flow capacities of existing crossings, you can identify sites that might benefit from an upgraded design.

First, you need to determine the 50-year storm flow. The easiest way to do this is to use the peak flow map developed by the Oregon Department of Forestry. Part of this map is shown in the following figure.

The map shows some areas where the 50-year peak flow is between 100 and 150 cubic feet per second (cfs) per square mile (640 acres) of drainage area. For a stream crossing in such a location, first estimate the watershed area that drains to the crossing, and then adjust the map value accordingly.

For example, if the drainage area above a local culvert crossing is 160 acres, the 50-year flow is calculated as follows:

160 acres ÷ 640 acres = 0.25 sq mile
100 cfs x 0.25 = 25 cfs
150 cfs x 0.25 = 37.5 cfs
50-year flow = 25–37.5 cfs

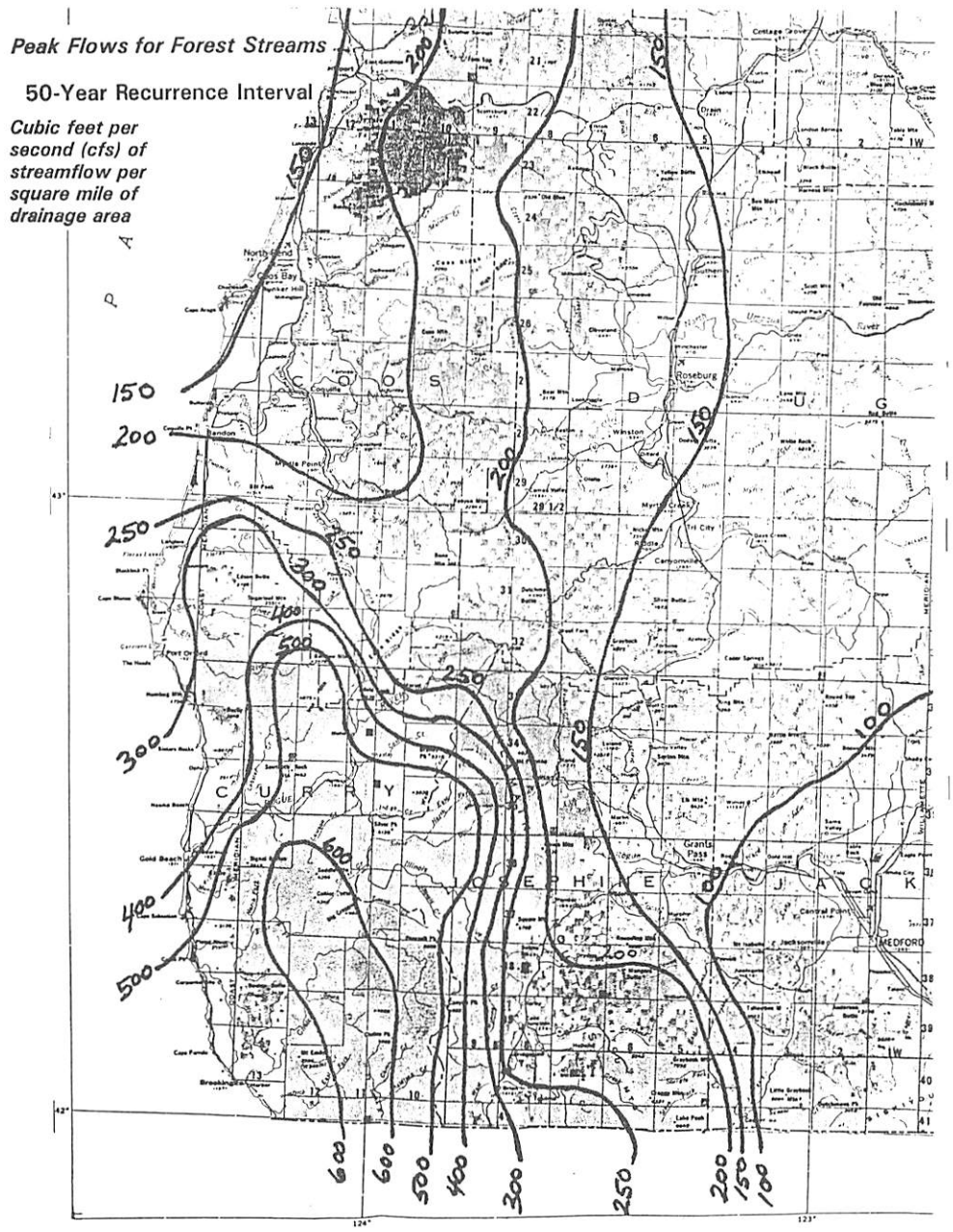
The next step is to measure the size of the culvert to see whether it can handle this flow. Table 3 shows the flow capacities of some common sizes of round culverts.

If the culvert crossing in our example has a pipe 36 inches or smaller, it's in danger of experiencing a washout during a heavy storm. Replacing the culvert with a larger pipe could reduce this risk.

Keep in mind that in many parts of Oregon the storms of February and November 1996 were among the largest recorded in the past century. In some locations, the resulting streamflows probably were 25- to 50-year return events, or even greater.

The condition of stream crossings after these storms provides fresh evidence of locations where improvements may be warranted. Look for signs of eroding fill material around pipes, bridge approaches, and abutments. Also look for evidence that shows whether water flowed over the road as it ponded behind the fill.

Other guidance is available for estimating storm flows and the capacities of pipes and bridges to handle these flows. One source is the Oregon State University publication *Estimating Streamflows on Small Forested Watersheds for Culvert and Bridge Design in Oregon.* Another helpful tool is the "Checklist for Storm-Proofing Rural Roads: Stream Crossings."



CHAPTER ELEVEN

Riparian Assessment and Enhancement

by Mike Cloughesy, Tara Nierenberg, David Hibbs, Derek Godwin, and Bill Rogers

The management of riparian areas is extremely complex because plants, animals, soils, and water all interact with each other and constantly change over time. But the task is too important for your being put off by its complexity; in fact, the complexity is what makes it exciting.

There are many different approaches to setting riparian area goals and many management concepts used in meeting those goals. This chapter will get you started on understanding some aspects of riparian areas so you can begin thinking about your goals. It will also introduce you to evaluation, enhancement, and monitoring techniques for riparian areas.

Riparian area enhancement projects are the heart of watershed enhancement. They often are inexpensive, nontechnical, fun to do as a group, and great projects for volunteers. But don't let the ease of implementing these projects fool you. Projects that don't consider basic riparian functions have a high failure rate.

The purpose of this chapter is to provide a basic understanding of riparian area functions, assessments, enhancement projects, and monitoring plans. *Assessments* ideally compare present functions to desired functions by measuring variables or conditions that indicate those functions.

In this chapter you'll learn

- Management goals are more likely to succeed if they are based on ecological functions and processes rather than on physical conditions.
- Stream structure comes from many places and changes constantly.
- A mix of forest ages and types (conifer and broadleaf) along streams provides the greatest land and instream diversity.
- The quality of fish habitat naturally changes with time.
- Active management techniques can enhance riparian functions.

You will also learn

- The basic components of riparian assessments
- The features of three common assessment methods
- The common goals of riparian enhancement projects
- How to choose the right riparian vegetation for the right location
- Some methods for establishing and protecting vegetation
- The basic components of a riparian monitoring plan

Enhancement techniques change present functions and "speed up" ecosystem processes to reach desired functions. *Monitoring* evaluates these changes over time.

What Is a Riparian Area?

Riparian area is a term with a fuzzy meaning. At its simplest, it is a zone adjacent to water where the soil is wet. Thus, there are riparian areas around springs, ponds, and streams. In the context of streamside management today, the term has three components:

- *The aquatic area,* which includes the stream, side channels, and depressions in the floodplain away from the stream
- The area near the stream where vegetation is strongly influenced by water. This *wet terrestrial zone* either has wet soils or is often flooded.
- The *zone of influence,* which refers to the many land-based factors that influence instream processes. The zone of influence includes the plants that hang over the stream as well as trees growing farther away that might shade or fall into the stream. For some functions, the zone of influence extends from ridgetop to ridgetop.

The zone of influence includes the plants that hang over the stream as well as trees growing farther away that might shade or fall into the stream.

Riparian Functions and Management Goals

Today, many management goals exist for riparian areas. These goals include increasing fish populations, maintaining water quality, controlling water temperature, restoring historic habitat structures, stopping landslides, and harvesting timber. While all of these goals are well intended, they sometimes are contradictory and may be based on mistaken ecological assumptions.

The goals listed above focus on *conditions*, or how a riparian area looks today: the number, size, and species of plants; the location of the stream; the size and location of logs; and so on. Furthermore, managers tend to view these conditions as unchanging.

An alternative approach is to keep goals focused on desired ecological *functions.* Functions refer to the processes that support life: establishing new plants, providing instream structure, shading a stream, and so forth. This approach is more likely to succeed because it identifies processes that must be managed and it opens the door to considering more than one way to meet a goal.

Four functions are commonly involved in riparian management goals:

- Providing structural diversity in and near streams
- Providing wildlife habitat

- Maintaining stream productivity
- Maintaining forest productivity

Each of these functions is discussed below.

Providing structural diversity in and near streams

To most people, stream structure means large conifer logs, although in some streams, boulders also fill this role. Current federal and state riparian management rules focus on growing this wood on the stream bank. However, recent research shows that, historically, some of the large wood in some streams entered the riparian system in landslides from steep, unstable upper slopes. These landslides also are the critical source of gravel for spawning beds.

Thus, management activities focused on providing structural diversity might consider both the near-stream area and nearby upland areas. For example, an upslope option might be to identify unstable and potentially unstable slopes on which to leave trees that eventually will slide into the stream. These trees would balance the harvest of riparian trees that are unlikely to fall into the floodplain.

Providing wildlife habitat

Many different features of riparian zones attract wildlife. For example, riparian wildlife species such as salamanders need the high moisture conditions found in riparian zones. These species often are found at midslope springs and seeps as well.

Other wildlife species commonly associated with riparian areas are attracted by the vegetation characteristics, such as hardwood cover, conifer cover, or rotting logs. Many of these species also are found elsewhere in the forest where these vegetation conditions occur.

Because wildlife species are so diverse in the environmental cues they respond to, no simple or single management approach meets the needs of all of them. Therefore, management must be planned both at the local, streamside level (the stand level) and the larger, landscape level to provide a diversity of habitat conditions.

Maintaining stream productivity

The instream food chain is fed by sunlight, *litter* (leaves, needles, and branches) that falls into the water, and flying insects. The sunlight causes algae to grow on rocks. Insects eat the algae and the plant litter; fish eat the insects and algae; larger predators eat the fish. *Stream productivity* refers to how much food is generated at all levels of the food chain from the initial energy inputs.

Different kinds of trees have different effects on stream productivity. Conifer litter falls more evenly throughout the year than hardwood litter. It also has a lower nutrient content and breaks down more slowly. A deciduous canopy (such as alder, oak, or maple) provides summer shade and lets light through for winter photosynthesis. Stream productivity is sometimes limited by low levels of nitrogen. Thus, alder, which can capture nitrogen from the air and release it into the groundwater, can be important.

Even when you understand all of these principles, it's still difficult to know how to manage riparian vegetation to aid stream productivity. Little information exists on which streams' productivity is limited by temperature, energy, or nitrogen. There has been no systematic study of how different mixtures of hardwoods and conifers affect instream processes; all studies have been based on a single location. Thus, since both coniferous and deciduous species play different but important roles, it seems advisable to maintain an abundance of both kinds of trees along a stream.

Forest productivity refers to a site's ability to maintain productive plant growth, primarily trees, regardless of their use—timber, fish food, habitat, and so on.

Maintaining forest productivity

Forest productivity refers to a site's ability to maintain productive plant growth, primarily trees, regardless of their use—timber, fish food, habitat, and so on. Most riparian soils grow trees very well (whether for timber or riparian structure), although historically, riparian forests in some parts of the country had relatively few and irregularly spaced trees. Site conditions (drainage, soil texture, and flooding) vary greatly in riparian areas, affecting both which tree species are appropriate and how fast they grow.

Active management is required in many areas to obtain tree regeneration. Activities such as thinning may help you achieve management goals. To minimize soil disturbance and harvest costs, it's best to combine tree removal or instream log placement with nearby upslope thinning and harvest.

Why Do We Need an Assessment?

An assessment is the first step in establishing a riparian area that provides maximum potential benefits to fish, wildlife, water quality, and humans. An assessment can do the following:

- Describe existing functions with indicator variables, or conditions (more like an inventory)
- Compare existing functions to desired functions by measuring variables or conditions that indicate those functions
- Recommend projects or management changes to introduce or reintroduce streamside functions based on objectives

For example, an assessment describes the types of trees and grasses present, as well as how they affect fish habitat, water quality, and stream bank stability; identifies additional vegetation that could reintroduce desired functions; and outlines projects to reach proposed functions or processes.

A *reference site* is a riparian area with similar climate, landforms, stream gradients, soils, and potential vegetation throughout that is providing identified benefits to fish,

wildlife, water quality, and landowners. Reference sites can be used to identify ranges in local variability, but remember that they are just one snapshot in time and space and that the riparian environment is continually changing. In the absence of reference sites, reference conditions are established, based on historic conditions found in aerial photos, maps, books, pictures, and local knowledge. Also remember that functions or processes are the restoration goals—not particular structures found at another site.

The *proposed condition* is the desired riparian area, based on functions or processes (what is the maximum potential given the dynamic nature of riparian areas?). Proposed conditions must be within the area's potential or capacity for vegetation quantity and types. Examples of the range or variability of a site's capacity can be found in local reference sites or reference conditions.

Basic Components of Riparian Assessments

A riparian area assessment identifies which parts and functions of a riparian area are present and evaluates how they're functioning. Assessments commonly focus on the basic riparian components of vegetation, soils, and channel. The components can be broken down to subcomponents as follows:

Vegetation

- Species presence and diversity
- Overstory type (hardwood, conifer, open, or shrub)
- Age and size diversity
- Plant vigor
- Plant survival
- Root density
- Percent canopy cover (shade)
- Changes occurring in the plant community
- Future sources of large woody material for streams

Soils

- Soil type
- Percent of bare ground
- Percent organic matter or duff
- Erosion or deposition occurring
- Bank stability (i.e., presence of excessive erosion)
- Ease of water movement through soil (i.e., compaction)

Channel

- Size of floodplain
- Access to floodplain (e.g., is stream downcutting?)
- Riparian area growing or shrinking
- Beaver dam or logjams present

How you use this information to evaluate the riparian area and recommend changes depends on the functions you want to introduce or reintroduce to the area.

Considerations When Choosing an Assessment

Many types of assessments are available. The main difference among them is the detail of the data collected. Some basic assessments can be performed by landowners with a little guidance and other resources, while others require trained workers to gather and analyze the data.

The main question is, "How will the information be used?" If it will be used in a watershed assessment or combined with state agency information, it's best to follow accepted state protocols.

To conduct an assessment, list the questions you want to answer. Sample questions for a basic assessment could be, "How many conifers and hardwoods are present, and do I need to plant more conifers based on the functions I want the stream to achieve?" A sample question for a more detailed assessment could be, "What is the potential for future delivery of large woody debris into the stream channel given the current conditions?"

Make sure the assessment provides enough data to answer your questions. Review the types of data that will be gathered before conducting the assessment. Find some examples of data gathered with the methods you propose to use, possibly from natural resource agencies.

Divide the riparian area to be assessed into manageable units. This will give you more flexibility in using the data for planning enhancement projects and changes in management.

Some ways to divide riparian areas include

- Land use or management
- Riparian function (large areas of nonriparian vegetation versus areas with appropriate riparian species)
- Type of stream (small versus large, flows year-round versus only during storms)
- Valley type (wide floodplain versus steep canyons)
- Resource values (for example, different types of fish or water use)

Examples of Common Assessments

This section provides information on common riparian assessment methods. Its purpose is to familiarize you with common assessments and provide a basis for future training. This brief discussion isn't intended to be a guide for conducting assessments; all of the assessments presented require some training.

Basic assessments

Many types of basic assessments gather information for use on a local level. For example, landowners might want to evaluate their riparian area and make management changes, or a watershed group

might want to establish preliminary information and projects. The information collected does not always follow a statewide protocol and is used only by the people conducting the assessment. However, watershed councils in some states are strongly encouraged to follow statewide protocols for any sort of assessment.

One example is to combine photo plots with an inventory of quantity, quality, and type of trees present. The Oregon Watershed Enhancement Board has published a guide to establishing photo points for assessing watershed projects (see "Resources").

Another basic assessment is the Rangeland Watershed Program, which was created by the University of California Cooperative Extension. Its purpose is to help ranchers develop farm plans that address the condition of riparian areas, streams, and water quality. A rancher observes a stream and riparian area and then plans management practices based on these observations and their management objectives.

The evaluation sheet used for the Rangeland Watershed Program assessment requires a series of observations about the riparian area and stream and uses photos, data collection, and visual observations to identify whether an immediate management change is required or more information is needed. This method can be completed without extensive training in soils, hydrology, biology, or botany.

Intermediate and advanced assessments

The Bureau of Land Management and the U.S. Forest Service have developed a riparian area assessment method for evaluating the public lands they manage. They want this assessment to be adopted as a standard method by other agencies and private landowners, and they've hosted many workshops as part of their efforts. The method is called a Process for Assessing Proper Functioning Condition, or PFC. They determine potential condition by using "relic areas" and historic photos.

The process reviews characteristics similar to those listed above. To use this method, an assessor answers a series of questions. For example, are beaver dams present? If so, are they active and stable? Do riparian plants exhibit high vigor? Is there excessive erosion or deposition?

After completing the work sheet, the assessor rates the riparian area as either properly functioning, functional-at risk, or nonfunctional. A riparian area is considered to be *properly functioning* when adequate vegetation, landform, or large woody material is

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present to provide the basic functions appropriate for the area. A *functional-at risk* area is functioning but has a soil, water, or vegetation problem that is at risk of deteriorating. If the area is determined to be functional-at risk, the assessor determines whether this trend is deteriorating or improving. A *nonfunctional* area doesn't have the characteristics necessary to reduce erosion or improve water quality.

The PFC method should be used by a team of people with knowledge of soils, hydrology, and vegetation. The method requires observation but no data collection. It can, however, help identify data and monitoring needs and the source of problems. Copies of the PFC manual (#TR 1737-9 1993) are available from the Bureau of Land Management Service Center, SC-657B, PO Box 25047, Denver, CO 80225-0047.

The *Oregon Watershed Assessment Manual* includes a riparian assessment. This method assesses riparian conditions and relates the information to Oregon Department of Fish and Wildlife stream surveys and Department of Environmental Quality stream temperature information. The method also uses aerial photos and maps created by other assessments, which are described in the manual.

There are four steps to this method:

- The first step describes vegetation types and density, riparian area width, and the degree to which riparian areas are continuous throughout the drainage network (continuous versus clearings or patchy vegetation).
- Step two compares present levels of large woody debris in the stream with potential future large woody debris entering the stream from the riparian area.
- Step three measures the amount of shade on the stream and compares this with stream temperature data.
- Step four summarizes the overall riparian conditions and develops a map. Areas where increased shading levels, instream large woody debris, and improved riparian conditions may lead to improvements in stream habitat are identified.

For more information on the assessment manual and training, contact the Oregon Watershed Enhancement Board, Public Services Building, 255 Capitol St. NE, Salem, OR 97310-0203 (phone: 503-378-3589).

Riparian Silviculture

The four functions, or types, of management goals we discussed earlier lead easily into *silvicultural* (forest management) plans. The silvicultural principles of riparian areas are no different from those used elsewhere. However, there often are overriding riparian goals, such as creating stream shade or controlling soil erosion, that limit your choice of silvicultural system or physical activities.

Buffers

Forested buffers can be left along streams to protect instream and streamside riparian functions. Buffers or riparian management

areas are often required along many streams when timber is harvested.

Studies of buffers show that some can suffer blowdown, but at predictable locations. Most are biologically stable; that is, they develop largely as if they still were part of a continuous forest. Thus, buffers generally protect riparian functions for the life of the overstory trees.

Releasing conifers

Some riparian areas lack horizontal diversity of species. They often have young, healthy conifers in the understory of hardwood trees or brush. The conifers may not survive and grow through the overstory because of their shade intolerance. To allow them to grow, you'll need to *release* them by removing the overstory. The trees being released must have healthy crowns and be able to grow and occupy the space once the overstory is removed. Remove only the overstory trees that are affecting the desired trees. Spacing depends on the trees' tolerance to shade.

One way to release trees is to cut the overstory and remove it or leave it on the ground. Another method is to kill the overstory trees by cutting the cambium layer under the bark and letting the trees fall after they die. Chemical release is also effective, although you need to consider proximity of chemical use to the stream channel in order to protect water quality. This method uses aerial herbicide spray, manual spray, or a manual "hack and squirt" to kill the overstory trees. ("Hack and squirt" involves injecting or spraying a chemical on a scraped area of the tree.) Contact your local agency representative or a private licensed applicator for assistance and information on regulations.

Thinning

Thinning is most often used to maintain or increase rates of tree diameter growth. Heavy thinning starting when trees are young can produce very large trees in a relatively short time. These trees may be important for both wildlife habitat and for instream structural material.

Because of past fires in most of the United States and the dynamic nature of riparian areas, riparian tree cover today in many areas is dominated by less shade-tolerant species. Management activities often increase the amount of tolerant species. Because these species cast a dark shade, they decrease understory growth and diversity. Overstory thinning is one way to maintain this understory.

Riparian Enhancement Projects

Riparian enhancement projects aim to change the riparian area in order to restore or enhance essential ecosystem functions and maximize potential benefits. The most common goal of riparian enhancement is to create more shade and bank stabilization by planting trees. Increasing shade reduces solar input to these streams and may reduce water temperatures.

Riparian enhancement activities should not apply only to fish-bearing streams. Any

area that affects stream water quality is a candidate for enhancement. In fact, many non-fish-bearing streams in the uplands play an important role in providing cool, clean water.

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Many headwater streams and upland *ephemeral* channels (streams that flow only during storms) are potential sites for debris flows and landslides. This process supplies large wood to the stream system downslope. Current studies indicate that large trees in these areas can be the main source of large wood in streams.

Regeneration

Regeneration is the process by which new trees become established. Studies of tree regeneration in riparian areas (both those with buffers and those that are undisturbed) indicate that conifers and hardwoods can regenerate on their own in many areas. However, in many other areas, tree regeneration is limited by competition from understory plants, other overstory trees, and a shortage of nearby seed sources. In these areas, there isn't enough regeneration to replace the current forest, so active management for regeneration is needed.

The many ongoing studies of active management for tree regeneration in riparian areas clearly show that providing enough light and moisture and controlling browsing animals (beaver, deer, and cows) are critical to success. If these things are done, survival of planted seedlings is very good and growth is excellent.

Studies also show that heavy thinning of the overstory and removal of the shrubby understory provide adequate light for shade-tolerant species. On the other hand, less shade-tolerant species need small gaps (diameter greater than one tree height) for good regeneration. These less shade-tolerant species survive and grow slowly with less light, such as in the conditions created by an overstory thinning, but under these conditions their exposure to browsing animals is so prolonged that ultimate survival is limited.

The process of reestablishing trees in agricultural areas relies on planting seedlings or, for willow and cottonwood, cuttings. The two primary hazards to successful regeneration are (1) competition from grass and shrubs such as blackberry and (2) browsing by animals, including beaver, deer, elk, sheep, and cattle. Most agricultural tree regeneration projects use fencing to reduce browsing (see the section "Protecting Your Investment").

The right species for the right site

Riparian vegetation varies throughout the country, based on local conditions such as climate, soils, geology, and topography. Choosing the proper vegetation for a site is crucial for successful projects. Contact the

state department of forestry and the Cooperative Extension Service in your state for information about the proper species for your area.

Tree species vary in how well they tolerate floods or shade. Understanding these differences is critical to choosing where to plant trees in riparian areas. Plant trees that tolerate floods closer to the stream than those that do not. For example, willow trees tolerate floods and generally grow next to streams, while Douglas-fir does not tolerate floods and usually grows farther from streams.

Trees that tolerate shade generally survive better in the understory beneath other trees than do less shade-tolerant species. For example, in western Oregon, Douglas-fir does not tolerate shade, so it does not survive in the understory, whereas redwood and hemlock do.

Planting seedlings

Many publications explain how to buy, store, and plant seedlings with hoe dads, shovels, and augers. However, most publications are written for forest and agricultural land that has been cleared and prepared for planting and is outside of the riparian area.

Riparian areas, on the other hand, can have severe soil conditions. These zones are wet in the winter and dry in the summer and usually aren't prepared before planting. In addition to taking standard precautions when planting trees in these areas, you're most likely to be successful if you use superior nursery stock (vigorous, large trees in good condition) and prepare the site as much as possible.

Auger planting can be successful where the ground is hard and it's difficult to plant seedlings properly. Auger planting is more expensive and time consuming than planting with a hoe or shovel, but it may be necessary in some areas.

Spacing of trees in riparian zones differs from spacing in a timber stand. Since mortality can be high, a spacing of 8 feet by 8 feet isn't uncommon for nursery seedlings. When planting trees in a forested riparian area, spacing can be wider because soil conditions are usually less severe than in a riparian area that is being converted from pasture back to forest.

All riparian plantings require some maintenance to clear grass and brush around the seedlings. Also, scalping the surrounding grasses will reduce competition for water and give trees a boost during the first spring. Some people have been very successful planting trees on agricultural lands and providing irrigation in the summer.

Planting willows

Many agricultural riparian areas are being converted from grass to trees. Willows are often used to stabilize stream banks and begin this conversion process. Willows, cottonwoods, and some other hardwoods sprout readily from stumps and clippings. You can use a variety of methods to plant them. These methods are called *bioengineering*, which means using

vegetation and rock to restore stability to a site (usually stream banks, eroding hillsides, and eroding road cuts).

There can be many willow species throughout a watershed. Always take willow cuttings from a site near your enhancement site because these plants will be most adapted to conditions in the area. If you have to cut willows from a riparian area, limit the amount cut to maintain the existing willows.

The most common failure in planting willows is placing them in poor sites where they don't have enough water. Willows like to have their feet wet. Best success occurs when dormant willows are cut and planted in the winter, but because of flooding this is the hardest time of the year to plant. You can successfully cut and plant willows on a year-round basis if water is available (rain or irrigation). The lowest success has been reported when willows are cut while flowering.

Always plant willows within a few hours of cutting. Keep them wet and cool until planted.

Protecting your investment

There are many ways to protect planted or released trees from wildlife and livestock. A common way to protect trees from livestock grazing is to fence an area and provide water away from the stream. Another approach is to allow livestock to have minimal access to the stream through gaps in the fence called *water gaps*. With proper planning, seasonal grazing systems can also work in riparian areas.

Fences in riparian zones have a tendency to be flooded during storms. Smooth electric wire withstands floods the best and requires the least amount of maintenance after storms.

The most important point to remember when planning a grazing strategy is to use techniques that fit each landowner's management.

The most common and extensive wildlife damage to newly planted trees is from elk, deer, and beavers. Many kinds of tree protectors are available to reduce this damage. Most tree shelters reduce deer browse but don't work for elk. Large wire cages have had some success in limiting elk browse. Translucent, solid, plastic shelters have been used successfully to ward off beavers, as have chicken wire fences buried into the ground. To protect from beaver damage, some managers have found it effective to install hawk wire at three feet to four feet, and then lower down, at two feet, install chicken wire bent up in an L-shape. Tubex (solid plastic tubes) has also been effective in preventing beaver damage, especially for hardwoods. However, to prevent a chimney effect, install the Tubex well into the ground so no pocket of air exists between the ground and the base of the tube. The benefit of planting willows is that they usually resprout if browsed when young.

Monitoring Plans

A monitoring plan is essential for gauging the success of your efforts. It can show whether you are on track or have met your goals. For example, foresters establish monitoring plans known as forest inventories to evaluate the growth of a stand of trees over time. Ranchers establish monitoring plans to evaluate forage conditions in pastures throughout the year. However, the most important aspect of a monitoring plan is to know exactly why and what you are monitoring. Speak with a local technical specialist to help set up a proper design for monitoring.

Monitoring can keep you from repeating mistakes and justifies the investment of resources in your projects, whether private or public. If monitoring shows that the enhancement project has not established the proposed function through the information that indicator variables can provide, a new plan and project need to be developed.

Basic components of a monitoring plan

Some monitoring plans are as simple as an assessment that is repeated at regular intervals over time. Other monitoring plans include a formal explanation of the assessment, proposed project, and monitoring techniques. The Environmental Protection Agency has published several guides for developing and implementing monitoring plans. They describe a monitoring plan as containing three main components:

- Goals and objectives of the project
- Specific monitoring techniques and factors (*parameters*) to be measured
- A process to evaluate whether goals and objectives are being met. On the basis of this evaluation, you'll decide whether you need to change monitoring techniques or measured parameters.

The goals and objectives define the proposed future condition of the riparian area based on functions and the overall aim of the enhancement project. A goal is the overall aim of the project, whereas an objective is a subset of the goal and is measurable. One goal can have many objectives.

Some states might also have monitoring guidelines already in place. For example, in Oregon, the Governor's Plan for Salmon and Watersheds has such a guide, the *Water Quality Monitoring Technical Guide Book.*

Many monitoring plans establish intermediate desired conditions (benchmarks) between the present and desired future condition. For example, a newly planted riparian area will have an increasing volume of standing large wood over time. The intermediate benchmarks would be the desired large wood volumes at years 10, 25, 50, 75, and 100.

Specific monitoring techniques and parameters to be measured evaluate the riparian functions over time to see whether the objectives are being met.

Most good riparian monitoring techniques assess functions and indicators of functions over time. Thus, this chapter's section on assessments also applies to monitoring. The major difference between assessment and monitoring is that monitoring techniques generally focus on specific parameters related to an enhancement project, or a "treatment," and an assessment gathers data on multiple aspects of an area before any treatment takes place.

For example, a monitoring strategy might evaluate how many planted trees have survived and how many more trees are needed to fully stabilize a stream bank. Or each year you could evaluate the percentage of healthy conifers and hardwoods in a riparian area following a release of conifers.

One monitoring approach might be the following. Locate three points (two segments) on the same stream. Look at the average difference in the variable of interest between segment 1 and segment 2 (for example, the number of seedlings or the percent of established conifers). Install a treatment only in segment 2 (say, a fence). Take measurements in both segments over a given amount of time pertinent to the indicators you're measuring. Analyze the change between the two segments.

Monitoring techniques must be appropriate for your group. Consider factors such as cost, technical requirements, available equipment, and access.

Summary

- Management goals based on functions instead of physical condition create more opportunities for solutions.
- The following functions commonly are involved in riparian management goals:
  - —Providing structural diversity in and near streams
  - —Providing wildlife habitat
  - —Maintaining stream productivity
  - —Maintaining forest productivity
- Stream structures come from many and sometimes distant places; structure changes constantly.
- Different wildlife species use different aspects of riparian areas.
- The quality of fish habitat naturally changes with time.
- A mix of forest ages and types (conifer and broadleaf) along riparian corridors will provide the highest land and instream diversity.
- Active management techniques can enhance all riparian functions.
- An assessment tells you what is present, what is not present, and how the components are affecting what you value (water quality, fish habitat, and so on). It compares present function to desired functions and identifies management changes or enhancement projects that will establish the proposed functions.
- Basic components of a riparian area assessment include evaluations of how vegetation, soils, and the river channel are

functioning compared to a desired level of functioning.

- Several assessment methods are available.
- Riparian enhancement projects aim to restore or enhance essential ecosystem functions. They commonly involve increasing species diversity, age diversity, and width of riparian areas.
- Different tree species have varying tolerances for floods and shade. Consider these factors when choosing where to plant trees in riparian areas.
- A monitoring plan is an assessment of functions over time after an area has been "treated" with a project.
- Monitoring plans include three main components:
  - —Goals and objectives
  - —Specific monitoring techniques and parameters to be measured
  - —An evaluation process to see whether the desired function(s) are being met or monitoring techniques are adequate.

Resources

Training

For training events or personal consultation, contact your local watershed council, Extension Service office, soil and water conservation district office, Natural Resources Conservation Service office, or resource agency office (state department of forestry, state department of fish and wildlife, U.S. Forest Service, Bureau of Land Management, and so forth).

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Case Study

A Community Effort toward Watershed Management: Ames Creek, Sweet Home, Oregon

The Problem

Ames Creek is a semi-urban tributary of the South Santiam River, running through Sweet Home, Oregon (population 7,815). It is highly visible and important to the community, primarily because it runs through the city's Sankey Park, which hosts the annual Jamboree. The stream was dammed in the early 1930s to provide mill ponds for a large log mill. The dam remains, although it has not impounded water since the flood of 1996 filled the pond with sediment. Students from Sweet Home Junior High School, assisted by a U.S. Forest Service fisheries biologist, Todd Buchholz, have found steelhead smolts in the section of the stream between the dam and the South Santiam River and cutthroat trout in upper Ames Creek. Together they also tested the water quality and inventoried the riparian vegetation.

Among other findings, they discovered that the average daily peak water temperature often exceeded state standards for the long-term survival of both steelhead and cutthroat trout. As stream temperatures increase, the amount of dissolved oxygen available to aquatic biota decreases. As a result, even if food is abundant at higher temperatures, decreases in dissolved oxygen may metabolically stress salmonids, further increasing their susceptibility to disease. The results of the students' riparian surveys showed that nonnative vegetation, especially English ivy (*Hedera helix*) and Himalayan blackberry (*Rubus discolor*), was adversely affecting the shade trees along the stream through competition for light and moisture. Riparian conifers can provide shade over stream channels, channel-influencing root masses along the banks, and regular inputs of nutrients through the fall of litter. When these conifers die, they provide nutrients in the channel or on the forest floor, and refugia for fish and wildlife in the form of long-lasting woody debris. Hardwood species benefit stream ecosystems as well. The roots of hardwoods also provide bank stability. Although hardwoods provide only seasonal detritus, the quality of hardwood detritus is higher than that of coniferous detritus. Also, although hardwoods provide only seasonal shade, the shade occurs during critical periods of vegetative growth and intense solar radiation.

The South Santiam Watershed Council took special interest in this creek and worked with the city of Sweet Home and the U.S. Forest Service to improve the water quality and vegetation around Sankey Park. In summary, Ames Creek is a historic winter steelhead stream and was in need of habitat improvement.

Phase I—What Was Done

The watershed council applied for and received funding from the Oregon Watershed Enhancement Board, the Division of State Lands, and the U.S. Forest Service Willamette National Forest to improve conditions along a one-mile stream segment that runs through the park. They partnered with private homeowners, the Sweet Home School District, the Sweet Home Tree Commission, the Sweet Home Boys and Girls Club, and Linn County Affordable Housing. E&S Environmental Consulting Group was contracted to employ displaced timber workers and area youth from the Linn County Juvenile Department. Their efforts, combined with those of the volunteer watershed council and the community, removed blackberry and ivy and planted trees, shrubs, sedges, and rushes (which they decided they wanted to be native). They also removed garbage from the stream and reshaped berms of infill to make flatter regeneration surfaces for vegetation.

Because of the success of the work along the one-mile stream segment, the council pursued removing the dam in the park. This subject invoked larger, more involved meetings to discuss the pros and cons and repercussions. After a larger-scale effort to publicly promote this issue, invite key players, and hold multiple public meetings, the consensus was not to remove the dam. Instead, the council remembered that in the 1996 (100-year event) flood, the stream flowed *around* the dam, creating a new channel. They decided to help the stream find this path again and engineer it to flow around the dam, in the path of the 1996 flood. The partners hired a landscape architect to develop a plan to reestablish Ames Creek to a freer-flowing stream in the park and around the dam.

Phases II–V

As the community began Phase I of Ames Creek, they soon discovered that there was much interest in the project, and Sweet Home mobilized to improve other sections of the creek. Phase II will consist of work on property owned by 20 different landowners along a section of the creek running through the city of Sweet Home. Three-quarters of a mile below the dam, where there are houses on the banks, volunteers are sloping the banks back to their prehousing condition to reconnect the channel with the floodplain. Workers are also removing blackberry and planting trees and shrubs for shade and beautification.

Phase III will revitalize Ames Creek in the city of Sweet Home adjacent to Sanky Park, Sweet Home High School, and the new Community Center. The design for Phase III will incorporate the Sankey Pond dam, wetland conservation, boardwalks, trails, and fish passage to upstream areas. Phases IV and V will address the remaining stretches of Ames Creek, including modifying culverts that inhibit fish passage under a main road (Highway 20), addressing high levels of fecal coliform bacteria, and providing more riparian vegetation functions for water quality and fish habitat. Each project needs to address monitoring techniques. Overall project costs were estimated at $97,000. They received $47,000 in grant money and the rest from project partners.

Outcomes

Because of the watershed council's group enlistment and publicity of the Ames Creek projects, over 30 partners have since dedicated their time, energy, and funding to manage different parts of the stream that provide benefits to fish, wildlife, water quality, and city residents. These contributions taught the community what a project could look like that restores watershed functions. They not only improved conditions on the ground based on their objectives, but also advanced watershed council and community relations for years to come. And, for the first time in local memory, the governor of the state of Oregon paid a visit to Sweet Home to see the project for himself.

Key Strategies

1. Restore stream or watershed processes based on well-thought-out and explanatory objectives, not on an imposed reference site or an arbitrary point in time and space.
2. Have clear decision-making tools in place. The South Santiam watershed council chose consensus as their decision-making tool, which means that the group first flushed out differences in opinions and continued to have discussions until they arrived at item(s) they all agreed upon. They took action only on those items that everyone agreed upon.
3. Look to the community for monetary support.
4. Look to the community for local experts and data already possibly collected.
5. Involve local schools and natural resource agencies in collecting data, managing vegetation, and monitoring.
6. Identify all stakeholders in the geographic area using town or city records.
7. Widely publicize efforts.
8. Celebrate small successes.

For more information, contact Todd Buchholtz, U.S. Forest Service Sweet Home Ranger District, Willamette National Forest, 3225 Hwy 20, Sweet Home, OR 97386, 541-367-9217, tbuchholz@fs.fed.us.

Case Study

Christmas Tree Recycling Projects

by Mike Liffmann and Pam Blanchard

The Problem

Many regions of the country struggle with the effects of soil erosion. While the causes of erosion are often well known, doing something concrete to stymie the problem and raise public awareness is often more of a challenge. Two very different regions of the country struggling with the effects of soil erosion have turned to holiday spirit to help solve the problem. Catalina Island, California, and south Louisiana have begun using Christmas trees to reduce the effects of soil erosion, such as coastal wetlands and denuded hillsides and ravines. These Christmas tree recycling projects are important because they provide natural materials that can be used as a buffer to slow soil erosion in susceptible areas. In addition, the projects provide a means for the public to contribute to a solution as well as providing a way to recycle a multitude of Christmas trees that in the past would have been destined for a landfill.

What Was Done?

Christmas tree recycling projects are underway in many regions across the United States. Dead, dried-up Christmas trees are being rerouted from local landfills into projects that focus on reducing soil erosion.

Since 1992, the Catalina Island Conservancy has placed discarded Christmas trees in eroded areas and gullies on the island. Each year, as part of their conservation lesson called "Soil Stories," Catalina Island fourth grade students lay more than 300 trees end-to-end in these troubled areas. After more than 100 years

A Louisiana worker tosses another tree along a fence line, to slow erosion and help build and protect vulnerable areas within the marsh. The Christmas Tree Fence Project is operated by the Louisiana Department of Natural Resources.

of nonnative goats and pigs eating the vegetation and trampling the soil, barren hillsides wash away during rainstorms. As the trees slowly decompose in their new gully locations, they trap moisture, soil, and seeds, which allows plants to get a foothold in the new soil, thus slowing erosion.

Since 1989, the Louisiana Department of Natural Resources has been constructing Christmas tree fences to help protect the state's coastal wetlands. A wooden fence, or "pen," is first constructed in a shallow open-water area. Then, Christmas trees donated by Louisiana citizens after the holiday season are placed in the waiting pens. The Christmas tree fences serve as effective wave breaks in low-energy areas that help reduce marsh-edge erosion, enhance water clarity, and provide habitat for many fish and crustacean species. Over time, sediment will accumulate behind the fence and new marsh grass will begin to grow in areas that were once open water. Volunteers do most of the work involved in bundling the trees. State funds help cover construction costs of the tree fences in the marshes. A Louisiana State University researcher, John Day, modeled the concept after a similar practice in the Netherlands, where brush fences are woven from willow branches in shallow water to retain sediment carried in by the tides.

Fourth graders celebrate after helping place more than 300 Christmas trees end-to-end in erosional gullies on Catalina Island, California.

Outcomes

Between 1992 and 2000, nearly 3,000 Christmas trees were hauled to remote areas of Catalina Island to preserve topsoil and slow erosion. Native grasses and plants have begun to colonize under and around the trees. In Louisiana, hundreds of thousands of trees are used each year to stabilize vulnerable wetlands in 11 coastal Louisiana parishes. In 1998, the program had expanded to include 19 coastal parishes, and participants had built more than 38,000 feet of tree fences, using 780,000 Christmas trees. Both of these projects have made a

positive impact in protecting fragile areas, have raised the consciousness of citizens regarding erosion problems in their regions, and provided citizens with a way they can help protect these fragile areas.

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CHAPTER TWELVE

Stream Ecology, Evaluation, and Enhancement

by Derek Godwin and Jim Waldvogel

How do you increase salmon populations? How do you improve water quality? To answer these kinds of questions, you need some knowledge of the biological and chemical processes of aquatic ecosystems.

To be successful in managing timber, raising livestock, growing crops, or even planting a garden, you need to understand the basic needs and processes of the resources you're working with. The same is true of watershed enhancement. For example, before planning projects to enhance fish habitat, you need a knowledge of the basic life cycle of the species.

This chapter lays a foundation for understanding the biological and chemical processes of aquatic ecosystems, especially those that affect *salmonids*, the fish group that includes salmon, trout, and char.

It also identifies some techniques for evaluating and enhancing stream ecosystems and water quality. *Assessments* evaluate present functions of an area compared to desired functions that improve fish habitat, water quality, and so on—in other words, what you want the stream to look like in the future. *Enhancement* techniques change present conditions and speed up ecosystem processes to achieve desired functions for the area. (Note: For the purposes of this chapter, the term "enhancement" is used synonymously with the term "restoration.") *Monitoring* techniques evaluate changes over time.

Nearby riparian areas, wetlands, and forested uplands also have important relationships with stream ecosystems. Chapters 10, "Upland Evaluation and

In this chapter you'll learn

- How organic material is turned into food for fish
- The basic life cycle of salmonids and how life cycles differ among species
- Fish habitat needs
- Properties of water quality that affect fish survival
- How to assess a stream's present functions and its potential or capacity
- How to determine a stream's desired functions
- How to enhance the stream to reach the desired functions
- How to monitor changes over time to judge whether the stream is reaching the desired functions

Enhancement," 11, "Riparian Assessment and Enhancement," and 13, "Wetland Functions," discuss those parts of a watershed and explore their connections to water quality and fish habitat.

Parts of this chapter have been excerpted and adapted from the *Stream Scene* (ODFW, 1992) and the *Ecosystem Workforce Project Curriculum* (OSU, 1996; Adams and Dewberry chapter).

Aquatic Organisms

Healthy streams are highly diverse ecosystems. They contain food chains that range from microscopic organisms and algae to large fish. Two important indicators of water quality that help us study these food chains are *species diversity* (the number of species present) and *population size* (the number of individuals of each species present).

Benthic (bottom-dwelling) organisms are found on stones, in mud, or on vegetation. The stream bed serves as a place for them to attach in fast-moving streams. These organisms have specialized ways to obtain food. Some remain stationary and grasp food quickly or filter small food particles from the water. Others gather food from the bottom. Some insects leave their positions and are carried downstream short distances before reattaching to the stream bottom. All insects moving in the water, either as drifters or during emergence, are vulnerable to being eaten by fish.

Plankton are tiny plants and animals that float or swim freely throughout a stream. They cannot live where currents are rapid without being swept downstream. Consequently, they are abundant in slower waters of large streams and rivers. Many aquatic insects use streamside vegetation during emergence and as adults. Thus, overhanging vegetation is a source of insects, which become food for fish.

Primary food sources

Freshwater plants, also called algae, are one of the major sources of food for animals in streams. Algae often appear as a thin brown film on bedrock, boulders, gravel, and logs. This is what you slip on when walking in a creek. The film also may appear as long green threads floating in the water. Algae are very diverse, and a rock the size of a cantaloupe may have more algal species on it than the total number of species in the nearby forest.

In small forested streams, algae are most abundant during short periods in the spring and fall. Algal production is low during summer in streams that are completely shaded by the forest canopy. In larger streams with more open canopies, production is highest in the summer. In the Pacific Northwest, algal production is low during winter, when stream temperatures and light levels (short days) are low and storms scour the algae off rocks. However, in streams with deciduous vegetation, late winter algal blooms occur when leaves are off the trees.

Organic matter is the second major food category in streams. It includes leaves, needles, twigs, and logs. Leaves are the

most important source of food in this category. Some riparian tree leaves, such as maples, break down and are quickly available to organisms. Others, such as fir needles, take longer to decay but are available year-round. In small forested streams, organic matter may represent over 90 percent of the total food resources. Microorganisms are the food source located on this organic matter that is eaten by insects.

Most leaf litter comes from riparian zones along streams. Large winter storms bring in leaves from *ephemeral* channels (streams that flow only during major storms) and *intermittent* channels (streams that flow part of the year).

Wood, ranging in size from twigs to logs, also is a food source for some organisms. Large wood generally is a poor source of food, but it does trap smaller woody material and leaves. Most wood enters the stream during fall and winter storms as a result of tree blowdowns, bank erosion, and debris flows.

Fish biologists recently have researched the historic role of salmon carcasses as a major food source in streams in the Pacific Northwest. Significant numbers of spawning salmon have an impact on the nutrients available to an aquatic food chain.

Food processing

Aquatic *macroinvertebrates* ("macros") are organisms lacking a backbone that are large enough to be seen with the naked eye. Stream ecologists have devised a classification scheme for macros that identifies how they obtain food. This scheme aids in understanding how invertebrate communities are interconnected and how they work.

Shredders generally exist by shredding leaves into small pieces that they can eat. *Scrapers* (or grazers) live by scraping algae off rocks. *Collectors* gather small particles of organic matter. Some collectors make nets and filter the stream current for food, while others gather it from the bottom of the stream. *Predators* eat members of all of the macro groups. (Fish are members of the predator group.) Another macro group added by some scientists is *scavengers.* Although not yet identified adequately, this group feeds on salmon carcasses and other decaying material.

Figure 1 illustrates the pathways of energy from the sun to the four main macroinvertebrate groups. Some scientists add salmon carcasses as another source of energy. Figure 2 shows common macroinvertebrates found in stream systems.

River continuum

In forested streams, the relative importance of different food sources follows a predictable pattern from the *headwaters* (source) to the mouth of a stream system. This pattern is referred to as the *river continuum* concept. It is influenced by the size and slope (gradient) of the channel, bank stability, amount of sediment in the stream, nearby vegetation, light penetration, and temperature.

Figure 3 shows the river continuum of a typical stream system. Forests located at the

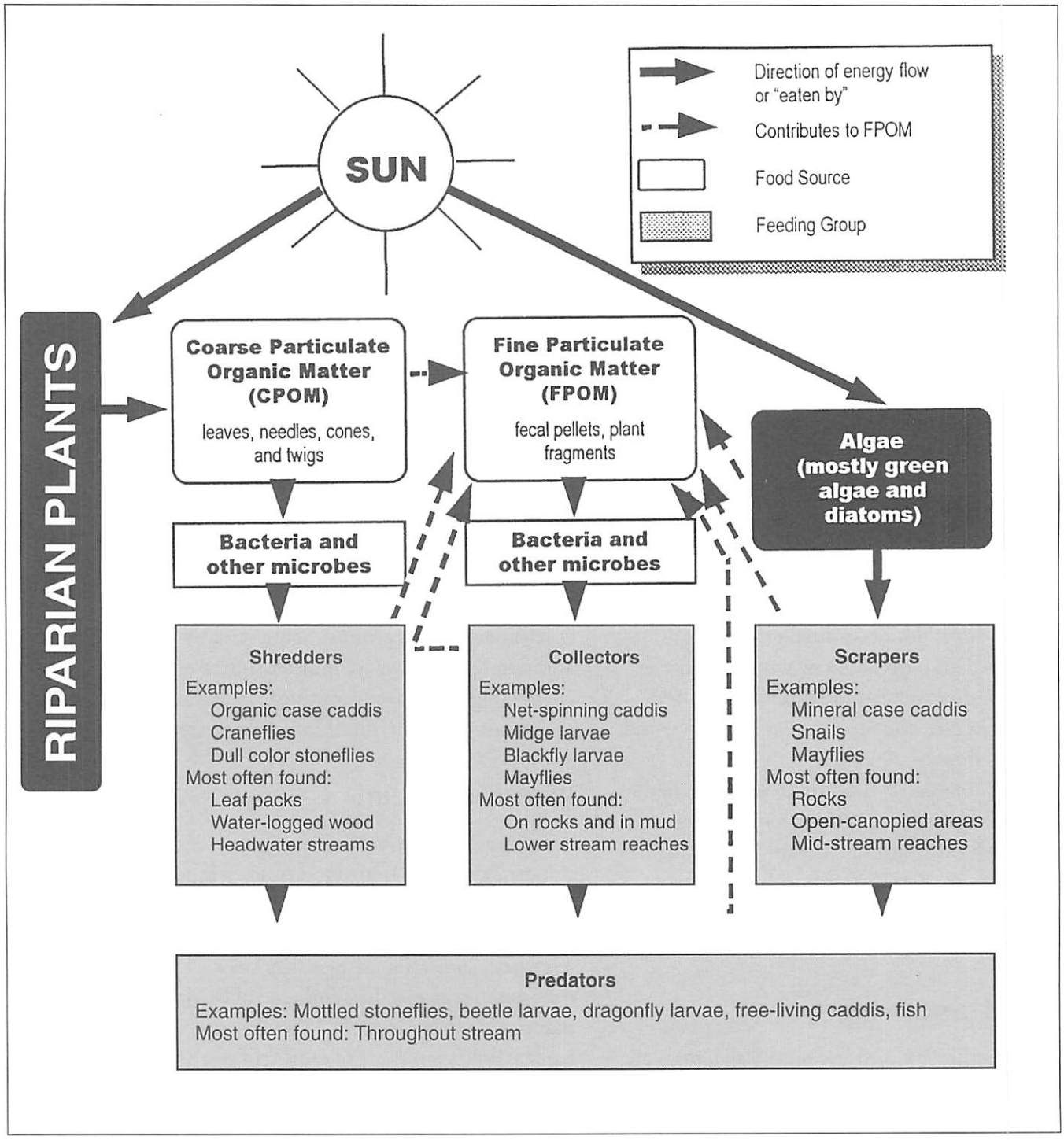

Figure 1. Food processing in streams. (Adapted from "From Headwater Streams to Rivers," by Ken Cummins, *American Biology Teacher,* 39:307 [1977]. Adapted with permission of the publisher.)

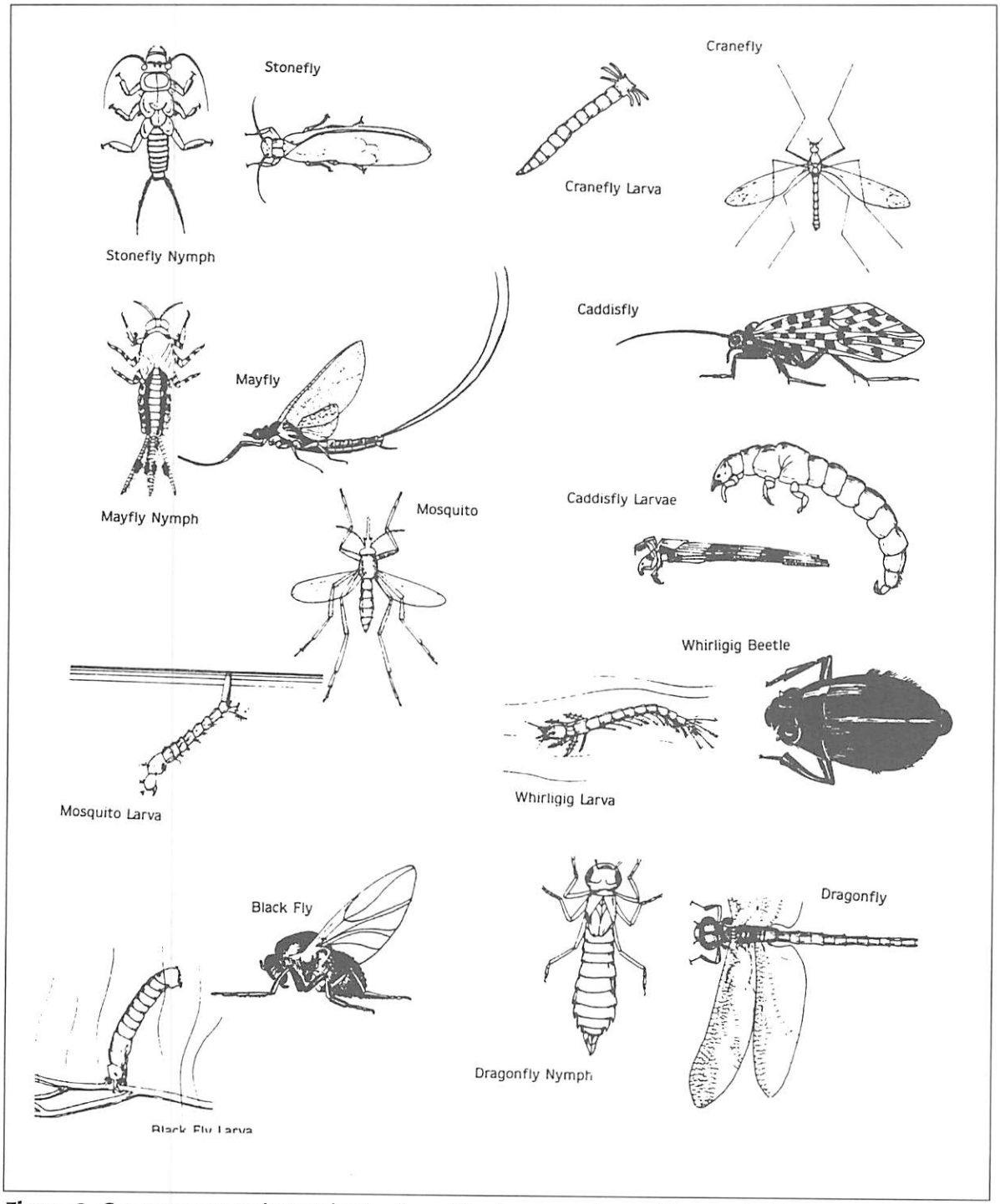

Figure 2. Common macroinvertebrates found in stream systems. (Source: *Project WILD Aquatic K–12 Curriculum and Activity Guide* [Houston, TX: Council for Environmental Education, 2001]. Reprinted with permission of the publisher.)

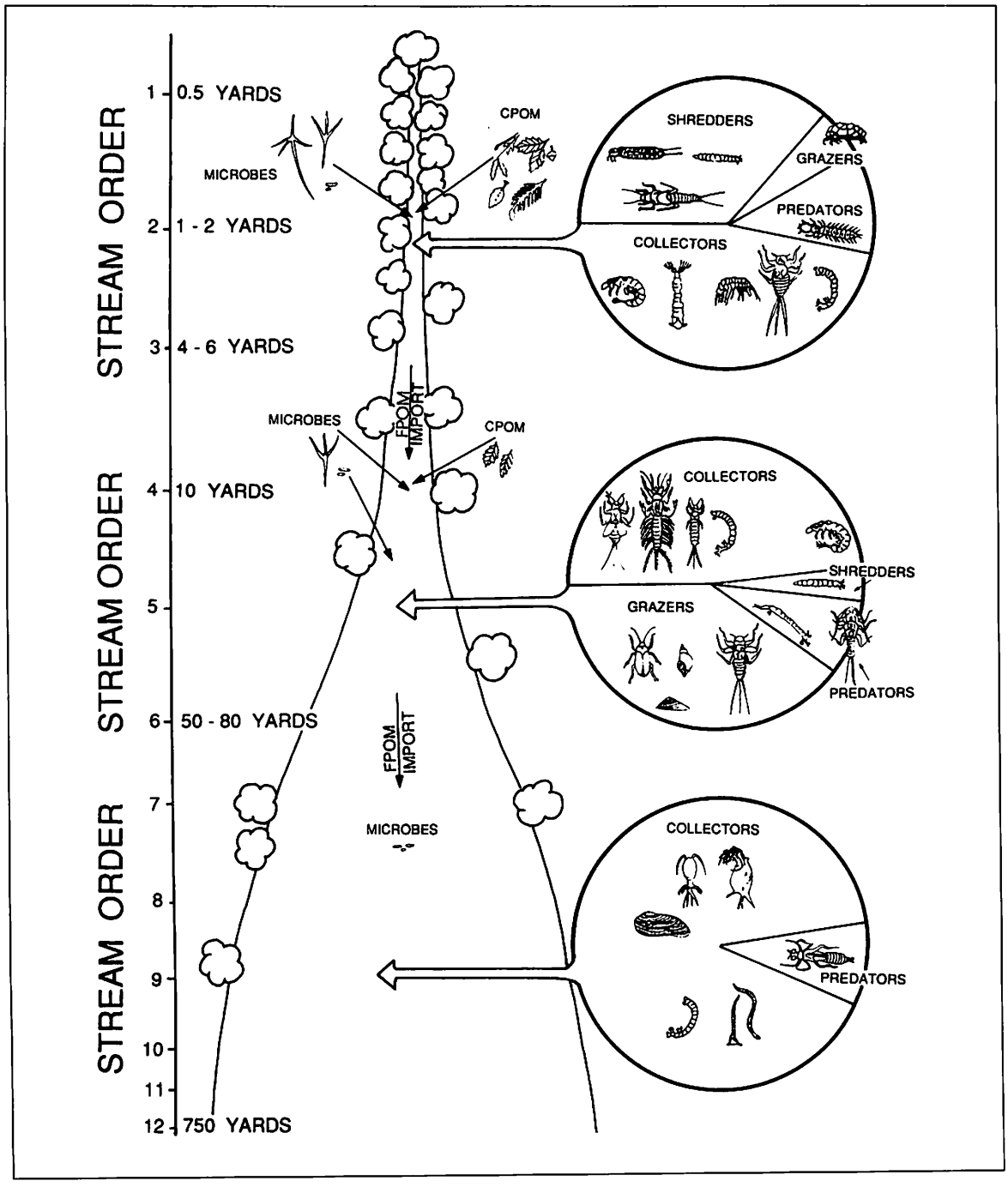

Figure 3. The river continuum concept (change in food processing and macroinvertebrates from headwaters to mouth). (Adapted from "From Headwater Streams to Rivers," by Ken Cummins, *American Biology Teacher,* 39:306 [1977]. Adapted with permission of the publisher.)

headwaters and along the banks have less influence as the stream gets larger. With less input from the riparian habitat, the energy base relies more on algae produced where the canopy is more open and on processed materials delivered by midriver tributaries. As organic material changes, there are fewer shredders and more collectors and scrapers.

Annual cycle of food resources in the Pacific Northwest

The annual cycle of food processing begins in early fall. In October, streamflows are low, and the amount of organic matter in a stream is low but increasing. Fall brings an increase in streamflow and leaf input to the stream. Many aquatic insects, that is, shredders, begin their life cycle at this time to utilize the increasingly abundant food.

By mid-November, streamflows have increased greatly and leaf fall is in full swing. As leaves fall and more sunlight reaches the stream, algal production increases. Adult salmon begin to return to the rivers to spawn. This is a time of maximum food availability.

When the first major storms of the fall occur in the Pacific Northwest, food supplies decrease. Most leaf litter can be transported downstream and deposited far outside the stream channel or buried in sediments. During winter, algal abundance continues to drop as high flows scour algae off rocks and gravel.

When spring arrives, streamflows decrease and algal production greatly increases until alders begin to leaf out. Spring is a highly productive time. Many macroinvertebrates complete their growth cycle and hatch. Spring also is a time of rapid growth for juvenile salmonids, which feed on macroinvertebrates.

Summer brings high productivity to a halt in most streams. Streamflows drop rapidly. Food resources are depleted because algal production is low. Juvenile salmonids rely heavily on insects from the riparian zone to make it through the summer.

Retention capacity

A factor in food processing is a stream system's *retention capacity* (its ability to store food resources). If organic material enters a stream system but is not retained, then few food resources are left for fish and other organisms. Streams that are properly connected to their floodplains have high natural retention capacity. Other important retention features in a stream channel include large wood, tree tops, root wads, debris jams, boulder clusters, backwaters, and alcoves. In general, the more complex and "messy" a stream is, the higher its capacity to retain material.

Salmonid Life Cycles for Selected Species in the Pacific Northwest

Salmonid is the group name for salmon, trout, and char. These fish have a common life history pattern. Many in the Northwest are *anadromous;* that is, they spawn in freshwater, migrate to the sea as juveniles, grow to maturity, and return to their freshwater stream to reproduce. Many

salmonids around the U.S. have similar life styles but never migrate as far as the ocean. Instead, these resident salmonids migrate to lower parts of river systems, lakes, and estuaries.

Adult salmonids spawn by burying their eggs in nests called *redds*. Spawning site selection depends on the species, gravel size, and flow pattern of the stream. A common spawning location is the "tail-out" of a pool—the area where a pool becomes shallow before entering a downstream riffle.

The eggs remain in the gravel for 45–70 days, depending on water temperatures. Hatching *alevins* (fry with yolk sacs for nutrients) remain in the gravel until the yolk sac is absorbed. They then work their way through the gravel and emerge into the stream channel as feeding fry. This is a critical stage for all salmonid species. During this part of their life, fry need adequate food and sediment-free water that contains lots of oxygen.

Natural mortality of juveniles is high during the first month. Many fry are eaten by birds, amphibians, reptiles, and other fish. Depending on the species, juvenile anadromous salmonids grow one to three years before migrating to sea as *smolts*. Smolts need to adapt from freshwater to salt water by spending transition time in the estuary. After maturing in the ocean, they return to the stream to spawn.

Generalizations often are made about where and when salmonids spawn within a river system. Life cycles vary greatly from river to river and among species (for example, winter vs. summer steelhead, spring vs. fall chinook, sea-run vs. resident cutthroat trout). Where several salmonid species coexist in a river system, each species has its own schedule for rearing, spawning, and migration, although it is not uncommon for juveniles and adults to occupy the same stream areas throughout the year.

Adult anadromous salmonids find their way back from the ocean to the streams where they were born. This feature of the life cycle is called *homing* and is one of the least understood yet most wonderful aspects of salmon ecology. Every local stream is a special home for a specific run of salmon—treasure it!

Figure 4 illustrates a general anadromous salmonid life cycle. Figure 5 shows the physical characteristics used in identifying juvenile salmonids.

Selected Salmonid Species in the Pacific Northwest

Chinook salmon *(Oncorhynchus tshawytscha)*

Chinook (king salmon) are the largest and longest lived of the Pacific salmon. They average 20–25 pounds as adults, although individuals as large as 100 pounds have been reported. There are two basic life-history patterns of chinook in Oregon—fall and spring. Fall chinook return from the ocean in late August through December. They spawn in main river channels and low-gradient tributaries. Since chinook are large, they can dig redds deep in the gravel, thus protecting the eggs from channel scouring during winter storms. If an unusually heavy

storm does scour the eggs and a year class is lost, successive generations can replace the stock because adult chinook spawn from three to six years of age. All chinook spawn once and then die.

Juvenile fall chinook emerge from the gravel in February or March. They stay in the stream only about 90 days. Most move into the estuary or lower main stem river by April to June. They generally spend the next three to four months in the estuary and then migrate to the ocean with fall rains.

Spring chinook adults return to rivers in the spring and spend the summer in deep pools. They spawn in early fall. The life histories of these juveniles are more variable than those of fall chinook.

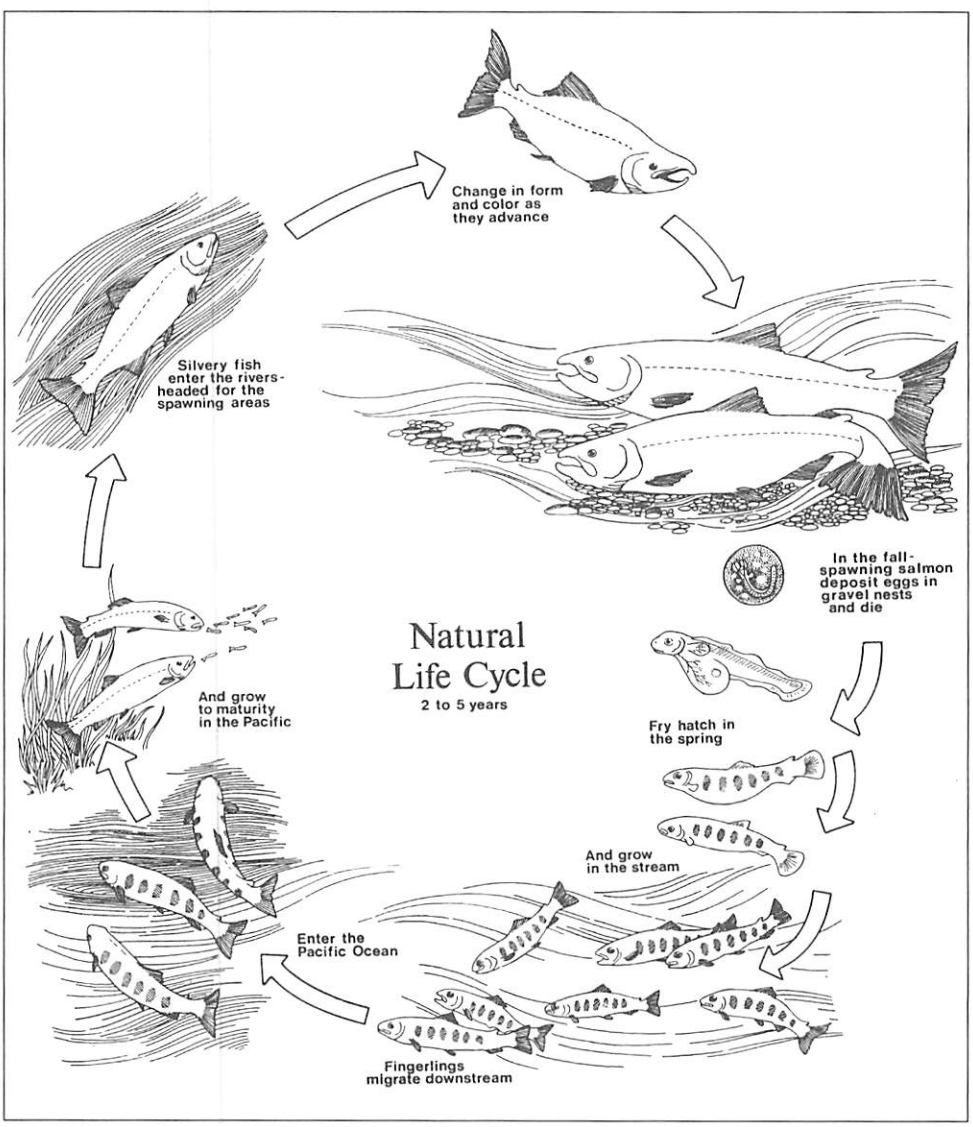

Figure 4. Typical salmonid life cycle. (Source: *The Stream Scene,* by P. Bowers et al., Oregon Department of Fish and Wildlife, Portland, OR, 1992)

Coho salmon *(Oncorhynchus kisutch)*

Coho salmon (silver salmon) historically were the most abundant salmon on the Oregon coast. Adults average 6–12 pounds and have a strict three-year life cycle. Because coho spawn mostly at age three with no year-class overlap, their survival is susceptible to catastrophic events. If a year class is lost, a

population is likely to remain depressed for a long time. Coho can recolonize tributaries from highly populated source areas. However, this species can be eliminated from a basin quickly if those areas deteriorate.

Coho spawn from November to March. They have two life-history patterns. Early coho enter streams on the first major storm of the year, usually in mid-November. If they are successful at spawning, their fry have the advantage of getting the first shot at the food resources. These fry also become the largest individuals, providing additional survival advantage.

Coho are not as large as chinook, they spawn in smaller gravel, and their redds are not as deep as those of chinook. Thus, their redds are more likely to be scoured out during winter storms. Therefore, a second stock of late coho has evolved to delay spawning until most major winter storms have passed, often as late as March or April. These two groups provide important genetic variation to the species and help coho withstand natural climate variations.

Coho juveniles generally emerge from the gravel from February through April. They prefer to live in pools with slow flow or in beaver ponds. Juveniles remain in the stream for a full year and then migrate to the ocean

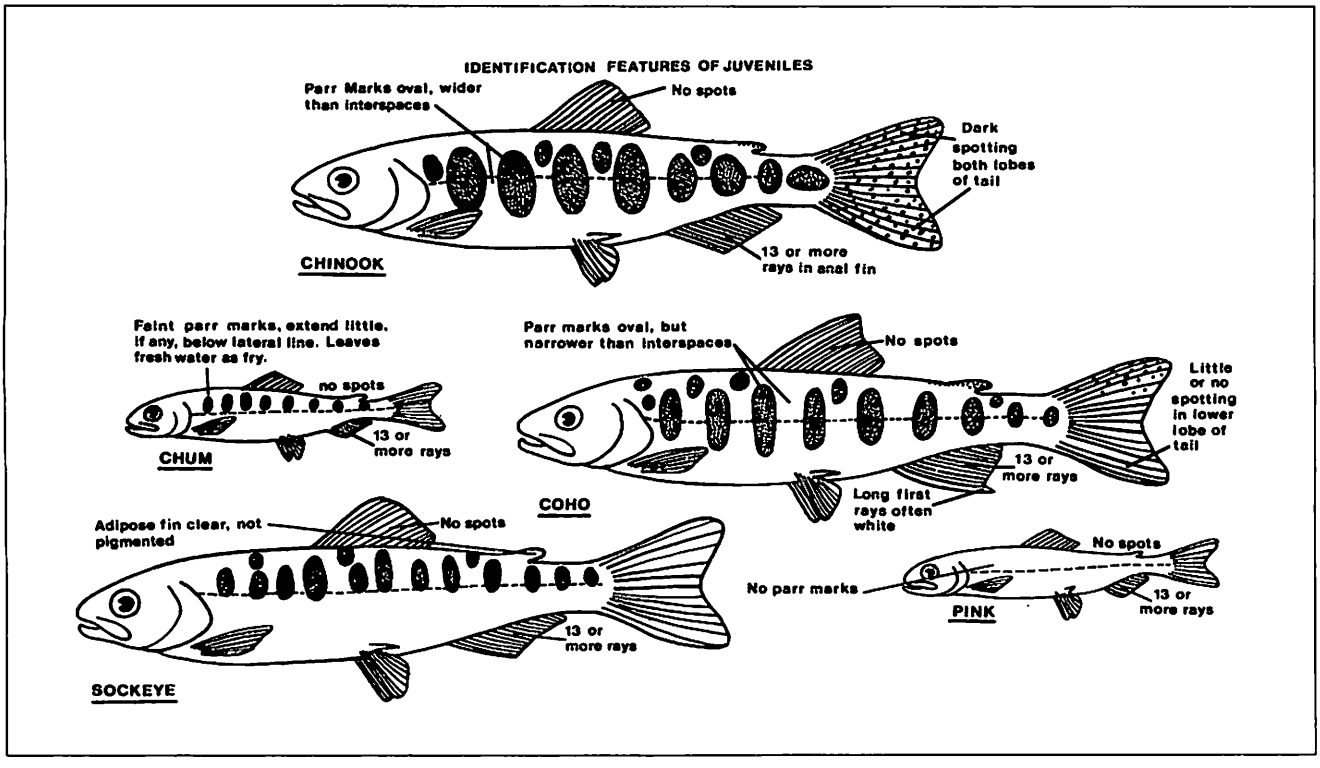

Figure 5. Physical characteristics used in identifying juvenile salmonids. (Source: *The Stream Scene,* by P. Bowers et al., Oregon Department of Fish and Wildlife, Portland, OR, 1992)

in April or May. Some coho return as two-year-old jacks (males), but most return as three-year-old adults.

Chum salmon (*Oncorhynchus keta)*

Chum salmon are the third most common species of salmon in the Pacific Northwest. Unlike coho and chinook, they spend little time in freshwater. Most chum adults spawn in the fall in lower river systems just above tidewater. The fry emerge from the gravel in the spring and immediately migrate downstream and quickly enter the ocean. Chum salmon usually live three to four years and weigh about 7 to 10 pounds.

Steelhead *(Oncorhynchus mykiss)*

Steelhead are seagoing rainbow trout. Adults average 8 to 12 pounds, and some adults live as long as seven years. Winter steelhead return from the ocean from December through April, allowing them to move into the headwaters of streams during winter flows. Like salmon, they deposit their eggs in gravel. However, not all steelhead die after spawning. About 30 percent survive to spawn again in the stream of their birth.

Juveniles emerge by June. During the first year they live in riffles and along the edges of stream channels. Therefore, low water conditions can severely affect steelhead. They spend two to three years in a stream before migrating to the ocean. This long freshwater residence time also makes them vulnerable if their habitat is degraded.

Summer steelhead adults enter river systems from April through August. Unlike winter fish, but like spring chinook, these steelhead need deep, cool pools to reside in until spawning in January–February. The juvenile life history of summer steelhead is similar to that of winter fish.

Cutthroat trout *(Oncorhynchus clarki)*

Cutthroat trout have variable life-history patterns. Some go to the ocean, while others remain in freshwater their entire lives. Some stay in certain portions of a stream, while others move throughout the river system. Cutthroat spawn in the fall and spring, depending on life-history patterns. Juveniles emerge by June or July. Cutthroat trout can be distributed throughout some river systems.

Bull trout *(Salvelinus confluentus)* and Dolly Varden *(Salvelinus malma)*

Bull trout and Dolly Varden are native char in the Pacific Northwest. Like other chars, they spawn in the fall, and the juveniles emerge in late winter or spring. Their life history is quite variable. Dolly Varden are the anadromous species, and bull trout is the similar resident species found in Oregon.

Most populations of bull trout are depressed. They are very dependent on cold

water seeps and springs. Bull trout do not tolerate fine-sediment input.

Habitat Needs for Salmonids

Salmonids use a variety of stream types. Although each species has its own specific habitat requirements, some generalizations can be made (figure 6).

Spawning habitat

Successful spawning and development from egg to fry stages require the following:

- No barriers to upstream migration for adults
- Spawning areas (usually in a riffle or at the tail-out of a pool) with stable gravel free of fine sediment
- A combination of pools and riffles that provides both spawning areas and places to hide nearby
- A constant flow of clean, well-oxygenated water through the spawning gravel

Rearing habitat

Fry are vulnerable to predators and must endure high streamflows and food shortages. They need pools for rearing, temperature regulation, and cover. Good juvenile-rearing habitat exhibits the following characteristics:

- Low to moderate stream gradient (slope) and velocity
- A good mix of pool and riffle habitats
- Clean, oxygenated water and cool stream temperatures
- A variety of bottom types to provide habitat for juvenile fish and food organisms
- Overhanging vegetation, large woody material, and stream cutbanks, which provide protection for juvenile fish and leaf litter for aquatic insect food
- Sufficient nutrients to promote algal growth and decomposition of organic material

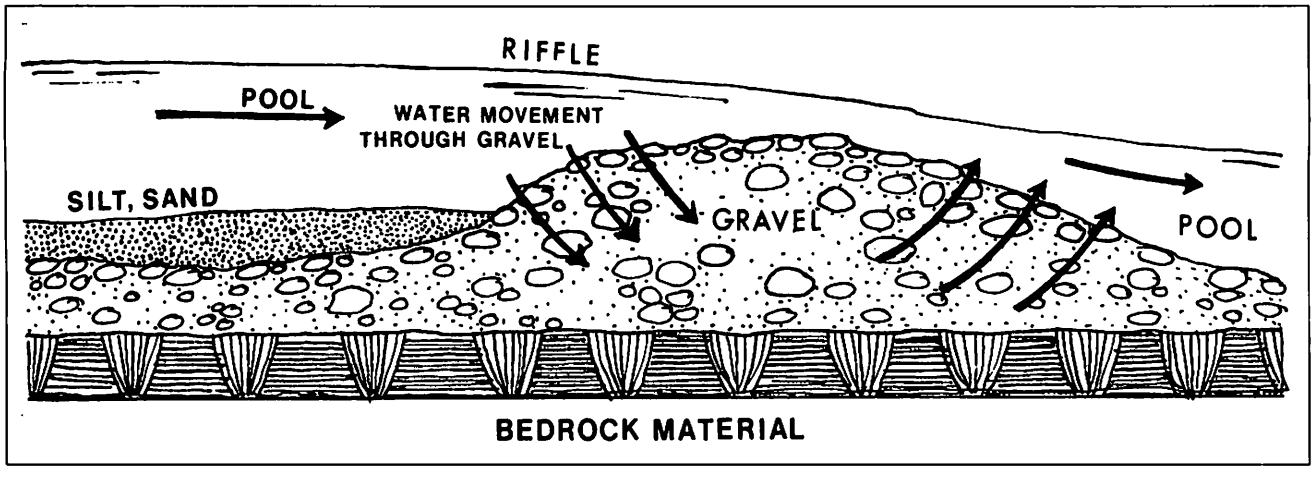

Figure 6. Spawning habitats. (Source: *The Stream Scene,* by P. Bowers et al., Oregon Department of Fish and Wildlife, Portland, OR, 1992)

As young fish grow, they seek increased summer flow, moving from the edge of a stream to midstream to take advantage of insect drift. In winter, all species seek areas of lower water velocity where they can conserve energy while food and growing conditions are limited.

Habitat use

Although their basic requirements are the same, salmonid species differ in the types of habitat they use. For example, juvenile coho prefer pool areas of moderate velocity in summer, especially those with slack water current near undercut stream banks, root wads, or logs. In winter, they seek slow, deep pools or side channels, using cover under rocks, logs, and debris.

Conversely, juvenile steelhead spend their first summer in relatively shallow, cobble-bottomed areas at the tail of a pool or shallow riffle. During winter, they hide under large boulders in riffle areas.

In summer, older steelhead juveniles prefer the lead water of pools and riffles where there are large boulders and woody cover. The turbulence created by boulders also serves as cover. During winter, these steelhead juveniles are found in pools, near streamside cover, and under debris, logs, or boulders.

Cutthroat trout habitat requirements are similar to those of steelhead with the exception that they spend the summer in pools.

Chinook juveniles tend to rear in large tributaries, and their habitat requirements are different from those of coho. For example, estuarine residence and growth are key elements in a chinook life-history pattern. Coho salmon require backwaters, beaver ponds, or side-channel rearing habitats to survive high winter flows and low summer flows.

Limiting factors

The quantity and quality of spawning and rearing habitat limit the success of spawning and the production of smolts. These limiting factors establish the *carrying capacity* of a stream. Carrying capacity is the number of animals a habitat can support throughout the year without harm to either the organisms or the habitat. Depending on the limits of available habitat, salmonid populations fluctuate annually as a result of varying environmental factors (for example, extreme high and low streamflows, high stream temperatures in the summer, or ice). A stream does not necessarily reach its carrying capacity each year because of these factors.

Water Quality and Quantity

Water quality for human uses as well as for fish and wildlife habitat is a primary interest in all watersheds. Even in areas undisturbed by human activity, streams do not have pure water. All water contains some dissolved chemical elements, particulate matter, and organic matter. The amounts of these substances vary with different watershed conditions.

Water-quality standards are established by state and federal agencies. For example, to avoid health problems, nitrate-nitrogen

concentrations must not exceed 10 parts per million in water used for human consumption. Water quantity affects water-quality parameters and subsequently fish, especially during summer low flow conditions. Extracting too much water from a system is just as harmful to fish as are certain water-quality parameters.

Physical

Important physical water-quality characteristics include temperature and sediment loads. Stream temperatures regulate the metabolism of cold-blooded animals such as fish. High temperatures can be stressful to fish, and extreme temperatures can be lethal. High temperatures increase metabolism, and fish cannot eat enough food to maintain body weight under these conditions. In addition, as temperatures increase, salmonids become less competitive in catching food and lose their appetite. High stream temperatures also promote disease organisms and excessive algal growth ("blooms").

Stream temperatures are affected primarily by solar radiation (sun), cool-water seeps, the volume of water in the stream, and the water temperature directly upstream. The relative impact of each of these factors varies within the watershed. In general, smaller streams are affected more by solar radiation and cool-water seeps, whereas larger streams are affected more by stream volume and water temperatures directly upstream (*Stream Temperatures,* 1997).

Sediments occur naturally as products of weathering and erosion. Nutrients necessary for life are carried as sediments in streams. There are two basic types of sediments in streams—suspended and bed load.

Suspended sediments are fine sediments, such as clays, silts, and fine sands, that are carried in the water. *Total suspended sediment* is a measure of how much sediment a stream is carrying. Too much fine sediment can damage gills and stress fish, reduce oxygen flow, and suffocate eggs. It also reduces light penetration, giving water a murky or cloudy appearance. *Turbidity* is the term used to describe and measure the degree to which light is blocked.

Bed load sediments are too heavy to be constantly suspended. They roll and bounce along the bottom of a stream. The location and size of the particles vary with the volume and speed of the water. Spawning gravel is transported as bed load during high winter flows. Excessive bed load movement can decrease or alter the spawning success and habitat of anadromous fish.

Chemical

Important chemical water-quality characteristics include dissolved oxygen, nutrients (for example, nitrogen, phosphorus, and potassium), manufactured chemicals, and pH.

Most salmonids need high oxygen levels to survive. Dissolved oxygen is measured in milligrams per liter of water, or parts per million of oxygen to water.

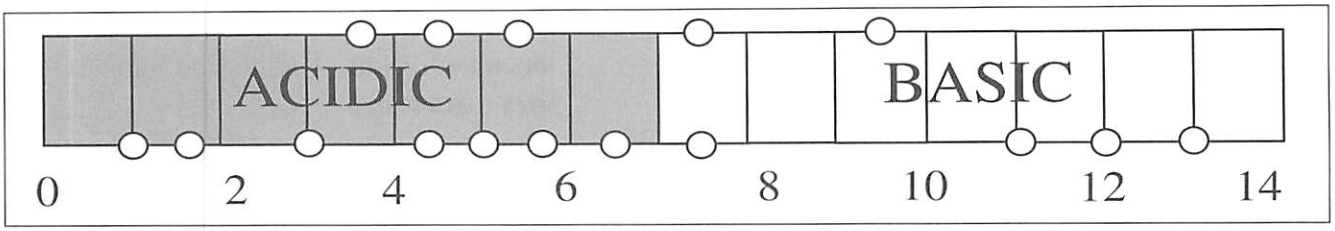

Figure 7. pH scale. (Source: *The Stream Scene,* by P. Bowers et al., Oregon Department of Fish and Wildlife, Portland, OR, 1992)

Dissolved oxygen levels are affected by altitude, water agitation, water temperature, types and number of plants, light penetration, and the amounts of dissolved or suspended solids. Since water absorbs oxygen from the air, waterfalls and turbulent water can add significant amounts of oxygen to water. Temperature directly affects the amount of oxygen in water; the colder the water, the more oxygen it can hold. Plant photosynthesis also can increase the amount of oxygen added to the water. The chemical decomposition of organic matter, on the other hand, removes oxygen. Most dissolved oxygen problems in streams occur in summer when temperatures are at their highest and streamflows are at their lowest.

Nutrients such as nitrogen, phosphorus, and potassium are needed for growth of the plankton and algae that form the food base for fish. However, excess amounts of these nutrients can cause excessive algal blooms. While alive, algae decrease light penetration, and when dead and decomposing, they decrease dissolved oxygen. Manufactured chemicals (pesticides, herbicides, oil, and so forth) also harm fish when excess amounts are present.

The concentration of hydrogen ions in a solution, called pH, determines whether a solution is acid or alkaline. The pH scale ranges from 1 (acid) to 14 (alkaline or basic), with 7 as neutral (figure 7). The pH can affect nutrient, chemical, and biological reactions and characteristics of water. Most organisms have a narrow pH range in which they can live.

Air pollution increases concentrations of sulfur and nitrogen oxides in the air, which fall with rain as weak sulfuric and nitric acids ("acid rain"). Acid rain has caused major changes in stream pH in portions of the eastern United States, but it is not a problem in western states.

Biological

Important biological water-quality characteristics include organic matter and living organisms. Organic matter such as leaves and similar material is very important for the aquatic food base, but excess amounts can reduce dissolved oxygen. All water has some organisms (for example, bacteria and insects) that are normal and often beneficial. However, imbalances or harmful pathogens (disease-causing organisms) may cause problems for fish, wildlife, or people.

Fecal coliform bacteria are used as an indicator of pathogenic bacteria. A large number of fecal coliform bacteria may indicate a contamination problem. Specific standards are set by each state to indicate when fecal coliform amounts are causing poor water quality.

Water-quality dynamics

Watershed hydrology and other characteristics (erosion, channel features, riparian areas, and so on) affect local water quality and how land use and management may alter water quality. (See chapters 8, "Watershed Science," 11, "Riparian Assessment and Enhancement," and 13, "Restoring Wetlands in Your Watershed.") In a given watershed, most water-quality characteristics vary over time. Streamflow and weather conditions are among the most important factors that can alter water quality seasonally or over shorter periods.

To accurately monitor water quality, it is necessary to take lots of samples, especially when attempting to identify changes, whether caused by human activity or natural influences. The interplay over time of water-quality parameters and salmon life history needs is important. Not only the quantity and quality of water, but the timing of flows specific to life cycle needs for salmon must be considered.

Why Do We Need an Assessment?

An assessment is the first step in establishing stream conditions that provide maximum potential benefits to fish and other aquatic life, water quality, wildlife, and humans. A stream assessment

- Describes existing conditions and functions
- Compares present conditions to reference conditions or desired functions that improve fish habitat or water quality
- Recommends projects to reach desired conditions or determines that current management provides desired conditions

For example, assessments describe the available fish habitat or water-quality conditions, estimate abundance of spawning fish or smolts, or measure a stream's length and its relation to its floodplain.

Basic Components of Stream Assessments

A stream assessment identifies the physical (stream channel), biological, and water-quality characteristics of a stream and evaluates how they're functioning. Table 1 summarizes the basic components of stream assessments.

How this information is used to evaluate stream conditions and recommend changes depends on local reference conditions (sites and best information available) and desired functions.

Considerations When Choosing an Assessment

Streams are affected by many watershed processes, land uses, climate, geology, and other factors that make assessment techniques

Table 1. Basic components of a stream assessment.

Stream channel	Biological	Water quality
Number and quality of habitat units (pools, riffles, glides, etc.)	*Fish population estimates (number of juveniles, spawning adults, etc.)	*Suspended sediment and bedload movement
Width, depth, and length of habitat units	Presence of different fish species	Turbidity
Streambed materials (gravel, cobble, boulders, sand, etc.)	*Abundance of fish utilizing available habitat	Stream temperature
Stream gradient (slope)	Number and type of macroinvertebrates	Dissolved oxygen
Relation of stream to its floodplain		pH
Single or multiple channel		Bacteria
Riparian condition and stream bank erosion		Nutrients (nitrogen, phosphorus, potassium)
Cover for fish (large wood, boulders, stream banks)		

*These components are more expensive and usually are obtained only by resource agencies.

complex. A combination of assessments that evaluates physical, biological, a*nd* chemical conditions is necessary to understand a stream. Many types of assessments are available; most are time-consuming and require technical skills. Choose an assessment that will work for your group, considering your time, money, and access to technical resources and training. Chapter 9, "Assessment and Monitoring Considerations," provides additional information about the complexity of assessment.

It is recommended that you use common assessment techniques that gather information in a standard format. Using standard methods allows the information to be analyzed and used by many different audiences, such as state and federal agencies, private consultants, and other watershed groups. For example, in Oregon, the Department of Fish and Wildlife has developed basic and advanced stream habitat surveys, the Department of Environmental Quality has developed water-quality assessments and monitoring techniques, and the Oregon Watershed Enhancement Board's *Oregon Watershed Assessment Manual* uses and builds on these assessments.

To conduct an assessment, list the questions you want the assessment to answer. Then choose an assessment that provides enough data to answer these questions. To assist in these steps, find some examples of data gathered using your proposed methods and the questions these assessments addressed.

Gather appropriate data to compare current conditions to reference sites or desired functions. A *reference site* is a similar stream that is considered to provide the desired functions to support fisheries and good water quality. In the absence of reference sites, *reference conditions* or *functions* are established for factors such as abundance of pools and amount of large wood. Because watershed conditions may have been changed by floods or human activity, historical photos and survey notes are useful for determining the reference condition or potential functions the site is capable of providing.

Consult local state, federal, and private representatives for information about appropriate reference sites or conditions.

Make sure the reference information and desired functions are pertinent to the local ecosystem (stream size, geology, climate, landscape, and so on). The same stream naturally has different characteristics at different locations in the watershed. For example, a small, steep coastal stream may be too steep to store large wood and may naturally consist of boulders with small, cascading waterfalls. As the stream grows larger and becomes flatter, it naturally may become able to store large wood.

Divide the stream to be assessed into manageable units. This will give you more flexibility in using the data for planning enhancement projects and changes in management. Some ways to divide stream segments include

- Land use or management
- Type of stream (for example, small versus large, flows year round versus seasonally)
- Valley type (for example, wide floodplain versus steep canyon)
- Resource values (for example, different types of fish or water use)

Assessments of Stream Biological Characteristics

Macroinvertebrate surveys

Macroinvertebrate surveys classify species based on the role they play in the food web. Stream macroinvertebrates are separated into four feeding groups—shredders, collectors, scrapers, and predators.

Macroinvertebrate surveys help you assess the food base of a stream ecosystem. You can use the results to analyze water quality and fish habitat. Each state has specific protocols for surveying macroinvertebrates and using the information to describe stream conditions (that is, water quality and fish habitat).

The following section provides a general overview of how macroinvertebrates are surveyed and how the information might be used. To use these techniques, you'll need to obtain additional training. The methodology described is based on Cummins and Wilzbach's survey procedures (see *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates*). Many agencies, institutions, and private entities have adapted these procedures for their own use.

General methods

The best times to conduct these surveys are midwinter through early spring, or mid- to late summer. At these times, individuals in the winter or summer populations have grown to full size and are easiest to see. Macroinvertebrates are collected from three to five of the following habitat types:

Coarse particulate organic matter—for example, leaves, needles, bark, and twigs (>1 mm in size)

- Large wood—large branches and logs
- Fine particulate organic matter (>0.5 um, and ≤1 mm)
- Periphyton—predominantly attached algae on rock and wood surfaces
- Attached vascular plants (only if extensive plant beds or moss cover is present)

To do a macroinvertebrate survey, assessors collect a handful-size sample from each habitat type. They then identify macroinvertebrates by functional group, sort them into separate containers, and count them. Appendix C provides a key to functional groups and a sample sheet for recording data. After individuals are counted, the next step is to compare total numbers in each group and calculate ratios of one group to another. For example, the shredder:collector ratio is compared to the scraper:collector ratio.

From survey to assessment

Use macroinvertebrate surveys to assess water quality and fish habitat by comparing the assessed stream to a reference stream or

conditions. Combining macroinvertebrate surveys with physical habitat and water-quality analyses provides a more thorough analysis. For example, a small stream with very few trees in the riparian area will have a different shredder:collector ratio than a reference stream with many trees. A stream dominated by riffle habitat will have different ratios than a reference stream with more pool habitat. A stream with poor water quality will have fewer organisms, and these organisms may show unhealthy characteristics. Contact your state agency for specific examples and assessment protocols.

Fish population surveys for salmonids

When assessing stream habitat and watershed health, don't forget to consider fish. Fish population surveys identify and estimate fish resources. Salmonids have differing life-history patterns; therefore, you should choose a sampling technique appropriate for the species or life stage you plan to assess.

All fish sampling and data collection must be approved by and coordinated through a state department of fish and wildlife. The recent listings of some salmonid species under the Endangered Species Act require permits from the National Marine Fisheries Service or the U.S. Fish and Wildlife Service or both to conduct surveys.

Fish population surveys document populations in a specific tributary or watershed. The following data are useful for evaluating fish populations:

- Presence or absence of species
- Spawning area distribution
- Species composition
- Relative abundance, that is, the number of adults or juveniles
- Timing of spawning or juvenile migration

Upper and lower limits of fish distribution

The techniques you choose depend on what information you need. Surveys may consist of simply noting whether a species is present in a particular stream or may include a comprehensive analysis of the fish population in the entire watershed. The survey may involve researching existing information or collecting new data.

You can obtain much of the information you need without capturing fish, in other words by using *noncapture* techniques. Use these techniques whenever possible because capture techniques sometimes kill fish.

Noncapture techniques

Use noncapture techniques to document what fish are present, how many are present, and how they are using certain habitats during different life stages. Techniques are categorized as *stream bank* (above water) or *direct* (underwater) observations.

Examples of stream bank observation are

- Visual spawning counts—number of live adults, carcasses, or redds (nests) in a survey area

- Visual verification of the presence or absence of juveniles or adults
- Surveys of existing sport fishery catches (*creel census*)
- Photographic or video surveys
- Sonic tracking—monitoring sonic-tagged fish

Spawning counts are used to create an *index of escapement* (the number of adult fish in a defined spawning survey area). These surveys provide good population estimates when conducted over a period of years.

Spawning data are collected by counting live fish, carcasses, redds (nests), or combinations of all three. Most spawning surveys of coho and chinook salmon use live fish and carcass counts. Redd counts commonly are used for steelhead because the adults may not die after spawning. Appendix D shows an example of the proper procedure for conducting a valid spawning survey on small coastal streams in Oregon.

Walking stream banks during summer low flow conditions is a good way to verify the presence or absence of fish. Using polarized glasses, you can see juvenile fish in small streams. However, it can be difficult to identify specific species of juvenile fish from the bank.

Direct underwater observation is a common technique to identify species, estimate numbers, or determine how different species and ages are using certain habitats. Experienced divers can quickly identify and count juvenile and adult fish. Underwater observations usually are conducted in pools and runs, not in riffles. This technique requires snorkeling equipment, a wet or dry suit, and trained divers.

Where sportfisheries exist, some methods of creel census are used. These surveys randomly sample sport angler catches. They are useful for identifying species and aging fish or for gathering return data for marked hatchery fish. Volunteer samplers and experienced biologists can collect data from large river sections using this method.

Photographic or video observations are used to identify species or count migratory fish, most frequently at fish ladders or other passage restrictors (traps, tunnels, or culverts). These techniques require technicians and expensive equipment.

Sonic tracking methods sometimes are used by fishery researchers. Sophisticated equipment is required, and technicians are needed to run these systems.

Capture techniques

Fishery biologists use several types of *capture* techniques to gather detailed information about fish populations (see *Methods for Stream Habitat Surveys*). These methods involve capturing, handling, marking, and releasing fish. Fish sometimes die during collection or after being captured. Therefore, it is important to choose the proper technique. Capture techniques include seining, trapping, electrofishing, and sportfishing. All of these methods require permits from a state department of fish and wildlife.

Seining is a standard fish survey technique used in estuaries and large rivers to monitor fish growth and movement. Small-mesh

beach seines catch juveniles, which then are measured and identified. Seining also can be used to capture adults in the lower river for tagging and migration studies.

Traps and *weirs* capture adults or monitor juvenile movement. Fixed pipe traps and floating screw traps are used in tributaries or small rivers to monitor the outmigration of juvenile smolts. Weirs and slot traps are used together to capture upmigrating adults. The effectiveness of traps depends on flow conditions. Traps often are washed out by high flow events.

Electrofishing is used to estimate populations of juvenile salmonids. Fish are stunned by electrical current and netted before they recover. Fish are released after species and length data are collected. Only experienced fish biologists with permits can use this technique. Electrofishing is dangerous (water is a good conductor of electricity), and fish mortality can be high if not done properly.

Sportfishing techniques can be used in isolated areas where juvenile fish exist and identification from the bank is difficult (for example, riffles, waterfalls, or deep pools). Lure and flyfishing gear catches most juvenile salmonids. However, fishing tends to catch fish of a certain size, and success depends on season and water clarity.

The following publications contain detailed explanations of proper procedures for stream fish surveys:

- *How to Do Spawning Fish Surveys* (Salmon-Trout Enhancement Program, Oregon Department of Fish and Wildlife)
- *California Salmonid Stream Habitat Restoration Manual*, by G. Flosi and F. Reynolds (California Department of Fish and Game, 1994), chapter 4
- *Fisheries Techniques*, by L. A. Nielsen and D. L. Johnson (American Fisheries Society, 1983)
- *A Review of Capture Techniques for Adult Anadromous Salmonids*, Information Report 96-5 (Oregon Department of Fish and Wildlife)

Water-Quality Assessments and Monitoring

Assessing water quality means documenting present conditions, whereas *monitoring* water quality means measuring conditions over time to track progress toward desired conditions. Most water-quality assessment techniques also are used for monitoring. This section provides a brief overview of the factors to measure and how to measure them.

Factors such as temperature, bacteria, and pH are known as *parameters* of water quality. State and federal agencies have established water-quality standards for most parameters discussed in this section. These standards are based on the water's beneficial uses (for example, drinking, recreation, humans, fish, or wildlife). Each state has developed a list of streams that are designated as *water quality limited* (the 303[d] list). In other words, they do not meet applicable water-quality standards. The list specifies which measured parameters cause the stream to be limited.

It's very expensive to measure all parameters for one stream. Water-quality monitoring programs address the parameters that likely are causing problems to the user or already are identified on the state 303(d) list. A few areas of the watershed are monitored to indicate where problems are located. Then, more detailed monitoring is conducted in the problem areas.

For example, if fish populations in an area are depressed, and assessments describe poor riparian vegetation, then stream temperatures are measured in a few areas. Where excessive stream temperatures are found, more detailed analyses are conducted. Likewise, if assessments describe excessive stream bank erosion and sediment in the stream, then sediment is monitored and upland erosion problems are surveyed.

States usually follow the monitoring guidelines established by the U.S. Environmental Protection Agency. See *Monitoring Guidelines to Evaluate Effects of Forestry Activities* and *Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management* for more information. The U.S. Geological Survey is another source of monitoring protocols, especially for streamflows and sediment loads.

Continuous, seasonal, and storm event monitoring

There are two basic approaches to water-quality monitoring and assessment—continuous random sampling and seasonal sampling. *Random sampling* is based on the concept that water quality varies, so it's best to collect large numbers of samples from a specific point on some arbitrary schedule (for example, every Monday at 10:00 A.M.). This approach tries to define overall water quality.

Seasonal sampling looks at water quality in specific seasons. For example, if you're concerned about water quality during low flow in western Oregon, you would collect samples only during the summer or early fall. The extreme of seasonal monitoring is *storm event monitoring.* In this type of monitoring, samples are collected only during and immediately after a rainfall or snowmelt event.

What to measure and how

The following sections identify different water-quality parameters and briefly explain how they're measured.

Stream temperature

Stream temperatures often are measured when riparian and stream assessments identify poor riparian vegetation along the stream. Stream temperatures commonly are measured with temperature *dataloggers*—matchbox-size recorders with temperature sensors. They can be programmed to record temperatures at set time intervals. Some dataloggers are waterproof or fit into waterproof containers for instream placement. Others have long probes that reach into the stream from dry ground. Examples of dataloggers from Onset Instruments are hobos, stowaways, and optic shuttles.

Stream temperature usually is measured in deep riffles or runs where water is well

mixed and temperatures are relatively constant. Sometimes stream temperatures are measured in pools or other types of habitat to identify cool water seeps and *refugia* (areas of cool water surrounded by warm water). Stream temperatures usually are measured from June to October if high temperatures are the focus of an assessment. Peak daily temperatures occur in mid-July or August.

Sediment and turbidity

Two kinds of sediment are measured—suspended sediment and bed load. *Suspended sediment* is assessed by measuring the weight of sediment in a given volume of water (usually milligrams per liter). *Bed load* sampling measures the weight and size of sediment moving along the stream bed during different-sized streamflows. To make sense of sediment measurements, you also need streamflow measurements. The sediment load in the stream at a given time can be calculated by looking at the sediment concentration and streamflow.

The difficulty with measuring suspended sediment and bed load is figuring out where and when to sample. The sediment concentration changes with the size of streamflow, the time of year, and whether the streamflow is rising or falling. The most common sampling method uses the Helley-Smith sampler. The U.S. Geological Survey and the Environmental Protection Agency are contacts for sampling procedures and equipment.

Turbidity is the degree to which light is blocked. It is a common monitoring parameter and is easy to measure. Some people measure turbidity by visual observations, whereas others use a *turbidimeter*. The turbidimeter measures the amount of light absorbed by a water sample compared to clean water. Turbidity varies according to the amount of organic material and type of suspended sediment. Turbidity is not a direct measure of suspended sediment, but turbidity measurements can be used together with sediment measurements to assess water quality.

Bacteria

A third water-quality parameter is bacteria. There are several different methods for measuring bacteria. Measurements typically count bacteria *indicators*. Indicators are kinds of bacteria whose high numbers indicate the presence of harmful bacteria. The most common indicators are *Escherichia coli* (*E. coli*) and fecal coliform. All methods involve filtering a water sample (100 milliliters) onto a medium (dish, filter paper, and so on). The sample is stained and bacteria are allowed to grow for a period of time. Then the bacteria colonies are counted. The results are given as number of bacteria per 100 milliliters of water.

Bacteria populations fluctuate in response to streamflow, disturbance of the stream bed, time of year, and time of day. Also, bacteria can survive for long periods on land and in stream sediments. Given this high variability, it's important to sample frequently. Take samples at the appropriate time of year on the basis of how the water is used. For example, sample

in summer to determine whether the water is safe for recreational swimming.

pH and dissolved oxygen

pH often is monitored because it's easy to measure. It's important to measure pH in the field as soon as the sample is taken. The procedure usually involves adding drops of solution that color the water; pH then is read on a color scale. Another method uses litmus paper, which changes color, depending on pH. Measurements vary, depending on the measuring kit.

pH varies by temperature, carbon dioxide concentrations, streamflow, time of year, and other conditions. Assessments of the effects of acid rain and mining operations include intensive pH monitoring.

Dissolved oxygen is easy to measure as long as precautions are taken to minimize disturbance of gas exchange. Dissolved oxygen varies with time of day, temperature, streamflow, and time of year. Most dissolved oxygen monitoring studies look at activities that supply a large amount of organic material to streams, especially point source pollution (for example, pulp mill, food processing, and municipal wastes). Some nonpoint source pollution activities, such as forestry, agriculture, and livestock management, may affect dissolved oxygen, especially when streamflow is low and temperature is high.

Nutrients

Nutrients can be measured as dissolved or particulate. Most monitoring programs measure dissolved nitrogen and dissolved phosphorus because they are readily available for uptake by primary producers in the stream. Some programs monitor particulate phosphorus that enters the stream with sediment.

Measuring procedures vary, depending on the measurement kit. Usually, chemicals are added to water samples, causing the water to change color. The color then is compared to a chart to determine the amount of phosphorus or nitrogen present.

Nutrients are measured if there is concern about algal growth or if the water is used for drinking. You might monitor nonpoint activities causing large organic or sediment inputs to streams as well as direct point sources of pollution. If you're evaluating nutrient inputs into streams, measure during storm events. Also monitor during seasons when beneficial uses (for example, algal growth or drinking water) are affected.

Herbicides and pesticides

Because monitoring herbicides and pesticides is expensive, it's done only if there is a strong belief that these chemicals pose a threat to water quality. When monitoring herbicides and pesticides, it's critical to select the right time and place to sample. State agencies have established procedures for sampling. Usually, one sample is taken before applying the chemical, and several samples are taken at various times after application. It's possible to evaluate how likely an application is to impair water quality, and the intensity of sampling can be adjusted to reflect this risk.

Stream Enhancement/ Restoration

In this section, the terms "stream enhancement" and "restoration" are used interchangeably. The main goals of stream enhancement are

- To restore essential physical and ecological functions (for example, the presence of large wood or vegetated stream banks) in a short time. These functions in turn maintain or restore channel stability, habitat for fish and other aquatic organisms, and water quality.
- To manage stream and riparian areas in order to restore desired functions over a longer period of time (for example, the management of riparian areas, floodplains, and wetlands)

Remember, stream enhancement might not require immediate changes. It might simply mean providing proper management that encourages desired functions over time.

An important concept in understanding channel stability is *stream geometry*. Think of stream geometry as the "shape" of the stream (dimension, pattern, and profile). It includes factors such as width, depth, gradient, and sinuosity (how meandering the channel is). Stream enhancement projects will affect these factors. Proper planning and design must be used to have positive effects on channel conditions for fish habitat and water quality.

The stream restoration techniques you use will depend on your goals, the type of stream, and the fish species present. No stream project will succeed if upland and riparian conditions influencing the stream are not addressed. To maximize project success, use technical guidance from hydrologists, fish biologists, engineers, geologists, and so forth.

All projects require consultation and permits. Contact your local state department of fish and wildlife for information. Many states must also consult with the National Marine Fisheries Service to ensure that projects don't violate the Endangered Species Act.

The following sections provide basic information on a variety of stream enhancement projects. Their purpose is to help you seek guidance for selecting and implementing these projects. Information on single-site stream bank stabilization techniques also is given to help landowners make their projects more beneficial to the stream and riparian area.

Enhancing fish habitat with instream structures

There are many types of fish enhancement designs. They differ according to the desired objective for each fish species. Each species has different life-cycle requirements and critical survival needs (for example, spawning versus rearing habitat). Choose a restoration technique based on the most critical need for the fish species.

For example, coho juveniles rear in tributaries and require slower moving water during high flow to survive to smolt size. Coho restoration techniques tend to focus

on increasing slackwater pools and woody material in the channel. Designs also depend on stream characteristics.

Many types of designs have been used with varying degrees of success. They have evolved from "let's just try this and see" to engineered designs. Most mistakes occur when people create structures without studying the basic characteristics of the river or the specific needs of the fish. Remember, the goal of improving fish habitat with structures is to mimic what would occur naturally in a particular stream type.

The various kinds of structural designs all serve the common purpose of imitating natural obstructions that disrupt the flow of water and sediment. By influencing *hydraulic conditions* (the movement of water), structures store and sort sediment, enhance scour, deposit stream bed material, diversify velocity and depth, and fix the position of bars and pools. As water and gravel are forced under, over, around, or between structures or are slowed by them, the stream bed is scoured or material is deposited. The result affects fish habitat and channel stability.

Many enhancement projects in the Pacific Northwest focus on placing large wood in streams. The emphasis is on matching the size of wood (length and diameter) to the stream size to provide for wood stability rather than relying on anchoring techniques. The goal is not to construct habitat directly, but to load the stream with wood that can reconfigure to a limited degree and work with the stream to create pools, store gravel, and provide cover.

In Oregon, wood should be at least two times as long as the active stream channel width (1.5 times the width for wood with root wad attached) and meet diameter requirements and stream size and slope requirements as outlined in the Oregon Department of Forestry and Oregon Department of Fish and Wildlife publication *A Guide to Placing Large Wood in Streams.* Figure 8 shows the effects of various placements of large woody debris.

Many agencies (including the National Marine Fisheries Service) discourage instream structures that are anchored to boulders, logs, and trees. Most stream enhancement projects in the past were designed using these techniques. The three general designs used for these instream structures are deflectors, weirs, and cover structures (figure 9). The agencies feel that these structures have not been very useful for restoring habitat in the long term or for increasing fish productivity. But they acknowledge instances in which these projects can temporarily increase fish production or at least attract fish to treated reaches.

Some key considerations when designing and using structures include the following (excerpted from the *Oregon Aquatic Habitat Restoration Guide*):

1. Is this a stream that normally would be expected to have large woody debris? Some meadow-based systems should not be expected to have large wood. Similarly, high-gradient reaches on large streams in most cases cannot hold wood.

2. Is the lack of wood a major contributing factor in declining fish populations in the reach? Sometimes other factors, such as the blockage of a fish passage, may be a leading factor in the decline of fish. In this case, adding wood makes little difference.

3. Does existing upslope and riparian management make large woody debris available for natural recruitment into the stream? Does it encourage stable banks and sediment dynamics, which in turn stabilize the channel?

4. Is large wood in the candidate stream reach currently depleted compared to expected values? (The Oregon Department of Fish and Wildlife has information on Oregon's benchmark values and on some individual streams.)

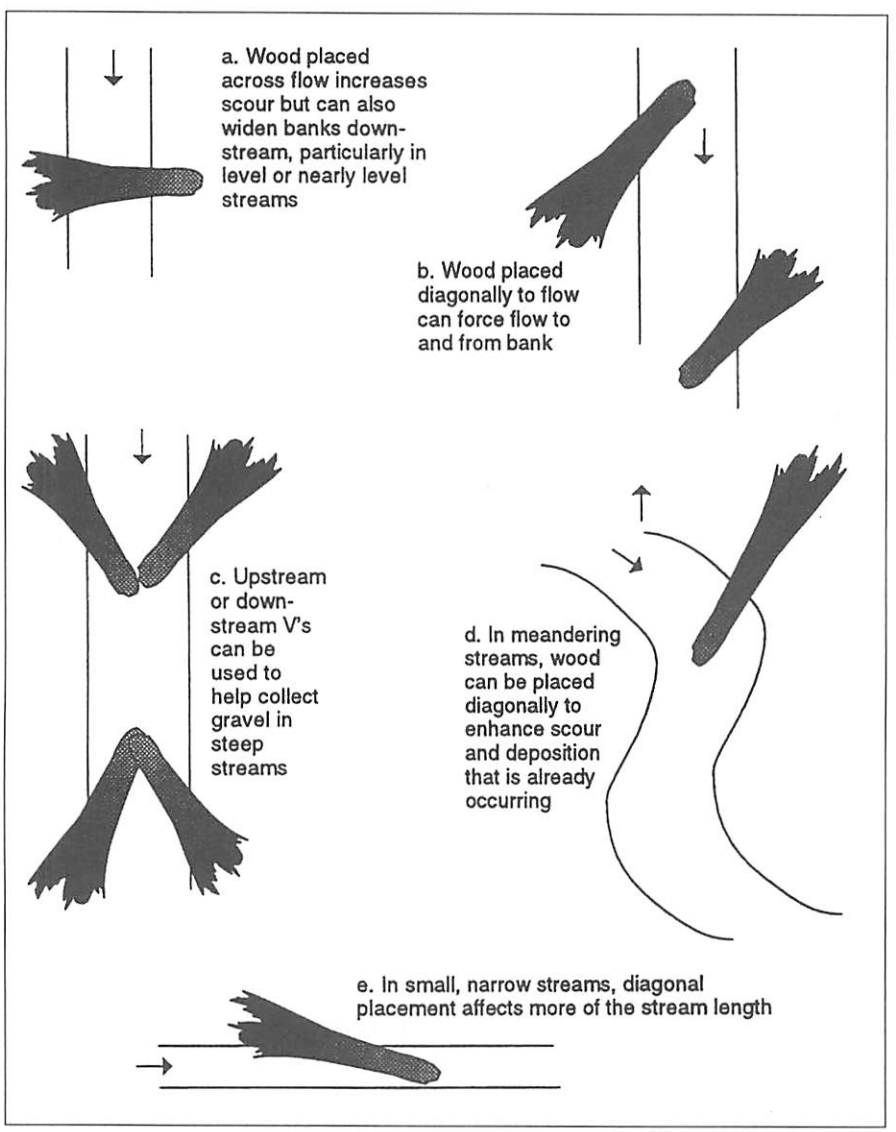

Figure 8. Effects of various placements of large woody debris. (Source: *A Guide to Placing Large Wood in Streams*)

Stream bank stabilization projects

The goals of single-site stream bank stabilization projects are to

- Slow the water velocity, causing sediment to deposit and build stream bank rather than to scour
- Stabilize the stream bank with vegetation

- Begin to establish riparian functions that improve fish habitat and water quality
- Provide some instream fish habitat where possible

One type of bank stabilization involves burying boulders or log deflectors in the bank and letting them extend into the stream channel (figure 10). These structures deflect flow away from the bank and help stabilize the bank until vegetation is established. Deflectors also increase stream velocity at the tip of the structure and cause a scour pool on the downstream side of the deflector. The scour pool dissipates some of the stream's energy and can provide some fish habitat.

Other designs that stabilize a stream bank and revegetate the riparian area use rock, wood, and trees to decrease velocities, deposit sediment, and grow vegetation. These designs are known as bioengineering methods. Contact the Natural Resources Conservation Service for information, designs, and technical assistance.

Monitoring Plans

Chapters 9, "Assessment and Monitoring Considerations," and 11, "Riparian Assessment and Enhancement," discuss monitoring plans in detail. Monitoring is an important part of stream enhancement projects, so this section will give a brief overview of the key points.

Why do we need a monitoring plan?

Monitoring will measure the results of your enhancement project. It can help you avoid repeating mistakes and justifies the investment of resources (whether private or public) in your project. If monitoring shows that the enhancement project has not

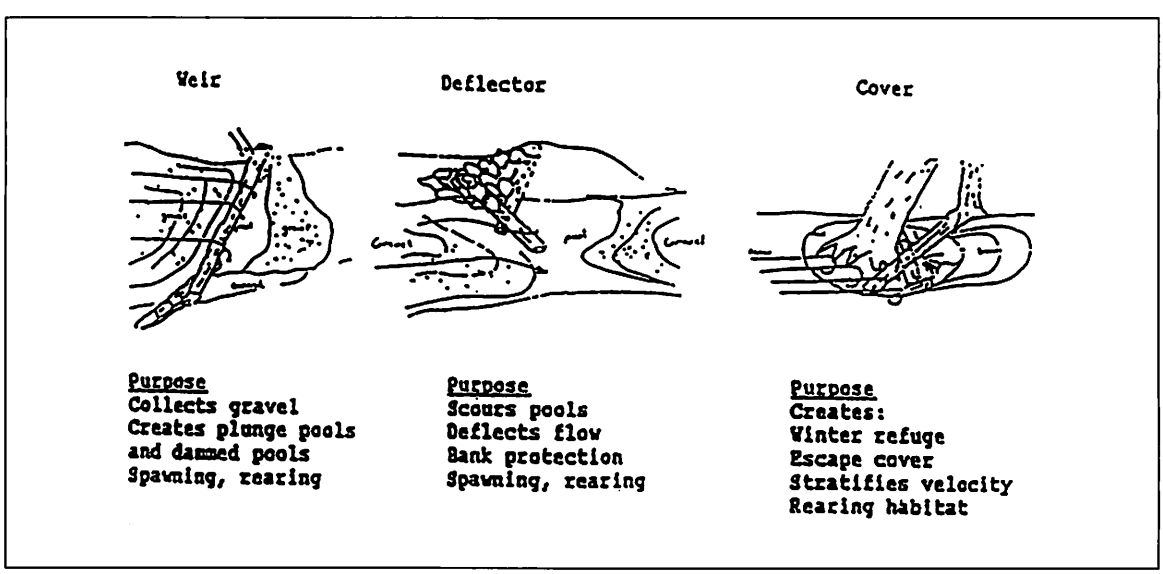

Figure 9. Types of in-stream structures. (Source: *Ecosystem Workforce Project Curriculum*)

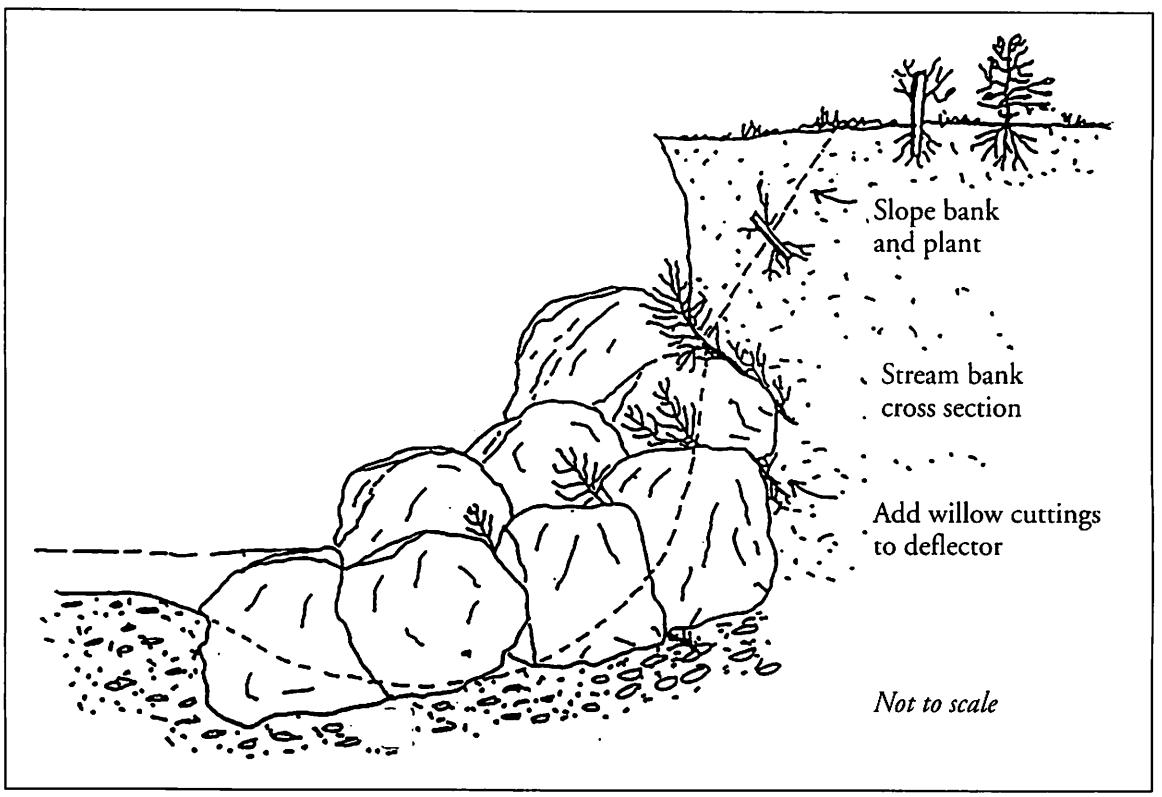

Figure 10. Boulder deflector used for stream bank stabilization. (Source: John Schwabe, Confluence Consulting)

achieved the desired stream functions, you should reevaluate the objectives of the project.

Basic components of a monitoring plan

Most stream monitoring plans repeat components of assessment and survey techniques over time. These techniques help you evaluate present conditions as well as how conditions are changing over time as they move toward the desired future condition. A monitoring plan has three main parts:

- Goals and objectives of the enhancement project
- Specific monitoring techniques and parameters measured
- A process for evaluating whether goals and objectives are met and for deciding whether a change in monitoring techniques or measured parameters is necessary

A monitoring plan starts with a clear statement of goals and objectives (the questions you want to answer with monitoring). Choose monitoring techniques that will provide the right kind of data to

answer these questions. Make sure the techniques you choose are appropriate for your group. Take into account factors such as cost, technical requirements, training, available equipment, and access.

Your monitoring plan should indicate whether your enhancement projects are helping the stream achieve its desired condition. If a project is not meeting your objectives, the plan should help you identify factors causing the problem and ways to fix the problem.

Example of a monitoring plan

Assessment of present conditions

Existing condition/limiting factors: Assessments indicate that this forested section of the coastal stream has very few pools. Alder trees reduce solar input but do not provide a future source of large woody material. As a result, salmon spawning and rearing habitat has been reduced.

Probable cause: Assessments on reference streams and evaluations of historic information indicate that past forest practices included removing woody material from the stream and did not adequately reestablish mixed patches of conifer and hardwood trees in the riparian area.

Goals and objectives

Goal: Improve spawning and rearing habitat in the forested stream reach by increasing the number of pools. Improve future supply of large wood in the stream by increasing the number of conifer trees in the riparian zone. Maintain stream shade to protect cool stream temperatures in summer.

Objective: Increase number of pools by placing large woody material twice the size of the active stream channel width in key locations. Convert patches of the alder-dominated riparian area to conifers by manually releasing present conifers in the understory. Keep a 25-foot-wide buffer of alder trees to maintain stream shade.

Enhancement projects implemented

Following state fish and wildlife guidelines, workers strategically placed 20 large pieces of woody material (conifer) in the stream channel and banks to create nine pools with cover. Following the state forest practices rules, workers manually released conifer trees from the understory of alders present in the riparian zone. They left a 25-foot-wide "no-touch" zone next to the stream. The project improved fish habitat, established a future supply of large wood to the stream and riparian area, and maintained stream shade.

Monitoring techniques and parameters measured

- An Oregon Department of Fish and Wildlife aquatic habitat inventory was conducted before the project was implemented, one year following implementation, and once every five years thereafter. This inventory will monitor stream habitat and riparian conditions.
- All logs were surveyed and locations marked on a map. Logs will be

resurveyed once a year for the first five years to evaluate the movement of logs and stream conditions.

- Photos will be taken at permanently established photo points before and after the project is implemented and once every five years at the same time the habitat survey is done.
- A riparian area survey to assess tree survival will be conducted once every year for the first two years, then once every five years.
- Spawning surveys will be conducted to count spawning fish and map their locations to see whether they are using our newly created spawning areas.
- Stream temperatures were measured above and below the project site throughout the summer to monitor changes in stream temperatures through the reach. Baseline conditions were established the summer before the project began and were compared to summer conditions following implementation of the project.

Follow-up evaluation

If monitoring shows that enhancement projects have not led to the desired future conditions, a new monitoring plan and enhancement projects will be implemented. If the monitoring data do not describe stream conditions adequately, different monitoring techniques will be used.

Summary

A basic understanding of biological and chemical processes affecting aquatic ecosystems is essential to planning fish habitat and water-quality enhancement projects. Understanding these processes will help you identify factors affecting salmonid populations and begin to plan detailed assessments and enhancement projects.

Primary food sources for organisms in streams are freshwater algae, organic matter (such as leaves, needles, twigs, and logs), and possibly salmon carcasses. Organisms throughout the food chain rely on these sources as the basis of their existence. Food sources are most abundant in early spring before trees leaf out and in early fall when leaves fall and streamflows increase.

Fish feed on macroinvertebrates, which are the main processors of primary food sources. The primary macroinvertebrate feeding types include shredders, scrapers, collectors, predators, and scavengers. A stream system's ability to retain its organic food sources (retention capacity) is a factor in macroinvertebrate and fish productivity.

Salmonids have a common life history, but differing patterns allow several species to occupy compatible niches in the stream system. It's important to understand basic fish habitat needs and to identify the habitats that each species occupies at all life stages.

Sediment and stream temperature are important physical water-quality characteristics that may affect fish and other stream organisms. Both suspended and bed load sediments can affect egg and juvenile

survival. Temperatures alter the metabolism of macroinvertebrates and cold-blooded organisms such as fish. Extreme water temperatures inhibit fish growth, decrease their ability to compete for food, reduce appetite, or cause death.

Dissolved oxygen, nutrients (for example, nitrogen, phosphorus, and potassium), manufactured chemicals, and pH are important chemical water-quality characteristics that may affect salmonids. Fish need high dissolved oxygen levels in water. Dissolved oxygen is affected by variables, including stream temperature, water agitation, plants, and light penetration. Nutrients are essential for fish survival, but excessive amounts can be lethal. Some manufactured chemicals can be tolerated only at minimal levels. Fish and other aquatic organisms can tolerate only certain pH levels. High and low ranges may be toxic.

Organic matter and microorganisms are important water-quality characteristics that affect fish and other stream life. Excessive amounts of organic matter reduce dissolved oxygen. All waters have organisms (bacteria, insects, and so forth) that are beneficial, but some have organisms that are pathogenic (disease causing).

Water-quality characteristics vary with watershed hydrology and other characteristics (erosion, channel features, riparian areas, and so on), and each characteristic varies with time.

An assessment compares present conditions to reference conditions, identifies enhancement projects, and helps establish a monitoring plan. Basic components of a stream assessment include evaluations of physical, biological, and water-quality conditions compared to a reference site or reference conditions. A variety of assessment methods are available.

Physical stream assessments evaluate habitat types; width, depth, and length of units; stream bed materials; stream bank stability; relation of the stream to its floodplain; stream gradient; riparian condition; large wood; and cover for fish.

Biological stream assessments evaluate fish populations (smolts, juveniles, spawning adults), fish species present, abundance of fish using available habitat, and the number and type of macroinvertebrates.

Water-quality assessments evaluate suspended and bed load sediment, turbidity, stream temperature, dissolved oxygen, pH, nutrients, and bacteria.

Stream enhancement projects aim to restore essential physical, biological, and chemical characteristics in order to restore natural channel stability, habitat for fish and other aquatic organisms, or water quality. Enhancing fish habitat may involve strategically placing large wood in conjunction with riparian and upland management considerations.

Monitoring plans include three main components—goals and objectives, specific monitoring techniques and parameters to be measured, and an evaluation process to see whether desired conditions are being met or monitoring techniques are inadequate.

References

Training

Local state and federal agencies, universities, nonprofit groups, private interest groups, and trained volunteers may offer training opportunities in your area.

Contact your local watershed council, Extension Service office, soil and water conservation district office, or resource agency office (department of forestry, department of fish and wildlife, U.S. Forest Service, Bureau of Land Management, and so on) for training events or personal consultation.

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Case Study

Examples of Stream Channel Assessments from Oregon

Oregon Department of Fish and Wildlife Stream Habitat Surveys

Stream habitat surveys are designed to obtain basic information about stream habitat. The data collected will help you identify good habitat to be maintained, poor habitat needing enhancement, and factors contributing to present habitat conditions. The data also will help you establish monitoring programs and management plans.

The Oregon Department of Fish and Wildlife (ODFW) has developed a methodology for stream habitat surveys that is designed to be compatible with other stream habitat inventory and classification systems. It involves recording data about habitat units, amounts of large wood in the stream, and characteristics of the riparian area. These data are recorded on various forms.

This section describes the ODFW method and includes adapted excerpts from the *Ecosystem Workforce Project Curriculum* and *Methods for Stream Habitat Surveys*. Detailed survey techniques and definitions are found in *Methods for Stream Habitat Surveys*. Appendices A-1 through A-6 show the forms used for recording data. To obtain quality data with this survey, you'll need training and oversight by experienced personnel.

Stream habitat surveys are based on continuous walking surveys along major streams and tributaries in a watershed. Surveys move from a stream's *mouth* (at the ocean, lake, or estuary) or its *confluence* (where it joins another stream) all the way to its *headwaters* (where it originates). This approach relies on visual observations and regular measurements to estimate habitat area and characteristics.

Every stream is divided into sections called *reaches*. Reaches vary in length from approximately 1,500 feet to 5 miles. A reach is defined as a segment between tributaries or between two points marked by a change in valley and channel form, vegetation, land use, or ownership.

Data describing the reach are gathered and recorded on a data sheet (Appendix A-1). Data describe channel form, valley form, valley width, streamside vegetation, land form, land use, and a few other characteristics.

A habitat survey describes each reach as a sequence of habitat *units*. Each unit has relatively similar slope, depth, and flow pattern. This information is recorded on the unit-1, unit-2, wood, and riparian forms (Appendices A-2

through A-5). Each unit is longer than one *active channel width*, which is the distance across the channel at annual high flow. Active channel width usually is recognized by slope breaks, high water marks, and changes in vegetation.

Unit-1 and Unit-2 Forms

Information on instream habitat units is recorded on unit-1 and unit-2 forms (Appendices A-2 and A-3). There are many kinds of instream habitat units. A few examples follow:

- *Pools*—units with a water surface slope approximately zero (flat)
- *Glides*—units of generally uniform depth and flow with no surface turbulence
- *Riffles*—fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble. They usually have a 0.5–2 percent slope.
- *Cascades*—fast, turbulent flow with many hydraulic jumps, strong chutes, and eddies. They usually have a 3.5–10 percent slope.

Assessors collect and record the following information for each habitat unit:

- Channel form (length, width, slope, and depth measurements)
- Stream bed materials, or *substrate* (size class and percent distribution)
- Boulder counts (number of boulders protruding above the water surface at low flow)
- Woody material (complexity, particularly as it influences fish habitat)
- Exposure of the stream to the sun (denoted as "shade left" and "shade right" on the data form)
- Stream bank characteristics (erodibility and amount of undercut banks)

Wood and Riparian Forms

The wood inventory estimates the volume and distribution of large wood in the stream reaches. *Large wood material* is defined as wood greater than 6 inches in diameter and longer than 10 feet. (Root wads do not have to meet the length criteria.) The wood is counted and measured, and its location and configuration are described on the wood form (Appendix A-4).

The riparian inventory is designed to provide additional information about the kinds, quantities, and sizes of riparian zone vegetation. Measurements are taken along a line known as a *transect* to measure and describe vegetation, land forms, slope, and canopy closure in the riparian zone. These data are recorded on the riparian form (Appendix A-5).

From Survey to Assessment

Information gathered from a stream survey will help you evaluate fish habitat and channel structure as well as compare streams. It also will help you locate potential problems, enhancement sites, and unique features.

Habitat unit descriptions indicate fish habitat potential (spawning, rearing, and cover habitat) and what components are missing. For example, stream bank classification and riparian forms indicate channel stability, sediment sources, and riparian conditions influencing instream habitat. Large wood forms describe how much large woody material is actively influencing habitat or might be available in the future.

OWEB's Oregon Watershed Assessment Manual

Two chapters of the Oregon Watershed Enhancement Board's (OWEB) *Oregon Watershed Assessment Manual* provide techniques for evaluating physical stream characteristics—"Channel Habitat Type Classification" and "Fisheries Assessment." The following descriptions include excerpts from the manual.

Channel Habitat Type Classification

OWEB has developed basic channel types for Oregon streams called *channel habitat types* (CHT). This classification system is designed to help identify which parts of a watershed have the highest potential for fish use and how various channel types respond to land-use impacts or restoration efforts. This information in turn will help you identify potential restoration projects that are likely to benefit fish habitat the most. The assessment uses and complements Oregon Department of Forestry stream classification maps and ODFW's stream habitat information.

CHTs are organized on a valley segment scale. Examples are illustrated in figure 1. CHTs are defined by channel gradient (slope), channel pattern, degree of valley constraint, and, in some cases, stream size. Stream size is considered primarily because the role of woody debris differs in small and large streams.

Other information used to describe the CHT includes the ratio between valley width and active channel width, the position of the channel within the drainage network, and the gradient of the confining side slopes. Finally, field measurements that further describe CHTs include the degree of entrenchment or depth of the channel, the nature and size of the material making up the channel banks, and the size of particles on the streambed.

CHTs are identified and mapped using U.S. Geological Survey topographic maps and aerial photos. Field visits help verify questionable CHTs. The OWEB *Oregon Watershed Assessment Manual* provides the following information for each CHT:

- Physical description
- Fish utilization information
- Riparian management considerations
- Riparian enhancement and channel restoration options

Fisheries assessment

This assessment is designed only to provide a way to compile and evaluate available fish populations, habitat, and barriers to passage. It is used to

- Identify which fish species are present in the watershed, where they occur, and what is known about their population
- Identify potential interactions between species of concern
- Compile and compare existing ODFW habitat data to established ODFW/ National Marine Fisheries Service benchmarks to evaluate instream habitat conditions
- Identify human-caused barriers to fish passage and prioritize them for enhancement

An example of a data sheet for compiling and evaluating habitat conditions is shown in Appendix B.

Fish passage

Fish passage surveys are discussed in Chapter 10, "Upland Evaluation and Enhancement."

Case Study

Restoring Anadromous Fish Passageways in the Hudson River Estuary

by Robert Kent

The Problem

Historically, anadromous fish-spawning runs were common in New York Harbor and the Hudson River. Their populations have decreased because of poor stream conditions, including an increase of obstacles to migration. Anadromous fish are still found on the Hudson River and several New Jersey streams. Restoration would improve these conditions and would result in healthier streams. Furthermore, anadromous juveniles would return to being an important forage species for larger fish, and their contributions to the fisheries would become evident. The term *anadromous* is used to describe those species of fish that normally reside in salt water but that migrate to fresh or nearly freshwater to spawn. The most common anadromous fish of the region include alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), striped bass (*Morone saxatilis*), and American shad (*Alosa sapidissima*). River herring stocks (alewife and blueback herring) on the Atlantic coast have declined in the past 25 years as measured by commercial landings, and many states have reported declines in these stocks as well. Construction of dams and decline in water quality are prominent issues.

An impediment is any factor that prevents migrating fish from being able to arrive at suitable spawning habitat. An impediment might occur in the form of either a physical barrier, such as a dam, or a nonphysical parameter, such as water quality, pollutants, debris, or siltation. Some common examples in this estuary include

- Tide gates that are constructed to restrain natural flood tides by blocking the upstream flow of salt water
- Culverts, which are pipes placed beneath roads and railways to facilitate drainage
- Concrete beds constructed to channelize water flow, often to alleviate local flooding or to allow for development by changing the course of a waterway
- Inadequate water quality, which does not meet the specific ranges of temperature, salinity, pH, and dissolved oxygen required by spawning anadromous fish
- Sedimentation and siltation, which decrease the clarity of streams

What Was Done

The New York–New Jersey Harbor Estuary Program funded two studies to examine what could be done to restore anadromous fish populations in the region. One focused primarily on streams in New Jersey, the other on the Hudson River between New York City and Albany. The studies had a similar goal, which was to study all the tributaries in the region and document for each one what the barriers were and what the options were for restoring fish passageways.

Outcomes

After examining the barriers in the Hudson River tributaries, researchers in one study ranked the barriers on a scale of 1 to 5, with 1 being very easy with little expense to overcome barriers and 5 being prohibitively difficult or expensive. Each tributary was then assigned a final ranking for restoration. An example of such a ranking follows. It can serve as a model for how communities in other regions might approach studying and setting priorities for stream restoration.

ULSTER COUNTY, NEW YORK

Rondout Creek
Priority Ranking for Enhancement 2

River Mile: 91
USGS Quadrangle: Kingston East & Kingston West
Date Visited: June 8, 1995

Status of Herring Run:
A large herring run exists in this creek (Schmidt and Limburg, 1989) and spawning occurs just below the first barrier.

Status of Other Migratory Fishes:
Researchers reported larvae of white perch, yellow perch, and spottail shiner from this creek. The Rondout also supports a run of rainbow smelt in years with high smelt abundance.

Water Quality: Overall Assessment: Rank = 2
Narrative:
We did not take water quality measurements since access to the barrier is limited to the tidal river. Researchers reported some water-quality measurements from the tidal waters of the creek. The Rondout is turbid and there are pollution inputs further upstream.

Barrier #1:

The first barrier to upstream movement is the Eddyville Dam, a 4 m high structure located in Eddyville (41°53'30"N by 74°1'18"W) about 0.4 km upstream of the Rt. 213 bridge (Map 38, p.150) and about 5 km upstream from the mouth.

Ease of Construction of Fish Passage Facility: Rank = 1

The dam is already partially broken on the west edge (Figure 68, p.151) and construction of a passage facility would be fairly simple.

Priority of Fish Passage at Barrier: Rank = 1

There are large runs of several migratory fishes already. Passage would open a large spawning area that historically held migratory fishes.

Rationale for Priority of Enhancement:

Passage would allow a large number of migratory fishes access to a large spawning area.

Elements of Further Study:

1. Determine the magnitude and species composition of migratory fish runs.

Some final thoughts: There remains some uncertainty about whether a fish ladder will be successful in terms of establishing a spawning population. One less expensive way to address the issue is to have "herring heaves"—throwing individuals over barriers to observe their behavior. This would be an inexpensive prelude to investing money in a passage facility. Fish passage facilities require long-term maintenance. Volunteer Fishway Stewardships program where local groups are trained to provide frequent low-level maintenance of fish ways is an option.

For more information, contact the Outreach Coordinator, NY–NJ HEP, New York Sea Grant, c/o USEPA, 290 Broadway, 24th Floor, New York, New York 10007.

This case study was adapted from these two reports:

1. *Impediments to the Spawning Success of Anadromous Fish in Tributaries of the NY/NJ Harbor Watershed,* by Susan J. Durkas (Highlands, NJ: American Littoral Society, 1991).
2. *A Catalog of Barriers to Upstream Movement of Migratory Fishes in the Hudson River Tributaries: Final Report to The Hudson River Foundation,* by Robert E. Schmidt and Susan Cooper (Annandale, NY: Hudsonia, 1996).

REACH

PAGE:_____OF:_____

STREAM:_____

CREW:_____

BASIN: _____

USGS 7.5' MAP NAMES:_____

DATE	REACH #	UNIT NUMBER	CHANL FORM	VALLEY FORM	VWI	VEG CLASS DOM.	VEG CLASS SUB-DOM.	LAND USE DOM.	LAND USE SUB-DOM.	WATER TEMP	STRM FLOW	LOCATION TWN-RNG-SEC-1/4	PHOTO # /TIME	REACH NOTE
													/	

UNIT-1

PAGE:_____OF:_____

STREAM:_____ DATE:_____ ESTIMATOR:_____

REACH #	UNIT #	UNIT TYPE	CHANL TYPE	% FLOW	UNIT LENGTH	UNIT WIDTH	SLOPE %	SHADE (0-90) LEFT	SHADE (0-90) RIGHT	ACTIVE CHANNEL HT.*	ACTIVE CHANNEL WIDTH	FLOOD PRONE HT.	FLOOD PRONE WIDTH	TERRACE HT.	TERRACE WIDTH	VWI	NOTE

* MEASURE FROM THE STREAMBED TO THE TOP OF THE ACTIVE CHANNEL . TAKE THE MEASUREMENT AT POOL TAIL CREST ON POOL UNITS.

UNIT-2

PAGE:_____ OF:_____

STREAM:_____ DATE:_____ NUMERATOR:_____

UNIT #	UNIT TYPE	DEPTH*	DEPTH** PTC	VERIFIED LENGTH	VERIFIED WIDTH	PERCENT SUBSTRATE S/O	SND	GRVL	CBLE	BLDR	BDRCK	BLDR COUNT	% ACTIVE EROSION	% UNDER CUT	COMMENT CODES	NOTE
V																
V																
V																

* MAX DEPTH POOLS - MODAL DEPTH IN FAST WATER UNITS

** ONLY MEASURED @ POOLS (EXCEPT OFF-CHANNEL POOLS)

Appendix A-4 Wood form

PAGE:______ OF:______

STREAM:______________________ DATE:______________ NAME:______________________

UNIT	UNIT	DEBRIS			DBH	LENGTH CLASS (m)												WOOD NOTE
NUMBER	TYPE	CONFIG	TYPE	LOCAT	CLASS	RW <3	3	6	9	12	15	18	21	24	28	32	36+	

RIPARIAN

PAGE:_____ OF:_____

STREAM:_____ DATE:_____ NAME:_____

UNIT NUMBER	SIDE	ZONE	SURFACE	SLOPE	CANOPY CLOSURE	SHRUB % COVER	GRASS/FORB % COVER	COUNT (DBH in CENTIMETERS) TREE	3-15	15-30	30-50	50-90	90+	RIPARIAN NOTE
	LEFT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	RIGHT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	LEFT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	RIGHT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						

Appendix A-6 Photo record form

PHOTO RECORD: ODFW AQUATIC INVENTORY

STREAM: _____ CREW: _____

BASIN: _____ ROLL #: _____

DISTRICT: _____ MAILER #: _____

PHOTO	UNIT	DATE	TIME	DESCRIPTION
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
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21				
22				
23				
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25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				

FORM F-2: Habitat Condition Summary: This form will be filled out for each sub-watershed where ODFW or other comparable habitat data exists measured values are recorded & compared to rating criteria.

Name: **Date:** **Page of**

Subwatershed:

Channel Habitat Type Code*	Miles of CHT in Sub watershed	Miles of CHT surveyed	Survey Date	Pool Area		Pool Frequency		Gravel Availability (% gravel in riffles)		Gravel Quality (% fines in riffles)		Overall Rating
				Measured	Rating	Measured	Rating	Measured	Rating	Measured	Rating	
FP1												
FP2												
FP3												
AF												
LC												
MM												
MC												
MV												
BC												
SV												
VH												
MH												
Other:												
Other:												

* see Channel Habitat Type section for a description of the codes.

These rating criteria are applied to evaluate Measured values:

Poor: Measured conditions less than 75% of the ODFW/NMFS benchmark
Fair: Measured conditions levels close to benchmark (>75% and <125%).
Good: Measured conditions exceed benchmark (>125%).

These criteria are used to develop an overall rating:

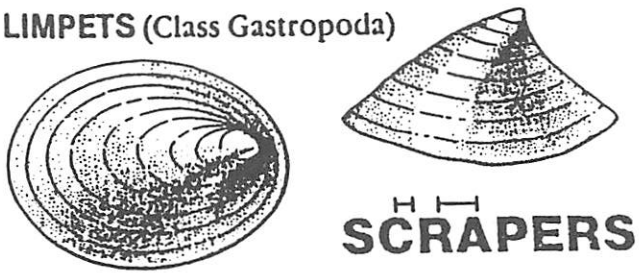
GOOD: all parameters are rated Good or Fair
INDET: one or two parameters are rated Poor
POOR: three or more parameters are rated Poor
ND: No data.

KEY TO FUNCTIONAL FEEDING GROUPS

⊢ ⊢——⊣ Indicates size or range of sizes

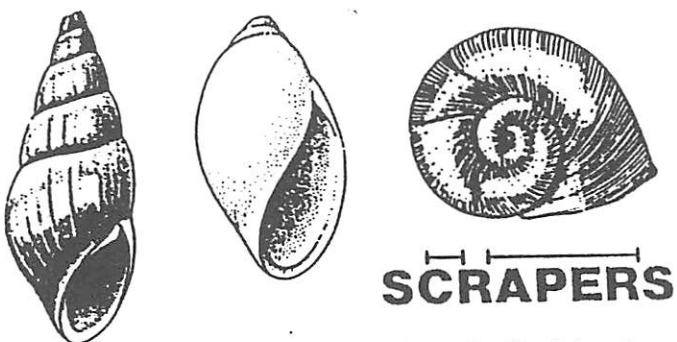
1. ANIMALS IN HARD SHELL (Phylum Mollusca)

a. LIMPETS (Class Gastropoda)



SCRAPERS

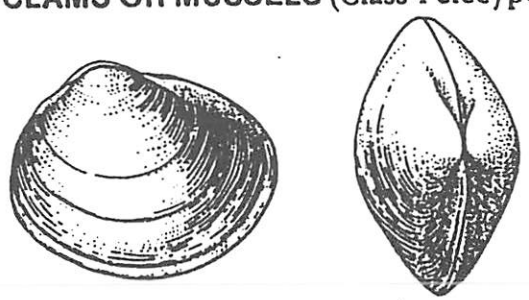
b. SNAILS (Class Gastropoda)



SCRAPERS

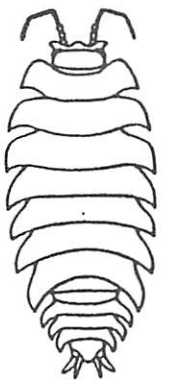
Snails are generalized (facultative) feeders and can also function as Shredders.

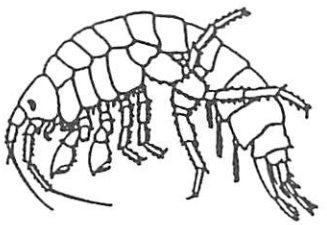
c. CLAMS OR MUSSELS (Class Pelecypoda)



FILTERING COLLECTORS

2. SOW BUG OR SHRIMP-LIKE ANIMALS (Class Crustacea)





SHREDDERS

Generalized, can also function as Gathering Collectors.

3. LARVAE IN PORTABLE CASE OR "HOUSE"

Go to page 6.

4. LARVAE IN FIXED RETREAT WITH CAPTURE NET

Note: Care must be taken when collecting to observe nets.

Go to page 8.

5. WITHOUT CASE OR FIXED RETREAT

a. WORM-LIKE LARVAE WITHOUT JOINTED LEGS

Go to page 10.

b. NYMPHS OR ADULTS WITH JOINTED LEGS

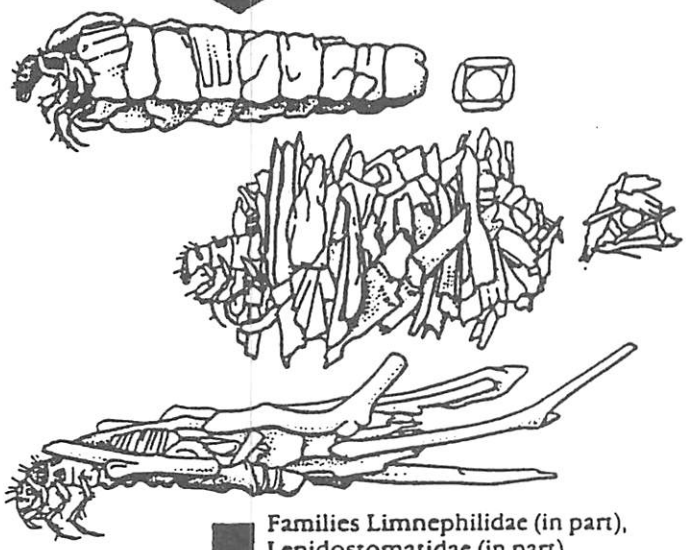
Appendix C—Key for identifying stream macroinvertebrates and sample data form.

(Source: *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates*)

FIRST LEVEL OF RESOLUTION

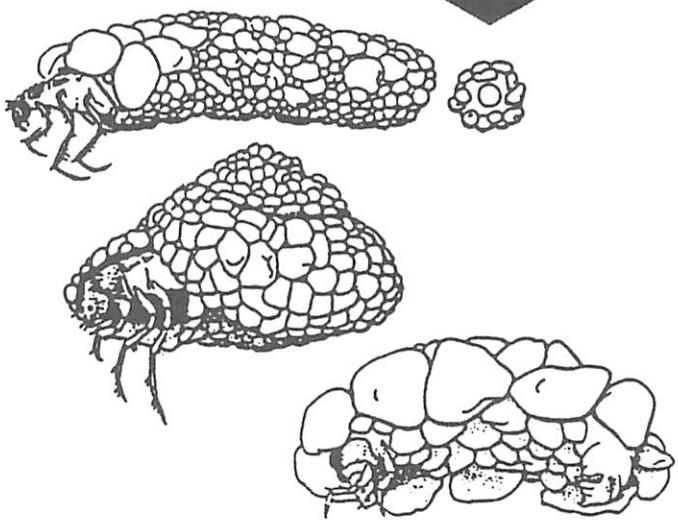
LARVAE IN PORTABLE CASE
Caddisflies (Order Trichoptera)

CASES ORGANIC
Leaf, stick, needle, bark



Families Limnephilidae (in part), Lepidostomatidae (in part), Phryganeidae, Leptoceridae (in part)

CASES MINERAL
Sand, fine gravel



Families Glossosomatidae, Limnephilidae (in part), Helicopsychidae

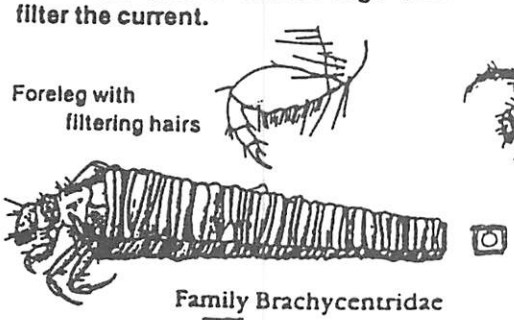
SHREDDERS

SCRAPERS

SECOND LEVEL OF RESOLUTION considers a few fairly common caddisflies that would be misclassified above on the basis of case composition alone.

CASES ORGANIC

Cases square in cross section and tapered, with no bark or flat leaf pieces included. Front attached to substrate. Larvae extend legs and filter the current.



Family Brachycentridae

FILTERING COLLECTORS

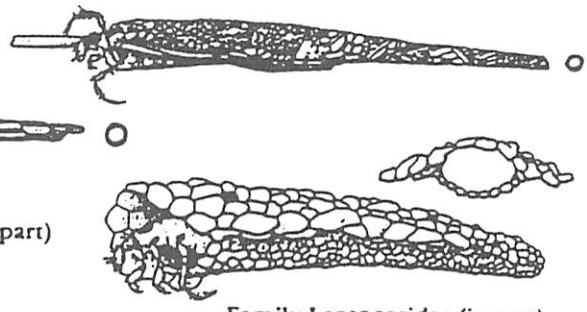
Cases long, slender, and tapered, made of plant material

Family Leptoceridae (in part)

GATHERING COLLECTORS

CASES MINERAL

Cases long, slender, and tapered (mostly fine sand) *or* cases ovoid and very flat in cross section



Family Leptoceridae (in part)

GATHERING COLLECTORS

Appendix C—Key 3

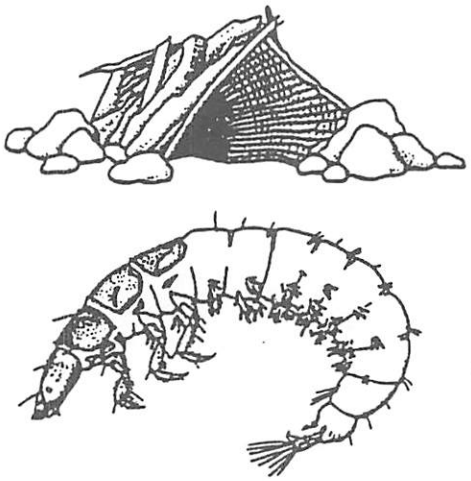
FIRST LEVEL OF RESOLUTION

LARVAE WITH FIXED RETREAT AND CAPTURE NET

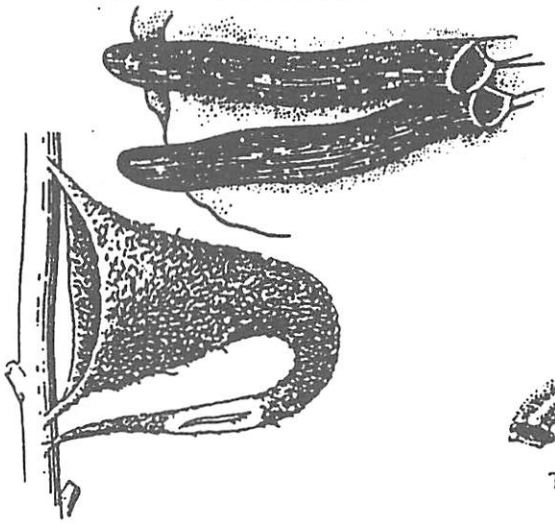
Note: Care must be taken when collecting to observe nets.

Caddisflies (Order Trichoptera)

COARSE NET IN "SCAFFOLDING"

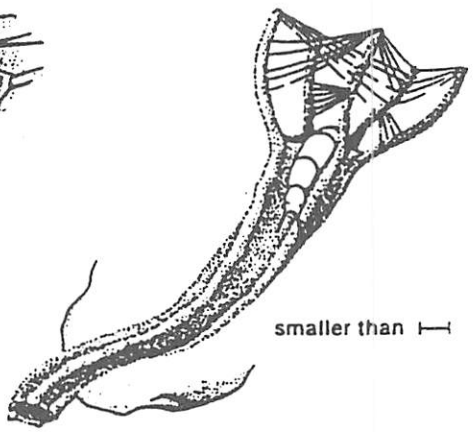


FLATTENED SOCK-LIKE OR TRUMPET-SHAPED NET OF FINE MESH



True Flies (Order Diptera)

TUBE WITH SILK STRANDS STRUNG BETWEEN TERMINAL PRONGS



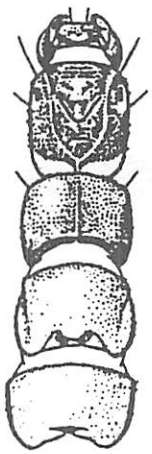
True Midges (Family Chironomidae)

Families Hydropsychidae, Philopotamidae, Polycentropodidae

FILTERING COLLECTORS

SECOND LEVEL OF RESOLUTION separates from free living larvae those net spinning caddisflies that may have been inadvertently collected without being associated with their nets.

NET SPINNING CADDISFLIES
Frequently separated from their nets

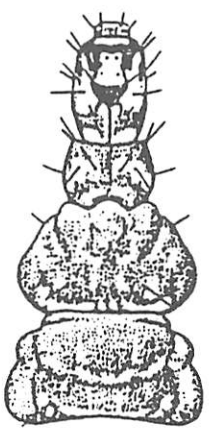


HEAD AS WIDE AS THORAX

Especially Philopotamidae (bright yellow) and Hydropsychidae (bright green or brown)

FILTERING COLLECTORS

FREE LIVING CADDISFLIES
Non net spinning



HEAD LONG, SMALL, AND NARROWER THAN THORAX

Rhyacophilidae (often bright green)

PREDATORS

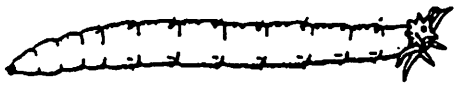
FIRST LEVEL OF RESOLUTION

WORM-LIKE LARVAE WITHOUT JOINTED LEGS

LARGE

larger than ⊢——⊣

Head retractile and poorly developed
Caudal lobes with eye-like spiracles



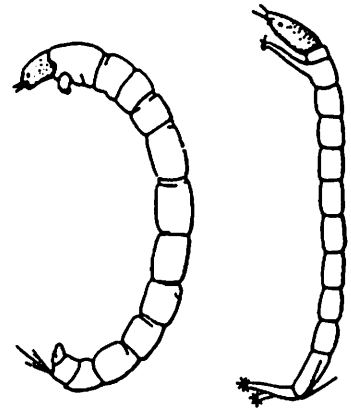
Craneflies (Family Tipulidae in part)

SHREDDERS

SMALL

smaller than ⊢——⊣

LONG AND SLENDER



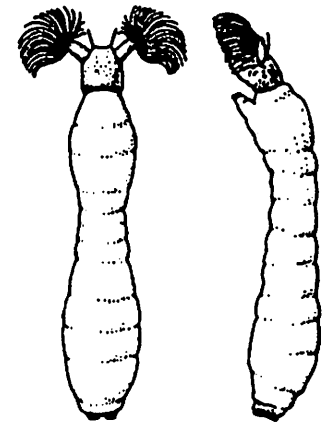
True Midges (Family Chironomidae)

Note: Subtract 10% of count for Predators.

GATHERING COLLECTORS

BOWLING PIN SHAPE

Bulbous base usually fastened tightly to substrate



Blackflies (Family Simuliidae)

FILTERING COLLECTORS

SECOND LEVEL OF RESOLUTION considers some common worm-like Predators that would be misclassified in the above key.

WORM-LIKE LARVAE WITHOUT JOINTED LEGS

LARGE

⊢——⊣

Posterior segment swollen
Head retractile

Family Tipulidae (*Eriocera* type)

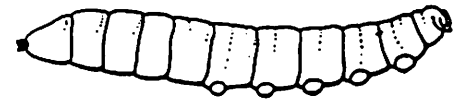
SMALL

⊢——⊣

Prolegs along entire length
Head visible

Family Athericidae (*Atherix*)

Prolegs poorly developed or absent
Jaws well developed
Very active



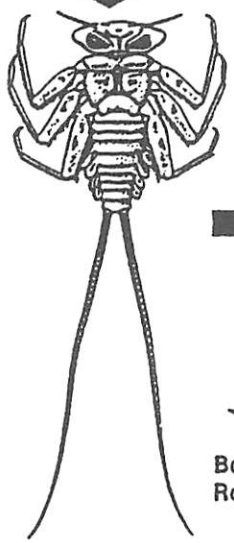
Family Tipulidae (*Dicranota* type)

PREDATORS

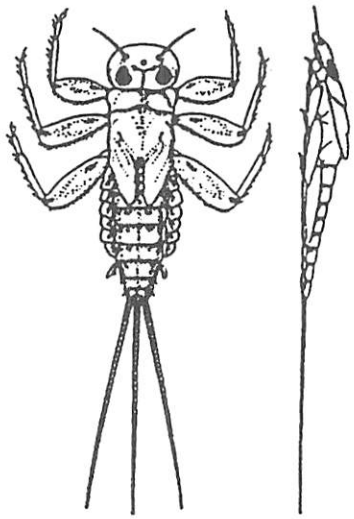
FIRST LEVEL OF RESOLUTION

NYMPHS WITH JOINTED LEGS

THREE (OR TWO) TAILS
WITH LATERAL ABDOMINAL GILLS
Mayflies (Order Ephemeroptera)



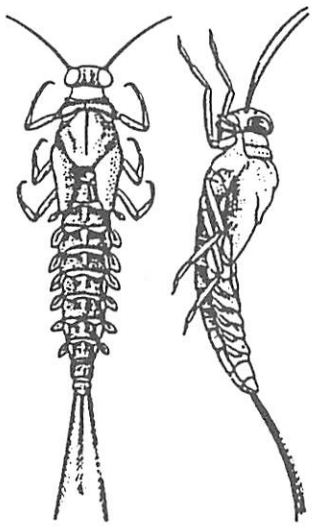
Body shape ovoid
Flat in cross section



Families Heptageniidae, Ephemerellidae (in part)

SCRAPERS

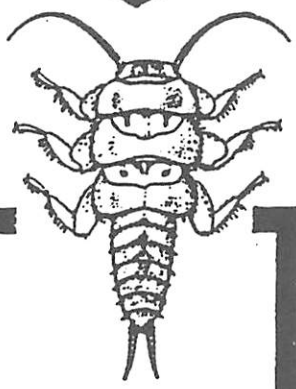
Body shape cylindrical
Round in cross section



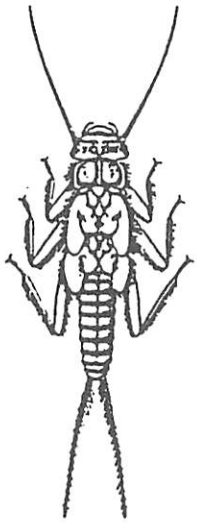
Families Baetidae, Leptophlebiidae, Ephemerellidae (in part), Ephemeridae

GATHERING COLLECTORS

TWO TAILS
WITHOUT LATERAL ABDOMINAL GILLS
Stoneflies (Order Plecoptera)



Bright color pattern
Very active



Setipalpian Stoneflies

PREDATORS

Dull brown or black
Sluggish

Filipalpian Stoneflies

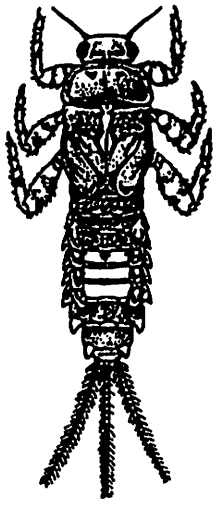
SHREDDERS

SECOND LEVEL OF RESOLUTION considers some fairly common insects that do not fit in the above key or would be misclassified on the basis of body shape alone.

LARVAE OR NYMPHS WITH JOINTED LEGS WITHOUT CASE OR FIXED RETREAT

WITH LONG TAILS
Mayflies (Order Ephemeroptera)

Body shape ovoid
Rear end often erected
scorpion-like when disturbed

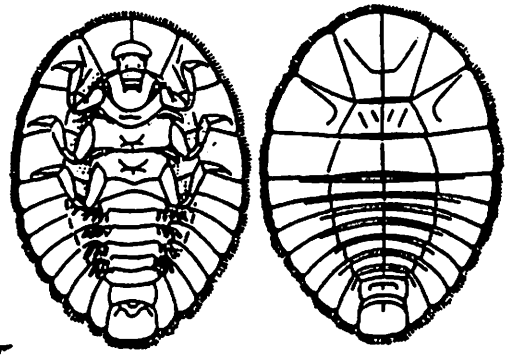


Families Ephemerellidae (in part), Caenidae, Tricorythidae

GATHERING COLLECTORS

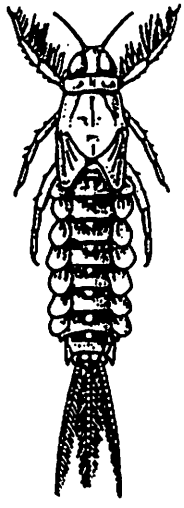
WITHOUT LONG TAILS
Beetles (Order Coleoptera)

Disc shape
Head and legs totally concealed beneath



Water Pennies (Family Psephenidae)

Body shape cylindrical
Long hairs on inside of front legs
Often with stripe down back

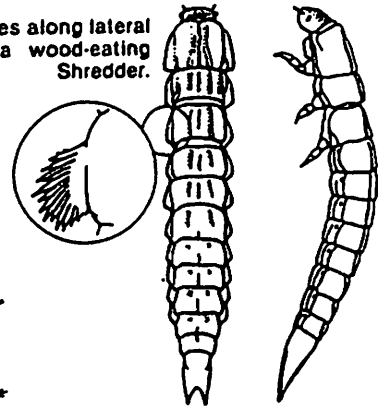


Family Siphlonuridae

FILTERING COLLECTORS

Slender
Triangular in cross section
Hard, yellowish brown covering

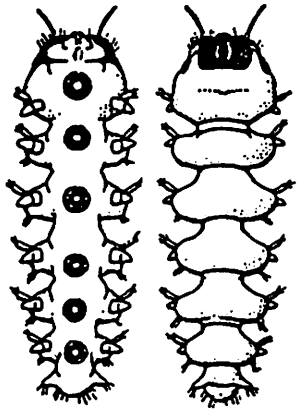
If larva has spines along lateral margins it is a wood-eating Shredder.



Riffle Beetles (Family Elmidae)

GATHERING COLLECTORS

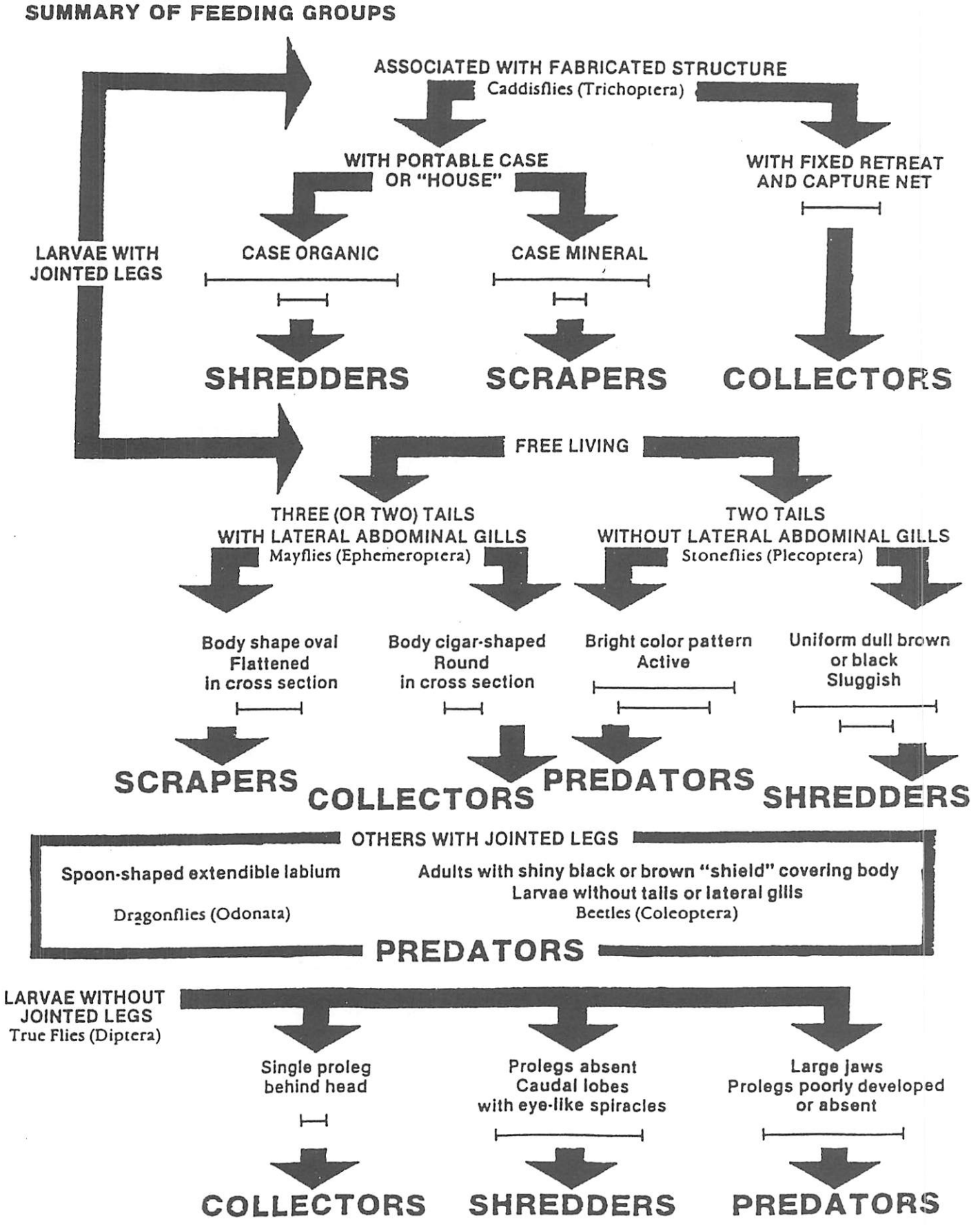
Lobed body
Ventral suckers



Family Blephariceridae

SCRAPERS

Appendix C—Key 7



Data Sheet for Macroinvertebrate Functional Group Analysis Date _____ Name _____

Site _____ Description _____

Functional Group	Habitat-Organic Resource Categories											
	Leaf Pack		Rock (Periphyton)		Fine Sediments (Pools)		Wood		Vascular Plants		Σ
Shredders (SH)	Count	F*	Count	F*	Count	F*	Count	F*	Count	F*	
Collectors - Total (C)											
Filtering (FC)											
Gathering (GC)											
Scrapers (SC)											
Total w/o Predators (T)											
Predators (P)											
Total with Predators (PT)											

*F = Recruitment factor to indicate importance of new generations entering a given group

RATIOS (General ranges in parentheses) Riparian Habitat	Stream Orders 1-3 (Approx. 0.5-10 m wide)		Stream Orders 4-6 (Approx. 10-0 m wide)	Stream Orders > 6 (Approx. > 30 m wide)
	Shaded well developed, trees and/or shrubs	Open low shrubs and/or herbs and/or grasses	Open variable, trees and/or shrubs	Variable, flood plain or "green belt" forest
Functional Group Ratios	Calculated (Examples)	Calculated (Examples)	Calculated (Examples)	Calculated (Examples)
SH/C	(> 0.30)	(> 0.15)	(< 0.10)	(< 0.05)
SC/C	(< 0.25)	(> 0.25)	(> 0.25)	(< 0.10)
FC/GC	(< 0.50)	(≈ 0.40)	(≈ 0.50)	(≈ 0.50)
SH/T	(> 0.25)	(> 0.10)	(< 0.05)	(< 0.01)
C/T	(> 0.50)	(> 0.40)	(> 0.50)	(> 0.75)
SC/T	(< 0.10)	(≈ 0.25)	(> 0.40)	(< 0.10)
P/PT	(≈ 0.10)	(≈ 0.10)	(≈ 0.10)	(≈ 0.10)

Appendix D—*How to Do Spawning Fish Surveys*

(Source: Salmon Trout Enhancement Program, Oregon Department of Fish and Wildlife)

STEP

SALMON TROUT ENHANCEMENT PROGRAM

Oregon Department of Fish and Wildlife

HOW TO DO SPAWNING FISH SURVEYS

INTRODUCTION

Spawning fish surveys are done regularly on many streams by Department of Fish and Wildlife field biologists. The information collected is vital to assessing the escapement of salmon and steelhead runs. It is an index to the status of those populations and helps predict future runs. They offer insight to whether a stream is being adequately seeded by spawners in a given year. Selected typical sections of streams are surveyed throughout the spawning season to cover the peak run. Adult salmon and steelhead are counted and fish per mile are calculated.

The department needs additional spawning escapement information on most streams. Volunteers doing spawning surveys will add valuable data that can guide Salmon and Trout Enhancement Program (STEP) efforts.

Some training, provided by ODFW personnel, is needed to prepare volunteers to do this survey. As with all STEP projects, certain procedures and guidelines must also be followed:

1. The volunteer must submit a project proposal for approval by ODFW staff. Your local STEP biologist will assist in making the application, and in selecting a stream to survey.
2. Contact landowners along the stream for permission to cross their property.
3. Training by ODFW personnel is required (about 2 hours). Classroom, hatchery and/or field trip to stress fish identification.
4. A "Volunteer Partial Liability Release Form" must be submitted and is available from STEP biologists.

GEAR AND EQUIPMENT

1. Map of stream section. Copy of USFS, BLM or USGS map in 2 inches/mile scale or larger.
2. Rain gear, hip boots or waders, warm clothes. Footgear should have non-slip material on soles, such as felt or outdoor carpet.
3. Walking stick, polarized glasses, knife, tape measure, thermometer.
4. Recording material; pencils, clipboard, stream survey form, scale envelopes (supplied by ODFW).
5. Knapsack, lunch, plastic bags for fish snouts, miscellaneous.

TIME COMMITMENT

Spawning surveys should be at least one-half mile long or longer. Under normal conditions, it takes about 1-2 hours to survey one mile of stream, plus be surveyed once every 7-10 days for duration of spawning period, which varies with species. Average 8-10 weeks. Total, about 8-10 half-days.

INSTRUCTIONS FOR SPAWNING SURVEY

Your STEP biologist will help you select a stream section to survey. He will also help you prepare a map.

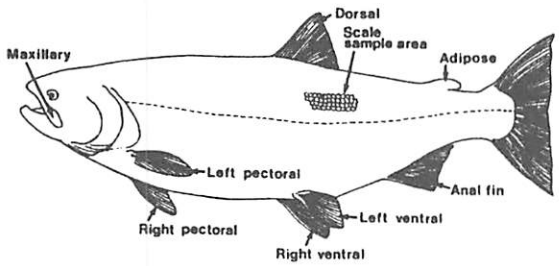
Once the section has been selected, mark the upper and lower ends so that you can return to the same spot each time you survey. Note on the map, and on the Section Description Form the STEP biologist will fill out, the beginning and end points and how it is marked.

SAMPLING FISH CARCASSES

While doing surveys, be on the lookout for carcasses of marked hatchery fish. One or more fins may be missing. If found, list under comments and include species, sex, length and fins missing. If the adipose fin (on back in front of tail) is missing, it may mean a coded-wire tag is imbedded in the fish's nose. Cut off the snout as close to the eyes as possible, note identification of stream, species, sex, date, and size in inches

on slip of paper and put in plastic sandwich bag with snout and turn it in to the STEP biologist.

The biologist may ask you to collect some scales from carcasses you find. Take several scales from the side of the fish in the area below the dorsal fin and above the lateral line (see illustration). The STEP biologist will provide scale envelopes. The daily survey form slips should be turned in each week.



SUMMARY

It is highly advisable to work in pairs while doing these surveys, with extra eyes helping to observe for all spawners in the section. Since surveys are often done in rough terrain and in isolated areas, working in pairs also adds a measure of safety.

After the first time or two on the survey, you will learn where fish tend to spawn and the hiding places they use. Look under overhanging brush, under logs or cut banks and other likely places. You will soon get the hang of it and be spotting the fish with ease.

EXAMPLE: SPAWNING FISH SURVEY FORM

BASIN	Nestucca R.	WEATHER	0
SUBBASIN	Three Rivers	FLOW	M
SURVEY	Alder Cr.	VIS.	1
DATE	Nov. 15, 1984	TEMP.	43°

	LIVE		DEAD			
	A	J	M	F	J	U
CHF						
CO						

Redds	

Basin: Main river name, e.g. Nestucca River

Sub-basin: Fork creek branch, e.g. Three Rivers

Survey: Creek name, e.g. Alder Creek

Date: Date of survey

Weather: C=clear, O=overcast, F=foggy, R=rain, S=snow

Flow: Record the streamflow as L=low, M=moderate, H=high, F=flooding

Visibility: The ability to see in the water:
1=can see well on riffles and in pools
2=can see on riffles
3=cannot see on riffles or in pools

Temperature: Record water temperature in nearest whole degree Fahrenheit

Fish Observed: Mark abbreviations in column on side: CHF=fall chinook

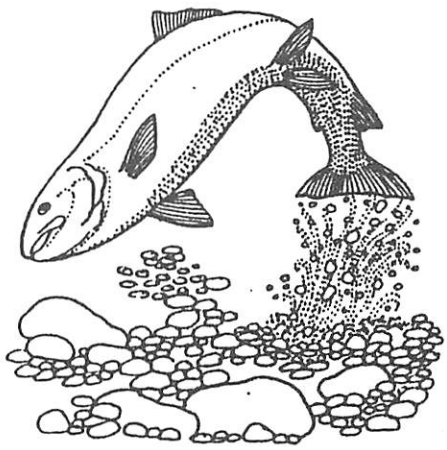
Species: CHS=spring chinook, Co=coho, CS=chum salmon, STW=winter steelhead, STS=summer steelhead

Live: Make tally marks for fish seen A=adults (over 20 inches), J=jacks (under 20 inches). At end of survey add total at bottom and circle, e.g. twenty

Dead: Record all carcasses seen with tally marks, or lengths if desired. M=male, F=female, J=jacks, U=unidentifiable. Total at bottom and circle, e.g. seventeen

Redds: Tally the number of redds observed (optional). Total and circle, e.g. eleven

Comments: Note any conditions or occurrences that are appropriate



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