WATERSHED STEWARDSHIP

A LEARNING GUIDE

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Contents

Section III. Evaluating, Managing, and Improving Watershed Functions

Glossary

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Watersheds Are Forever– Seeing the Whole Picture

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The term watershed is very popular these days. It's used in several ways, including as a physical boundary, as a key component in ecosystem management approaches to resource management, and as a metaphor for dramatic change.

As a physical boundary, a watershed is everything within a drainage basin. It includes everything from the ridgetops to the mouth of the largest river. If a drop of water falls on the top of a ridge, it flows down one side or the other, into one watershed or the other. Unfortunately, political and bureaucratic boundaries rarely are based on watersheds.

The ecosystem management approach considers how management decisions for one resource in a watershed affect other resources and the ecological functions of that watershed. While this "consider-everything-at-once" approach is more complicated, it accurately reflects the complexities and interrelationships in a natural system.

As a metaphor for dramatic change, a watershed event is something that signifies an entirely new way of thinking or doing something. It is accurate to say that the adoption of a watershed as the foundation for ecosystem management decisions is a dramatic change in resource management philosophy.

Watershed Stewardship: A Learning Guide is intended to help residents and volunteers be good stewards of their watershed. The driving force for the development of this guide was the 1995–97 Coastal Salmon Restoration Initiative. However, the focus of this guide is all salmonids (salmon, trout, and char) west of the Cascades.

Improved habitat for coastal salmon will benefit more than salmon. Most of the concepts, principles, and elements of this guide are relevant to other salmonid species and regions. Because other regions have watersheds with different ecological characteristics, make sure the projects you pursue are appropriate for your local environment.

How did we get where we are today?

Salmon have been an important part of life in the Pacific Northwest for centuries. Essential to the functioning of the ecosystem, salmon also have been important to humans. Native people continue to maintain some of the ancient expressions of their sacred relationship with the salmon.

While many newer residents also appreciate and enjoy this magnificent fish, the relationship between salmon and humans has changed fundamentally. The driving forces behind this change are the tools of our own success–industrial technology and development, global markets, and an exponentially growing demand for goods and services.

The decline of salmon and other native species reflects these trends. Until the mid-1800s, harvest technologies were simple, markets were local and regional, and there were few people relative to fish. By the turn of the century, harvest technologies allowed for a greater catch, canning and shipping created a national market, and more people started eating salmon. Since the 1950s, we've continued to increase our ability to catch, share, and consume salmon.

Ongoing developments in timber, agriculture, mining, damming, and urban growth have reduced the ability of natural systems to produce salmon as abundantly as they once did. At the same time, an ever-increasing population has created a greater demand for all of these products.

Fisheries managers have used hatcheries to fill the gap between historical expectations and current returns, but this technology has not countered the significant decline in returning salmon. With narrower margins of return, natural occurrences such as El Niño events and poor ocean conditions become a serious threat to the survival of some species.

As we enter a new century, salmon and the people interested in them are faced with the cumulative effects of humans' increasing ability to catch and eat salmon combined with a decreasing ability of the natural environment and hatcheries to produce salmon. We have done such a good job with our productive technologies that we now face the task of developing our social and cultural technologies. The challenge is to bring our physical needs into alignment with our other values–including the value of having salmon in our rivers.

TAKING ACTION–
FROM INDIVIDUALS TO GROUPS

Individuals and fishery-related organizations have been expressing concern about the declining numbers of salmon runs for more than 100 years. Early efforts at recovery were undertaken by those most directly affected–fishermen, cannery owners, fisheries managers, etc. Fishing seasons, limits, licenses, prohibitions, and propagation were used to increase the numbers of returning fish. Non-fishing users of waterways also were asked to help in obvious ways, but by and large fish were the concern of fishermen and fishery managers.

Later efforts to improve water quality in rivers also helped fish. However, these benefits were more incidental than designed. Water quality was improved for human uses, and fish also benefited.

The focus of early water quality efforts was directed at the most obvious sources of pollution such as effluent from industrial and sewage facilities, known as *point sources* of pollution. The basic tools used to improve water quality were government regulations, enforcement, and fines. The players were point sources of pollution, regulatory agencies, and a few watchdog organizations.

As point sources of pollution were controlled, the quality of the water near the sources improved significantly. However, the overall quality of water in our waterways remained degraded. Some areas were better off than others, but chronic water-quality problems persisted–even in rural areas away from point sources.

With the advent of the science of ecology, important realizations emerged with regard to fish health. One was that considerable degradation of water quality resulted from the cumulative impacts of runoff from a wide variety of *nonpoint sources* including city streets, lawns, farms, ranches, and timberlands. Another was the critical connection between the quality of salmon rearing habitat and salmon survival.

Thus, salmon recovery efforts shifted from simply plugging pipes to considering the impact across the entire landscape; and from increasing the numbers of fish to improving the ability of returning fish to thrive. This shift from treating specific symptoms to addressing root causes was reflected in the ecosystem management approach.

Along with a wider view of the root causes of salmon decline comes a wider collection of affected individuals. Fish no longer are the sole responsibility of fishermen and fisheries managers; in varying degrees, everyone in the watershed has an effect on fish.

It seems easier to use technology to solve specific problems of production than it is to create social technologies to manage collective actions across a landscape. The development of consensus among numerous stakeholders is complex and difficult. However, resolving issues through true dialogue and good faith attempts at understanding creates more effective solutions.

One of the first and longest lasting multi-partner efforts at salmon habitat improvement is the Salmon and Trout Enhancement Program (STEP). Since 1981, this group of volunteers has advised the Oregon Department of Fish and Wildlife (ODFW) on salmon enhancement efforts. STEP volunteers work on local habitat improvement projects, learn from their experiences, and share that learning through educational programs in schools.

The Oregon legislature established the Governor's Watershed Enhancement Board (GWEB, now the Oregon Watershed Enhancement Board, or OWEB) in 1977. In 1995, GWEB was given the charge of overseeing funding for habitat improvement projects proposed by emerging local groups called watershed councils. These councils are diverse groups of local residents and technical advisors from related agencies and organizations. They have been busy implementing projects and conducting educational programs with local landowners and residents. Despite the huge scope of the task, they're making progress.

In 1995, the National Marine Fisheries Service (NMFS) proposed to list coastal coho salmon under the Endangered Species Act (ESA). In response, the State of Oregon devised a Coastal Salmon Restoration Initiative (CSRI). This proposal was an attempt to restore and enhance habitat for salmon through *voluntary* actions leading to positive measurable results, rather than through new federal regulations. The National Marine Fisheries Service decided to give the CSRI a chance to work and has deferred the listing of coho salmon in most of coastal Oregon.

Watershed councils are the heart of the CSRI. They are to identify, prioritize, plan, and implement projects through voluntary local efforts that will improve conditions and increase the numbers of fish in the system.

In 1997, the same scenario happened with certain runs of steelhead. The state then combined the steelhead recovery effort, the CSRI, and a related water-quality program (the Healthy Streams Partnership) into one comprehensive effort and renamed it The Oregon Plan. As happened with its predecessor, The Oregon Health Plan, the federal government responded to this innovative approach by allowing the state to achieve agreed-upon outcomes in its own way, rather than imposing solutions.

Watershed councils have taken on added responsibilities with the emergence of the Oregon Plan. The deferred listings by NMFS give some time for local efforts to bear fruit. This does not mean that anything councils do in good faith is good enough. They must meet specific required outcomes established by the federal government.

Councils can get help identifying outcomes for their specific area and measuring the success of their efforts. No one person, publication, or guide (including this one) can be the only source of information and assistance. Two key references are forthcoming from other sources. The *Oregon Aquatic Habitat Restoration Guide* will provide guidelines for projects to enhance habitat. The *Oregon Watershed Assessment Manual* will define monitoring protocols to be used by councils to ensure quality and comparable data across regions.

An area of increasing importance is identifying and managing the workforce to do this important restoration work. Projects of the scope and scale needed to address outcomes adequately and monitor results appropriately require considerable time, effort, and expertise. Most likely, an all-volunteer council won't have all of the resources needed. The benefits of restoration work are multiplied when local residents can build new skills and successfully compete for emerging jobs in environmental restoration.

How this guide fits in

Watershed Stewardship: A Learning Guide was created–planned, written, reviewed, and published–by people who care about our watersheds and the people and businesses that depend upon them. It is a practical learning tool for a varied audience. This guide, like watersheds themselves, is a work in progress. As such, we've tried to keep in mind our vision *and* our realities–to learn, share, and work together; to do what we can now to have positive effects; to evaluate what we've done; and to make appropriate changes for the future.

We recognize that watersheds are complex systems, and the connectedness of all of the parts–from the mountaintops to the shoreline and beyond–cannot and should not be ignored. In this first edition of the guide, we purposefully limited our focus to the area from the mountaintops to the shoreline.

We also recognize that watershed stewards know a lot about some things, but no one knows everything about everything. This also was true of the writing team. We recognize that there are differences of opinion in materials presented. The intent was to present a broad brush of material that is factually correct.

Ultimately, this guide was created to help individuals and groups build a mutual foundation of basic knowledge about watersheds and what it takes to work together to enhance them. You can build upon this basic foundation through continued learning, sharing, and advanced training. In that vein, the guide also will encourage you to search for and obtain appropriate information to help you make the best decisions for your watershed.

In short, this guide i*s not* the Sistine Chapel of curricula, an encyclopedia, or a bible for all of watershed stewardship. Rather, it *is* a practical, useful, and resourceful *tool for watershed stewards*–for *individuals* (landowners, land managers, workers, and others who care for the watershed) and for *groups* (watershed councils, educators, affinity groups, etc.). This guide is a work in progress. The authors (listed at the end of this chapter) want and need to hear your ideas for improving the guide.

HOW TO USE THE GUIDE

This guide was written for watershed stewards–people who own, manage, work, volunteer, or in some other way care for or depend upon a watershed. It also provides guidance for groups of people who have come together formally or informally to be guardians of the watershed.

The guide is intended to be an easy-to-use collection of information. It can be the core component for training new group members or others who want to learn about the complexity of watersheds. It is a resource that provides core knowledge about resolving problems or making sound decisions and serves as a conduit to other resources about specific problems or decisions.

You can use the guide individually or as a group to the degree, speed, and depth that fits you personally. You can read the guide from cover to cover to get the full picture. The chapters in each section complement each other and provide information to better understand the complexity of watersheds and working together as watershed stewards.

You can enhance learning further by coordinating the use of the guide with training based on local needs and wishes. The chapters are written with the idea that they can be used as part of workshops along with other materials (slides, videos, etc.).

But you also can use the guide a chapter at a time, either alone or with other chapters in the same section or other sections. Each chapter is meant to stand alone if necessary, although a chapter may refer to information presented in other chapters or other sections. However, if you use the chapters individually, you'll still have the opportunity to gain some basic understanding of the topic, albeit in a limited context. In other words, you won't necessarily get the big picture.

Each chapter in the guide follows the same outline:

- *Introduction* to the topic and what you'll learn in the chapter
- *The core subjects*–the things you really need to know
- *A summary/self review*
- *Exercises* to give you the opportunity to practice what you've learned
- *Resources* for further training and information
- *Three next steps to put this into practice*–a place for you to fill in (in your own words) steps, actions, thoughts, contacts, etc. you plan to take to move yourself, your farm, land management agency, community, group, etc. ahead.

The Resources section of each chapter is a reminder that this guide is only one of many available resources on this topic. OWEB, NMFS, For the Sake of the Salmon (4SOS), Pacific Rivers Council (PRC), and many other groups, agencies, and universities are continually increasing the knowledge and resource base for this exciting area. In some cases, the funding or success of a restoration project may lie in following certain steps or procedures listed in technical manuals. This guide is a starting place. *The key is to know–and stay current with–what's out there and how to get it.*

Authors and Reviewers

Many people helped create this guide. A multi-disciplinary team of authors from the OSU Extension Service worked for several months to gather and present in a helpful, useful format the information in each section. But it didn't stop there. Drafts were reviewed internally by team members and their OSU colleagues. Then the guide underwent a rigorous external review–more than 60 individuals representing *groups or agencies* (U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, OWEB, Natural Resources Conservation Service, Soil and Water Conservation Districts, Pacific States Marine Fisheries Commission, 4SOS, Oregon Forest Resources Institute, etc.), *industry* (consultants, landowners, etc.), *watershed councils, academia,* etc.–to help assure that the guide is the best it can be for this first edition. A heartfelt thanks to the authors and reviewers. Special thanks to Teresa Welch, project editor; Karen Skjei and Rick Cooper, layout and design; and Tom Weeks, cover design. We also thank the Oregon Forest Resources Institute and the OSU Extension Service for financial support.

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Section I. Working together to create successful groups

1. Creating Successful Partnerships

2. Choosing Your Group's Structure, Mission, and Goals

3. Effective Meetings Management

4. Decision Making

5. Communication Skills

6. Dealing with Stumbling Blocks

1

Creating Successful Partnerships

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, association, or coalition, members share 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 is the first chapter of this section on Working Together to Create Successful Groups. It highlights some of the unique aspects of watershed groups and points out how they can be formed and sustained successfully. This chapter will provide you with a basic understanding of partnerships.

In this chapter, weÕll speak as if you were starting a partnership from scratch. In practice, most groups already are involved in some kind of partnerships. If thatÕs the case with your group, youÕll still find lots of ideas here to help you.

In this chapter youÕll 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

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

See Section I, Chapters 2–6, and Section II, Chapter 1 for information related to this chapter.

Section I

2 Group Structure

3 Meetings

4 Decisions

5 Communication

6 Stumbling Blocks

Section II

1 Planning

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.

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 a common 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 since 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're 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 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 may 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 I-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 I-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 I-4, "Decision Making," for more information on effective decision-making methods.
- *Pooled resources*–Partnerships improve on-the-ground management by pooling 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 I-5, "Communication Skills," and Chapter I-6, "Stumbling Blocks.") 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.

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 systems, economic systems, community and political systems).

Collective involvement

Watershed groups are primarily voluntary groups and therefore require voluntary involvement. People contributing their time and good will 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 systems, economic systems, 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 include 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, 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 often is easier to get people involved when they know they've been referred by someone they trust.

The following list (also 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

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. Some tips (from the *Partnership Handbook*) include:

- 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. In order 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 due to changes in management practices. But someone else could rightly say, "What about fishermen?" Another person might say, "What about the public, who is paying more for water treatment and receiving less 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 means 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. The existing Salmon Safe program is an example (see the Resources section).

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

While watershed groups tend to be voluntary partnerships, project implementation may require outside help. Despite broad membership in your group, you may 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 may have experience in contracting, or you may 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 non-local firms that have done this kind of work before. While 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 may 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 where 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 (SBDC) at your local community college
- Your local Natural Resource Conservation and Development Council (RC&D)
- The regional office of the Oregon Employment Services Department
- The local provider for the federal Job Training Partnership Act (JTPA) program
- Your local Soil and Water Conservation District (SWCD)
- The Salmon Trout Enhancement Program (STEP)

CONSULTANT SELECTION CHECKLIST

Len Marrs of PHC Reclamation offers a consultant selection checklist (see Resources). He suggests you ask whether the prospective firm has:

- Successful experience with sites similar to yours
- Completed projects within budget guidelines
- Experience working with government agencies
- Clearly defined methods and protocols
- Proven technical and scientific abilities
- Experienced personnel
- A clear and detailed proposal
- A good reporting plan

Shared vision

The most important element of any partnership with diverse membership is its shared vision–the basic reason why 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 I-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 I-2, “Choosing Your Group’s Structure, Mission, and Goals,” is one effective method of goal setting. Chapter II-1, “Principles of Planning,” 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 I-2 and II-1 for more information.

Summary/Self review

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 upon 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 may 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 everyone in the watershed to contribute to the vision in the best way they can.

EXERCISE

The following exercise will help you check how well your local watershed partnership compares to the ideal partnership. You can do this exercise on your own or as a group discussion.

1. Reflect on your experience with other, more homogenous, groups (for example, a commodity group, agency, or environmental group). Compare that experience with your experience in the watershed group and answer the following questions:
   - How does a diverse partnership such as a watershed group make participation in the group more difficult?
   - What outcomes can a diverse partnership achieve that can't be achieved by a homogenous group?
2. Next, evaluate your watershed group in terms of the ideals for a successful partnership:
   - How does it currently measure up to the goal of collective involvement?
   - How often do you review and articulate your common vision?
   - Could an outsider to your group look at the stated goals and objectives and see how they will be measured?

RESOURCES

Training

The OSU Extension Family Community Leadership program at Oregon State University has excellent publications and training opportunities–often free or for a nominal charge–in many Oregon counties. Contact your county office of the OSU Extension Service for details.

University Associates offers a variety of training programs on group process and organizational development. They can be contacted at 3505 North Campbell Ave., Suite 505, Tucson, AZ 85719; phone: 520-322-6700; fax: 520-322-6789; email: info@universityassociates.com; Web: www.universityassociates.com

Christopher Roach, Dialogue Dynamics, is a Corvallis-based trainer who has expertise on this subject. He can be contacted at 966 NW Sequoia, Corvallis, OR 97330; phone: 541-754-5521.

Information

*Collaboration Framework (*The National Network for Collaboration, Fargo, ND). Phone: 701-231-7259; email: nncoinfo@mes.umn.edu; Web: http://www.reeusda.gov/4h/cyfar/cyfar.htm

Creating Community Anywhere, by C.R. Shaffer and K. Anundsen (Jeremy Tarcher/Putnam Book, New York, 1993). ISBN 0-87477-746-1.

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

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

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/CTIC/Catalog/WatershedManagement.html

The address and phone number for ordering CTIC material is:

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 USDA NRCS Iowa in cooperation with other state and federal agencies and associations. 20 pages.

Building Local Partnerships: A Guide for Watershed Partnerships. Booklet with good sections on identifying and involving partners, communication, teamwork, and building consensus. 10 pages.

Building Local Partnerships Guide. Describes who should be involved and what they can bring to the group. 12 pages.

Farmer-led Watershed Initiatives Conference Proceedings. Manual includes case studies of five farmer-led watershed initiatives (Heron Lake, MN; North Fork Ninnescah/Cheney Reservoir, KS; Embarras River Basin, IL; Otter Lake, IL; Catskill-Delaware Watershed Complex, NY). Also includes brief descriptions of presentations on farming practices and innovative management practices. 32 pages.

Farming for Maximum Efficiency (MAX) Kit. MAX has been used successfully by farmers to evaluate return on their inputs (e.g., nutrients, tillage practices, pesticides, etc.). Now CTIC and corporate sponsors Monsanto, Bayer, and Case are working with 13 watershed partnerships in 5 states to emphasize watershed issues and help farmers understand the economic benefits of conservation practices.

Geographic Information Systems (GIS): Introduction for Public Agencies Manual. Provides decision makers 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.

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 pages.

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 pages.

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 pages.

Leading and Communicating: A Guide for Watershed Partnerships. Booklet covering listening, discussion, brainstorming, and other communication skills. 6 pages.

Leading and Communicating Guide. Describes the skills needed (and serves to refresh your skills) to facilitate a diverse partnership of stakeholders. 8 pages.

Managing Conflict: A Guide for Watershed Partnerships. Booklet describing general negotiation skills and a five-step process for managing conflict. 6 pages.

Managing Conflict Guide. Describes how you can turn conflict into a healthy discussion resulting in viable ideas. 8 pages.

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 pages.

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.

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.

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.

Operation Greenstripe Kit. This packet provides information on Operation Greenstripe, a program developed by Monsanto to provide monetary incentives for FFA chapters 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.

Putting Together a Watershed Management Plan Guide. Describes the process of putting together a plan that all with a stake in the watershed can agree to implement. 16 pages.

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 pages.

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, IL Stormwater Management Commission. 6 pages.

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 and/or be recognized in the press and/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.

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 Services Agency, Natural Resources Conservation Service, Fish and Wildlife Service, U.S. Geological Survey, U.S. Environmental Protection Agency Regions, Great Lakes Nonpoint Source, and National Estuary Program. 24 pages.

"Think Globally-Act Watershed" bumper stickers. Also provides a telephone number for obtaining information about watersheds. $2 for 1, $1 for each additional sticker

U.S. Watershed Map. This map shows the 2-digit, 4-digit, 6-digit, and 8-digit watersheds using the USGS numbering system. Originally printed by USGS.

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.

A Watershed Approach to Urban Runoff: Handbook for Decisionmakers Guide. Outlines the process for understanding your watershed; the watershed management approach to assessing, planning, implementing, and evaluating; and 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 EPA Region 5. 115 pages.

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.

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.

MOVING FORWARD—THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in strengthening your partnership.

1. ______________________________

2. ______________________________

3. ______________________________

2

Choosing Your Group's Structure, Mission, and Goals

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 I-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 of the players in your watershed group
- What to do when things go wrong (or right)

Being clear about your mission also is 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?

See Section II, Chapters 1 and 3–6; and Section II, Chapter 1 for information related to this chapter.

Section I
1 Partnerships
3 Meetings
4 Decisions
5 Communication
6 Stumbling Blocks

Section II
1 Planning

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. The next, more important, step is to answer: "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, 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: "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" *(Creative Organizational Theory)*.

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!

"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."

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 Borg 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 ultra-stable. 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.

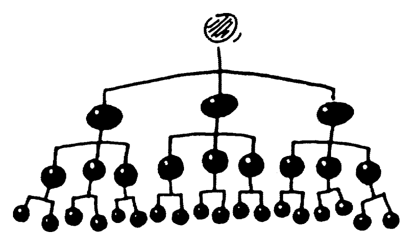


Figure 1.–The rigid organization.

- *Environment is ultra-stable*
- *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

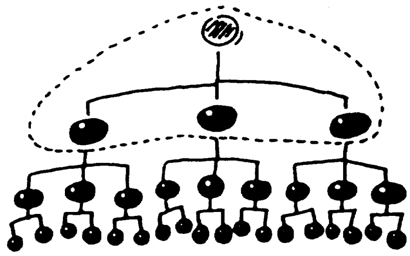


Figure 2.–Senior management team.

- *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*

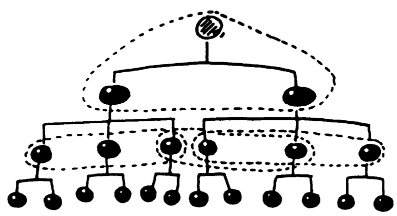


Figure 3.–Project teams and task forces.

- *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*

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).

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 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. Since 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 organization 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.

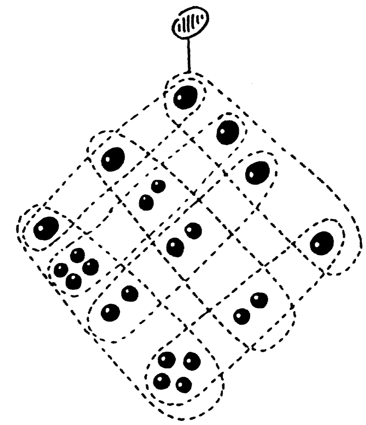


Figure 4.—The matrix organization.

- *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*

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 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.

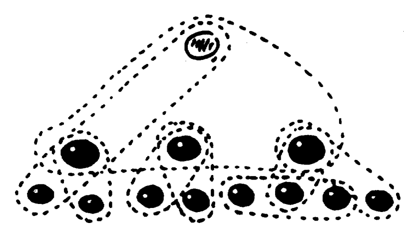


Figure 5.—The project organization.

- *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*

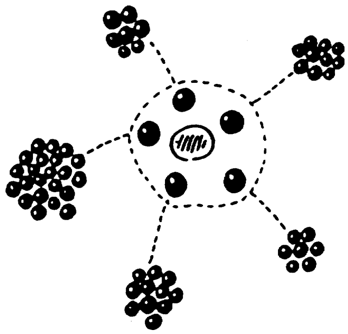


Figure 6.—Organic network.

- *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*

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).

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*, 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 I-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."

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.

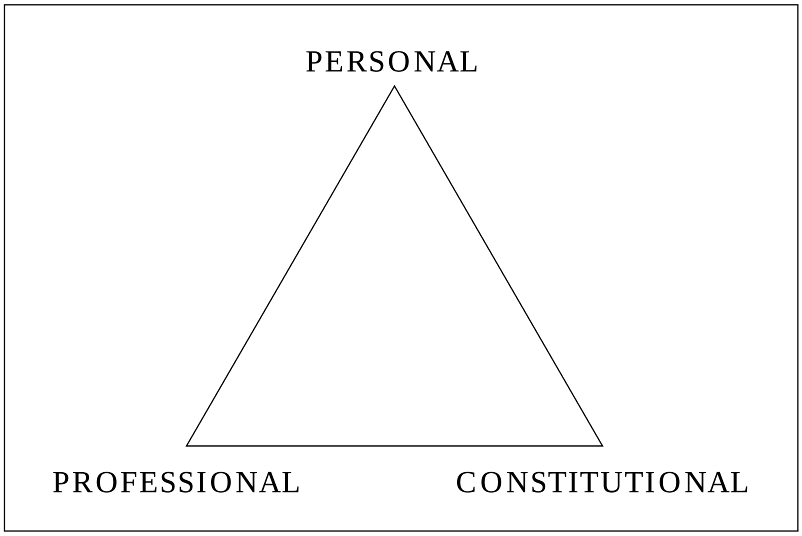


Figure 7.—Our personal, professional, and constitutional values interact to define how we relate to the world.

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 about 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 your 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*, say it best: ". . .we 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.”

> *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.

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 1 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 these 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. See Chapter II-1, “Planning for Watershed Restoration,” for more about goals and objectives.

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! To 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 I-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 I-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 big-picture oriented *(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)*

Group chair

Letting go of old assumptions is the hardest part of being the chairperson. We all remember when the chairperson "ran" the meeting, called for reports, kept everyone on task, made the decisions, and basically told group members what to do. The old job description for chairperson mixed content and process roles, combining the "what you do" with "how to do it."

But the assumption that group members share the responsibility for creating successful meetings eliminates the need for this duality. In fact, one of the biggest deterrents to group success can be a chair who isn't able to relinquish the process role.

So, what does an enlightened chair do? In addition to *all the responsibilities of a group member*, an effective chair does the following.

Before the meeting:

- Works hand-in-hand with the meeting manager to prepare and organize the meeting agenda.

During the meeting:

- Focuses on the *content*, ensuring that everything the group does moves the group closer to its goals.
- Embodies facilitative leadership.

Between meetings:

- Channels communications between staff/committees/members.
- Represents the group to the outside world.

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)*

Some watershed groups are fortunate enough to have staff. Staff:

- 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 I-3, "Effective Meetings Management.")

WHEN THINGS GO WRONG

Every group goes sideways. While it would be nice to go from Point A to Point B in a straight line, that rarely happens. Generally, a mix of forward 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 I-6, "Dealing with Stumbling Blocks," discusses some common stumbling blocks that partnerships often face, and suggests some 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 that 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/SELF REVIEW

The following checklist will remind you of the key points in this chapter and will help you see where your group may 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?

Exercises

Think of a group you belong to. Because we've been talking about watershed groups, you might want to choose that one, but any group will do. Work together as a group to complete this exercise.

Visioning

This exercise will help your group quickly develop a working framework of vision, mission, values, and goals. It begins with individuals, who then "compare notes" in small groups, which bring the results to the full group.

1. *15 minutes*: First, ask each person to think about what the organization is and what it is trying to accomplish. Then, imagine an event in the year 2007. Your organization is receiving an award for innovative, outstanding work. You are at the podium to receive the award on behalf of your group. The master of ceremonies is reading the citation right now. You are listening intently, leaning slightly forward, focused on his every word. What is he saying? Write it down.
2. *30 minutes*: Get together with a group of three to five people. Ask each person to read his or her citation. After listening to each other, record the major points on flipchart paper. Also, write down individual value-laden adjectives and nouns such as "innovative," "stewardship," and "comprehensive."
3. *60 minutes*: Now, hand all of the flipcharts to a committee of two or three people who really like to wordsmith. The committee's job is to use the words and phrases on the flipcharts to draft vision, mission, values, and goals statements for the group.

   This task isn't as difficult as it sounds. Use the definitions found earlier in this chapter. Vision phrases will have an idealistic "apple pie and motherhood" sound. Mission and goal statements may look similar at first, but missions are bigger and more encompassing than goals. Value-laden words can be developed into operating principle statements. One of the most famous operating principles of all time is: "We hold these truths to be self-evident. All men are created equal." Starting your statements with "We believe. . ." can help. Don't agonize over this process.
4. After you've drafted reasonably good statements, put them on flipcharts and post them at the next meeting. Ask group members to write their comments on post-it notes and stick them on the charts. Tell them you welcome positive comments as well as suggestions for improvements. You'll notice this technique prevents the deadly "everybody's an editor" syndrome.
5. Now rework the statements, incorporating the suggestions as much as possible. The only trick to this job is to make sure you use the actual words and sentiments of the people who made suggestions, not just your own.
6. Now take the "new, improved" statements (on flipcharts) back to the group. Ask them to adopt them for a year. Remind them that you've merely wordsmithed what they wrote down. Almost universally, groups will accept the statements on a trial basis for a limited amount of time.

If the worst happens, and several people are adamantly opposed to the statements, suggest that since your committee has accomplished its task, you will hand over all of the working flipcharts to them. Encourage them to create their own draft for approval by the full group. Request a similar timeline. Guaranteed, this technique works!

Desired characteristics for group members

This short exercise will help your group easily identify the desired characteristics for new members.

1. First, when the whole group is together, ask each person to write on a post-it note the one, most important characteristic a group member should have.
2. Collect the post-its and give them to a committee of wordsmiths (a different group than the ones who worked on the first exercise). This committee will take about 30 minutes to draft the characteristics into “desired qualifications” statements. If the committee gets stuck, they can modify the Marines’ slogan, “We’re looking for a few good people who. . . .” Use these qualifications when recruiting new group members.

RESOURCES

Training

The *OSU Extension Family Community Leadership program* at Oregon State University has excellent publications and training opportunities–often free or for a nominal charge–in many Oregon counties. Contact your county office of the OSU Extension Service for details.

Information

The Art of the Long View, by P. Schwartz (SAGE Publications, Newbury Park, CA, 1996). ISBN 0-385-26732-0

Creative Organizational Theory, by G. Morgan (SAGE Publications, Newbury Park, CA, 1989). ISBN 0-8039-2831-9

Images of Organization, by G. Morgan (SAGE Publications, Newbury Park, CA, 1986). ISBN 0-8039-2831-9

Starting Up: A Handbook for New River and Watershed Organizations (River Network). PO Box 8787, Portland, OR 97207; phone: 503-241-3506

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in determining and evaluating your organizational structure, roles and responsibilities, vision, mission, and goals.

1. ______________________________

2. ______________________________

3. ______________________________

3

Effective Meetings Management

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, we love our tall trees, pristine beaches, and towering mountains. What do we dislike the most? Attending meetings, especially public meetings!

Since meetings are a required part of our lives, let's see if we can make them better. After all, if your meetings are more effective, you'll probably have more time to do what you really want to do, such as visit tall trees, pristine beaches, and towering mountains.

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. For example:

- 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 may 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

True openness means 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.

Open

We have open public meetings in Oregon. It's 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 already have been made

- Acknowledging that some issues–e.g., 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
- 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.

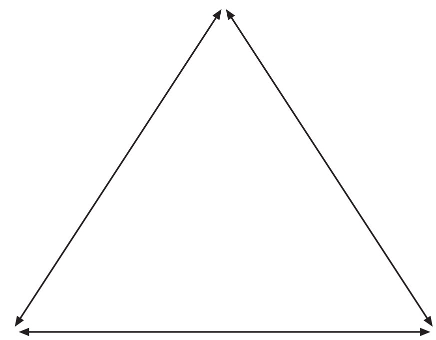


Figure 1.–All three principles should be in place and in balance, something like an equilateral triangle.

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 info 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 Christmas tree 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.

See Section I, Chapters 1, 2, 4, 5, and 6 for information related to this chapter.

Section I

1 Partnerships
2 Group Structure
4 Decisions
5 Communication
6 Stumbling Blocks

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's just picked up his cell phone).

4. Use wall notes for group memory.

Wall notes–chalkboards, butcher paper, flipcharts–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 flipchart 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 comprised 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 these methods:

Try nonverbal communication.

"We've spent a lot of time talking around this issue. How about everybody taking 5 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 I-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 I-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, the father of meeting management and environmental education in Oregon, 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 I-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.

For example:

"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!"

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.

"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 flipchart. Wait, before you dash out, do we have it correctly written down?"

If it's a major decision, you may 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 I-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:

- *3 minutes*: One person volunteers to record. On a flipchart, 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.
- *1 minute*: Ask each member to do the same exercise individually. Have one person collect and tabulate results.
- *3 minutes*: Hang a flipchart at the exit of the room. As people leave, have them mark on a line how successful the meeting was for them (Figure 2).

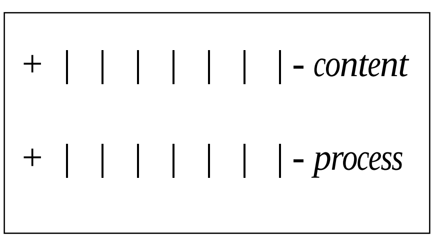


Figure 2.–Have people mark on a line how successful the meeting was for them.

ROLES AND RESPONSIBILITIES FOR SUCCESSFUL MEETINGS

Making your meetings successful is your responsibility. It is not the chairperson's job nor the high-paid outside facilitator's job; 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)

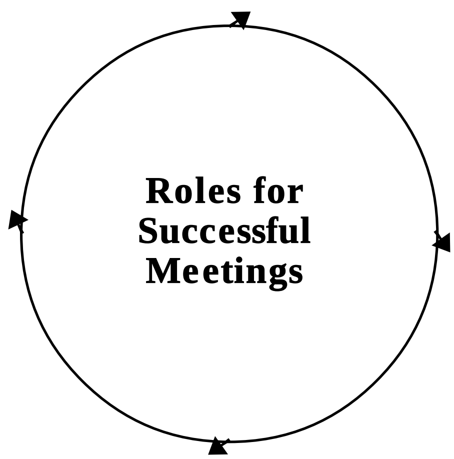
- Helps group focus on task.
- Depersonalizes ideas.
- Is instant record of meeting progress.
- Minimizes repetition.
- Encourages participation because it respects each idea.
- Ensures that ideas are recorded accurately.
- Helps problem solving by preserving information through different phases.
- Helps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

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.)

☼ Summary/Self review

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-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 Oregon'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 you promise?

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, flipcharts 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?

EXERCISES

Dealing with difficult participants

You can do this exercise on your own in about 10 minutes.

Every group has at least one member whose behavior sometimes slows progress. This person can be a talker who never seems to pause, or someone who waits until a decision is made, then drops the bombshell, or. . . . I'm sure you can come up with your own scenarios.

In this exercise, your job is to think up at least three ways to pleasantly deal with the situation. Keep in mind the fair-open-honest philosophy. Then, the next time he or she strikes, you're ready to go into action!

Remember, every group member is responsible for helping the group move forward. Don't wait for the meeting manager to take care of it.

Keeping your meeting focused

Do this exercise at one of your group meetings. It should take about 10 minutes.

If you're intrigued about these meeting management ideas but aren't ready to take on a whole meeting, here's a low-risk exercise to get your feet wet. Talk to the meeting manager first so he or she will know what's going on.

At your next meeting, as soon as everyone's settled and the meeting is ready to start, grab a marking pen, walk up to a flipchart, and ask the group to help you answer this question: "What will make this meeting successful?" Write down their responses. Post the flipchart paper on the wall and sit down.

Now, during the meeting, focus on helping achieve these successes. At the end of the meeting, take 3 minutes to refer back to the chart and check off the items the group has accomplished. Are you surprised how easy it was to take these steps?

Resources

Training

The Family Community Leadership (FCL) program of the OSU Extension Service. Check with your county OSU Extension Service office.

CISPUS Inter-Agency Public Meetings Training. If you work for a federal or state natural resource agency, call Susan Saul at 503-231-6121 about the training schedule.

Information

The Fifth Discipline, by P. Senge (Doubleday, New York, 1990). ISBN: 0-385-26094-6

The Fifth Discipline Fieldbook, by P. Senge (Doubleday, New York, 1994). ISBN: 0-385-47256-0

How to Make Meetings Work, by M. Doyle and D. Straus (The Berkley Publishing Group, New York, 1985).

The Skilled Facilitator, by R. Schwartz (1994). ISBN: 1-55542-638-7

We've Got to Start Meeting Like This! by R. Mosvick and R. Nelson. ISBN: 1-57112-069-6

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in improving meeting management skills.

1. ____

2. ____

3. ____

4

Decision Making

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 I-3 and I-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 the decision-making process is unclear, different people can leave a meeting with a different understanding of the decision.

If there are official and nonofficial members, 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, vision statement, etc.) 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 may not 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 flipchart 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 flipchart 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 non-decisions at the end of the meeting.

Include decisions and non-decisions 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 decision at hand. Listed below are six common ways groups make decisions and the limitations of each of these methods (Miller et al.).

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

These 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

These 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.

See Section I, Chapters 3, 5, and 6 for information related to this chapter.

Section I

3 Meetings

5 Communication

6 Stumbling Blocks

"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

This 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 add four general "approaches" to decision making: the authoritarian, majority, minority, and consensus approaches.

Authoritarian decisions

In this 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 often are framed as either/or choices that oversimplify the issues.

Minority decisions

In practice, majority rule often is 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.

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 often are surprised to find out how often supposedly "opposite" positions actually share many common interests.*

Groups often are surprised to find out how often supposedly "opposite" positions actually share many common interests. 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 may 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

Most 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 (De Vries, 1994). 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 yea's and nay's, 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 I-2, "Choosing 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 I-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 (Mosvick and Nelson). 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.

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

☼ 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 made?

- 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?

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 at the left is a model for making important decisions on complex issues. The "deciding" in these cases actually is an extended form of problem solving.

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

The framework below incorporates a step-by-step process (in italics) 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 (see Chapter I-6, "Dealing with Stumbling Blocks," for more information):

- *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 also is the one most likely to be implemented.

SUMMARY/SELF REVIEW

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.

EXERCISES

Decision-making methods

Review the section on different ways groups make decisions. During your next group meeting, notice which methods are used (e.g., majority decision, yes/no, or default). Do the methods change depending on the situation? Are there times when a more complex decision-making process is necessary?

Documenting decisions

At your next group meeting, pay particular attention to whether or not your decisions are documented. If necessary, propose formal adoption of a decision-making process and a means for documenting and tracking important decision.

Resources

Training

The OSU Extension Family Community Leadership program at Oregon State University has excellent publications and training opportunities–often free or for a nominal charge–in many Oregon counties. Contact your county office of the OSU Extension Service for details.

University Associates offers a variety of training programs on group process and organizational development. They can be contacted at 3505 North Campbell Ave., Suite 505, Tucson, AZ 85719; phone: 520-322-6700; fax: 520-322-6789; email: info@universityassociates.com; Web: www.universityassociates.com

Dialogue Dynamics, Christopher Roach, is a Corvallis-based trainer who has expertise on this subject. He can be contacted at 966 NW Sequoia, Corvallis, OR 97330; phone: 541-754-5521.

Information

How to Run a Meeting, by M.A. De Vries (Plume/Penguin Books USA, Inc., New York, 1994). ISBN 0-452-27128-2.

Rural Resource Management, by S.E. Miller, C.W. Shinn, and W.R. Bentley (Iowa State University Press, Ames, 1994). ISBN 0-8138-0686-0. 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 (Park Avenue Productions, Indianapolis, 1996). ISBN 1-57112-069-6. 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 are directed at community collaboration for a broad range of purposes, including economic development and social programs as well as land-use planning. All 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. 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. 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. This guidebook geared toward local government managers and other community leaders covers strategies and techniques for using participatory group processes to resolve community problems, including: when consensus programs are appropriate; what types of problems lend themselves to the consensus approach; and the formats, phases, and considerations for running a consensus program. Includes case studies illustrating the techniques.

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in improving decision-making skills.

1.______________________________

2.______________________________

3.______________________________

5

Communication Skills

Flaxen D.L. Conway

C*ommunication*—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.

Learning how to communicate effectively 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 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 a common interest and 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.

In Chapter I-6, you'll find some common pitfalls that many groups run into. Many of these pitfalls are related to communication problems. See that chapter for more ideas on how to prevent or overcome these problems.

In this chapter you'll learn:

- Why active listening is important, and the key elements to doing it well
- Ways to express yourself directly
- Ways 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

ACTIVE LISTENING

See Section I, Chapters 1, 2, 3, 4, and 6 for information related to this chapter.

Section I
1 Partnerships
2 Group Structure
3 Meetings
4 Decisions
6 Stumbling Blocks

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

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 makes them feel 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 (for example, face the person and 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
"Wow, 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 Feds'."

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 coworkers?"

or

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

Step 4. Summarize and clarify.

Now, pull together what you've heard. Getting clear keeps you from falling into "selective perception" and the problematic "as if" zone. In this case, you respond in a certain way ("as if") because you expect the other person to react in a predetermined way (either because he or she has reacted that way before in situation X or Y, or because it's how you would react in the same situation). When you're in the "as if" zone, you're not waiting for reality, you're predetermining it. This scenario often happens despite the fact that it isn't clear communication and is unhelpful for both the speaker and the listener.

In addition, getting clear can help the speaker clarify possible choices. For example:

"You've mentioned firing him or just letting it go. I wonder if those are your only options."

or

"Sounds to me like you see several options, although some are more appealing than others. Is there any way you can get clearer on which one(s) 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. Remember, sharing your opinion is most helpful if you ask whether the speaker is willing or wants to hear it. Here's one way to ask:

1. Pause for a moment.
2. Preface your opinion with a statement such as, "Would you be open or interested in hearing my opinion on this issue/situation?"
3. If they respond with "no," let it go. Maybe they just needed to talk and they'll figure it out on their own. If they respond with "yes," use the skills presented throughout this chapter to guide you through a helpful exchange of ideas and feelings.

✲ Pitfalls in active listening

Like everything in life, there are pitfalls to avoid in active listening. For example:

- *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 may 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.

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 nondefensive*. 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 3–10 assertions to deliver a message that a listener actually gets. The key to success is to be clear about "What I want" and "What I'm 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 it–can decide whether a change in behavior is desirable at this time.

Feedback is useful *only* when it is:

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

Through active listening and clear, direct expression, two or more people in a conversation–when willing–can truly communicate their ideas and feelings 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 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 very important tool to watch and use in groups. It's especially important when a group is making a decision. Are people saying "yes" with their words but "no" with their bodies? Chapter I-4 talks about decision-making steps and strategies for groups.

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:

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

A. *I feel A . . .*
"I' m feeling really frustrated . . ."

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

C. When you do C . . .
". . . and you keep talking to me, but I can't hear everything you're saying."

- By talking about yourself first, you avoid bringing out listeners' need to defend themselves. By being descriptive, you let listeners know exactly what situation you feel angry about.
- 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 us, without an agenda, time pressures, or trying to solve something.

Dialogue is more than talking. It 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 of communication is to decide something, do something, or convince someone, then the goal of dialogue is listening 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 your group works together and communicates with each other and the outside world about its benefits, challenges, successes, and failures.

Dialogue is a conversational practice. Like 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 farther 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 its internal and external communications (how and when to get a topic on a meeting agenda, communicating with the media, etc.). 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. Setting protocols might feel time-consuming, tedious, and artificial at first. However, creating and following protocols is 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 may 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.*

> *Clear communication protocols can improve understanding among group members, raise trust, and make working together more fun and comfortable.*

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, etc. If all group members understand the protocols, they'll 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 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, etc.?
- 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, etc.), don't resist a discussion to make 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 greatly.

To the right are three examples of actual external communication protocols that were developed by one group (here called Group A) to enhance effectiveness, trust, and safety within the group. This group is made up of many different people, with diverse interests and perspectives, but a common mission. It's set up as a membership group with a board of directors.

Your group's structure may be different, and y*our group's protocols should be suitable for its structure*. See Chapter I-2 for information about organizational structures and what makes them work.

Group A's external communication protocols

Protocol #1–Communicating with the media: Press releases

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

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

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

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

Step 3. All directors and members get final news releases.

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

Protocol #2–Communicating with existing/other groups

- Group A developed a mutually-agreed-upon "canned general statement" about their group and its mission, goals, etc. 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, Group A members may join.
- Who joins should be based on comfort, area of interest (subcommittee members?), geographic location, etc.
- You must poll Group A's board of directors before you commit.
- If membership costs, poll Group A's board of directors and membership to see whether it is worth it to join.
- If you sit on existing groups ("wear another hat"), please poll Group A's board of directors before you wear our (Group A's) hat.

☼ Summary/Self review

Active listening is important because it allows speakers to feel heard and gives them the opportunity to clarify their meaning. It helps people accurately assess the situation. The key elements of good listening include acknowledging feelings first, reflecting what's being said, asking clarifying questions, and summarizing your understanding of the communication.

The key points of direct expression (including oral, written, and action) are being clear on what you want and what you're willing to give. Tools for direct expression include using "I statements," giving feedback appropriately, and being aware of your body language and what it might communicate 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 skills include giving others enough time and space to finish a thought, and listening deeply without the need to fix, counter, argue, or resist. By practicing dialogue, you can improve these skills.

Protocols are codes of behavior or conduct that help groups run smoothly. Internal communication protocols are ways to interact and communicate within the group. They 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 its goals and accomplishments with the world. The key to good communication protocols is to make sure they're clear, documented, and in the hands of all group members.

Exercises

Giving feedback in a helpful way

You can do this exercise alone or as part of a group.

Most of us don't have a lot of practice at giving feedback in a helpful way. This exercise will give you a chance to practice learning how to give helpful feedback.

1. Think about a group situation, preferably outside of your watershed group, where someone repeatedly did something that irritated you. At the top of a piece of paper, briefly describe the situation (one or two sentences will do).
2. Now draw a vertical line down the center of the paper, and on the left side write a brief description of what you normally would say or do to handle the situation (again, one or two sentences). On the right side, try a new way of giving feedback. Review the Feedback section of this chapter and write down your ideas using the "A, B, C approach."

   I feel (A) ____
   in this situation (B) ________________________________
   when you say/do (C) ________________________________
3. Lastly, write down what you are thinking of doing (your intentions) as a result of your feelings.
4. Once you are done, look over the Feedback section of this chapter and evaluate what you've written. If you are doing this exercise as a group, ask a couple of people who feel comfortable doing so to share their situation and their old and new ways of giving feedback.

Active listening

You'll need at least one other person to help you do this exercise.

Most of us can't boast about being effective listeners! This exercise will give you a chance to practice effective listening and to see how it feels to truly be heard.

If you're doing this exercise in a group, break up into pairs. If you're doing it outside of your group, find someone you can really do this exercise with and then laugh about it later!

1. Holding the Active Listening section of this chapter in front of you, take 5 minutes to listen to your partner talk about a topic that interests him or her (your partner's choice). Use the steps in this chapter to guide your listening and responding.
2. Switch and repeat the exercise–you'll be the talker and your partner will be the listener.
3. After you both have taken a turn at talking and listening, take 5 minutes to talk about what it felt like to be heard. If you are doing this exercise in a group, ask some pairs who feel comfortable doing so to share their experience.

RESOURCES

Training

The OSU Extension Family Community Leadership program at Oregon State University has excellent publications and training opportunities–often free or for a nominal charge–in many Oregon counties. Contact your county office of the OSU Extension Service for details.

Sharon Ellison, Ellison Communication Consultants, Eugene (phone: 541-485-2221), offers workshops on powerful, nondefensive communication.

Glaser & Associates, Inc., communication educators and consultants in Eugene (phone: 541-343-7575), offer workshops and excellent materials (audiotapes, etc.) on communication and conflict management.

Information

Communicating with a Group. Part of the *On Common Ground: Skills for Discovering and Building Common Ground* series (National Land Use Collaboration, National 4-H Council, 1994).

The Communicator's Handbook: Tools, Techniques, and Technology (Maupin House). 1-800-524-0634.

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

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

Getting Coverage: A Guide to Working With the News Media, by B. Kauffman (For the Sake of the Salmon, 1996). 319 SW Washington St., Suite 706, Portland, OR 97204; phone: 503-223-8511; Web: http://www.4sos.org

Getting Past No, by W. Ury (Penguin, New York).

Getting To Yes, 2nd edition, by R. Fisher, W. Ury, and Patton (Penguin, New York, 1991).

Getting Together, by R. Fisher and S. Brown (Penguin, New York, 1988).

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

Partnership Handbook: A Resource and Guidebook for Local Groups Addressing Natural Resource, Land Use, or Environmental Issues, by A. Moote (Water Resources Research Center, College of Agriculture, University of Arizona, Tucson, 1997). Web: http://ag.arizona.edu/azwater

People Skills, by R. Bolton (Simon & Schuster, 1979).

Starting Up: A Handbook for New River and Watershed Organizations (River Network). PO Box 8787, Portland, OR 97207; phone: 503-241-3506; Web: http://www.rivernetwork.org/howwecanhelp/howpub.cfm

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

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in improving communication skills.

1. ______________________________

2. ______________________________

3. ______________________________

6

Dealing with Stumbling Blocks

Flaxen D.L. 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 may 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 share 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, and it's a normal part of the group development process.

Working together can be productive, creative, effective, and fun (believe it or not!) 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 enhancement.*

In Chapters I-1 through I-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.

See Section I, Chapters 1, 2, 3, 4, and 5 for information related to this chapter.

#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 always is 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
- Need to be right

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

- "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.
- "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.
- "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 others are 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. In conflicts, people often voice their *positions*. They state their "stand" and then "dig in" on what seem to be two or more drastically opposing sides. Once a discussion or interaction gets stuck on positions, no deeper understanding or resolution occurs. On the other hand, when *interests*–the myriad beliefs and values that underlie positions–are explored and communicated, similarities can be noticed and built upon to acknowledge or create common ground.

3. Ironically, 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 I-5, "Communication Skills," 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 I-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 to fill this role (for example, a mediator) if and when you or your group feels it's necessary.

#2–FACTS, MYTHS, UNKNOWNS, AND VALUES

To understand or confront important issues, people often break them down into parts. It's always easier to deal with life in bite-sized pieces. Problems often occur, however, when different people break an issue down into different elements. What one person calls a "fact" another calls a "myth" or a "value." Unknowns pose even more problems because most of us feel vulnerable admitting what we don't know. And so begins the difference of opinion or perspective, sometimes eventually leading to a full-blown conflict.

To begin dealing with this stumbling block, let's look at some definitions and examples:

- *Fact:* a statement of what is. It is verifiable and supported by evidence.

  "Water runs downhill."

  "The sun rises in the east and sets in the west."

- *Myth:* a falsehood, treated as if it were a fact. A notion based more on tradition or convenience than on fact.

  "Girls don't do well in math."

  "Certain ethnic groups are better at sports or engineering."

- *Unknown:* a statement that is ambiguous or characterized by great uncertainty. All statements are uncertain to some degree, but the degree of uncertainty may be important in resolving issues. Unknowns often are treated as facts.

  "There is life on other planets."
  "Oregon will have a major earthquake within the next 10 years."

- *Values:* statements of preferred end results or outcomes. Value statements can't be proven right or wrong, and they often differ among interest groups and individuals.

  "We can't trust government to clean up the environment."
  "Every American deserves a job."

- *Ethics:* special forms of value statements that describe what ought to be done and how things should be handled. They represent moral judgment for a preferred course of action, regardless of the preferred outcome.

  "Business is only interested in making a profit; it can't afford to protect the resources."
  "Basic human rights should be guaranteed to all people."

The first thing to do in increasing understanding or managing any conflict about an issue is to deal with facts, myths, unknowns, and values. Here are a few tools to help you wade through the turbulence and confusion:

- Use the above definitions to *clarify facts, myths, values, and unknowns.* This step helps you deal directly with a situation where someone is using an unknown or a myth as a fact. Unknowns and myths aren't inherently bad, and facts aren't inherently good–they're just different and shouldn't be used interchangeably. When possible, destroy myths and replace them with facts or unknowns.

- *Anticipate and accept value differences.* Compare perspectives on the issue and focus the discussion on the most "productive" differences—those that can be built upon to create a stronger, more stable outcome.

- *Recognize your own values and ethics.* Articulate your own myths and unknowns about various aspects of the issue.
- *Support the orderly formation of policy alternatives* based on this new, clarified discussion of the issue.

Remember, this process isn't magic. It's not going to make a world filled with gray areas turn into one with clear and concise black and white areas. Nor should it. Frankly, the grays 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.

> ☀ *Unknowns and myths aren't inherently bad, and facts aren't inherently good—they're just different and shouldn't be used interchangeably.*

#3—Resources and 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."

For example, who is either on 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 in terms 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 may be legal, social, economic, or technical. Once again, do a brief assessment. Using Chapters I-1 through I-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), etc.? 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 about 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 its partnership or group structure, or has a lack of clarity around group processes, meetings management, and communication protocols (see Chapters I-1 through I-5). Sometimes people leave things muddled on purpose, and the lack of clarity and inclusiveness makes it easier to carry out concealed, self-serving plans. But most often, unintentional confusion constructs an environment in which unwarranted paranoia creeps up that "some type of covert agenda is going on here."

The keys to keeping either imaginary or real covert agendas from happening are in Chapters I-1 through I-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, so everyone can help keep your activities guided toward them.
- Cultivate skilled participants and leaders.
- Build the decision-making and communication skills necessary to keep yourselves going along efficiently and effectively.

By cultivating an environment where 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 in the early stages of a group's life. During this time, trust has not developed, and protocols, structures, and agreements don't exist yet. Although it's usually not intentional, members talk outside of meetings and forget they're not the only ones with opinions or perspectives. These "decisions" can be treated as if they were made by the larger group, thereby leaving others “out.” When this happens intentionally, it can splinter a group and damage relationships.

It’s easy to paint a picture with only three or four 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.

Typically, diverse members bring challenges to the group, but they also bring different skills and viewpoints that ultimately strengthen the group.

The keys to preventing this problem are clearly defined in Chapters I-3, “Meetings Management,” and I-4, “Decision Making”: 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 upon a clear group decision-making process. Also refer to Chapter I-5, “Communication Skills,” 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 who calls meetings and a facilitator who manages them, *all* members play a part in helping your group work well or causing it to fall apart.

Good group meetings, or any other situations where people come together to accomplish or learn something, have four things in common:

- They have a clear purpose.
- They’re well organized and effectively handled so all participants can share, learn, and teach.
- They encourage all participants to share, learn, and teach.
- Participants leave feeling that they gained something from the experience and were encouraged to give something to others.

In Chapters I-1, “Creating Successful Partnerships,” and I-2, “Choosing Your Group’s Structure, Mission, and Goals,” you learned about roles and responsibilities as related to content–who needs to be part of your group and why. In Chapter I-3, “Effective Meetings Management,” you learned about roles and responsibilities as related to process–who does what and when. If your group is running up against this stumbling block, it would be a good idea to review these chapters. Serious problems in group process may require the effort to stop the topical discussion and revisit basics such as process, bylaws, etc.

The key to dealing with this stumbling block is knowing what makes good group members–with regard to both content and process. There is nothing more fun and functional than to have the entire group understand and appreciate good group process enough to challenge themselves, each other, or the facilitator if a ground rule is broken or the environment becomes suspicious.

#7–LACK OF CLARITY REGARDING DECISIONS

This stumbling block is similar to, but not exactly the same as, #5 (decision making outside of meetings). It feels different and rarely is premeditated. When agreements or decisions aren't made clearly or documented in group memory or minutes, one of two things happens: either the topic is repeated at meetings or, worse, decisions are remade outside the group and denied later. Fortunately, like most stumbling blocks, taking the time and energy to form, or reform, clear structure and protocols really alleviates this problem.

The keys to doing just that are clearly defined in Chapters I-2 through I-4. Having a clear organizational structure and effective meetings management is the beginning. Add to that a clear understanding of how decisions will be made, and you'll have a framework to keep your group from stumbling over this problem. Any member of the group can help with this vital function by keeping track of whether or not decisions are clearly stated and recorded. At the very least, you will be able to pick yourselves up, dust off your knees, and keep from stumbling over this one again.

#8–POLITICS AND HISTORY OF WORKING TOGETHER

Labels such as "it's the ol' boys club," or "that's the tree-huggers group," or any number of others are used to describe this impediment to good group work. If you've never run into this problem before, consider yourselves delusional, blessed, or both. Many groups have people that "are used to working together" or represent only one aspect of an issue. Although it might seem easier at first to work only with people you're comfortable with, this approach causes many groups to run into trouble or ultimately fail.

Effective watershed groups are effective because they have members that represent *all* aspects of the watershed's interests. When you're seeking members, ask yourselves, "What benefit/ drawback will this person(s) have in relation to our purpose?"

As mentioned earlier, diverse members typically bring challenges to the group. But they also bring different skills and viewpoints that ultimately strengthen the group by helping it reach a broader audience, get the attention of new or different elected officials, or gain access to needed resources. Good group processes and a clear group mission help keep *all* members–no matter how diverse–on track.

The keys to avoiding this stumbling block are found in Chapters I-1 through I-3. In addition, look around at other groups–not just watershed groups, but other partnerships that have weathered the tests of time. You may be able to get some ideas from them to help your group successfully blend a variety of viewpoints.

> ✸ *When you're seeking members, ask yourselves "what benefit/drawback will this person(s) have in relation to our purpose?"*

#9–RULES, REGULATIONS, AND BUREAUCRACIES

Legal stumbling blocks also can get in the way of working collaboratively. A few are listed briefly below. When in doubt about whether your group is affected by one of these laws or regulations, stop and find out for sure!

Antitrust laws, designed to protect a competitive market, don't exactly foster collaboration. These laws are more of a problem for private commodity groups and corporations, but it's a good idea for your group to learn about what you can and can't discuss or agree to.

FACA, or the Federal Advisory Committee Act, limits the types of input from federal agencies and their participation in partnership groups. FACA essentially defines advisory groups as any group that a federal agency consults before making management or regulatory decisions. Under FACA, advisory groups must follow specific procedures, including formally announcing meetings and opening all meetings to the public.

Some people have interpreted FACA as prohibiting agencies from taking advice from partnership groups that are not formal advisory committees under FACA. If your watershed group includes one or more federal agencies, you should be aware of FACA and follow its prescriptions for advisory committees unless directly told not to. Consult with agency representatives about how FACA relates to your group.

Natural resource and environmental laws can further impede partnerships by dividing ecosystems by arbitrary political boundaries, legislating separate management of single resources, and being overly prescriptive and inflexible. Federal agencies attempting to manage resources on an ecosystem basis are restricted by these aspects of federal law.

#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 I-1 through I-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 why some tasks may 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 that could have been 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 some parts of the projects require technical expertise that just doesn't exist in your cadre of volunteers, landowners, etc.

You realize that you'll 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 good work *and* sustain high-skill, high-wage work for the 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 thought, multiple objectives can be accomplished and multiple rewards achieved.

☼ Summary/self review

It's a fact that stumbling happens, and the best way to cope with it is to go with the flow and not give up. In this chapter, we discussed 10 of the common stumbling blocks that groups face and some key ways to overcome 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 the 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, unknowns, and values*

Breaking issues down into bite-sized elements can help you confront or understand them. 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 ethics; articulate your own myths and unknowns; and support the formulation of alternatives based on this new, clarified discussion of the issue.

3. *Resources and barriers*

Briefly assess and clarify your group's resources and barriers. Think of resources in terms of various currencies. Figure our whether each barrier is internal or external, and exhaust every possibility about how to get through, over, under, or around it.

4. *Covert agendas*

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

5. *Decision making outside of meetings*

This problem happens a lot in the early stages of a group's life. Prevent it by making a temporary or permanent ground rule related to decision making; then create a clear and agreed-upon group decision-making process.

6. *Group members not taking ownership of the group process*

The keys to dealing with this problem are knowing what makes good group members–both with regard to content and to process.

(continued)

Summary/self review *(continued)*

7. *Lack of clarity regarding decisions*

Taking the time and energy to form, or reform, clear structure and protocols alleviates this problem. Having a clear organizational structure and effective meetings management is the beginning. Add to that a clear understanding of how decisions will be made and why, and you'll have the framework to keep your group from stumbling over this problem.

8. *Politics and history of working together*

Effective watershed groups are effective because their members represent all interests in the watershed. Successful groups are made up of people who share a common interest and commitment, but have a variety of perspectives and positions.

9. *Rules, regulations, and bureaucracies*

Rule of thumb: "When in doubt, stop and check it out." Always check with the "powers that be" to learn what you should and should not discuss or agree to.

10. *If not your group, then who?*

If you come up with a task or problem you can't do, solve, or figure out, research who else could or should be doing it. Avoid tunnel vision. Take time to look up and out the window every now and then.

Exercises

Observing conflict

You can do this exercise on your own or as a group.

Most of us feel uncomfortable and unskilled at managing conflict. This exercise will give you a chance to practice listening–both externally and internally. Through this observation, you may be able to increase both your understanding of and comfort with conflict.

The next time you're watching television, or are around at least two other people, pay close attention if you notice a conflict starting. Practice your listening and observation skills. Is one of the people trying to avoid the conflict? Are they both expressing themselves directly and honestly? Do they both express a strong desire to be right? What kind of communication skills are they using ("I" statements or "You" statements)? Is either of them exhibiting active listening skills? Is the conflict escalating? If not, and they seem to be coming to a resolution, why?

Facts, myths, values, and unknowns

Do this exercise with at least one other person.

Although these items should be clearly distinguishable, it's remarkable how two (or more) people don't necessarily identify them the same way. By doing this exercise, you'll probably learn that distinguishing between these four is not always as easy as it seems. Inevitably, different people identify them differently. In a sense, it's more important to think about and recognize the differences between perspectives than it is to be right or wrong.

Choose a newspaper article. Use four different colors of highlighters–one each for facts, myths, values, and unknowns. Highlight the fact, myth, value, or unknown in each sentence or paragraph. Have someone else do the same. Then discuss what each of you came up with. Use the section of this chapter on facts, myths, values, and unknowns to guide your discussion.

RESOURCES

Training

The Family Community Leadership program at Oregon State University has excellent publications and training opportunities–free or for a nominal charge–in many Oregon counties. Contact your county OSU Extension Service office for details.

The *National Civic League* offers training and presentations in negotiation, collaboration, facilitation, and mediation, and maintains a network of professionals working in the field of community collaboration. For more information, contact the National Civic League, 1319 F St. NW, Suite Suite 204, Washington, DC 20004; phone: 800-308-9414.
Web: http://www.ncl.org/

The Center for Conflict Studies, Portland, OR, offers workshops on conflict, negotiation, and mediation; phone: 503-236-3149.

Information

Community Participation and the New Forest Economy: Citizen Participation in Resource Management, an annotated bibliography, by A.L. Booth and G. Halseth (Environmental Studies Program, University of Northern British Columbia, Prince George, BC, 1997).

Getting Past No, by W. Ury (Penguin, New York).

Getting To Yes, 2nd edition, by R. Fisher, W. Ury, and Patton (Penguin, New York, 1991).

Getting Together, by R. Fisher and S. Brown (Penguin, New York, 1988).

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

Partnership Handbook: A Resource and Guidebook for Local Groups Addressing Natural Resource, Land Use, or Environmental Issues, by A. Moote (Water Resources Research Center, College of Agriculture, University of Arizona, Tucson). Web: http://ag.arizona.edu/azwater

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in avoiding and dealing with stumbling blocks.

1.____

2.____

3.____

Section II. Watershed science and monitoring principles

1. Planning for Watershed Restoration

2. Watershed Hydrology

3. Stream Processes

4. Watershed Soils, Erosion, and Conservation

5. Assessment and Monitoring Considerations

1

Planning for Watershed Restoration

Jim Good

If you don't know where you're going, you're likely to end up somewhere else.

–Lawrence J. Peters

Throughout the United States, citizens are coming together to help solve local natural resource problems. The catalysts for voluntary citizen action on behalf of the environment are varied:

- In Oregon and elsewhere, the listing of fish or wildlife species as threatened or endangered under the federal Endangered Species Act has been a powerful impetus for local citizens to organize and solve problems from the bottom up rather than the top down.
- Proliferation of trash along once-pristine shores has made beach cleanup an annual event in many states, attracting thousands of volunteers.
- The closing of popular swimming and fishing areas has motivated citizens to control pollution and monitor water quality.
- Rapid population growth, urbanization, and loss or degradation of wetlands, streams, riparian vegetation, and other fish and wildlife habitat have spurred citizen action.
- Schools are using local environmental problems as opportunities for students to learn about their roles as citizen stewards of natural resources.

In this chapter you'll learn:

- Why a watershed approach to planning is important
- Principles for watershed planning
- Features of a watershed restoration and enhancement action plan
- Steps in developing a watershed restoration and enhancement action plan
- Steps for implementing your plan project by project

See Section I, Chapters 3 and 4 for information related to this chapter.

Section I

3 Meetings

4 Decisions

The U.S. Congress and the Oregon legislature, recognizing the wisdom and effectiveness of a bottom-up approach to solving environmental problems, have created a variety of incentive-based programs that support local citizen groups with financial resources, training, technical expertise, and other assistance. For example, the Oregon Watershed Enhancement Board has provided millions of dollars to local watershed councils for restoration and stream enhancement projects. At the national level, the U.S. Environmental Protection Agency, through the National Estuary Program, provides financial and technical assistance to communities near 28 of the nation's most important and threatened estuaries, including the Columbia River and Tillamook Bay. 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 have one thing in common–they approach problems from a *watershed* perspective. Whether dealing with fish habitat restoration, wetland or riparian protection or rehabilitation, or runoff pollution, these groups view the watershed as their planning unit. This approach has won strong support from government agencies charged with maintaining the health of our nation's ecosystems and natural resources.

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 just isolated parts.

The watershed is emerging as one of these integrated frames of reference in which environmental problems should be addressed. 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 water with groundwater, and forests, farmlands, and cities with one another.

A watershed approach to environmental problem solving also makes sense from economic, social, and political perspectives. Uses of land and water upstream have impacts on people downstream, affecting drinking water quality, flooding potential, fishing, and other elements of quality of life.

What is a watershed?

The term *watershed* describes an area of land that drains downslope to the lowest point (Figure 1). The water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers, which become progressively larger as the water moves downstream, eventually reaching an estuary and the ocean. However, in some arid regions, the water drains to a central depression, such as a lake or marsh, with no surface-water exit. Other terms used interchangeably with watershed include *drainage basin, river basin,* or *catchment basin*.

Watersheds can be large or small. Every stream, tributary, or river has an associated watershed, and small watersheds join to become larger watersheds. It is relatively easy to delineate watershed boundaries using a topographic map that shows stream channels. Watershed boundaries follow major ridgelines around channels and meet at the bottom, where water flows out of the watershed, a point commonly referred to as the mouth of a stream or river. Try locating your local watershed on a USGS 1:62,500 scale map, or several maps if needed.

The connectivity of the stream system is the primary reason for doing aquatic assessments at the watershed level. Connectivity refers to the physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and water. Because water moves downstream, any activity that affects the water quality, quantity, or rate of movement at one location can affect locations downstream. For this reason, everyone living or working within a watershed needs to cooperate to ensure good watershed conditions.

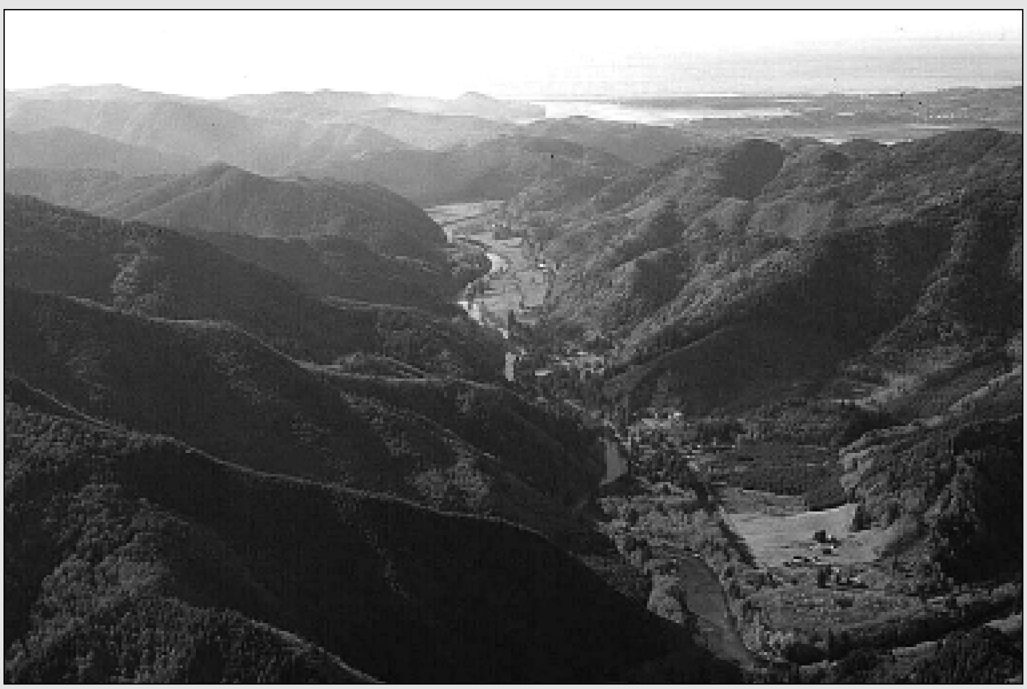


Figure 1.—The Little Nestucca River valley looking west toward the estuary and ocean. In mountainous areas like this on the Oregon coast, watershed boundaries are easy to see. (Photo: Jim Good)

The watershed approach also is valuable because it brings together people from different walks of life–loggers, miners, farmers, ranchers, recreational users, business, industry, and urban dwellers. Individuals from all of these groups must be involved; inclusiveness is the first step toward consensus. Because political boundaries are arbitrary and government agency missions narrow, the watershed approach also fosters needed intergovernmental cooperation.

PRINCIPLES FOR WATERSHED ACTION PLANNING

Plans are nothing–planning is everything.

–Dwight D. Eisenhower

Another common feature of successful community-based efforts to solve environmental problems is that they are based on *sound planning*. Planning sometimes raises a red flag among citizens, particularly in rural areas, conjuring up images of excessive governmental regulation of land use, control of access to traditionally used areas, and limits on hunting, fishing, and similar activities. However, planning that incorporates the legitimate concerns of property owners and traditional users of public lands has and will continue to play an important role in addressing environmental issues.

What do we mean by sound planning? First, sound planning involves the people who are most affected–local property owners, for example. It uses an open decision-making process and the best available scientific information. Decisions are well documented so that new people can easily become involved. Sound planning is focused and incremental–it sets priorities and includes both short-term and long-term goals and actions. Finally, although good process is important, sound planning is action oriented and leads to results.

Although every watershed, no matter how small, is unique, there are many commonalities as well. We can learn valuable lessons by looking over ridgetops to see how our neighbors are solving similar problems–not just next door, but across the nation. Some of these lessons were presented at a Watershed Innovators Workshop sponsored by the Rivers Network. They are summarized below as a set of *principles for watershed conservation*.

- *Use a mixture of top-down and bottom-up approaches*. Top-down approaches to watershed conservation do not work, but neither does total reliance on bottom-up approaches. Partnerships are the key. State and federal agencies can provide incentives and technical and financial support. Local watershed groups can educate, plan, take action, monitor results, and apply lessons learned to other projects.

- *Use consensus rather than adversarial approaches to decision making.* Recently, there has been a shift from contentious litigation to consensus-building as an approach to environmental problem solving. This is particularly important when you are trying to voluntarily change the behavior of landowners and local decision makers, based on principles of good land stewardship and ethics. Consensus decision making promotes partnerships among potential adversaries, including businesses, developers, landowners, farmers, forest managers, environmentalists, and others, because the emphasis is on balancing individual interests with community and ecosystem sustainability.
- *Don't expect a single cookie-cutter approach to work for all situations.* Watershed issues vary among different regions of the state and between urban and rural areas. So do governmental situations (for example, state and local land-use regulations or growth management strategies). Watershed councils must recognize and work with these differences as they design strategies and actions for their watersheds.
- *Get all of 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 stake in the long-term management of the watershed. Be inclusive, get all parties to the table, and recruit if necessary. It is wise to get key stakeholders to attend the very first meeting if possible.
- *Be creative about who foots the bill.* Be innovative about who pays for 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 and regulatory approaches and more on local, voluntary, and in-kind contributions. Promote government 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 be perfect.* Decisions always will be made with some uncertainty, but the use of sound science will increase the likelihood of success. Information 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 and of watersheds in particular. Engage the public in a sustained

educational program about the watershed–how it functions, what its value is, how human activities affect its health, and how people can work for improvement 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, seeing gaps in plans, and finding ways to solve problems. Leadership is a key ingredient in success.

FEATURES OF A WATERSHED RESTORATION AND ENHANCEMENT ACTION PLAN

What does a good watershed action plan include? That depends on your watershed and the unique set of issues you are addressing, the people involved, and the available resources. Although watershed assessments and plans differ in emphasis, most have some common features:

- *A professional-quality watershed assessment*–The assessment should include an *inventory and evaluation of the watershed's aquatic and terrestrial resources* and how they have changed over time. A *good base map* of the watershed is necessary to add information such as the location of rivers and streams, lakes, wetlands, floodplains, transportation networks, political and land ownership boundaries, land use, and other data. Major *point sources of pollution*–factories, sewage treatment plants, and other pipeline discharges–should be identified. *Polluted runoff or nonpoint sources* also need to be identified, including pollution from urban streets and parking lots, lawns, timber-cutting areas, and farms. Finally, based on these inventories and information from local residents, the assessment should include a *well-documented list of priority issues*–problems, opportunities, findings, and goals.
- *A program to protect headwater areas and the very best areas of undisturbed, natural habitat throughout the watershed*–These areas serve as refuges for rare, threatened, and endangered species and generally have high levels of biological diversity.
- *A program designed to protect and restore streams, rivers, lakes, wetlands, and native riparian vegetation*–These areas 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.

- *A program to clean up and prevent pollution*—This program should include actions to minimize accidental spills and pollution discharge that could harm human and ecosystem health, as well as actions to minimize runoff pollution. One example is to work with communities, industry, and landowners to improve retention and treatment of polluted runoff.
- *A program to provide for adequate stream flows for fish and wildlife*—Stream flow should correspond as closely as possible to the natural level and timing of flows. Actions might include wetland restoration projects to increase natural water storage capacity or water conservation programs for industry and urban residents.
- *A program that addresses the threat of nonindigenous species introduction and the need to control existing nuisance species*

STEPS IN DEVELOPING A WATERSHED RESTORATION AND ENHANCEMENT ACTION PLAN

Although we cautioned against a cookie-cutter approach to evaluating watershed health and developing an action plan, it is useful to begin with a model process and adapt it to local conditions and needs. The model outlined in the box on page 9 and explained below draws from a variety of examples. The key to using this or other models effectively is to adapt them to your existing situation, plans, and activities. After reviewing the model, ask yourselves which steps already have been done locally and which remain to be done. The resulting list of tasks will be *your* watershed planning process.

The model process is presented here as sequential steps, suggesting that you finish one before moving to the next. This is partly true–you must establish goals before taking on projects, for example. However, in practice, each step feeds information into future steps or to already completed work. For example, problems and opportunities identified during the watershed assessment (Step 1) immediately suggest goals (Step 2) and potential solutions (Step 3), including specific projects. It is important not to lose these ideas as the process evolves. One group put potential goals, projects, and constraints into “bins” so that when they got to these steps, they would be able to link the work already done to future tasks.

Similarly, identification of constraints to restoration (Step 4) might influence previously identified goals or objectives. For example, it is clear that Interstate 5 will not be relocated to restore

Even for a relatively small watershed, planning is a significant undertaking.

the meandering of Willamette Valley streams. It also is important to include in the planning process structured activities such as research, educational field tours, workshops, surveys, and priority-setting exercises. These structured activities draw in property owners and other stakeholders and bring order to the planning process.

The process outlined on page 9 sounds relatively simple…or does it? Even for a relatively small watershed, planning 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 vision for watershed protection and restoration. Top-down help also is needed for locating and interpreting information as well as for accessing financial resources.

This process might take 6 months, a year, or more. However, it will be immediately clear that some projects are desirable, feasible, and address real problems that everyone agrees need attention. Start working on these projects as soon as possible. *Early success in implementing actions or projects is critical to building and maintaining community support*.

A good plan is important and will help you get financial support, but we all know about plans that gather dust on a 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. The process outlined here draws from a variety of sources, including the *Oregon Watershed Assessment Manual*, developed by and available from the Oregon Watershed Enhancement Board. (Download a copy of this and other publications from their Web site (http://www.oweb.state.or.us/publications/index.shtml).

Watershed action planning steps

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

- What were the historical extents, conditions, processes, and functions of watershed ecosystems and resources?
- What are the current extents, conditions, processes, and functions of watershed ecosystems and resources? How have things changed over time?
- What are the principal ecological problems and foreseeable threats to watershed health?
- What areas within the watershed are most important to salmonids, and what factors are limiting salmonid production?

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

- What are the long- and short-term watershed goals and priorities for protection, restoration, enhancement, management, research, monitoring, and public and decision-maker education? When developing goals and priorities, consider current and historical conditions, present ecological problems, and threats.

Step 3. Identify potential watershed projects and priorities.

- 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?
- What kinds of restoration and enhancement activities address factors that limit salmonid production?

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

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

Step 5. Synthesize planning results, write an action plan, and begin work. Begin this process early and let the written plan evolve.

- What are the overall vision, goals, and priorities 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 implementation project by project.
- Monitor progress and periodically reevaluate priorities. Remember that goals and constraints might change over time.

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

- What were the historical extents, conditions, processes, and functions of watershed ecosystems and resources?
- What are the current extents, conditions, processes, and functions of watershed ecosystems and resources? How have things changed over time?
- What are the principal ecological problems and foreseeable threats to watershed health?
- What areas within the watershed are most important to salmonids, and what factors are limiting salmonid production?

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

Current conditions might seem the easiest part of the assessment. There are maps of existing habitats, for example, plus detailed aerial photos and at least some water-quality data.

However, you quickly will find there is little published information that explains how your particular watershed works at a system-wide scale. 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 step is discussed in more detail below. Completing these tasks will leave you with an initial list of potential projects and other actions to restore or enhance your watershed.

Gathering good information is the first step in any planning process. To evaluate your watershed's health, you need a reference point.

What were the historical extents, conditions, processes, and functions of watershed ecosystems and resources?

Because ecosystems change constantly in response to both natural and human influences, the first challenge for the ecosystem historian is to select a time frame for beginning the 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. Euro-American settlement, however, resulted in dramatic and long-lasting changes to the landscape–intensive agricultural development, diking and draining of wetlands, channelization of streams and rivers, improvements for navigation, and harvesting of timbered riparian and upland areas. Consequently, the baseline selected for historical ecosystem analysis generally is as close as possible to the beginning of Euro-American settlement. During this period, landscape changes began to be well documented, and these records still are available.

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 or impedes fish passage with a larger culvert or small bridge would benefit the watershed without negatively affecting road use. 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 past 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. Neither would it be realistic from the perspective of present inhabitants.

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 river, stream, wetland, estuary, and lake habitats on USGS 1:24,000 scale quadrangle maps (Many human alterations, such as dikes and drainage ditches, also are shown.)
- *County soil surveys* and maps, which show 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 Coos Bay on the southern Oregon coast.)

- *Original public lands survey records* from the mid-1800s, which include maps and descriptions of forested and grassy areas, creeks, streams, and other landscape features
- *Oregon Natural Heritage Program's Coastal Lowlands Ecoregion Historical Conditions*, which use original public lands survey data to characterize vegetation along coastal rivers and their estuaries
- *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* documenting fish runs and harvests
- *Historical ground photos and written accounts*
- *Local diking and drainage district records*

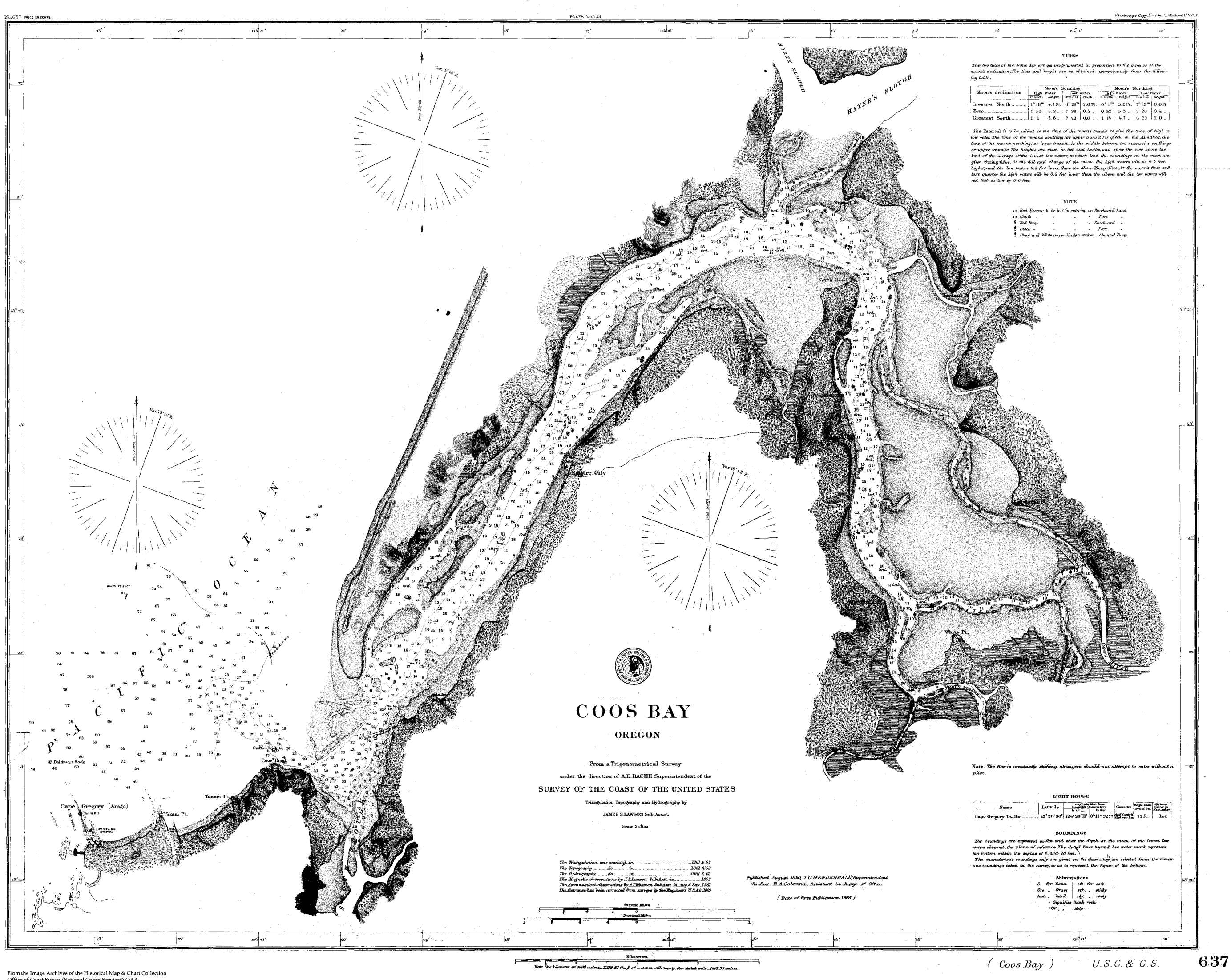


Figure 2.–Early Coast Survey navigation chart of Coos Bay (1901), showing channels, tidal flats, tidal marshes, and estuary–upland boundaries. (Source: Archives of the historical map and chart collection, Office of Coast Survey, National Ocean Service, National Oceanic and Atmospheric Administration)

- Other *historical habitat evaluations* that have been conducted for the Columbia River estuary, Tillamook Bay, and Willamette Valley

These data sources and how to acquire them are described in more detail in Appendix A.

What are the current extents, conditions, processes, and functions of watershed ecosystems and resources? How have things changed over time?

A comparison of historical watershed conditions and current conditions is one indicator of watershed health. For example, changes in land use and cover can be used to estimate changes in the timing and quantity of stream flow. Changes in stream channels, wetlands, and riparian areas can be used to estimate a watershed's capacity to support salmon and other aquatic life. This information can 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 through zoning. Freshwater wetlands and riparian areas, particularly in urban environments and 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 the Oregon Division of State Lands (see the "Resources" section at the end of this chapter). The Oregon Department of Fish and Wildlife and other resource agencies can provide information on important areas for salmonid production and relevant limiting factors.

Recent physical alterations

Corps of Engineers regulatory records for permitted dredge, fill, and in-water construction projects are a good source of data on recent physical alterations, although these data sometimes are difficult to access. The Oregon Division of State Lands, which runs the state Removal/Fill Program, is another source of similar data.

Aquatic nuisance species

Some introduced species are welcome in Oregon–striped bass, the Japanese oyster, and the softshell clam are examples. Others are not. Invasive species such as purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and bullfrogs (*Rana catesbeiana*) are serious threats to watershed ecosystems in many areas of the state, while the European green crab *(Carcinus maenas)* and saltmarsh cordgrass *(Spartina alterniflora)* threaten coastal estuaries.

As part of your watershed assessment, collect information about aquatic and terrestrial nuisance species in your watershed–the severity of infestations, potential sources of introductions, and possible control strategies. Early detection of new nuisance species populations sometimes allows successful control or eradication. A variety of on-line resources is available on the World Wide Web; begin your search on the Pacific Northwest's Marine Invasive Species Team site (http://seagrant.orst.edu/mist/links.html), which has links to many other resources.

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. The Oregon Department of Environmental Quality (DEQ) staff might be able to provide technical assistance.

Pipeline-introduced or *point source* pollution is strictly regulated by DEQ as part of the National Pollutant Discharge Elimination System permit program. Information on these discharges can be obtained from DEQ.

Information on broadly distributed runoff pollution–referred to as *nonpoint source pollution*–that comes from farm, forest, rural, and urban areas is much more difficult to obtain. DEQ does have water-quality measurements for many rivers, lakes, and estuaries, but often the data have not been analyzed thoroughly.

In estuaries where shellfish are produced commercially, bacterial contamination is monitored routinely by the Oregon Department of Agriculture (ODA). In 1999, the National Oceanic and Atmospheric Administration (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.* Of the 19 estuaries where insufficient data were available to make an assessment, 10 were in Oregon, suggesting the need for additional monitoring and research here.

Pollution problems in streams and rivers associated with farming and ranching operations have been given special attention in recent years. Responding to the federal Clean Water Act, the 1993 state legislature passed the Agricultural Water Quality Management Act

(Senate Bill 1010). The overall goal of SB 1010 is to reduce agriculture's contribution to water pollution in Oregon. This law requires ODA to develop watershed-level plans to address nonpoint source water-quality problems associated with farming and ranching. Examples include soil erosion, nutrient loss from fields, and degraded streamside areas. As of 2001, area plans had been completed for most watersheds in the state. ODA also developed a set of *best management practices* that individual producers use voluntarily to address problems on their farm or ranch.

Watershed councils should work with ODA, local Soil and Water Conservation Districts (SWCD), and local Extension Service agents to incorporate Agricultural Water Quality Management Area Plan findings and strategies into their watershed action plans. See the ODA Web site for details (http://www.oda.state.or.us/Natural_Resources/sb1010.htm).

Watershed councils also can find out whether and how communities along streams and rivers 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, or start a local 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 (Chapter III-8, "Water-quality Monitoring"), runoff pollution (Chapter II-4, "Watershed Soils, Erosion, and Conservation"), and actions to reduce pollution (Chapter III-6, "Managing Rural Homes and Small Acreages to Protect Watersheds").

What are the principal ecological problems and foreseeable threats to watershed health?

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

> *It is very important to make problem identification and goal setting a community-based process.*

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

- What are the goals and priorities for restoration, enhancement, protection, management, research, monitoring, and public and decision-maker education? When developing goals and priorities, consider current and historical conditions, ecological problems, and threats.

As problems are identified in the community-based process discussed above, begin developing 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 protection and restoration opportunities.

Setting goals is relatively simple once there is consensus about key problems and priorities. Simply turn problem statements from negative to positive to create a goal. Before finalizing goals, present them to the community and ask for feedback. Do the priorities make sense? Is it clear what needs to be done first, second, and so on? Are any serious constraints being overlooked? This process takes time, but it is worthwhile in terms of building support and understanding in the community and among property owners.

After setting goals, identify objectives–the specific things that need to be done to reach each goal. See the box on page 17 for one approach.

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. (Photo: Jim Good)

EXERCISE

IDENTIFYING OBJECTIVES FOR WATERSHED RESTORATION AND ENHANCEMENT (SNOW CARD EXERCISE)

Assume that your group has identified a number of issues and set goals accordingly. For example, based on your watershed assessment, goals might include reducing nutrient loading of rivers and streams, improving rearing habitat for juvenile salmonids, and educating property owners and the public about the value of aquatic ecosystems and the need for restoration. Using these goals (or substituting those developed by your group), use the process below to identify specific objectives related to each goal.

1. Give each participant three to five 3" x 5" cards. The number of cards per person depends on the number of participants. You probably won't want more than 100 cards.
2. Ask participants to write on each card a specific objective they would like to see the watershed group achieve in the next 5 years. Remember, objectives can be thought of as measurable accomplishments. They are broader than actions but more specific than goals.
3. Have the participants put a piece of masking tape on the back of each card and tape the cards to a wall. The cards will cover the wall like snow; hence the name "snow card" exercise.
4. Have either the whole group or a subgroup put similar cards together in columns or categories. This step is important, so don't rush. Sometimes it's helpful to write one or two words on a larger card to name each category. Try to have no more than 10 categories. You might need a catch-all or miscellaneous category.
5. Review the categories as a large group. Try to agree on which objectives belong together.
6. Divide the large group into small groups of three or four people. Give each small group one or more categories of cards. Ask each group to write a one-sentence objective that covers the ideas on the cards in each of their categories. Then they'll write their objective or objectives on a flip chart. This list represents the group's objectives.
7. The large group then can validate or prioritize the objectives. This step can be done through discussion and voting.

Step 3. Identify potential projects and priorities.

- Considering the results from Steps 1 and 2, what specific projects will do the most to accomplish each watershed goal? What actions or projects fit into short-term versus long-term priorities?
- What kinds of restoration and enhancement activities address factors that limit salmonid production?

The next step in developing a realistic watershed action plan is to screen the protection, restoration, and enhancement opportunities identified in Step 1 for their potential to help solve problems and

Figure 4.–Small work groups using a variety of resources such as National Wetland Inventory maps are a good way to identify and rate potential restoration and enhancement projects. (Photo: Jim Good)

achieve the goals identified in Step 2. This process requires a careful, even tedious, examination of each project as it relates to each goal (Figure 4).

It might 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. Some goals might need to be weighted more heavily than others, depending on their relative importance. This sort of process can be helpful but needs to be supplemented by common sense. See the box on page 19 for an alternative way to set priorities.

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

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

One result of Step 3 is a list of priority projects based on the match between identified restoration or enhancement opportunities and your group's goals. However, other constraints need to be taken into account. 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?
- Will the project last long enough to provide the hoped-for benefits?
- Where will the money and labor come from to implement and monitor the project?

Answers to some of these questions might eliminate some actions, sites, or projects immediately. Project feasibility might change over time; what is not feasible today might be feasible 5 years from now, for example, if land ownership changes or funding becomes available.

Using specified criteria to set priorities among proposed watershed restoration and enhancement actions

Few human endeavors have all of the resources needed to accomplish their goals. Watershed groups are no exception. You will need to set priorities. For example, you might need to decide on a few actions for implementation in the next year. Many approaches to priority setting rely on comparing alternatives to a set of criteria and ranking them on how well they achieve each criterion. Here are some examples of criteria you might use to decide what actions should have priority:

- *Ability to achieve objectives*–Choose alternatives that clearly contribute to the achievement of your goals and 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 might not want to cooperate with a watershed group in improving the riparian area along a certain stream reach. The group might not be able 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 might be the best long-term solution, you also might need to choose other 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 calculated. One way to do a cost/benefit analysis is to compare the costs 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 might 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.

Some projects might require working to get land-use or water-quality rules changed. 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. Similar constraints exist in other areas.

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

- What are the overall vision, goals, and priorities for watershed protection, restoration, enhancement, management, research, monitoring, and public and decision-maker education?

Commit the plan to writing, including maps and drawings. Begin its implementation project by project. Monitor progress and periodically reevaluate priorities, recognizing that goals and constraints might change over time.

Your action plan is a vision for improving your watershed's health and condition. Document your planning process and decisions with maps and text.

IMPLEMENTING THE PLAN–PROJECT BY PROJECT

Even if you're on the right track, you'll get run over unless you keep moving.
–Mark Twain

A watershed action plan based on this or a similar process will result in a set of prioritized restoration projects designed to achieve watershed goals. It likely will have the support of the community and property owners.

The next step–carrying out and monitoring projects–is the rewarding part. But it is not as 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. All projects require the same general steps, although specific needs will vary.

There is a growing body of knowledge about the best ways to enhance aquatic habitats and ecological functions. From these experiences, it is possible to derive a general process and principles for carrying out watershed restoration or enhancement projects. This process consists of four tasks:

- Task 1. Planning and design
- Task 2. Project construction
- Task 3. Monitoring
- Task 4. Reevaluating the project based on monitoring results

This approach to restoration projects often is called *adaptive management*. It recognizes our limited ability to predict outcomes and thus treats projects as experiments and learning opportunities.

Task 1. Project planning and design

Planning and design considerations vary by project type. However, all projects share some general aspects of project planning and design. First, a thorough assessment of historical and current site conditions is needed. Next, clear goals and objectives consistent with site potential and the 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 project will have unique design considerations. Establishment of salt marsh vegetation on a dredged material island, for example, requires different design specifications than an eelgrass planting, culvert replacement, or riparian zone revegetation project.

For detailed guidance on various types of restoration and enhancement projects, refer to the *Oregon Aquatic Habitat Restoration and Enhancement Guide*, developed by and available from the Oregon Watershed Enhancement Board. (Download a copy of this and other publications from their Web site at http://www.oweb.state.or.us/publications/index.shtml) The guide consists of five sections: "Overview of Restoration Activities," "Activity Guidelines," "Overview of Agency Regulatory Functions and Sources of Assistance," "Grants and Assistance," and "Monitoring and Reporting." The guide provides standards that must be met when using state funds for aquatic habitat restoration.

The type of project used here to illustrate design considerations is a *tidal marsh restoration*—a common opportunity in Oregon's estuaries, given the extensive wetland diking, draining, and ditching that took place during and after Euro-American settlement (Figure 5). 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.

Figure 5.—Three years after dike removal, brackish marsh vegetation is taking over this former pasture in the Salmon River estuary, Lincoln County. (Photo: Jim Good)

On the basis of previous tidal marsh restoration experience in Oregon and elsewhere, specialists recommend the following design principles and planning considerations. They can serve as a checklist for groups undertaking similar projects or can be modified to apply to other watershed 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 might or might not be a good predictor of site restoration potential, given past alterations. However, understanding how the site has been used and its likely condition prior to physical alterations will help you set goals, design the project, and understand 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 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" 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, wind, waves, tidal influence, salinity, and freshwater input.
- *Buffers*—Minimize boundaries 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.

Consider opportunities to simultaneously plan and construct [other] projects to increase effectiveness and efficiency at the watershed level.

- *Corridors*–Consider the need for water and vegetation 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 failed 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 might 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.
- *Permits*–You will need permits from the U.S. Army Corps of Engineers, the Oregon Division of State Lands, and possibly local agencies. (See OWEB's *A Guide to Oregon Permits Issued by State and Federal Agencies* in the "Resources" section.) Involve agencies early. Specialists from these agencies, and from others such as the Oregon Department of Fish and Wildlife, nongovernmental organizations, and universities, can be helpful.

Task 2. Project construction

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

- *Follow construction plans*–Construction should follow the site plan. 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 onsite 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 tidal and other hydrologic cycles as well as seasonal cycles of vegetation growth and fish and wildlife activities.

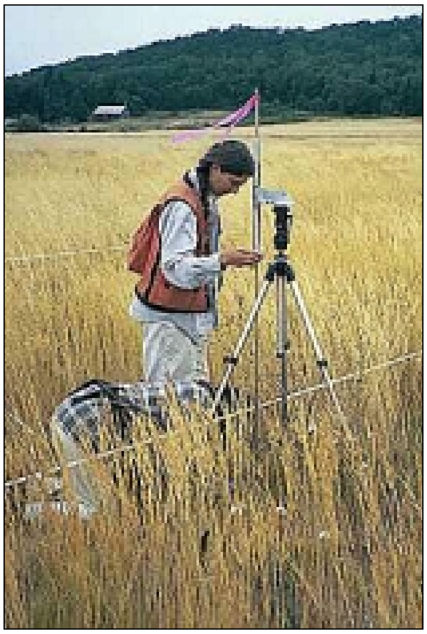


Figure 6.–Monitoring is an essential component of project implementation. Monitoring provides the information necessary to gauge success. (Photo: Scott Duckett)

Task 3. Monitoring

Every project should be monitored (Figure 6). The importance of monitoring restoration or enhancement sites cannot be overemphasized. 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, monitor drainage pattern development, sedimentation, erosion, fish and wildlife use, and vegetation establishment. In the long term, monitor whether the restored 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. Design the monitoring effort as part of the overall project design, considering what to monitor, where sampling sites should be located, what sampling intervals are needed in time and space, and how monitoring data will be used. Because there always is uncertainty about outcomes of projects, adopt a "learn-by-doing" mentality. This is the essence of adaptive management. To adapt, however, you must have good monitoring data that tell you what is working and what is not.

A *basic monitoring* effort, which can be carried out by trained volunteers or watershed council members with engineering, map-making, and other skills, might include the following:

- *Photo documentation*–Take photos from established locations before, during, and 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*–Map vegetation development and change, based on field sampling or photo documentation. Field documentation might include percent cover, species composition, or plant community distribution. If relevant, compare the success of planted areas with natural vegetation reestablishment.

- *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 OWEB's *Oregon Water Quality Monitoring Technical Guidebook* in the "Resources" section.)
- *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 might not be statistically accurate, these methods can give a good overall view of changing site use by aquatic organisms.
- *Recreation 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, technical expertise, funds, or equipment might not be available. The extent and frequency 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* is desirable. In this case, professionals and scientists probably already are involved. In-depth 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" might require at least 10 years of postrestoration monitoring. Sites take time to develop, and needed corrective actions might 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 might allow longer term tracking of project success.

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

Task 4. Reevaluating the project based on monitoring results–adaptive management

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

What does *adaptive management* mean in this context? As noted earlier, watershed restoration and enhancement projects are carried out under great uncertainty regarding future conditions, relationships among components and projects, user response to projects, management objectives, and other variables beyond our control. Nevertheless, we continue to take action despite this uncertainty. If we hope to improve our restoration and enhancement success, we must learn as we go. That is the essence of adaptive management–learning as we go.

Often the most effective way to learn is to view the projects we undertake as experiments. Then we can design them and their monitoring plan to produce the information needed to evaluate what worked and what did not. This information reduces uncertainty, not just for the current project, but for future projects as well. As the knowledge base broadens, we will get better at designing projects that perform as desired in the face of continued uncertainty and ever-changing conditions.

Project planning in the adaptive management mode is not a linear process, but rather a cycle. Design, construction, monitoring, and evaluation interact and provide feedback and learning (Figure 7). Adaptive management can be applied at a variety of scales and with differing degrees of sophistication. What is most important for watershed councils is to become familiar with the concept and how to use it to improve restoration success in their watershed.

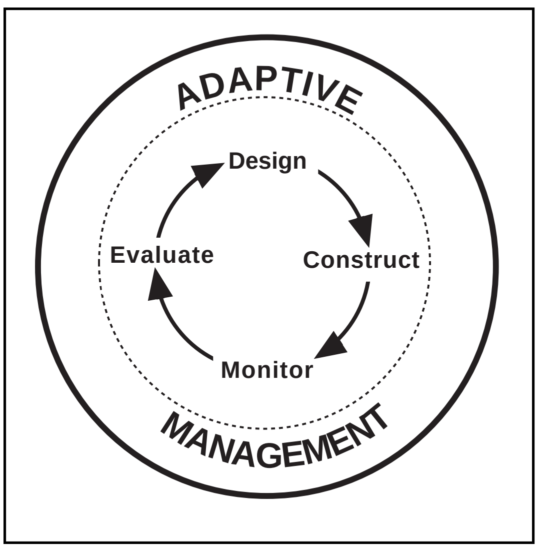


Figure 7.–Adaptive management for restoration and enhancement projects can be thought of as a cyclic process with feedback loops among stages.

Summary/Self review

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 food chain; water-quality maintenance; moderation of floodwaters; shoreline stabilization; and a variety of economic, recreational, and educational benefits.

Successful planning involves:

- Using a mixture of top-down and bottom-up approaches
- Using consensus rather than adversarial approaches to decision making
- Avoiding a "cookie-cutter" approach
- Getting the right people involved
- Being creative about who foots the bill
- Using the best scientific information available
- Including watershed education activities
- Nurturing watershed leaders

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

1. Assessing historical conditions, current conditions, and present risks and threats
2. Setting and prioritizing restoration and enhancement goals
3. Identifying potential restoration, enhancement, management, or educational projects
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.

State agency contacts and resources

Oregon Department of Agriculture (ODA)
635 Capitol St. NE
Salem, OR 97310
Natural Resource Division
Phone: 503-986-4700
Fax: 503-986-4730
Web: http://www.oda.state.or.us

Oregon Department of Environmental Quality (DEQ)
811 SW 6th Ave.
Portland, OR 97204
Phone: 503-229-5696
Toll-free in Oregon: 1-800-452-4011
Web: http://www.deq.state.or.us/
Water Quality Division: 503-229-5279
Air Quality Division: 503-229-5359
Waste Prevention and Management Division: 503-229-5913

Oregon Department of Fish & Wildlife (ODFW)
2501 SW First Ave.
PO Box 59
Portland, OR 97207
Web: http://www.dfw.state.or.us
Habitat issues (Habitat Division):
Phone: 503-872-5255
Fax: 503-872-5269
Fish sampling or transport (Fish Division):
Phone: 503-872-5252
Fax: 503-872 5632

Oregon Department of Forestry (ODF)
2600 State St.
Salem, OR 97310
Web: http://www.odf.state.or.us
Scott Hayes, Forest Practices Operations Unit Manager
Phone: 503-945-7475
Fax: 503-945-7490
You also may contact your local ODF office.

Oregon Department of Geology & Mineral Industries (DOGAMI)
1536 Queen Ave. SE
Albany, OR 97321
Dawn Marshall, Administration Specialist
Phone: 541-967-2039, ext. 21
Fax: 541-967-2075
Web: http://sarvis.dogami.state.or.us

Oregon Department of Parks and Recreation (OPRD)
1115 Commercial St. NE
Salem, OR 97310
Tammy Baumann, Policy and Planning Division
Phone: 503-378-4168, ext. 293
Fax: 503-378-6447
Web: http://www.prd.state.or.us

Oregon Department of Transportation (ODOT)
355 Capitol St. NE
Salem, OR 97310
Berri L. Sellers, Citizens' Representative
Phone: 888-275-6368, 503-986-4366
Fax: 503-986-3432
Web: http://www.oregon.gov/ODOT/

Oregon Department of Land Conservation and Development (DLCD)
635 Capitol St. NE
Suite 150
Salem, OR 97310
Christine Valentine, Coastal Specialist
Phone: 503-373-0050, ext. 250
Fax: 503-378-5518
Web: http://www.lcd.state.or.us

Oregon Division of State Lands (DSL)
775 Summer Street NE, Suite 100
Salem, OR 97310
Phone: 503-378-3805
Fax: 503-378-4844
Web: (Removal-Fill Program): http://statelands.dsl.state.or.us/r-fintro.htm

Oregon Economic and Community Development Department (OECDD)
775 Summer St. NE
Salem, OR 97310
Rich Grant, Regulatory Specialist
Phone: 503-986-0159
Fax: 503-581-5115
Web: http://www.econ.state.or.us

Oregon Marine Board (OMB)
435 Commercial St. NE
PO Box 14145
Salem, OR 97309
Phone: 503-378-8587
Fax: 503-378-4597
Web: http://www.boatoregon.com

Oregon Office of Energy (OOE)
625 Marion St. NE, Suite 1
Salem, OR 97310
David Stewart-Smith, Secretary, Energy Facility Siting Council
Phone: 503-378-4040, 800-221-8035
Fax: 503-373-7806
Web: http://www.energy.state.or.us

Oregon State Police (OSP)
255 Capitol St. NE
400 Public Service Bldg.
Salem, OR 97310
Dave Cleary, Lieutenant of Fisheries
Phone: 503-378-3720, ext. 4308
Fax: 503-363-5475
Web: http://www.osp.state.or.us

Oregon State University Extension Service
3180 Center St. NE, Room 1361
Salem, OR 97301
Derek Godwin, Watershed Management Specialist
Phone: 503-566-2909, 800-718-2668
Fax: 503-585-4940
E-mail: Derek.Godwin@orst.edu
Web: http://extension.oregonstate.edu

Oregon Water Resources Department (OWRD)
158 12th St. NE
Salem, OR 97310
Ken Dowden, Water Right Information Staff
Phone: 503-378-8455, ext. 273
Fax: 503-378-6203
Web: http://www.wrd.state.or.us

Oregon Watershed Enhancement Board (OWEB)
775 Summer St. NE, Suite 360
Salem, OR 97301-1290
Bonnie King, Executive Assistant
Phone: 503-986-0181
Fax: 503-986-0199
Web: http://www.oweb.state.or.us/

Federal agency contacts and resources

U.S. Army Corps of Engineers (ACOE)
Portland Office, Regulatory Program
PO Box 2946
Portland, OR 97208
333 SW First Ave., 8th floor
Portland, OR 97204
Phone: 503-808-4373
Fax: 503-808-4375
Web: http://www.nwp.usace.army.mil/

U.S. Bureau of Land Management (BLM)
PO Box 2965
Portland, OR 97208
1515 SW 5th Ave, 9th floor
Portland, OR 97201
Joseph Moreau, Fishery Biologist
Phone: 503-952-6418
Fax: 503-952-6021
Web: http://www.or.blm.gov

U.S. Environmental Protection Agency (EPA)
811 SW Sixth Ave., 3rd floor
Portland, OR 97204
Yvonne Vallette, Wetlands Coordinator
Phone: 503-326-2716
Fax: 503-326-3399
Web:
Region 10 Office:
http://www.epa.gov/region10
Office of Watersheds, Oceans, and Wetlands:
http://www.epa.gov/OWOW/
Watershed Information Network:
http://www.epa.gov/win/

U.S. Fish and Wildlife Service (USFWS)
2600 SE 98th Ave., Suite 100
Portland, OR 97266
Willa Nehlsen, Salmon Restoration Coordinator
Phone: 503-231-6179
Fax: 503-231-6195
Web:
Pacific Region Office: http://pacific.fws.gov
Division of Fish and Wildlife Management Assistance and Habitat Restoration:
http://www.fws.gov/cep/cepcode.html
National Wetlands Inventory:
http://wetlands.fws.gov

U.S. Forest Service (USFS)
Pacific Northwest Region
PO Box 3623
Portland, OR 97208
333 SW First Avenue
Portland, OR 97204

U.S. Forest Service (USFS)
4077 Research Way, Corvallis, OR 97333
Scott Peets, Oregon Plan Liaison
Phone: 541-750-7181
Fax: 541-750-7234
E-mail: speets@fs.fed.us
Web: http://www.fs.fed.us

U.S. National Marine Fisheries Service (NMFS)
525 NE Oregon St., Suite 500
Portland, OR 97232
Mike Tehan, Oregon Branch Chief, Habitat Conservation Division
Phone: 503-231-2224
Fax: 503-231-6893
Web:
Northwest Regional Office:
http://www.nwr.noaa.gov
Community-based Restoration Program:
http://www.nmfs.noaa.gov/habitat/restoration/

USDA Natural Resources Conservation Service (NRCS)
101 SW Main, Suite 1300
Portland, OR 97204
Web: http://www.or.nrcs.usda.gov
Dave Dishman, Leader–Implementation
Phone: 503-414-3252
Fax: 503-414-3103
Roy Carlson, Leader–Technology
Phone: 503-414-3231

Watershed councils

Watershed councils are locally organized, voluntary, nonregulatory groups established to improve the condition of watersheds in their area. Councils are required to represent the interests in the basin and be balanced in their makeup. Councils offer local residents the opportunity to independently evaluate watershed conditions and identify opportunities to restore or enhance conditions. Through the councils, partnerships between residents, local, state, and federal agency staff and other groups can be developed. To get in touch with your local watershed council, contact the Oregon Watershed Enhancement Board at 503-986-0181 or visit their Web site (http://www.4sos.org/group/gweb_wscs.htm).

Soil and water conservation districts

Soil and water conservation districts (SWCDs) identify natural resource problems and offer assistance in resolving them. Guiding this assistance are boards of local leaders who know the people in their communities and are familiar with local conservation needs. SWCDs help private land users make appropriate and responsible resource management decisions by providing science-based technical assistance, the support of stakeholders, and incentives to address issues that will benefit primarily the public. SWCDs help people carry out voluntary conservation actions on private land in a watershed-based approach.

To get in touch with your local SWCD, contact the Oregon Association of Conservation Districts at 503-472-6307 or visit their Web site (http://www.oacd.org).

Publications

Oregon Watershed Enhancement Board

A Strategy for Achieving Healthy Watersheds in Oregon (January 2001)

Oregon Watershed Assessment Manual (July 1999)

Oregon Aquatic Habitat Restoration and Enhancement Guide (May 1999)

Oregon Water Quality Monitoring Technical Guidebook (July 1999)

A Guide to Oregon Permits Issued by State and Federal Agencies (Spring 2000)

All of the above publications can be downloaded from the OWEB Web site (http://www.oweb.state.or.us/publications/index.shtml). Hard copies can be ordered at cost from:

Publication Request
Oregon Watershed Enhancement Board
775 Summer Street NE, Suite 360
Salem, OR 97301-1290
503-986-0178

Other publications

Restoring Wetlands at a River Basin Scale: A Guide for Washington's Puget Sound: Operational Draft, Publication No. 97-99 (Washington Department of Ecology, Olympia, WA, 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 (Conservation Technology Information Center, West Lafayette, IN, 1997). Available from CTIC, 1220 Potter Dr., 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 (National Association of Counties, Washington, DC, 1999). Available from NACO, 440 First St., Washington, DC 20001; phone: 202-393-6226.

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

Web sites

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

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

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

Pacific Northwest's Marine Invasive Species Team site.
http://seagrant.orst.edu/mist/links.html

Moving forward–the next steps

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in improving your understanding of watershed planning.

1.____

2.____

3.____

APPENDIX A

SOURCES OF HISTORICAL INFORMATION ABOUT WATERSHED 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 Oregon regions and watersheds are available from local government and private sources.

National Wetlands Inventory

NWI maps and data are available from the U.S. Fish and Wildlife Service (http://wetlands.fws.gov/) and the Oregon Division of State Lands (http://statelands.dsl.state.or.us/). 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, also are 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 county Extension offices.

U.S. Coast Survey charts

Topographic surveys (T-sheets), hydrographic (bathymetric) surveys, and composite charts from the 19th and early 20th centuries are available for some coastal areas. (Figure 2 is a sample for Coos Bay, OR.) 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 19th 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 (see address above). 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 generally are 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 other useful sources of data. Data are available from the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries), state fish and wildlife agencies, and university libraries.

Historical ground photos, written accounts, 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 old-timers are other useful sources.

2

Watershed Hydrology

Paul W. Adams
and Derek C. 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 body of water. The specific water body of concern is what defines the watershed. If the Columbia River is this water body, the watershed consists 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

In this chapter you'll learn:

- How watersheds are defined and identified
- The general patterns of water movement through a landscape, known as the hydrologic cycle
- Impacts of impermeable surfaces on stream flow
- Land management effects on stream flow
- The nature of extreme events

See Section II, Chapter 4 and Section III, Chapter 4 for information related to this chapter.

Section II

4 Watershed Soils

Section III

4 Stream Ecology

water resources downstream. Likewise, the unique natural features (geology, soils, etc.) and processes of each watershed can influence water resources directly, 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.

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 those of some of the smaller tributary basins that make up the larger watershed.

USGS topographic maps are available for most areas in Oregon. 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

A list of Oregon retail outlets for USGS maps also is available on the Web (http://geography.usgs.gov/services.html#order_maps).

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*. Figures 2 and 3 highlight the key parts of the hydrologic cycle at different scales. These parts are defined briefly below. Most are discussed in greater detail later in this chapter.

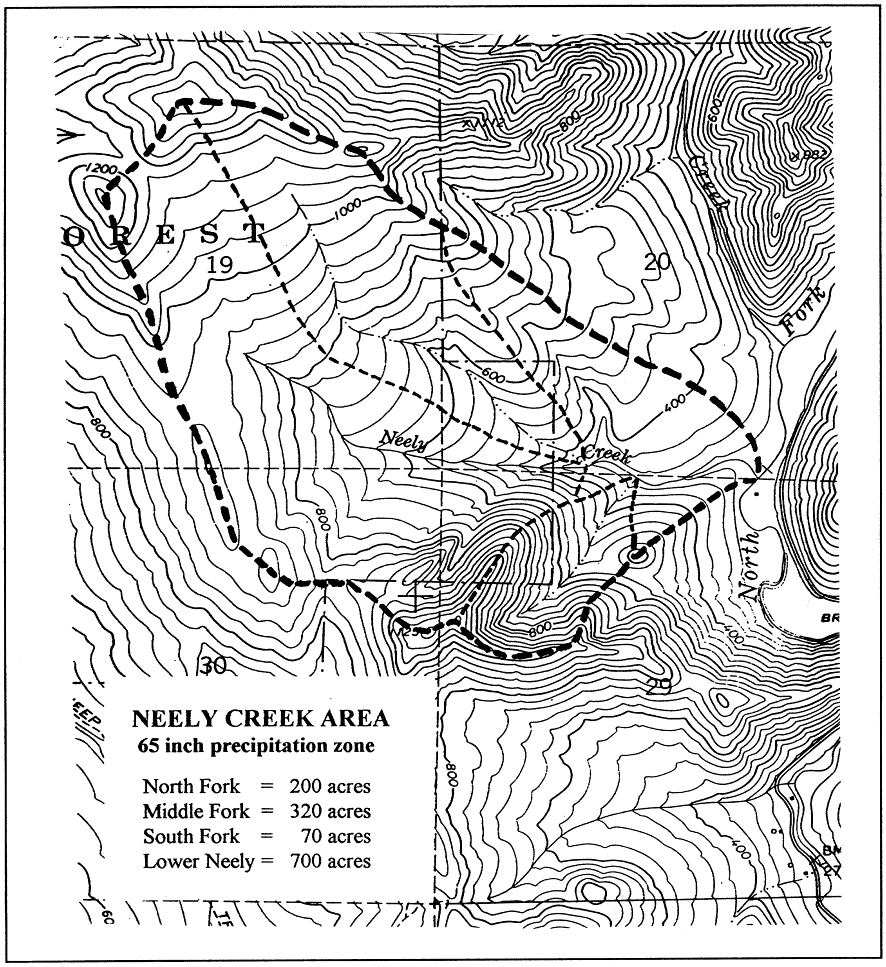


Figure 1.–Precipitation zone map showing watershed boundaries (dashed lines).

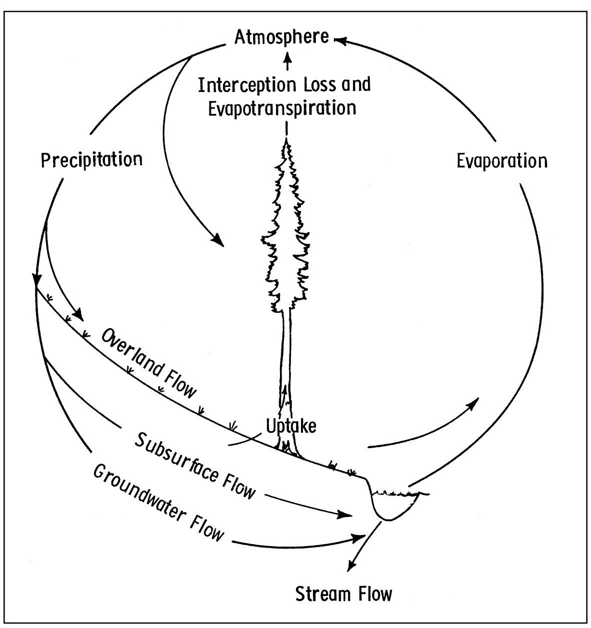


Figure 2.–Forest hydrologic cycle. (Source: U.S. Forest Service)

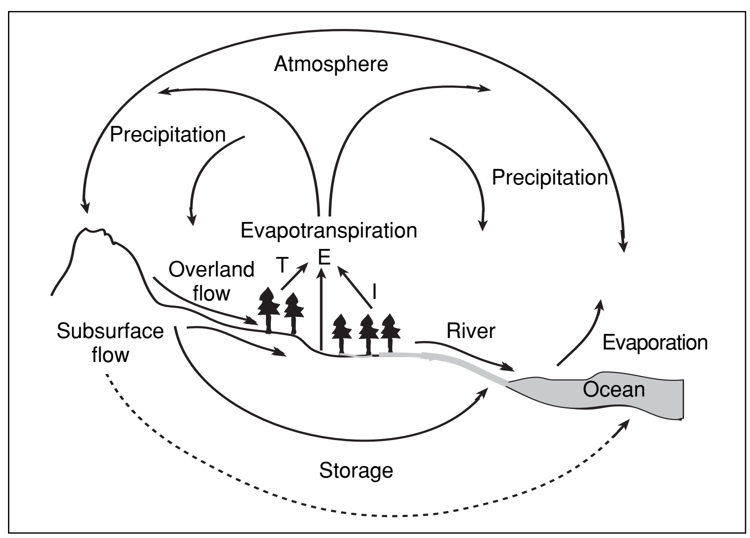


Figure 3.–The hydrologic cycle. The transfer of water from precipitation to surface water and groundwater, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle. E=Evaporation; T=Transpiration, I=Interception.

- *Precipitation*: Water from the atmosphere that reaches plants, the ground, or bodies of water. Depending on local weather conditions, precipitation can be deposited in many forms, including rain, snow, sleet, hail, and condensation (dew, frost, etc.).
- *Interception*: The action of plant surfaces catching precipitation that otherwise would reach the ground. Depending on local weather conditions and plant canopy characteristics, intercepted precipitation might evaporate quickly, leaving less water to reach the ground and contribute to stream flow.
- *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 forest streams. The type and amount of precipitation in Oregon varies 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 are checked manually at regular intervals, such as every 24 hours or once 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 general rule that 1 foot of snow contains 1 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 snow’s water content 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.

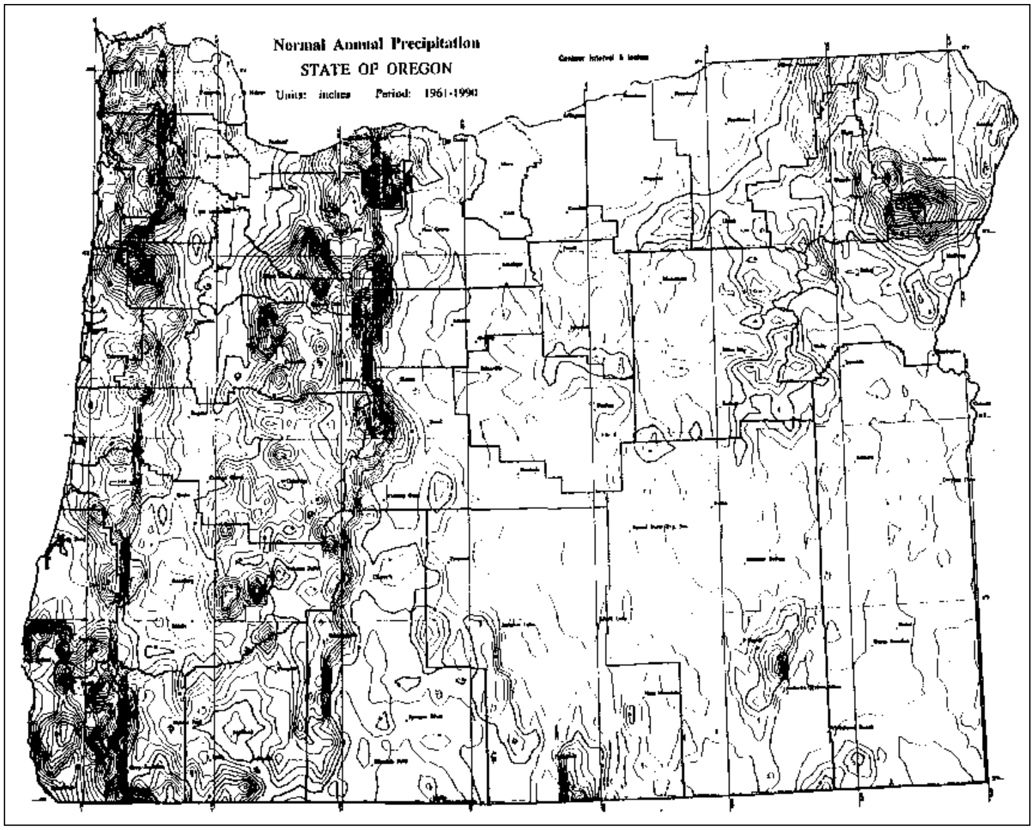


Figure 4.—Normal annual precipitation for Oregon.

Within a given region or even an individual watershed, precipitation differences can be dramatic. One key factor is elevation. Generally, as elevation increases, so do the amounts of rain or snow. Another major influence is the local terrain as it relates to the direction that storms typically travel. Because storms in Oregon often move from west to east, more rain or snow usually falls on west-facing slopes.

The office of the State Climatologist at Oregon State University has published an annual precipitation map for Oregon (Figure 4). Each line on the map intersects locations that are expected to have the same annual precipitation. Each adjacent line represents a 5-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. Note the areas of high precipitation in western, central, and northeastern Oregon.

Oregon’s 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 might 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 it compares with records from nearby weather stations.

Vegetation, soils, and stream flows

Vegetation can have a strong effect on the amount of water available for stream flow. 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, as often occurs in western Oregon.

Second, plant roots can take up water that reaches the soil before it has a chance to move to the deeper soil layers that contribute to stream flow. 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*.

In eastern Oregon forests, evapotranspiration losses can equal about 80 percent of the total annual precipitation. For example, in an upland forested area where 30 inches of precipitation falls annually, about 24 inches of that water returns to the atmosphere. In western Oregon forests, evapotranspiration losses can equal about one-quarter to one-half the total annual precipitation. For example, in an upland forested area where 56 inches of precipitation fall annually, about 20 inches of that water returns to the atmosphere before it reaches deep soil layers or adds to stream flow. 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 stream flow.

The calculations below for a 320-acre forest watershed in western Oregon (1 acre = 43,560 square feet) show the total and average stream flows 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

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

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

Ground surface and soil characteristics also play an important role in how precipitation affects stream flow. 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 might move over the ground as surface runoff that quickly adds to stream flow.

Soil depth and ability to store water also influence stream flow. 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 5–10 feet of the surface, as in many upland forest soils in western Oregon, precipitation water can move fairly quickly to streams. As a result, stream flows respond to individual storms in a "flashy" manner (rising and falling quickly). The stream *hydrograph* (a graph of changing stream flow over time) in Figure 5 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 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 during wet weather they can generate considerable runoff. Note also that one soil (Witham) can be expected to have a shallow *water*

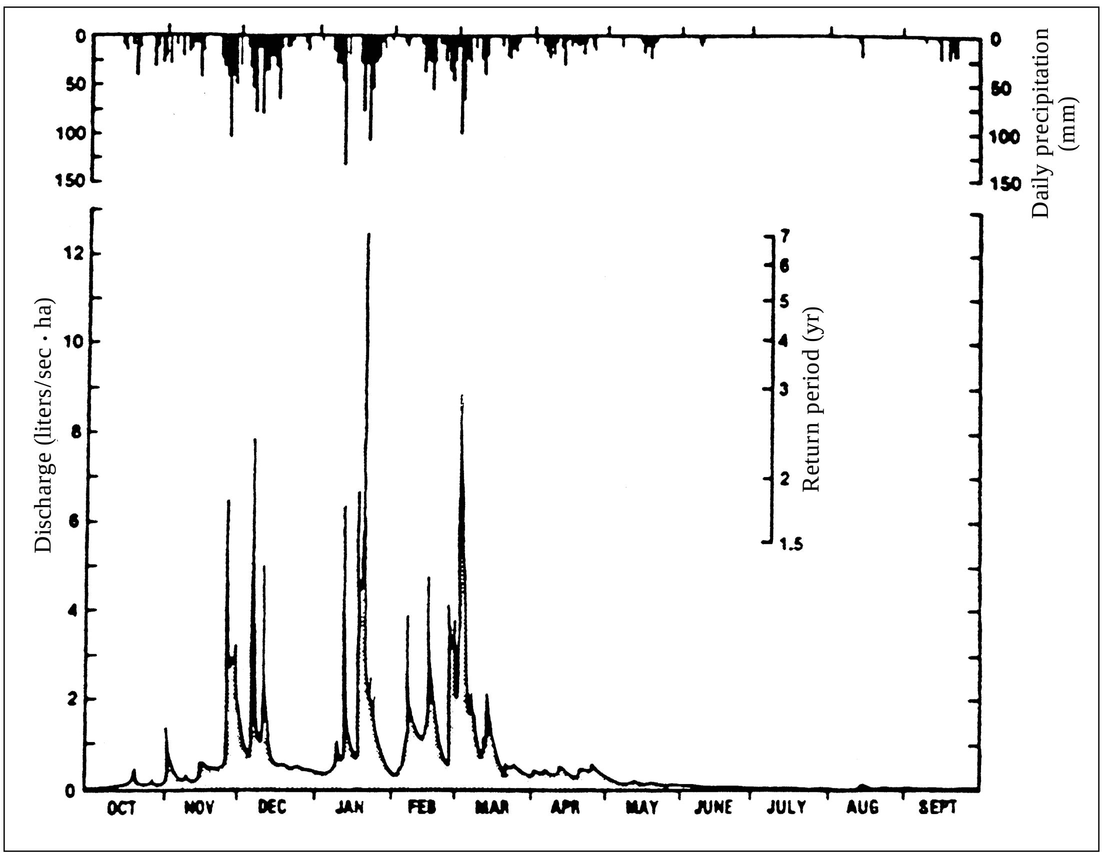


Figure 5.–Hydrograph showing daily precipitation and instantaneous stream flow for a forested watershed in the Oregon Cascades, 1972 water year.

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

Soil type	Surface permea-bility (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

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. See Chapter II-4, "Watershed Soils, Erosion, and Conservation," for more detailed descriptions of soil types and processes.

Types of precipitation also affect stream flow. Rainfall-dominated watersheds typically have their highest flows from November to March. Those dominated by snowfall typically have their highest flows from March to May, as the snow pack melts and releases its reservoir of water. Figure 6 shows how monthly stream flows in a rain-dominated watershed in western Oregon

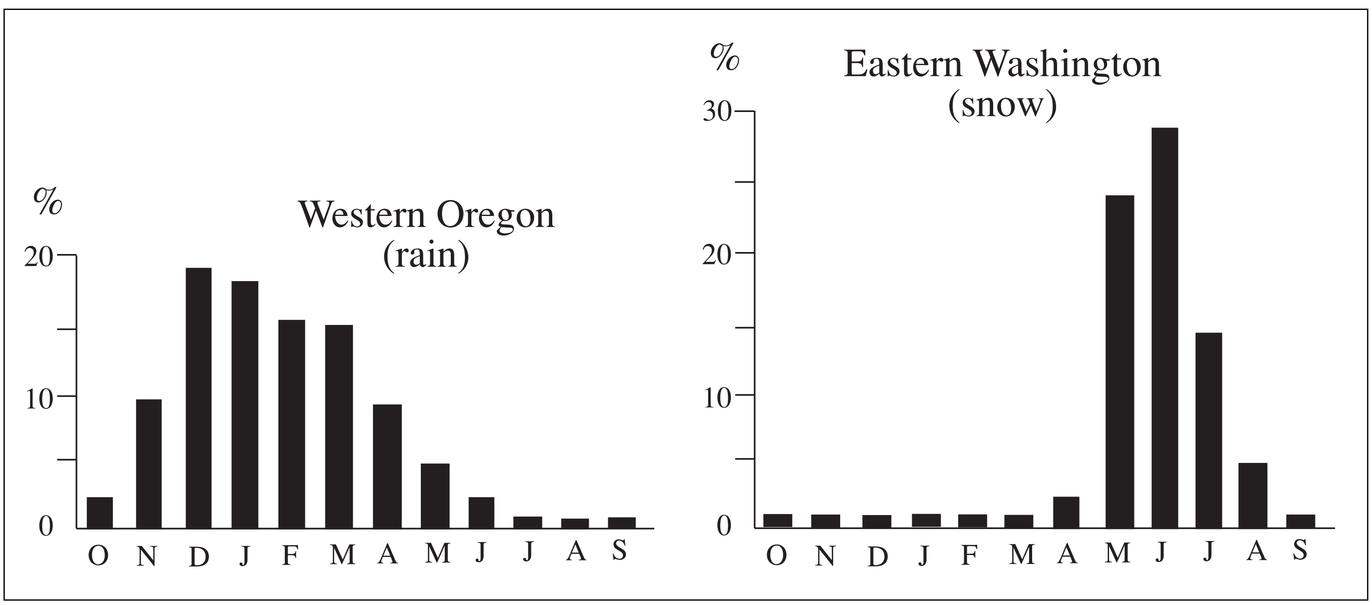


Figure 6.–Monthly stream flow in a rain-dominated western Oregon watershed versus a snow-dominated eastern Washington watershed.

differ from those in a snow-dominated watershed in eastern Washington.

Subsurface and groundwater flow

Movement of water in the atmosphere and on land is easy to visualize, but the movement of groundwater is not. Underground water moves through the pores of rocks and soil as well as through the cracks and joints of rocks. These pores, cracks, and joints are numerous near the surface and less abundant with increasing depth.

Variations in rock type and soil-forming processes (such as weathering and earth movement) determine subsurface water movement and storage. These variations can be seen at road-cuts along mountain roads. Chapter II-4 provides more detail on soil types and processes.

In general terms, water seeps down from a rain-soaked surface to an impermeable or less permeable layer of rock. A layer of rock or soil above this less permeable layer becomes saturated, hence it is called the *saturated zone*. The top of the saturated zone is called the *water table*.

An *aquifer* is rock or soil that contains and transmits water. A *confined aquifer* is rock or soil surrounded by less permeable soil and rock. Water can be transferred to and from confined aquifers through the surrounding soil, but very slowly. Some confined aquifers maintain water under pressure. This water then rises to the surface as geysers or human-made artesian wells.

Surface water and groundwater interact at many places throughout the landscape. Groundwater moves from areas of recharge to areas of discharge. In *recharge areas,* water enters the underground soil and rock from the surface or a body of water. In *discharge areas,* water moves from the subsurface zones to a water body, spring, or well that pumps water to the surface.

Figure 7 illustrates groundwater movement from recharge areas to discharge areas. The arrows depict general paths of groundwater

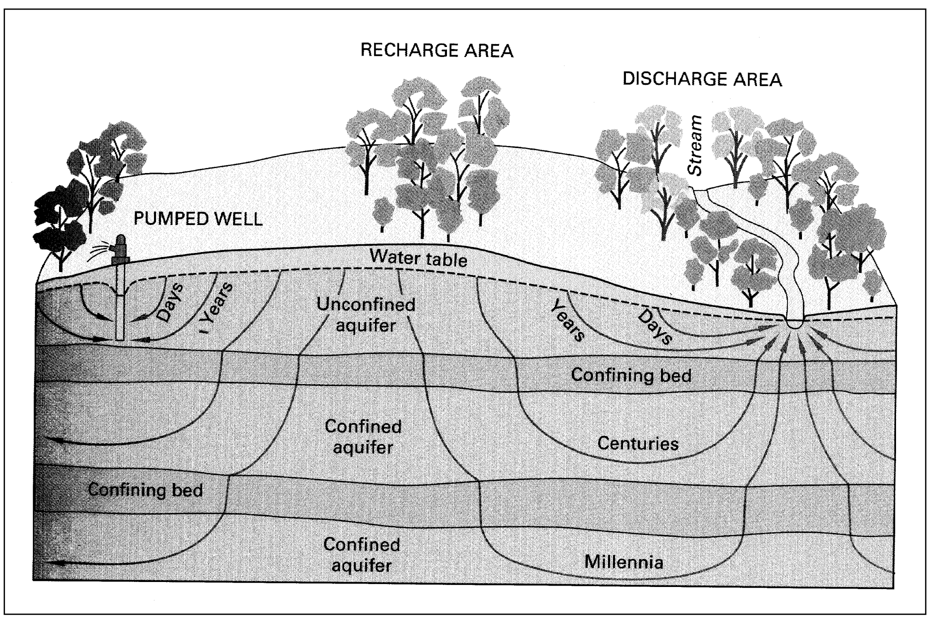


Figure 7.–Groundwater flow paths vary greatly in length, depth, and travel time from points of recharge to points of discharge in the groundwater system. (Source: Ground Water and Surface Water: A Single Resource*, USGS, 1998)*

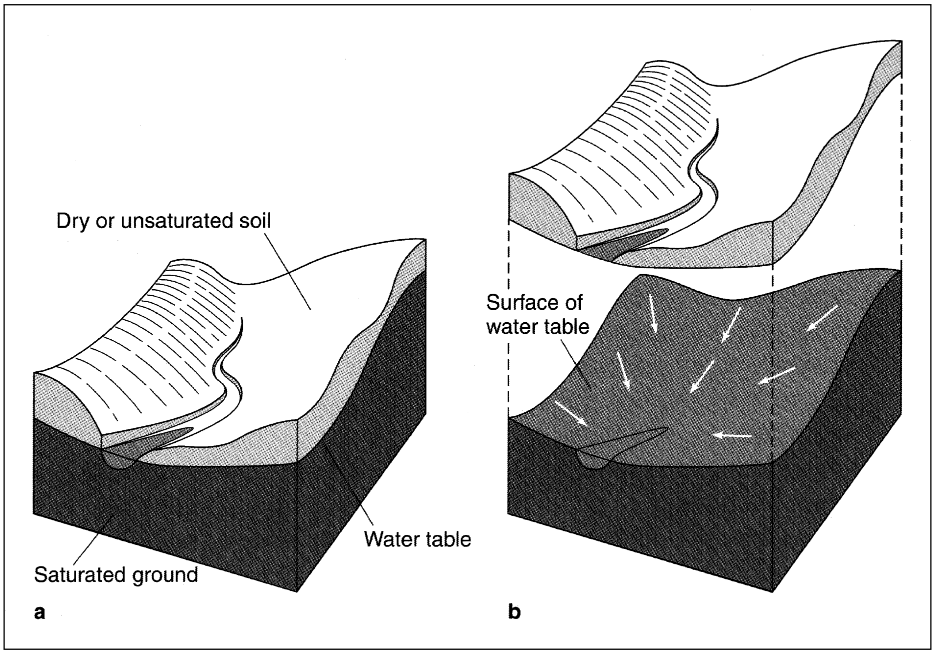


Figure 8.–(a) The water table meets the gound surface wherever there are surface water bodies such as springs, streams, wetlands, or lakes. (b) Water moves downhill in the direction of the water table's steepest slope. (Source: Water, Rivers, and Creeks, *by L. Leopold, University Science Books, Sausalito, CA, 1997)*

movement. You can see that the amount of time it takes for water to move from a recharge area to a discharge area varies greatly depending on the type of rock. Figure 7 simplifies the subsurface movement of water to streams and subsurface water reservoirs. In reality, water movement through soils and rock crevices is a complex process that varies greatly at different times and places.

The water table meets the ground surface at springs, stream channels, rills, wetlands, and lakes (Figure 8). Note that the water table is not flat because water moves through pores, cracks, and other tiny openings at different speeds. The arrows in Figure 8b show that water moves downhill in the direction of the water table's steepest slope.

Streams interact with groundwater in three basic ways:

- They gain water when groundwater flows in through the streambed (Figure 9).
- They lose water when groundwater flows out through the streambed (Figure 10).
- They do both, gaining in some reaches and losing in others.

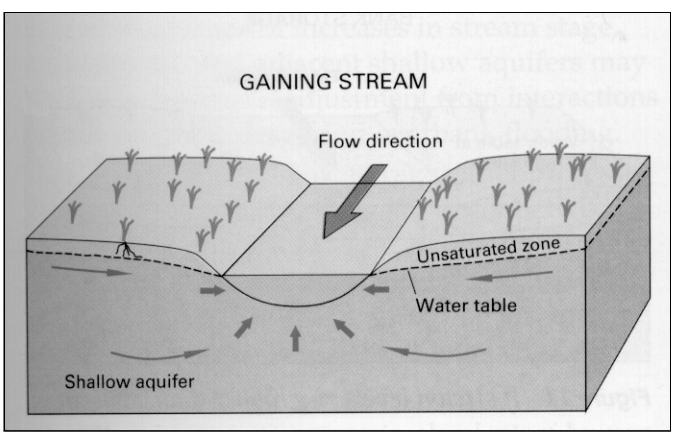


Figure 9.–Gaining streams receive water from the groundwater system. (Source: Ground Water and Surface Water: A Single Resource, *USGS, 1998)*

Stream reaches generally gain water from groundwater when the water table is higher in elevation than the streambed. They lose water to groundwater when the water table is lower in elevation. The process of gaining cool groundwater is important for salmon and trout survival in streams with high water temperatures.

Flow direction into or out of a stream can vary greatly over a short distance. Storms and temporary flood peaks moving down a stream channel can cause stream flows to rise rapidly, thus causing water to move into surrounding soil, rock, and groundwater. This movement of water from streams and floodplains into unsaturated soils during a storm event recharges the water table, reduces flood peaks, and supplements stream flows after storm events. Transpiration of groundwater by streamside vegetation also can affect the exchange of surface and groundwater.

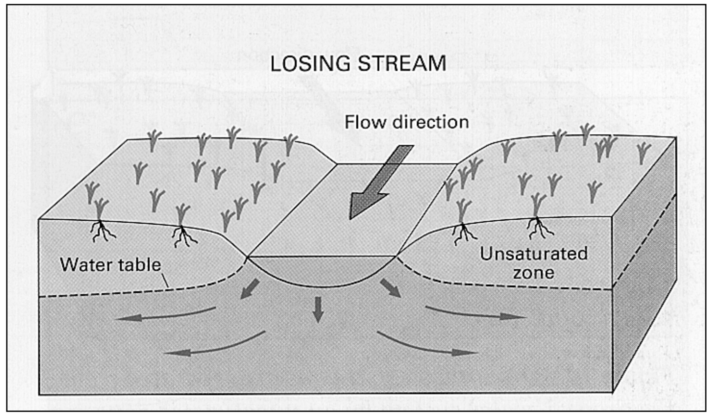


Figure 10.–Losing streams lose water to the groundwater system. (Source: Ground Water and Surface Water: A Single Resource, *USGS, 1998)*

HOW IMPERVIOUS SURFACES AFFECT STREAM FLOW

Development of towns, cities, and suburbs covers land with impermeable surfaces. When water falls on these surfaces, the soil cannot capture it and release it slowly to the groundwater. Instead, the water runs overland or through drainage systems (downspouts, sewers, and road gutters) to streams. Thus, peak stream flows might arrive sooner, be higher, last for shorter periods of time, and occur more frequently.

The effects of urbanization are depicted in Figure 11, a hypothetical hydrograph before and after urbanization. Notice the change in lag time–the time between the rainfall and the arrival of the runoff at a given point in the stream. If lag time decreases, the amount of flow must increase in order to carry the same volume of water in a shorter time.

A study conducted in Maryland provides a real-life example of the effect of urbanization on flood peaks and frequency (Table 2). The number of houses within the 3.7-square-mile Watts Branch watershed near Washington, DC increased from 140 in 1950 to 2,060 in 1984. As the number of houses increased, the number of times stream flow exceeded 220 cubic feet per second also increased. Meanwhile, the number of times the stream overflowed its bank increased from 2 times per year to 7 times per year (Leopold, 1994).

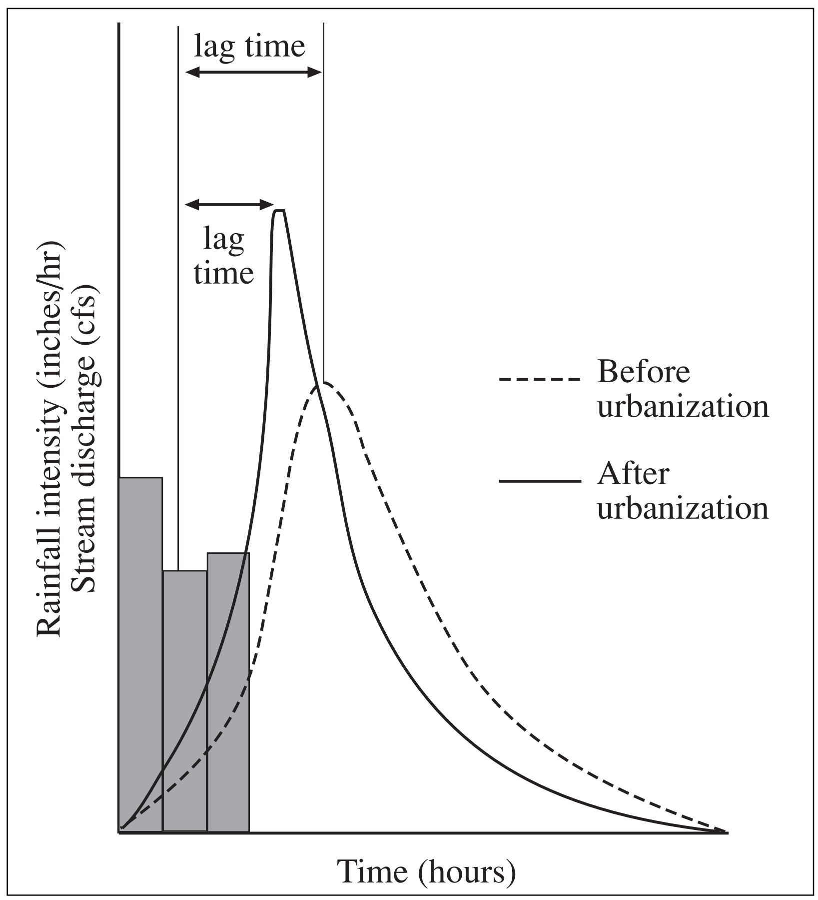


Figure 11.–The effects of urbanization on lag time. (Source: Water, Rivers, and Creeks, *by L. Leopold, University Science Books, Sausalito, CA, 1997)*

Table 2.–Urban development and stream flow in the Watts Branch watershed.

Year	Number of houses	Period of discharge records	Number of times discharge exceeded 220 cfs*	Number of times discharge exceeded 350 cfs
1950	140			
1955	420			
1965	780	1958–1967	21	10
1984	2060	1978–1987	73	32

**220 cubic feet per second is considered the bankfull discharge for Watts Branch. The bankfull discharge was determined to be a 1.5-year flow event.*

Many urban restoration projects focus on building stormwater detention ponds and re-establishing riparian areas and wetlands. These projects aim to mimic historic conditions and improve the watershed's ability to capture water, store it, and release it slowly over time.

EXTREME EVENTS

Extreme events are periods of very high or very low precipitation or stream flow that might create problems for people, soil, and water. The storms and floods of February and November 1996 were recent and very vivid examples of extreme events. If you have some idea of the size and likelihood of extreme events that can occur in a watershed, you can take steps to prevent or reduce the problems they might cause. For example, you could install a larger road culvert in a stream crossing to prevent a washout or landslide.

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 "2-year, 1-hour peak rainfall." The 50-year flow is the stream flow level that, on average, is likely to occur about once every 50 years. The 2-year, 1-hour peak rainfall is the maximum total rain for a 1-hour period that is likely to fall once every 2 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 might occur once, several times (like the two 1996 storms), 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 (e.g., El Niño) are becoming better understood and more predictable.

Table 3 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 stream flow records.

The stream flows in Table 3 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 4 shows the estimated 1-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 stream flows.

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.

The height of the 100-year flood is not an exact number, and several sources of error can influence the accuracy of the calculation. One is the length of time records have been kept. The shorter the record, the greater the error in calculating the height of the 100-year flood. Many stream gauges in Oregon have been recording data for only 30 years. Therefore, the 100-year flood height has to be projected from data that might not have recorded a 100-year event. For a gauge record of 25 years, the confidence level is 85 percent. In other words, the height of the 100-year flood could be off by 15 percent.

Another source of error is changing watershed conditions. For instance, as urban areas grow, the amount of land covered by impermeable surfaces increases, leading to faster, higher, and more frequent water runoff during rain events. Thus, storms that might not have caused a flood in the past might overflow the stream's banks after urbanization.

Table 3.–Flynn Creek peak flows.

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

Table 4.–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
50	1.3

Summary/Self review

Watersheds are dynamic, and certain processes have particularly important implications for both their characteristics and management. These key processes and related concepts can help you better understand watershed features, behavior, and response to management practices. They include:

- Location is the most fundamental watershed characteristic and the first key to understanding watershed features and behavior. Topographic maps provide a simple, useful tool for locating watershed boundaries.
- Hydrologic cycle components such as precipitation (i.e., type, amount, and distribution) have a major influence on upland and stream characteristics. Soils and vegetation play a key role in water storage, release, and evapotranspiration loss. Published precipitation, soil, and stream flow data are helpful resources, but you might need to collect local data to better understand your watershed.
- Surface water and groundwater often are treated as separate entities, but in reality, they are connected. The movement of water over and through the ground surface is an important part of watershed and stream processes.
- Most major watershed impacts–whether natural or management-related–occur during times of extreme precipitation and stream flow. Understanding and planning for such events are essential for effective watershed management and restoration.

Exercises

Some exercises to help you better understand watershed features, behavior, and response to management practices include:

- Identify and outline a watershed on a topographic map.
- Research the precipitation records and stream flows for gauges in or near the selected watershed.
- Work with a hydrologist to analyze stream flow records for various peak flow events (e.g., 2, 10, 25, 50-year return intervals), wet and dry cycles, and changes in flooding due to urbanization.
- Take a course to learn how stream flow and precipitation are measured.
- Take a course to learn how groundwater wells are established and how they are monitored for subsurface flows.

Resources

Training

Training specifically on watershed processes is not widely available outside of formal university classes, although basics sometimes are reviewed as part of short courses and seminars offered by various organizations. To learn about available training opportunities, maintain good communication with government agencies and other groups. In addition, many textbooks and other references are available if you're interested in self-instruction.

Information

Forestry and Water Quality, 2nd ed., by G.W. Brown (OSU Book Stores, Inc., Corvallis, OR, 1985). 142 pp. ISBN 0-88246-007-2

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Principles of Forest Hydrology, by J.D. Hewlett (University of Georgia Press, Athens, 1982). 183 pp. ISBN 0-8203-0608-8

Stream Dynamics: An Overview for Land Managers, USDA Forest Service General Technical Report RM-72, by B.H. Heede (Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, 1992).

A View of the River, by L. Leopold (Harvard University Press, Cambridge, MA, 1994). 298 pp.

Water in Environmental Planning, by T. Dunne and L.B. Leopold (W.H. Freeman and Co., New York, 1978). 818 pp. ISBN 0-7167-0079-4

Water Resource Measurements—A Handbook for Hydrologists and Engineers, by B.P. Van Haveren (American Water Works Association, Denver, CO, 1986). 132 pp. ISBN 0-89867-345-3

Water, Rivers and Creeks, by L. Leopold (University Science Books, Sausalito, CA, 1997). 185 pp. ISBN 0-935702-98-9

Watershed Hydrology, 2nd ed., by P.E. Black (Ann Arbor Press, Ann Arbor, MI, 1996). 425 pp. ISBN 1-57504-027-1

Wildland Watershed Management, 2nd ed., by D.R. Satterlund and P.W. Adams (John Wiley and Sons, Inc., New York, 1992). 436 pp. ISBN 0-471-81154-8

Moving forward–the next steps

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in improving your understanding of watershed hydrology.

1. ______________________________

2. ______________________________

3. ______________________________

3

Stream Processes

Derek C. Godwin
and Barbara Ellis-Sugai

Many people are seeking to improve habitat and water quality for salmon and trout in the Pacific Northwest. The most common approach is to conduct stream and riparian enhancement projects. An understanding of river processes, floods, and floodplains is invaluable in planning successful projects.

This chapter will provide basic information to help landowners, watershed groups, and resource professionals implement successful enhancement projects and management plans that ultimately improve fish habitat and water quality.

IN THIS CHAPTER YOU'LL LEARN:

- Basic stream channel classifications
- How and why streams meander and erode stream banks
- Floodplain functions
- Impacts of land management on rivers, floods, and floodplains
- Considerations for conducting stream restoration and enhancement projects

STREAM CHANNEL CLASSIFICATIONS

A watershed is an area of land that collects rain and snow and discharges much of it to a stream, river, or other body of water. A watershed's stream network is composed of a main stream and the tributaries that flow into it. Not all streams within a watershed have the same characteristics. Several stream classification systems have been developed to describe differences among streams and compare one stream to another.

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 calls the channel where a small stream first appears a *first-order stream* and then increases 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 1).

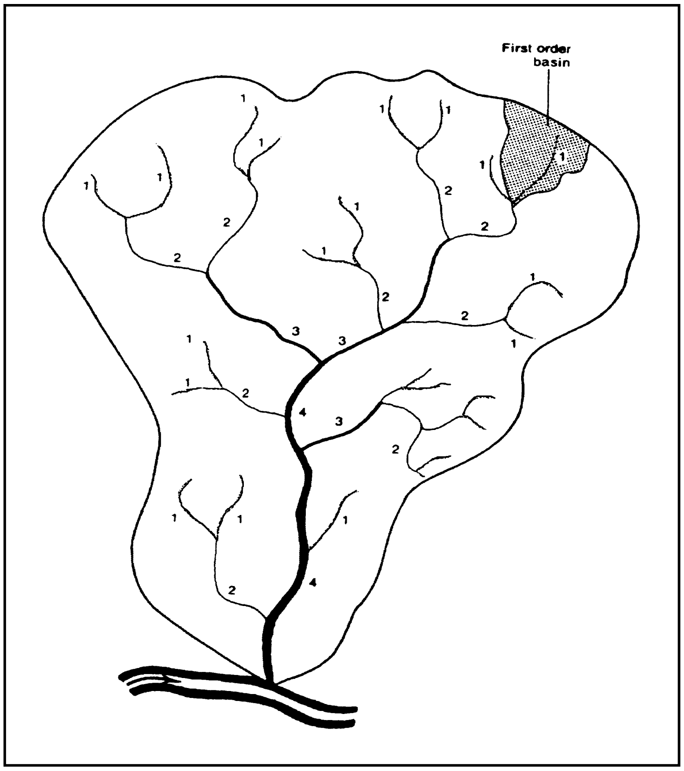

Figure 1.–Stream orders according to Horton's system of classification. (Source: Principles of Forest Hydrology, *by J.D. Hewlett, University of Georgia Press, 1982)*

Source, transport, and deposition

Montgomery and Buffington (1998) devised another useful stream classification system. They separate streams into three categories: *source*, *transport*, and *depositional* streams (Figure 2). They use measurable characteristics to identify these stream types. One characteristic is the stream's slope or gradient. Another is the ratio of stream width to the width of the valley floor. The following are general descriptions of these stream types. See Montgomery and Buffington (1998 and 1997) for more detailed descriptions.

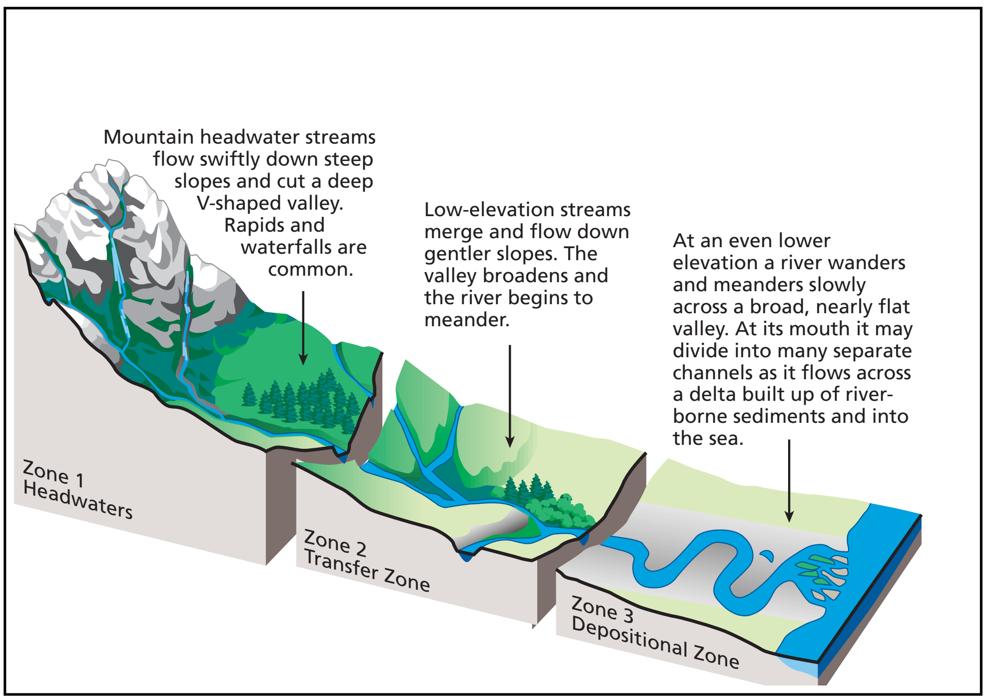

Figure 2.–Example of three different stream types in a watershed. (From Living in the Environment: Principles, Connections, and Solutions, *7th ed., by G.T. Miller. ©1992. Reprinted with permission of Wadsworth, an imprint of the Wadsworth Group, a division of Thomson Learning. Fax 800-730-2215)*

- *Source streams*: These are headwater streams that are steep (>20 percent), straight, and have no floodplain. They are source areas for sediment and wood. In mountainous areas, they can be prone to landslides in the stream channel, which carry wood, sediment, and water downstream (debris torrents).
- *Transport streams*: These streams typically have a moderate gradient (3–20 percent). They develop small meanders in moderately narrow valleys with small floodplains. Sediment and wood are stored here temporarily while moving from source to depositional areas.
- *Depositional streams*: These streams are low-gradient (<3 percent). They meander through wide valleys with large floodplains (relative to stream size). Sediment and wood are deposited here for long periods of time. These streams are the most sensitive to changes in the watershed (for example, a change in sediment supply).

Oregon Watershed Assessment Manual

The Oregon Watershed Assessment Manual classifies stream types by stream gradient, confinement class (based on the ratio of stream width to valley width), and stream size (based on Oregon Department of Forestry designations). Figure 3 (page 4) illustrates some of the stream types described by this classification system.

Rosgen stream classification

Dave Rosgen (1996) developed a more site-specific stream classification system, which has been adopted by several resource agencies and groups. His system is more complex and categorizes streams by differences in channel gradient, bed materials, ratio of width to depth, degree of meandering (sinuosity), and extent of downcutting into the floodplain.

STREAMS ARE ALWAYS CHANGING

Streams constantly adjust their shape to changing conditions. The following stream characteristics influence a stream's shape.

- *Channel slope or gradient* (drop in elevation over a given distance)
- *Stream flow or discharge* (the volume of water moving through the channel at a given time, usually expressed as cubic feet per second)

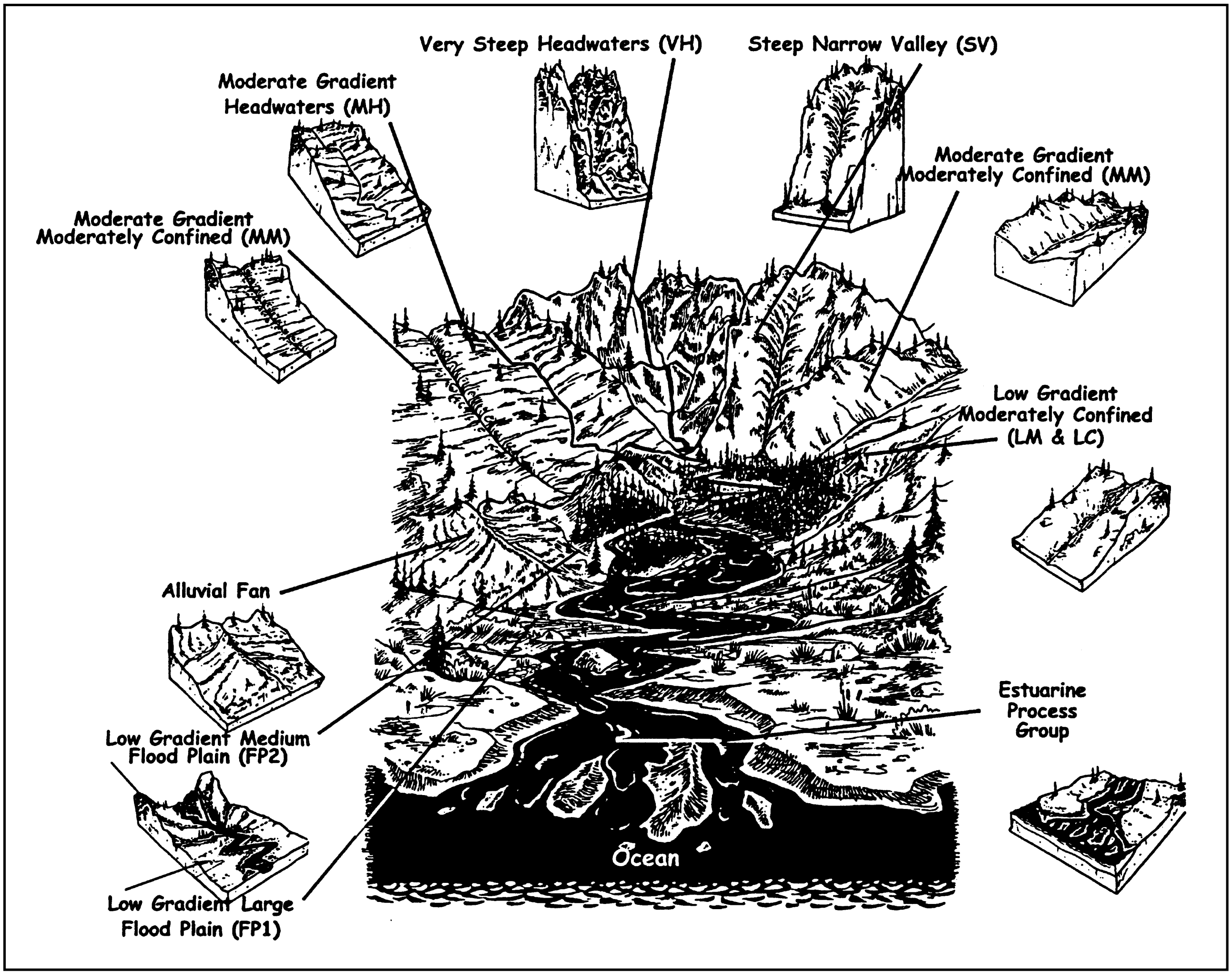

Figure 3.–Examples of Channel Habitat Types and their relative position in the watershed. (Source: Oregon Watershed Assessment Manual, *Oregon Watershed Enhancement Board, Salem, OR, 1999*)

- *Material in the streambed and banks* such as silt, clay, sand, gravel, cobble, boulders, bedrock, large wood, and tree roots
- *Amount of sediment moving through the stream network* (silt, clay, sand, gravel, cobble, and boulders)
- *The ratio of the stream's width to its depth* (Figure 4) ranging from wide and shallow to narrow and deep
- *Sinuosity* (Figure 5, page 6), the distance a river travels divided by the straight-line distance from start to finish. A perfectly straight channel has a sinuosity equal to one. The more the channel meanders, the higher the number.
- *Amount and type of riparian vegetation,* such as trees, shrubs, and grasses

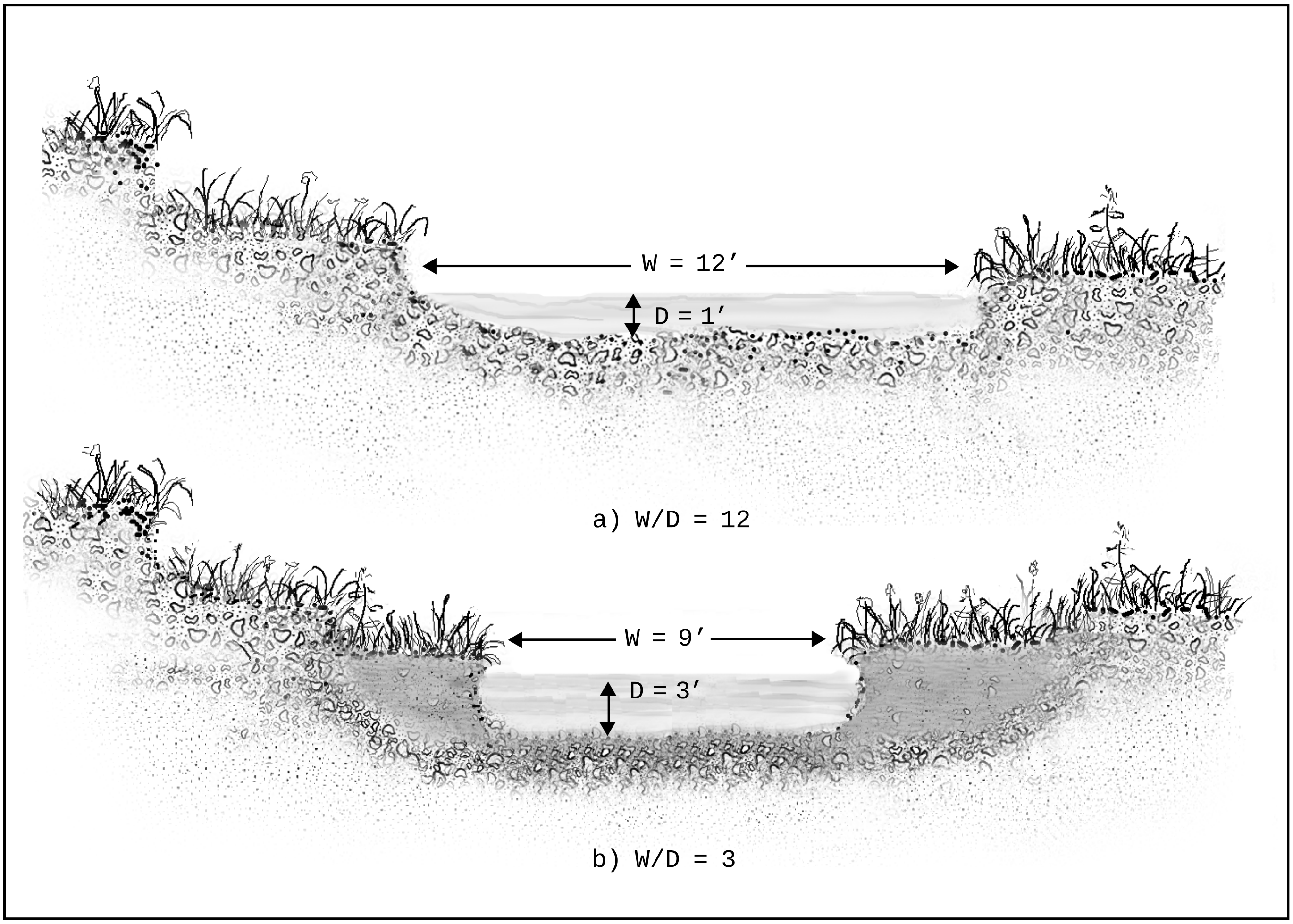

Figure 4.—Width-to-depth diagram. (Illustration: Ralph Penunuri)

All of these factors are linked. If one variable changes, the others will change in response. For example, if erosion increases in the watershed, thus increasing the supply of sediment, there are several possible results:

- If the stream's capacity to transport the sediment is overwhelmed, the sediment might be deposited, thus raising the elevation of the streambed.
- Gravel bars might get bigger, causing erosion of the opposite bank in order to maintain the same channel size.
- Pools might fill in, reducing the quality of fish habitat.
- The stream might increase from a single channel to multiple channels.

Montgomery and Buffington (1993) offer several examples of how increased sediment can affect streams. One is the Williams River in Saskatchewan, Canada. As it passes through sand dunes, the river picks up sediment and becomes a braided channel five times wider and half as deep as it is upstream.

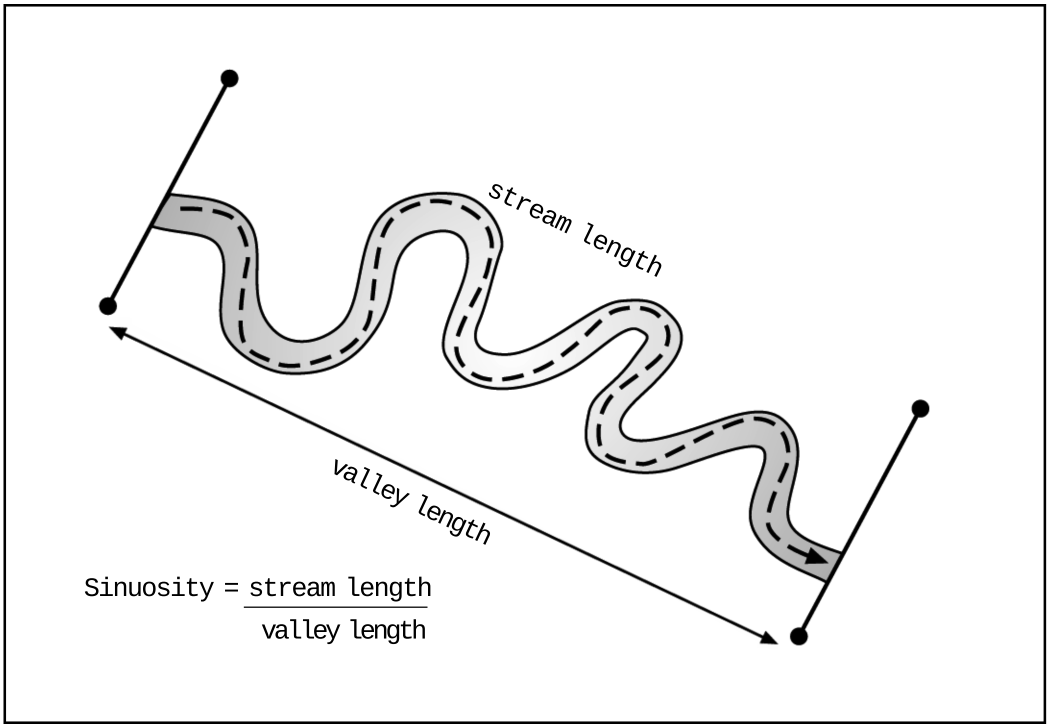

Figure 5.–How to measure and calculate sinuosity. (Illustration: Ralph Penunuri)

Another well-studied example shows the effects of hydraulic mining in the Sierra Nevada Mountains of California. Large amounts of sediment were added to rivers in the foothills of the Sierras between 1850 and 1880 as miners used high-pressure water hoses to wash rock and soil into streams, where it could be sluiced for gold. As a result, channels filled in and widened. This effect progressed downstream. Then, after the "wave" of sediment passed through the stream, the stream downcut into the material left behind.

Stream bank erosion is likely to increase if riparian vegetation is removed along depositional streams with banks that are sensitive to erosion. As a result, more sediment is deposited downstream, possibly leading to channel widening and further bank erosion downstream. Figures 6a and 6b illustrate two riparian conditions along West Creek. Figure 6a depicts conditions with little bank erosion. Figure 6b depicts an overgrazed riparian area with increased erosion.

WHY DO STREAMS MEANDER?

Ninety percent of the world's low-gradient rivers are single-channel, meandering streams (Leopold, 1994). The word "meander" is derived from a Greek word that means "to wander."

A stream's pattern develops naturally to dissipate energy and carry sediment. Streams with steep gradients (source and transport streams) dissipate their energy by creating pools through a series of steps, falls, and plunges (Figure 7, page 8). They look relatively straight on a map compared to meandering depositional streams. This "step pool" pattern can be thought of as meanders turned on their side.

As the stream's slope (gradient) flattens, the depositional segments of a stream dissipate energy by creating a meandering flow pattern (Figure 8, page 9). Meanders cause the river to dissipate its energy as the water is forced around the bends. Meanders in a river are analogous to switchbacks in a mountain road. They reduce the river's slope and therefore the velocity of the water. Energy also is used up through friction of the water against the stream's bed and banks.

Figures 6a and 6b.—West Creek. 6a (top) depicts riparian conditions with little stream erosion. 6b (bottom) depicts an overgrazed riparian area with increased erosion. (Source: USFS)

Figure 7.–A step pool transport stream. (Source: USFS)

A regular meander pattern can be seen from a distance. You might recognize meanders on a map or from an airplane by looking at the shape of a river. Each meander might look different, but the basic pattern often is repeated over long distances.

Research has shown that meanders have a predictable size and shape (Figure 9, page 10). Regardless of a river's size, there is a fairly constant relationship between the wavelength of the meanders, the channel width, and the radius of curvature. For example, low-gradient meandering streams (depositional streams) tend to have a meander wavelength that is 10–14 times the channel width and a meander radius of curvature 2–3 times the channel width. Figure 10 (page 11) depicts common stream channel geometry measurements.

The Walla Walla River was channelized and diked around Milton-Freewater, Oregon to provide flood control. During the 1964 flood that affected much of the Pacific Northwest, the river broke through dikes in several places when the flow exceeded the capacity of the artificial channel. Once the river overtopped the channel, it developed a regular meander pattern that was superimposed over the straight channel. Figure 11 (page 11) shows the river during the 1964 flood. The river is flowing from the bottom of the photo to the top.

POOLS, RIFFLES, AND GRAVEL BARS

During high flows, the water's velocity is greatest on the outside of a bend and slowest on the inside. As a result, a pool is scoured on the outside, and sediment is deposited on the inside. The inside of the bend becomes a sand or gravel bar, also known as a point bar.

Figure 8.–General landscape view of a meandering stream (Pudding River, Oregon). (Source: Farm Services Agency, Marion County)

Water flowing through the straight parts of the channel between bends tends to have lower velocity and form riffles. Riffles are another form of gravel bar, in this case extending across the width of the channel. Figure 12 (page 12) illustrates pools, riffles, and point bars.

A gravel bar is an accumulation of sediment ranging in size from sand and gravel to cobbles. Some of the sediment might move downstream during high flows. However, the location and general size of gravel bars tend to remain the same relative to the meander bends. An everyday analogy is a group of cars stopped at a red light. There always are a few cars stopped at the intersection, even though individual cars move down the street from one intersection to the next.

The shape of a stream channel is formed during annual high flows. Although dramatic channel changes can occur during less frequent flood events, it is the annual high flows that establish

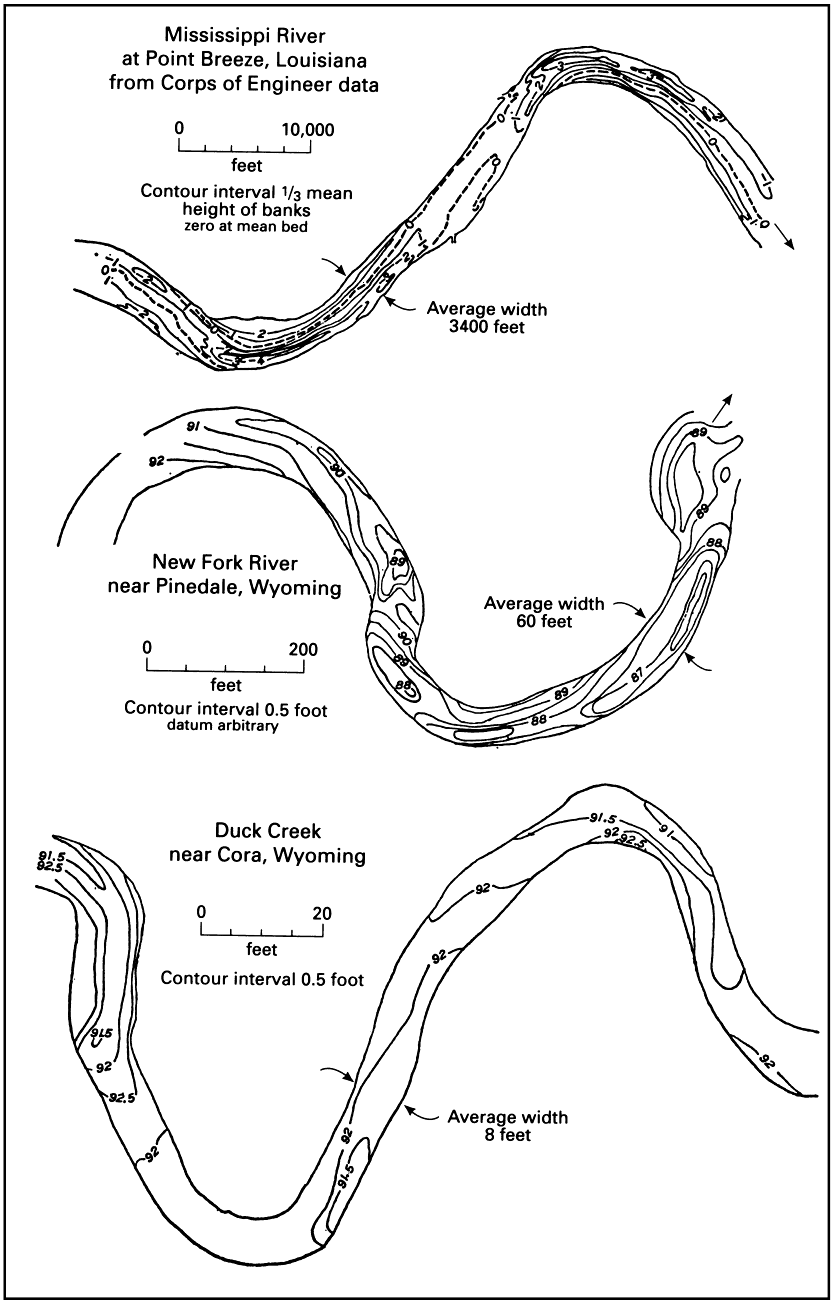

Figure 9.–Leopold's diagram of meanders of different size rivers. (Reprinted by permission of the publisher from A View of the River, *by Luna B. Leopold, Harvard University Press, Cambridge, MA © 1994 by the President and Fellows of Harvard College; originally published in* American Scientist *50:525 [1962].)*

channel dimensions. Because annual flows occur often, they move more sediment over time than do less frequent floods. Gravel bars are deposited during high flows, then remain in place and define the path of the channel during low flows.

During low flows, pools are flatter, deeper, and slower moving than riffles. Riffles are steep and shallow.

THE EFFECTS OF CHANNELIZING RIVERS

Streams often are channelized to make them more efficient at transporting water, to reduce flooding, or to drain wetlands. Sinuosity is reduced when meandering streams are "straightened" or "channelized." This practice can have several effects on the stream. The length of the channel is reduced, the gradient is increased, and the water velocity is increased.

These changes lead to higher erosive forces, and the straightened channel is likely to start eroding its banks and/or downcutting into the floodplain. The banks become higher, steeper, and more prone to erosion. Such a stream is known as *incised,* and the stream banks prevent it from flooding onto its floodplain during 1- to 2-year flow events. The number and depth of pools decrease. Increasing erosion can increase sediment deposited downstream of the channelized stretch of stream. The straightened stream often tries to reestablish a meandering pattern through bank erosion. The result is a stream that is trying to rebuild its floodplain and meander pattern, but at a lower elevation due to downcutting into the floodplain. Figures 13a and 13b (pages 13, 14) show two examples of stream evolution and adjustment.

THE STABLE STREAM CONCEPT

A "stable" stream is not a static stream. A stream is considered "stable" if its channel characteristics (the channel width, depth, gradient, sinuosity, and sediment type and amount) remain relatively constant over time and the stream neither deposits excessive sediment (*aggrades*) nor scours and downcuts (*degrades*) (Rosgen, 1996). The stream's ability to transport sediment is in balance with the sediment supply.

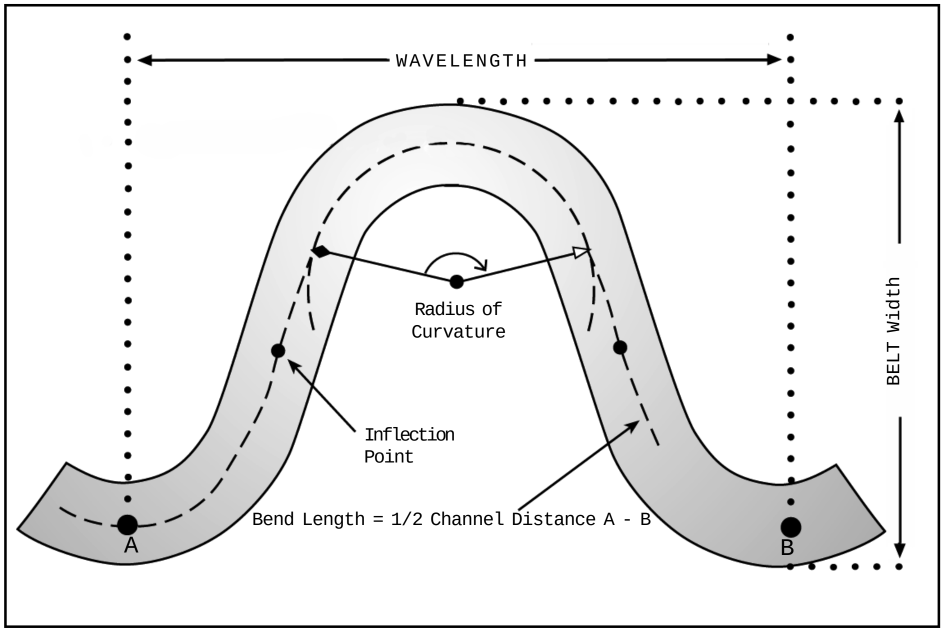

Figure 10.–Graphic of stream channel geometry. (Illustration: Ralph Penunuri)

"Stable" streams migrate

A stream channel can maintain an average meander pattern and characteristics over a long distance. However, *the location of the channel doesn't necessarily remain in the same place in the valley floor.* Meander bends migrate in a downstream direction, and river channels can move laterally across the valley floor over time. This migration occurs as the outside of bends erode and gravel bars are deposited on the inside of bends. The channel migrates in the direction of the strongest energy located on meander bends. This pattern tends to make meander bends migrate downstream (Figure 14, page 15).

Sometimes a stream forms an oxbow lake during high flows by cutting off a meander and leaving the old meander bend isolated from

Figure 11.–Walla Walla River in the 1964 flood showing meanders in a channelized section near Milton-Freewater. (Source: OSU Archives)

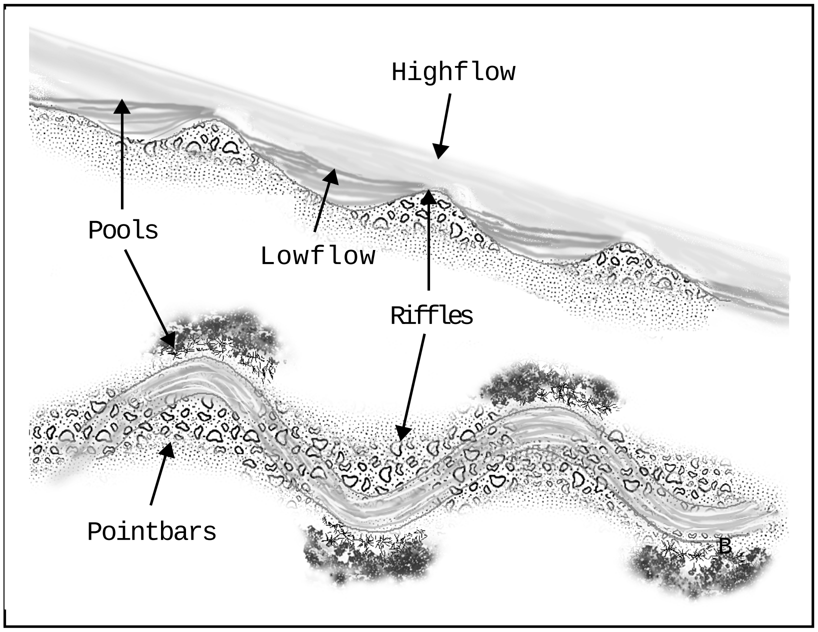

Figure 12.–Profile and plan view of pools, riffles, and point bars. (Illustration: Ralph Penunuri)

the stream. These cutoffs are formed because the stream's sinuosity has become too large and the slope too flat. The stream adjusts its gradient by straightening out a bend.

Stream channels tend to migrate laterally as banks erode. Changes in a stream's characteristics can cause it to migrate excessively as it adjusts. Typical examples of accelerated changes include vegetation loss and increased sediment load.

Predicting the extent of channel migration

Even rivers that are actively migrating and meandering tend to stay within a predictable area of the valley floor known as a *meander belt*. A meander belt is delineated by drawing two parallel lines, one on each side of the river, that connect the outside of meander bends (Figure 15, page 16). Like meander length and radius of curvature, meander belt width is related to channel width. A stream's meander belt width tends to vary from narrow for steep source streams to very wide for very low-gradient depositional streams.

The area occupied by the meander belt, sometimes called the *channel migration zone*, can be mapped to show where future bank erosion and lateral channel migration are likely to occur. In narrow valleys, the meander belt might occupy the entire width of the valley floor. Understanding and mapping the channel migration zone can help people planning transportation systems, rural and urban infrastructure (zoning and location of houses, buildings, roads, etc.), and riparian vegetation restoration projects. Figures 15 and 16 illustrate the channel migration of the Marys River over time.

STREAM BANK EROSION AND STABILIZATION

Streams are constantly changing by meandering, migrating, and rearranging pools, riffles, and gravel bars. Stream bank erosion is an inherent part of these processes.

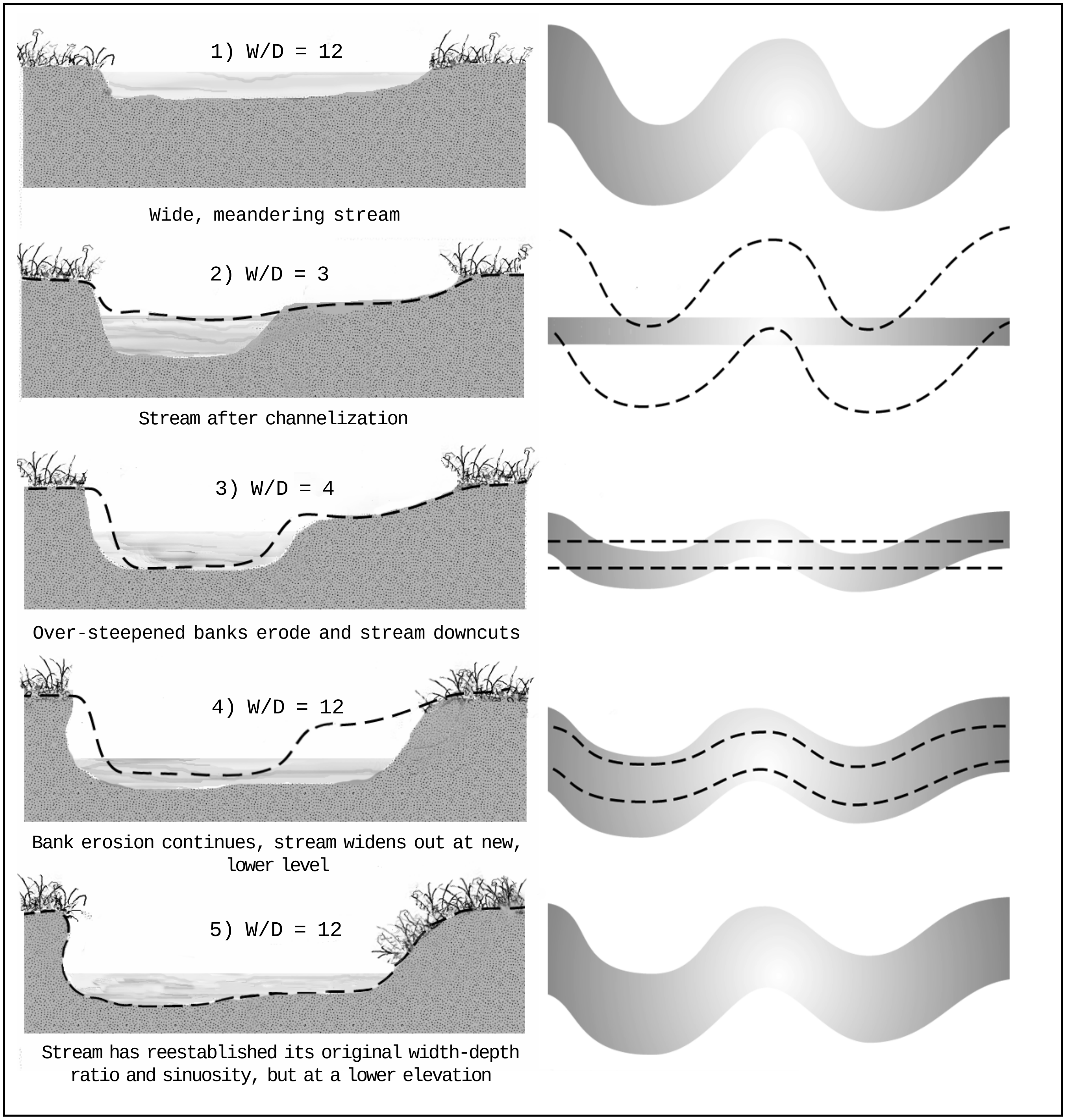

Figure 13a.–Example of stream evolution and adjustment. This stream initially was wide and shallow. (Illustration: Ralph Penunuri)

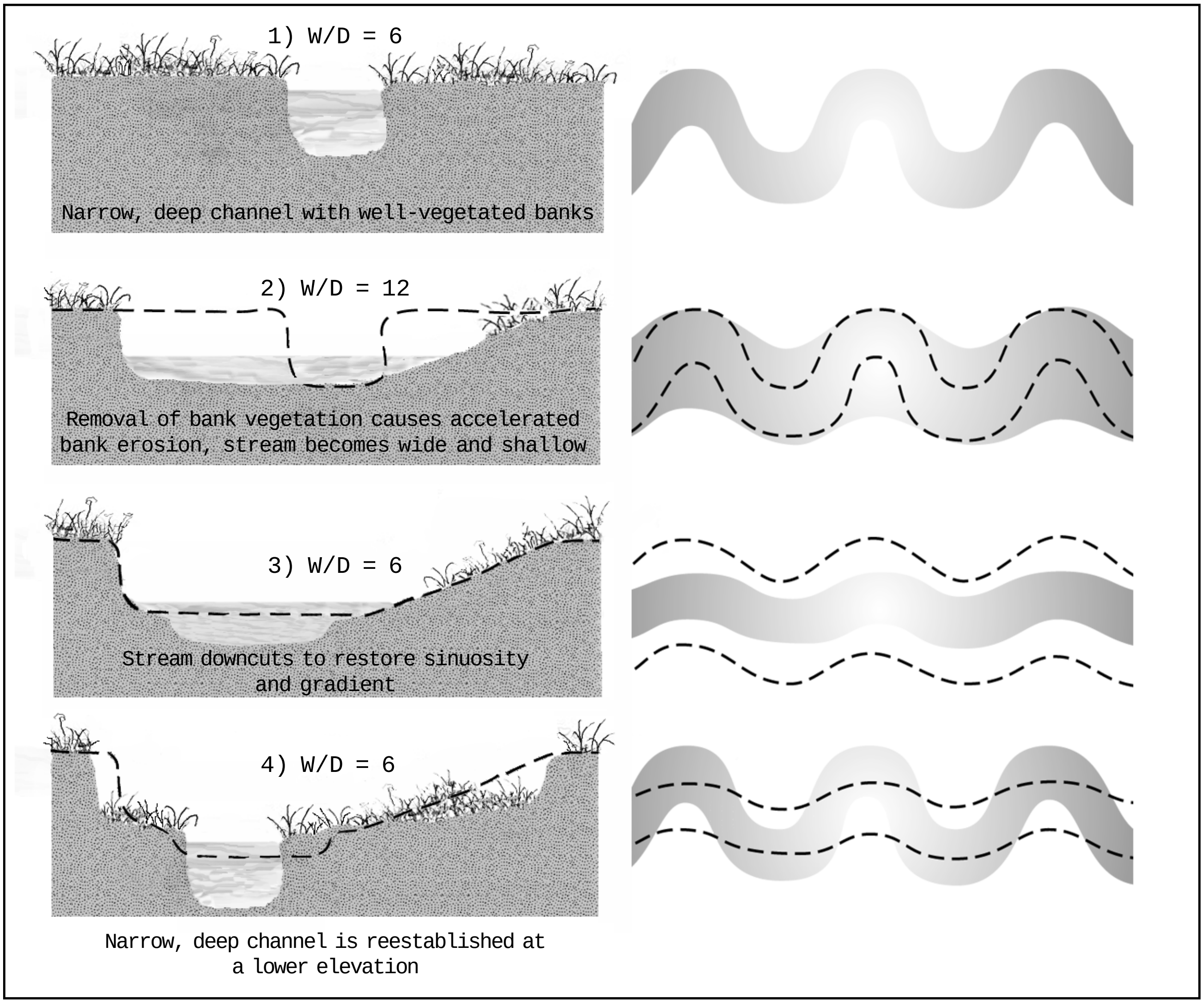

Figure 13b.–Example of stream evolution and adjustment. This stream initially was narrow and deep. (Illustration: Ralph Penunuri)

A stream bank is a complex network of vegetation, roots, wood, and sediment (clay, gravel, bedrock, etc.). Its roughness provides resistance to the stream as it flows by. The stream dissipates energy as it flows past this resistance. Erosion occurs when the stream applies more energy to the bank than the bank can withstand.

Bank erosion sometimes is a symptom of changes in riparian vegetation. Less vegetation means less root strength, making the stream bank more susceptible to erosion. Banks also are more prone to erosion if the stream downcuts below the rooting depth of the streamside vegetation.

A narrow strip of riparian vegetation often is kept next to streams to benefit fish, wildlife, and water quality. As conditions change, a meandering stream might erode through this narrow buffer, leaving an unstable bank prone to excessive erosion (Figure 17, page 17). A wider riparian buffer would allow for change and help maintain bank stability.

Bank erosion also can be a symptom of larger changes in the watershed. Watershed-wide changes, such as increased flow, water velocity, and/or sediment deposition on gravel bars, can force more energy into the stream bank.

"STABILIZING" STREAM BANKS

A "stable" stream meanders and migrates but maintains its characteristics over at least two meander lengths (Rosgen, personal communication). A "stable" stream might make minor adjustments in its characteristics to maintain its stability, for example, by cutting off a meander and leaving an oxbow lake. Its stream bank has a complex network of vegetation, roots, and wood to allow some erosion while maintaining its characteristics (e.g., width-to-depth ratio, sinuosity, and slope).

Many projects try to permanently prevent a stream from eroding and migrating. These projects typically place rock on the bank (riprap) or build rock deflectors (barbs, groins, jetties, etc.) to deflect flow away from the bank. Various amounts and sizes of rock are used. However, if the stream is not allowed to erode and migrate to adjust to changing conditions, it will have to adjust downstream or upstream of the project area. These adjustments often result in more bank erosion and sediment deposits than would have occurred without stabilization.

A good bank stabilization method temporarily withstands bank erosion until riparian vegetation is established. Any project should be designed to have minimum impacts upstream and downstream. Many current methods use native plants (e.g., willows), natural materials that decompose (e.g., fiber mats), logs, and some rocks. The amount and size of rock and longevity of materials should permit the bank to reestablish vegetation and allow the stream to adjust over time. Analyzing the channel migration zone (belt width) can help with planning the location and width of riparian vegetation.

Remember, stream bank erosion is caused by many factors and is a sign that a river is adjusting its characteristics to handle upstream and downstream changes. All bank stabilization projects should account for these off-site effects. Establishing and managing the proper type and quantity of riparian vegetation is critical to supporting stable stream conditions. See the "Resources" section for technical assistance and more information.

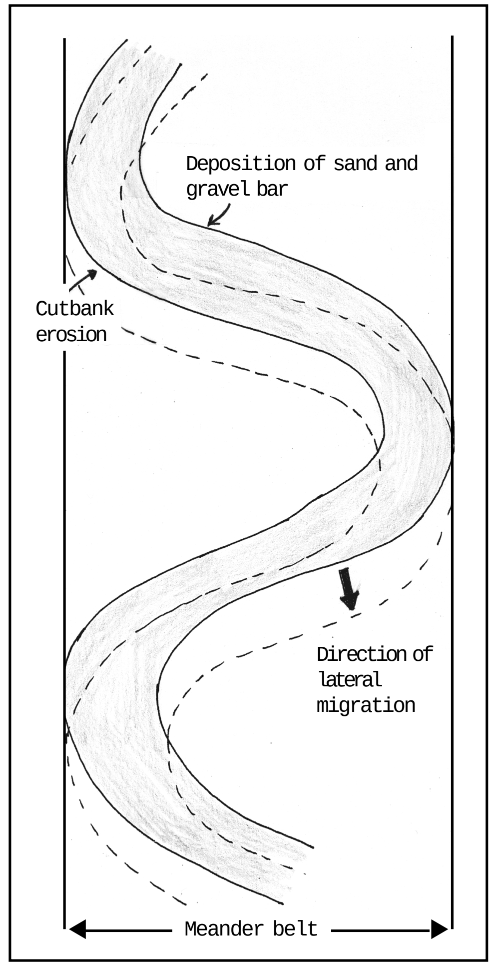

Figure 14.—Lateral channel migration of a meandering stream. (Source: USFS)

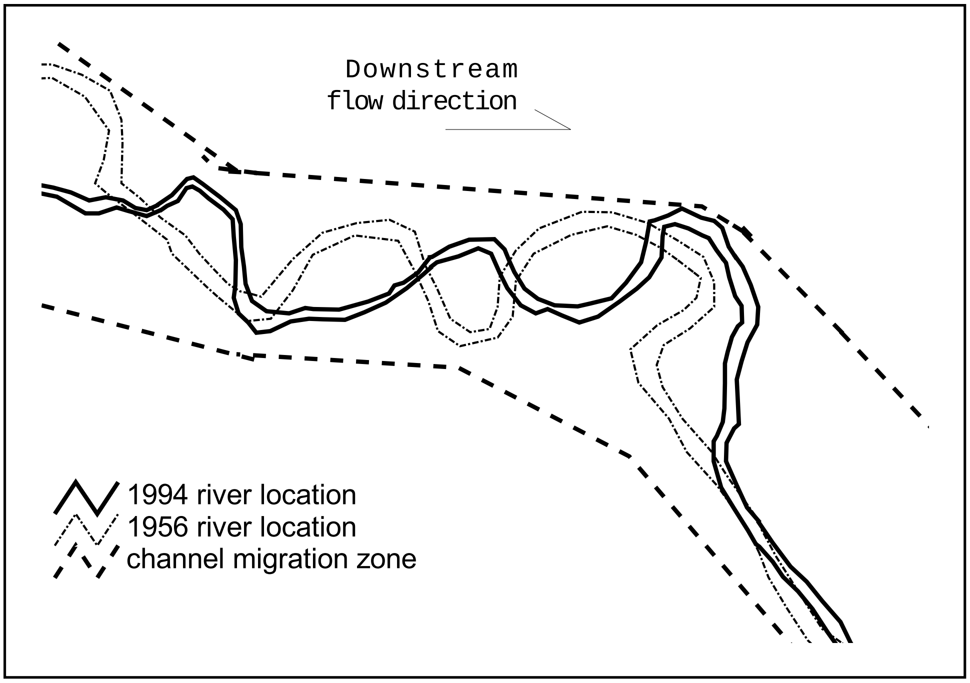

Figure 15.– Downstream meander migration of the Marys River between 1956 and 1994. (Source: USFS)

LARGE WOOD IN STREAMS AND FLOODPLAINS

Random events such as debris torrents, landslides, and windstorms deliver sediment and organic materials to streams. In many areas west of the Cascades, these events introduce trees and large wood to streams and floodplains. Streams adjust to the new wood over time by depositing sediment (all sizes) behind the wood, scouring pools, changing sinuosity, eroding stream banks, etc.

Much of this wood was removed in the past to improve river navigation, transport logs downstream, and facilitate salmon migration. Recent research has shown that large wood is a critical part of salmon habitat in many streams. It provides refuge during high flows, nurse logs for reestablishing vegetation, wildlife habitat,

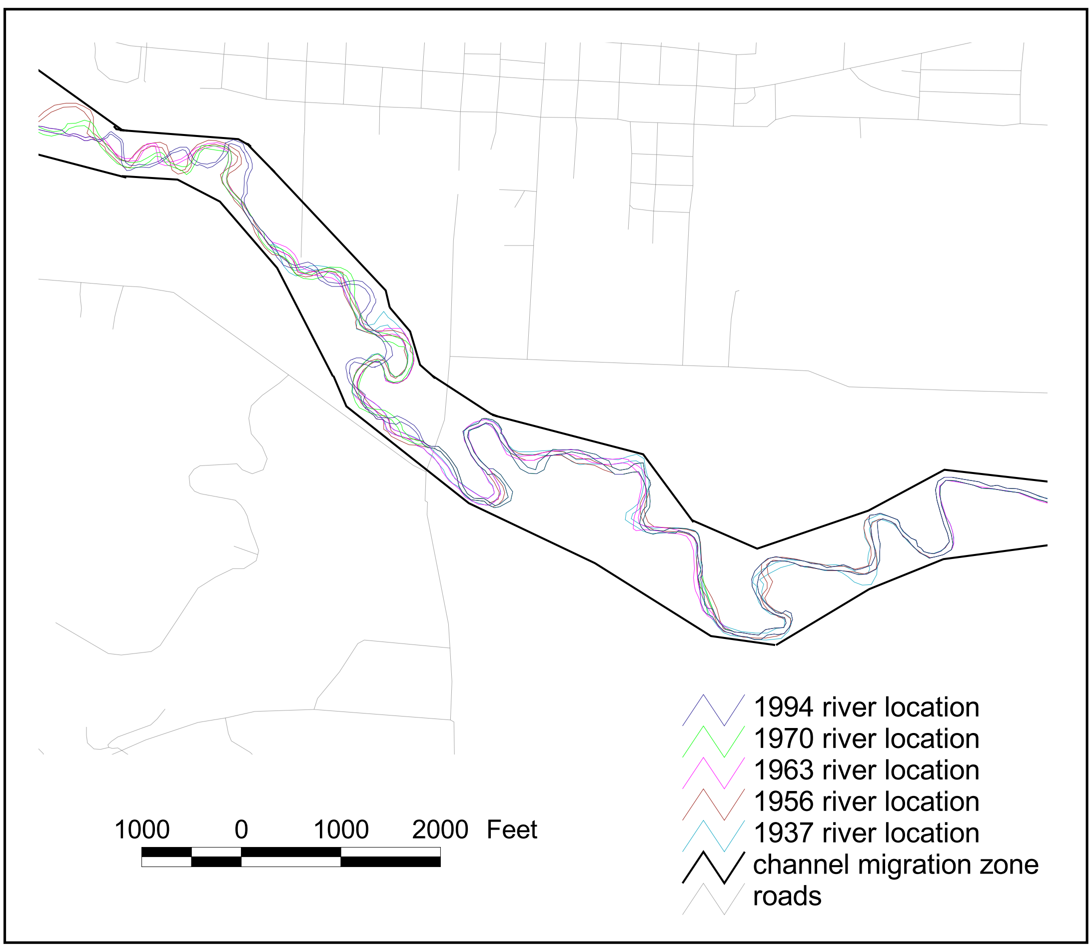

Figure 16.–Location of Marys River channel between 1937 and 1994. (Source: USFS)

and future habitat when the stream migrates.

As part of the effort to restore stream habitat, large wood is being placed in many western Oregon streams and floodplains to replenish the amount historically present (Figure 18, page 18). This wood typically is longer than $1^{1}/_{2}$ times the stream channel width and more than 2 feet in diameter. The wood often moves during high flows but stays in the general area if sized and placed properly.

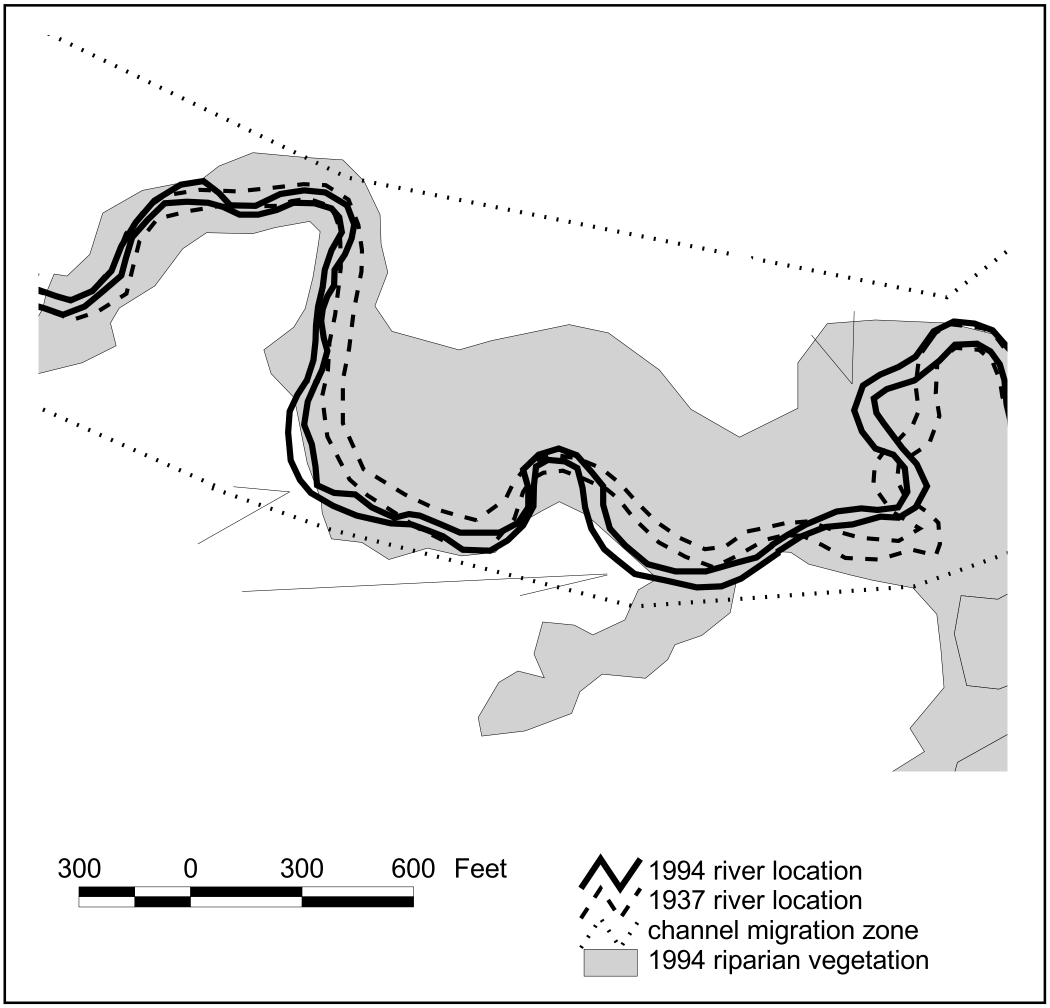

Figure 17.—Marys River eroding through a narrow buffer. Note that the channel migration has pushed the location of the channel beyond the woody vegetation in the riparian zone in several places. The dotted line is the channel migration zone. (Source: USFS)

The size, amount, and placement of large wood can have major effects on stream conditions and fish habitat. Therefore, it is important to evaluate the short- and long-term effects on stream conditions and habitat when designing these projects. In addition, always consider the upstream and downstream effects.

Establishing and managing the proper type and quantity of riparian vegetation should complement the addition of large woody material to the stream and floodplain. There should be enough riparian vegetation to allow the stream to migrate without losing its vegetation to erosion. Such changes occur within the overall meander belt. Also, riparian vegetation should be managed to provide a long-term source of large wood and shade.

Figure 18.–Large wood being placed in the stream channel and floodplain of Beaver Creek in Curry County, OR. (Photo: Derek Godwin)

FLOODPLAIN FUNCTIONS AND MANAGEMENT

In spite of our efforts to control floods, flood damage in the United States has increased steadily and now averages more than $2 billion per year (1992 Federal Interagency Floodplain Management Task Force). Many of these costs are repetitive (e.g., replacement of structures on multiple occasions). Understanding the function of floodplains and rivers and managing floodplains better can help reduce these costs.

What is a floodplain?

There are several definitions of a floodplain, such as:

> "A floodplain is a level area near a river channel, constructed by the river in the present climate and overflowed during moderate flow events. Note the phrase 'in the present climate,' because a floodplain can be abandoned and at least partly destroyed when the climate becomes drier. An abandoned floodplain is called a terrace." (Leopold, 1994, p. 8)

> ". . .all the alluvial surfaces that can still be reached by the occasional great flood" (Schmudde, 1963, in Rechendorf, 1996). This definition implies that there might be more than one floodplain level adjacent to the river.

Perhaps the most basic and insightful definition was given by the Army Corps of Engineers (1964):

> "(A floodplain is) the relatively flat land bordering a river; *it is actually a part of the river channel* and as such, carries water during times of flood." (italics added)

All definitions agree that the floodplain and river are part of the same system.

Functions of a floodplain

The floodplain serves as a "safety valve" for a river. During a flood, a river spreads out of its banks and over the floodplain (Figure 19). The water that covers the floodplain moves more slowly, and sediment carried by the floodwaters is deposited on the floodplain.

These events often develop fertile land along rivers. Vegetation on floodplains filters sediment and other materials from water before it reaches the river channel, thus helping to maintain water quality.

The floodplain acts as a sponge to absorb floodwaters and slowly release the water as the flood recedes. A floodplain can act as a natural reservoir, thus reducing the height of the flood downstream.

Figure 19.–A creek flowing outside of its banks and onto the floodplain. (Photo: USFS)

Chapter II-2, "Watershed Hydrology," defined flood frequencies and how return intervals (e.g., a 100-year flood event) are based on the history of measured events. Remember that it is entirely possible to have more than one "100-year flood" in a century. For example, floods that occurred in the Willamette Valley in 1861, 1890, and 1964 were classified as greater than or equal to the theoretical 100-year flood level in Salem (Coulton, 1997).

The height of the 100-year flood is not an exact number, and several sources of error can influence the accuracy of the calculation. Chapter II-2 discusses the sources of error in estimating flood size and return intervals.

LAND MANAGEMENT EFFECTS ON FLOOD EVENTS

Floods are natural *processes* and only become *disasters* when people and property are affected. If we build houses and businesses in flood-prone areas, we put ourselves at risk. Over the years, we have changed rivers in a variety of ways to provide flood control, drain land for development or agriculture, or prevent bank erosion. These projects sometimes have unintended consequences. We have implemented many policies and practices that have changed how rivers handle flooding, for better or worse. Some of these practices are discussed below.

Dams

Dams and reservoirs can hold back floodwaters and reduce the height of peak flows. For instance, during the February 1996 flood, the Corps of Engineers estimates that the height of the flood was reduced by 9 feet in Eugene and 7.5 feet in Salem because of the dams in the Willamette River basin (Branch, 1997).

Dams can give people a false sense of security. For instance, within the Willamette River basin, dams and reservoirs control only 27 percent of the area. Flood control effectiveness diminishes downstream from the reservoirs as undammed tributary streams add to the river's flow (Coulton, 1997).

Levees, dikes, and roads

Levees and dikes are built to prevent land adjacent to rivers from flooding. Although flooding might decrease in the area adjacent to the levees, it might increase downstream. Because levees and dikes block the river's access to its floodplain, the water that would have spread across the floodplain is funneled downstream, possibly increasing peak flows downstream. The water velocity also is greater because of the funnel effect, worsening bank erosion downstream. When the upper Mississippi River flooded in 1993, the flood crests at St. Louis were as much as 9 feet higher than those for an earlier flood of the same size because of upstream levees (Williams, 1994).

When a levee does fail, the effects can be sudden and catastrophic (Williams, 1994). During the 1996 floods, farmers in the Willamette Valley found that scour due to levee breaks caused more damage to their fields than did floodwaters (American Institute of Hydrology, Pacific Northwest Water Issues Conference, October 1997).

Roads often are built on levees in floodplains, producing the same consequences.

Undersized bridges and culverts

Bridges and culverts that are too small to carry a stream's flow during flood events can back up water and cause flooding upstream. Flooding problems in Salem during the February 1996 flood were compounded by undersized bridges (Reckendorf, 1997). Undersized bridges also can cause sediment deposition upstream because they slow the water, causing sediment to drop out. Undersized bridges and culverts also are prone to plugging up with debris, which can increase upstream flooding problems.

Channelization

Channelization was a common practice in low-gradient streams and floodplains between the 1930s and 1960s. Meandering stream channels were straightened to make the stream more efficient at moving water, to reduce the amount of land used by the stream, and to drain the land next to the stream. More land then was perceived to be available for agriculture, housing, roads, and other development.

Straightening stream channels might make a stream more efficient at moving water through that part of the stream but can cause increased flooding downstream. Low-gradient streams naturally follow a sinuous, meandering course. When meanders are eliminated, the stream length is shortened. As a result, the gradient becomes steeper, leading to higher water velocities and higher instantaneous flows.

Many stream restoration projects around the United States are rebuilding meandering stream channels where straightening has degraded water quality and fish habitat.

Developing land for towns, cities, and suburbs makes more of a watershed's surface area impermeable. Rainfall no longer is captured and stored in the soil, and water runs off the land and into streams more quickly.

Urbanization

Developing land for towns, cities, and suburbs makes more of a watershed's surface area impermeable. Rainfall no longer is captured and stored in the soil, and water runs off the land and into streams more quickly. As a result, high flows become higher, arrive sooner after a storm starts, last for shorter periods of time, and occur more frequently. Stream channels have to become larger to carry the increased instantaneous runoff. This adjustment often is made through bank erosion (which widens the stream channel) and/or stream downcutting (which deepens the stream channel). Streams also carry less water during nonrainfall periods, providing less fish habitat.

Many streams in urban areas have been filled to increase the land area for buildings. This practice magnifies the problems as the water is routed to another nearby stream. Chapter II-2, "Watershed Hydrology," discussed some of the impacts of impervious surfaces on stream flows.

Streams in urban settings often are straightened (channelized), cleared of riparian vegetation, or contained by levees. Their banks often are reinforced by rock, concrete, or other materials. These channels are more efficient at transporting water quickly, but often at the price of greater flooding and erosion downstream.

Floodplain encroachment

Filling in floodplains with soil to build houses, businesses, and roads reduces their ability to disperse energy by spreading out water, to filter and absorb water, and to lessen the impact of floods. Also, buildings placed in floodplains are at higher risk of flood damage. For example, housing and business developments established on floodplains in Tualatin and Salem were flooded in 1996 (Reckendorf, 1997).

CONSIDERATIONS FOR STREAM RESTORATION

Improving stream functions and processes for aquatic life is an important part of the Pacific Northwest salmon recovery effort. Streams are complex systems influenced by many variables. Thus, it is absolutely necessary to have a good understanding of any stream under consideration for an improvement project.

Since people have different values and goals for streams, it is important that everyone involved with a project define commonly used terms to ensure a common vision. In this chapter, the terms *rehabilitation*, *restoration*, and *enhancement* are used interchangeably to imply the restoration of stream functions and processes to support stated goals. Some common stream restoration goals include improving salmon and trout habitat and establishing a stable stream that carries its sediment load without aggrading or degrading.

The term *condition* refers to how well functions and processes have been restored to meet these goals. Stream *functions* include carrying and storing water, sediment, large wood, organic matter, and other particles in the stream, riparian area, and floodplain. Functions also include providing habitat, food, and water for people, fish, and wildlife. Stream *processes* describe how the stream carries and stores these materials and how it affects habitat, food, and water quality.

The following are generally accepted steps for planning and conducting a restoration project.

1. Define goals and functions to restore. For example, “improve habitat for salmon and trout.”
2. Assess the stream’s present conditions. Stream classification systems can be used to describe present functions and processes. For example, “The stream is providing minimal deep pools for fish habitat due to a high width-to-depth ratio, excessive erosion, and a steep gradient.” These systems also might help determine potential conditions.

3. Identify the factors limiting the stream's ability to reach stated goals. For example, the management of a nearby road might be limiting the amount and types of riparian vegetation, the extent of erosion and channel migration, and the use of the floodplain. This step requires a clear, detailed description of the factors affecting the stream (e.g., bank erosion, downcutting, wide and shallow channel, riparian conditions, upslope problems). If possible, compare the degraded stream to a "stable" stream in the same area with similar features (gradient, valley width, channel size, etc.). At a minimum, identify the drainage area, stream flow characteristics (timing, response to rainfall events, etc.), bankfull discharge, and sediment type and transport characteristics.
4. Determine what stream characteristics and processes need to be altered to reach the restoration goals. Consider short- and long-term changes. A stream's condition is directly related to changes upstream and downstream and to land-use changes throughout the watershed. Most stream improvement projects involve changing the factors causing the present stream conditions and letting the stream adjust over time. Assessing historic and current land-use practices will help you understand how the stream developed its current condition (e.g., landslides, urbanization, change in riparian vegetation). Knowing the history of the watershed also might help you identify changes needed to support a more "stable" stream condition.

In some cases, intervening to improve stream characteristics quickly is necessary. Consider all options with respect to their capacity to improve conditions relative to cost and potential impacts to the area. Before deciding to modify a stream, you must thoroughly understand the stream's conditions and characteristics. All of the variables must fit together, such as amount of water, amount of sediment, size of the channel, size of meanders, etc.

Stream characteristics also must be related to the watershed and valley features. For example, modifying a low-gradient, meandering stream with a wide floodplain into a narrow, confined, steep-gradient stream is not feasible. It also is not wise to modify a stream's characteristics without taking into account urbanization or changing flood flows in the watershed. A restored stream's designed characteristics must account for urbanization and corresponding runoff. It might not be possible to recreate a stream's historic characteristics if conditions within the watershed have changed.

Because of the complexity of stream processes and potential impact of restoration projects on aquatic life and water quality, it is recommended that a team of specialists design and evaluate possible projects (hydrologists, stream ecologists, fish biologists, riparian specialists, engineers, geologists, etc.).

Before deciding to modify a stream, you must thoroughly understand the stream's conditions and characteristics.

In the area of stream restoration, there are many examples of inappropriate “fixes” that have done more harm than good and created unintended consequences. For example, streams were straightened to provide flood control, and check dams were installed in meandering streams with erodable banks. In order to “first, do no harm,” stream improvements should be approached with a respect for the complexity of the stream system. Each site and situation is different. There is no “cookbook” and no one-size-fits-all remedy. Each project must be compatible with the stream type, the valley setting, and the stream’s natural tendencies.

By definition, all stream restoration projects must improve riparian and floodplain conditions. The river, the riparian zone, and the floodplain are all part of the same system, and the river’s characteristics are determined by characteristics and conditions throughout the watershed.

In addition, stream improvement projects must consider upstream and downstream causes of present stream conditions. For example, high rates of erosion and sediment might be transported downstream to the project site, or a headcut (downcutting or erosion of the streambed) might be progressing upstream.

Summary/Self review

Streams change over time while maintaining their basic characteristics. The location of a stream might change as the bank erodes on the outside of meander bends and gravel bars are deposited on the inside of bends. If the gradient becomes too flat, a meander cutoff might occur, leaving the meander bend behind as a side channel or oxbow lake. These adjustments are part of a “stable” stream system. Stable streams maintain their average width, depth, gradient, meander geometry, and size and amount of sediment moving through the system, as well as the timing and duration of flows.

Streams are complex systems formed and influenced by many variables. What happens upstream can affect downstream areas and vice versa. Many changes to the land and streams in a watershed (both natural and human caused) cause streams to become “unstable” for periods of time. Examples of such changes include vegetation removal, landslides, urbanization, and roads. The stream conditions during these unstable periods might negatively affect fish habitat and water quality.

Understanding a stream’s characteristics and how they change with changing watershed conditions is crucial to successful improvement projects. Several stream classification systems can assist in assessing and monitoring streams.

Improvement projects involve fixing the cause of problems–whether upstream, downstream, or in adjacent riparian areas–and allowing the stream to adjust over time. The improvements also might include direct in-stream manipulation of stream characteristics (width, depth, gradient, sinuosity, etc.).

Many lessons can be learned from past restoration projects. Improvements should support a stream’s “stable” characteristics, while allowing it to adjust over time within its channel migration zone. Projects also should protect or improve the stream, floodplain, and riparian zone functions and processes based on stated goals for the stream.

Floodplain protection and restoration are crucial to stream restoration projects.

Exercises

You can do these exercises on your own.

Exercises that can help you better understand stream types, processes, and classification systems include:

1. Identify and outline a watershed on a topographic map. Outline the three basic stream types described by Montgomery and Buffington (source, transport, and depositional). Visit several field sites to check your classifications.
2. Conduct the previous exercise following the OWEB stream classification guidelines in the *Oregon Watershed Assessment Manual* (1999).
3. Work with a hydrologist, fluvial geomorphologist, engineer, and/or fish biologist to visit a variety of stream bank erosion and stabilization projects. Investigate the causes of the erosion. Remember that erosion often is an indicator of upstream or downstream processes contributing to bank instability.
4. Work with a hydrologist to evaluate some culverts and bridges to see whether they could accommodate a 50- or 100-year flow event.
5. Visit a stream restoration or enhancement project and evaluate its positive or negative impacts on stream processes related to width, depth, sinuosity, erosion, deposition, and channel migration.
6. Take a course on how to use one of the stream classification systems mentioned in this chapter.

RESOURCES

Training

Regular public training specifically on watershed processes is not widely available outside of formal university classes, although some basics might 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 if you're interested in self-instruction.

Books

Applied River Morphology, by D.L. Rosgen (Wildland Hydrology, 1481 Stevens Lake Road, Pagosa Springs, CO, 1996).

"Channel processes, classification, and response," by D.R. Montgomery and J.M. Buffington. In *River Ecology and Management*, R. Naiman and R. Bilby, eds. (1998).

Stream Hydrology, An Introduction for Ecologists, by N.D. Gordon, T.A. McMahon, and B. Finlayson (John Wiley & Sons, New York, NY, 1992). 526 pp.

A View of the River, by L. Leopold (Harvard University Press, Cambridge, MA, 1994). 298 pp.

Water, Rivers and Creeks, by L. Leopold (University Science Books, 1997). 185 pp. Available from 55D Gate Five Road, Sausalito, CA 94965. Fax: 415-332-5393

Waters of Oregon: A Source Book on Oregon's Water and Water Management, by R. Bastasch (Oregon State University Press, Corvallis, OR, 1998). 278 pp.

Government reports

Channel Classification, Prediction of Channel Response, and Assessment of Channel Condition, Report TFW-SH10-93-002, by D.R. Montgomery and J.M. Buffington (prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement, 1993). 84 pp.

Floodplain Information, Lane County, Oregon, 5 volumes, Summary Report (U.S. Army Corps of Engineers, November, 1964). 17 pp.

Manuals

Oregon Watershed Assessment Manual (Watershed Professionals Network for the Governor's Watershed Enhancement Board, Salem, OR, 1999). Copies can be ordered from the Oregon Watershed Enhancement Board in Salem, OR. Phone 503-986-0178.

A Rehabilitation Manual for Australian Streams, by I.D. Rutherford, K. Jerie, and N. Marsh (Cooperative Research Center for Catchment Hydrology, Department of Civil Engineering, Monash University, Clayton, VIC 3168, 1999). Phone: (03)9905 2704.

Stream Corridor Restoration: Principles, Processes, and Practices (The Federal Interagency Stream Restoration Working Group, 1998). Available on the Web at www.usda.gov/stream_restoration. Can be downloaded from the Web or ordered in hard-copy format with color photos and diagrams. Also available on a CD. Hard copies can be ordered from the National Technical Information Service at 1-800-533-NTIS or from their Web site at www.ntis.gov.

Articles

"Application of fluvial relationships to planning and design of channel modifications," by N.R. Nunnally, *Environmental Management* 9(5):417–426 (1985).

"Calculating the odds: The probability of a 100-year flood event," by A. Laenen. In *The Pacific Northwest Floods of February 6–11, 1996*, A. Laenen, ed. Proceedings of the Pacific Northwest Water Issues Conference, Portland, OR, October 7–8, 1996 (American Institute of Hydrology, 1997). 318 pp.

"Causes of river bed degradation," by V.J. Galay, *Water Resources Research* 19(5):1057–1090 (1983).

"Channel-reach morphology in mountain drainage basins," by D.R. Montgomery and J.M. Buffington, *Geological Society of America Bulletin* 109(5):596–611 (1997).

"A classification of natural rivers," by D. Rosgen, *Catena* 22:169–199.

"Effects of coarse woody debris on morphology and sediment storage of a mountain stream system in western Oregon," by F. Nakamura and F. Swanson, *Earth Surface Processes and Landforms* 18:43–61 (1993).

"Flood control vs. flood management," by P.B. Williams, *Civil Engineering* (1994):51–54.

"A hierarchical framework for stream habitat classification: viewing streams in a watershed context," by C.A. Frissell, W.J. Liss, C.E. Warren, and M.D. Hurley, *Environmental Management* 10(2):199–214 (1986).

"An integrated land–aquatic classification system," by F.B. Lotspeich and W.S. Platts, *North American Journal of Fisheries Management* 2:138–149 (1982).

"Lateral channel migration and bank erosion along the Marys River, Benton County, Oregon," by B. Ellis-Sugai. *Wildland Hydrology* June/July 1999:105–111 (American Water Resources Association).

"Much of the flood damage was predictable: Flooding in Salem," by F. Reckendorf. In *The Pacific Northwest Floods of February 6–11, 1996*, A. Laenen, ed. Proceedings of the Pacific Northwest Water Issues Conference, Portland, OR, October 7–8, 1996 (American Institute of Hydrology, 1997). 318 pp.

"The Pacific Northwest Floods: Lessons learned?" by K.G. Coulton. In *The Pacific Northwest Floods of February 6–11, 1996*, A. Laenen, ed. Proceedings of the Pacific Northwest Water Issues Conference, Portland, OR, October 7–8, 1996 (American Institute of Hydrology, 1997). 318 pp.

"Stream channel morphology and woody debris in logged and unlogged basins of western Washington," by S.C. Ralph, G.C. Poole, L.L. Conquest, and R.J. Naiman, *Canadian Journal Fisheries and Aquatic Science* 51:37–51 (1994).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in improving your understanding of stream processes.

1.____

2.____

3.____

4

Watershed Soils, Erosion, and Conservation

Hudson Minshew,
Paul W. Adams,
J. Herbert Huddleston,
and Derek C. Godwin

Soil conditions, and the connections among soils throughout a watershed, play important roles in controlling how water moves into, over, and through the watershed. Water movement, in turn, affects both surface water and groundwater quality.

By understanding the relationships among soil properties, soil positions in the landscape, and watershed hydrology, you can make better decisions about watershed plans and activities. Because soils affect so many practical things–riparian plantings, stream bank protection, agricultural productivity, forest management, homesite development, fence building, road construction, erosion, and sedimentation–a general knowledge of soils is essential for implementation of a successful watershed enhancement program.

In this chapter you'll learn:

- What soils are and why they are important in watershed ecosystems
- Key soil properties that can influence watershed functions and management
- Key interpretations of soil behavior for watershed management
- Essential functions of soils in relation to watershed hydrology
- Erosion processes and erosion control techniques in forested, agricultural, and urban areas
- Watershed enhancement with respect to road drainage, stream crossings, new road construction, and unstable terrain

WHAT IS SOIL?

Of the many ways we can think about soils, perhaps the most important is that ***soils are essential natural resources.*** Soils, along with air, water, and sunlight, are necessary for both plant and animal life. All of these resources function together as a unit–an ecosystem or a watershed.

Unlike their resource partners, however, soils are under foot and out of sight. It's easy to forget the critical roles they play in watershed ecosystems. Soil is much more than "dirt"! Perhaps Russell Lord's (1962) definition best captures the essential nature of soil resources: "Soil, ever flowing in streams to the sea, is like a *placenta* that allows living things to feed upon the earth."

On a more practical level, soils can be defined as complex mixtures of weathered mineral grains (sand, silt, and clay), decomposed organic material (humus), living soil organisms (roots, bacteria, fungi, and insects), and varying amounts of air and water. This definition identifies essential soil components, but it doesn't explain how they interact to create a dynamic system that performs several vital watershed functions (Figure 1).

Figure 1.—Soil is made up of mineral components, decomposed organic material, living soil organisms, air, and water. (Source: Natural Resources Conservation Service)

See Section II, Chapters 1, 2, and 5, and Section III, Chapters 1, 3, and 4 for information related to this chapter.

Section II

1 Planning

2 Hydrology

5 Assessment

Section III

1 Riparian Functions

3 Livestock

4 Steam Ecology

SOIL FORMATION AND VARIABILITY

Soils form through the actions of *climate* (rainfall and temperature) and *organisms* (vegetation, animals, and insects) operating through *time* on a *parent material* (e.g., basalt, gravelly deposits, or volcanic ash) located in a specific *landscape position* (e.g., hilltop, valley sideslope, stream terrace, or floodplain). We call the italicized terms the five factors of soil formation; each unique combination of these factors results in a unique kind of soil.

Because there are many, many subdivisions of each factor, it's easy to see how there can be hundreds of thousands of kinds of soils worldwide. Even within a single watershed, there can be many kinds of soils, each with different implications for watershed use and management.

Here's an important take-home lesson: **Just because a management practice works well in one part of a watershed does not necessarily mean it will work equally well in another part of the same watershed.** Soil and other resources must be evaluated within each part of the watershed where management practices are planned.

Variability is a normal, natural feature of soils. You must accept variability and learn to live with it. **Resist the temptation** to throw up your hands and say the soil is so variable you might as well ignore the differences and assume it is the same throughout the watershed!

The best way to deal with variability is to define management units that minimize it. Trained observers identify parts of the landscape where the five factors of soil formation are reasonably uniform (Figure 2). Gently sloping ridgetops, steep hillslopes, undulating slump benches, and concave footslopes are examples. Within these landforms, soils, though not exactly the same everywhere, are reasonably homogeneous. Thus, they can be managed with the expectation that their behavior and response to treatment will be fairly uniform.

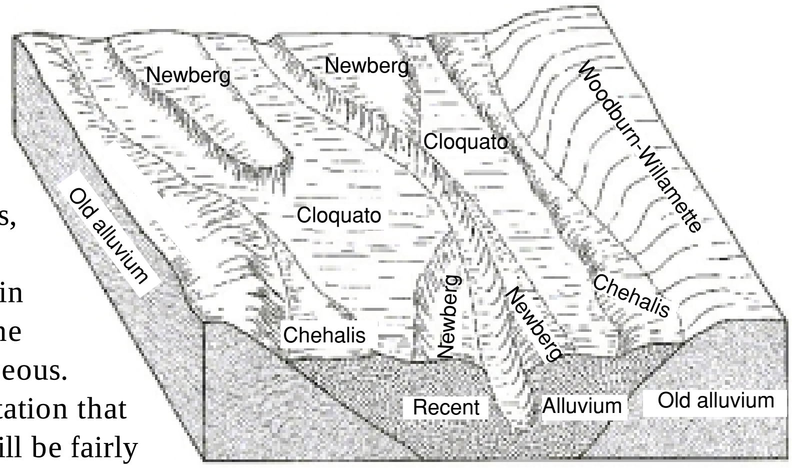

Figure 2.–Spatial relationships among soils, parent materials, and landscape position for a riparian portion of a watershed in western Oregon.

THE SOIL SURVEY

Dividing the landscape into units based on soil-landform elements enables us to make a *soil survey* (for example, of a watershed or county). Each part of the landscape with reasonably homogeneous soils is called a *body of soil* (analogous to a single plant or animal). Its representation on a soil map is called a *delineation*. A *map unit* is the collection of all delineations of the same kind of soil in a watershed or survey area. Each map unit is defined in terms of its dominant kind or kinds of soil. These relationships are illustrated in Figure 3.

Even within a map unit, there is some natural variability. Variations from the dominant soil are called *inclusions*. These are small areas of very different soils that might behave quite differently than the dominant soil. Due to their small size, they cannot be shown separately on a map. Inclusions are discussed in map unit descriptions, thus indicating what kinds of variability might be expected. Inclusions might be particularly important for site-specific uses such as homesites or on-site waste disposal facilities.

Soil surveys have three parts:

- *Maps* show the location of each piece of the soil–landscape mosaic.
- *Text* describes the different kinds of soils and highlights some of their key properties and behaviors.
- *Tables* provide a wealth of interpretations for a wide variety of urban, agricultural, and forestry uses.

To be most useful, all three parts must be used together. Specific examples of each are used throughout this chapter.

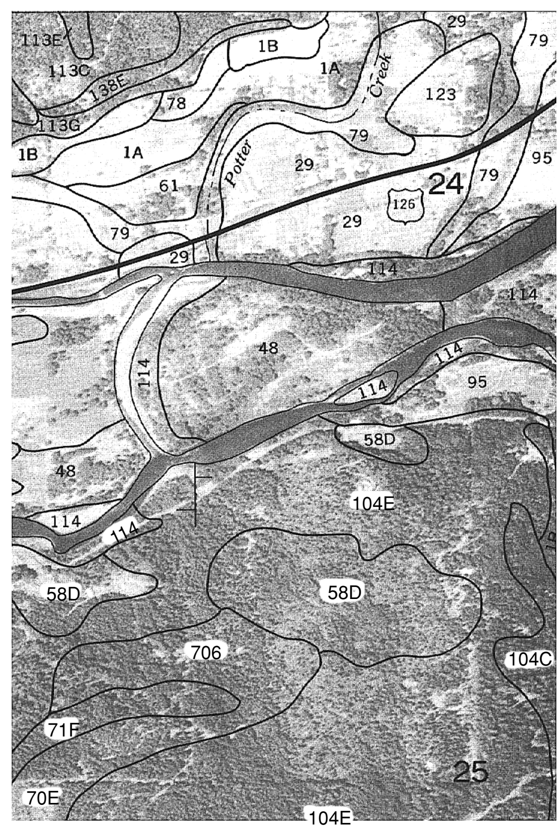

Figure 3.–Sample soil survey of representative watershed landscapes. Map units 58D and 104E are steeply sloping forest soils. Map units 48 and 114 are frequently flooded riparian soils along the McKenzie River. Map units 1A, 1B, 29, 61, 78, and 79 are productive agricultural soils on low river terraces.

KEY SOIL PROPERTIES AFFECTING WATERSHED MANAGEMENT

Soil resources are characterized by many chemical, physical, and biological properties. These properties can be observed in the field or measured in a lab. Here we'll discuss a few that are most directly related to watershed management.

Texture and structure

Soil *texture* refers to the amounts of sand, silt, and clay in a soil sample. A *loam* is a mixture of sand, silt, and clay. A typical loam might contain 40 percent sand, 40 percent silt, and 20 percent clay. An equal mixture of sand, silt, and clay is a *clay loam* because of the strong influence clay has on soil properties. Soils containing more than 50 percent sand are *sandy loams*, or, when the soil consists almost entirely of sand, *loamy sands* or *sands*. Soils with very little sand, a lot of silt, and small amounts of clay are *silt loams*. A similar soil with a little more clay is a *silty clay loam*. Soils with more than 40 percent clay are either *silty clays* or *clays*.

Soil texture is important because it is closely related to many aspects of soil behavior that are important for watershed management. Water moves into and through sandy soils faster than through loamy and clayey soils. Loamy soils, however, can store and release more water for plants than either sandy or clayey soils.

Sandy soils provide better foundations for roads and houses than loamy or clayey soils. Wet, clayey soils can be quite sticky and moldable and are very difficult to excavate or garden in. On the other hand, they might release water to streams over long periods of time, including during the dry season. Some clays expand a lot when wet and contract when dry, creating very unstable conditions for any kind of structure.

Soil *structure* refers to the aggregation of individual grains of sand, silt, and clay into larger units called *peds*. Peds form with the help of binding agents such as plant roots, sugary substances secreted by plants and animals in the soil, and the stickiness of clay particles. Peds are separated from each other by cracks or spaces, which create areas of weakness in the soil, allowing plant roots to penetrate and gardeners to dig in the soil.

The structural framework created by peds and the zones of weakness between them is important because it complements the effects of soil texture, especially in controlling the movement and storage of air and water in soils. Water moves rapidly through the relatively large spaces between peds. These spaces also provide oxygen to plant roots. Conversely, the much smaller spaces between grains within peds retain water much longer and make it available to plants as needed. Soils with a well-developed, stable structure provide a favorable combination of aeration and water storage.

Organic matter

Soil *organic matter*, or humus, is composed of decomposing plant and animal tissues, the microorganisms that feed on and decompose these tissues, and the secretions produced by the microorganisms. Organic matter, especially in surface soils, is extremely important because it provides food for soil bacteria, fungi, and other decomposers. These organisms, in turn, are responsible for the release and recycling of essential plant nutrients, particularly nitrogen, phosphorus, and sulfur. Sticky organic substances also play a large role in the formation and stabilization of soil structure, which, as we have seen, promotes water retention, aeration, and workability of the soil.

Healthy soils have plenty of organic matter. Impoverished soils often have lost some or all of the organic-rich topsoil and cannot support diverse microbial populations. Thus, a fundamental principle of watershed management is to **do everything possible to maintain or increase the organic matter content of the surface soil.**

When excavating, especially in urban watersheds, try to set the rich topsoil aside and return it to the surface when finished. Adding several inches of compost in areas to be used for lawns or landscaping is helpful. You can increase the organic matter content of lawn and garden soils by incorporating compost, manure, bark chips, leaves, or grass clippings. In gardens, growing winter cover crops will increase soil organic matter.

In agricultural fields, return as much crop residue as possible to the soil. Additions of manure and municipal biosolids also help. In forested watersheds, minimize disturbance of the natural forest floor, and try not to scrape away any of the organic-rich topsoil.

Porosity, density, and compaction

Porosity is simply the total amount of pore space, or void space, in the soil. As important as total pore space, however, is the mix of pore sizes. Large pores are needed for water and air movement, while small pores store water for plant use. Similarly, large pores might deliver water relatively quickly to streams, while small pores drain slowly and can be important for dry-season flows.

Soil *density* is the dry weight of soil per unit volume of soil, including all of the pore space. Soil *compaction* is the compression of soil particles into a smaller volume, which increases density.

Do everything possible to maintain or increase the organic matter content of the surface soil.

Density and porosity are clearly related, as an increase in one causes a decrease in the other. A typical cultivated agricultural soil might have a total porosity of 50 percent and a density of 1.3 grams per cubic centimeter (gm/cc). Near the surface, many undisturbed forest soils have porosities as high as 70 percent and densities of about 0.7 gm/cc. Dense or highly compacted soils, on the other hand, might have porosities as low as 30 or 35 percent and densities of 1.8 gm/cc. Intentional compaction of soils for earth dams and runway subgrades can yield densities of almost 2.0 gm/cc.

Undisturbed soil often is soft, highly porous, and allows water to penetrate easily. Traffic by animals, people, or farm or logging vehicles easily compacts it. Compaction degrades soil structure, reduces the volume of pores (especially the large, water-conducting pores), increases density, and impedes root growth. If these changes occur over large areas, surface runoff and erosion might increase and stream flow patterns might be less favorable (e.g., larger peak flows and smaller low flows). Areas of potential concern include slopes with many heavily compacted logging skid trails, heavily grazed pastures, livestock feedlots, urban construction sites, and intensively cropped fields. 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 clayey soils have naturally slow drainage, so take care to distinguish this natural condition from slow drainage caused by human activities.

Poorly growing vegetation is another indicator of compaction and low porosity. Compacted soil is difficult for plant roots to penetrate, and the tiny pores often cannot provide roots with enough oxygen. Under these conditions, most plants don't grow well.

One way to measure porosity and compaction is with a *ring infiltrometer*. After partially inserting an open ring into the surface soil, an observer adds a measured amount of water and notes how long it takes the water to enter the soil. This technique is especially useful for demonstrating the difference between undisturbed soil and heavily compacted soil.

Other evaluation methods use *soil cores* and *penetrometers*. Soil cores allow you to remove a sample of known volume, from which you can calculate the bulk density. 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. Specialized devices provide quantitative measurements. For example, some probes give values in pounds per square inch.

When assessing changes in soil porosity and compaction, it can be challenging to identify relatively undisturbed soils as a baseline for comparison. This is especially true in agricultural and urban areas, but even forested areas might have old, compacted trails that are difficult to see.

It's also a challenge to take enough samples to assess soil conditions accurately, especially if you want to determine whether soil changes are affecting watershed hydrology. To make such an assessment, you first need an accurate estimate of natural soil variability, i.e., the location of soil variations throughout the watershed. With this base knowledge, you can monitor changes in the soil over time.

Many watershed management objectives require a good understanding of the interactions between water and soil.

Depth to bedrock

The soil survey report presents depth-to-bedrock information for the dominant soil in each map unit. Depth to bedrock is directly related to the volume of soil available for plant roots, the amount of water that can be stored for plants and dry-season stream flow, the potential for water to move laterally through the soil above bedrock, and the potential for excavation and use of the bedrock as construction materials (e.g., gravel for roads). The shallow soils found in mountainous terrain often contribute to "flashy" streams that rise quickly after rain or snowmelt.

KEY SOIL INTERPRETATIONS FOR WATERSHED MANAGEMENT

Many watershed management objectives require a good understanding of the interactions between water and soil, i.e., the way water runs into, through, and over the soil. Although it's possible to carefully measure the rates of these processes, it usually isn't practical to do so. It is possible, however, to make good estimates based on knowledge of the soil's texture, structure, organic matter, density, and horizons (soil layers).

These estimates are called *soil survey interpretations*, and they can be found in published soil surveys. Specifically, the soil survey tables on Physical and Chemical Properties and on Soil and Water Features contain a lot of information that is directly relevant to the understanding and management of watershed soils. Table 1 (page 8) shows the kinds of information found in those tables, and the following sections of this chapter describe the interpretations.

Table 1.–Sample soil survey information on hydrological features of watershed soils.

Soil	Permeability Surface (in/hr)	Permeability Subsoil (in/hr)	Depth to bedrock (in)	Water table (ft)	Hydrologic group	K factor
Dominantly agricultural soils						
Clawson	2–6	2–6	>60	2.0	C	0.28
Holland	0.6–2.0	0.2–0.6	40–60	>6	B	0.37
Dominantly forested soils						
Jayar	0.6–2.0	0.6–2.0	20–40	>6	C	0.17
Pearsoll	0.2–0.6	0.06–0.2	10–20	>6	D	0.20

Infiltration and permeability

Infiltration refers to the rate of water entry into the soil. *Permeability* refers to the rate of water drainage through the network of soil pores. Infiltration and permeability are not the same, as infiltration refers only to the process by which rainwater, snowmelt, or irrigation water at the ground surface enters the soil. Once in the soil, water moves in response to the processes that control permeability.

Infiltration is a very complex process that is affected by many factors (Table 2). One is time. You might observe that water readily enters dry soil, but as the soil gets wetter, the rate of entry slows down. In other cases, water might run off a very dry soil until the soil becomes moistened.

Many other factors affect infiltration, including the kind and amount of vegetative cover, the amount of soil organic matter, and the strength and stability of soil structure. Compaction, which reduces porosity, can slow infiltration substantially. Hot forest or range fires can create vapors of organic compounds that condense in the soil, making it water-resistant and decreasing infiltration.

Because infiltration is such a complex and dynamic process, it's difficult to define a characteristic infiltration rate for a given soil, and you won't find infiltration data in a soil survey report. Sometimes we use the permeability of the surface soil as an indicator of potential infiltration, but this is not a true infiltration rate.

More often, we evaluate infiltration in relative terms, based on key properties of the surface soil. Then we compare relative infiltration potentials among several soils in a watershed. For example, the litter layer and surface soil in an undisturbed Coast Range forest soil is so porous that virtually all rainfall infiltrates, even on steep slopes after prolonged storm events. Once in the soil, the water might build up pressure and cause a landslide, or it might move through the soil to lower positions in the landscape.

Permeability rates range from very slow (<0.06 in/hr) in tight, clayey soils to very rapid (>2.0 in/hr) in coarse, gravelly soils. Medium-textured soils (loams and silt loams) usually have moderately slow (0.2–0.6 in/hr) to moderate (0.6–2.0 in/hr) permeability. For a given texture, a high organic matter content and high porosity increase permeability. If soil with the same texture has very little organic matter or is more dense, permeability can be much slower.

Table 2.–Factors that influence infiltration rates.

Ground surface characteristics	Soil properties
Texture	Vegetation cover
Structure	Amount of duff and litter
Organic matter	Amount of impervious surface
Porosity	Surface roughness
Depth	Surface cracking
Layering	Surface crusting and sealing
Shrink-swell	
Physical conditions	**Water repellancy**
Antecedent water*	Natural plant chemicals
Frozen soil	Fire-induced hydrophobicity
Trapped air	Extreme dryness

**The amount of water in the soil at the onset of a rainfall or irrigation event.*

Permeability information is given in a soil survey for each of three or four major layers in the soil. If the texture changes little with depth, permeability is similar in all layers.

Many soils, however, have subsoils whose texture or density differs dramatically from that of the surface layer. Heavy, clay layers, layers of weathered bedrock, and naturally dense layers all have much slower permeability than the layers above them. These restrictions cause water to *perch* above them, and the water is diverted laterally to flow parallel to and above the restricting layer. We refer to this type of flow as *throughflow*.

Water moving laterally through the landscape might break out at the surface, forming seeps or springs elsewhere in the watershed, or it might discharge directly into a stream, wetland, or lake. In any case, throughflow is a major hydrological process in many landscapes.

Leaching

Leaching is the process by which water moving through the soil carries with it soluble materials picked up en route. In humid regions, leaching removes soluble salts, gypsum, and carbonates and eventually acidifies the soil. Leaching can carry nitrates and other soluble fertilizer materials below the root zone. Leaching also can transport soluble residues from some chemical pesticides.

Leaching can result in contamination of groundwater if unwanted materials move with water downward through the soil. Lateral leaching also occurs as water moves through the landscape roughly parallel to the land surface. Throughflow discharge into streams and lakes, as well as discharge of leaching water from drainage lines in the soil, can add contaminants to surface water bodies.

Runoff and hydrologic group

Runoff is simply overland flow that occurs when inputs from rainfall or irrigation exceed the infiltration capacity of the soil. The goal of watershed management is to conduct runoff water downslope in ways that minimize its potential to cause erosion on hillslopes and sedimentation in streams and lakes. Techniques for achieving this goal are discussed in the sections on erosion control and road construction and maintenance.

Hydrologic group is a soil survey interpretation that groups soils with similar runoff potential given similar storm and groundcover conditions. Soil properties that influence runoff potential include texture, structure, depth to a seasonally high water table, permeability after prolonged wetting, and depth to a very slowly permeable layer.

In soil surveys, there are four basic hydrologic groups–A, B, C, and D:

- Group A soils have low runoff potential. They have both high infiltration rates and high permeability rates and consist mainly of deep sands or gravels.
- Group B soils have moderately low runoff potential and moderate rates of infiltration and permeability. They consist mainly of silt loams, silty clay loams, loams, clay loams, and sandy loams that are more than 20 inches deep.
- Group C soils have moderately high runoff potential. Slow rates of infiltration and permeability are caused either by clayey textures or by a slowly permeable subsoil layer.
- Group D soils have high runoff potential because of very slow rates of infiltration and permeability. Because they drain so slowly, they remain wet for long periods and cannot absorb much additional water. High shrink-swell clays, soils with a permanent high water table, those with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material are in this group.

Erodibility

Erodibility reflects a soil's susceptibility to the erosive force of water running over bare soil. Texture, structure, and organic matter content are the primary properties that influence erodibility of exposed soils. Sandy soils with adequate amounts of organic matter and well-developed structure are the least erodible. Silty soils with low amounts of organic matter and very weak structure in the surface soil are most erodible.

Erodibility is characterized by the K factor in the Universal Soil Loss Equation (A = RKLSCP). K is simply a number that has been derived from numerous experiments in which simulated rainfall is applied to a wide variety of soils. Values of K range from 0.02 to 0.67, with higher numbers indicating higher erodibility. K values are provided in soil survey reports and are particularly useful for comparing the relative erodibility of two or more soils. (For example, see Table 1.)

Soil functions help us think about what soils do for us in the watershed.

Depth to water table

Water tables can be measured, but because of high seasonal and annual variability, only long-term records provide useful information. Because long-term data are scarce, water table information in soil surveys is based largely on an interpretation of color patterns in the soil.

Well-aerated soils have brown colors because iron oxides coat soil grains, much as rust coats a piece of iron. In saturated soils, some of the iron is removed in solution, leaving gray, uncoated soil grains. As the soil dries out and air reenters the larger pores, iron might again oxidize, creating a bright yellowish-brown spot.

These patterns of gray and yellowish-brown colors are interpreted by soil scientists as indicators of the long-term average position of the seasonally high water table. These estimated depths are the numbers reported in soil survey reports.

Presence of a high water table might affect buildings, septic systems, crops, pastures, plant species, riparian plantings, and use of mechanized equipment.

KEY FUNCTIONS OF WATERSHED SOILS

Soil functions help us think about what soils do for us in the watershed, or, more properly, their roles in making the watershed operate as an integrated unit. Thinking about soil functions, and their interaction with other watershed resources, helps us evaluate how specific management practices might affect not just soils but all other aspects of watershed behavior that are linked to soils.

Regulate watershed hydrology

This probably is the soil function most influenced by human activities. Simply put, **soils regulate the balance between infiltration and runoff**. Rainfall, snowmelt, or irrigation water that reaches the ground surface can do only one of two things: it either soaks in, or it runs off. If it soaks in, it continues to move within the soil–landscape system according to the principles of permeability. Lateral throughflow, downslope discharge, leaching to groundwater, and buildup of pore water pressures all become possibilities. If it runs off, its velocity and erosion potential are determined by the steepness of slope, the length of the slope, and the barriers to flow created by vegetation or topography.

The important lesson here is that **any land-use activity probably will change the balance between infiltration and runoff**. Many practices or activities shift the balance toward less infiltration and more runoff. For example:

- Soil compaction with heavy equipment (or countless pairs of feet on hiking trails) reduces porosity and infiltration, thus increasing density and runoff.
- Covering soil with asphalt and buildings causes a dramatic shift toward runoff.
- Removal of organic-rich topsoil reduces infiltration and exposes subsoil. This change not only increases runoff but also increases erosion potential, as the subsoil is likely to be more erodible (higher K value) than the original surface soil.
- Loss of soil organic matter through burning or cultivation destabilizes soil structure and decreases infiltration.

Sometimes, however, we intentionally shift the balance toward more infiltration, as when we add compost to garden soils or use deep tillage to break up compacted layers or natural hardpans.

Any watershed project must assess the relative advantages and disadvantages of infiltration versus runoff. There always are trade-offs. If erosion control is the objective, you might strive to increase infiltration. However, increased infiltration might increase the risk of groundwater contamination or landslides. If groundwater protection is the objective, you might wish to minimize infiltration and leaching. The tradeoff is higher potential for runoff, erosion, and lateral leaching to surface water bodies. The key is to find a balance and to use soil regulation of watershed hydrology to achieve your desired goals.

Regulate nutrient cycling

Soils are vast reservoirs of plant nutrients. The organic part of the soil in particular is a major source of nitrogen, phosphorus, and sulfur. Biological decomposition of organic matter makes these nutrients available to plants. Other major nutrients, such as calcium, magnesium, and potassium, also reside in large pools in the soil and are constantly cycling between vegetation and soil.

Regulate water quality

Soils improve water quality by filtering out contaminants (nonpoint source pollution) before they are carried to groundwater or streams. Soils are naturally leaky, however, so some pesticides and fertilizer nitrates might be leached all the way to groundwater. Surface water might be contaminated by sediment carried in runoff water or by phosphorus or pesticide residues attached to eroded soil particles.

Provide habitat for living organisms

Soil is home not only to plant roots and burrowing animals but also to billions of bacteria, fungi, algae, protozoa, mites, insects, nematodes, collembola, and earthworms. Soils provide all of these organisms with air, water, nutrients, and space to live. They in turn facilitate structure formation, infiltration, permeability, nutrient cycling, and water purification—the processes that allow the entire watershed ecosystem to function as a whole.

PROCESSES OF SOIL EROSION

We've seen how important soils are in regulating watershed hydrology and that many common watershed practices can tilt the balance toward runoff and erosion. Because erosion and sedimentation affect both soil and water quality, we'll now examine in more detail key erosion processes and some methods for dealing with them.

Erosion is an important watershed process. It is responsible for shaping landscapes of great scenic beauty; for the creation of rich alluvial soils; and for depositing large wood, spawning gravel, and fine sediment that help salmon determine when and where to spawn. Erosion is a natural, ongoing process, but erosion types and rates vary widely with climate, soils, terrain, and vegetation (Figure 4, page 14). Erosion often increases during periods of unusually high rainfall or rapid snowmelt.

Erosion is essentially a three-stage process: detachment, transport, and deposition.

Our concern with soil erosion is not so much with the natural process as with accelerated erosion due to human activities—

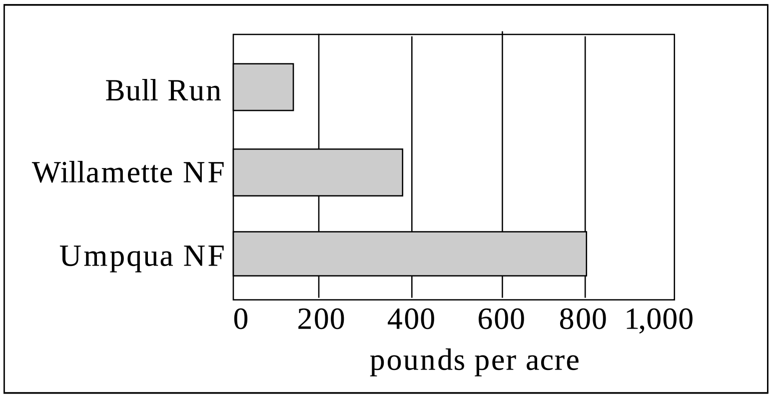

Figure 4.–Average annual erosion, undisturbed forests.

cultivation, logging, grazing, urban construction, and road building. These activities add a more or less constant pulse of erosion above what we would call “natural,” or background, erosion.

In the continental U.S., an estimated 1 billion tons of sediment is delivered to streams and lakes each year.

In Oregon, there are three major agents of erosion: wind, water, and gravity. Glacial ice also erodes soils and landscapes, but it operates as a natural geologic process and has little impact on Oregon watersheds.

Erosion is essentially a three-stage process: detachment, transport, and deposition. Detachment requires energy to physically separate a particle of soil from the ped or soil mass of which it is a part. Detachment forces are resisted by forces that create soil strength and hold the soil together. That’s why the first line of defense against accelerated erosion is to use vegetation, soil organic matter, and soil structure to minimize the potential for detachment.

Once a particle is detached, it is suspended in runoff water and carried downslope. Or, in the case of wind erosion, it is suspended in air and carried downwind.

In either case, deposition occurs when the velocity of flow decreases to the point that suspended particles settle out. For water erosion, deposition often occurs at the base of a slope, where the gradient decreases. Note that a significant portion of the eroded material is deposited before it reaches a stream or river. This deposition still can cause damage, however, for example by burying a neighbor’s crops. Furthermore, these sediments might enter the stream later if a major flood causes the stream to erode its banks and cut into the area of prior deposition.

Wind erosion occurs mainly in eastern Oregon, where strong, steady winds blow over dry, sparsely vegetated soils that are low in organic matter and have weak structure. The force of the wind detaches fine sand, silt, and clay particles and transports them, sometimes for great distances. In addition to loss of topsoil, wind erosion can cause other problems. The abrasive action of soil particles can cause serious crop damage, and reduced visibility can lead to traffic accidents.

Water erosion

Water erosion begins when rainfall exceeds infiltration, a thin layer of saturated soil forms at the surface, and overland flow begins.

Runoff itself sometimes has limited energy to detach soil particles, but the impact of raindrops on this thin film of saturated soil splashes soil particles in the air, detaching them from soil peds. Some of these particles simply slake off and settle in adjacent pores, leading to surface sealing, reduced infiltration, and increased runoff. Some are carried along by runoff water and act as abrasive tools to detach additional soil particles.

As runoff water begins to concentrate in microchannels, the cutting action creates a series of channels, or rills, a few centimeters deep. Rill erosion often is evident on recently cultivated, sloping soils following heavy rainfall. Continued flow and cutting might enlarge rills to the point that they cannot by crossed with field equipment. Such channels are called gullies. As gullies get larger and deeper, vast amounts of soil can be removed, and local water tables might be lowered.

Water erosion is particularly severe on cultivated soils in eastern Oregon where the soil freezes. Rain falling on thawing soil quickly forms a layer of saturated soil lying directly on frozen soil. This layer of saturated soil has very little strength, and runoff easily forms a network of deep rills that transport large amounts of soil off the field. This soil is deposited at the base of slopes and in road ditches at field edges.

In agricultural watersheds of western Oregon, soils in the midslope position often are more prone to erosion than those near hilltops. These midslope soils have slowly permeable layers at relatively shallow depths. Water that infiltrated higher on the slope flows laterally through these layers, causing midslope seeps to develop when water pressure builds up in the soil downslope. These seeps saturate the soil, weaken it, and provide a starting point for rill erosion.

Mass wasting

Gravity manifests itself in two ways: dry ravel and pore water pressure. With *dry ravel*, both individual grains and small soil aggregates simply tumble down a slope in response to gravity until they reach a more stable position. This process occurs mainly on steep mountain slopes and might be accelerated where vegetation has been removed by logging, road construction, or fire. Granitic soils on steep slopes are particularly prone to dry ravel.

Pore water pressure refers to the pressure exerted on the soil mass by the weight of water filling the soil pores. Pore water pressure is a major factor triggering landslides and other forms of mass movements, which are common in steep, unstable terrain in the Coast Range and Cascade Mountains. In these soils, infiltration

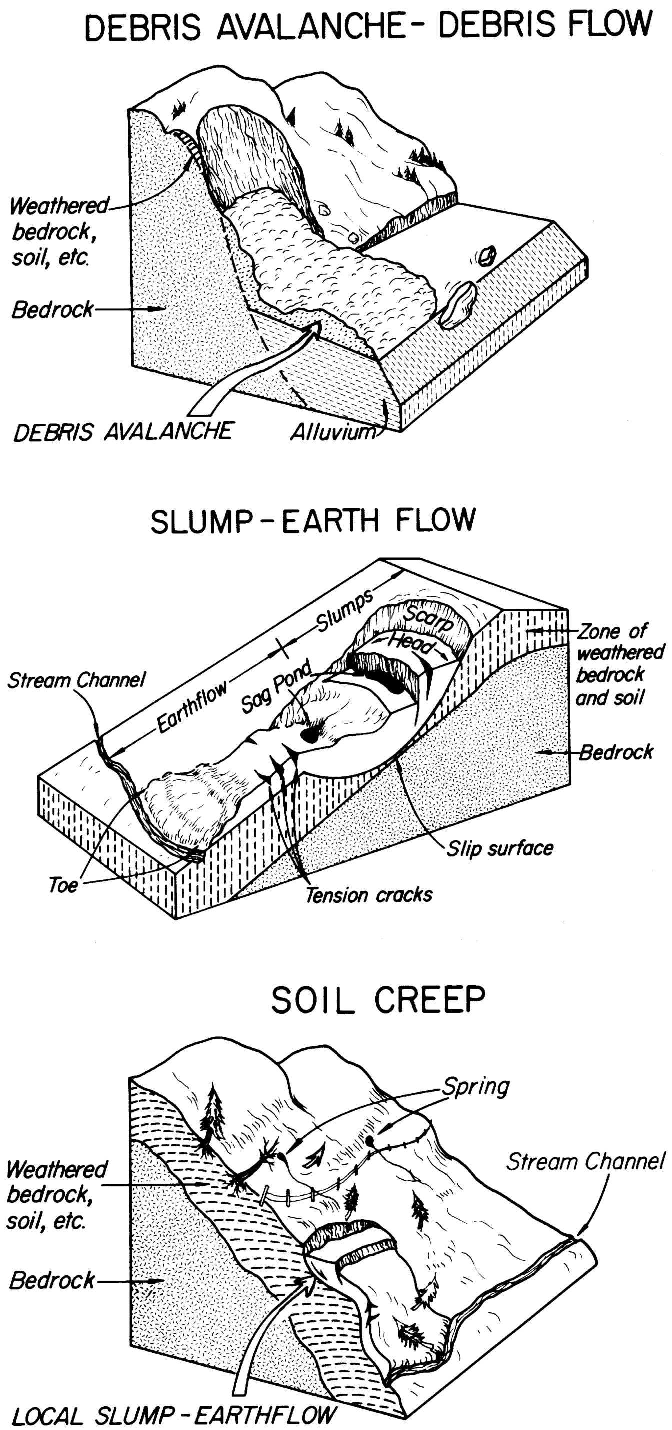

Figure 5.—Types of mass movement.

rates tend to be very high, so most rainfall enters the soil, contributing to a buildup of pore water pressure. Usually, the soil has enough strength to counteract this pressure. During episodes of prolonged, heavy rainfall, however, sustained, very high pore water pressures can exceed soil strength. In this case, the whole mass fails and slides downslope.

Mass movements can be rapid and dramatic or very slow and subtle (Figure 5). *Debris avalanches* or *slides* are shallow, rapid mass failures that are common in steep, upland areas with thin soils over bedrock. If debris avalanches or slides reach a stream channel, they might become fluid and change to a *debris flow*, or *debris torrent*. These flows can scour extensive lengths of stream channels, but they also deposit large quantities of sediment and other debris where they stop.

Slumps and *earth flows* are large, slow mass movements in areas of deep, fine-textured soils. Rotational slumps usually are storm-driven phenomena in which soil moves only a few feet. Slumps can plug road ditches, leading to further erosion and sedimentation from inadequately drained roads.

Earth flows are slow and gradual and might move only inches per year, but they might be an important, chronic source of sediment where they occur near stream and river channels.

UNSTABLE TERRAIN

Unstable terrain is land that is particularly susceptible to mass failures. Places where landslides occur can be important sources of stream sediment and woody debris, both natural and management related. Identifying these areas can help you understand current watershed conditions and prescribe management activities.

Keep in mind that different types of slope instability can present different concerns for watershed management. Slow-moving earthflows that are a chronic, natural source of stream sediment might be difficult or impossible to control. On the other hand, landslide potential might be reduced locally by avoiding road construction along a slope that shows evidence of past debris avalanches.

It's not possible to identify exactly where failures will occur, but broad areas of current and potential instability can be recognized. Some clues include:

- Very steep slopes (e.g., >65 percent)
- Slope depressions or other areas where water might concentrate
- Slopes with active seeps or springs (Indicators include localized water-loving plants and black or "mottled" soils.)
- 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 (leaning in many directions)
- "Pistol-butt" trees (curved trunks at the base)
- Slopes with tension cracks or "cat steps" (soil slippage that forms small benches on the slope)
- Bedrock faults or rock beds parallel to the landscape surface

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 locations of steep slopes. Likewise, aerial photos failed to show many existing landslides, especially in forested areas.

STRATEGIES FOR EROSION CONTROL

Erosion is most likely to have a significant environmental impact on bare, exposed, or compacted areas. Important locations where such conditions might be found include road rights-of-way, construction or development sites, recreational areas, agricultural fields, grazed areas, or logged areas.

Preventing or controlling erosion and sedimentation from these critical areas is largely a matter of exercising common sense. The following sections discuss key concepts for doing so.

Consider extreme events

Extreme events are periods of very heavy precipitation or high stream flow that might trigger mass failures or major water erosion. The nature of extreme events and their implications for watershed management are discussed in more detail in Chapter II-2, "Watershed Hydrology."

Promote infiltration and permeability

One method of restoring infiltration and permeability is deep tillage of heavily compacted areas. Another is to improve growing conditions for protective vegetation. Where topsoil has been lost or removed (e.g., in heavily eroded areas or on abandoned roads), you might need to add fertilizer, organic amendments, or nitrogen-fixing plants (legumes) to restore productivity.

Soil organic matter and soil structure improve soil porosity, decrease density, and promote infiltration. Organic matter tends to "fluff up" the soil, increasing the total pore space, and it stabilizes soil structure and increases the diversity of pore sizes. Good management of watershed soils often means preserving or adding organic matter and avoiding compaction so as to improve porosity.

Use physical barriers and sediment traps

You also can enhance infiltration by slowing down surface water so that it has time to soak into the soil. One method is to leave surface duff (plant litter), logging slash (tree debris), or crop residues on the soil surface. Adding mulch accomplishes the same thing. Another technique is to leave the soil surface as rough as possible. Farming across slopes, using minimum tillage, and constructing diversion terraces are other methods for slowing down water and trapping soil.

Use vegetation and buffer strips

Vegetation enhances infiltration. Plants and their litter shield the soil from raindrops, which can break down soil structure and clog large pores, resulting in surface runoff. Plants, roots, and plant litter also help slow runoff, hold soil in place, and promote soil porosity.

Watershed enhancement thus can include measures to improve vegetation cover and litter accumulation. Such improvements are especially important 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.

The *Oregon Interagency Seeding Guide* and the OSU publication *Seeding to Control Erosion along Forest Roads* are two helpful references for enhancing vegetation. You might need to improve soil conditions through tillage, fertilization, or organic amendments to ensure that new plants thrive and cover the area well.

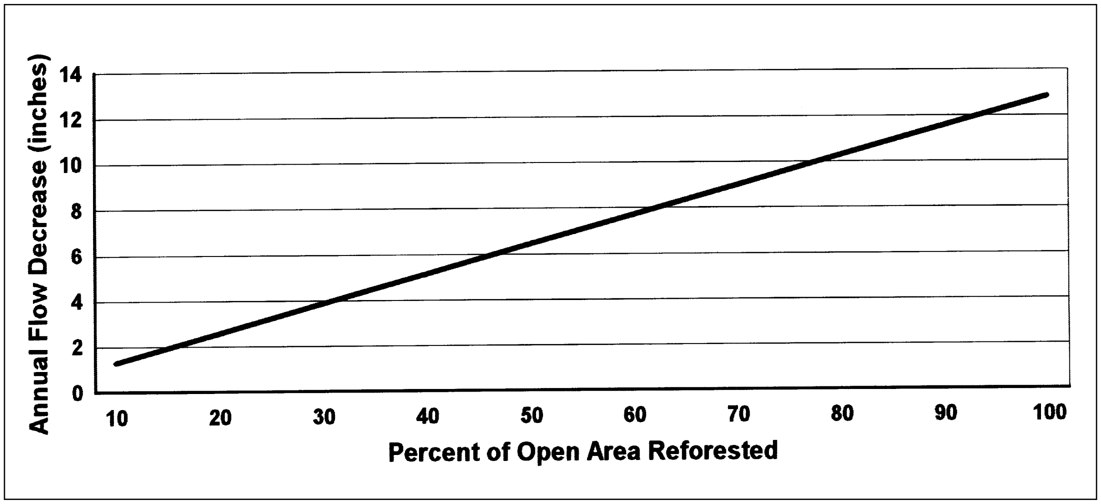

Figure 6.—Relationship of stream flow to increasing forest cover.

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 logging of riparian forests, reduced summer flows (probably from heavy water uptake) or water-quality effects (e.g., increased color and dissolved organic matter) sometimes have been noted.

Reforestation of agricultural fields or other open lands also might reduce local stream flows because forests use more water than do crops and other plants. Figure 6 shows how stream flows in other regions generally decreased as forest cover increased. While streamside plantings often are desirable to provide shade, which helps maintain cooler water temperatures, carefully consider the trade-off with potential stream flow reductions.

Control erosion in urban areas

Most erosion in urban areas is associated with runoff originating from construction sites or impervious surfaces such as roofs, streets, and parking lots. Controlling erosion from bare, exposed soil at construction sites is largely a matter of common sense: minimize the amount of soil exposed, keep water off disturbed or compacted soil, plan for catch basins and sediment traps in case runoff does occur, mulch, and revegetate as soon as possible. Many communities now require silt fences, sediment basins, and covering piles of excavated soil.

Runoff from impervious surfaces causes erosion when large volumes of water are concentrated into very small channels that discharge onto the ground surface or into natural stream channels.

Homeowners can help control erosion by making sure gutter downspouts don't discharge directly onto bare soil.

At the community level, runoff from houses, driveways, and streets usually enters the storm sewer system. The point of concern is where the sewer enters a natural drainage channel. Because storm events can generate very high discharge volumes, soil in the channel and along the banks is particularly susceptible to erosion. The first line of defense is to make sure stream banks are as fully vegetated as possible, both to anchor soil in place and to dissipate the energy of the stormwater flows. Riprap might be necessary to provide additional stabilization.

Runoff from most parking lots also enters the storm sewer system. Increasingly, however, some commercial establishments and public agencies are turning runoff from roofs and parking lots into an asset rather than a liability. They collect the water on-site and use it to create wetlands and other water features that are both aesthetically pleasing and beneficial to wildlife.

Control erosion in agricultural areas

Erosion control strategies on agricultural soils focus on promoting infiltration, slowing runoff, and reducing stream bank erosion. Continuous vegetative cover promotes infiltration, so it's always a good idea to use *permanent cover crops* on highly erodible soils wherever possible. Winter cover crops help protect soil during the rainy season if crops are not being grown.

Replacing traditional moldboard plowing with *minimum tillage* practices also reduces erosion potential. With these techniques, residues from previous crops are left in place. This practice reduces the exposure of bare soil and minimizes compaction from machine traffic.

Runoff gains speed as it flows over long slopes, and runoff velocities are higher on steep slopes. A major goal of erosion control is to slow down the water as it moves over the landscape.

Contour tillage (tilling across the slope instead of up and down) avoids creating pathways for water to flow downslope and produces a series of miniature check-dams to keep water velocities low and encourage infiltration. Similarly, leaving the surface as rough as possible and leaving crop residues on the soil both place physical barriers in the path of flowing water.

Constructed *bench terraces* shorten the length of slope over which water runs. Runoff collected behind these terraces is diverted across the slope to a *grassed waterway* in which water can move downslope without contacting bare soil.

Techniques for reducing stream bank erosion include stabilizing banks, establishing riparian buffers, and managing livestock access.

Bank stabilization can be accomplished with vegetation or, in some cases, with energy-absorbing structures such as tree branches or rock riprap. A *riparian buffer* is a zone of natural vegetation several feet wide on each side of the stream. Buffers are created by not cultivating, grazing, or logging all the way to the edge of the stream.

Where grazing animals have unrestricted access to stream channels, soils immediately adjacent to the stream often become denuded, compacted, and less resistant to erosion. By locating water troughs and salt licks in uplands, you can attract livestock away from wet soils, streams, and small drainages. A permit is needed to divert water from streams for such uses, but permit fees are kept low to encourage such improvements. See Chapter III-3, "Livestock and Forage Management," for more information about ways to minimize livestock damage to riparian areas.

Control erosion in forested areas

We've already touched on many of the principles of erosion control on forested soils. Because undisturbed forest soils have naturally high infiltration rates, the most important goal is to disturb as little of the natural forest floor as possible. Control equipment traffic to minimize compaction, and try not to scrape away any more of the natural topsoil than necessary.

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. Similarly, develop and maintain designated trails for hikers, bikers, horses, and off-road vehicles to minimize compaction.

Where soils have been compacted, infiltration and productivity can be improved by breaking up the compacted soil with tillage equipment. 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 7.

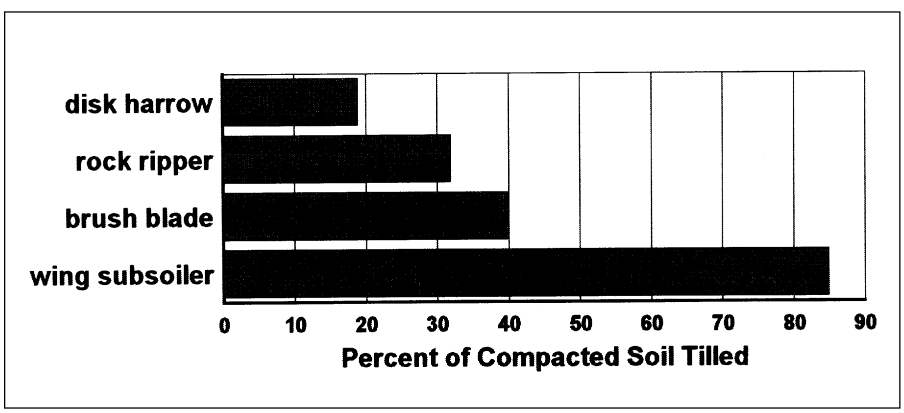

Figure 7.—Tillage results from four different types of equipment.

Forest managers often use slash treatment or scarification to increase reforestation success after logging. Slash treatment usually involves piling or burning, while scarification consists of mechanically disturbing the topsoil. Both techniques can enhance seedling survival. Both, however, also expose more soil surface, which might increase the risk of runoff, especially on sloping terrain.

You can help reduce surface runoff by leaving some duff and by piling slash in windrows along slope contours. Try to manage slash to balance the needs of site preparation and 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.

Learn to recognize the signs of unstable terrain, and try to avoid actions in these areas that would increase the potential for future failures of devastating proportions. Do nothing that might increase the amount of *hydraulic loading* (the amount of water accumulating in the soil) in such areas, and avoid practices that cut into slopes and decrease their strength and resistance to mass movements.

It's often very difficult or costly to improve slope stability in very unstable terrain. 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.

One such practice is to direct road drainage away from unstable slopes. Another is to avoid broadcast burning or herbicide applications that remove duff and vegetation over large areas. Rock buttresses can be used along unstable road cutbanks, and tree planting on steep, grassy slopes might add some root strength. Experts familiar with slope stability problems and solutions can 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 clearcutting, but some locations and young forests have shown fewer landslides after such cutting.

The Oregon Department of Forestry recently was given greater control of forest operations in highly unstable terrain, and other efforts to deal with landslide hazards are underway. However, it's essential to recognize that, in very unstable terrain, a significant landslide risk will exist regardless of human activities.

CONTROLLING EROSION FROM ROADS

Unpaved roads often are a significant source of erosion and sedimentation in rural areas. This is true throughout a watershed, but especially in forested landscapes. The most important erosion control practice is to build and maintain roads properly.

Road use and maintenance

In most cases, landowners and managers rely heavily on existing roads. How these roads are used and maintained should be a major part of your watershed evaluation and 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 might be wise to reduce or suspend traffic on unpaved roads during wet weather. Likewise, scheduling timber harvest and log hauling during the summer might 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 8 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 cleaned out promptly to prevent serious problems such as gullies, washouts, or landslides.

To help you determine what kind of road maintenance is

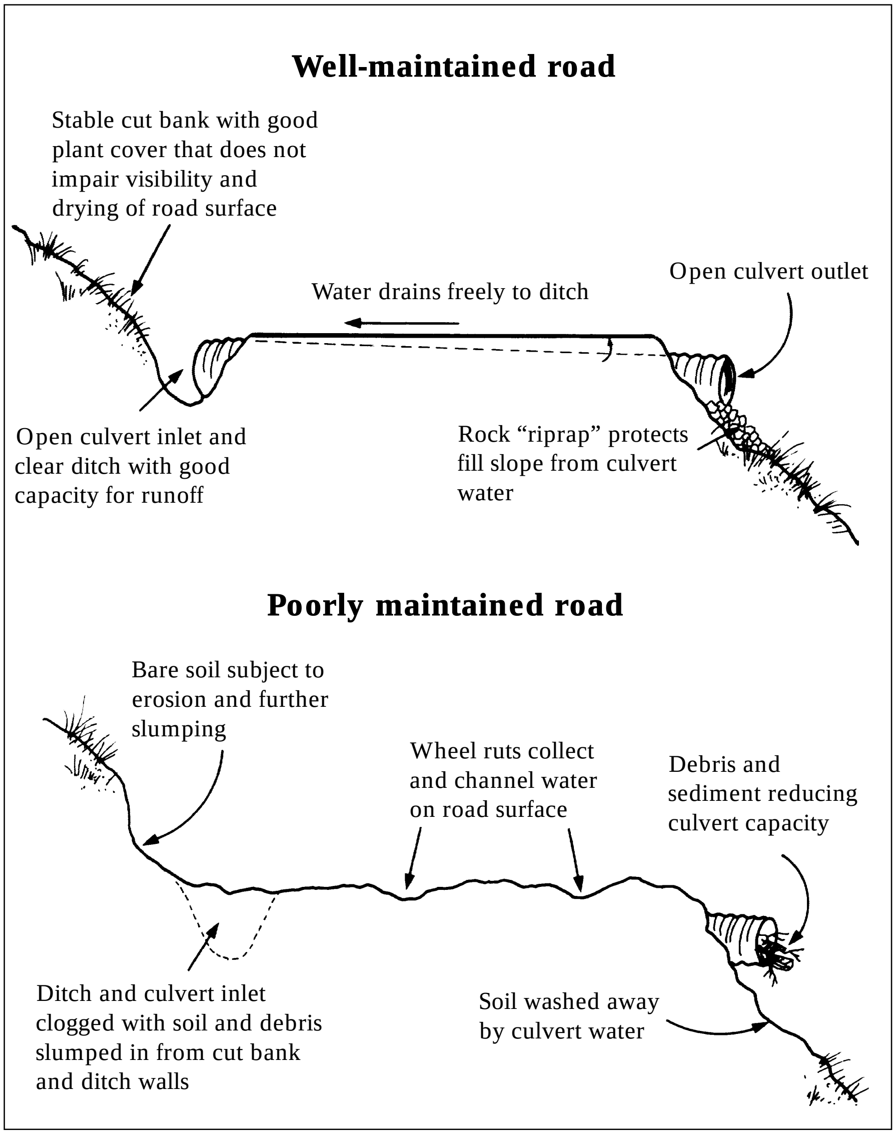

Figure 8.—Examples of some important differences between well-maintained and poorly maintained woodland roads.

needed in your watershed, see the “Checklist for Storm-proofing Rural Roads: Road Maintenance” (Appendix A).

Drainage design

Road improvements to prevent or reduce watershed problems usually focus on drainage systems. To move water off quickly to a ditch or roadside, road surfaces usually are designed with a crown (drains evenly to both sides), inslope (drains toward the inside road edge), or outslope (drains to the outside road edge). Generally, these slopes should be 2–3 percent greater than the travel grade; otherwise, water will move down the road surface rather than off to the side.

Simple maintenance grading is sufficient to provide surface drainage on many roads. In some cases, however, a road might need additional soil or rock to create an adequate slope.

The OSU 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” (Appendix B). Be aware that road design can be quite complex, and you might need help from an engineer or other specialist.

Where roads are cut into a slope, ditches and cross-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 with many cross-drains, however, heavy storm flows might cause erosion 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 3 and 4 summarize key features 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 important concern with stream crossings is that some culverts are a barrier to migrating fish.

Table 3.–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 might 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 (Oregon State University College of Forestry, Corvallis, 1991).

Table 4.–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.

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 might be good candidates for enhancement projects.

Some relatively inexpensive bridge designs are available. Examples include log and rail car bridges as well as some newer prefabricated, sectional designs.

Where traffic is very light, carefully designed fords or temporary crossings may be used. A *vented ford* crossing is a unique way to minimize the disturbance and expense of large road fills (e.g., in floodplains) while maintaining clean water and adequate fish passage during low flows. These crossings combine a small culvert (i.e., capacity for moderate storm flows) with heavily armored fill at or near the crossing to handle overflows during heavy storms.

Flow capacity

It's critical that stream crossings have adequate flow capacity to prevent erosion or washouts during large storms. Oregon's Forest Practices Rules 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 (ODF). Part of this map is shown in Figure 9.

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 5 shows the flow capacities of some common sizes of round culverts.

Table 5.–Flow capacities of round culverts.

Culvert diameter (inches)	Flow capacity (cfs)
24	5–11
30	12–20
36	21–31
42	32–46
48	47–64
54	65–87
60	88–113

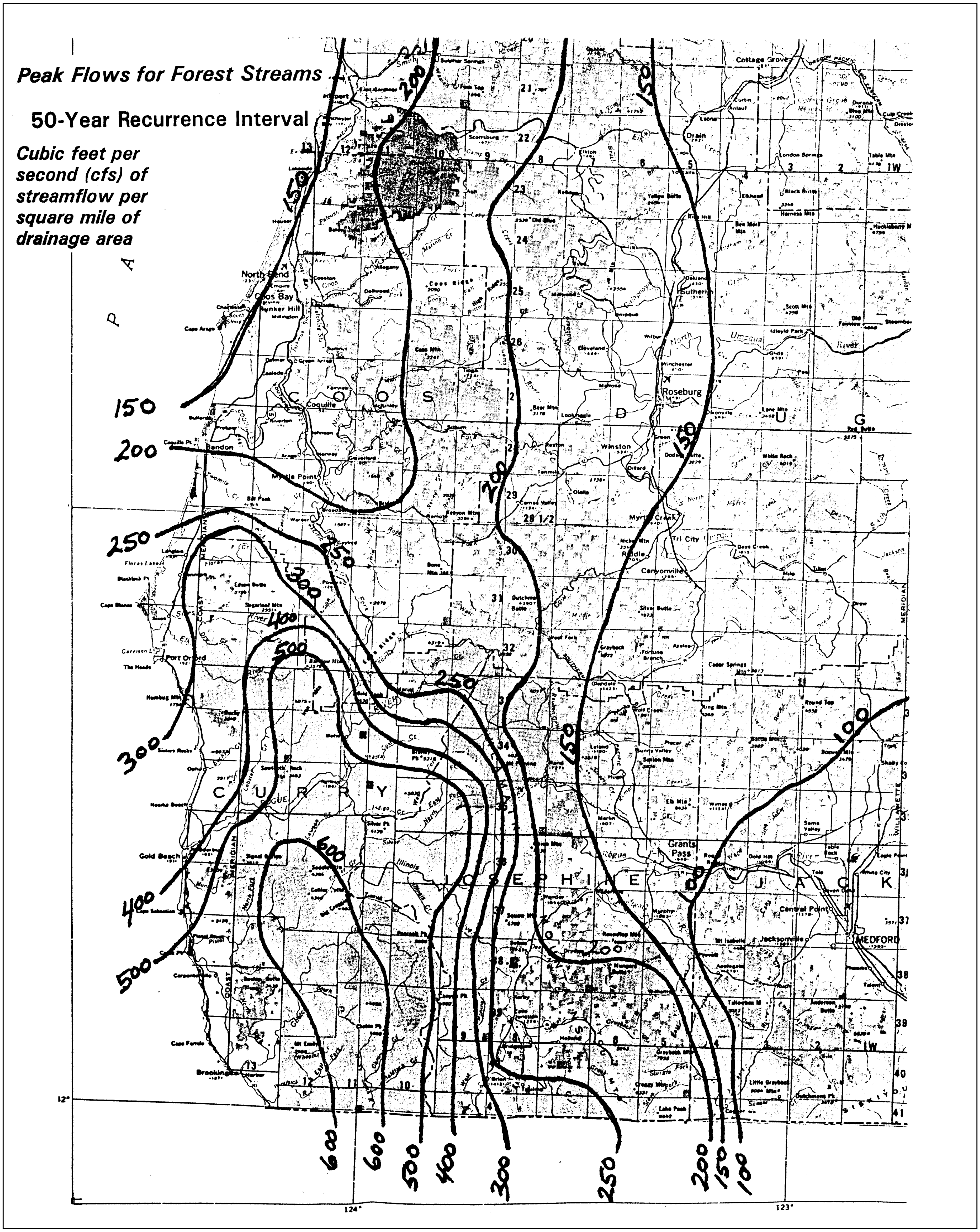

Figure 9.–Peak flow map for forest streams. (Source: Oregon Department of Forestry)

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 stream flows probably were 25- to 50-year return events, or even greater.

The condition of stream crossings after these storms provides evidence of locations where improvements might 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 OSU publication *Estimating Streamflows on Small Forested Watersheds for Culvert and Bridge Design in Oregon*. Another is the "Checklist for Storm-proofing Rural Roads: Stream Crossings" (Appendix C).

Because stream crossing issues are complex, you might need help from engineers and other technical specialists for successful evaluation and enhancement projects. Replacing or installing culverts larger than those shown in Table 5 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. Oregon's Forest Practices Rules require that new stream crossings provide for upstream and downstream passage of both adult and juvenile fish.

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 might represent an important watershed enhancement opportunity. More detailed information on this topic is available in Chapter III-5, "Stream Assessment and Restoration."

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 (e.g., 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 from streams and other drainages, minimizing the number of crossings, and avoiding potentially unstable areas.

In steep terrain, ridgetop roads can limit soil excavation and exposure. They also 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 design features that 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 road strength and reduce rutting and drainage problems.

Gravel surfacing is another way to reduce erosion and sedimentation from forest roads. The OSU publication *Rocking Woodland Roads* provides further information.

Soils freshly exposed by construction can be especially prone to erosion, so build roads early enough in the year to allow soils to stabilize before the rainy season. The OSU publications *Planning Woodland Roads* and *Road Construction on Woodland Properties* include a suggested construction schedule and other ways to reduce problems. Another helpful resource is *Seeding to Control Erosion Along Forest Roads,* which includes guidance on both species and application method.

Summary/Self review

- Soil is a key component of watershed and ecological function. If you improve your understanding of soils, you can improve your ability to make wise watershed management decisions.
- Soils are essential natural resources that make life on earth possible. They are a complex array of minerals, organic matter, organisms, and pore space. They provide support and sustenance for plants and also store and influence water resources.
- Soils form under the influence of five factors: climate, time, parent material, organisms, and topography.
- Soils can be quite variable, and understanding landscape positions can help you recognize and deal with soil variability more effectively.
- Soil surveys contain practical information about the soils in your watershed, including map unit descriptions and various tables.
- Key soil properties are texture, structure, organic matter content, density, porosity, and depth to bedrock. All of these properties affect water and air balance in soils.
- Adding or building organic matter can improve the physical, chemical, and biological properties of the soil. Organic matter is the main energy source for soil organisms.
- Soil compaction can decrease porosity and increase density, which decreases infiltration, increases runoff, and restricts root growth.
- Key processes that reflect soil behavior and are directly related to soil properties include permeability, infiltration, leaching, runoff, and erosion.
- Depth to water table is an important soil feature of site hydrology and can have many practical implications for land-use and watershed management.
- Soils regulate hydrology, nutrient cycling, and water quality. They also provide habitat for living organisms.
- You can minimize erosion by taking some key steps to prevent it. Providing cover or vegetation on bare ground and keeping soil on-site are two basic measures.
- Unpaved roads can be a major source of erosion and sedimentation. You can reduce road impacts by designing and maintaining roads properly. You can improve road drainage through road grading, ditch and culvert cleaning, and adding new surface gravel.

Exercises

You can do these exercises on your own, but it will be helpful to work as a group so you can compare notes and discuss your findings.

Soil drainage enhancement plan

Identify a local farm, woodland, or construction site that shows evidence of a significant soil drainage problem such as excess runoff or surface erosion. Give priority to areas where the runoff or eroded soil enters a stream channel. Develop a plan to improve soil infiltration and permeability, using the following key steps and information:

1. Visit areas where surface runoff and/or erosion seem to be increased by compaction from farm or forest operations. Evaluate and rank the severity of observed problems, noting particularly whether recent storm runoff and/or sediment has been delivered directly to a stream channel.
2. Examine data on storm intensities and soil infiltration rates in local climate summaries and soil surveys. Using ring infiltrometers or other field methods, test and compare infiltration rates at a significant problem area with a relatively undisturbed adjacent area. If differences exist, evaluate the probable primary source of these differences (e.g., soil compaction, soil exposure, or lack of runoff barriers).
3. Consider infiltration enhancement options for the problem area (e.g., soil tillage, modified farm or forest practices, mulching, seeding, or planting) and develop preliminary project plans. Estimate labor, materials, construction, and maintenance requirements and costs for the different options. If possible, have a soil scientist review the options and plans.
4. Review the advantages and disadvantages of each enhancement option. If funding is available, contact potential contractors for bids. Be sure to check about necessary notification or other requirements by agencies such as ODF.
5. Develop a preliminary plan for monitoring the implementation and results of the treatments, including soil behavior under both normal and extreme conditions (e.g., major storms) over time.

(continued)

Stream crossing enhancement plan

Identify a small, local stream crossing that shows evidence of a significant problem such as restricted fish passage or overtopping or erosion during recent major storms. Develop a plan to replace or improve the crossing, using the following key steps and information:

1. Estimate the 10-, 25-, and 50-year peak flows for the crossing, using topographic maps and the ODF peak flow map. Collect and consider site-specific information (e.g., shallow soils or terrain features) in determining an appropriate design flow. See *Estimating Streamflows on Small Forested Watersheds for Culvert and Bridge Design in Oregon* for more information.
2. Examine and evaluate the current crossing for:
   - Sufficiency to pass expected flows
   - Specific problems such as erosion, debris clogging, etc.
   - Upstream and downstream adult and juvenile fish passage
3. Using the above information, consider crossing enhancement or replacement options and develop a preliminary design. For example, you might be able to reduce erosion by adding riprap or other protection to road fills or bridge abutments. Excavating a resting pool below a culvert crossing might enhance fish passage. An undersized pipe could be replaced by a larger pipe or bridge. Estimate labor, materials, construction, and maintenance requirements and costs for the different options. If possible, have a hydrologist, engineer, or road specialist review the options and plans.
4. Review the advantages and disadvantages of each enhancement option. If funding is available, contact potential contractors for project bids. Be sure to check about necessary permits or scheduling requirements by agencies such as ODF, ODFW, etc.
5. Develop a plan for monitoring the installation and performance of the stream crossing, including maintenance under both normal and extreme conditions (e.g., major storms).

Resources

Training

Oregon State University (College of Forestry, Extension Service, etc.) and the *Oregon Department of Forestry* occasionally offer public seminars, field trips, and short courses on topics related to upland watershed management and enhancement. Training programs also might be offered by nonprofit and private organizations, including consultants. If you're interested in self instruction, consider the publications and audiovisual programs listed below.

Information

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Forest Practices and Surface Erosion, slide-tape 795 (Oregon State University Forestry Media Center, Corvallis).

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Oregon Interagency Seeding Guide (revised 1988). Available from local offices of the Natural Resources Conservation Service.

Oregon Watershed Assessment Manual. Available from the Oregon Watershed Enhancement Board, Salem.

Oregon's Forest Practice Rules, EC 1194, by P. Adams (Oregon State University Extension Service, Corvallis, revised 1996).

Oregon's Soil: A Resources Condition Report, by USDA Soil Conservation Service (NRCS, Portland, 1985).

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"Infiltration and soil water processes," by A.D. Ward and J. Dorsey. In *Environmental Hydrology*, A.D. Ward and W.J. Elliot, eds. (Lewis Publishers, 1995).

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Soil Compaction on Forest Lands, film/video 850 (Oregon State University Forestry Media Center, Corvallis).

Soil Compaction on Woodland Properties, EC 1109, by P. Adams (Oregon State University Extension Service, Corvallis, reprinted 1998).

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Tilling Compacted Forest Soils, slide-tape/video 876 (Oregon State University Forestry Media Center, Corvallis).

Waterbars, ODF Forest Practice Note No. 1 (Oregon Department of Forestry, Salem).

"Watershed studies of factors influencing infiltration, runoff, and erosion on stony and non-stony soils," by W.M. Edwards, P.F. Germann, L.B. Owens, and C.R. Amerman. In *Erosion and Productivity of Soils Containing Rock Fragments*, SSSA Spec. Pub. 13, J.D. Nichols, P.L. Brown, and W.J. Grant, eds. (1984).

Erosion and conservation

Crop Residue and Management for Conservation: Proceedings of a National Conference (Soil and Water Conservation Society, 1991).

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Unstable terrain

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Urban soils

Erosion and Sediment Control Handbook, by S.J. Goldman, K. Jackson, and T.A. Bursztynsky (McGraw-Hill, New York, 1996).

Groundwater Contamination from Stormwater Infiltration, by R. Pitt (Ann Arbor Press, Chelsea, MI, 1996).

Managing Soils in an Urban Environment, ASA Agronomy Monograph 39, by R.B. Brown, J.H. Huddleston, and J.L. Anderson (2000).

Urban Soils: Applications and Practices, by P.J. Craul and R.J. Lienhart (Wiley, New York, 1999).

Ordering instructions

OSU Extension Service publications are available from county offices of the OSU Extension Service or from: Extension & Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; fax: 541-737-0817; Web: eesc.oregonstate.edu. Call for current prices.

OSU Extension Service videos are available for purchase from: Extension & Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; fax: 541-737-0817; Web: eesc.oregonstate.edu (These programs also might be available for viewing or loan from county offices of the OSU Extension Service.)

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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: fmc.cof.orst.edu/

Oregon Department of Forestry publications are available from local ODF offices, or from: Oregon Department of Forestry, 2600 State St., Salem, OR 97310; phone: 503-945-7422, fax: 503-945-7212;
Web: www.odf.state.or.us/

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in improving your understanding of watershed soils, erosion, and conservation.

1.____

2.____

3.____

Appendix A
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:

____

____

Appendix B
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 feature: ___________________________________

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 might 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 might not divert all ditch water into pipe
- ❒ Flow from outlet could cause erosion or instability
- ❒ Other risky feature: _______________________________________

Appendix C
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 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:

____

____

5

Assessment and Monitoring Considerations

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 to identify both 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 in order 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,

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

including the Governor's Watershed Enhancement Board (GWEB), Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Forestry (ODF), and USDA Forest Service (USFS).

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.

See and Section III, Chapters 1, 2, 5, and 8 for information related to this chapter.

Section III

1 Riparian Functions

2 Riparian Enhancements

5 Stream Assesment

8 Water-quality Monitoring

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 (e.g., increasing, decreasing, 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 (e.g., fish habitat, stream shading, or soil infiltration), especially when you want to determine how management activities may 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 (e.g., 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 may 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, i.e., 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 may 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 require 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 (e.g., 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 so much with time and stream flows.

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.)

The effect of stream flow 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.

Figure 1 shows how suspended sediment levels in a stream in the Oregon Coast Range change as stream flow rises and falls in response to a winter storm. Note that for the same stream flows, 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.

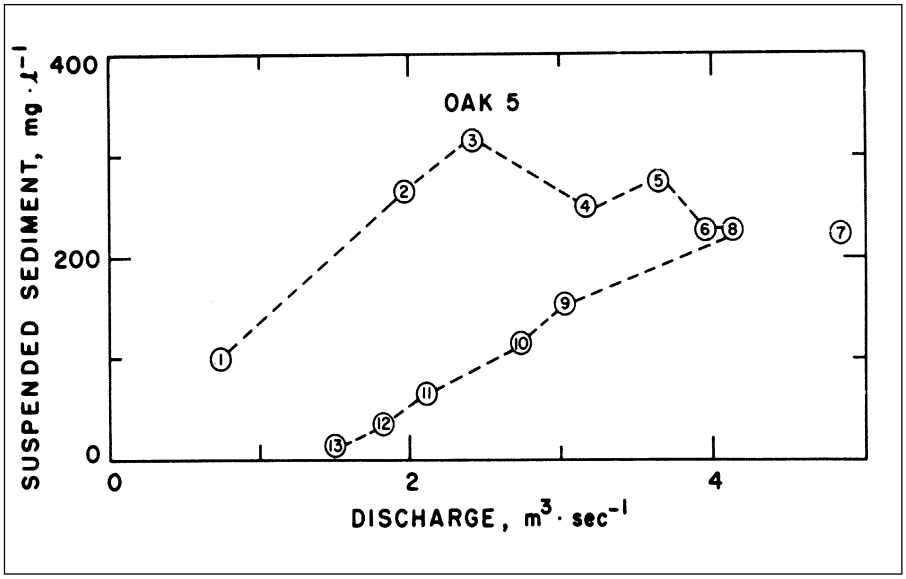

Figure 1.–Suspended sediment levels and stream flows for a small Oregon Coast Range stream.

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 may 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 (e.g., 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 (e.g., use of truly random or systematic samples), your results or their interpretation may be invalidated or seriously questioned.

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 often is 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 specifically are used to check handling and analytical procedures. *Control* samples contain known amounts of the material or other characteristic being evaluated (e.g., 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 also can 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 may want to identify 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.

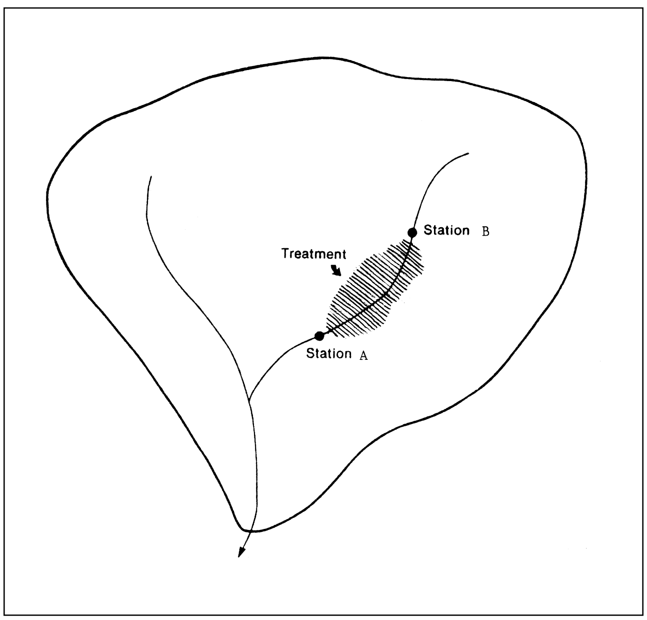

Figure 2.–An upstream-downstream comparison looks at measurements taken from stream locations immediately upstream and downstream of a stream reach where a particular practice is used.

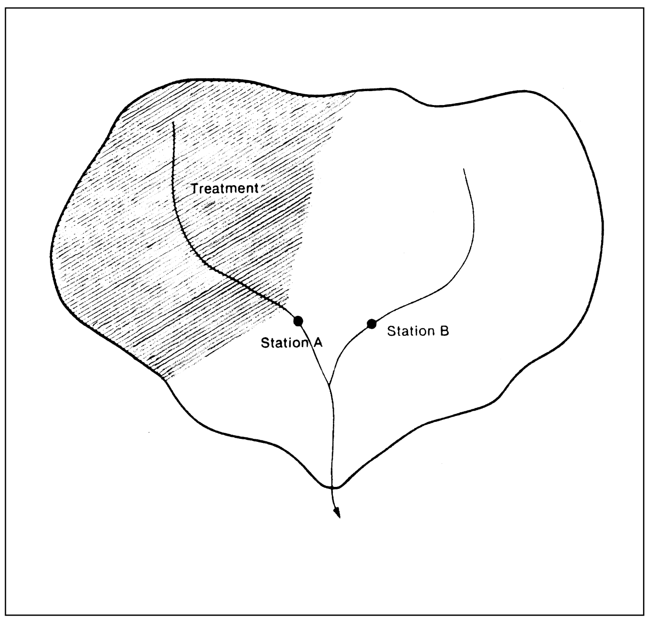

Figure 3.–A paired watershed comparison looks at conditions in two nearby watersheds.

It can be very difficult to distinguish between effects of management and other factors because no two streams or stream reaches are exactly alike. There always are 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 due to 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 may 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 how much measurements can vary based on changing background conditions such as stream flow.

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 may 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 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/Self review

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

Exercises

Do these exercises as a group with the help of appropriate experts.

Visit a watershed study site with a researcher.

The objective of this exercise is to see, discuss, and learn more about what it takes to answer questions about watershed conditions and influences with a reasonable level of accuracy and confidence. Ask the researcher to focus specifically on demonstrating and providing insights about study design, sampling, and analytical requirements, including such factors as:

- Degree and sources of variability in samples/measurements
- Numbers and location of samples/measurements
- Timing and frequency of sampling/measurements
- Handling and lab/office analysis of samples/measurements
- Type and expense of field and lab/office equipment
- Time and expense of field and lab/office personnel
- Role of experience and expertise of personnel

Visit a USGS stream/river monitoring site and discuss agency databases.

The objective of this exercise is to see and learn how some of our streams and rivers are regularly monitored. As in the exercise above, sampling equipment and design should be discussed, including issues of variability, sampling/measurement accuracy, and equipment and personnel needs and costs.

In addition, the broad array of available USGS and other agency monitoring databases should be discussed. Ideally, do this portion of the exercise indoors so that some of the databases can be shown. If World Wide Web access is available, you'll be able to view some of these databases online (e.g., http://wwworegon.wr.usgs.gov/).

RESOURCES

Training

Oregon State University and government organizations occasionally offer short courses on topics related to watershed evaluation and monitoring. Training programs also may be 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." In *Stream Hydrology–An Introduction for Ecologists*, by N.D. Gordon et al. (John Wiley & Sons, Inc., New York, 1992). ISBN 0-471-95505-1. Available by order through bookstores.

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, EPA 910/9-91-001, by L.H. MacDonald et al. (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/clariton

Oregon Watershed Assessment Manual (NonPoint Source Solutions for the Governor's Watershed Enhancement Board, Salem, 1998).

"Reliability of water analysis kits," by C.E. Boyd, *Transactions of the American Fisheries Society* 109:239–243 (1980). Available through university and other technical libraries.

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, DC. Also available on the Web at http://www.epa.gov/clariton

Water Quality Monitoring Programs, Technical Paper WSDG-TP-00002, by S.L. Ponce (Watershed Systems Development Group, USDA Forest Service, Fort Collins, CO, 1980). Available through university and other technical libraries.

Wildland Water Quality Sampling and Analysis, by J.D. Stednick (Academic Press, Inc., San Diego, 1991). ISBN 0-12-664100-5. Available by order through bookstores.

Moving forward–the next steps

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in understanding watershed assessment and monitoring.

1.____

2.____

3.____

Section III. Evaluating, managing, and improving watershed functions

1. Riparian Area Functions and Management

2. Riparian Area Evaluation and Enhancement

3. Livestock and Forage Management in Oregon Riparian Areas

4. Stream Ecology (Salmonid Biology)

5. Stream Assessment and Restoration

6. Managing Rural Homes and Small Acreages to Protect Watersheds

7. Wetland Functions and Management

8. Water-quality monitoring

1

Riparian Area Functions and Management

John Runyon,
David Hibbs,
and Tara Nierenberg

Riparian areas are dynamic zones of interaction between upland and aquatic systems. It is useful to think of aquatic systems and riparian areas as working together, with each influencing the other and changing across the landscape and through time. Riparian areas play a key role in watersheds and present important opportunities for enhancing fish and wildlife habitat and water quality.

Soils, vegetation types, and natural disturbances such as floods and fires influence the interactions between riparian areas and aquatic systems. This complexity, overlaid with current and past land uses and introduced plant and animal species, presents unique management challenges.

There are many approaches to setting management goals and many concepts used in meeting those goals. This chapter will help you understand riparian areas so you can think about goals and management options. Chapter III-2 will introduce riparian area evaluation, enhancement, and monitoring.

To effectively set goals or make decisions about specific management activities, you will need to learn a lot about riparian area functions and processes and

In this chapter you'll learn:

- Riparian areas are very diverse and dynamic, varying among different parts of the state, throughout watersheds, and through time.
- Riparian areas and aquatic systems are linked, each influencing the other.
- A mix of ages and types of vegetation (conifer and broadleaf trees and shrubs) along aquatic areas provides the greatest land and aquatic diversity.
- Management goals are more likely to succeed if they are based on ecological functions and processes rather than on physical conditions.
- Active management techniques can enhance all riparian functions for fish and wildlife habitat and water quality.

how they interact with other parts of the landscape and the aquatic system. We can cover only a small part of what you need to know here. Other chapters contain important related information on watershed processes and aquatic systems.

WHAT IS A RIPARIAN AREA?

See Section III, Chapters 2 and 4, for information related to this chapter.

Section III

2 Riparian Enhancement

4 Stream Ecology

Riparian area is a term with fuzzy meaning. At its simplest, it is a zone bordering water (streams, lakes, ponds, springs, or wetlands) where the soil is wet. A riparian area also can be thought of as a larger zone of interaction. In this sense, the riparian zone includes the plants that hang over the aquatic area as well as vegetation growing farther away that might shade or fall into the water. The aquatic area, in turn, can influence riparian vegetation by maintaining soil moisture or creating disturbances such as channel migration and flooding.

The zone of interaction also might be thought of as the area that provides *functions* to the stream. For example, when riparian trees contribute to the well-being of fish and wildlife habitat, or to water quality, the vegetation is providing functions.

The characteristics of riparian vegetation–types, distribution, and other attributes–either directly or indirectly can provide key functions and building blocks for fish and wildlife habitat and water quality (Table 1). In the aquatic system, riparian vegetation provides cover and shade. When large trees fall into the stream, they create pools and structure that hold spawning gravel and other materials. Riparian vegetation provides many important wildlife habitats, including trees and snags for birds and hiding areas for many animals. In dry parts of the state, riparian vegetation often is the only habitat with trees and dense cover, providing access to water, cooler air temperatures, travel corridors, and other important functions for wildlife.

The zone of interaction, or width of the riparian area, is not set by a defined boundary. Rather it varies greatly, depending on the characteristics of the riparian and aquatic systems and surrounding landscape.

For some functions, the riparian zone of interaction can range from a relatively narrow corridor along a small stream to an entire valley floor along a large river. For other functions, such as trees being carried into streams by landslides, the zone of interaction can extend from ridgetop to ridgetop.

Table 1.–Some key riparian area ecological functions.

Aquatic habitat

- Creating a vegetation canopy to provide hiding areas for fish
- Providing organic material nutrients that serve as food for fish and other aquatic life
- Stabilizing stream banks to reduce siltation of gravel streambeds
- Contributing large wood that creates pools and hiding cover for fish
- Slowing floodwaters to create areas for fish to hide during high flows
- Altering how much sunlight reaches the aquatic system for photosynthesis

Terrestrial habitat

- Providing various microclimates to accommodate many types of wildlife
- Contributing large wood that provides hiding places and cool areas for wildlife such as amphibians
- Creating travel corridors that allow wildlife to move around the landscape and have access to water
- Providing food for various types of wildlife
- Contributing standing snags for cavity-nesting birds and other wildlife

Water quality

- Slowing floodwaters and creating areas for sediment deposition during high flows
- Creating shade to cool water temperatures
- Filtering pollutants such as nutrients from overland runoff and subsurface flow to prevent them from entering the aquatic system

RIPARIAN AREA VARIABILITY

Riparian area plant communities and functions vary throughout the state, within watersheds, through time, and as a result of past disturbance or management actions. Understanding the factors that influence this variability is important for setting management goals.

Patterns of riparian vegetation communities respond to regional differences in climate, geology, and other factors. This regional variability is characterized by dividing the state into distinct areas, or *ecoregions*, as defined by the Environmental Protection Agency and the Oregon Natural Heritage Program. Each ecoregion has characteristic patterns of climate, geology, vegetation, soils, land use, wildlife, hydrology, and disturbance regimes. The ecoregion descriptions in the *Oregon Watershed Assessment Manual* are useful for interpreting riparian vegetation conditions across the state (Watershed Professionals Network, 1999 and 2001).

In areas with a lot of precipitation, such as western Oregon, riparian areas typically have a mix of trees and shrubs next to the water, with species variation depending on soil moisture conditions and disturbance history (Figure 1).

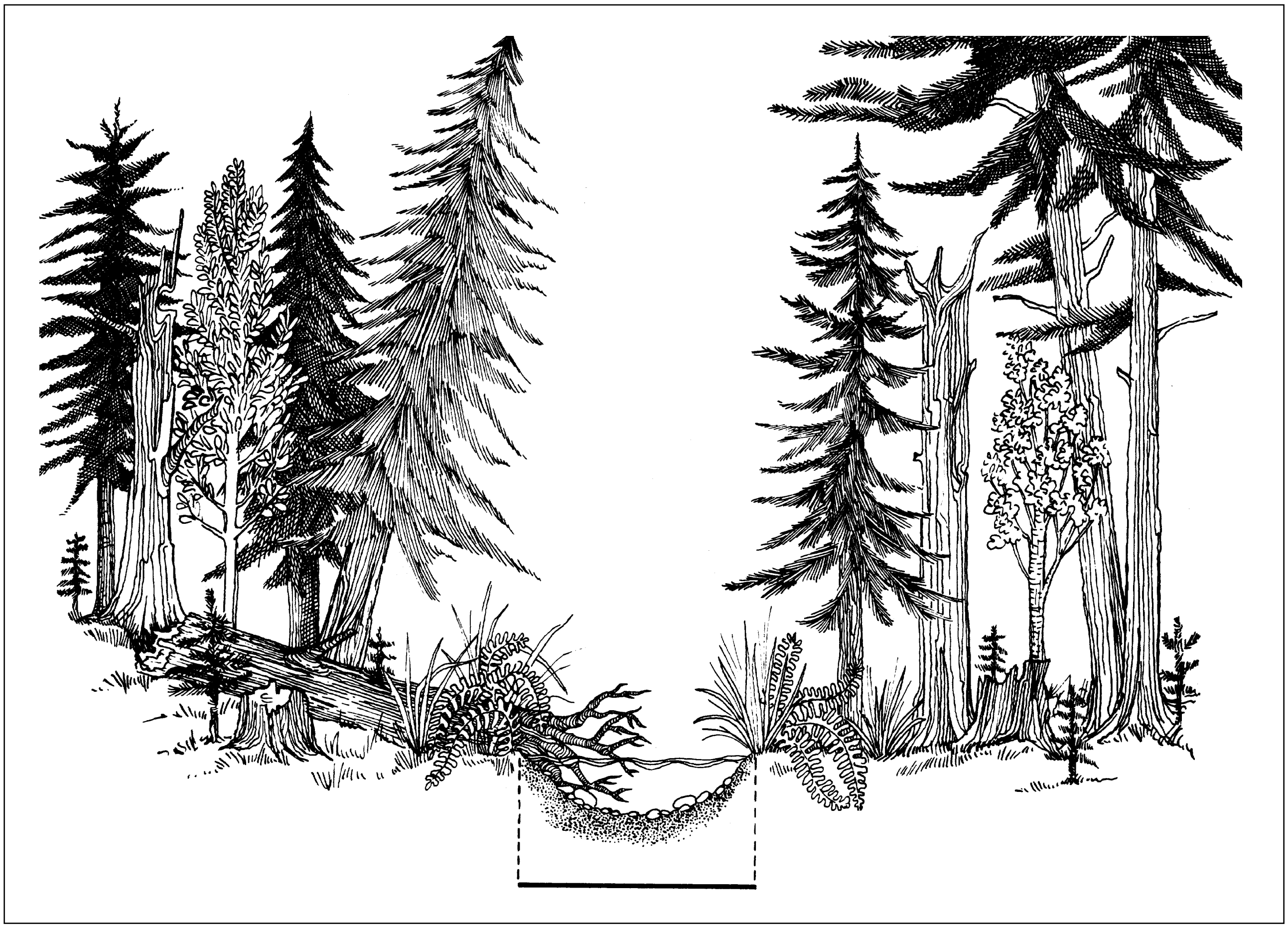

Figure 1.–Riparian and aquatic areas typical of western Oregon. (Source: Life on the Edge: Improving Riparian Function*, by D. Godwin, Oregon State University Extension Service, Corvallis, 1999)*

In areas characterized by dry climates, such as eastern Oregon, riparian vegetation is influenced strongly by wet soils from the adjacent aquatic system. In these riparian areas, there might be distinct bands of vegetation, with the area next to the water dominated by grasses, shrubs, sedges, and rushes; trees, when they are present, tend to be in the outer bands (Figure 2).

In addition to variability around the state, riparian areas vary within watersheds. Riparian plant communities and functions can vary as you move downstream from small headwater streams to large river systems because of differences in stream gradient, valley width, channel meandering, and disturbance patterns. Thus, a watershed perspective is critical when considering riparian management options (Figure 3, page 6).

Small headwater streams often run through narrow valleys, where riparian vegetation is influenced little by stream meanders or flooding. In these small streams, flood-dependent riparian plant communities tend to be limited, and upland trees and shrubs that do not tolerate wet soils or flooding grow near the stream. In contrast, large streams and rivers with wide floodplains and frequent flooding often have riparian plant communities that tolerate or require disturbances such as floods or channel movements.

Riparian vegetation patterns also change as you move upslope from the edge of the aquatic area. It is important to understand how landforms near the water can influence riparian vegetation.

Riparian area landforms can be classified by how much they are influenced by the stream channel and by associated differences in soil type, flood frequency, and water table depths. There are four zones, moving upslope from the edge of the water's surface: active channel, floodplain, terrace, and hill slope (Figure 4, page 7).

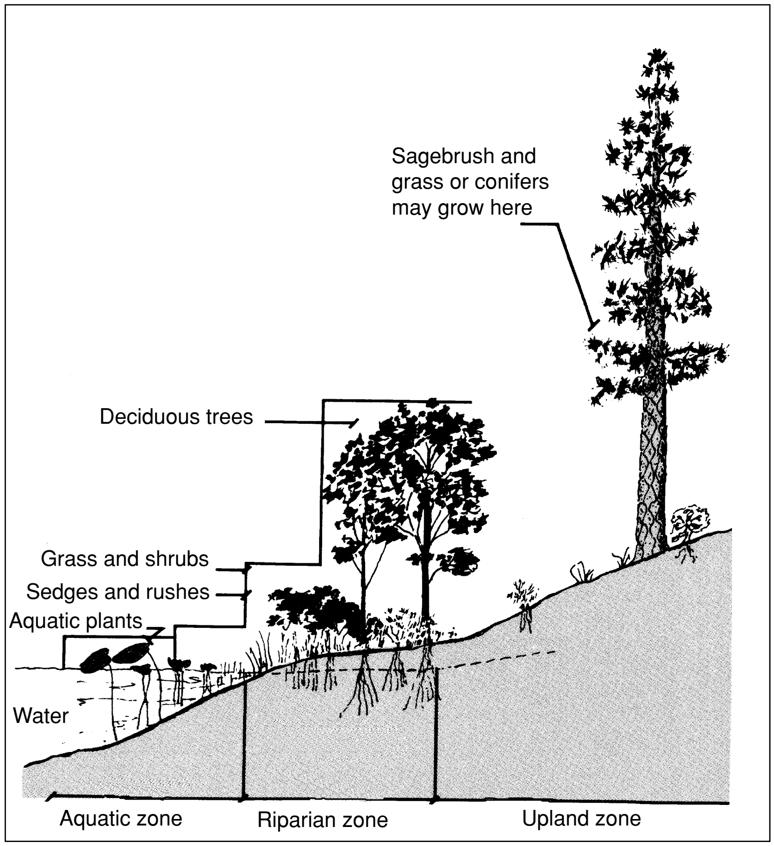

Figure 2.–Riparian and aquatic areas typical of eastern Oregon. (Source: Life on the Edge: Improving Riparian Function, *by D. Godwin, Oregon State University Extension Service, Corvallis, 1999)*

Active channel areas are subject to frequent disturbance from flooding and deposition of coarse material and sediments. Here riparian vegetation communities tend to be short lived and dominated by herbs and shrubs that can colonize and grow quickly.

Floodplains are areas where frequent overbank flooding influences the patterns of soils and vegetation. Past floods and sediment deposition create a wide range of habitats on floodplains, including cobble and gravel bars, side channels, wetlands, and patches of wet soils throughout the year. Plant communities on floodplains can be very diverse, often including trees and shrubs that tolerate periodic flooding. Examples include cedars, alders, cottonwoods, and willows.

Terrace areas are above the active channel and floodplain. They flood less frequently and usually have lower soil moisture, thus providing areas where less flood-tolerant trees and other vegetation can establish. Douglas-fir often dominates on terraces.

Moving farther away from the area under the direct influence of the aquatic system, we find hillsides. These areas almost never are

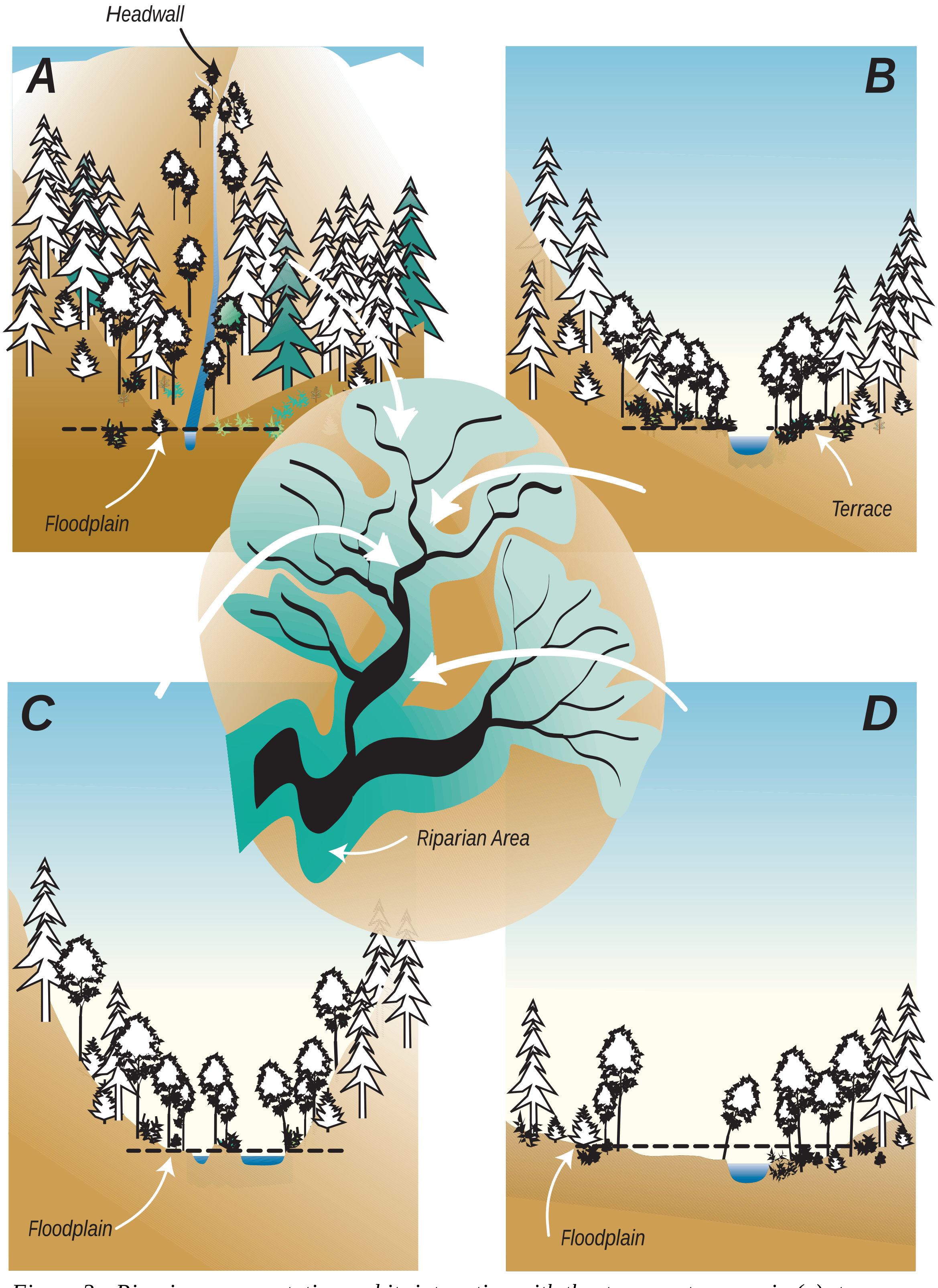

Figure 3.—Riparian area vegetation and its interaction with the stream system vary in (a) steep headwaters, (b) narrow valleys, (c) low-gradient channels with narrow floodplains, and (d) broad valleys with active channels and wide floodplains. (Source: Silvicultural Practices for Riparian Forests in the Coast Range, *by W. Emmingham et al., Oregon State University College of Forestry, Corvallis, 2000)*

affected by flooding or river channel migration.

Riparian plant communities change over time. Many kinds of riparian vegetation depend on disturbance to become established. Flooding, channel migration, landslides, and fire are the most common natural disturbances in riparian areas. These events often create new areas for vegetation to colonize.

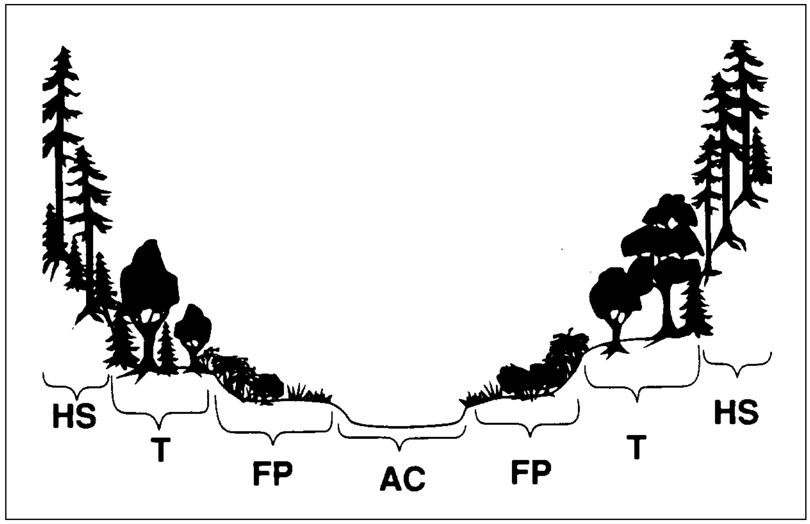

Figure 4.—The variety of landforms next to a stream. AC: Active channel. FP: Floodplain. T: Terrace. HS: Hill slope. (Source: Field Guide for Riparian Management, *by S. Gregory and L. Ashkenas, Willamette National Forest, Eugene, OR, 1990)*

The differing regeneration strategies of various vegetation types lead to characteristic patterns of plant succession following disturbance. For example, some plant species, such as willows and cottonwoods, colonize newly deposited sediments after flooding. Over time, these plants create light and moisture conditions that allow other types of vegetation to grow and gradually replace early colonizers.

A discussion of riparian area variability is not complete without touching on ways in which land-use management and other human actions have altered riparian characteristics and functions. Land management has, in many cases, altered riparian vegetation and aquatic system interactions. The patterns of vegetation communities have been changed through actions such as urban development, timber harvest, fire suppression, grazing, and the introduction of exotic plant species such as reed canarygrass.

In many places, land management has cut the link between the aquatic and riparian areas. For example, river bank stabilization to protect urban areas and other development can limit channel movements, which in turn influence riparian processes such as large trees falling into the river.

MANAGEMENT STRATEGIES

Riparian area management usually focuses on a range of goals for protecting or creating fish and wildlife habitat and enhancing water quality. Goals also might emphasize other values such as creating attractive views from nearby homes.

Riparian management goals often are based on desired *conditions:* the number, size, and species of plants; the location of the stream; the size and location of logs; and other factors. However, this approach tends to view riparian conditions as unchanging.

An alternative approach is to focus on the desired ecological *functions*. Functions refer to the processes that support life: providing in-stream structure, shading a stream, filtering pollution, etc. This approach is likely to succeed in the long term because it enables the riparian area to work without human intervention.

Riparian restoration emphasizes improving these functions to achieve a range of goals for fish and wildlife habitat, water quality, and humans. Focusing on ecological functions also provides management flexibility because it opens the door for more than one way to meet the desired goals.

The remainder of this chapter focuses on riparian management. Chapter III-2 discusses riparian evaluation and enhancement.

DEVELOPING RIPARIAN AREA MANAGEMENT GOALS

Once you understand key ecosystem functions, you can begin to design riparian management goals. Developing riparian management goals requires that you think about the resource goals you want to achieve now and in the future. It is important to note that because riparian areas support multiple ecological functions, there can be more than one resource goal. Riparian areas can be managed to support a combination of benefits for fish, wildlife, water quality, and other values.

Riparian areas can be managed to support a combination of benefits for fish, wildlife, water quality, and other values.

Riparian areas are not static. Constantly changing plant communities and structure at a specific site and across the watershed can achieve multiple goals over time. For example, an eroding bank planted with willows can stabilize in a few months, while it will take many decades for trees at the same site to grow large enough to contribute large wood to the stream.

It also is important to understand how the riparian management site fits into the watershed as a whole. Management strategies might be very different for a riparian site on a river with a large floodplain than for one on a small stream in a steep canyon.

Altering watershed processes through management can affect riparian vegetation succession. For example, if stream meandering or overland flooding is impeded by channelization, special effort might be required to maintain riparian plant communities that depend on those processes.

The steps for developing riparian management goals and actions are outlined in the box on pages 10 and 11. The process entails the following:

- Defining the resource goals
- Understanding the current and potential riparian ecosystem functions required to achieve those goals
- Evaluating the ability of current and potential ecological functions to achieve the goals
- Considering management and regulatory constraints
- Developing management strategies to support the desired functions
- Monitoring progress over time

In some cases, the planning effort will lead you to conclude that active riparian management at the site is not an effective investment of resources. If key ecological functions have been lost, restoring them might be prohibitively expensive. For example, restoring riparian vegetation to a streamside parking lot might not be a wise use of resources if other areas in the watershed have more potential for restoration success with less investment of resources. For this reason, protecting areas with intact, functioning riparian systems usually is a higher priority than restoration projects.

Steps for developing riparian area management strategies

Step 1: Define the resource goals.

- What are you trying to achieve now and over time?
- Is the focus on fish habitat, wildlife habitat, water quality, or a combination?
- Are there other goals (for example, aesthetics or agricultural production) that are achievable and consistent with the resource goals?
- If you're having trouble setting goals, you might need to evaluate the riparian area's current and potential ecological functions. In this case, skip to Step 3 and then come back to Step 1. However, you'll need to have some understanding of key riparian functions to carry out these steps.

Step 2: Describe the watershed functions that support achievement of the goals.

- Are there multiple functions that support the goals? For example, trees and shrubs along the stream bank might improve fish habitat by stabilizing eroding banks, increasing shade, and contributing large wood to the stream.

Step 3: Evaluate the ability of current and potential ecological functions to achieve the goals. If you don't already have goals in mind, this step should help you form them.

- What ecological functions (related to each goal, if you have them) currently are working or operating at reduced levels? For example, related to the goal of fish habitat, deciduous trees might be providing shade and some wood but not creating a long-term supply of large wood to the stream channel.
- What ecological functions are missing? For example, exotic plant species such as blackberry might be preventing tree establishment and thus limiting shade over the stream and long-term inputs of large wood.
- How long will it take for the functions to begin operating at a level that will achieve the resource goals? Some functions, such as providing wildlife habitat (shrubs and other vegetation) might be achieved relatively quickly. Others, such as inputs of large wood into the aquatic area, might take decades to recover completely.
- Are there ecological functions that never will recover? For example, upriver dams might limit flood flows that would enable flood-dependent riparian vegetation to recolonize naturally.
- Do other sites provide clues about the range and variability of riparian conditions? (See Chapter III-2, "Riparian Area Evaluation and Enhancement.") For example, you might find that similar sites support a variety of conifers, while only hardwood trees are growing on terraces on your site.

Continued

Step 4: Determine ways to manage for the missing or impaired ecological functions.

- Are there short-term solutions that can recover the missing or impaired functions while long-term recovery takes place?
- Are there “passive” solutions that do not require much maintenance? An example is fencing a riparian area to allow natural revegetation rather than actively planting trees and shrubs.
- Is active management required? For example, you might need to control exotic vegetation.
- Will you manage for ecological processes that will not recover?
- What kind of ongoing maintenance will be required to ensure success? For example, it might be necessary to supply water and control competing brush while vegetation is getting established.

Step 5: Describe the watershed and site-specific considerations and limitations.

- How big is the river or stream system?
- What are the riparian vegetation conditions in the surrounding landscape, including upstream and downstream from the site?
- What are the characteristics and extent of the streamside surfaces (floodplains, terraces, wetlands, hill slopes)?
- What are the disturbance patterns, such as floods and channel migration, for each zone at the site?
- Will the site require ongoing maintenance?

Step 6: Consider management and regulatory constraints.

- Are there financial, personnel, and other resources to support the project, ongoing maintenance, and monitoring?
- What regulations govern the site?
- Does the area have any federal- or state-listed wildlife or fish species?
- Are any state and/or federal consultations or permits required?

Step 7: Monitor progress.

- Was the project implemented as planned?
- Are conditions meeting the stated goals? Intermediate benchmarks might be necessary to measure progress toward long-term goals.

RIPARIAN MANAGEMENT CONCEPTS

Active management techniques can enhance all riparian functions, including tree regeneration, creation of fish spawning areas, and providing hiding and feeding areas for wildlife. Some management approaches work together to improve ecosystem functions, while others might conflict.

To choose appropriate management techniques, you need to understand the growth and regeneration requirements (light, moisture, and protection from animals) of desired plant species, as well as how the present and future riparian area will interact with the aquatic system. It also is important to understand how to manage the diversity and density of trees and shrubs. Overstory trees can affect the structure of the area and influence their own growth as well as that of plants in the understory.

A mix of ages and types of riparian vegetation provides the greatest land and aquatic diversity and is most likely to achieve multiple ecological functions in the long term. You can manage for three kinds of diversity: plant species, horizontal structure and patterns, and vertical structure and patterns.

A mix of species–both hardwood and conifer trees and shrubs–creates a range of habitats. When establishing riparian plants, pay close attention to microsite conditions such as light and moisture. These factors are important because plants have different needs and tolerances. Chapter III-2, "Riparian Area Evaluation and Enhancement," provides a list of tree and shrub species and proper planting techniques.

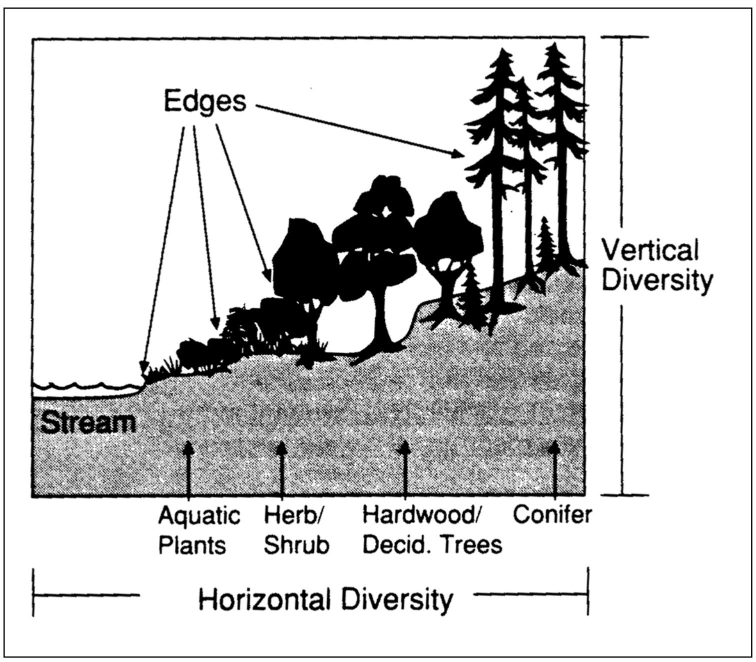

Figure 5.–A variety of riparian vegetation types contributes to horizontal and vertical diversity. (Source: Field Guide for Riparian Management, *by S. Gregory and L. Ashkenas, Willamette National Forest, Eugene, OR, 1990)*

The structural diversity of vegetation influences the quality of wildlife habitat and other functions such as nutrient and wood inputs to the aquatic system. Structural diversity has two components, horizontal and vertical (Figure 5).

Horizontal diversity refers to the patterns and structure of vegetation as you move upslope from the edge of the aquatic system. It is influenced by the types of vegetation, ranging from a variety of shrubs to different kinds of trees.

Vertical diversity focuses on the height and structure of vegetation. Vegetation types, tree ages, and structures such as snags influence vertical diversity.

Riparian management can be “active” or “passive.” *Active management* refers to creating vegetation planting sites or actually planting seedlings. Removing exotic species and planting native trees are examples of active riparian management. *Passive management* addresses the causes of riparian vegetation loss, allowing natural processes to revegetate the site. An example of a passive approach is fencing a riparian area from livestock grazing to permit natural seeding and growth of vegetation.

It is important to understand how the aquatic system might influence your riparian enhancement project. For example, an area that is subject to annual flooding probably is not suitable for establishing conifers. Similarly, a meandering channel might “move” into the riparian project area. For this reason, the project should work within the stream’s “zone of influence” and be wide enough to encompass the area where future channel changes could occur. A riparian fencing project, for instance, should consider the area of long-term channel migration.

You also need to plan for ongoing maintenance of a riparian project. Competing brush, lack of water, and animal damage can destroy your investment. Chapter III-2, “Riparian Area Evaluation and Enhancement,” provides information on riparian area maintenance.

EXAMPLES OF RIPARIAN MANAGEMENT

Regional characteristics, land-use constraints, and landowner values all influence riparian management goals (see the examples on pages 15–17). In western Oregon, riparian enhancement often focuses on the long-term goal of improving fish and wildlife habitat by establishing diverse patches of tree and shrub species. Many projects focus on converting an area dominated by hardwood trees and/or brush to a mix of conifers, hardwoods, and shrub species. These enhancement projects improve terrestrial habitat structure; shade the stream; add nutrients to the aquatic system; and, over the long term, deliver large wood to create fish habitat.

In eastern Oregon, riparian enhancement can focus on increasing the quality and variety of vegetation. In rangeland areas, riparian enhancement often focuses on management of livestock or wildlife grazing. Changing the timing and intensity of grazing usually is adequate to enhance riparian conditions. This “passive approach” to riparian vegetation management usually does not require planting trees or shrubs; with changes in grazing management,

Figure 6.—This Willamette Valley stream illustrates urban impacts on a riparian area and stream. Note the trash in the stream and blackberries growing on the bank. (Source: Cheryl Hummon, City of Albany)

abundant natural seeds usually establish native grasses, sedges, and rushes.

Urban areas, housing developments, and other developed lands along aquatic areas present challenges for enhancing riparian vegetation (Figure 6). In many urban settings, lawns and other landscaping have replaced native riparian vegetation, exotic species such as blackberries occupy stream banks, and banks are hardened with riprap and other materials to prevent erosion.

Riparian enhancement in areas around homes and other intensive use areas must take into account human needs and future uses. It should focus on improving a targeted set of riparian functions. Urban riparian enhancement, for example, can increase the width of the functional riparian area by controlling exotic weeds and planting some native trees and shrubs. These activities can improve habitat and water quality, while also creating attractive landscaping.

MONITORING FOR SUCCESS

All projects require a monitoring plan. (See Chapter III-2, "Riparian Area Evaluation and Enhancement," and Chapter II-5, "Assessment and Monitoring Considerations," for overall monitoring concepts.) Monitoring plans will tell you whether your riparian project met your original goals. They often include benchmarks, or intervals in time, when you evaluate how your project is progressing toward your goals. It is helpful to create a list of evaluation criteria in the project planning stage, so you'll know what to look for over time.

Case example: western Oregon

A low-gradient stream runs through an abandoned pasture. Brush and hardwood trees now occupy the riparian area along the upper floodplain and terraces. Although the water quality is good, channel cleaning has left very little wood in the stream channel to create pools and retain spawning gravels for native coho salmon and trout.

Resource goals: Improve fish habitat by supplying in-channel wood; enhance wildlife habitat diversity.

Riparian area functions that support the goals: Long-term large wood loading to the stream; production of wildlife habitat and food sources.

Objectives: Increase conifers, the width of the functional riparian area, and horizontal and vertical diversity.

Actions: Control brush. Where appropriate, establish patches of conifers and hardwood trees (and perhaps shrubs).

Maintenance and monitoring for success:

Set benchmarks or evaluation criteria related to goals:

- First 10 years: Thin the trees and shrubs yearly to ensure survival (see Chapter III-2, "Riparian Area Evaluation and Enhancement," for more details); evaluate tree survival.
- 10–40 years: Thin trees and shrubs as needed to provide enough space to grow the desired size classes of trees.
- 10–100 years: Thin as needed; evaluate the potential of conifers falling into the stream to provide long-term structure and refugia for fish; evaluate the mixture and survival rate of conifers, hardwoods, and shrubs and replant accordingly.

Case example: eastern Oregon

A stream with a meandering channel runs through a large ranch. The riparian area, which has been actively grazed for more than 100 years, is a mixture of grasses with some willows in a narrow band along the edge of the stream.

Resource goals: Improve habitat and water quality for salmon and trout, while continuing to graze livestock in the remaining pastures.

Riparian area functions that support the goal: Shading the stream channel to reduce stream temperatures; controlling erosion; nutrient and large wood loading to the stream for fish habitat and sediment retention.

Objectives: Increase vegetative cover and root strength near the stream.

Actions: Fence a 50-foot-wide area along the stream, extending the fence width for areas where there might be future channel meanders. Where appropriate, plant patches of willows. Allow natural seeding of native tree and grass species.

Maintenance and monitoring for success:

Set benchmarks or evaluation criteria related to goals:

- First 5 years: Periodically check fence for maintenance needs; assess whether the fence is effective in protecting the stream from livestock and allowing for meandering; check to see whether new vegetation (willows, etc.) is seeding in on its own within the fenced area; if not, plant desired vegetation.
- 5–20 years: Evaluate the presence or absence of root strength along the banks; plant more trees or native grasses or shrubs accordingly. If vegetative cover is beginning to shade the stream, start monitoring stream temperatures to see whether they are decreasing.
- 10–100 years: Evaluate the potential of conifers falling into the stream to provide long-term structure and refugia for fish and capture sediment; evaluate the mixture and survival rate of conifers, hardwoods, and shrubs and replant accordingly.

See Chapter III-3, “Livestock and Forage Management in Riparian Areas,” for additional information on riparian grazing practices.

Case example: urban area

A stream runs along the edge of a large shopping complex. The stream, once a meandering channel, is now riprapped in some areas, while other portions of the bank are actively eroding. Blackberries and other nonnative plant species dominate the riparian area. Pollution from overland runoff (oil from cars, etc.) is another concern.

Resource goals: Cool the stream; stabilize eroding banks; enhance fish and wildlife habitat; control pollution runoff; and create attractive landscaping.

Riparian area functions that support the goal: Shading the stream channel; controlling erosion; nutrient and large wood loading to the stream for fish habitat; producing habitat diversity and food for wildlife; intercepting pollutants before they reach the stream; and creating visual diversity for the public.

Objectives: Create vegetation cover and root strength on stream banks and riprapped areas; increase horizontal and vertical diversity; create attractive patterns of vegetation and view corridors.

Actions: Control exotic vegetation. Establish patches of native trees and shrubs. Plant stream banks with willows and other stabilizing vegetation. Plant dense patches of native grasses and shrubs adjacent to the parking lot.

Maintenance and monitoring for success:

Set benchmarks or evaluation criteria related to goals:

- First 5 years: Control blackberries and other nonnative plants and monitor reestablishment; assess and evaluate stream bank erosion; check whether planted trees and shrubs are successful; monitor shade levels; monitor stream water quality.
- 5–20 years: Continue to control nonnative plants; evaluate root strength along the banks; plant more trees or native grasses or shrubs accordingly; continue to monitor shade and pollution levels; evaluate wildlife habitat structure and diversity.
- 20–100 years: Monitor and evaluate erosion; plant more trees or native grasses or shrubs accordingly; continue to monitor shade and pollution levels; evaluate the potential of trees falling into the stream to provide long-term structure and refugia for fish and capture sediment; evaluate the mixture and survival rate of conifers, hardwoods, and shrubs and replant accordingly.

❖ Summary/Self review

Riparian areas are dynamic zones of interaction between upland and aquatic systems. They are influenced by soils, vegetation types, and natural disturbances such as floods and fires. Riparian vegetation varies among regions, within watersheds, and at project sites.

Landforms near the aquatic system affect riparian vegetation, which in turn influences ecological functions, such as providing large wood to the stream. These functions affect a variety of watershed processes and create key building blocks for fish and wildlife habitat and water quality.

Design management strategies to enhance ecological functions. Before setting riparian management goals, you need to understand key riparian attributes, such as requirements for plant growth and regeneration (light, moisture, and protection from animals) and how the present and future riparian area will interact with the aquatic system. It also is important to understand how to manage the diversity and density of trees and shrubs to enhance water quality and habitat for fish and wildlife.

Protecting the investment in a riparian enhancement project requires ongoing maintenance (including watering and vegetation and animal control) as well as monitoring for success.

Exercises

These exercises can be done on your own, but it's best to do them as a group so you can discuss your observations.

Riparian area exploration

Carefully explore a small section of riparian area to:

- Observe how much soil, topography, drainage, and plant composition vary over short distances
- Gain an understanding of how physical features (soil, topography, and drainage) affect plants

Visit a local stream with a large riparian area. The stream should be one that you can wade across. Make a real (perhaps with string) or imaginary (in your mind) line that crosses the stream, covers the flatter areas near the stream, and starts to go up the adjacent hillsides.

Now make a drawing of how far the soil surface is above the stream at different points along the line. It might be easiest to think of the water level in the stream as being like sea level; it marks the zero height, and the ground on either side of the stream goes up from there. It is common to discover that the soil is higher near the stream than back toward the hill slope. Can you think of a reason why?

The shape of this drawing can vary greatly among streams or even along the same stream. There might be more than one flat surface (terrace) that steps up away from the stream. There might be shallow, dry channels or wet, swampy spots far from the stream.

Now look at the vegetation, both the trees and the understory. How do they change as the elevation of the line changes. What patterns can you detect? Are some plants found most often on the stream bank, at the foot of the slope, on logs? Look for signs of wildlife. What elements in the habitat do they seem to be using?

What signs of management or other disturbance can you detect? Is the influence local or quite extensive? How have plants responded to the disturbance? How would they respond to a management activity you would do? What will this area look like in 50 years and in 100 years if left alone?

Go up the stream 100 yards and do the exercise again (or have several teams working at different locations at the same time). Do you come to the same conclusions?

Comparing riparian areas

After training your eye in the exercise above, enlarge your perspective on the variation that exists over a landscape and over time.

1. Visit several riparian areas, chosen to make contrasts between:
   - Large and small streams
   - Ponds, lakes, and wetlands
   - Aquatic systems in areas of high and low precipitation
   - Areas with similar amounts of precipitation–one that gets a lot of it as snow and one that gets little snow
   - Streams of similar size within different land uses: forestry, agricultural, and urban
2. Visit the same riparian area at several times of the year. It certainly will have more water during the wet season than during the dry season. But look more carefully:
   - Following a rainstorm, are there new wet areas in the riparian area?
   - At high flow, where does the water go besides in the main channel? How fast does it move on the floodplain compared to in the main channel?

RESOURCES

Training

Contact your local office of the Oregon Department of Forestry, the Oregon State University Extension Service, and the Natural Resources Conservation Service.

Information

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“A sustained-yield scheme for old-growth Douglas-fir,” by M. Newton and E. Cole, *Western J. Applied Forestry* 2(1):22–25 (1987).

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MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself, your land management agency, your watershed group, etc. ahead in improving your understanding of riparian area functions and management.

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Riparian Area Evaluation and Enhancement

John Runyon
and Tara Nierenberg

Riparian area enhancement projects are an important part of improving watersheds. They are fun to do as a group and great projects for volunteers. Don't let the ease of implementing these projects fool you, however. Projects that don't take into account riparian area and aquatic system conditions and functions have a high failure rate.

Chapter III-1, "Riparian Area Functions and Management," provides a firm foundation in riparian management and should be used with this chapter. Chapters II-1, "Planning for Watershed Restoration," and II-5, "Assessment and Monitoring Considerations," contain other important information that will help you plan riparian area projects.

The purpose of this chapter is to provide a basic understanding of riparian area evaluation, enhancement projects, and monitoring plans. It introduces basic principles used in statewide approaches such as the *Oregon Watershed Assessment Manual.*

Riparian evaluation involves understanding and appraising present ecosystem conditions and functions. *Enhancement* techniques change present conditions and "speed up" ecosystem processes to achieve specific goals. *Monitoring* evaluates change over time and lets you know whether you are achieving the desired riparian functions.

In this chapter you'll learn:

- Basic components of riparian area assessment and evaluation
- How to evaluate riparian functions as a first step in developing enhancement goals
- Features of common assessment methods and how to obtain these methods
- Common goals of riparian enhancement projects
- How to choose the right riparian vegetation for a given location
- Methods for establishing and protecting vegetation
- Basic components of a riparian monitoring plan

The first step in defining riparian enhancement goals is to evaluate the area. You need to determine which ecosystem functions are in place, which are missing or operating at reduced levels, and what conditions and functions are possible in the future. (See Chapter III-1, "Riparian Area Functions and Management," for more information.) Once you have evaluated the riparian area's functions and created management goals, you can begin to plan your project. To maximize success, you'll need to understand five things about the riparian area:

- Its present condition and the status of riparian functions
- Its potential to support the desired ecosystem functions now and in the future
- Its proposed future riparian functions
- How to enhance the area to reach the proposed functions
- How to monitor change over time to judge whether the area is reaching the proposed functions

See Section I, Chapter 2; Section II, Chapters 1 and 5; and Section III, Chapters 1 and 3 for information related to this chapter.

Section I

2 Group Structure

Section II

1 Planning

5 Assessment

Section III

1 Riparian Functions

3 Livestock

EVALUATING PRESENT CONDITIONS AND FUNCTIONS

Riparian *conditions* are traits that describe what we see in a riparian area and its interaction with the stream channel at a specific time. Examples include: "50 percent conifers; a pool-to-riffle ratio of 1:2; little large woody material in the stream; moderate daytime stream temperature, incised stream banks."

Riparian *functions* (also known as *processes)* have to do with *how* the conditions are working or contributing to the ecosystem; they are something that is "happening." For example, trees in a riparian area can provide the aquatic system functions of shading, wood loading, bank stability, and nutrient cycling. Functions do not necessarily change in time or space. One way to think about these two terms is to say we manage *conditions* to provide *functions*.

An assessment is the first step in establishing a riparian area that meets your goals for riparian functions and provides maximum benefits to fish, wildlife, water quality, and humans. It quantifies and summarizes the condition of the riparian area. For example, an assessment describes the types, sizes, and patterns of trees and other vegetation. Evaluating this information helps you see how the riparian conditions influence the key functions related to fish and wildlife habitat and water quality.

Chapter III-1, "Riparian Area Functions and Management," discussed the basic parts and functions of a riparian area. Some of the functions include:

- Supplying nutrients and woody material to the stream
- Filtering and holding sediment during floods
- Improving floodwater retention and groundwater recharge
- Providing shade to the stream
- Serving as a home for many types of plants and animals
- Keeping stream banks stable

Different kinds of information are necessary to evaluate each of these functions. Information on tree size, species, and location, for example, is needed to evaluate the potential of the riparian area to contribute large wood to the aquatic system.

Table 1 lists the basic parts of a riparian area assessment.

Table 1.—Basic components of a riparian area assessment.

Vegetation	Soils	Landscape/river channel
Species present and diversity	Soil type	Size and locations of floodplain and other streamside surfaces (terraces, hill slopes, etc.)
Age and size diversity	Percent of bare ground (e.g., is stream downcutting?)	Access to floodplain
Plant vigor	Percent organic matter or duff	Riparian area growing or shrinking
Plant survival	Erosion or deposition occurring	Beaver dams or log jams present
Root density	Bank stability (i.e., presence of excessive erosion)	
Percent canopy cover (shade)	Ease of water movement through soil (i.e., soil compaction)	
Changes occurring in the plant community		
Future sources of large, woody material for the stream		

CONSIDERATIONS WHEN CHOOSING AN ASSESSMENT

There are many methods for assessing riparian areas. They differ mainly in their level of detail. Landowners and others can perform some assessments with a little guidance and some basic equipment, while other assessments require training.

Your objectives will determine the appropriate assessment approach. The central issue to consider is, "How will the information be used?"

A related question is, "At what scale will the information be useful?" Riparian assessments usually are designed to answer questions at a specific scale: the site, the watershed, or the larger landscape. The *Oregon Watershed Assessment Manual,* for example, describes a watershed-scale riparian assessment protocol. For project-specific planning, however, your assessment must answer questions about a specific site. Examples include a detailed vegetation inventory or shade assessment.

Also consider whether the information will be used in a watershed assessment or combined with state or federal agency information, such as stream surveys or other inventory efforts.

The first step is to list the questions you want to answer based on your overall resource goals. Table 2 provides examples of questions for different scales of assessment. A question for a basic assessment could be, "What is the current and future potential for delivery of large wood into the stream channel given the current conditions of riparian trees?" This question can be assessed at a watershed scale and/or a site scale (e.g., one property owner's land or one stream reach).

Make sure the assessment provides enough information to answer your questions. Before conducting the assessment, review the types of data that will be gathered. Find examples of data gathered with the methods you propose to use.

The first step is to list the questions you want to answer based on your overall resource goals.

Whether you are looking at an entire watershed or a site, it is important to divide the riparian area into manageable assessment units. This will give you more flexibility to use the data for planning enhancement projects and management changes.

Some ways to divide riparian areas include:

- Land use or management
- Riparian condition (areas of nonriparian vegetation versus those with appropriate riparian species)
- Type of stream (small versus large, flows year-round versus only during storms)

- Valley type (wide floodplain versus steep canyon)
- Landform adjacent to the aquatic system (active channel, floodplain, terrace, hill slope)
- Resource values (various types of fish, water use, etc.)

Because a riparian area and its aquatic system influence each other, it is useful to classify both the stream channel and the riparian area based on characteristics of the surrounding landscape and stream network. A useful approach, described in the *Oregon Watershed Assessment Manual*, is to classify a watershed into Channel Habitat Types–stream segments with similar stream size, valley form, and gradient. See Chapter III-5, "Stream Assessment and Restoration," for more information.

Table 2.– Examples of riparian assessment and evaluation questions at the project and watershed scales.

Project or stream reach scale

- What is the potential for current and future delivery of large wood into the stream channel given the current condition of riparian trees?
- How do the numbers and species of trees and shrubs at the project site compare to other sites in the same ecoregion with similar landforms (floodplain, terraces, hill slope) but different management regimes?
- What is the current and future potential for shade over the stream channel?
- What are the current and future wildlife habitat characteristics within the riparian area, especially multilayered canopies and snags?
- Are the quantities or kinds of riparian vegetation on the banks contributing to ongoing erosion or channel movements?
- Are exotic plant species such as blackberries preventing the establishment of native trees and shrubs in the riparian area?

Watershed scale

- What is the width and composition (hardwoods, conifers, shrubs, etc.) of riparian vegetation along streams in the watershed?
- What percentage of riparian areas in the watershed are dominated by invasive plant species such as blackberries?
- On what stream types (valley bottom, headwater, etc.) are older conifer trees present?
- On what stream types (valley bottom, headwater, etc.) are invasive plant species present?
- What percentage of riparian areas in the watershed have older conifer trees that will contribute wood to stream channels? Where are these riparian areas?
- What percentage of streams in the watershed have high levels of canopy cover (over 70 percent) and riparian shade?

EXAMPLES OF COMMON ASSESSMENTS

This section introduces common riparian assessment methods. Its purpose is to familiarize you with these methods and provide a basis for future training. This brief discussion isn't intended to be a guide for conducting assessments; to use any of these assessments, you'll need to obtain the listed resources.

Overview of riparian conditions

The *Oregon Watershed Assessment Manual* describes a riparian assessment that provides an overview of riparian conditions throughout a watershed. This method provides information on key riparian functions, especially potential large wood delivery, aquatic shade, and wildlife corridors. Combining aerial photos with limited field verification, this method characterizes:

- Current riparian area width
- Vegetation types (hardwood, conifers, brush, grass, or no vegetation)
- Tree size classes
- Tree stand density (dense, sparse, or nonforest)

The collected information on vegetation types is compared to potential conditions for the ecoregion. This information, combined with stream sizes and types (based on valley type and channel confinement), provides a foundation for understanding riparian protection and enhancement opportunities throughout the watershed. It highlights areas for more detailed ground-based assessments designed to determine site-specific management approaches. For example, a terrace area occupied by blackberries, but with potential to support coniferous trees, might be the focus for a riparian enhancement project.

To obtain the *Oregon Watershed Assessment Manual*, call OWEB (503-378-3589) or visit their Web site: http://www.oweb.state.or.us/publications/index.shtml

Stream shade and canopy cover

Many riparian enhancement projects are designed to increase canopy cover over the stream to provide shade and cool water temperatures. *Stream shade* is the amount of solar energy obscured or reflected by vegetation. *Canopy cover* is the percent of the sky covered by vegetation or topography.

The *Oregon Water Quality Monitoring Technical Guide Book* (Oregon Plan, 2000) describes approaches for assessing stream shade and cover at three scales: project or reach, watershed, and landscape or regional. To obtain the *Oregon Water Quality Monitoring Technical Guide Book,* call OWEB (503-378-3589) or visit their Web site: http://www.oweb.state.or.us/publications/index.shtml

Project-level assessments

Many types of basic assessments gather information at the project level. For example, a landowner might want to evaluate a riparian area and make management changes, or a watershed group might want to gather information about possible project sites.

An example is the Rangeland Watershed Program, created by the University of California Cooperative Extension. Its purpose is to help ranchers develop farm plans that address the needs of riparian areas, streams, and water quality. A rancher observes a stream and riparian area and then bases management practices on these observations.

Appendix A shows the evaluation sheet used for the Rangeland Watershed Program assessment. It 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. For more information, contact the Rangeland Resources Department at Oregon State University (541-737-3341).

DETERMINING THE CAPACITY TO SUPPORT DESIRED ECOSYSTEM FUNCTIONS

It can be challenging to determine a riparian area's capacity to support ecosystem functions. Riparian conditions are always changing, both across the watershed and through time. For example, there might be very few overstory trees following a disturbance (fire, flood, etc.), but many a few years later. Change is influenced by many factors, including climate, soil types, and management history.

One way to think about the range of possible conditions in a given area is to look at *reference sites*. A *reference site* is a riparian area with similar climate, landforms, stream gradients, soils, and vegetation types.

Of course, no two sites are exactly the same since no two areas experience the same disturbance patterns, fire history, and management. Thus, reference sites do not necessarily represent the ecological capability of a similar area and should not be thought of as models to copy. Instead, they can provide ideas for resource goals and give you a feel for the range in variability for traits such as vegetation types. A reference site can be one piece of information to help you understand which riparian ecosystem functions are in place and which are missing or operating at reduced levels. Reference sites are most helpful when considered on a stream-wide or watershed scale rather than on a site-level scale.

To be useful, the reference information should be relevant to the local ecosystem (stream size, geology, climate, landscape, etc.). Not all riparian areas in the same watershed work the same way. For example, a riparian area along a small Coast Range stream provides large wood to create pools and shade. In contrast, one along a large river improves stream stability and provides cover for fish during high flows.

A good source of information about riparian vegetation and reference sites is the *Oregon Watershed Assessment Manual's* Ecoregion Descriptions (Watershed Professionals Network, 1999 and 2001). They outline potential riparian vegetation (deciduous and conifer trees and shrubs) and vegetation patterns relative to the stream channel and valley form (wide or narrow floodplain, etc.). If reference sites are not available, reference conditions are based on historic conditions found in aerial photos, maps, books, pictures, and local knowledge.

Ecoregion descriptions can help you identify what riparian vegetation would be present in the absence of human-caused disturbances (tree removal, grazing, road or building construction, etc.). However, remember to take into account site-specific conditions and constraints, such as a section of bank that is too wet to support certain trees. Also, remember that historic conditions are not meant to be copied. They simply can give you a broader understanding of what might be possible at a stream or watershed scale.

DEFINING FUTURE RIPARIAN FUNCTIONS

Proposed conditions are the composition and structure of riparian area vegetation that will maximize the area's potential to perform desired ecological functions. Proposed conditions must be within the area's capacity. Reference site information, while not establishing absolute conditions, can help you develop a range of desired future conditions for your site.

Project goals and objectives define the proposed future conditions of the riparian area. A goal is the overall aim of the project, while objectives are a subset of the goal and are measurable. One goal can have many objectives. Goals and objectives of a sample project are shown in Table 3. See Chapters I-2, “Choosing Your Group’s Structure, Mission, and Goals,” and II-1, “Planning for Watershed Restoration,” for more information on setting goals and objectives.

Key issues to consider when establishing riparian enhancement goals include:

- What ecological functions are missing? For example, exotic plant species such as blackberry might be preventing tree establishment and thus limiting shade over the stream and long-term inputs of large wood.
- How long will it take for the functions to begin operating at a level that is within the range seen at similar sites within the ecoregion? Some functions, such as providing wildlife habitat (shrubs and other vegetation), might be achieved relatively quickly. Others, such as contributing large wood to the aquatic area, might take decades to recover completely.
- Will some ecological functions never recover? For example, upriver dams might limit flood flows that would enable flood-dependent riparian vegetation to recolonize naturally.

The following case studies build on those in Chapter III-1, “Riparian Area Functions and Management.” In this instance, they show ways to evaluate riparian functions and identify desired future conditions. The results can be used to develop resource management goals and site-specific management plans.

Table 3.– Sample goals and objectives.

Goal: Improve water quality to support cold-water fisheries by increasing riparian shade over the stream.
Objective: Increase riparian vegetation density and shade to help lower average daily stream temperatures to below 64°F during the summer.
Goal: Improve stream bank cover and stability to decrease bank erosion.
Objective: Increase vegetative cover on stream banks so that 80–90 percent of the banks are rated as covered and stable.

Source: *Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams,* by S. Bauer and T. Burton (Idaho Water Resources Research Institute, University of Idaho, Moscow, 1997).

Case example: western Oregon

A low-gradient stream runs through an abandoned pasture. Brush and hardwood trees occupy the riparian area along the upper floodplain and terraces. Although the water quality is good, past channel cleaning has left very little wood in the stream channel to create pools and retain spawning gravel for native coho salmon and trout.

Riparian assessment question: What is the current and future potential for delivery of large wood into the stream channel given the current conditions of riparian trees?

Assessment approach: Collect information on the distance of trees from the stream channel, tree species (especially conifer versus hardwood), tree height, and streamside surfaces (floodplain, terrace, hill slope, and others).

Evaluation of the information: Most of the riparian area is in brush and small hardwood trees, with little potential to supply large wood to the stream channel now or in the future. Based on conditions in similar areas in the ecoregion, the site should be able to support conifer trees, especially on the terraces and hill slope.

Defining future conditions: In the future, the riparian area, especially within 200 feet of the stream, will support a diverse mix of conifer trees (Douglas-fir, cedar, and hemlock), providing large wood to the aquatic system.

Case example: eastern Oregon

A stream with a meandering channel runs through a large ranch. The riparian area, which has been actively grazed for more than 100 years, is a mixture of grasses with some willows in a narrow band along the stream bank.

Riparian assessment question: What is the current and future potential for shade over the stream channel?

Assessment approach: Collect key information about the distance of shrubs and trees from the stream channel, shrub and tree species, tree height, and streamside surface (floodplain, terrace, hill slope, and others). Measure effective shade and canopy cover over the channel.

Evaluation of the information: Most of the riparian area is in a narrow band of willows, resulting in very little current or future shade over the stream channel. When compared to similar areas in the ecoregion, the site should be able to support a diverse mix of hardwood and conifer trees within 50 to 100 feet of the stream channel, providing 70 percent effective canopy cover over the stream.

Defining future conditions: In the future, the riparian area, especially within 50 feet of the stream, will support a diverse mix of conifers, hardwood trees, and shrubs. The vegetation will shade the stream channel and provide 70 percent effective canopy cover over the channel.

RIPARIAN ENHANCEMENT PROJECTS

Sometimes enhancement projects provide short-term fixes, such as creating a pool deep enough to sustain the current year's trout fry. However, the ultimate goal is the restoration of a dynamic equilibrium that no longer requires human intervention. (See Chapter III-5, "Stream Assessment and Restoration.") The most common goal of riparian enhancement is to restore native vegetation and the width of the riparian area to increase ecosystem functions for fish and wildlife habitat, water quality, and other values.

The riparian management area includes the riparian area itself as well as the land influencing this area and the stream. (See Chapter III-1, "Riparian Area Functions and Management.") Any area that affects stream water quality is a candidate for enhancement. For example, many non-fish-bearing streams play an important role in providing cool, clean water. Increasing shade reduces solar input to these streams and might reduce water temperatures downstream.

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. Trees in these areas can be the main source of large wood in some streams.

The ultimate goal is the restoration of a dynamic equilibrium that no longer requires human intervention.

The right species for the right site

Riparian vegetation varies throughout Oregon based on local climate, soils, geology, and topography. Choosing vegetation adapted to your project site is crucial for success.

Riparian tree and shrub species vary in how well they tolerate flooding or shade. Understanding these differences is critical to choosing where to plant trees and shrubs in riparian areas. Plant trees that tolerate floods closer to the stream; plant those that don't tolerate periodic flooding above the annual flood line. For example, willow trees tolerate floods and generally grow next to streams, while Douglas-fir don't tolerate floods and usually grow farther from streams.

Trees that tolerate shade generally survive better beneath other trees than do less shade-tolerant species. Douglas-fir don't tolerate shade, while redwood and hemlock do.

Table 4 lists common species for western Oregon riparian areas and their associated tolerances. Table 5 lists common riparian species found in eastern Oregon, but does not indicate tolerance for floods or shade. For the most part, shrubs and deciduous trees (e.g., cottonwood) grow close to streams, while conifers

Table 4.–Common tree and shrub species in western Oregon riparian areas and their associated tolerance to flood and shade.

Species	Tolerance to flooding	Tolerance to shade
Conifer trees		
Douglas-fir	Low	Low
Ponderosa pine	Medium	Low
Redcedar	Medium	Medium
Redwood	High	High
Spruce	Medium	Medium
Shore pine	Medium	Low
Hemlock	Low	High
White fir	Medium	Medium
Hardwood trees		
Willows	High	Low
Alders	Medium	Low
Poplars	Medium	Low
Bigleaf maple	Medium	Medium
Vine maple	Medium	Medium
Dogwood	Low	High
Ash	High	Medium
White oak	Medium	Low
Black oak	Medium	Low
Hawthorn	Low	Low
Wild pear	High	Low
Cascara	Medium	Low
Cherry	Medium	Low
Oregon myrtle	Medium	Medium
Shrubs		
Salmonberry	High	Low
Serviceberry	Medium	Medium
Snowberry	High	High
Spirea	High	Low
Vine maple	Medium	High
Indian plum	High	medium
Hazel	Low	Medium
Thimbleberry	Medium	High
Devil's club	High	High
Stink currant	High	High
Ninebark	Low	Medium
Red-osier dogwood	High	Low
Fool's huckleberry	Medium	Low
Red huckleberry	Low	High
Mockorange	Medium	Low

Table 5.–Common tree and shrub species in eastern Oregon riparian areas.

Species
Conifer trees
Douglas-fir
Ponderosa pine
White fir
Lodgepole pine
Englemann spruce
Hardwood trees
Willows
White alders
Black cottonwood
Quaking aspen
Shrubs
Snowberry
Vine maple
Douglas spirea
Mountain alder
Sitka alder
Bitterbrush
Bog blueberry
Wax currant
Water birch
Osier dogwood
Shrubby cinquefoil
Hawthorn

Source: *Oregon Watershed Assessment Manual*: Appendix A, Ecoregion Descriptions (Governor's Watershed Enhancement Board, 2001) (e.g., ponderosa pine) grow best in areas with lower soil moisture and less flooding.

Additional information about native trees is available from the Oregon Department of Forestry (ODF) and OSU Extension Service.

Planting seedlings

Many publications explain how to buy, store, and plant seedlings. However, most apply to nonriparian forest and agricultural land that has been cleared and prepared for planting.

Riparian areas can have severe soil conditions. They 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 and shrubs in these areas, you're most likely to be successful if you use superior nursery stock (large, healthy, vigorous trees and shrubs) and prepare the site as much as possible.

The following suggestions generally work in western Oregon. However, contact your local OSU Extension agent and ODF representative for proper tree planting and site preparation methods for your area.

Auger planting can be successful where the ground is hard and it's difficult to plant seedlings properly. However, it is more expensive and time-consuming than planting with a hoe or shovel.

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. When planting trees in an already-forested riparian area, spacing can be wider since soil conditions usually are less severe.

Clear grass and brush from around the seedlings. Scalping the surrounding grasses will reduce competition for water and give trees an additional boost during the first spring.

Some people have been very successful planting trees on agricultural lands and providing irrigation in the summer.

You're most likely to be successful if you use superior nursery stock (large, healthy, vigorous trees and shrubs) and prepare the site as much as possible.

Planting willows

Many agricultural riparian areas need total conversion from grass to trees. Willows often are used to stabilize stream banks and begin the conversion process. Willows, cottonwoods, and some other hardwoods sprout readily from stumps and clippings. There is a variety of ways to plant them. These methods are called *bioengineering*, which means using vegetation and rock to restore stability to a site (usually a stream bank, hillside, or road cut).

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 local conditions. If you must cut willows from a riparian area, be sure to leave enough to maintain the existing stand.

The most common failure in planting willows is placing them in sites with inadequate water. Willows like to have their feet wet. Best success occurs when dormant willows are cut and planted in the winter, but this is the hardest time of the year to plant due to flooding. You can successfully cut and plant willows on a year-round basis if water is available (rain or irrigation). Success is lowest when willows are cut while flowering.

Always plant willows within a few hours of cutting. Keep them wet and cool until planted.

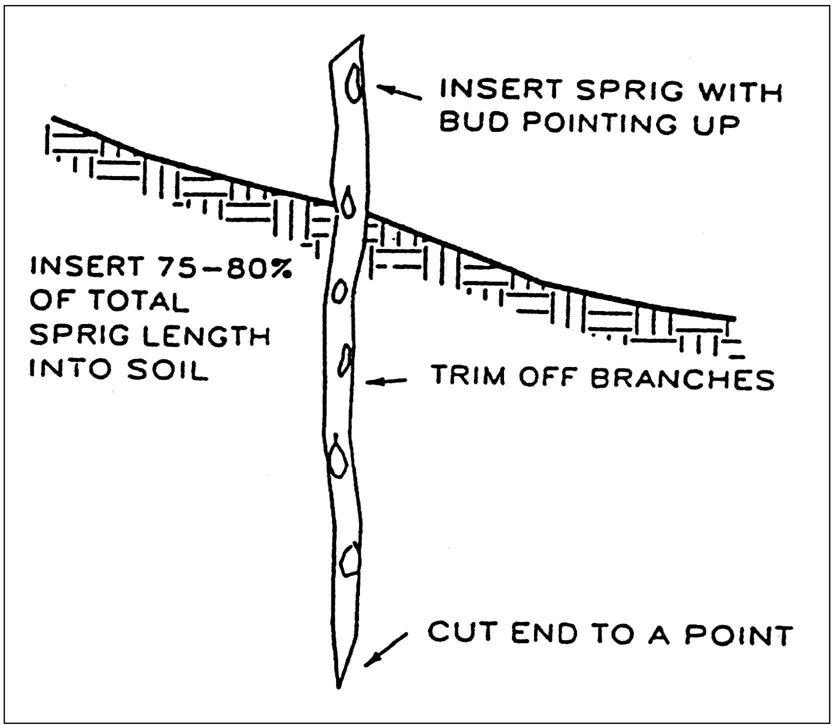

Figure 1.–Planting willow cuttings (also known as stakes, sprigs, etc.). (Source: Engineering Field Handbook, *Natural Resources Conservation Service, 1996)*

Hand planting

Willow branches (less than 2 inches in diameter) can be planted with a bar or shovel. You'll probably be most successful if you use branches more than 1 inch in diameter and plant 70–80 percent of the willow into the ground (Figure 1).

Planting larger willow stakes or cuttings with a sledgehammer is a very common and highly successful method. Stakes are 3–4 inches in diameter and 3–4 feet long. Sharpen each stake to a point on one end and pound it into the ground with a large wide-head sledgehammer to minimize splitting.

Other common planting methods include willow mattresses, fascines, willow baffles, and willow bundles (Figures 2–5). The Natural Resources Conservation Service has an *Engineering Field Handbook* describing these techniques (see "Resources").

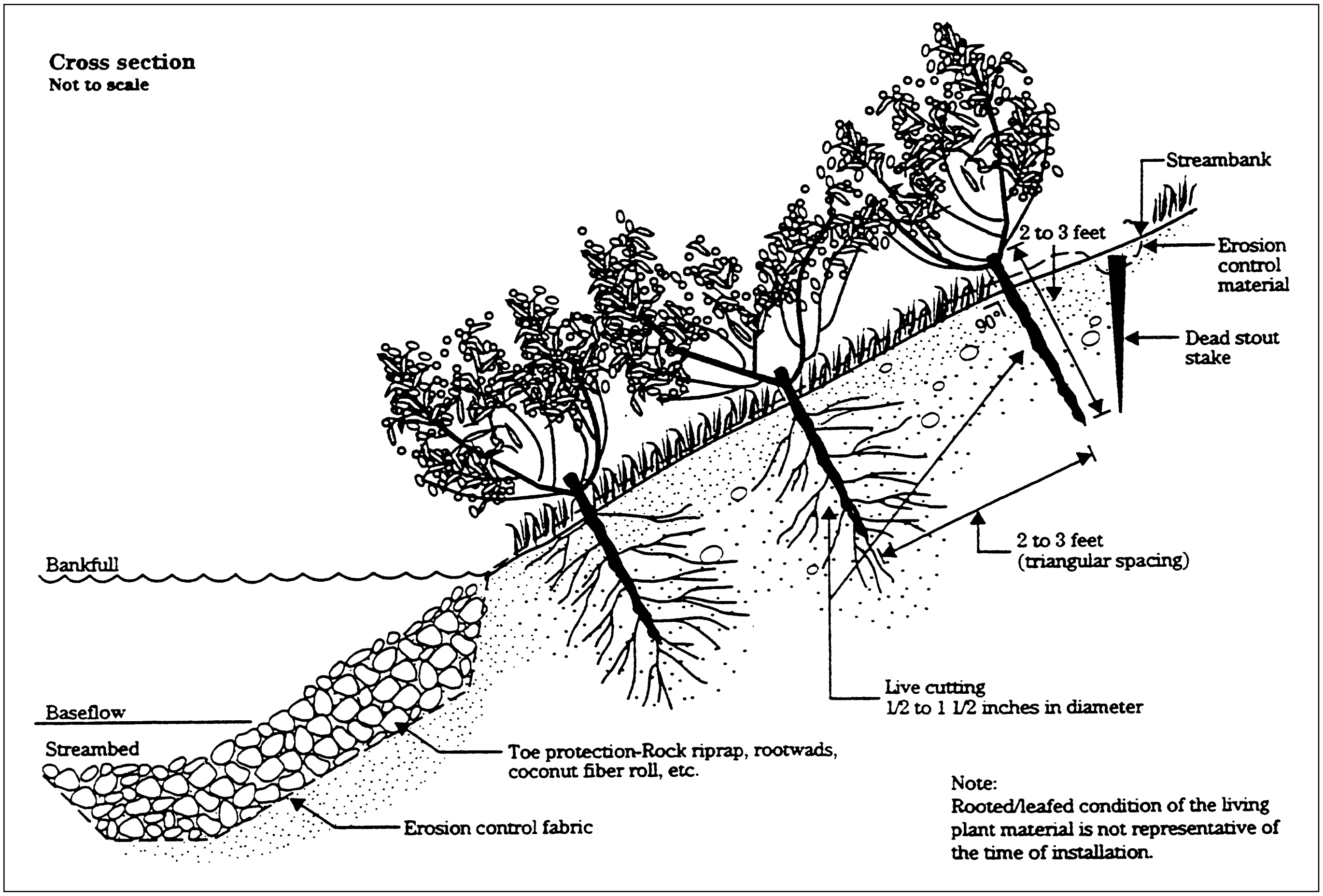

Figure 2.–Live willow stakes. (Source: Engineering Field Handbook, *Natural Resources Conservation Service, 1996)*

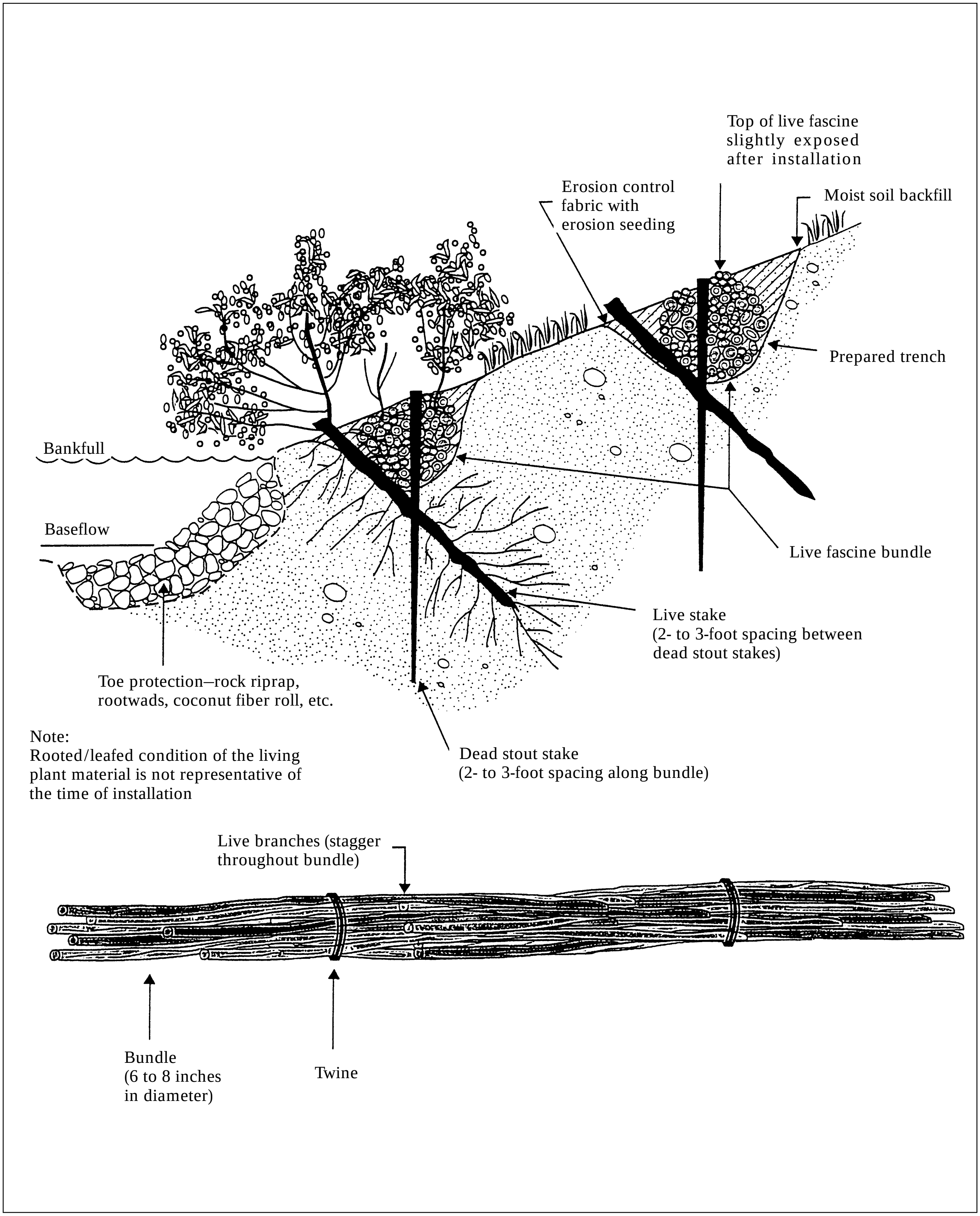

Figure 3.–Live fascine. (Source: Engineering Field Handbook, *Natural Resources Conservation Service, 1996)*

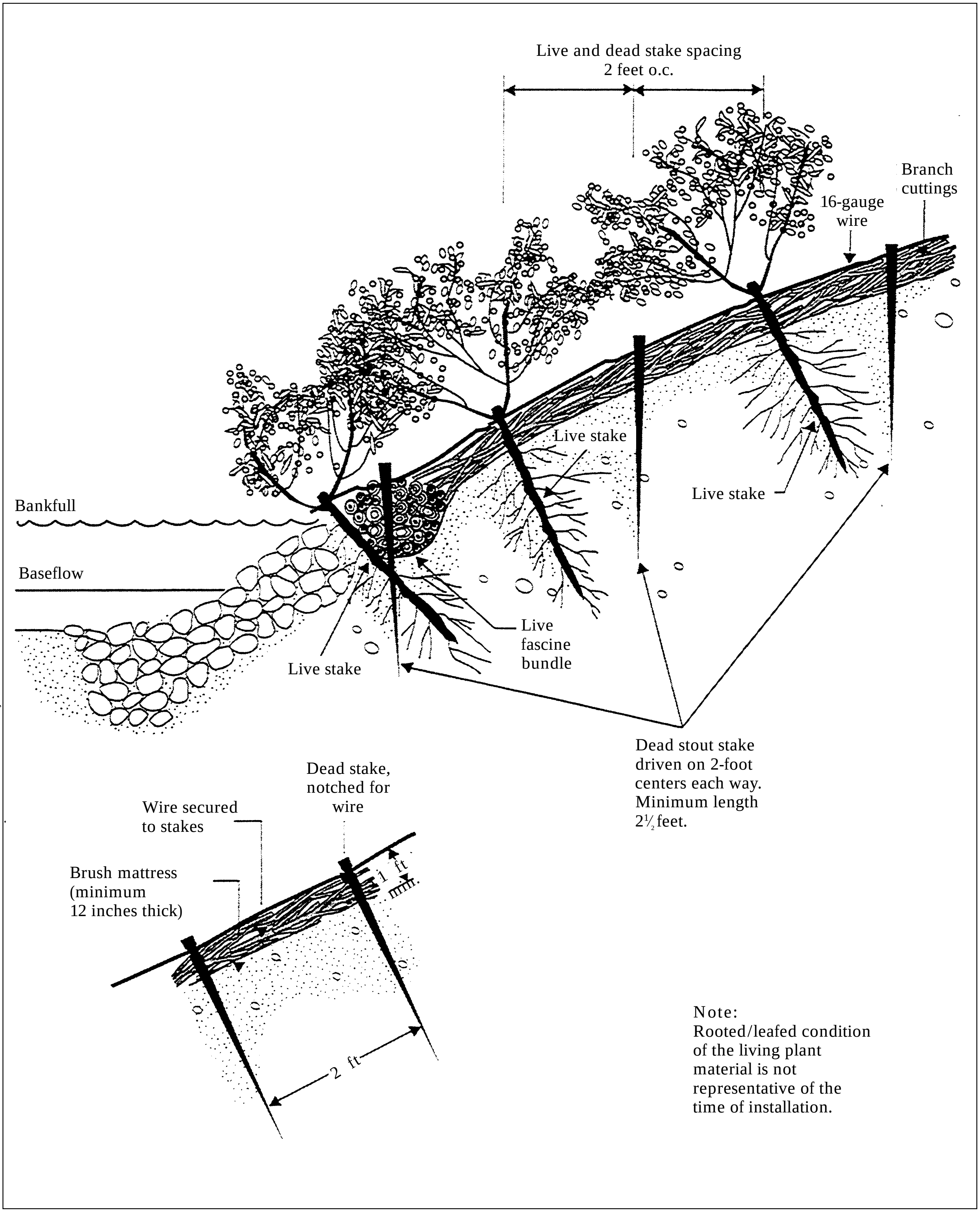

Figure 4.–Brush mattress. (Source: Engineering Field Handbook, *Natural Resources Conservation Service, 1996)*

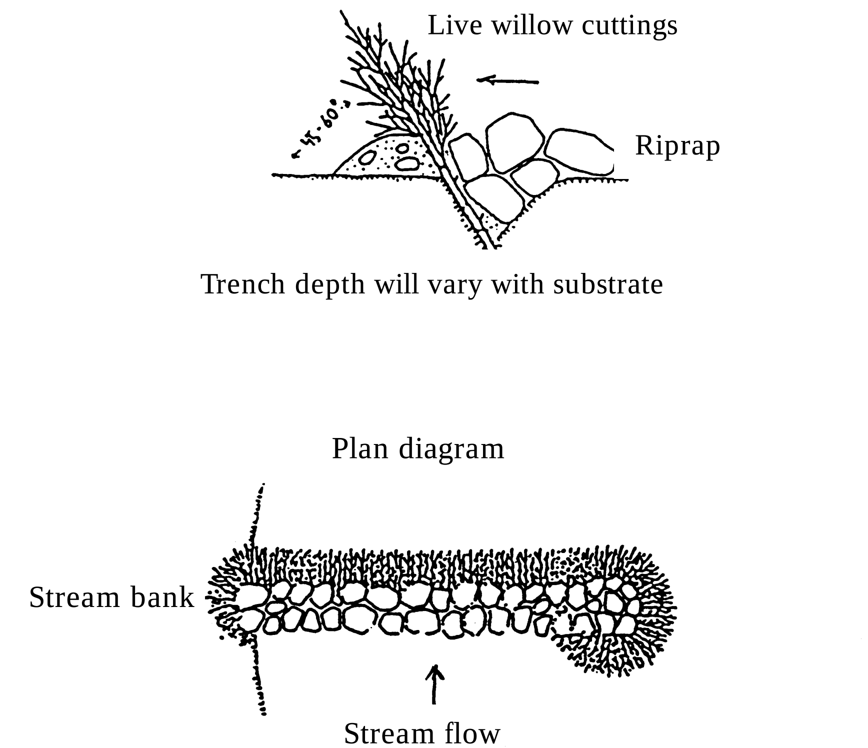

Figure 5.—Live siltation baffle (willow baffle) (also known as stakes, sprigs, etc.). (Source: Engineering Field Handbook, *Natural Resources Conservation Service, 1996)*

Machine planting

Machine planting willows often increases the success rate and the area that can be planted in a short amount of time. One method involves cutting large willow stakes (more than 3 feet long and more than 3 inches in diameter), cutting a point on the bottom end, and pounding them into the ground with a machine (for example, a backhoe, excavator, or front end loader). A similar method uses a machine called a stinger to create a hole and then pound the willow into the ground. Another method is to dig out a whole willow tree with a front end loader or excavator and transplant it to another site. This method works well for establishing an extensive root system in a short time.

Releasing conifers

Some riparian areas lack species diversity. They might, however, have young, healthy conifers in the understory of hardwood trees or brush. The conifers might 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 also is popular. This method uses an aerial herbicide spray, manual spray, or "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.

Protecting your investment

Once you have planted your riparian trees and shrubs, your work is not over. Protecting your investment is hard work. Competing vegetation, animal browsing, or lack of water can quickly destroy the vegetation.

The time to think about maintenance is during project planning. The key issues to consider include:

- **Watering:** New tree seedlings and shrubs require adequate moisture. Many planting sites have coarse soils and experience dry periods. Clearing vegetation from a 3-foot-diameter circle around the base of seedlings reduces competition for water. In some cases, it might be necessary to irrigate. A drip system is one option. Watering might have to continue for several years until root systems are extensive enough to access adequate moisture.
- **Vegetation control:** Competing brush can reduce available sunlight and water. It must be controlled until the trees grow above it–usually for about 5 years. Thereafter, thinning often is used to maintain or increase rates of tree diameter growth. Heavy thinning, beginning when trees are young, can produce very large trees in a relatively short time. These trees can be important for both wildlife habitat and in-stream structural material. Thinning also is a way to maintain the understory, by allowing more light to reach the forest floor.
- **Animal control:** Browsing by deer, elk, livestock, and other animals can affect seedling survival. A common way to protect trees and shrubs from livestock grazing is to fence the 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*. Seasonal grazing systems also can work in riparian areas. Wildlife, livestock, and floods can damage fences, so it is important to plan for periodic inspection and repairs. See Chapter III-3, "Livestock and Forage Management in Riparian Areas," for more information.

  Tree protectors over seedlings can reduce wildlife browsing. Wrapping the base of seedlings with aluminum foil can protect them from rodents. For beaver protection, install hawk wire 3 or 4 feet above ground level and chicken wire bent up like an L 2 feet above ground; plant in clusters. Beavers will travel more than 100 feet from a stream. Tubex (solid plastic tubes) can deter beavers–especially for hardwoods–but you'll need to sink them well into the ground to prevent a hot, chimney effect.

  You might want to live-trap mountain beavers.

MONITORING PLANS

Why do we need a monitoring plan?

A monitoring plan is essential for assessing the success of riparian area enhancement projects. Monitoring information will demonstrate whether you are on track or have met your goals. For example, are you establishing the quantities and kinds of riparian vegetation that will enhance functions such as shading and contributions of large wood to the aquatic system?

Monitoring can keep you from repeating mistakes and justifies the investment of resources in your projects, whether private or public. If monitoring shows the enhancement projects have not established the proposed condition, a new approach should 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. Vegetation photo points are an example. Other monitoring plans include a formal explanation of the assessment, proposed project, and monitoring techniques.

A monitoring plan contains four main components:

- Goals and objectives of the enhancement project
- The monitoring questions
- Specific monitoring techniques and factors (*parameters*) to be measured to answer the monitoring questions
- A process to evaluate whether goals and objectives are being met. Based on this evaluation, you'll decide whether you need to change monitoring techniques and/or measured parameters.

It is important to ask monitoring questions relevant to your goals. The monitoring questions should be specific enough to provide guidance on what information to collect. A question such as "Did the riparian enhancement project improve wildlife habitat?" is too general. A better question is "Will the surviving shrubs and trees create multiple canopy layers over the next 5, 10, 15, and 20 years?" Table 6 shows examples of monitoring questions.

Many monitoring plans establish intermediate desired conditions (benchmarks) between the present and desired future condition. For example, the volume of large wood will increase over time after tree planting. Intermediate benchmarks would be the desired large wood volumes at years 10, 25, 50, 75, and 100. Effective monitoring requires a long-term commitment!

Chapter II-5, "Assessment and Monitoring Considerations," discusses the basic types of monitoring, including trend, baseline, implementation, effectiveness, project, validation, and compliance monitoring. It also describes several monitoring designs such as reference area, paired watershed, above and below, and before and after.

Most riparian monitoring techniques assess conditions over time. Thus, this chapter's section on assessments also applies to monitoring. The major difference between assessment and monitoring is that monitoring generally focuses on specific parameters related to an enhancement project and tracks trends over time. For example, you 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.

Considerations when creating a monitoring plan

Monitoring techniques must be appropriate for your group. Consider factors such as cost, technical requirements, available equipment, and access.

Monitoring plans should identify enhancement projects to reach the proposed condition. If objectives are not being met, the monitoring plan identifies factors causing the problem and alternative projects to meet objectives.

This chapter's section on "Considerations when choosing an assessment" also relates to monitoring plans.

Example of a monitoring plan

In addition to the basic components mentioned above, most monitoring plans include information obtained from the initial assessment and describe proposed enhancement projects. Here's an example of a riparian monitoring plan.

Assessment of present conditions

Existing condition/limiting factors: Excessive fine sediment in the stream has reduced salmon spawning habitat.

Probable cause: An initial assessment in the degraded spawning areas noted that bank stability is reduced significantly in some grazed areas, leading to increased erosion. Plant species composition is quite different from that at reference sites and from the site's potential.

Table 6.–Examples of riparian monitoring questions at the project scale.

- What percentage of the planted trees and shrubs are surviving after 1, 2, 5, and 10 years?
- Where are the different species of planted trees and shrubs surviving (floodplain, terrace, etc.)?
- What kind of management (watering, vegetation control, etc.) did the surviving planted trees and shrubs receive?
- Will aquatic shade levels increase as a result of removing brush and planting trees?
- How much will aquatic shade levels increase over the next 5, 10, 15, and 20 years?
- Will the surviving shrubs and trees create multiple canopy layers over the next 5, 10, 15, and 20 years?
- Is the planted vegetation reducing stream bank erosion?

Goals and objectives

Goal: Improve stream bank cover and stability to decrease bank erosion.

Objective: Increase trees, shrubs, and native grass vegetation on stream banks so that 80–90 percent of the banks are rated as covered and stable.

Monitoring question: What is the percent of stabilizing vegetation on the stream banks at 1, 5, and 10 years?

Enhancement practices/management changes implemented

Short-duration late spring grazing by limited numbers of cattle might allow desired vegetation to recover. As a result, banks should be strengthened, and there should be less fine sediment in the stream. Grazing management was modified to include riparian pastures, temporary electric corridor fencing, hardened access points, and pasture rotation. Riparian pastures are grazed for a short time in late spring.

Monitoring techniques and parameters measured

The area will be monitored as follows:

- Canopy cover, plant species composition, and percent eroding stream banks will be measured seasonally.
- Photos will be taken at permanently established photo points at least once a year to give a general view of stream bank recovery and vegetation changes.
- Regularly scheduled aerial photos will be taken to show major vegetation changes. If possible, copies will be made of photos borrowed from county road and planning departments, resource agencies, etc.
- Permanent stream cross-sections will measure the amount of stream bank eroded each year.

Followup evaluation

If monitoring shows that management changes are not leading to the proposed conditions, new practices and a new monitoring plan will be implemented. If the monitoring data do not adequately describe stream bank cover and stability, different techniques will be used.

Summary/Self review

An assessment tells you what is and is not present and helps you evaluate how existing conditions are affecting key riparian functions. Design assessments to answer specific questions. Looking at a range of riparian sites in the same ecoregion with similar conditions (location within the watershed, streamside landforms, etc.) can provide clues about your site's potential to support desired ecosystem functions. This information is useful for developing an enhancement plan.

Several assessment methods are available. OWEB has developed an approach for characterizing a watershed's riparian vegetation and targeting more detailed assessments.

Riparian enhancement projects aim to restore or enhance essential ecosystem functions. They commonly involve increasing plant species diversity, age diversity, and width of riparian areas. Different tree species and shrubs have varying tolerances for floods and shade. Consider these factors when choosing where to plant trees in riparian areas.

It's difficult to establish shrubs and tree seedlings and cuttings in riparian areas. These areas often are wet in winter, dry in summer, and have a lot of competing vegetation. Plant large nursery stock and follow all recommended tree planting procedures. Watering in the summer, controlling vegetation, and protecting from animal damage might be necessary.

A monitoring plan is an assessment of conditions over time. It tells you whether your goal or desired riparian functions are being met. Monitoring helps prevent repeated mistakes and justifies the investment of resources, whether private or public. Monitoring plans include four main components:

- Goals and objectives to achieve the desired ecosystem functions
- Specific monitoring questions
- Specific monitoring techniques and parameters to be measured
- An evaluation process to see whether the desired condition is being met and/or monitoring techniques are adequate.

EXERCISES

You can do these exercises on your own, but it will be helpful to work as a group so you can compare notes and discuss your findings.

Assessment methods

Use one of the assessment methods discussed in this chapter to assess the condition of at least two sites. These methods will train you to look for unseen problems. A seemingly healthy site actually might be degrading.

1. Select a site that seems to be in good condition and follow the steps for one of the assessment methods.
2. Select a site that seems to be deteriorating and repeat the assessment using the same method.

Photo points

Establish a permanent photo point in a nearby riparian area and take photos every 3 months. Why? It's interesting to record changes through time. Many changes are difficult to remember, much less prove, without photos.

Enhancement

Get involved with two types of riparian enhancement activities–tree planting and tree release. Review the assessments used to plan the enhancement activities.

Monitoring

Establish a monitoring program (or follow an existing one) for a site where a change in management or an enhancement project has been implemented. Set up one monitoring program to evaluate project success for the first year (survival, stability, etc.) and one program to evaluate progress toward the desired condition over time.

Resources

Training

Contact your local watershed council, OSU Extension Service office, Soil and Water Conservation District office, or resource agency office (Oregon Department of Forestry, Oregon Department of Fish and Wildlife, U.S. Forest Service, Bureau of Land Management, etc.) for training events or personal consultation.

Information

Assessment

Oregon Watershed Assessment Manual (Watershed Professionals Network for the Governor's Watershed Enhancement Board, Salem, 1999). Available from OWEB; phone: 503-378-3589.

Procedures for Ecological Site Inventory—with Special Reference to Riparian–Wetland Sites, Tech. Reference 1737-7, by Leonard et al. (Bureau of Land Management, 1992). Describes the ESI assessment method.

Riparian and Wetland Classification, Tech. Reference 1737-5, by Gebhardt et al. (Bureau of Land Management, 1990). Provides a review of the more common procedures used to classify, inventory, and describe riparian–wetland areas.

Riparian Area Management, Publication TR 1737-9 (Bureau of Land Management, 1993). Explains the Proper Functioning Condition assessment. Available from the BLM Service Center, SC-657B, PO Box 25047, Denver, CO 80225-0047.

Rangeland Watershed Management Program Stream/ Watercourse Site Evaluation, Fact Sheet 23, by J. Stechman and J. Clawson (Rangeland Watershed Program, USDA Natural Resources Conservation Service and University of California Extension Service, Davis, 1994). For more information, contact the Oregon State University Department of Rangeland Resources; phone: 541-737-3341.

Monitoring

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, EPA/910/9-91-001 (U.S. Environmental Protection Agency, 1991).

Monitoring Primer for Rangeland Watersheds, EPA 908-R-94-001, by T. Bedell and J. Buckhouse (U.S. Environmental Protection Agency, 1994).

Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams, by S. Bauer and T. Burton (Idaho Water Resources Research Institute, University of Idaho, Moscow, 1997).

Monitoring Rangelands and Associated Riparian Zones with Blimp Borne Cameras, by Harris et al. (Oregon Agricultural Experiment Station, Oregon State University, Corvallis, 1995).

Photo Plots (Governor's Watershed Enhancement Board, Salem, 1993).

Photo Points as a Monitoring Tool, Fact Sheet 16, by J. Stechman and J. Clawson (Rangeland Watershed Program, USDA Natural Resources Conservation Service and University of California Extension Service, Davis, 1993).

Rangeland Monitoring Handbook, Publication H-1734-2 (U.S. Forest Service, 1988).

"Shadow length estimation for woody vegetation," by L. Larson and P. Larson. In *Riparian Ecology and Management Workshop Proceedings* (Oregon State University Extension Service, Corvallis, 1997).

Types of Monitoring, Fact Sheet 15 (Rangeland Watershed Program, USDA Natural Resources Conservation Service and University of California Extension Service, Davis, 1992).

Monitoring (continued)

The Use of Aerial Photography to Inventory and Monitor Riparian Areas, Tech. Reference 1737-2, by Batson et al. (Bureau of Land Management, 1987).

Types of Monitoring, Fact Sheet 15 (Rangeland Watershed Program, USDA Natural Resources Conservation Service and University of California Extension Service, Davis, 1992).

Enhancement

Also see the list of resources in Chapter III-1.

Guide for Using Willamette Valley Native Plants Along Your Stream (South Santiam Watershed Council, Natural Resources Conservation Service, and Linn Soil and Water Conservation District, 1999).

Life on the Edge video, VTP 33 (Oregon State University Extension Service, Corvallis, 1999).

Life on the Edge: Restoring Riparian Function, EM 8738, by D. Godwin (Oregon State University Extension Service, Corvallis, 1999).

“Terrestrial riparian area functions and management.” In *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game, 1997).

“Streambank and shoreline protection.” In *Engineering Field Handbook* (Natural Resources Conservation Service, 1996).

Woodland Workbook (Oregon State University Extension Service, Corvallis, updated frequently).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your group ahead in understanding riparian area evaluation and enhancement.

1.____

2.____

3.____

Appendix A—Form for the Rangeland Watershed Management Program stream/watercourse site evaluation. (Source: University of California Cooperative Extension)

Rangeland Watershed Program

A Water Quality Education & Technical Assistance Program for California Rangelands

FACT SHEET

U.C. Cooperative Extension and U.S.D.A. Soil Conservation Service

No. 23 November 1993

Rangeland Watershed Management Program
Stream/Watercourse Site Evaluation[1]

RANCH NAME______________________________ QUARTER SECTION_____________

STREAM NAME OR DESCRIPTION____

LOCATION/WITNESS POINTS____

PHOTO STATION: _____ Perpendicular _____ Oblique to stream

STREAM TYPE: _____ Perennial/year around _____ Intermittent/seasonal

CURRENT PRECIPITATION YEAR: _____ Wet _____ Normal _____ Dry

CHANNEL TYPE/PATTERN:

a. _____ Deeply entrenched _____ Moderately entrenched _____ Slightly entrenched

b. _____ Well confined _____ Moderately confined _____ Poor/no confinement

c. _____ Straight/slightly sinuous _____ Meandering or braided

STREAM GRADIENT: _____ Steep (over 10%) _____ Moderate (4-10%) _____ Gentle (<4%)

STREAM WIDTH/DEPTH RATIO:

PREDOMINANT STREAMBANK CONDITIONS (% stability):

_____ Stable (<5% degradation): armored with rock/vegetation/roots/overhang/no headcuts/little impact of high flow or access traffic

_____ Some instability (5-25% degradation): occasional sloughing/erosion/exposure to bare soil/strata/evidence of travel impacts

_____ Significant instability (>25% degradation): frequent sloughing/exposed soil/headcuts/chiselling compaction by vehicles, livestock, or people

VEGETATION:

_____ Typical riparian perennial water-loving species dominating; bottomland/alluvial or upland perennial watercourse

_____ Riparian herbaceous and woody species infrequent; upland foothill intermittent watercourse

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[1]To be used with individual streams or stream reaches.

VEGETATION: *(continued)*

_____ Principal watercourse/stream flood plain cover:

	0 -25%	25-50%	50-75%	75-100%
Trees - canopy	_____	_____	_____	_____
Shrubs - canopy	_____	_____	_____	_____
Herbaceous - canopy	_____	_____	_____	_____

Major Species ____

Watercourse residual/mulch/plant cover filter strip function: _____ High _____ Moderate _____ Low

Utilization of riparian vegetation: _____ None _____ Light _____ Moderate _____ Heavy

Grazing or browsing by: _____ Livestock or _____ Wildlife

WATER TURBIDITY/CONDITION: (period since last storm: _____ <2 days _____ >2 days)

_____ Clear or very slightly turbid/muddy: bottom objects clearly visible to depths of up to 3 feet

_____ Considerable/moderate turbidity: objects visible to only about 1½ to 3 feet depth

_____ Very turbid/muddy/sediment-loaded: objects not visible at more that ½ to 1½ feet depth

WATER TEMPERATURE: _____ Cold (<50%) _____ Cool (50 to 70%) _____ Warm (>70%)

CHANNEL BOTTOM CONDITION:

_____ No evidence of recent bed material movement/deltas/sediment bars/scouring; pools free from deposition

_____ Some or few fine gravel/sand/silt bars/deltas present and without vegetation cover

_____ Abundant evidence of erosion and/or deposition; sediment bars/deltas present and unvegetated; pools silted

_____ % bedrock _____% gravel _____% sediment

AQUATIC BIOLOGY (Riparian, perennial streams, or pools)

	Abundant/Diverse	Some/Few	None
Fish	_____	_____	_____
Amphibians	_____	_____	_____
Insects	_____	_____	_____
Emergent Plants	_____	_____	_____
Algae	_____	_____	_____

ADDITIONAL COMMENTS: ____

MANAGEMENT ACTIONS

_____ Changes in management are not justified

_____ Further examination of watershed is needed

_____ Request visitations and advice by resource specialist

_____ Consider prompt changes in kind, degree, time of land use

_____ Develop water quality management plan or element of ranch management plan

Prepared by John Stechman, UC Cooperative Extension, USDA Morro Bay Hydrologic Unit Area Project, and Jim Clawson, Extension Range Specialist, Agronomy & Range Science, University of California, Davis.

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3

Livestock and Forage Management in Oregon Riparian Areas

Pete Schreder,
Garry Stephenson,
and Bill Rodgers

Properly managed livestock grazing can be an important tool in restoring and maintaining riparian areas. On the other hand, poorly managed livestock grazing can erode stream banks, compact soil, reduce water quality, and destroy riparian vegetation.

Many riparian areas are used for livestock grazing. By learning how riparian plants respond to grazing and by developing good management and grazing strategies, ranchers can avoid or reduce impacts to riparian habitat and improve livestock production at the same time.

Successful riparian grazing strategies need to fit within each rancher's time and financial constraints. Due to the great variety of sites and landowner situations, no single recommendation is the answer to all problems.

Chapter III-1 talks more about the functions of riparian areas, and Chapter III-2 discusses evaluation, enhancement, and monitoring of these areas.

In this chapter you'll learn:

- How livestock can affect water quality and riparian areas
- What plants to expect in a riparian area
- How plants respond to grazing
- How to set grazing management goals
- Some grazing management strategies
- Some important considerations before implementing a grazing strategy

IMPACTS OF GRAZING LIVESTOCK

In a settled and fenced landscape, there is greater risk of constant grazing pressure on riparian areas. When grazing is too intense or happens too often during vulnerable periods, and without rest, riparian functions will decline. Riparian plants do not get a long enough rest period to regrow and store essential energy (carbohydrates) for growth the following year. There also is an impact from livestock hoof action, which causes trampling, stream bank erosion and soil compaction. The relationship between livestock grazing and reduced water quality can be difficult to see because the grazing might occur over a long period of time far from the place where the water-quality problem is identified.

See Section III, Chapters 1 and 2 for information related to this chapter.

Section III

1 Riparian Function

2 Riparian Evaluation

Potentially harmful grazing activities fall into three interrelated categories: improper grazing, hoof impacts, and livestock waste concentration. Figure 1 shows these three categories and the beneficial uses of water they affect.

Improper grazing can be too heavy, too long, or involve improper timing. Frequent heavy grazing or improper timing can weaken and remove riparian vegetation. Vegetation protects soil from erosion, helps keep sediment out of streams, and increases water infiltration into the soil. Thus, loss of streamside vegetation might cause bank erosion and allow pollutants and sediment to reach streams. Also, vegetation removal might cause stream temperatures to increase, which can be harmful to cold-water fishes. Loss of streamside vegetation results in deteriorated wildlife habitat.

Hoof impacts can destroy vegetation and physically break down stream banks. These impacts occur when livestock concentrate repeatedly or in large numbers in a small area for water, shade, or feed. The resulting unstable stream banks might lead to channel widening or downcutting. These effects can result in shallower, warmer streams and poor aquatic habitat.

Livestock waste can pollute streams, especially if livestock deposit wastes directly into streams. This pollution comes in two forms–excess nutrients (e.g., nitrogen and phosphorus) and pathogens (disease-causing organisms).

Much of the nitrogen and phosphorus consumed by livestock in feed returns to the environment in feces and urine. If sufficient amounts of these nutrients enter a stream, they stimulate excessive algae growth. The algae use up dissolved oxygen needed by fish.

Pathogens that can enter streams in livestock waste include fecal coliforms, *giardia,* and *cryptosporidium*. It's important to note, however, that these pathogens can come from wildlife and human waste as well as from livestock waste.

On the positive side, livestock grazing can benefit riparian vegetation in certain situations. Light to moderate grazing can stimulate growth of some woody species such as willow, cottonwood, birch, maple, and dogwood. Light grazing also can maintain high levels of grass production by removing excess litter (decomposing plant material).

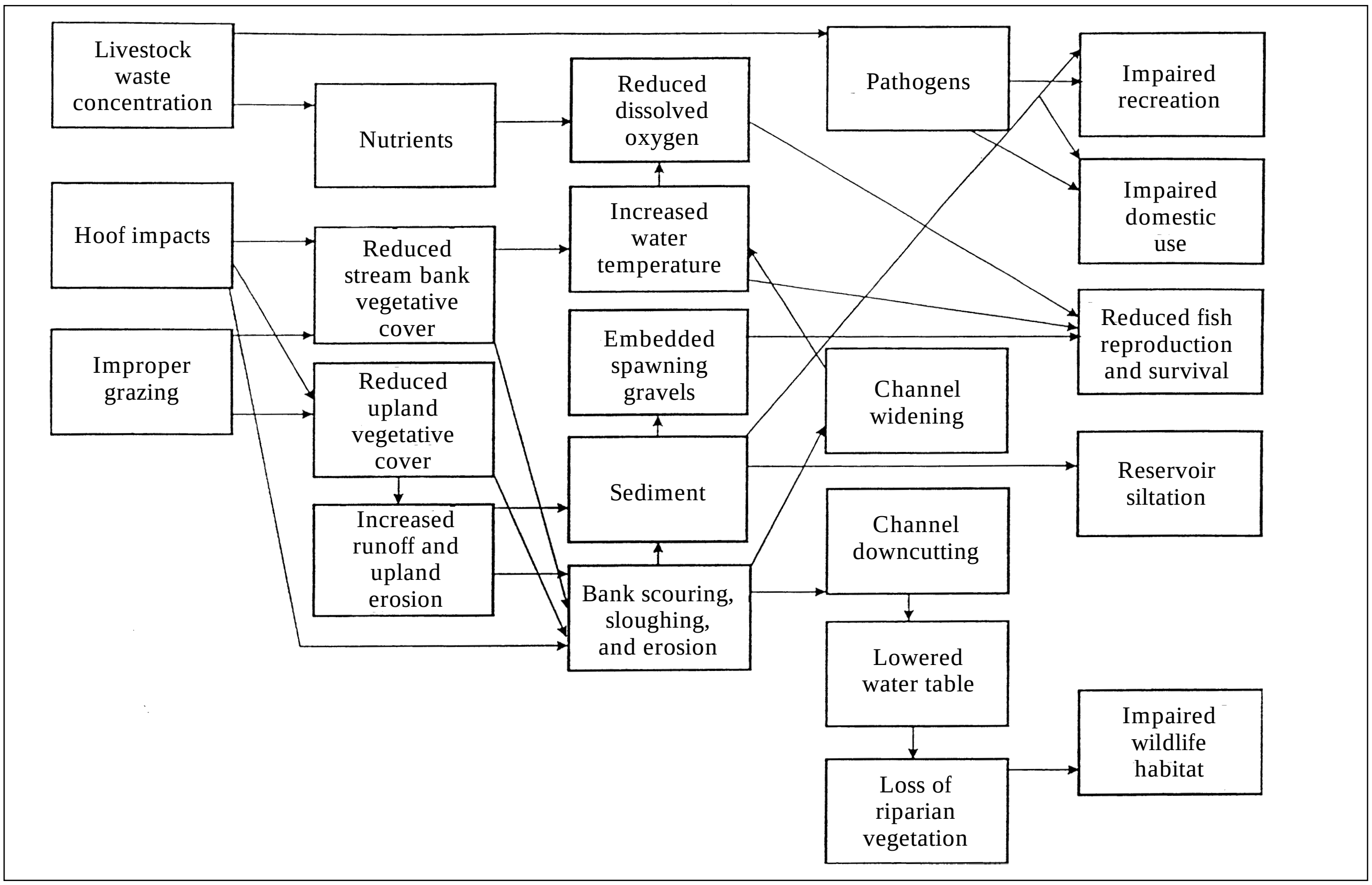

Figure 1.—Livestock waste concentration, hoof impacts, or improper grazing (left column) may set off a chain of events that ends in the impairment of the beneficial uses of water (right column). (Adapted from Nonpoint Sources of Pollution on Rangelands, *by M. George, University of California Cooperative Extension, 1996)*

With properly planned periods of grazing and rest, riparian functions will be restored. Riparian areas can recover quickly from impaired function, probably because they typically have rich soil and plenty of moisture. Using a riparian area conservatively often restores many plant populations. Sometimes a rest period before implementing improved management practices jump-starts the recovery process.

IDENTIFYING RIPARIAN PLANTS

Knowing what plants to expect in a functioning riparian area will help you develop management goals to restore or maintain the area. Often, riparian areas have populations of well-adapted plants. In some cases, these plant populations are stable or in decline. Other areas are extremely degraded.

When you're trying to determine what plants should be present in a given riparian area, look at similar sites that haven't been severely disturbed. These sites might be in areas where the terrain or fencing has prevented agricultural activities, homesite development, and road and trail building. Other possibilities are areas that are being managed as natural areas, or those that have been managed properly for other uses.

For simplicity, let's divide plants into three categories:

- *Plants that are native to riparian areas.* If these plants are present, encourage them through management. Alternatively, you can purchase and plant them. However, with thoughtful management, native plants often appear naturally.
- *Plants that are not native but are not aggressive in riparian areas.* You can manage these plants to enhance riparian functions.
- *Plants that are not native and spread aggressively.* These plants can be considered "invaders." Consider removing them, or at least manage them carefully so they don't spread.

Plants that are native to riparian areas

There are hundreds of native riparian plants. Good references for identifying native plants are *Plants of the Pacific Northwest Coast* and *Wetland Plants of Oregon and Washington.* (See "Resources" in this chapter.) Native plants are desirable for several reasons. For example, they require less water than exotics and allow for more diversity since they usually don't aggressively inhibit surrounding vegetation.

Table 1 is a short list of plants commonly found in Oregon riparian areas. This is not a comprehensive list. Encourage these and other native plants through good management.

Plants that are not native but are not aggressive in riparian areas

Many plants fall into this category. Examples include some pasture grasses and nonnative cottonwoods.

These plants can play the same role as native plants in improving water quality. They can stabilize banks, provide shade and cover for fish and other wildlife, and filter runoff. If the plants already are present and are not dominating or inhibiting diversity, and if there are no immediate plans to restore the area to native plants, they can be managed to enhance the riparian area.

Examine these plants on a case-by-case basis. You can get help to identify them and assess their usefulness from the Natural Resources Conservation Service (NRCS), the OSU Extension Service, other professional conservationists, and the materials in the "Resources" section of this chapter.

Table 1.–Native plants commonly found in riparian areas in eastern and western Oregon.

Native grasses and forbs	
American brookline *Veronica americana*	One-sided sedge *Carex unilateralis*
American slough grass *Beckmannia syzigachne*	Slender cinquefoil *Potentilla gracilis*
Bog trefoil *Lotus pinnatus*	Slender rush *Juncus tenuis*
Common camas C*amassia quamash*	Slough sedge *Carex obnupta*
Common downingia *Downingi elegans*	Spike bentgrass *Agrostis exarat*
Dense sedge *Carex densa*	Spreading rush *Juncus patens*
Large leaf avens *Geum macrophylum*	Tufted hairgrass *Deschampsia cespitosa*
Mannagrass *Glyceria* spp.	Western witchgrass *Panicum occidentale*
Meadow barley *Hordeum brachyantherum*	
Trees	
Bigleaf maple *Acer macrophyllum*	Oregon white oak *Quercus garryana*
Black cottonwood *Populus trichocarpa*	Pacific dogwood *Cornus nuttallii*
Douglas-fir *Pseudotsuga menziesii*	Red alder *Alnus rubra*
Grand fir *Abies grandis*	Western redcedar *Thuja plicata*
Oregon ash *Fraxinus latifolia*	
Shrubs	
Black hawthorn *Crataegus douglasii*	Pacific crabapple *Pyrus fusca*
Cascara *Rhamnus purshiana*	Pacific nine bark *Physocarpus capitatus*
Common snowberry *Symphoricarpos albus*	Red-osier dogwood *Cornus stolonifera*
Douglas spiraea *Spiraea douglasii*	Vine maple *Acer circinatum*
Highbush cranberry *Viburnum edule*	Western serviceberry *Amelanchier alnifolia*
Indian plum *Oemleria cerasiformis*	Willows *Salix lasiandra, S. scouleriana, S. hookeriana, S. sitchensis*
Nootka rose *Rosa nutkana*	

Plants that are not native and spread aggressively

These plants invade riparian areas, reducing diversity and crowding out more favorable plants. Remove them if possible, or at least manage them so they don't spread. If herbicides are necessary, be careful not to spray or cause drift too close to the stream.

An example of an aggressive, nonnative plant is reed canarygrass, which is used as pasture in many wet areas. With proper grazing, this plant can be kept in check and provide livestock feed. However, it invades riparian or wetland areas and dominates them. Although reed canarygrass can provide riparian functions, it dramatically reduces diversity and limits the ability of species such as willows and cottonwoods to provide riparian functions.

The following are a few of the most invasive plants:

- Reed canarygrass *Phalaris arundinacea*
- Teasel *Dipsacus sylvestris*
- Himalayan blackberry *Rubus procerus*
- Scotch broom *Cytisus scoparius*
- Purple loosestrife *Lythrum salicaria*
- English ivy *Hedera helix*

HOW PLANTS RESPOND TO GRAZING

Knowing the positive impacts of well-timed and appropriate grazing and the negative impacts of overgrazing or poorly timed grazing is important for developing a grazing strategy.

Plants use energy stored in their roots to grow new foliage, which then produces more energy through photosynthesis. Some of this energy is used to grow additional roots, and some is stored for future use. When plants are grazed too heavily, they use stored energy to initiate regrowth of the foliage they lost.

Plants that are appropriately grazed and rested have enough time to regrow foliage and provide energy for a sound root system and future energy needs. They can compete with other plants for space, light, moisture, and nutrients, and they survive year after year. Normally, rest implies absence of grazing for a full growing season or during a critical period of plant development.

When plants are grazed often and don't get to rest between grazings, they use up their energy stores trying to grow new foliage. Their root system shrinks and they become stunted and less vigorous. They can't compete with more aggressive plants, and their population declines. Plants that take their place might be less productive, less palatable to livestock, and less beneficial for stream bank protection and wildlife uses.

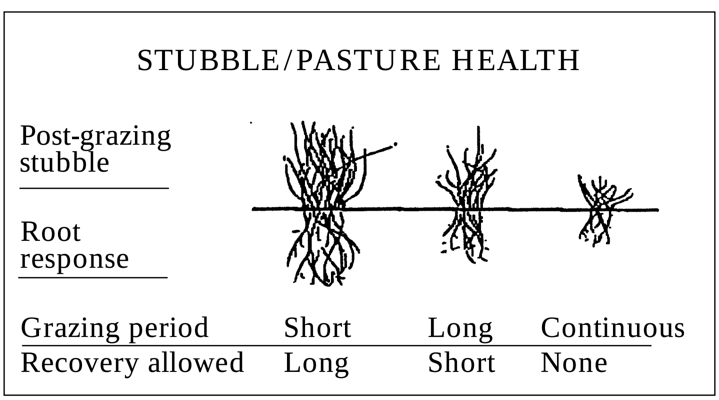

Figure 2.–Relationship between plant health, grazing, and recovery periods with grasses. (Source: Living on a Few Acres in Wyoming, *by C. and S. Buffington and N.D. Cotton, University of Wyoming, undated)*

Figure 2 shows the relationship between plant vigor, grazing, and recovery periods with grasses.

Riparian areas are made up of a mixture of grasses, forbs (broadleaf plants), shrubs, and trees. The exact combination depends on the site's potential. There can be hundreds of species in a riparian area. Each of these plants has times when it is most susceptible to grazing damage. When animals are allowed to continuously graze riparian areas, they'll regraze individual plants repeatedly at the most susceptible growth stage. This overgrazing is detrimental to all types of riparian plants.

Because different kinds of plants are susceptible to overgrazing at different times of the year, grazing management in riparian areas is a serious challenge. There is no blanket recommendation that works in all situations. Develop plans to fit each specific site based on the characteristics of the stream and the plants that live there. Grazing strategies are covered later in this chapter.

GRAZING MANAGEMENT GOALS

Basic principles of range management include:

- Balancing animal needs with available forage supply
- Distributing livestock evenly
- Avoiding or minimizing grazing when the vegetation is fragile or vulnerable
- Providing plants with effective rest during the growing season

To improve riparian management, where do you begin?

- **Highlight problem areas.** Use aerial photographs or another map base to highlight areas of heavy and light livestock use. Identify riparian areas that deserve the highest priority for improvement. This process will provide an overview of areas that are in satisfactory condition and those that require special or immediate attention.
- **Decide what needs attention.** Your management objectives should address soil, water, and vegetation needs. Objectives should be attainable and measurable.
- **Put your plan into practice and watch for results.** A successful strategy doesn't come from a cookbook. Improvement comes through adaptive management and learning by doing. Imagination, trial, and sometimes error are required.

As a landowner, it's part of your job to think about where your operation is going and how and when it's going to get there. Families and businesses are most likely to achieve the things they want in life when they know what they're trying to accomplish, how they will carry out their actions, and when their efforts will be completed. The answers to these questions are found in your goals. Goals reflect personal values and beliefs, the resources available, and the opportunities and limitations you face.

Goals provide direction to all management efforts. Identifying goals for a riparian area will help you make management decisions and monitor progress.

Some goals take a lifetime to achieve; others can be attained much more quickly. If possible, short-term goals should directly support achievement of long-term goals. When short-term and long-term goals conflict, priority setting will help you analyze the conflict and identify which goals are most important or urgent.

Remember these points when identifying goals:

- Write goals as action statements: "To complete. . . ." or "To rehabilitate. . . ."
- Specify a completion date, but recognize that factors such as climatic variability can influence time frames.
- Make goals believable. Can they be achieved in the time allotted? Can they be achieved at all?

An example of a long-term goal might be:

To create a functioning riparian area that supports fish, plant, wildlife, and livestock production.

Short-term goals to support this goal might be:

- Remove or manage the spread of undesirable plants.
- Fence a riparian pasture.
- Cull animals that favor the riparian area.
- Plant appropriate trees, shrubs, and other plants.
- Develop a water source away from the stream.
- Intensively graze for 2 weeks in late spring.

See Chapter II-1, "Planning for Watershed Restoration," for more information on setting goals and objectives.

GRAZING MANAGEMENT STRATEGIES

Use appropriate grazing management strategies to support your goals. Some strategies include:

- Attracting livestock away from the riparian area
- Removing "riparian-hugging" individuals from the herd
- Installing natural barriers to protect sensitive areas
- Herding livestock or excluding livestock with fencing
- Managing riparian areas as special-use pastures
- Implementing a different grazing system

Each of these strategies is discussed below.

Attracting livestock away from the riparian area

Cattle tend to concentrate in a riparian area in the following situations:

- Water is not well distributed.
- The land outside the riparian area is steep or rocky.
- Salt is placed in or near riparian areas.
- The weather is hot, and riparian shade is available.
- Nonriparian forage is less palatable than riparian forage.
- Individual animals develop behavior patterns that favor riparian areas.
- Animal distribution is not maintained by herding.
- The grazing rotation is too long.

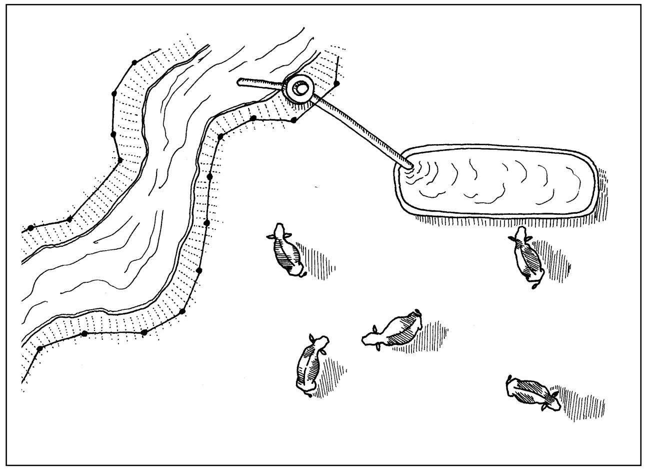

Figure 3.–Gravity flow or pumped water provides a drinking area away from the stream bank.

You can try to attract livestock away from riparian areas by providing shade, drinking water, feed, salt, or supplements in other areas of the pasture (Figure 3). Miner, Buckhouse, and Moore (1993) found that under winter feeding conditions, animals spent 90 percent less time in the stream when a water tank was located away from the stream. Reseeding and fertilizing upland pastures and thinning timber create better forage, which attracts livestock.

Removing "riparian-hugging" individuals from the herd

Older cattle lead new members to favored grazing areas, so use patterns are passed on from year to year unless individuals are replaced. Culling rids the herd of "riparian huggers."

Installing natural barriers to protect sensitive areas

You can protect sensitive stream areas with barriers such as rock fields, shrub thickets, dense timber stands, or fallen trees.

Herding livestock or excluding livestock with fencing

Herding and fence construction are options for controlling grazing. Herding is labor-intensive, and its use has declined as labor costs

Figure 4.–Livestock pasture (left) and exclosure (right).

have increased. Fencing can be used to exclude livestock from riparian areas (exclosures) or to create riparian pastures (Figure 4). Fencing can be permanent or temporary. Temporary electric fencing often is effective and less expensive than permanent wire fencing.

Managing riparian areas as special-use pastures

Riparian pastures generally are much larger than exclosures. Fenced riparian pasture can include uplands, or it can follow ecological boundaries. For example, a pasture might include all of the bottomland to the base of an adjacent hill.

If all of the available pasture is in streamside bottomland, you can create a series of riparian pastures through fencing. You then can rotate livestock through the pastures and allow sufficient recovery time between grazing periods. The cost of fencing riparian pastures might be less than the cost of fencing riparian exclosures because the fences can be straighter and require less maintenance.

The cost of fencing riparian pastures might be less than the cost of fencing riparian exclosures because the fences can be straighter and require less maintenance.

Regardless of the system you use, short-season grazing is important to minimize effects on regrowth. Use can be heavy if the season is short and sufficient moisture is available for plant regrowth.

How you use riparian pastures depends on the vegetation present. For example, shrubs and trees are most likely to be damaged by grazing in late summer, fall, or winter. Thus, areas dominated by these species should be grazed in spring and early summer. Two years of rest can't make up for grazing that removes 3 years' growth on woody species.

Spring and early summer grazing also works well when overall livestock distribution favors nonriparian areas. Grazing in the late spring offers several advantages. In late spring:

- Stream banks generally are firm.
- There still is sufficient moisture for riparian vegetation to regrow before summer.
- Sediments in spring floodwaters have been trapped by last year's standing dead growth.
- Herbaceous plants still may be green, so livestock are less likely to graze woody species.

On the other hand, rotational systems that include late summer and early fall grazing work well in areas dominated by grass, sedges, or rushes. If riparian vegetation is mostly grasses and forbs, then early fall grazing is appropriate. With fall grazing, it is important to allow for regrowth or to leave sufficient grass height to protect the soil at peak water flow.

Ideally, riparian pastures should be located and designed to fit the livestock production operation. You can save labor by locating them where cattle and sheep will use them automatically in the normal rotation sequence.

GRAZING SYSTEMS

Rotational grazing

How does it work?

Rotational grazing involves a planned sequence of grazing and rest periods.

Rotational grazing normally requires subdividing the range into smaller pasture units. It also might be possible to implement a rotational grazing program with existing pasture units or even through herding practices (Figure 5).

A grazing rotation enables the manager to better apply the key principles of range management:

- Animal distribution improves because animals are forced to use the entire range landscape more evenly.
- Livestock grazing is less selective, especially in riparian areas.
- More effective rest is achieved by shortening the grazing period. Grazed plants have a chance to rest and regain vigor rather than being stressed by repeated grazing. Rest can be provided either by periods of deferral (delayed early grazing) or by periods of rest after grazing.

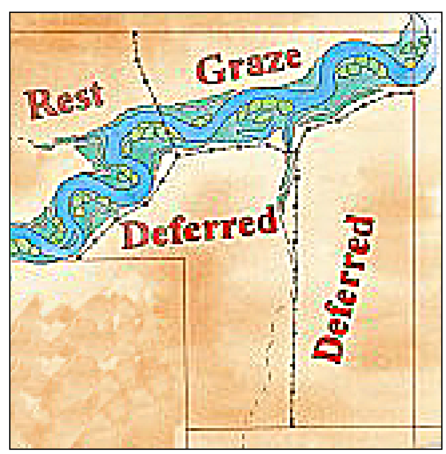

Figure 5.—Rotational grazing.

- Season of use can be controlled to avoid or reduce the stress of grazing during vulnerable periods such as during spring runoff when banks are fragile and easily trampled.
- Better overall carryover of decomposing plant material is achieved.
- More uniform grazing reduces grazing intensity in riparian areas and makes more efficient use of upland forage.

Rest–rotation grazing

A diversity of trees and shrubs is an integral part of functioning riparian areas. Riparian values such as channel stability, groundwater maintenance, and forage production often depend on the presence of “big wood.” Trees and shrubs also provide livestock with shelter.

A deferred rotation might allow new woody seedlings to establish in the short term, but without sufficient rest, the young plants might be grazed out by livestock. When it’s critical to restore woody vegetation in riparian areas, a more conservative grazing strategy might be necessary. An example is rest–rotation grazing.

Rest–rotation means providing a field with a rest period for the entire growing season or even a calendar year (Figure 6). In some cases, the rest period might need to be several years! The amount or sequence of rest periods needed depends on the species of trees and shrubs in the riparian area. For example, if riparian cottonwoods are unable to establish or grow above the reach of cattle, there will be no young trees to replace the old ones that eventually die. In these circumstances, a field might require 3 or 4 years of complete rest to allow new seedlings to establish and grow large enough to resist grazing.

Figure 6.–Rest–rotation grazing.

Riparian pastures–a landscape approach

How does it work?

Rotational grazing systems involve recurring patterns of grazing and rest. The riparian pasture option takes us a step farther to consider how we define and fence pasture units. A riparian pasture system means defining fields in a way that reduces the variation within a given field. For example, uplands might be fenced separately from the floodplain.

Like rotational strategies, riparian pastures are grazed in a planned, purposeful sequence. The major difference between riparian pastures and other rotational strategies is the separation of pasture units based on land type or landscape unit (Figure 7).

Figure 7.–Riparian pastures.

Is it effective?

Riparian pasture systems might require more fencing than rotational grazing systems, but they are one of the most successful strategies for riparian grazing because:

- When land is fenced "like-with-like" (in homogeneous units), you can more easily control livestock distribution.
- Animal distribution is improved in both uplands and riparian areas, often allowing you to increase the land's sustainable carrying capacity.
- Controlling livestock grazing during high-risk periods allows for rapid recovery of riparian area health and productivity.
- A riparian pasture will help you restore and maintain woody vegetation.

Holding pastures

Holding pastures are fields where livestock are held or "parked" for prolonged periods such as for winter feeding or calving (Figure 8). Supplemental feed normally is provided.

These fields provide shelter through topography and/or wooded cover. Holding pastures also can describe fields where animals are gathered and held at high stocking densities for a relatively short period.

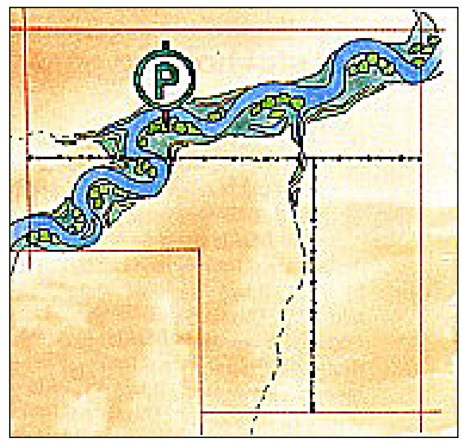

Figure 8.–Holding pastures.

Problems posed by holding pastures

Holding pastures in riparian areas can experience serious livestock impacts due to trampling of banks and intensive grazing of herbaceous and woody plants. Repeated, heavy use will threaten the woody plants that are vital for livestock shelter and bank stability. Cattle browsing might damage woody seedlings and saplings that must be allowed to "release" and replace older trees or shrubs that die.

When can holding pastures work?

Holding pastures are hard to manage. The first step in successfully managing these pastures is to recognize that livestock shelter and stable banks are the first priorities.

Don't regard the vegetation in a holding pasture as forage. Provide adequate supplemental feed, although livestock sometimes prefer native vegetation to supplemental feeds. Monitor livestock browsing of woody regrowth. Provide more rest if tree replacement is suppressed. Provide easy access to water or off-stream watering sites. Direct herd pressure to the most resistant areas of the field through placement of supplements.

Corridor fencing

Corridor or exclusion fencing involves eliminating livestock grazing on a narrow fringe of the riparian area (Figure 9). Generally, corridor fencing is considered a measure of last resort. Keeping livestock out of the stream corridor doesn't necessarily deal with grazing problems throughout the ranch landscape. However, in landscapes where topography and vegetation patterns are complex, land holdings are small and fragmented, or stream banks are very fragile or severely degraded, corridor fencing might be the only feasible option. Corridor fencing also can be a valuable first step to raise awareness about riparian area management by demonstrating the effect of rest on riparian vegetation.

Corridor fencing is expensive and requires more fencing for a given area protected than any other option. Maintenance costs might, over the long term, exceed construction costs.

Figure 9.—Corridor fencing.

Keep up the good work

Experience in eastern Oregon has shown that carefully managed grazing of riparian areas can dramatically improve both the riparian area and the quantity of available livestock feed. Once recovery is underway, it's tempting to return to previous grazing practices. However, a few years of inappropriate grazing can undo what years of careful management have accomplished.

Graze for forage maintenance if riparian conditions are satisfactory or for forage improvement if conditions are not yet satisfactory.

IMPORTANT CONSIDERATIONS WHEN CHOOSING A STRATEGY

Managing grazed riparian areas is difficult because much is unknown. Be cautious when trying new management techniques. Be willing to learn from your own experience and the experiences of others.

Evaluate your own time, skill, and finances before implementing a management strategy. You might not have enough time to implement a rotational grazing system or enough money to install permanent fencing. Understanding your resources will help you prioritize.

Because there are so many differences in soils, existing vegetation, grazing history, climate, and landowner abilities and finances, no one recommendation can succeed in all situations.

Set up a photo monitoring program to evaluate trends toward or away from your goals. Make adjustments to your management practices as necessary to keep progressing toward your goals.

Summary/Self review

Properly managed livestock grazing can be an important tool in restoring and maintaining riparian areas. Poorly managed livestock grazing can destroy riparian vegetation, erode stream banks, compact soil, and reduce water quality.

Improper grazing, hoof impacts, and the direct deposit of livestock wastes into streams can degrade water quality. Loss of vegetation might lead to an increase in stream temperatures and stream sedimentation. Added livestock wastes can lead to excess nutrients and pathogens in water. However, nutrients and pathogens also come from wildlife and other sources.

Knowing what plants to expect in a functioning riparian area will help you develop management goals to restore or maintain the riparian area.

Grazing strategies are more successful if the manager understands how plants respond to grazing. Plants that are appropriately grazed and rested have enough time to regrow foliage and provide energy for a sound root system and future energy needs.

Goals provide direction to management efforts. If possible, short-term goals should directly support the achievement of long-term goals.

Use appropriate management strategies to support goals. Some strategies include:

- Attracting livestock away from the riparian area
- Removing “riparian-hugging” individuals from the herd
- Installing natural barriers to protect sensitive areas
- Herding livestock or excluding livestock with fencing
- Managing riparian areas as special-use pastures

Managing grazed riparian areas is difficult because much is unknown. Set up a photo monitoring system, and make adjustments as necessary to achieve progress toward goals.

EXERCISES

You can do these exercises alone or as a group.

Plant identification

Identify the most common plants in a riparian pasture and keep a record of their location and condition. This information could be used to develop a grazing management plan.

Collect complete samples, including seed heads, flowers, and leaves or needles. Dry the samples and put each into a separate plastic bag with a label identifying when and where the sample was collected. (Example: *South bank streamside pasture, 12 feet from edge of water on October 20, 2001)*

Note the condition of plants and how commonly they are found. (Example: *Mature ungrazed grass, 24 inches tall, very common*) Look closely for signs of past heavy browsing, especially on shrubs.

Resources for identifying plants include the Natural Resources Conservation Service, the OSU Extension Service, and the OSU Herbarium.

Grazing patterns

Observe your herd's grazing patterns over a period of time. Are there animals that prefer the riparian area? Are they leaders or loners? If leaders, separate them from the rest of the herd. Does their isolation change how the herd uses the riparian area?

RESOURCES

Training

Contact local offices of the OSU Extension Service, the USDA Natural Resources Conservation Service, or the Oregon Cattlemen's Association for availability of training workshops, programs, or individual consultation.

Information

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Trees to Know in Oregon, EC 1450, by E.C. Jensen and C.R. Ross (Oregon State University Extension Service, Corvallis, reprinted 1999).

Wetland Plants of Oregon and Washington, by J. Guard (Lone Pine Press, Redmond, WA, 1995).

Will a Water Trough Reduce the Amount of Time Hay-Fed Livestock Spend in the Stream (and Therefore Improve Water Quality)? Fact Sheet 20, by J.R. Miner, J.C. Buckhouse, and J.A. Moore (University of California Cooperative Extension, Rangeland Watershed Program, Davis, 1993).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself, your ranch, your land management agency, etc. ahead in improving your riparian livestock and forage management.

1. ______________________________

2. ______________________________

3. ______________________________

4

Stream Ecology (Salmonid Biology)

Mary Holbert

Ecology is the study of relationships between organisms and their environment. Stream ecology is wonderfully complex. Streams are the recipients of input from uplands and riparian areas and must be considered in the context of their watershed, rather than as separate entities. With that context in mind, we can talk about the intricacies of the stream community itself. At the same time, we can broaden our understanding of how watershed components are inseparably connected.

In Chapter III-5, you'll learn about assessing and restoring stream ecosystems. Riparian areas, wetlands, and forested uplands are tied to stream ecosystems. Chapters II-4, "Watershed Soils, Erosion, and Conservation," III-1, "Riparian Area Functions and Management," and III-7, "Wetland Functions," discuss other 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*, Adams and Dewberry chapter (Oregon State University and LERC at University of Oregon, 1996).

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 and key habitat components

FOOD

See Section II, Chapters 2 and 4, and Section III, Chapters 1, 2, and 5 for information related to this chapter.

Section II

2 Hydrology

4 Soils

Section III

1 Riparian Functions

2 Riparian Enhancement

5 Stream Assessment

Freshwater plants are one of the fundamental sources of food in streams. Algae, the predominant plants in Pacific Northwest stream systems, often appear as a thin film on bedrock, boulders, gravel, and logs. This is what you slip on when walking in a creek. Long, green or brown threads floating in the water are another form of algae. Algae are very diverse, and a rock the size of a cantaloupe might have more algal species on it than the total number of plant species in the nearby forest.

Algae require sunlight for photosynthesis. In small, forested streams, algae are most abundant during short periods in the spring and fall. During summer, algal production is low in streams that are completely shaded by the forest canopy. In streams too wide for canopy closure, 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 high flows scour the algae off rocks. In streams with deciduous vegetation, late winter algae blooms occur when leaves are off the trees.

Many kinds of organic matter–leaves, needles, twigs, and salmon carcasses–also provide food in streams. Leaves are the most important item in this category. This is why hardwood trees are an important part of the riparian community. Some leaves, such as those of maples, break down quickly and are available to aquatic organisms soon after they enter the stream. Others, such as fir needles, take longer to decay and provide a year-round food resource.

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). In small, forested streams, organic matter derived from riparian vegetation might represent over 90 percent of the total food available to aquatic organisms.

Large wood generally is a poor source of food. Its role in the stream food web is primarily structural. Large pieces of wood trap smaller woody material and leaves and provide a substrate where microorganisms grow. Aquatic insects utilize big wood as habitat, feeding on the trapped materials and microorganisms. The insects, in turn, provide food for other insects, fish, and birds. Most wood enters the stream during fall and winter storms as a result of blow-down, bank erosion, and debris flows.

Salmon carcasses are a major food source in streams that still support healthy populations of salmon. Juvenile salmon and trout eat the flesh of dead salmon, as do aquatic insects, birds, and other animals. The carcasses provide habitat and cover for stream-dwelling insects and fish. Interestingly, organic nutrients in the form of carbon and potassium can be identified in riparian vegetation as marine derived, brought into the system by spawning salmon.

Aquatic macroinvertebrates and their role in the food web

Aquatic *macroinvertebrates* are spineless organisms large enough to be seen with the naked eye. Snails and crayfish are two common macroinvertebrates. However, in most streams the majority of invertebrates are insect larvae. Stream ecologists have devised a classification system for these animals based on how they obtain food. This system is helpful in understanding how invertebrate communities utilize food. It is interesting to observe how the feeding strategy of one group affects the activities of other groups.

Shredders shred leaves into small pieces that they can eat. *Scrapers* (or grazers) scrape algae off rocks. *Collectors* gather small particles of organic matter, often the leftovers from the feeding activities of shredders and scrapers. Some collectors make nets and filter the stream current for food, while others gather it from the bottom of the stream. *Predators* eat collectors, shredders, and scrapers. *Scavengers* feed on salmon carcasses and other decaying material.

Figure 1 illustrates the pathways of energy from the sun to the four macroinvertebrate groups. Figure 2 shows common macroinvertebrates found in salmon-bearing streams. Additional illustrations are found in Appendix C of Chapter 8, “Stream Assessment and Restoration.”

> *An important factor in a stream system’s productivity is its retention capacity, or ability to retain food resources.*

Retention capacity

An important factor in a stream system’s productivity is its *retention capacity*, or ability to retain 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. High water events transport material within the floodplain. Some resources are utilized immediately, while some remain in the floodplain as storm waters recede. The latter are stored in the floodplain for reallocation during the next high water event. Some streams are no longer connected to their floodplains, due to the removal of large wood, ditching, or diking. Where there is no interaction between the stream and its floodplain, materials often are swept downstream by high velocity flows.

In addition to the floodplain, other retention features in a watershed include large wood, treetops, root wads, debris jams,

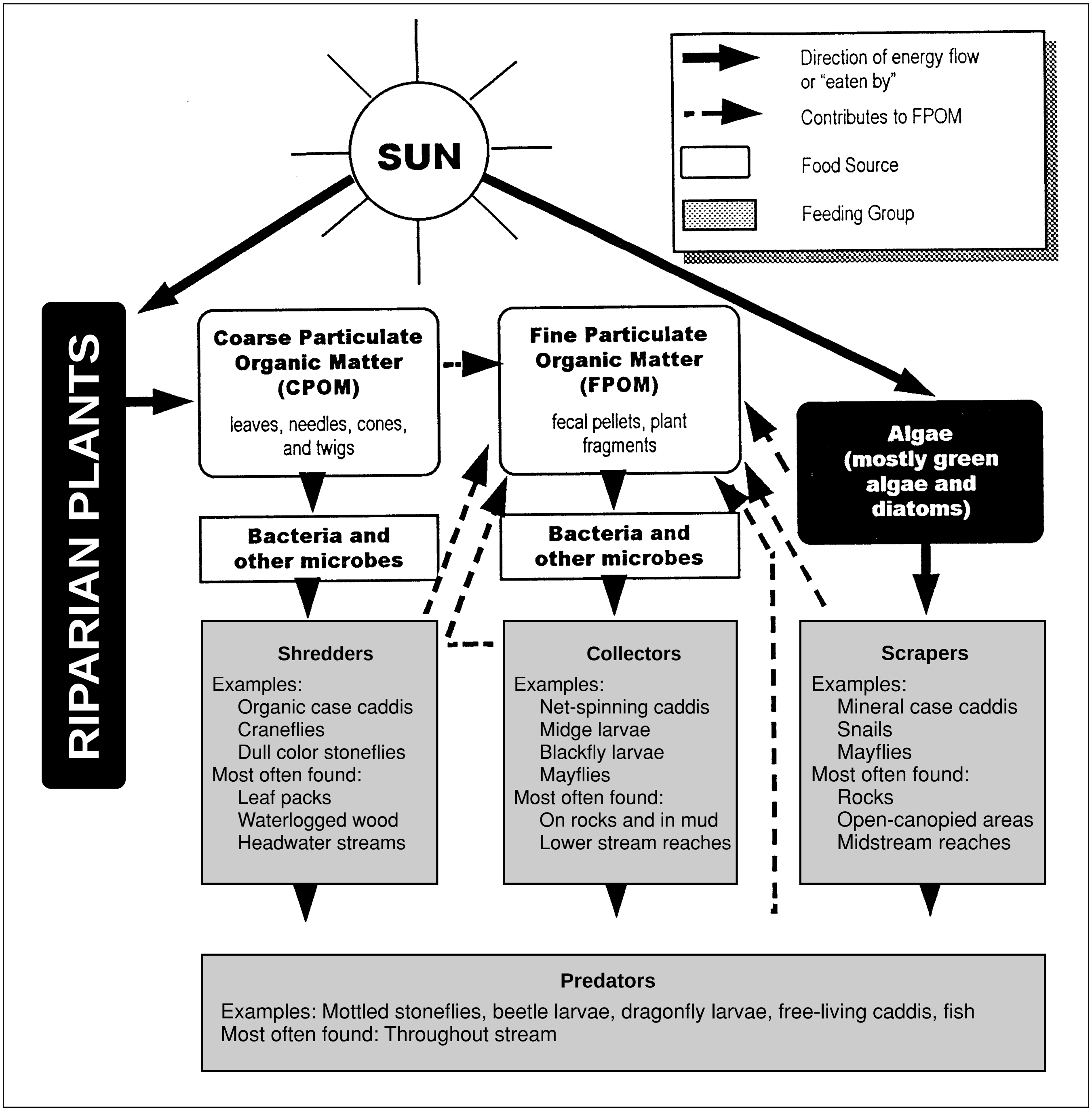


Figure 1.–Food processing in streams. (Source: "From Headwater Streams to Rivers," by Ken Cummins, American Biology Teacher, *May 1977, p. 307)*

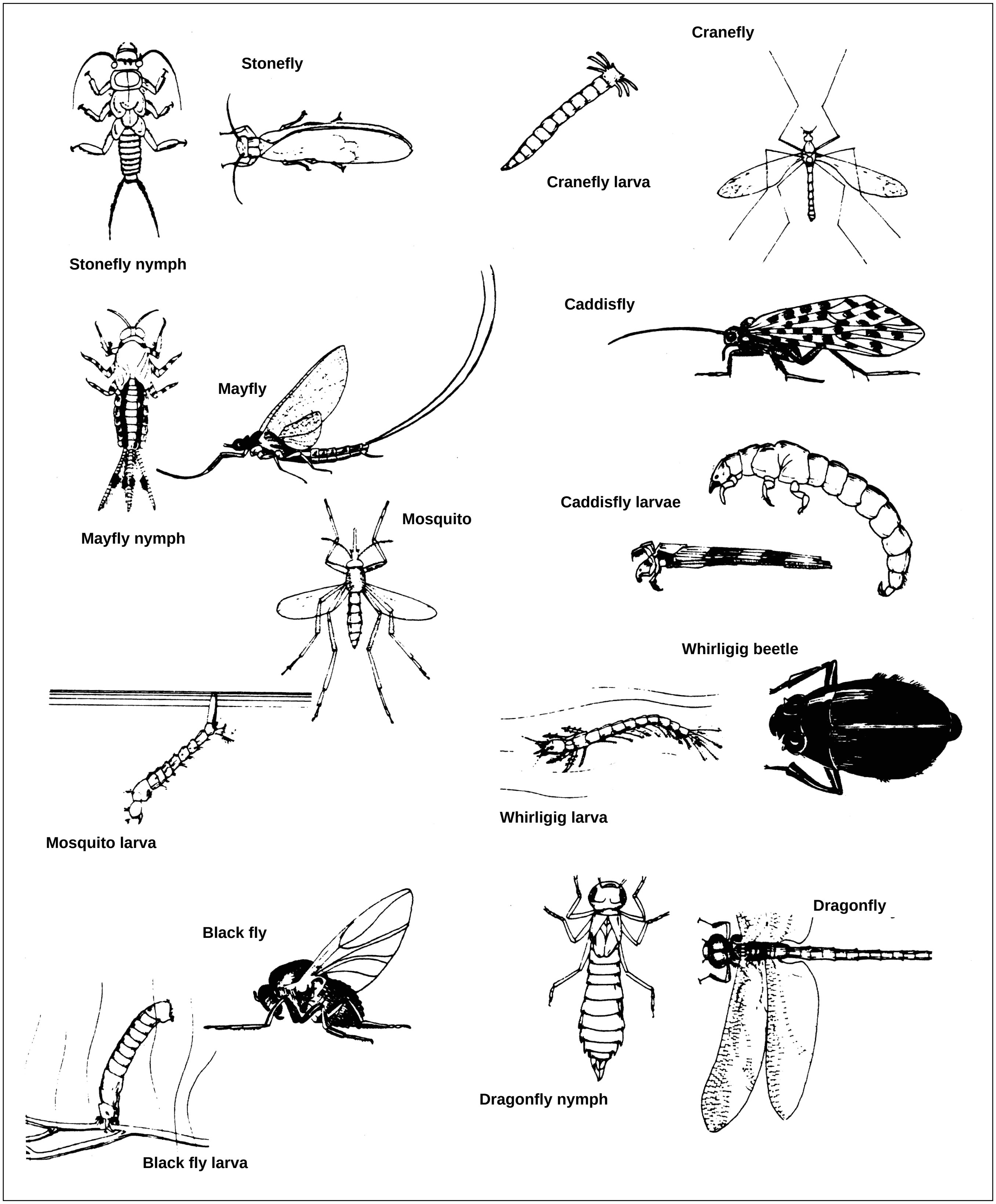
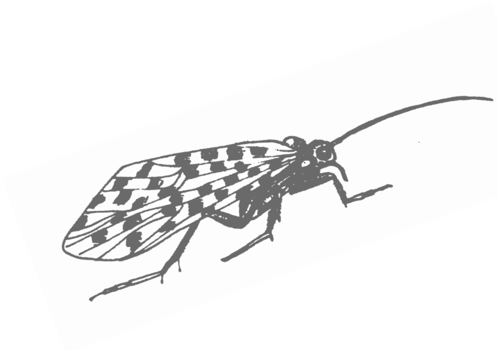


Figure 2.–Common macroinvertebrates found in stream systems. (Source: 1987 Western Regional Environmental Education Council)

boulder clusters, backwaters, and alcoves. In general, the more complex a stream is, the higher its capacity to retain material.



Annual cycle of food resources

On the west side of the Cascades, the annual cycle of food resources could be described as follows. In late summer and early fall, stream flows are low, and the amount of organic matter present is low. Fall brings an increase in stream flow and leaf input to the stream. Many aquatic insects come out of dormancy at this time to utilize the leaf litter. By mid-November, stream flows generally are higher, and leaf fall is in full swing. As leaves fall, more sunlight reaches the stream, and algal production increases. Adult salmon begin to return to the rivers to spawn. When they die, their carcasses become an important part of the stream food web. This is a time of maximum food availability.

In sparsely vegetated eastern Oregon riparian areas, algae, through the conversion of sunlight to edible forms of energy, are the main source of nutrients.

On both sides of the Cascades, adult salmon begin to return to the rivers to spawn. When they die, their carcasses become an important part of the stream food web. This is a time of maximum food availability.

When the first major storms of the fall occur in the Pacific Northwest, food supplies decrease. In the absence of historically abundant in-stream wood, most leaf litter is 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, stream flows decrease west of the Cascades, and algal production greatly increases until alders begin to leaf out and shade small streams. On the east side, spring brings snowmelt and accompanying high flows.

Spring is a highly productive time. Many macroinvertebrates complete their growth cycle and leave the aquatic system as adult insects. Spring also is a time of rapid growth for juvenile salmonids, which feed on macroinvertebrates and terrestrial insects that fall into the stream.

Summer brings lower productivity to most streams. Stream flows drop. Food resources are reduced as algal production slows. Juvenile salmonids prey on insects from the riparian zone in order to continue their growth during the summer.

SALMONID LIFE CYCLES

Salmonid is the group name for salmon, trout, steelhead, and char. Although these fish share a common life history pattern, Pacific salmon die after spawning, whereas char, trout, and Atlantic salmon can live to spawn multiple times. Many salmonids are *anadromous*, i.e., hatch in fresh water, migrate to sea as juveniles, grow to maturity, and return to freshwater streams to reproduce. Non-anadromous salmonids might or might not undergo a migratory life cycle within the freshwater system.

Spawning site selection differs from species to species, with considerable variation within species as well. Stream gradient, gravel size, and flow pattern of the stream all affect site selection. Spawning generally occurs in stream riffles and tail-outs of pools, but, as noted earlier, there are exceptions to most generalizations regarding salmonid biology. In the case of sockeye salmon, lake margins, rather than streams, might be the choice location.

When spawning, fish select optimal habitat for reproductive success. Lower quality areas come into play in years of high spawner abundance, when the best spawning areas already are occupied. In years of high abundance, spawning on top of existing redds occurs, as salmon seek to optimize their reproductive success.

Eggs and milt are deposited in a *redd* or spawning nest that the female fish creates by beating her body over the gravel. The construction produces a depression in the gravel that is relatively free of fine sediment. After spawning, the female uses the same method to cover the eggs. She remains on the site until she dies, fanning the redd to improve water circulation and protecting it from predation or disturbance by other spawners.

The eggs remain in the gravel for several weeks or months 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, as they are weak swimmers and can easily be swept downstream if habitat is not available for refuge from high flows. As in all other phases of their lives, fry need adequate food and cold, sediment-free water high in dissolved oxygen.

Natural mortality of juveniles is high. Many young fish are eaten by birds, amphibians, reptiles, and other fish. Juvenile anadromous salmonids spend from a few days to more than 3 years in fresh water. Estuarine environments are utilized by some species for several months before migrating to sea as *smolts*. Smolting involves physiological and behavioral changes in preparation for the transition from fresh to salt water. In many systems, smolts spend transition time in the estuary. In systems that do not have an estuary, smolts must adapt abruptly to saline conditions. It is not well understood how the two types of adaptations might affect survival.

As in the time spent in fresh water, there is much variation among species in terms of time spent in the ocean. All anadromous salmonids eventually return to fresh water to spawn. Generally, time in the ocean ranges from a few months, in the case of sea-run cutthroat trout, to 6 years or more in the case of some chinook salmon.

Salmon of all species produce precocious males known as *jacks*. These fish spend a brief time in the ocean and return to fresh water to pursue a reproductive strategy of attempting to contribute milt to redds protected by a dominant male.

Each species of salmonid has a general life history, described below and summarized in Table 1. Note that life cycles can vary greatly within a species. This variation can be seen when comparing river basins. Within a particular basin, each species has a range of strategies as well.

Variation is a mechanism to ensure adaptability to environmental uncertainty, akin to the idiom "don't put all your eggs in one basket." Just as flower timing varies widely within a given plant species, timing for fish behavior varies around a norm within each species. This variation results from important genetic variability. If all fish of a particular species spawned within a week or two of each

Table 1.–Life history of several salmonid species.

Species	Spawning Habitat	Freshwater Residence after Emergence	Juvenile Behavior	Usual Month of Ocean Entry	Usual Size at Ocean Entry	Estuarine Residence of Smolts	Ocean Residency
Steelhead	large and small streams	1–4 years	agonistic *	April–June	100–200 mm	<1 month	0.2–4 yr.
Cutthroat	tiny tributaries of coastal streams	1–6 years	agonistic	April–June	100–200 mm	<1 month	0.2–0.5 yr.
Coho	coastal streams, shallow tributaries	0–4 years	agonistic	May–June	60–120 mm	few days	0.5–1.5 yr.
Chinook	large and small rivers	0–2 years	agonistic	May–Oct	40–110 mm	days–months	0.5–6 yr.
Chum	coastal streams and rivers	days–weeks	school	Mar–June	30–40 mm	7–14 days	2–4 yr.
Sockeye	streams, usually with connecting lakes	0–2 years	school	May–June	60–100 mm	few days	1–5 yr.
Pink	large and small streams, intertidal	days–weeks	school	May–June	30–40 mm	few days	1.6 yr.

*Territorial, nonschooling

other, poor environmental conditions at that time could devastate the entire population. Varying the timing of life history activities creates a safety net that ensures survival for some members of the population.

Most adult anadromous salmonids find their way back from the ocean to their natal streams. This life cycle feature is called *homing* and is one of the least understood aspects of salmon ecology. Straying does

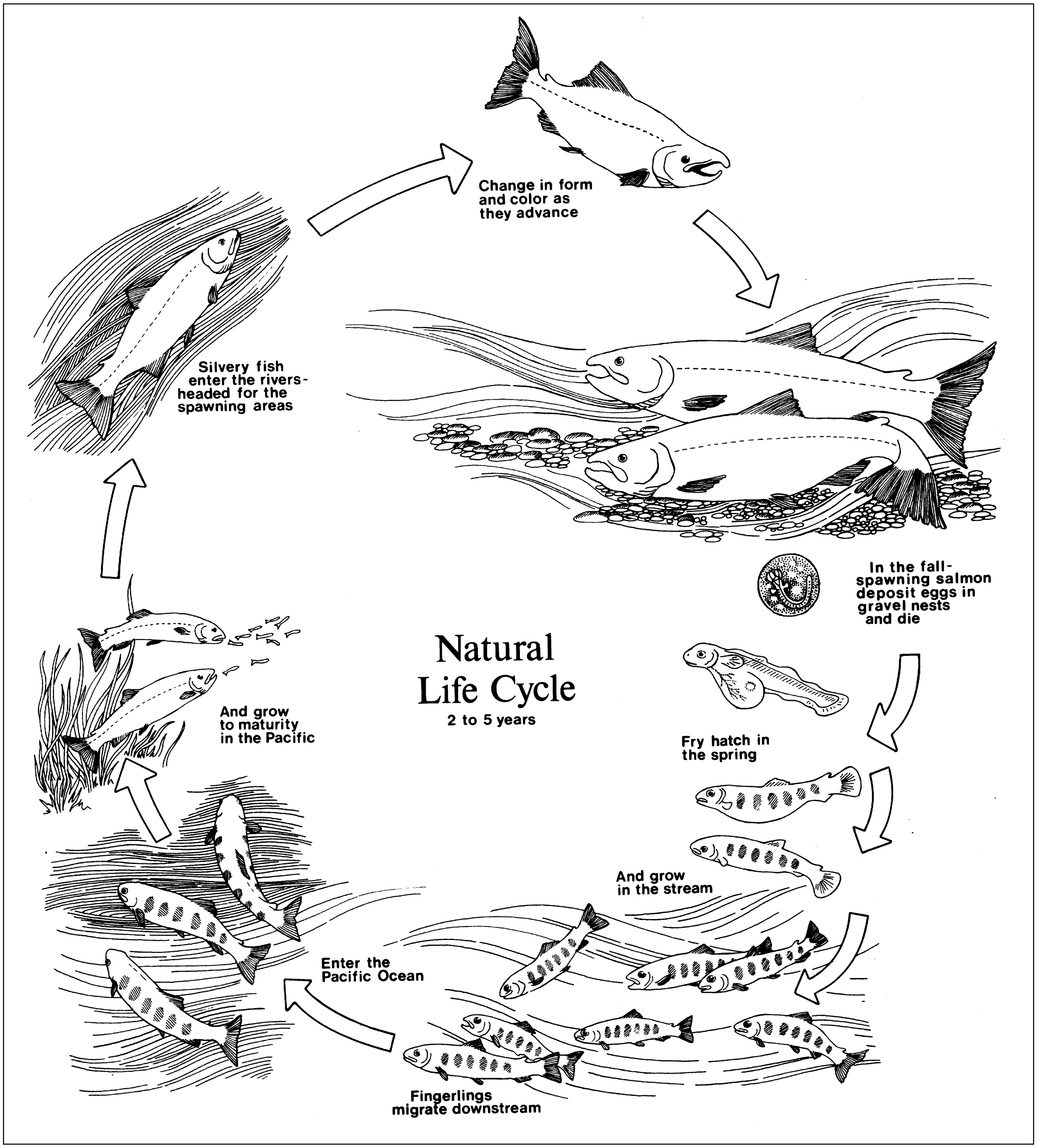


Figure 3.–Typical salmonid life cycle. (Source: The Stream Scene, *by P. Bowers et al., Oregon Department of Fish and Wildlife, 1992)*

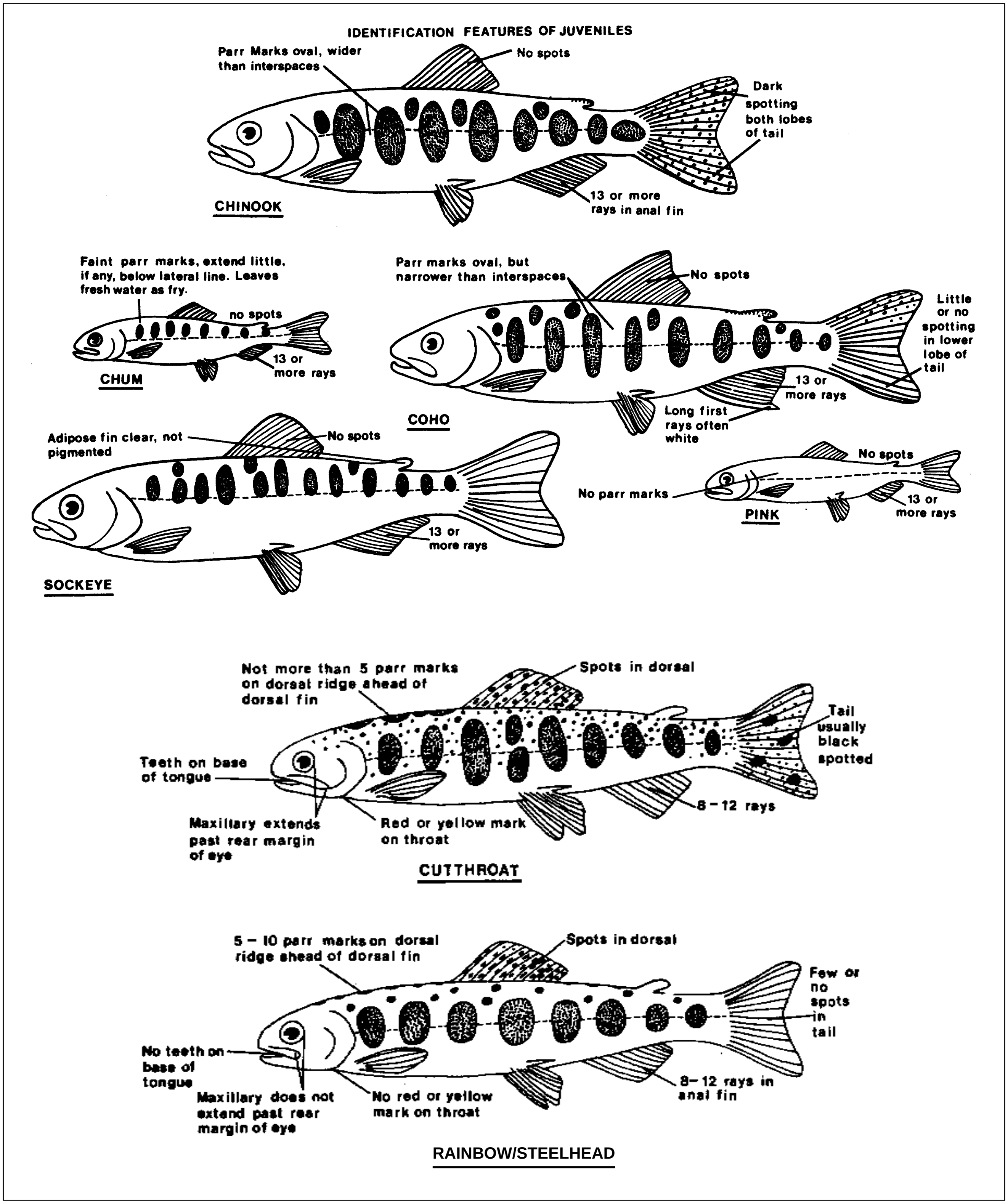


Figure 4.–Physical characteristics used in identifying juvenile salmonids. (Source: The Stream Scene, *by P. Bowers et al., Oregon Department of Fish and Wildlife, 1992)*

occur and provides fresh genetic material to the population of the stream where the stray spawns. In some cases, recolonization of streams where runs have been eliminated occurs through straying.

Figure 3 illustrates a general salmonid life cycle. Figure 4 shows the physical characteristics used in identifying juvenile salmonids.

COMMON SALMONID SPECIES OF THE PACIFIC NORTHWEST

Chinook salmon
(Oncorhynchus tshawytscha)

Chinook or king salmon are the largest and longest lived of the Pacific salmon. They exhibit a variety of life history strategies. Juveniles spend 1–3 years in fresh water before out-migrating. Chinook return from the ocean at 2–7 years of age. This variability provides insurance against the loss of a particular brood year because of temporarily poor freshwater conditions.

Chinook spawn in main river channels and low-gradient tributaries. The most consistent feature in selection of spawning sites is the presence of strong subsurface flow to oxygenate eggs. Females lay from 2,000 to 17,000 eggs. The time that juveniles emerge from the gravel depends on water temperature. The range generally is 2–3 months.

Behavior of juveniles after hatching varies, among and within runs. Some move down to the estuary within a few weeks or months. Others spend a year or more in fresh water. All juvenile chinook eventually move to the estuary, where they spend several weeks or months. Chinook and chum utilize estuarine habitat for a longer period of their life cycles than do any other Pacific salmon.

Coho salmon *(Oncorhynchus kisutch)*

Coho salmon (silver salmon) historically were the most abundant salmon on the Oregon coast. These salmon have a 3-year life cycle, split about equally between fresh and salt water. Unlike chinook, all coho spawn at age 3. Because there is no variability within this strategy, their survival is susceptible to catastrophic events. If a year's run 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 these source areas deteriorate.

Coho spawn from November to March. They do not utilize large main-stem areas for spawning. They tend to move higher in the basin and utilize smaller gravel in low-gradient tributary streams. Females lay an average of 2,500 eggs.

Coho juveniles generally emerge from the gravel from February through April. During summer, they rear in pools. In winter they seek quiet water, such as side channels and beaver ponds, where high flows won't wash them downstream. Out-migration to the ocean occurs in April or May of their second year.

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 fresh water. Unlike other salmonids, they are not able to pass barriers such as waterfalls. Chum 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 enter the estuary, where they spend several days or weeks before migrating to the ocean. Chum salmon spend 3–4 years in the ocean.

Sockeye salmon *(Oncorhynchus nerka)*

Sockeye salmon are unique in their frequent use of lakes as spawning and nursery habitat. Sockeye are found most often in association with lakes. Like rainbow trout, sockeye occur in two types. The nonanadromous form of sockeye is called kokanee.

Sockeye generally spawn in lake tributaries or in spring-fed upwellings on lake margins. Juveniles generally rear in lakes for 1–3 years before migrating to the ocean, although variations include out-migration within a few days of emergence. The oceanic part of the life cycle is 1–4 years long.

At the turn of the 20th century, the Columbia Basin sockeye run was more than 1 million strong. Less than one-third of the original lake systems utilized by sockeye in the Columbia still are accessible to them, and production no longer is significant.

Steelhead *(Oncorhynchus mykiss)*

Steelhead are seagoing rainbow trout. Adults average 8–12 pounds, and some adults live as long as 7 years. Winter steelhead return from the ocean from December through May. They spawn in main-stem and high-gradient tributaries, often taking advantage of small gravel pockets. Some females survive to spawn again.

Juveniles emerge by June. During the first year, they live in riffles, pools, and along the edges of stream channels. They spend 2–3 years in a stream before migrating to the ocean. Like other species with a long freshwater residence time, steelhead are vulnerable to freshwater habitat degradation.

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.

Redband trout *(Oncorhynchus mykiss)*

Resident rainbow are commonly referred to as redband trout east of the Cascade Mountains. In the southeastern part of Oregon, these fish tolerate stream temperatures much higher than those tolerated by other trout.

Coastal cutthroat trout *(Oncorhynchus clarki)*

Cutthroat trout have variable life-history patterns. Some go to the ocean, like salmon or steelhead, while others remain in fresh water their entire lives. Some stay in certain portions of a stream, while others move throughout the river system.

Cutthroat spawn in the fall or spring, depending on life-history patterns. Adults do not die after spawning. Juveniles emerge by June or July. Cutthroat trout can be distributed throughout river systems, including small, low-gradient areas not utilized by other salmonids. They also can be found above fish passage barriers in some systems, where populations of these fish have been surviving in isolation for thousands of years.

West-slope cutthroat *(Salmo clarki lewsi)*

West-slope cutthroat variety life-history strategies are similar to those of nonanadromous coastal cutthroat. These fish are unique among trout in their preference for insects over other fishes as food.

Populations exist in the John Day system and are depressed due to habitat degradation, competition, and predation by introduced species.

Bull trout *(Salvelinus confluentus)*

Bull trout are native Pacific Northwest char. Like other char, they spawn in the fall, and juveniles emerge in late winter or spring. Their life history is quite variable. Bull trout generally are resident.

Most populations of bull trout are depressed. They are very dependent on cold-water seeps and springs. Bull trout do not

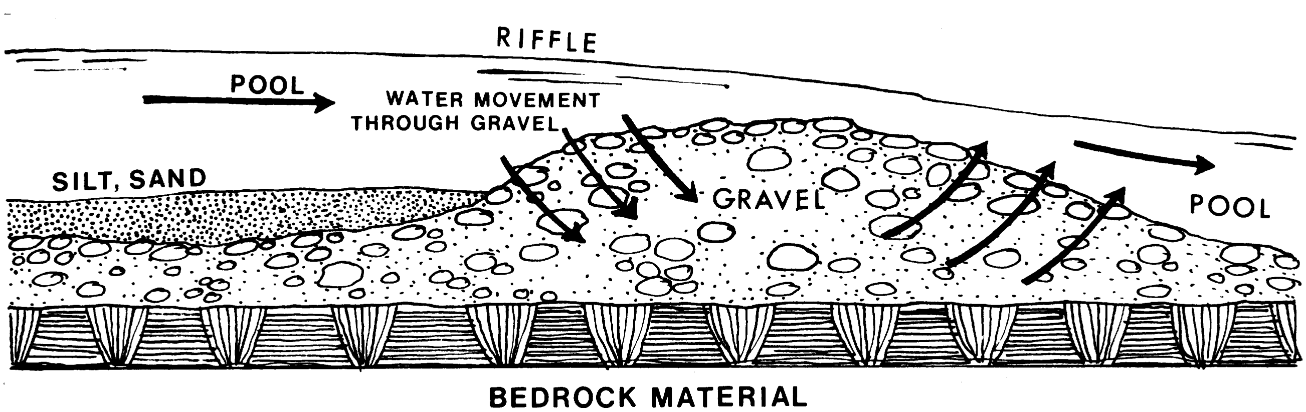


Figure 5.–Spawning habitat. (Source: "From Headwater Streams to Rivers," by Ken Cummins, American Biology Teacher, *May 1977, p. 307)*

tolerate fine sediment input. Habitat degradation has isolated many populations in pristine headwater areas.

FISH HABITAT NEEDS

Salmonids use a variety of stream types. Although each species has its own specific habitat requirements, some generalizations can be made.

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 (Figure 5)
- A combination of pools and riffles that provide 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, high stream flows, and food shortages. They need pools for rearing, temperature regulation, and cover. Good juvenile-rearing habitat exhibits the following characteristics:

- No barriers to upstream migration–juveniles must be able to migrate out of warm areas

- Low to moderate stream gradient (slope) and water velocity
- A good mix of pool and riffle habitats, with off-channel areas and in-stream wood to provide refuge from high water events
- Clean, oxygenated water and cool stream temperatures
- A variety of substrate types to provide habitat for juvenile fish and food organisms
- Overhanging vegetation, large woody material, and undercut stream banks, which provide protection for juvenile fish and leaf litter for aquatic insect food
- Sufficient nutrients to promote algal growth

As young fish grow, they can endure increased summer flow, and so move from the edge of a stream to midstream to take advantage of insect drift. Since many streams are too warm in summer for survival, juveniles migrate to cold-water areas, if possible. In winter, all species seek areas of lower water velocity where they can conserve energy during the season characterized by limited food.

Habitat use

Although their basic requirements are the same, salmonid species can differ in the types of habitat they use. For example, juvenile coho prefer pools in summer, especially those with slow water current near undercut stream banks, root wads, or logs. In winter, they seek slow, deep pools or side channels, utilizing 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, but trout spend the summer in pools.

Like all fry, chinook juveniles are found at stream margins and other quiet water. As they mature, they occupy a variety of habitats within the stream or estuarine system.

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 (e.g., extreme high and low stream flows, high stream temperatures in the summer, or ice). A stream does not necessarily reach its carrying capacity each year because of these factors.

Anadromous salmonids are subject to varying ocean conditions, as well as those in the freshwater environment. The ocean, like the freshwater system, has a carrying capacity affected by nutrients, currents, temperature, and other variables.

Chapter III-8, "Water-quality Monitoring," details some of the most important factors limiting salmonid production.

Summary/Self review

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 stream flows 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 share 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.

EXERCISES

The best way to understand biological and chemical processes is to measure and observe them in stream systems. Listed below are some field exercises to pursue with local state agencies to clarify these processes. Other agencies (e.g., U.S. Forest Service, Bureau of Land Management), private interest groups (e.g., Oregon Trout), and trained volunteer groups (e.g., STEP) also conduct these surveys.

- Review local watershed assessments. Find the types of fish present, their population estimates, and a list of possible limiting factors.
- Volunteer to participate with a field crew of agency personnel or trained volunteers performing an Aquatic Macroinvertebrate Survey on a stream in your area. Review data, analyses, and results.
- Volunteer to participate with an Oregon Department of Fish and Wildlife field crew in performing resource surveys (fish habitat, spawning, or population surveys).

RESOURCES

Training

Local state and federal agencies, universities, nonprofit groups, private interest groups, and trained volunteers might offer training opportunities in your area.

Information

Ecosystem Workforce Project Curriculum, various authors (Oregon State University and LERC at University of Oregon, 1996).

Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats, W. Meehan, ed. (1991). ISBN 0-913235-68-7

Methods in Stream Ecology, by F. Hauer and G. Lamberti (Academic Press, San Diego, CA, 1996).

Pacific Salmon Life Histories, by C. Groot and L. Margolis (University of British Columbia Press, 1991).

"The river continuum concept," by R. Vannote, G. Minshall, K. Cummins, J. Sedell, and C. Cushing, *Can. J. Fish. Aquat. Sci.* 37(1980):130–137.

The Stream Scene, by P. Bowers et al. (Oregon Department of Fish and Wildlife, Portland, 1992).

Stream Temperatures: Some Basic Considerations, EC 1489, by J. Moore and R. Miner (Oregon State University Extension Service, Corvallis, 1997).

"Structure and function of stream ecosystems," by K. Cummins, *BioScience* 24(1974):631–641.

"Trophic relations of aquatic insects," by K. Cummins, *Annual Review of Entomology* 18(1973):183–206.

Moving forward–the next steps

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in understanding stream ecology.

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Stream Assessment and Restoration

Guillermo Giannico,
Derek C. Godwin,
and Jim Waldvogel

It is no wonder that stream enhancement projects are popular; people have something to show for their work when they are finished. However, such projects frequently are expensive and require technical expertise. In many cases, they do not achieve their goals, but nobody notices because the project was not evaluated properly. Few stream enhancement projects include adequate post-completion monitoring of long-term performance.

Chapter III-4, “Stream Ecology,” provided introductory information about stream ecosystems. This chapter covers stream assessments, stream restoration and enhancement, and monitoring plans.

Assessments can be thought of in two ways: as *inventories* or as *evaluations.* An inventory simply characterizes or identifies the physical, chemical, and biological features of a stream. An evaluation determines how well the stream is functioning, based on restoration goals. (See Chapter III-1, “Riparian Areas Functions and Management.”)

Although the words *restoration* and *enhancement* often are used interchangeably, in this chapter they have different meanings. Restoration seeks to bring a stream or river to a self-regulating state by reestablishing watershed components and processes. Watershed *components* include hydrologic patterns, water quality, riparian

In this chapter you'll learn:

- How to assess streams
- How stream surveys are carried out
- Basic restoration and enhancement principles
- About the importance of monitoring and evaluation plans

forests, and habitats. Examples of watershed *processes*, or *functions*, include water chemistry and temperature modification, flow regulation, gravel retention, input of litter and wood from the riparian forests, accumulation of wood in the channel, etc. *Self-regulation* implies that the stream does not require the periodic intervention of humans to maintain a state of dynamic equilibrium. Examples of restoration goals might include improving water quality and aquatic habitats in a watershed or maintaining native species diversity.

In contrast, enhancement implies a narrower set of goals, such as improving a specific set of stream conditions for the benefit of a particular species (e.g., steelhead trout) or type of habitat (e.g., spawning gravel beds). Often, enhancement is aimed at achieving a more immediate, but shorter lasting, effect than restoration. Enhancement activities tend to focus on a single issue such as reducing bank erosion or recruiting spawning gravel.

The term *preservation*, as used in this chapter, differs from both enhancement and restoration. While restoration addresses only degraded ecosystems, preservation attempts to prevent negative human-induced changes to intact ecosystems. It acknowledges that ecosystems change over time (e.g., riparian vegetation succession) and that management actions (e.g., prescribed upland fires, removal or control of invasive species, etc.) might be needed to maintain the system's functions and components.

Preserving intact ecosystems should represent the priority of any watershed-scale restoration plan. Preservation initiatives are important for several reasons:

- They often are easier to implement and less expensive than restoration and/or enhancement projects.
- Intact ecosystems are important sources of biological diversity.
- Intact ecosystems serve as models that resource managers can use in their restoration projects. Modeling restoration activities on nearby intact ecosystems is preferable to using handbooks.
- The success rate of protecting fully functional sites is far higher than that of restoring degraded ecosystems.

The role of *monitoring* activities in stream restoration and enhancement is briefly discussed at the end of this chapter. Monitoring evaluates the results of projects over time and helps determine whether the goals were achieved. For additional information on this topic, see Chapter II-5, "Assessment and Monitoring Considerations."

This chapter will help you understand the basic principles used in statewide stream restoration and enhancement programs

See Section II, Chapters 1–5; and Section III, Chapters 1, 2, and 4 for information related to this chapter.

Section II

1 Planning

2 Hydrology

3 Stream Processes

4 Soils

5 Assessment

Section III

1 Riparian Functions

2 Riparian Enhancement

4 Stream Ecology

(e.g., the *Oregon Watershed Assessment Manual* from the Oregon Watershed Enhancement Board). It also suggests field exercises and references for additional information and training.

WHY DO WE NEED STREAM ASSESSMENTS?

An assessment is the first step in establishing stream components and functions that provide maximum potential benefits to fish and other aquatic life, wildlife, and humans. A stream assessment can:

- Inventory existing components and functions
- Evaluate the state of stream components and how functions are working
- Recommend and prioritize projects or determine that restoration or enhancement is not presently needed

For example, assessments commonly are used to characterize a stream reach and its relation to the adjacent land, to evaluate fish habitat quality and quantity, or to estimate the abundance and distribution of fish.

BASIC COMPONENTS OF STREAM ASSESSMENTS

A stream assessment can identify the physical (stream channel), chemical (water quality), and biological (aquatic organisms) characteristics of a stream. These characteristics were described in Chapters II-2, "Watershed Hydrology," and III-4, "Stream Ecology." Table 1 (page 4) summarizes the basic components of stream assessments.

How this information is used to evaluate stream function and recommend changes depends on goals, local conditions, constraints, and possible incentives. (See Chapter III-1, "Riparian Area Functions and Management.")

Stream assessments constitute the first step in any restoration plan. Assessments are most useful when conducted with a *watershed perspective*, thus taking into account upstream processes, which might affect the restoration project's success. They must be sufficiently detailed to show the stream reaches or habitat units where restoration work is needed.

Preliminary field evaluations help identify:

- Reaches that are not degraded by human activities and might be worthy of preservation

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.

- Reaches where restoration is feasible through changes in land-use practices or relatively low-cost projects
- Reaches where restoration is possible only at very high costs and where the chance of failure is high
- Reaches where restoration is not technically possible

CONSIDERATIONS WHEN CHOOSING AN ASSESSMENT

Assessments can be complex and labor intensive because they seek to capture the broad variety of watershed processes, land uses, climates, geologies, and other factors that affect streams. A combination of techniques that evaluate physical, chemical, and biological conditions is needed to characterize a stream.

There are different types of assessments; many are time-consuming and require specific technical skills. Choose an assessment that will work for you or your group, always taking into consideration your time, money, and access to technical expertise and training. Chapter II-5, "Assessment and Monitoring Considerations," provides additional information about the complexity of assessment.

It is recommended that you select assessments that gather information in an existing standard format. Doing so allows the information to be analyzed and used by many different stakeholders (e.g., state and federal agencies, private consultants, and other watershed groups). Such methods include the basic and advanced stream habitat surveys developed by the Oregon Department of Fish and Wildlife (ODFW), the water-quality assessment and monitoring techniques devised by the Department of Environmental Quality (DEQ), and the methods included in the *Oregon Watershed Assessment Manual* of the Oregon Watershed Enhancement Board (OWEB).

When selecting an assessment, the first step is to list the questions you want to answer. Then choose an assessment that collects adequate data to answer these questions. To simplify these steps, look for examples of the questions most common stream assessments answer and the type of data they gather. Chapter III-2, "Riparian Area Evaluation and Enhancement," discusses several considerations for designing riparian assessments. These considerations also apply to stream assessments.

Divide the stream to be assessed into manageable segments (i.e., *reaches*). This will give you more flexibility in using the data for planning projects and management changes. Streams can be divided into segments based on:

- Land use or management type
- Stream type (e.g., small versus large, flows year round versus seasonally)
- Valley type (e.g., wide floodplain versus steep canyon)
- Resource values (e.g., different types of fish or water use)

Using standard methods allows the information to be analyzed and used by many different stakeholders (e.g., state and federal agencies, private consultants, and other watershed groups).

EXAMPLES OF STREAM CHANNEL ASSESSMENTS

ODFW stream habitat surveys

Stream habitat surveys are designed to obtain basic information about fish habitat. The data collected will help identify "good" fish habitat to be maintained, "poor" fish habitat needing enhancement, and factors contributing to present habitat functions and 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 fish habitat surveys that is designed to be compatible with other stream habitat inventory and classification systems. It involves recording data about fish 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* (see "References" section). Appendices A-1 through A-5 show the forms used for recording data. To obtain quality data with this survey, training and supervision by experienced personnel are required.

Stream fish 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 fish habitat area and characteristics.

The data collected will help identify "good" fish habitat to be maintained, "poor" fish habitat needing enhancement, and factors contributing to present habitat functions and conditions.

Every stream is divided into sections called *reaches*. A reach is arbitrarily defined as a segment between tributaries or between two points marked by a change in valley and channel form, riparian vegetation, land use, or ownership. Reaches vary in length from approximately 1,500 feet to 5 miles. Data that describe channel form, valley form, valley width, streamside vegetation, land use, water temperature, stream flow, location, and other features used to define reaches are recorded on the Stream Reach form (Appendix A-1).

A fish habitat survey describes each reach as a sequence of *habitat units*. Each unit has relatively uniform slope, flow pattern, and substrate characteristics. This information is recorded on the Unit-1, Unit-2, Wood, and Riparian forms (Appendices A-2 through A-5). Habitat units are longer than the *active channel* is wide. (*Active* *channel width* is the distance across the channel at annual high flow. It can be recognized by bank slope breaks, high water marks, and changes in vegetation).

Unit-1 and Unit-2 forms

Information on stream habitat units is recorded on Unit-1 and Unit-2 forms (Appendices A-2 and A-3). The following are examples of the most common types of stream fish habitat units (for diagrams of these units see Appendix A-6):

- *Riffles*—shallow units where turbulent, fast water flows over submerged or partially submerged gravel and cobble. They usually have a 0.5 to 2 percent slope. Riffles offer habitat to many of the aquatic invertebrates used as food by salmon and trout. These gravel-rich units also provide prime spawning beds for salmon and trout, and juvenile steelhead and cutthroat use them as summer nursery habitat.
- *Rapids*—units characterized by swift, turbulent flow swirling around boulders and a slope that ranges from 2 to 8 percent. They may include chutes and small falls. Between 15 and 50 percent of the stream surface is covered by whitewater. Rapids normally do not sustain high fish densities, but young steelhead trout and resident cutthroat trout can be found in pockets of slow water velocity behind boulders and near the banks.
- *Cascades*—fast, turbulent flow with many hydraulic jumps, strong chutes, and eddies. They usually have a 3.5 to 10 percent slope. Whitewater normally covers 30 to 80 percent of the surface area of a cascade, and most of the exposed substrate is formed by boulders or bedrock bars. Cascades sometimes represent important natural barriers to fish migration. However, many salmonids are able to pass small step cascades at times of high water flows.
- *Falls*—single step cascades with a height ranging from a few feet to more than 100 feet. As with cascades, falls often are impassable to most fish. In some mountain streams, the formation of falls has isolated many small, distinctive populations of resident cutthroat trout since the end of the last glacial age some 10,000 years ago.
- *Glides* (or *runs*)—units of generally uniform depth along their entire length and relatively fast water flow with no surface turbulence. They tend to have relatively stable banks and, in the middle reaches of a watershed, a substrate dominated by gravel and sand. In floodplain reaches, however, they are deeper and have slower water velocities; as a result their substrate is finer, often formed by a thick layer of silt rich in organic matter.

Juvenile coho salmon and trout can be found in this type of habitat unit, provided water temperature and oxygen concentrations are within their tolerance range.

- *Pools*–units that normally have a water surface slope of zero (flat). They are shallower at both ends and have slow water velocity. The substrate of pools tends to be fine because their relatively slow-moving waters allow suspended particles to precipitate and accumulate in the deepest areas of the unit. Pool habitat is used predominantly by juvenile coho salmon and, to a lesser extent, by steelhead/rainbow and cutthroat trout. During periods of high flow (i.e., fall–winter in coastal watersheds and spring in interior ones), juvenile salmonids often seek shelter in off-channel habitat (i.e., lateral ponds, side channels, etc.) or in the deepest pools in the main channel. They especially favor pools that offer the best shelter from water currents. Examples include backwater and lateral scour pools.

  There are different types of pools. The most common ones are:

  - *Backwater pools*–units carved into one of the banks by eddies on the downstream side of structures such as boulder or logs. These pools tend to be shallow, with extremely low water velocity and a substrate dominated by sand and gravel.
  - *Lateral scour pools* (a.k.a. corner or side pools)–units that are deeper on one side than the other. As water moves around the outside of a channel bend or a partial obstruction, it speeds up. Thus, during high flows, it digs deeper into the substrate near the “outside” bank.
  - *Straight scour pools*–units formed by scouring of the gravel/cobble substrate in the middle of the channel.
  - *Trench pools*–long, central, and relatively narrow slots carved in the substrate, often found in bedrock-dominated channels. They tend to have a U-shaped cross-section.
  - *Plunge pools*–units created by water passing over a complete or near complete channel obstruction and dropping vertically into the channel below. They tend to sustain high densities of juvenile salmonids, possibly because their depth and water surface turbulence provide protection from bird predation.
  - *Dammed pools*–units formed by water dammed behind some kind of channel obstruction, such as a cluster of boulders or debris jam. These pools can be natural or created by beavers or humans.

Surveyors collect and record the following information for each fish habitat unit:

- Channel form (length, width, slope, and depth measurements)
- Streambed materials or substrate composition (size class and percent distribution)
- Boulder counts (number of boulders protruding above the water surface at low flow)
- Woody material (amount, size, and 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 (tendency to erode 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 recorded on the wood form (Appendix A-4).

The riparian inventory is designed to provide additional information about the kinds, quantities, and sizes of riparian vegetation. Measurements are taken along a line (*transect)* to describe vegetation, land surface and slope, and canopy closure in the riparian zone. For example, a transect across a stream channel is used to indicate where water velocity, substrate composition, or other indicators are recorded. A transect in the riparian zone normally is set perpendicular to the stream channel and is used as a guide to where vegetation, soil, and other samples or measurements are taken. All of these data are entered on the riparian form (Appendix A-5).

Note: If your main goal is related to the riparian area, a survey more specific to vegetation is needed. (See Chapter III-1, “Riparian Area Functions and Evaluation.”)

From survey to assessment

Stream survey information allows fish habitat and channel structure evaluations as well as comparisons among streams. It also helps locate potential problems, enhancement sites, and unique features.

Habitat unit descriptions indicate fish habitat potential (spawning, rearing, and cover habitat) and habitat components that are missing. For example, stream bank classification and riparian forms indicate channel stability, sediment sources, and riparian conditions influencing in-stream 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 OWEB's *Oregon Watershed Assessment Manual* describe techniques for evaluating physical stream characteristics. They are: *Channel Habitat Type Classification* and *Fisheries Assessment*. The following section includes excerpts from these chapters.

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 utilization and how various channel types respond to land-use impacts or restoration efforts. This information, in turn, will help you prioritize restoration projects that are likely to benefit fish habitat the most. The assessment utilizes 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 CHTs 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 materials making up the channel banks, and the size of particles on the streambed.

CHTs are identified and mapped using U.S. Geological Survey Department (USGS) topographic maps and aerial photos. Field visits help verify CHTs that are difficult to characterize or identify based on maps and photos. The OWEB's *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

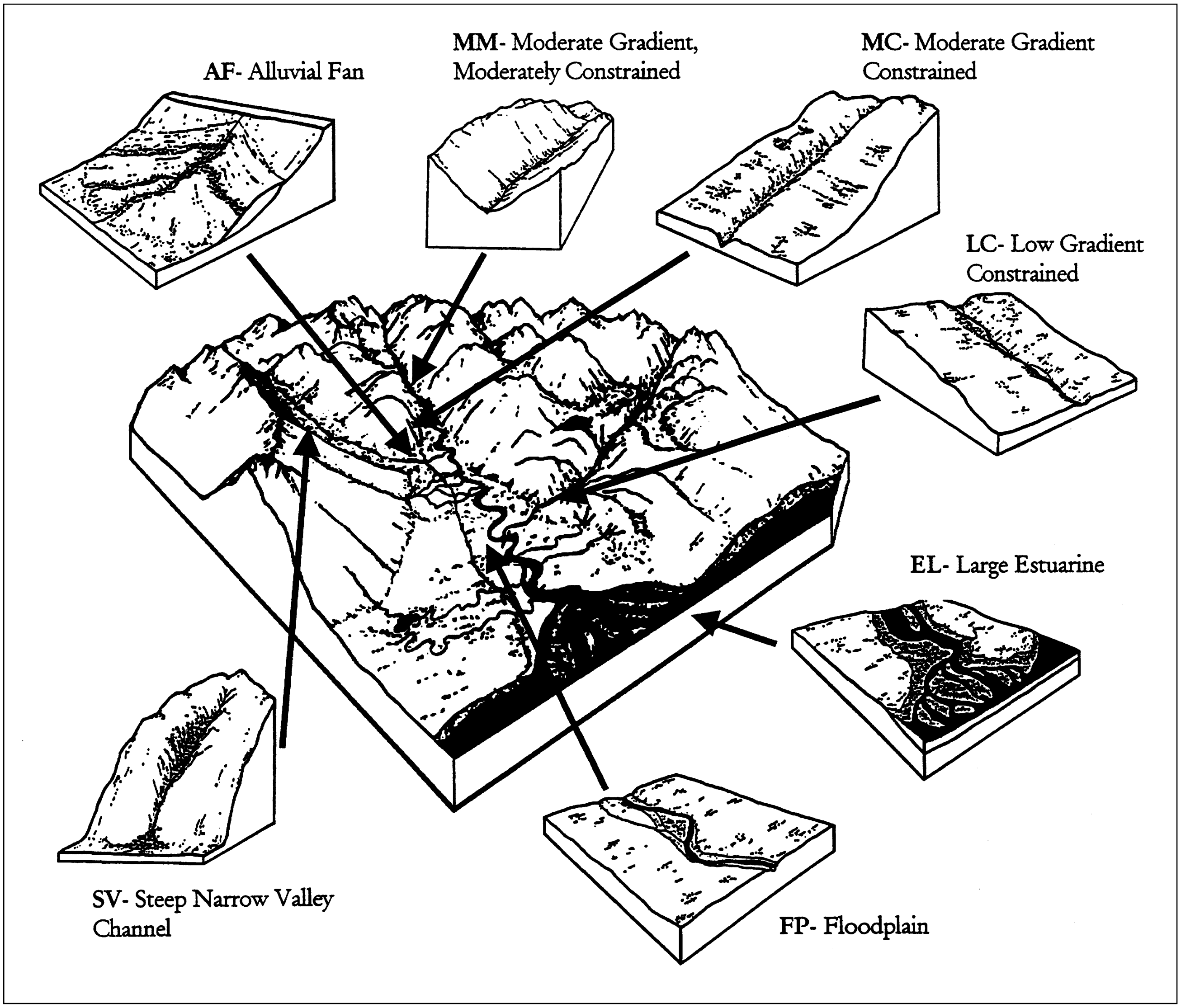


Figure 1.–Channel habitat type descriptions. (Source: Oregon Watershed Assessment Manual, *Oregon Watershed Enhancement Board, Salem, 1998)*

Fisheries assessment

This assessment is designed to:

- Identify fish species present in the watershed, their distribution, and population characteristics
- Identify potential interactions between species of interest
- Compare measured habitat data to preestablished ODFW/ NMFS (National Marine Fisheries Service) benchmarks to evaluate in-stream habitat functions and components
- Identify human-caused barriers to fish passage and prioritize their removal or modification

An example of a form used for compiling and evaluating habitat conditions is included in Appendix B.

ASSESSMENTS OF STREAM BIOLOGICAL CHARACTERISTICS

Macroinvertebrate surveys

Macroinvertebrates are those invertebrates that can be observed easily without magnifying equipment. They often are abundant and diverse in streams. Their habitat units are much smaller than those of fish. For example, a macroinvertebrate might spend much of its life on a single piece of bark or patch of leaf litter. There can be 30–100 different species in a single pool or riffle, and their total numbers often reach several hundred in a square foot of stream substrate.

Invertebrates vary a great deal in their sensitivity to sedimentation, oxygen levels, and other disturbances. Some species readily reoccupy areas that have been disturbed. Thus, invertebrates serve as good indicators of changes in streams and often are used to indicate responses to a wide array of human activities. The DEQ has specific protocols for sampling macroinvertebrates and using their relative abundance and diversity to evaluate stream conditions (i.e., water quality and fish habitat).

Surveys classify macroinvertebrates in different ways, but most classifications are based either on how different species obtain their food or how tolerant they are of water pollution and changes in oxygen concentration.

According to their feeding habits, macroinvertebrates can be sorted into four feeding groups: shredders, collectors (which either filter the water for food or gather food particles from the substrate), scrapers (or grazers), and predators. Chapter III-4, “Stream Ecology,” provides additional information on these groups and the roles they play in a stream ecosystem.

Insects with exposed gills (particularly mayflies, stoneflies, and caddisflies) generally are intolerant of low oxygen levels, high temperatures, and high levels of suspended silt. Their presence is a good indicator of high water quality and good habitat conditions. Stream degradation tends to result in reduced populations of these species.

The following section provides an overview of how to survey macroinvertebrates and how to use the resulting information. However, additional training is needed to apply these techniques effectively. The methodology described was obtained from *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates* (see “References”). Many agencies (e.g., DEQ), institutions, and private organizations have adapted these procedures for their own use.

General sampling methods

The best times to conduct macroinvertebrate 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 easy to observe. Invertebrates usually are collected from three to five of the following habitat types:

- Coarse particulate organic matter, such as leaves, needles, bark, and twigs (>1 mm in size)
- Large wood, large branches, and logs
- Fine particulate organic matter (between 0.5 um and 1 mm)
- Periphyton (the thin layer of algae that is attached to the surface of the stream substrate, submerged rocks, and wood)
- Rooted plants (only if extensive plant beds or moss cover is present)

To do a macroinvertebrate survey, surveyors collect a handful-size sample from each habitat type. All sample areas should be the same size, approximately 1 square foot, to make comparisons among sites possible.

Sampling of invertebrates from the stream's substrate relies on the use of *kick nets* (fine mesh nets shaped like "butterfly nets" with rectangular mouths supported by wooden or metallic frames). A net is placed on the downstream edge of the sample area with its opening facing into the flow. All stones and debris within the sample area are brushed or rubbed gently by hand to loosen the substrate invertebrates, which are swept into the net by the water current. The net is turned inside out and gently rinsed in a bucket half full of stream water. All macroinvertebrates are subsequently picked and sorted according to some classification system.

The sampled macroinvertebrates are classified by feeding group, sorted into separate containers (ice cube trays work well), and counted. Appendix C provides a key to feeding (or functional) groups and a sample sheet for recording data.

After counting individuals, the next step is to compare total numbers in each group and calculate proportions of one group to another. Differences in the proportional representation of the feeding groups can be used to characterize stream habitat. Changes in these proportions over time are useful indicators of possible habitat alterations.

From survey to assessment

Macroinvertebrate surveys are used to assess water quality and fish habitat. Combining macroinvertebrate surveys with physical habitat and water-quality analyses results in a very thorough examination of stream functions. For example, a small stream with few trees in the riparian area will have a different shredder/collector ratio than a stream with many riparian trees. A stream reach dominated by riffle habitat will have different ratios than another stream reach with more pool habitat. A stream with poor water quality will have fewer organisms, and of different types, than a system with good water quality. Contact DEQ for specific examples and assessment protocols.

Fish population surveys

When assessing stream components and functions, it is important to consider fish. Fish population surveys identify and estimate fish resources. Salmonids have different life-cycle patterns; therefore, choose sampling techniques that are appropriate for the species or life stage you plan to sample. See Chapter III-4, “Stream Ecology,” for more information about salmonid life cycles.

All fish sampling and data collection must be approved by and coordinated through a local ODFW biologist. The listing of many salmonid populations under the Endangered Species Act requires permits from the National Marine Fisheries Service (NMFS) and/or U.S. Fish and Wildlife Service (USFWS) to conduct fish surveys.

Fish population surveys document populations in a specific tributary or watershed. Depending on your objectives, the following information might be necessary for evaluating fish populations:

- Presence or absence of species
- Spawning area distribution
- Species composition
- Relative abundance (i.e., the number of adults or juveniles)
- Timing of spawning or of juvenile migration
- Upper and lower limits of fish distribution in the watershed

The techniques you choose depend on what type of information you need. The simplest survey might consist of noting whether a species is present in a particular stream, whereas a more exhaustive examination might require a comprehensive analysis of a fish population in the entire watershed. Surveys might entail researching existing information and/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 might stress, injure, or kill fish.

Noncapture techniques

Noncapture techniques can be used to document what fish are present, how many are present, and how they are using certain habitats during different life stages. These 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 (groups of nests) in a survey area
- Visual verification of the presence or absence of juvenile or adult fish
- Surveys of existing sport fishery catches (*creel census*)
- Photographic or video surveys
- Hydroacoustics (the use of systems such as sonar or acoustic tags to monitor fish movement)

Spawning counts are used to create an *index of escapement* (the number of adult fish that *escaped* fishing and returned to spawn in a defined survey area). These surveys provide good population estimates when conducted over a period of many years.

Spawning data are collected by counting live fish, carcasses, redds, 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 since these fish return to streams over a rather extended spawning season, and many of them survive spawning and migrate back to the ocean. Appendix D shows the proper procedure for conducting a valid spawning survey on small coastal streams.

Walking stream banks during summer low flow conditions is a good way to verify the presence or absence of fish. Juvenile fish can be observed in small streams using polarized glasses. 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 utilizing a variety of habitats. Experienced divers can quickly identify and count juvenile and adult fish. Underwater observations usually are conducted in pools and glides, not in riffles. This technique requires snorkeling equipment, a wet or dry suit, and trained divers.

Where sport fisheries exist, some methods of creel census are utilized. These surveys randomly sample sport angler catches. They are useful for identifying species and ages of fish, or for gathering return data for marked hatchery fish. Volunteer samplers and

Fish sometimes die during collection or after being captured; therefore, it is important to choose the proper technique.

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. They frequently are used at fish ladders or other passage restrictors (traps, tunnels, or culverts). These techniques require technicians and expensive equipment.

Fishery researchers sometimes use hydroacoustic tracking methods. Sophisticated equipment is required, and technicians are needed to operate it.

Capture techniques

Fishery biologists use several types of *capture* techniques to gather detailed information about fish populations. (See *Methods for Stream Habitat Surveys* in the “References” section.) These methods involve capturing, handling, sometimes marking, and releasing fish. Fish might be stressed, injured, or killed during collection or while captured. Therefore, it is important not only to choose the proper capture technique for the species and life stage being sampled but also to be careful in handling the fish.

Capture techniques include seining, trapping, electrofishing, and sport fishing. All of these methods require permits from ODFW.

Seining is a standard fish surveying technique. Seining is a simple and safe technique that, if used properly, does not cause fish mortality.

Beach seining (which requires boat assistance to extend and close the net) can be used in estuaries and large rivers to monitor fish growth and movement. Small mesh 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.

Pole seining is used to catch juvenile salmonids in streams that are shallow enough to be waded. Two people use a 10- to 30-foot long net with each end attached to a 6- to 8-foot long pole. The poles are used to handle the net and maneuver it around in-stream structures.

Traps and *weirs* can be used to capture adult or juvenile fish and to monitor their movements. Minnow traps (small wire mesh cylindrical baskets with funnel-shaped openings at each end) are used to catch small fish. If properly baited and placed, they can be very effective at catching juvenile salmonids. Fixed pipe traps and floating screw traps are used in tributaries or small rivers to monitor the out-migration of smolts. Weirs (or guiding in-stream fences) and slot traps are used together to capture up-migrating adults or out-migrating smolts. The effectiveness of traps depends on flow conditions. The downside of this technique is that traps might be washed downstream during 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.

Sport fishing techniques can be used in isolated areas where juvenile fish exist and identification from the bank is difficult (e.g., riffles, waterfalls, or deep pools). Lure and fly-fishing 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 (STEP), Oregon Department of Fish and Wildlife). See Appendix D.
- *California Salmonid Stream Habitat Restoration Manual*, Chapter IV (California Department of Fish and Game, 1994)
- *Fisheries Techniques*, by L. Nielsen and D. 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

Water-quality assessments and monitoring are discussed in Chapter III-8, "Water-quality Monitoring."

STREAM RESTORATION AND ENHANCEMENT

Although the terms restoration and enhancement often are used interchangeably, they do not necessarily mean the same thing. It is important to understand the distinction between them because they imply very different goals. The main goal of *restoration* activities is to reestablish self-sustaining natural processes among the aquatic, riparian, and terrestrial ecosystems.

Restoration reinstates essential *stream components* (e.g., large in-stream wood, riparian vegetation) and *processes* or *functions* (e.g., water temperature and flow regulation, gravel retention, riparian forest regeneration, etc.). Thus, it brings the system to a self-regulating state that maintains channel stability, fish habitat, and water quality among other things. A restored system does not require periodic human intervention (e.g., log placement or gravel addition).

Restoration can be *passive* or *active*. It is passive when it merely entails halting human activities causing degradation or preventing recovery. For example, riparian vegetation might recover after human-caused disturbances stop. This vegetation usually can cope with natural disturbances such as fires, landslides, and floods, but is not able to deal with the intensity and/or frequency of human-induced changes.

Passive restoration sometimes is insufficient because of other influences on the stream system. For example, the elimination of beavers, introduction of reed canarygrass or bull frogs, or flow regulation by dams might prevent a stream from returning to a state of dynamic equilibrium. (See Chapter II-2, "Watershed Hydrology.") Under such circumstances, *active* restoration can be considered. Active restoration includes the reintroduction of animal or plant species that have been eliminated from the area, the control of invasive species, the placement of in-stream logs, flow-release plans that emulate natural flow regimes, etc.

Remember that the main goal of restoration is to restore a system that can function without human management.

In contrast, the main goal of *enhancement* activities is to improve a particular condition for the benefit of a species or type of habitat.

Due to their tendency to focus on one species or on a particular habitat component, enhancement activities run the risk of creating unnatural conditions in the stream system. For example, certain in-stream structures, such as rock current deflectors, have been used with the objective of protecting banks and enhancing salmonid habitat. However, these structures can have a negative impact on sediment transport, bank erosion processes, and the hydrologic connection between the stream and riparian vegetation. When boulders are piled against a stream bank, conditions might no longer be suitable for the natural establishment of riparian vegetation nor for channel adjustments to accommodate natural variation in sediment transport and stream flow.

From a watershed perspective, enhancement projects represent short-term fixes. They are justifiable, however, for very specific goals in stream reaches where restoration is not possible. These projects must be engineered appropriately and take into consideration the system's hydrology and channel characteristics.

Prioritizing projects

Restoration work often is driven by opportunity when working with private landowners. However, it is very important to develop watershed-scale strategic plans to identify priority stream reaches and actions that maximize the benefits from restoration efforts.

When developing restoration plans for a watershed, keep in mind that the best results likely will be obtained in stream reaches identified as having rapid recovery capacity. Only after these types of reaches are improved should efforts be directed toward reaches showing a low recovery capacity. In such areas, in addition to determining the causes of degradation, it is most useful to identify the reasons behind the lack of recovery (e.g., changes in species composition, altered hydrology, etc.).

There are many areas where stream restoration is not economically, socially, or technologically possible (e.g., urban areas, dredged mine sites, etc.). In these types of scenarios, stream enhancement work can be very useful, particularly if it diminishes harm to downstream riparian and aquatic ecosystems.

Urban streams, because they often lie in valley floors or low-gradient areas, sometimes provide critical fish habitat. Although they are not likely to be fully restored, some enhancement projects might successfully create fish habitat. However, the ecological benefits of many projects are dwarfed by the negative impacts of thousands of acres of pavement, thousands of cars polluting the air and roads, thousands of gardens treated with a battery of chemicals, and storm runoff washing everything into ditches, creeks, streams, and rivers. In this context, one of the important aspects of urban aquatic enhancement projects is their visibility and public education value. Therefore, their importance should not be underestimated, and their potential contribution to raising public awareness about streams and fish habitat always should be evaluated.

Remember that no stream enhancement project will succeed if upland and riparian conditions influencing the stream are not addressed first. To maximize project success, a multidisciplinary approach is recommended. Obtain technical guidance from hydrologists, fish biologists, engineers, geologists, etc. See Chapters II-2, “Watershed Hydrology,” II-3, “Stream Processes,” II-4, “Watershed Soils, Erosion, and Conservation,” and III-1, “Riparian Area Functions and Management,” for more information.

All projects require consultation and permits from regulatory agencies. Contact your local ODFW or Oregon Division of State Lands office for information. The NMFS and the state are developing an *Oregon Aquatic Habitat Restoration Guide* under the Oregon Plan. These guidelines must be followed to get relief from

Remember that no stream enhancement project will succeed if upland and riparian conditions influencing the stream are not addressed first.

Section 9 taking prohibitions under the Endangered Species Act, where applicable.

Examples of stream restoration projects

Stream rewatering and livestock management

The two most common examples of successful passive restoration in the western United States are the rewatering of streams after years of excessive withdrawal for agricultural or municipal purposes and the adequate management of livestock in riparian zones.

Livestock grazing is one of the most important land uses affecting riparian zones. These areas, because of their relatively high plant productivity and close proximity to water, are preferred by livestock and tend to be overgrazed. Overgrazing of riparian zones causes:

- Loss of riparian vegetation
- Alterations to channel morphology and stream banks
- Soil compaction
- Lowering of the water table
- Reduction of summer stream flows
- Water pollution
- Increased summer water temperatures
- Increased winter icing

All of these changes have a negative effect on wildlife, fish, and other aquatic organisms. For additional information, see Chapter III-3, "Livestock and Forage Management in Oregon Riparian Areas," "The effects of livestock grazing on Western riparian and stream ecosystem," and "Range ecology, global livestock influences." (See "Resources.")

Combining the return of permanent in-stream flows with the end of riparian grazing has resulted in the relatively fast recovery of riparian and in-stream habitats.

Combining the return of permanent in-stream flows with the end of riparian grazing has resulted in the relatively fast recovery of riparian and in-stream habitats. The Mono Basin in California and McCoy Creek in eastern Oregon are good examples. Field reviews of fish habitat restoration and enhancement projects in eastern Oregon have clearly indicated that preventing livestock overgrazing of riparian areas is the single most effective approach to naturally restoring salmonid habitats. See "Field review of fish habitat improvement projects in the Grande Ronde and John Day river basins of eastern Oregon" and "Fish habitat improvement projects in the Fifteenmile Creek and Trout Creek basins of central Oregon: Field review and management recommendations." (See "Resources.")

Barriers to fish passage

Projects that remove barriers to fish passage might easily make miles of good-quality habitat available to fish. These projects are good examples of active restoration.

The assessment of barriers to fish passage is very important because salmonids migrate both upstream and downstream. Resident salmonids (e.g., rainbow, cutthroat, and bull trout), as well as other fishes (e.g., suckers), make extensive seasonal migrations in search of spawning or winter habitat, food, and suitable water quality.

Wherever barriers occur, fish can no longer access needed resources. As a result, their survival and the viability of their populations might be compromised. In many watersheds, fish populations are reduced by the simple inaccessibility of many miles of spawning or nursery habitat.

Many streams contain small dams or other artificial barriers that do not provide adequate fish passage. Fish passage is a major concern at stream–road crossings. In the past, road culverts were installed with little consideration for fish migrations. Hence, thousands of miles of valuable fish habitat are off-limits to migratory species because of street, highway, or logging-road crossings.

Culverts can create barriers to fish migration in the following ways (Figure 2, page 22):

- A steep slope or a small culvert results in water velocity that is too fast for the fish to swim against.
- There is no pool below the culvert where fish can jump and rest, so they cannot make it into the culvert.
- There is no resting pool above the culvert, so the fish are washed back downstream.
- Water in the culvert is so shallow during low flows that fish cannot swim through it.
- The culvert is so high above the stream that fish cannot jump into it.

One or more of these conditions can prevent fish upstream movement. It is not always clear whether a culvert is affecting fish passage. Some culverts become velocity barriers during high flows, but allow fish to swim upstream easily during low flows. Other culverts are not deep enough during summer low flows, but are adequate during higher flows. For these reasons, it is important to know the species of fish that occur in a watershed and when they tend to migrate in order to evaluate the impact of culverts on migration.

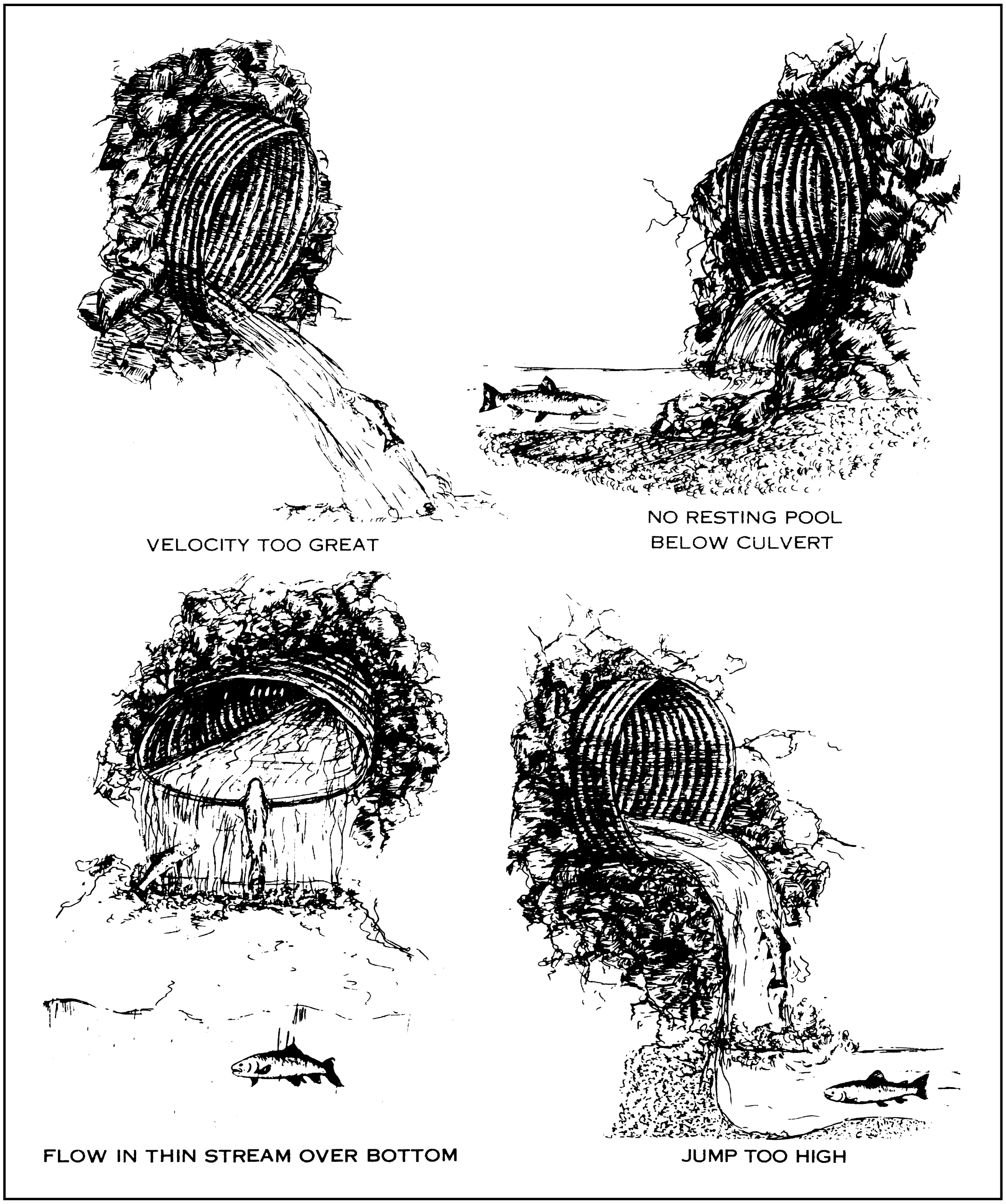


Figure 2.–Culvert installations that block fish passage.

The ability of fish to jump and swim against strong flows depends on species, body size, and how long the fish have been migrating. In general, adult steelhead trout and chinook salmon jump the highest and have the swiftest short-term burst speeds among salmonids. Chum salmon are not very agile jumpers and sometimes try to find a way through or underneath barriers rather than going over them.

ODFW allows a maximum jump height of 12 inches for adult salmon and steelhead and 6 inches for adult cutthroat trout, adult kokanee, and juvenile salmonids of all species. The minimum recommended resting pool depth is 1.5 times the jump height. When flows are too fast, wider bottomless culverts might solve the fish passage problem. When the jump is too high, a fish ladder might be needed.

Appendix E-1 summarizes basic criteria for determining fish passage based on guidelines provided in ODFW's *Interim Fish Passage and Culvert/Bridge Sizing Guidance for Road Crossing.* Appendix E-2 provides a copy of ODFW's Culvert Evaluation Form. The guidelines and evaluation form will help you determine the status of culverts you encounter while assessing streams.

If cost is not a constraint, replace culverts with free-spanning bridges. However, this is not always possible. The following two options often are used to improve fish passage through culverts: open-bottom culverts and oversized culverts. Open-bottom culverts have the shape of an inverted U or arch, and their bottom is that of the natural stream. Open-bottom and regular culverts should be oversized to avoid constraining flow during periods of high discharge. Their width should be at least two-thirds of the bankfull width.

As a temporary fix, culverts often are fitted with baffles (winglike structures attached to the walls and bottoms of culverts) to allow upstream fish migration. Because baffles reduce the capacity of the culvert to pass water, it is important to determine whether the culvert still will be able to accommodate the highest water discharges. There are several types of baffles, but all are designed to reduce water velocity and increase water depth in culverts.

Stream channel restoration

The active restoration of stream channels to a predisturbance state is a big challenge. However, there are examples of fish habitat restoration in uniform stream reaches using riffle–pool sequences and/or rebuilding the natural channel configuration. A channel reconfiguration project has been completed in a reach of the lower Umatilla River in northeastern Oregon.

Properly designed rock riffles or rapids can be constructed in uniform stream channels to reestablish some habitat. These habitat units recruit gravel, induce pool formation, and assist fish passage. Before attempting to rebuild a riffle–pool sequence, it is important to:

- Determine whether the existing channel conditions are the result of natural processes or human activities
- Establish what channel width and depth are needed for stream discharge during floods
- Find out whether pool and riffle creation will improve the desired habitats

These three tasks require a thorough analysis of the drainage basin, a survey of the reach to be restored, evaluation of the habitat requirements of the fish species in the watershed, and design of artificial riffles and pools that are as stable as natural ones. For a detailed description of a 10-step stream channel analysis and design process with examples, see *Stream Analysis and Habitat Design: A Field Manual* (see “Resources”).

Examples of stream enhancement projects

There are many types of stream enhancement projects. They differ according to the desired objectives and the species of fish involved. Each species has different life-cycle requirements and habitat needs. Consider the needs of the species that occupy your stream. See Chapter III-4, “Stream Ecology,” for more information on salmonid habitat needs.

For example, juvenile coho salmon use small streams as nursery habitat and need protection from water velocity during high flows. As a result, coho habitat restoration projects tend to focus on increasing backwater pools, off-channel areas, and wood in the channel. Techniques and specific designs depend on stream characteristics.

Many techniques 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 design 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 imitate what would occur naturally in a particular stream type.

In-stream structures

Various in-stream structure designs try to emulate natural obstructions that alter the flow of water and sediment. By influencing *hydraulic conditions* (the movement of water), structures store and sort sediment, enhance scour, deposit streambed material, diversify velocity and depth, and fix the position of bars and pools. As water and gravel are slowed down or forced under, over, around, or between structures, the streambed is scoured or material

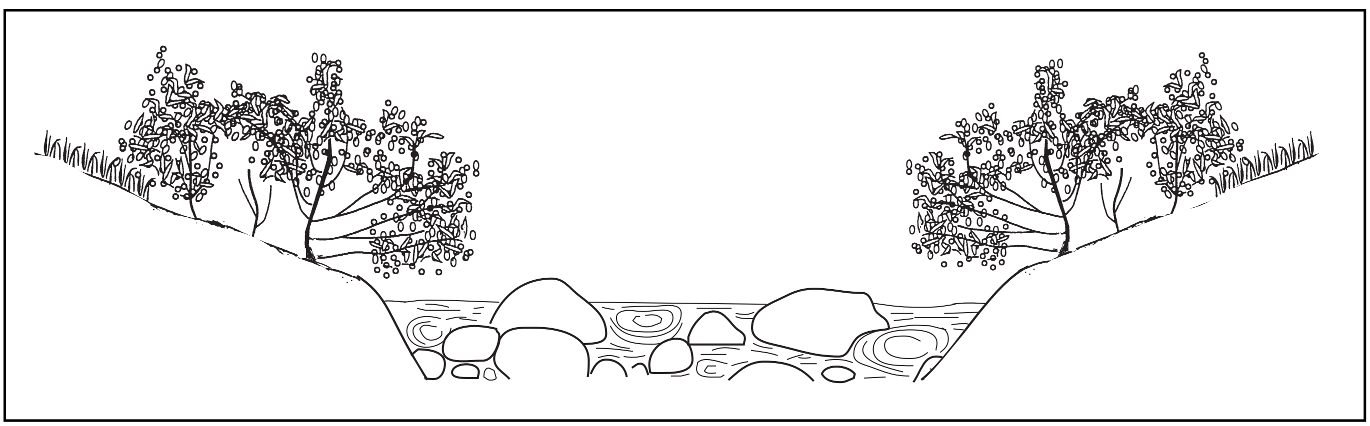


Figure 3.–Boulders are placed in stream reaches in order to increase channel complexity and alter flow patterns in a manner that creates more diverse fish habitat.

is deposited. The result is increased channel complexity and fish habitat diversity.

In-stream boulder placement (Figure 3) is a common technique used to create hiding and resting places for fish in channels that are very uniform and lack pool habitat. The boulders are scattered so that they alter the pattern of water flow and help create scouring areas and pools. Scouring results from the faster, more turbulent water flow around large rocks.

A deficit of large pieces of wood in streams is common throughout much of the Pacific Northwest. The main reasons for this deficit are historical riparian logging practices, splash damming, agricultural conversion, and active removal of wood from streams. Because the natural recruitment of wood can be slow, the artificial placement of logs might temporarily improve stream habitats until the riparian forest once again can contribute large logs and root wads.

The size of wood (length and diameter) must be proportional to the width of the stream channel to ensure wood stability. This eliminates the need for anchoring techniques. Wood should be at least twice as long as the active channel width (1.5 times the width for wood with a root wad attached). It also must meet diameter, stream size, and slope requirements as outlined in the ODF and ODFW publication *A Guide to Placing Large Wood in Streams* (see "Resources").

Current wood placement projects try to load the stream with wood that can be redistributed during peak flows and work with the stream to create pools, store gravel, and provide cover. They do not try to create artificial habitat by following a preconceived blueprint. Figure 4 shows the effects of various placements of large wood in a channel.

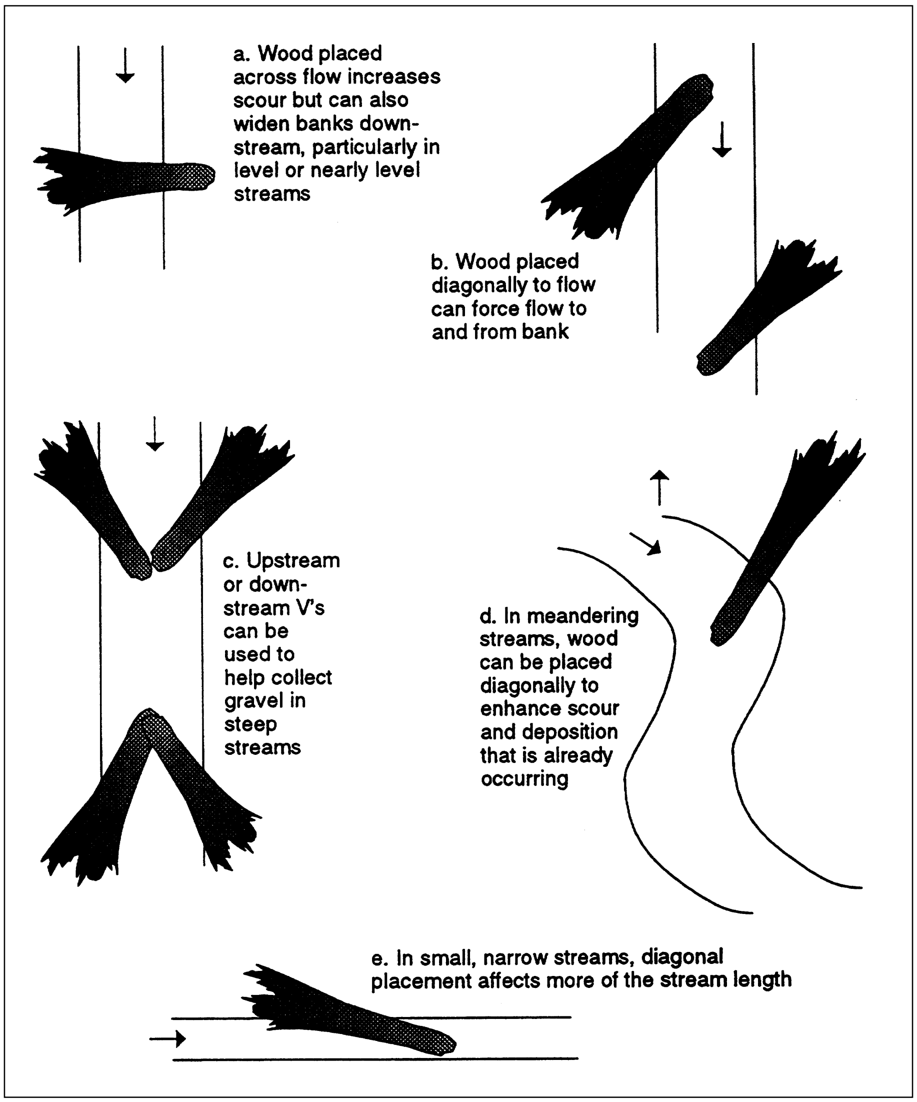
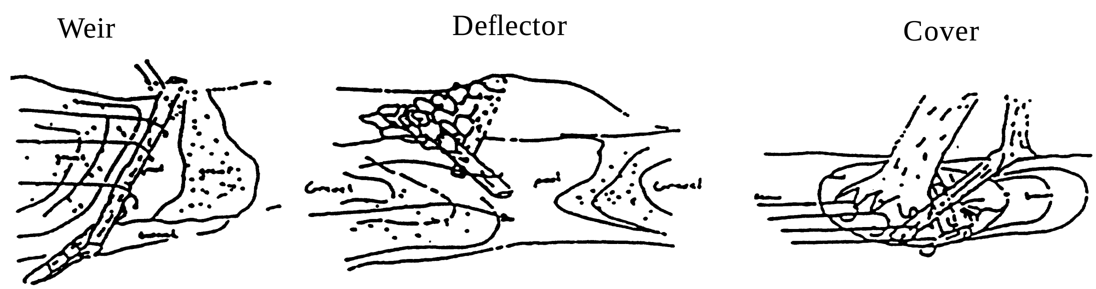


Figure 4.—Effects of various placements of large woody debris. (Source: A Guide to Placing Large Wood in Streams, *Oregon Department of Forestry and Oregon Department of Fish and Wildlife, May 1995)*



Weir	Deflector	Cover
Purpose	**Purpose**	**Purpose**
Collects gravel	Scours pools	Creates winter refuge
Creates plunge pools and dammed pools	Deflects flow	Escape cover
Spawning, rearing	Bank protection	Stratifies velocity
	Spawning, rearing	Rearing habitat

Figure 5.—Types of in-stream structures. (Source: Ecosystem Workforce Project Curriculum, *Oregon State University and LERC at the University of Oregon, 1996)*

NMFS, the *Oregon Aquatic Habitat Restoration Guide*, and the new authorization for the Division of State Lands discourage in-stream structures that are anchored to boulders, logs, and trees. Most earlier stream enhancement projects used these techniques. However, water flow cannot easily rearrange cabled structures. As a result, they might end up increasing bank erosion or interfering with stream processes rather than enhancing fish habitat.

Weirs, deflectors, and cover structures are three common types of in-stream structures (Figure 5). Rocks, logs, or a combination of both are used in their construction. Weirs are placed across the stream channel, perpendicular or at an angle to the stream flow. They are anchored to the stream banks and bottom. Their main functions are to reduce water velocity, collect spawning gravels, and create pools (both dammed and plunge). A series of weirs often is used to create a succession of steps that raise the water level to reach the downstream opening of culverts.

Deflecting structures are much shorter than weirs. They are anchored to one bank, extend only one-fourth to one-half the distance across the channel, and are placed diagonal to the stream flow. Their main functions are to deflect water flow from the bank to reduce erosion and, simultaneously, to create scour or back pools and collect gravel.

Logs and root wads often are used to provide cover and winter refuge to salmonids. These structures also reduce water velocity, allowing sediments, gravel, and organic material to collect. They might provide seeding beds for riparian plants and, depending on their position in the channel, might reduce bank erosion and help narrow and deepen the stream. Cover logs can be any shape and length, but the best results are obtained with large logs with limb stubs and branches.

It is important to know that numerous studies have indicated that these structures are not very useful for enhancing fish habitat in the long term or for increasing fish productivity in a stream. At best, they might improve local conditions and, as a result, attract fish to the treated reach. Thus, they seem to boost fish rearing densities at a local scale but do not increase the size of the fish population in the entire watershed *(Oregon Aquatic Habitat Restoration Guide)*.

Some key considerations when designing and using structures include (excerpted from the *Oregon Aquatic Habitat Restoration Guide*):

- Is this a stream that would be expected to have large woody debris given its known range in variability? Some meadow-based systems should not be expected to have large wood. Similarly, steep (high-gradient) reaches on large streams in most cases cannot hold wood.
- Is the lack of wood a major contributing factor in declining fish populations in the reach? Sometimes other factors, such as a fish passage blockage, are more important in the decline of fish. In this case, adding wood makes little difference.
- Does present upslope and riparian management make large woody debris available for natural addition to the stream? Does it encourage stable banks and sediment dynamics, which in turn stabilize the channel?
- Is large wood in the candidate stream reach currently depleted compared to expected values? (ODFW has information on Oregon's benchmark values and on some individual 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
- Reduce stream bank erosion with vegetation
- Begin to establish riparian vegetation
- Provide some in-stream fish habitat where possible

One type of bank stabilization involves burying boulders or log deflectors into the bank and letting them extend into the stream channel. 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 might provide some fish habitat.

Other designs that stabilize a stream bank and help reestablish the riparian area use rock, wood, and trees to decrease velocities, deposit sediment, and grow vegetation. These designs are known as *bioengineering* methods and are discussed in Chapter III-1, "Riparian Evaluation and Enhancement." Contact the Natural Resources Conservation Service and Division of State Lands for information, designs, and technical assistance.

MONITORING PLANS

Monitoring is an important part of stream enhancement projects. Chapters II-5, "Assessment and Monitoring Considerations," and III-2, "Riparian Area Evaluation and Enhancement," discuss monitoring plans in detail. This section will briefly review the key points of monitoring plans.

What are monitoring plans for?

Monitoring will determine the results of your restoration or enhancement project. It can help you avoid repeating mistakes and, therefore, wasting resources (whether private or public) in future projects. If monitoring shows the restoration or enhancement project has not achieved the desired stream functions, you should consider implementing a corrective plan and, in turn, monitor and evaluate the outcome of the new plan.

Basic components of a monitoring plan

Most stream monitoring plans use the assessment and survey techniques discussed in this chapter. These techniques help you evaluate present stream components and functions as well as how they change over time in response to the restoration or enhancement project. Any monitoring plan has three main components:

- Identification of the goals and objectives of the restoration or enhancement project
- Selection of specific monitoring techniques and parameters to be measured
- A process for evaluating whether goals and objectives are met and for deciding whether a change in monitoring techniques and/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 collect data that answer the questions. Make sure the techniques are appropriate for you or your group. Take into account factors such as cost, technical requirements, training, available equipment, and access.

Monitoring should indicate whether your projects are helping the stream achieve the desired goals. If a project is not meeting your goals, the monitoring plan should help you identify factors causing the problem and ways to solve it.

Example of a monitoring plan

Assessment of present components and functions

Current state/limiting factors: Assessments indicate a forested section of the coastal stream has very few pools. The riparian alder-dominated forest shades the stream and provides important nutrients to the stream but is not a good source of large wood. As a result, the stream channel lacks structural complexity, and salmon spawning and nursery habitat has been reduced.

Probable cause: Evaluations of historic information indicate that past forest practices included removing wood from the stream and did not reestablish mixed stands of conifer and hardwood trees in the riparian area.

Monitoring . . . can help you avoid repeating mistakes and, therefore, wasting resources (whether private or public) in future projects.

Goals and objectives

Goal: Improve salmonid spawning and nursery habitat in the forested stream reach by increasing gravel bars and pools. Improve future supply of large wood in the stream by increasing the number of conifers in the riparian zone.

Objective: Collect spawning gravel and increase number of pools by placing large woody material, twice the size of the active stream channel width, in key locations. Convert half of the alder-dominated riparian forest to conifers by removing some alders so that existing conifers in the understory can grow.

Enhancement projects implemented

Following ODF and ODFW guidelines, 20 large conifer logs were strategically placed in the stream channel and banks to create 9 pools with cover. Following ODF Forest Practices Rules, conifer trees were manually released from the understory of alders in the riparian zone. The project improved fish habitat and established a future supply of large wood to the stream and riparian area.

Monitoring techniques and parameters measured

- An ODFW aquatic habitat inventory was conducted prior to project implementation. It will be repeated 1 year following implementation and once every 5 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 5 years to evaluate 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 5 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 2 years, then once every 5 years. Thinning will be carried out as needed to ensure maximum tree growth.
- Spawning surveys will be conducted to count spawning fish and map their locations to see whether they are using the newly created spawning areas.

Follow-up evaluation

If monitoring shows that projects have not achieved goals, a new (corrective) enhancement project and a monitoring plan will be implemented. If the monitoring data do not describe stream components and functions adequately, different monitoring techniques will be used.

Summary/Self review

Stream assessments are carried out to inventory the physical, chemical, and biological characteristics of streams and/or to evaluate how well the stream is functioning based on restoration goals. Assessments are necessary to identify restoration and enhancement opportunities, and they are the foundation of any monitoring plan.

A variety of assessment methods is available. Physical stream assessments evaluate habitat types; width, depth, and length of units; streambed materials; stream bank stability; relation of the stream to its floodplain; stream gradient; riparian characteristics; large wood availability; and cover for fish. Biological stream assessments evaluate fish populations (juveniles, smolts, spawning adults), fish species present, abundance of fish utilizing available habitat, and the abundance and type of macroinvertebrates.

Stream restoration projects aim to reestablish essential physical, biological, and chemical components and processes between the stream and the riparian ecosystems. The goal is to reinstate channel stability, water quantity and quality, and the aquatic habitat for many organisms (not just fish).

Stream enhancement projects try to solve more localized and immediate habitat problems and often are directed to one or a few target species. They are not self-sustaining and, therefore, have a limited life span. They might be useful to reduce the downstream impact of severely altered reaches (e.g., urban, industrial) and/or to increase the chances of success of larger scale restoration initiatives. In high-traffic areas, their visibility makes them important educational projects.

Watershed processes dictate that restoration and enhancement projects take into account upstream and upland management considerations.

Monitoring plans include three main components:

- Goals and objectives
- Specific monitoring techniques and parameters to be measured
- An evaluation process to see whether desired conditions are being met and/or monitoring techniques are adequate

Exercises

You can do these exercises on your own, but it's helpful to work as a group so you can compare notes and discuss your observations.

Stream assessment

Volunteer to help an agency or private consultant conduct two different assessments of at least two sites (preferably a degraded site and one with a complex channel structure, good water quality, and a well-developed riparian forest). Review the analysis of data and discuss different enhancement projects recommended to achieve a desired condition.

Restoration and enhancement

Get involved with two stream restoration and/or enhancement projects. Review the assessments used to plan these activities.

Monitoring

Establish a monitoring program for a site where a restoration or enhancement project has been implemented. Review an existing monitoring program that has evaluated a project for several years in a stream that is reaching the desired condition.

Resources

Training

Contact your local watershed council, OSU Extension Service office, Soil and Water Conservation District office, or resource agency office (Oregon Department of Forestry, Oregon Department of Fish and Wildlife, U.S. Forest Service, Bureau of Land Management, etc.) for training events or personal consultation.

Information

"An ecological perspective of riparian and stream restoration in the western United States," by J.B. Kauffman, R.L. Beschta, N. Otting, and D. Lytjen, *Fisheries* 22(5):12–24 (1997).

"Applied river morphology," by D. Rosgen. In *Wildland Hydrology* (1996).

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Ecosystem Workforce Project Curriculum, various authors (Oregon State University and LERC at the University of Oregon, 1996).

"Estimating total fish abundance and total habitat area in small streams based on visual estimation methods," by D. Hankin and G. Reeves, *Canadian Journal of Fisheries and Aquatic Sciences* 45:834–844 (1988).

A Guide to Field Identification of Bankfull Stage in the Western United States, video (USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Stream Systems Tech. Center, Fort Collins, CO, 1995).

A Guide to Placing Large Wood in Streams (Oregon Department of Forestry and Oregon Department of Fish and Wildlife, May 1995). Available from the Oregon Department of Forestry, 2600 State St., Salem, OR 97310.

Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates, by K. Cummins and M. Wilzbach (Appalachian Environmental Laboratory, University of Maryland, 1985).

"Field review of fish habitat improvement projects in the Grande Ronde and John Day river basins of eastern Oregon," by R.L. Beschta, W.S. Platts, and J.B. Kauffman. In DOE/BP-21493-1 (U.S. Department of Energy, Bonneville Power Administration, Portland, OR, 1991).

Fisheries Techniques, by L. Nielsen and D. Johnson (American Fisheries Society, 1983).

"Fish habitat improvement projects in the Fifteenmile Creek and Trout Creek basins of central Oregon: Field review and management recommendations," by J.B. Kauffman, R.L. Beschta, and W.S. Platts. In DOE/BP-18955-1 (U.S. Department of Energy, Bonneville Power Administration, Portland, OR, 1993).

How to Do Spawning Fish Surveys (Salmon Trout Enhancement Program, Oregon Department of Fish and Wildlife, undated).

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Monitoring Primer for Rangeland Watersheds, EPA 908-R-94-001, by T. Bedell and J. Buckhouse (U.S. Environmental Protection Agency, 1994).

Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams, by S. Bauer and T. Burton (Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 1997).

Oregon Aquatic Habitat Restoration Guide: Under the Oregon Plan for Salmon and Watersheds (National Marine Fisheries Service and Oregon Department of Fish and Wildlife, 1998). Available from ODFW, PO Box 59, Portland, OR 97207.

Oregon Watershed Assessment Manual (Oregon Watershed Enhancement Board, Salem, 1998).

Photo Plots (Oregon Watershed Enhancement Board, Salem, 1993).

"Range ecology, global livestock influences," by J.B. Kauffman and D.A. Pyke. In *Encyclopedia of Biodiversity*, 5:33–52 (Academic Press, 2001).

A Review of Capture Techniques for Adult Anadromous Salmonids, Information Report 96-5 (Oregon Department of Fish and Wildlife, undated).

"Streambank and shoreline protection." In *Engineering Field Handbook* (Natural Resources Conservation Service, 1996).

Stream Analysis and Fish Habitat Design: A Field Manual, by R. Newbury and M. Gaboury (Newbury Hydraulics Ltd., Box 1173, Gibsons, BC, Canada V0N 1V0, 1994).

"The effects of livestock grazing on western riparian and stream ecosystem," by C. Armour, D. Duff, and W. Elmore, *Fisheries* 19(9):9–12 (1994).

Woodland Workbook (Oregon State University Extension Service, Corvallis, OR).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in understanding stream assessment and enhancement.

1.____

2.____

3.____

Appendix A–Forms for a stream habitat survey.

A-1–Stream reach form

REACH

STREAM: ____________ BASIN: ____________

CREW: ____________ USGS 7.5' MAP NAMES: ____________

PAGE: ______ OF: ______

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	S/O	PERCENT SUBSTRATE 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)

WOOD

PAGE:______ OF:______

STREAM:________________ DATE:________________ NAME:________________

UNIT NUMBER	UNIT TYPE	DEBRIS CONFIG	DEBRIS TYPE	DEBRIS LOCAT	DBH CLASS	LENGTH CLASS (m) RW <3	3	6	9	12	15	18	21	24	28	32	36+	WOOD NOTE

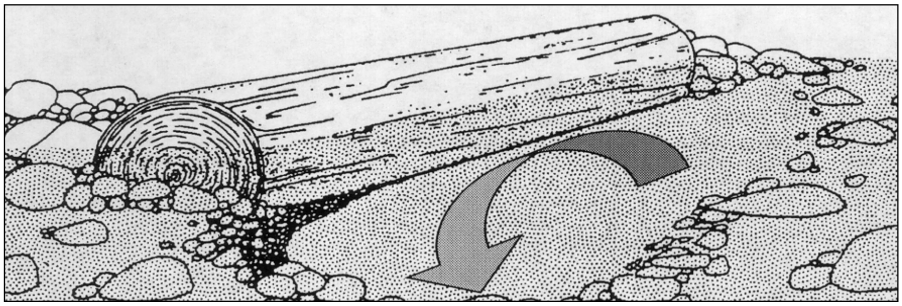
A-5—Riparian form

RIPARIAN

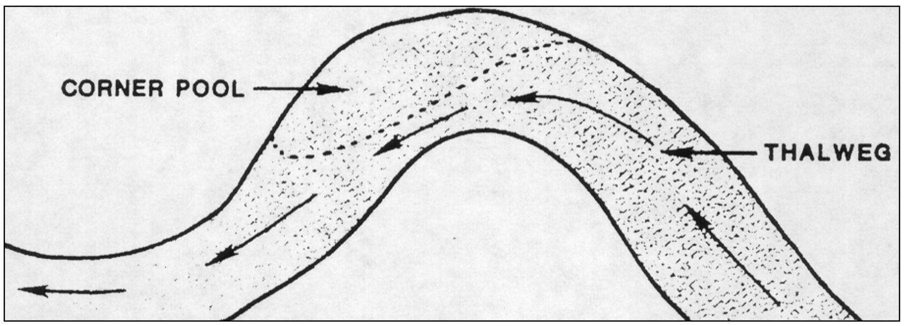
PAGE:______ OF:______

STREAM:________________ DATE:____________ NAME:________________

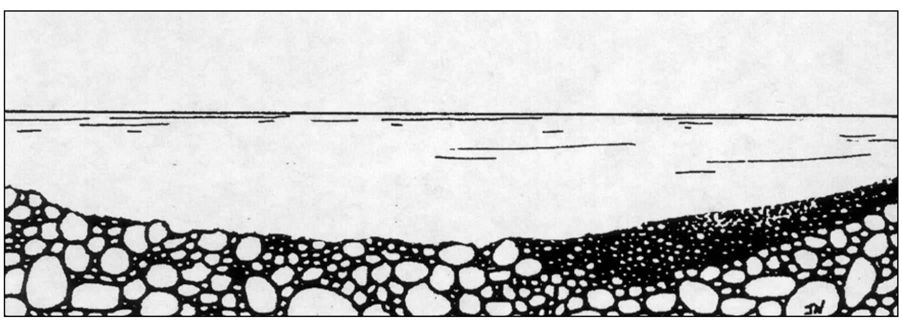
UNIT NUMBER	SIDE	ZONE	SURFACE	SLOPE	CANOPY CLOSURE	SHRUB % COVER	GRASS/FORB % COVER	TREE	COUNT (DBH in CENTIMETERS) 3-15	15-30	30-50	50-90	90+	RIPARIAN NOTE
	LEFT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	RIGHT	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						



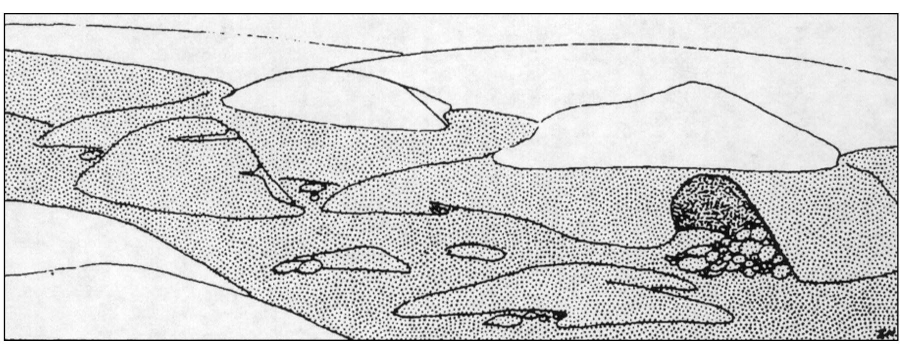
Lateral scour pool (LP): Formed by water against one stream bank or partial obstruction (logs, root wad, bedrock).



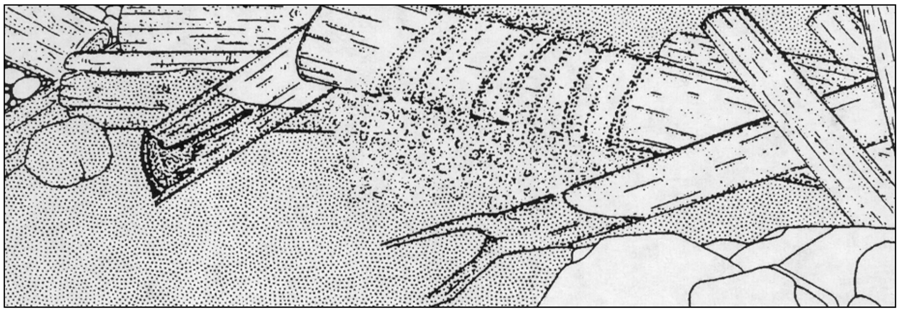
Lateral scour pool (LP): Often forms corner pools in meandering lowland or valley bottom streams.



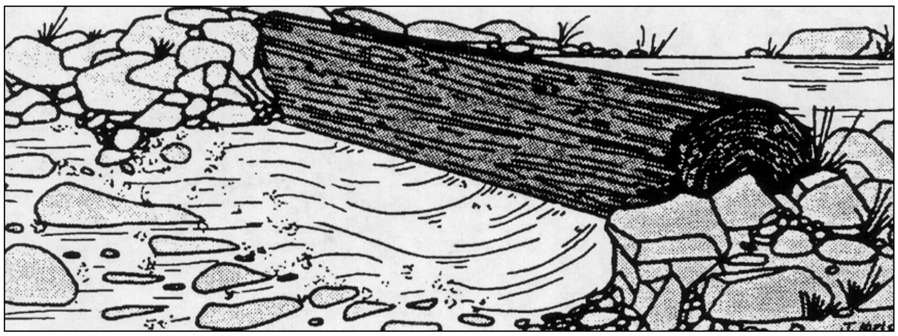
Straight scour pool (SP): Formed by midchannel scour, generally with a broad scour hole.



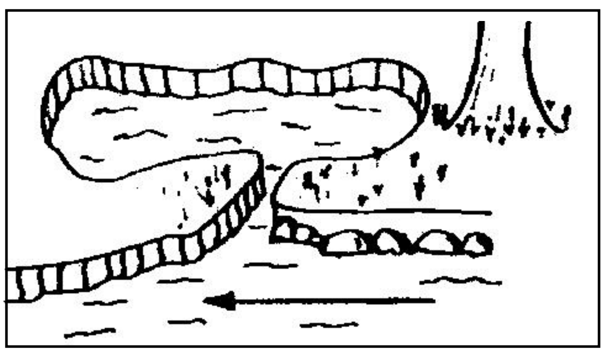
Trench pool (TP): a relatively long, slotlike depression in the streambed, often found in bedrock-dominated channels.



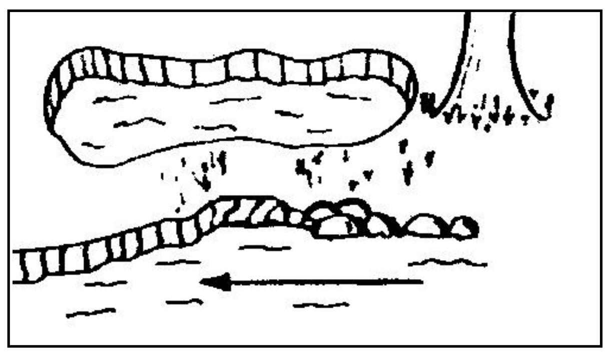
Plunge pool (PP): Formed by water passing over a complete or nearly complete channel obstruction (e.g., logs, boulders, bedrock).



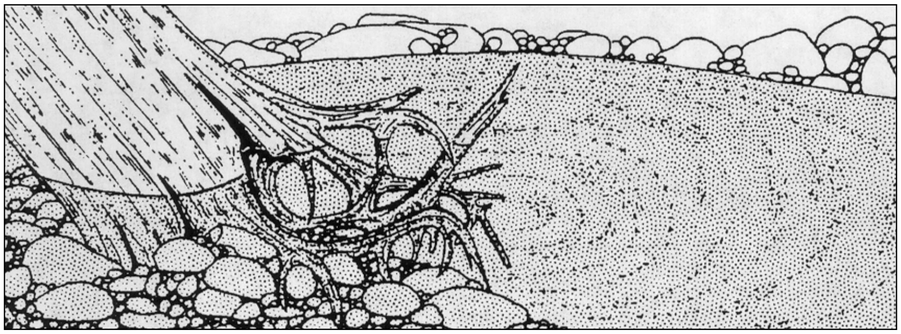
Dammed pool (SP): Sometimes formed by scouring under a stream obstruction such as a log.



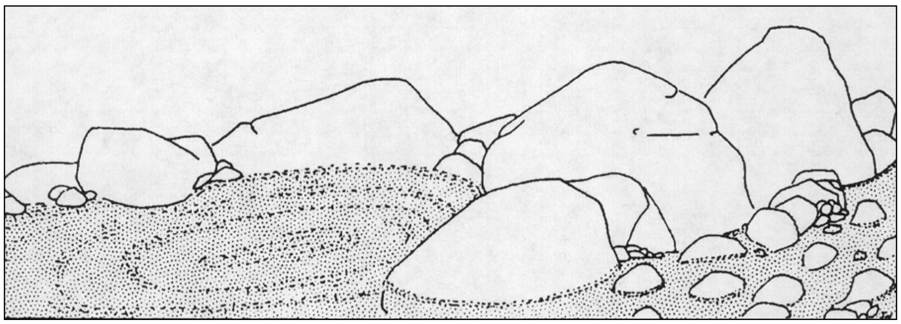
Alcove (AL): A backwater along the shoreline; not scoured during typical high flows.



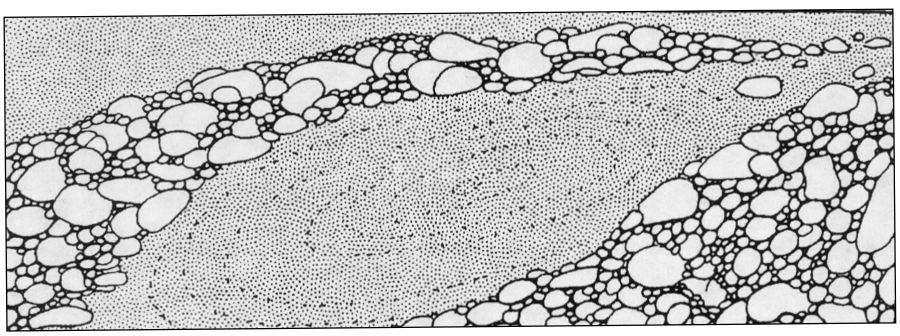
Isolated pool (AL): Pools formed outside the primary wetted channel but within the active channel.



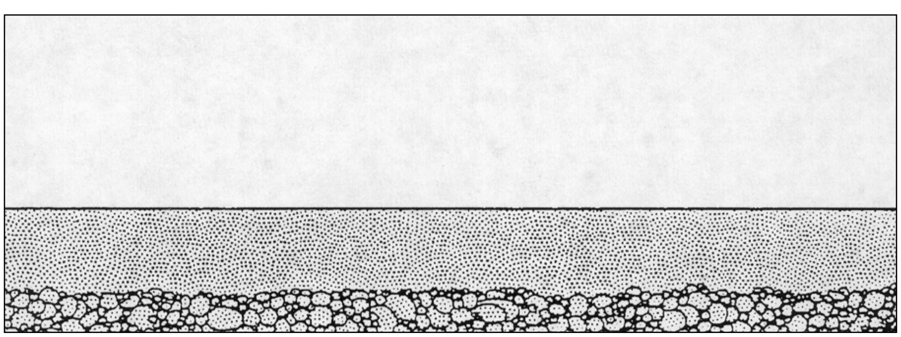
Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.



Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.

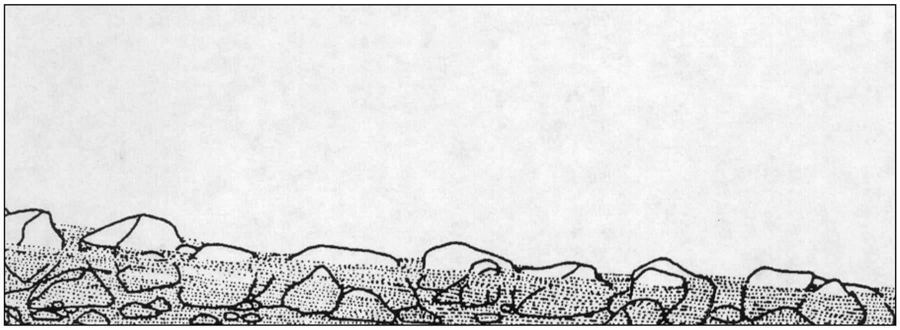


Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.

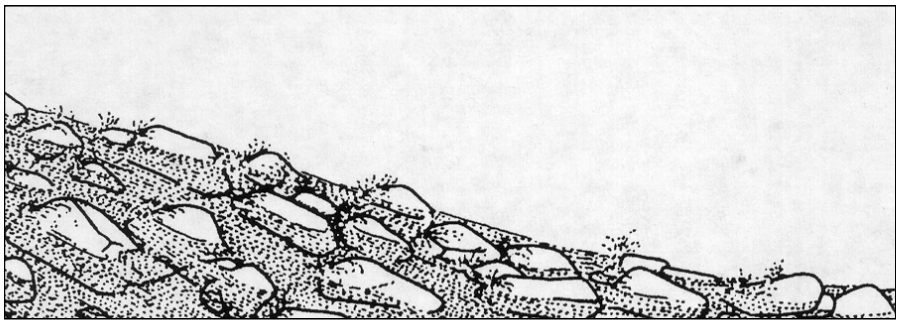


Glide (GL): Generally uniform depth and flow with no surface turbulence, low gradient (0–1 percent slope).

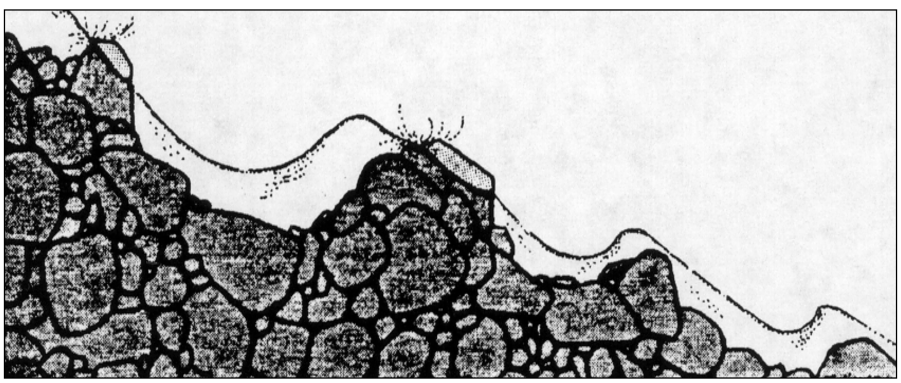
A-6—Types of habitat units continued



Riffle (RI): Fast, turbulent, shallow flow over gravel or cobble substrates, low gradient (0.5–2 percent slope, rarely up to 6 percent), 5–15 percent surface area with whitewater.



Rapid with protruding boulders (RB): Swift, turbulent flow with chutes and hydraulic jumps, moderate gradient (usually 2–4 percent slope, occasionally 7–8 percent), 15–50 percent of surface with whitewater.



Cascade over boulders (CB): Fast, turbulent flow, step-pool structure, 30–80 percent whitewater, high gradient (usually 3.5–10 percent slope), sometimes greater.

Source: Graphics in Appendix A-6 are from *Glossary of Stream Habitat Terms,* William T. Helm, ed. (American Fisheries Society, Bethesda, MD, 1985).

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.

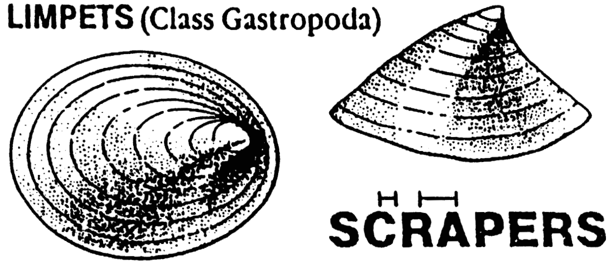
Appendix C–Key 1. Key for identifying stream macroinvertebrates and sample data form. (Source: *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates*)

KEY TO FUNCTIONAL FEEDING GROUPS

|—| |———| Indicates size or range of sizes

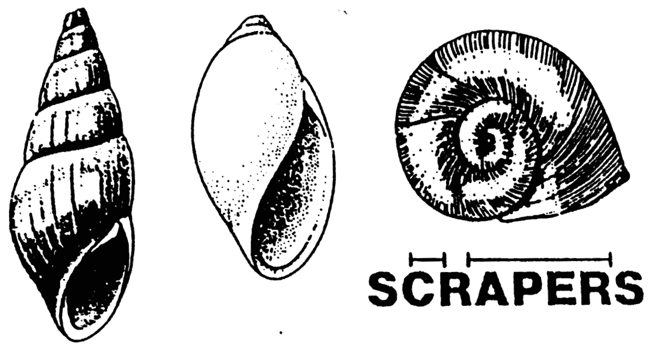
1. **ANIMALS IN HARD SHELL** (Phylum Mollusca)

   a. **LIMPETS** (Class Gastropoda)



SCRAPERS

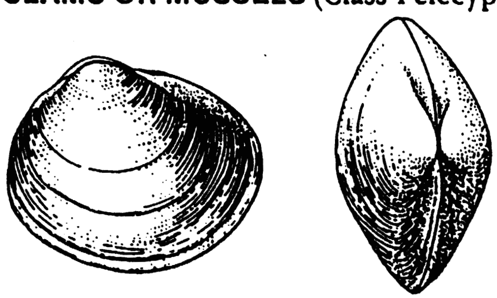
   b. **SNAILS** (Class Gastropoda)



SCRAPERS

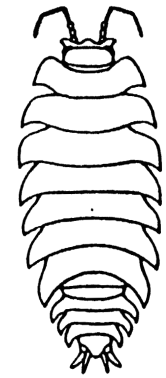
Snails are generalized (facultative) feeders and can also function as Shredders.

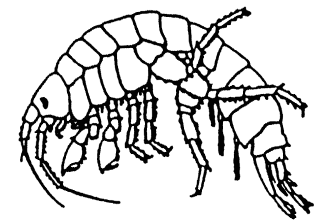
   c. **CLAMS OR MUSSELS** (Class Pelecypoda)



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"**

4. **LARVAE IN FIXED RETREAT WITH CAPTURE NET**

   Note: Care must be taken when collecting to observe nets.

5. **WITHOUT CASE OR FIXED RETREAT**

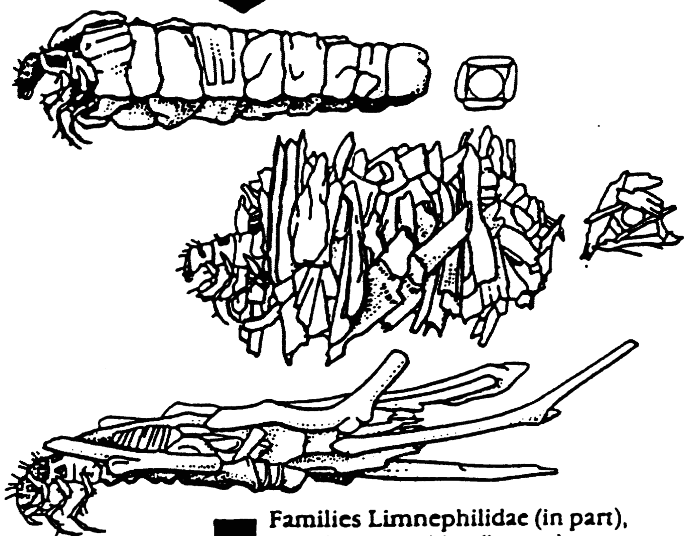
   a. **WORM-LIKE LARVAE WITHOUT JOINTED LEGS**

   b. **NYMPHS OR ADULTS WITH JOINTED LEGS**

FIRST LEVEL OF RESOLUTION

LARVAE IN PORTABLE CASE
Caddisflies (Order Trichoptera)

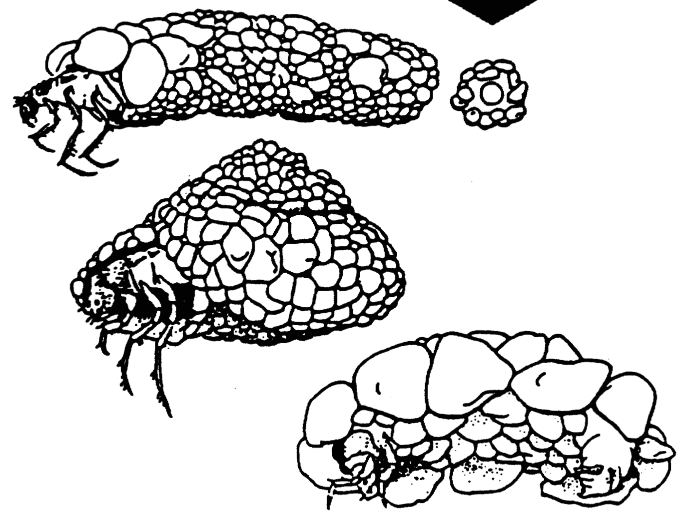
CASES ORGANIC
Leaf, stick, needle, bark



Families Limnephilidae (in part), Lepidostomatidae (in part), Phryganeidae, Leptoceridae (in part)

SHREDDERS

CASES MINERAL
Sand, fine gravel



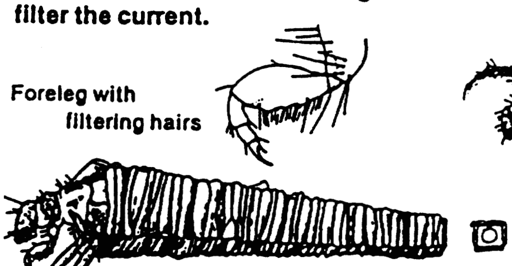
Families Glossosomatidae, Limnephilidae (in part), Helicopsychidae

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

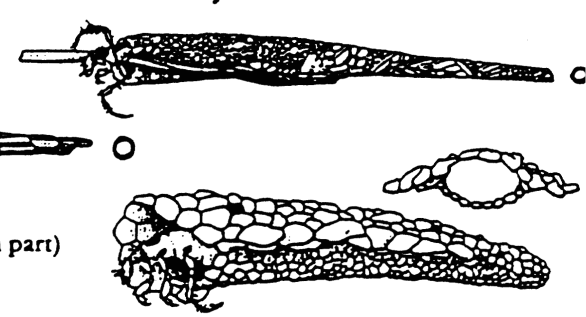
Cases long, slender, and tapered, made of plant material

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

FIRST LEVEL OF RESOLUTION

LARVAE WITH FIXED RETREAT AND CAPTURE NET

Note: Care must be taken when collecting to observe nets.

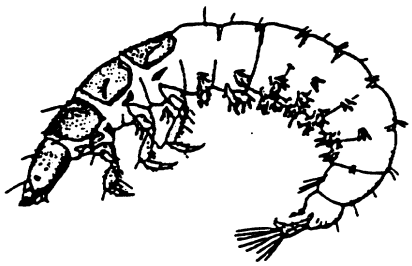
Caddisflies (Order Trichoptera)

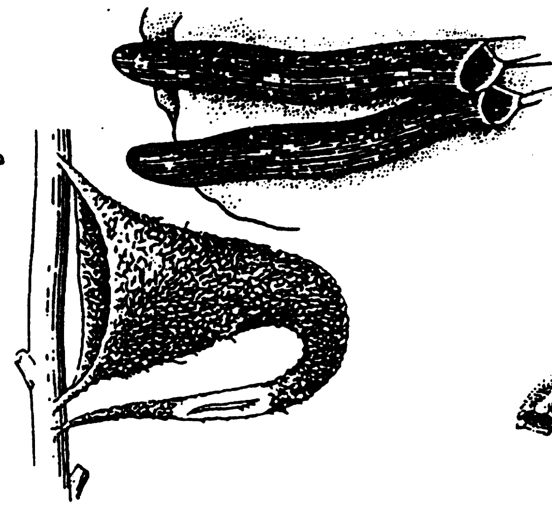
True Flies (Order Diptera)

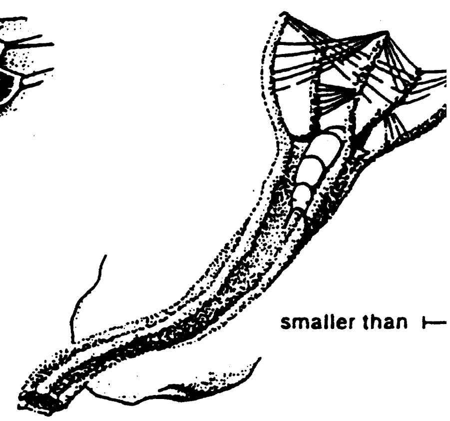
COARSE NET IN "SCAFFOLDING"

FLATTENED SOCK-LIKE OR TRUMPET-SHAPED NET OF FINE MESH

TUBE WITH SILK STRAND STRUNG BETWEEN TERMINAL PRONGS







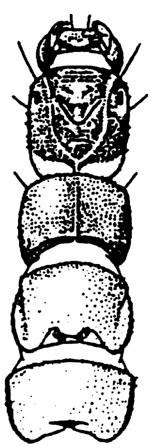
True Midges (Family Chironomidae

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

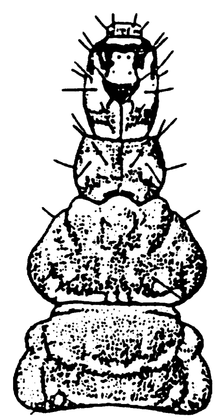


HEAD AS WIDE AS THORAX

Especially Philopotamidae (bright yellow) and Hydropsychidae (bright green or brown)

FILTERING COLLECTORS

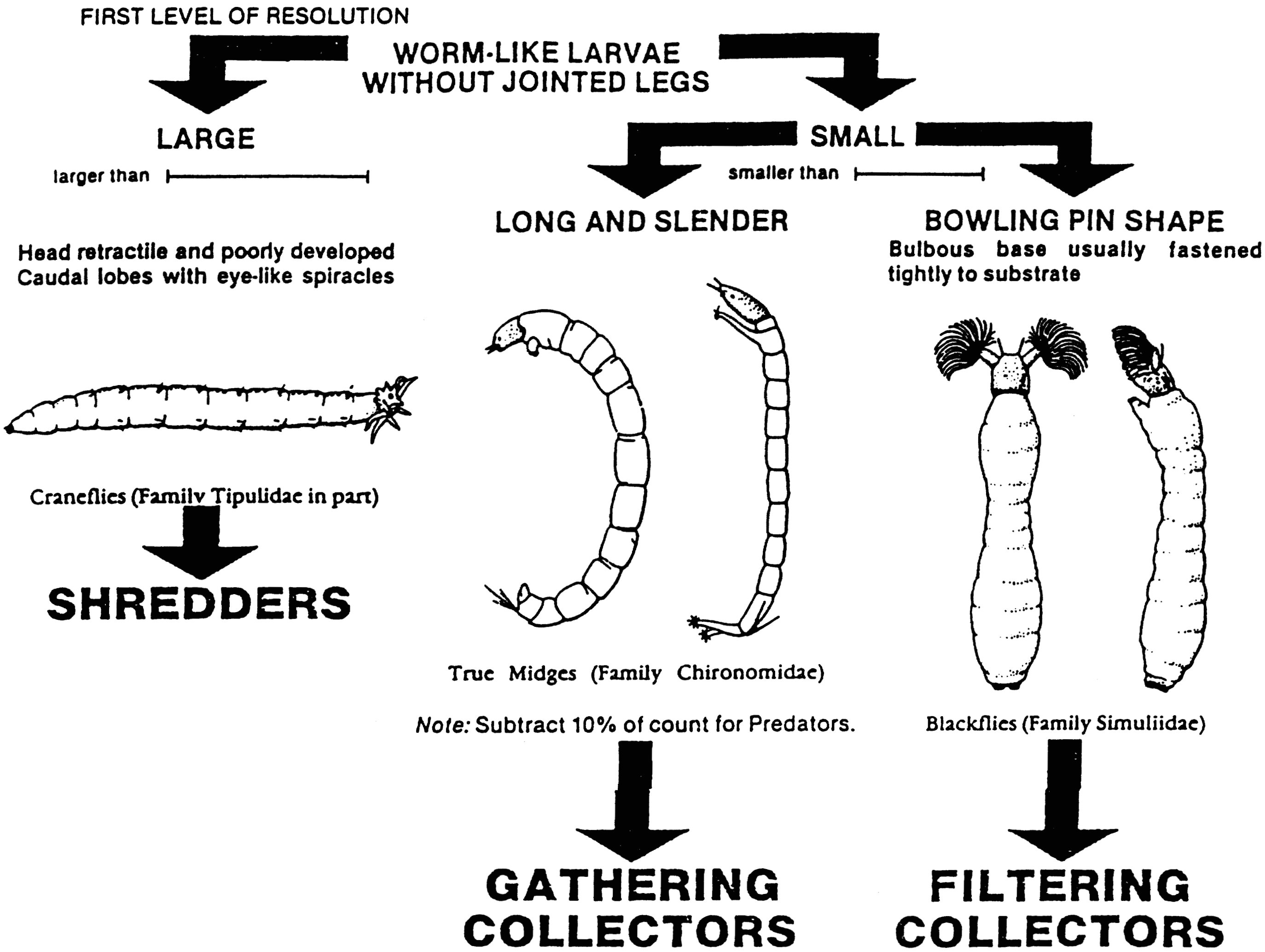
FREE LIVING CADDISFLIES
Non net spinning



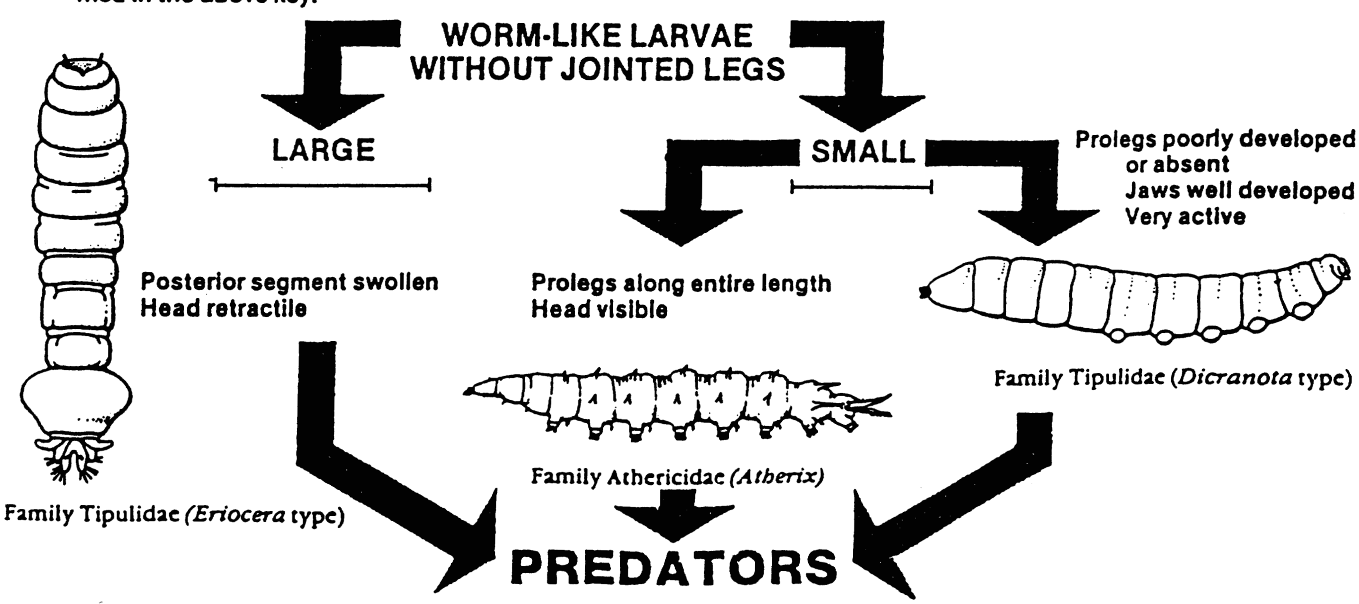
HEAD LONG, SMALL, AND NARROWER THAN THORAX

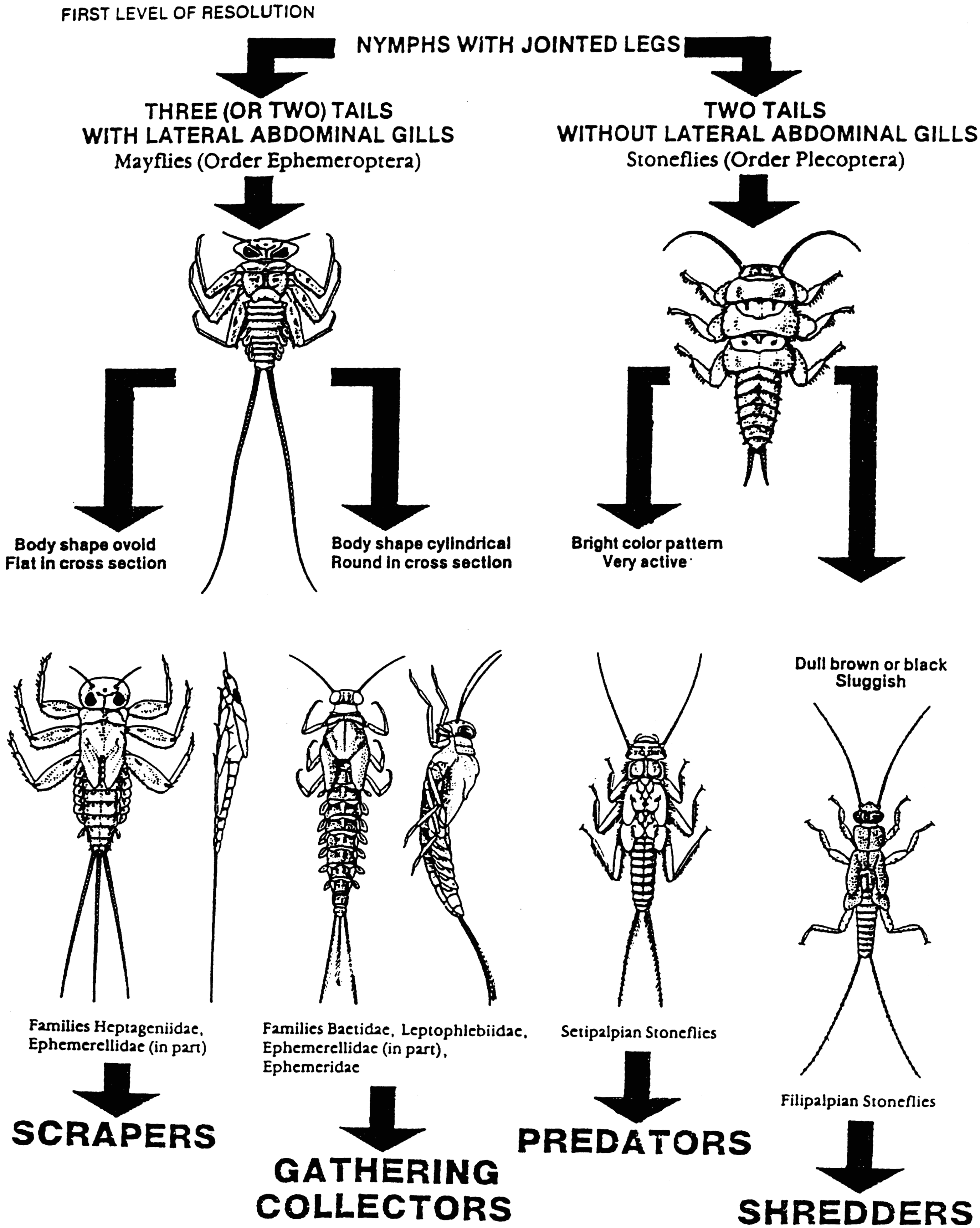
Rhyacophilidae (often bright green)

PREDATORS



SECOND LEVEL OF RESOLUTION considers some common worm-like Predators that would be misclassified in the above key.



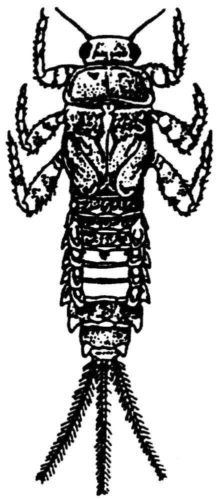

FIRST LEVEL OF RESOLUTION
NYMPHS WITH JOINTED LEGS
THREE (OR TWO) TAILS
WITH LATERAL ABDOMINAL GILLS
Mayflies (Order Ephemeroptera)
TWO TAILS
WITHOUT LATERAL ABDOMINAL GILLS
Stoneflies (Order Plecoptera)
Body shape ovoid
Flat in cross section
Body shape cylindrical
Round in cross section
Bright color pattern
Very active
Dull brown or black
Sluggish
Families Heptageniidae,
Ephemerellidae (in part)
Families Baetidae, Leptophlebiidae,
Ephemerellidae (in part),
Ephemeridae
Setipalpian Stoneflies
Filipalpian Stoneflies
SCRAPERS
GATHERING
COLLECTORS
PREDATORS
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)

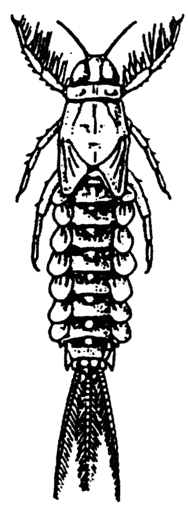
Body shape ovoid
Rear end often erected
scorpion-like when disturbed



Families Ephemerellidae (in part), Caenidae, Tricorythidae

GATHERING COLLECTORS

Body shape cylindrical
Long hairs on inside of front legs
Often with stripe down back

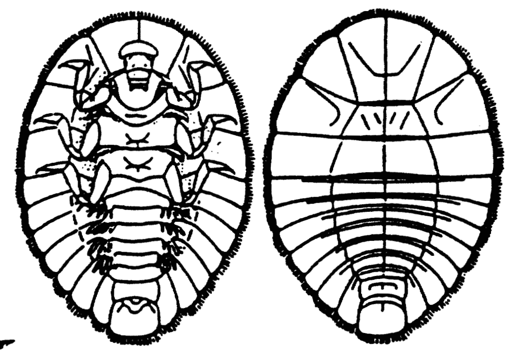


Family Siphlonuridae

FILTERING COLLECTORS

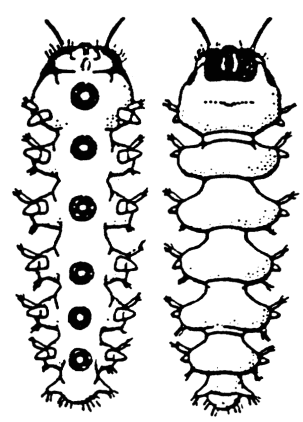
WITHOUT LONG TAILS
Beetles (Order Coleoptera)

Disc shape
Head and legs totally concealed beneath



Water Pennies (Family Psephenidae)

Lobed body
Ventral suckers

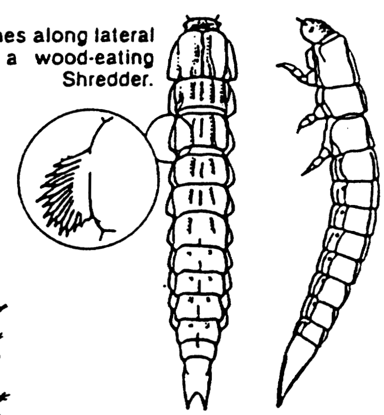


Family Blephariceridae

SCRAPERS

Slender
Triangular in cross section
Hard, yellowish brown covering

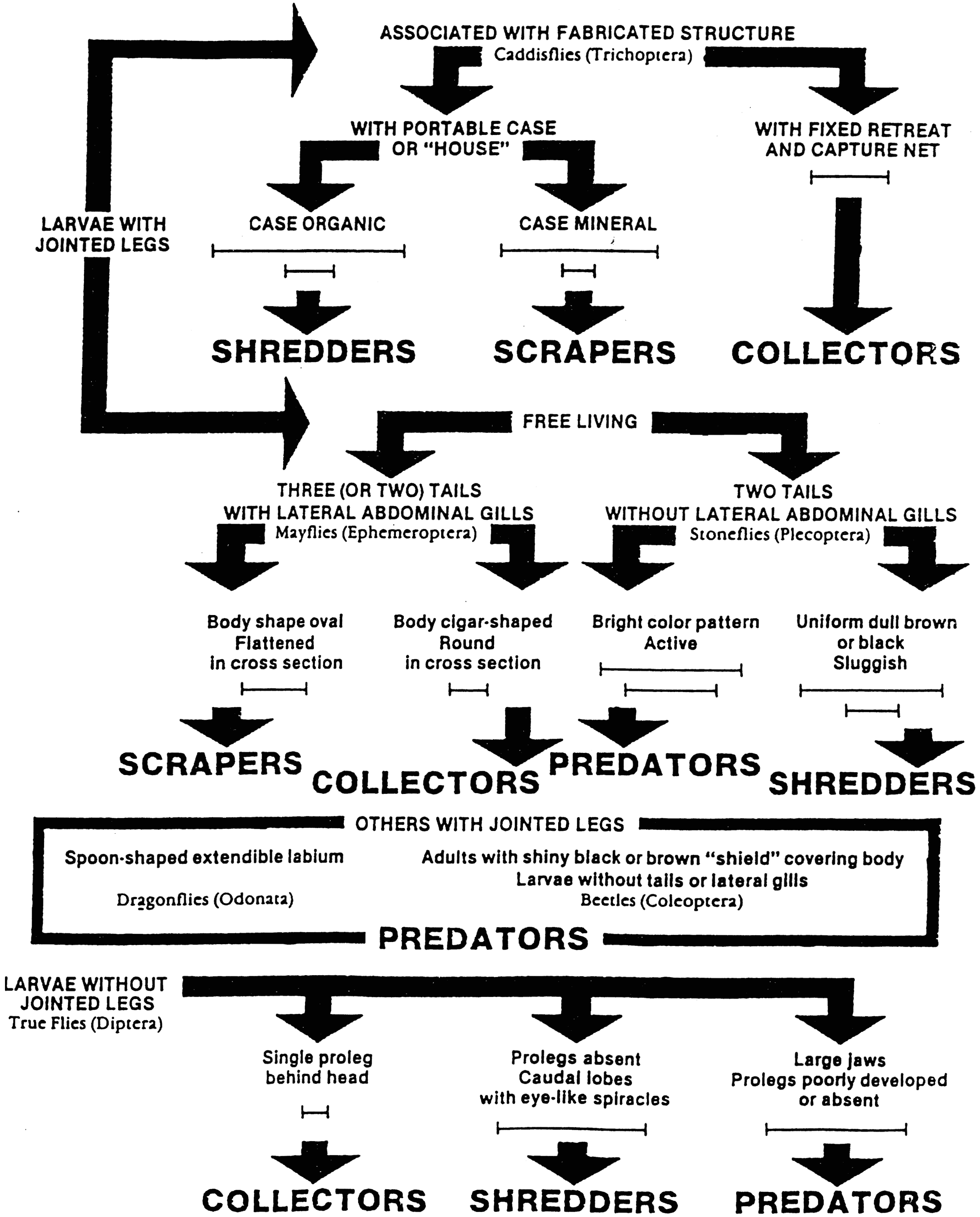
If larva has spines along lateral margins it is a wood-eating Shredder.



Riffle Beetles (Family Elmidae)

GATHERING COLLECTORS

SUMMARY OF FEEDING GROUPS



Data Sheet for Macroinvertebrate Functional Group Analysis Date______ Name______

Site______ Description______

Functional Group	Habitat-Organic Resource Categories: Leaf Pack Count	F*	Rock (Periphyton) Count	F*	Fine Sediments (Pools) Count	F*	Wood Count	F*	Vascular Plants Count	F*	Σ
Shredders (SH)											
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)	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)
Riparian Habitat	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

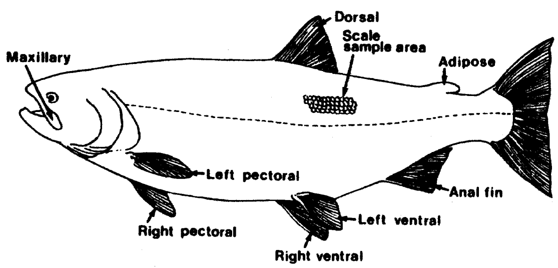
Your STEP biologist will help you select a stream section to survey. He will also help you prepare a map.

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

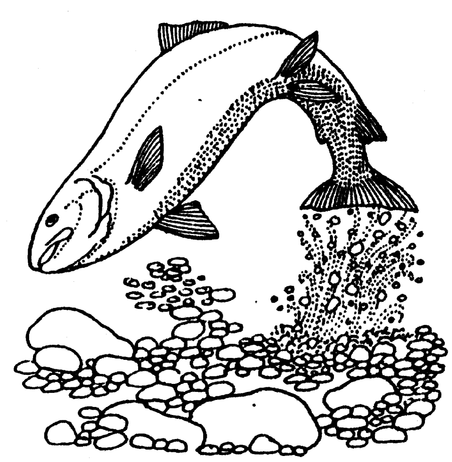
Species: CHS=spring chinook, Co=coho, CS=chum salmon, STW=winter steelhead, STS=summer steelhead

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



Oregon Department of Fish & Wildlife Guidelines and Criteria for Stream–Road Crossings

Criteria for Upstream Movement of Adult Fish

Adult anadromous fish generally expend approximately 80% of their stored energy reserve during normal upstream migration to suitable spawning areas. Undue exertion or delay at stream–road crossings due to unsuccessful passage attempts at inadequate (blocking) structures can lead to reduced spawning success and prespawning mortality.

Where fish passage is required by ODFW (in general, wherever fish are present), the following guidelines shall be utilized for preliminary design. Design flows for culvert passage are calculated based on monthly periods when fish migrate.

Maximum Water Velocities

Table 1: Average Water Velocity (fps) at High Flow Design Discharge for:

Culvert Length (ft)	Salmon & Steelhead	Adult Trout (>6")	Juvenile Salmonids
Under 60'	6.0	4.0	2.0
60' to 100'	5.0	4.0	2.0
100' to 200'	4.0	3.0	*See note below*
200' to 300'	3.0	2.0	*See note below*
Over 300'	2.0	1.0	*See note below*

Note: For juvenile fish, only designs incorporating streambed simulation solutions will be considered for culverts over 100' in length. “Streambed simulation” refers to the situation where substrate and flow conditions in the crossing structure mimic the natural streambed above and below the structure.

Table 1 presents the hydraulic criteria for the design of culverts for passage of salmonids. Satisfaction of these criteria is essential to the adequacy of a culvert installation to meet fish migration needs. These criteria are based on several references.

In a natural stream channel, the average water velocities indicated in Table 1 are often exceeded. The diversity of natural channel beds and formations, however, provides paths of access with suitable depths, velocities, and resting opportunities with only brief exposure to excessive conditions. Velocity requirements noted above may be exceeded within structures with natural beds upon approval by the ODFW Fish Passage Coordinator, Portland.

Minimum Depth at Low Flow Discharge

For nonembedded culverts, minimum water depth during expected fish passage periods shall be:

Twelve (12) inches for adult steelhead and chinook salmon;
Ten (10) inches for salmon other than chinook, sea-run cutthroat trout and other trout over 20 inches in length; and
Eight (8) inches for trout under 20 inches, kokanee, and migrating juvenile salmon and steelhead.

For embedded (stream simulation) culvert designs, minimum depth at low flow discharge during expected fish passage periods must meet or exceed conditions found in the adjacent natural channel.

Entrance Jump; Maximum Vertical Height

A backwatered or partially submerged culvert entrance is preferred, but the following maximum jumps are allowable where justified:

One(1) foot for salmon and steelhead adults
Six (6) inches for trout and kokanee adults and salmon and steelhead juveniles.

The above are also the maximum jump heights when a series of jumps and pools are required.

In cases where entrance jumps are planned, a jump pool of at least 1.5 times the jump height or a minimum 2 feet deep must be provided.

When planning for any jump into a culvert, project designers must show why the culvert could not be designed with no jump.

Criteria for Upstream Migration of Juvenile Salmonids

Upstream juvenile migration occurs in response to instream habitat conditions, predation, and population pressures. Juvenile migration and redistribution is a means for increased survival and optimizing production. An obstruction to juvenile migration can limit production both upstream and downstream from the barrier.

Juvenile salmonids, by virtue of their small size, are less capable swimmers when compared to adults. Therefore, maximum water velocity, jump, and swimming distance criteria are necessarily lower than those for adults.

Preferred Road–Stream Crossing Structures

Where fish passage facilities are required by ODFW, the following structure types shall be considered for use in the displayed order of preference:

1. Bridge (with no approach embankment into the main channel)
2. Streambed simulation strategies using a Bottomless Arch or embedded culvert designs
3. Streambed simulation strategies using embedded round metal or concrete box culvert designs
4. Nonembedded culvert; placed at less than 0.5% slope
5. Baffled culvert (various designs); placed at 0.5 to 12% slope or a structure with a fishway.

ODFW Stream–Road Crossing Guidelines, page 3

Again, streambed simulation refers to the situation where substrate and flow conditions in the crossing structure mimic the natural streambed for fish passage flows.

The landowner or agency must justify their proposed structure type if a more preferred structure type is not selected.

General Considerations

At any given flow, slope is an important factor affecting water velocity in culverts. Culvert size also affects velocities, especially when a structure is considerably undersized and a head (pooling above culvert) is developed.

Gradients (slope) for nonembedded, nonbaffled culverts shall not exceed 0.5% unless a tailwater situation exists to backwater the culvert to a suitable depth for its length. Properly baffled or weired culverts are appropriate for steeper gradients depending on design. Structures with fishways (i.e., fish ladders or culverts with weir-type baffles) generally will be required where culvert gradients exceed 5% and streambed simulation is not employed.

Corrugated metal culverts are generally preferred over smooth-surfaced culverts. Deep corrugations are preferred over shallow corrugations.

Bottomless arches and all styles of embedded culverts shall be placed at or near the same gradient as the natural streambed and shall be at least as wide as the active stream channel (i.e., no lateral encroachment on the active stream channel). All embedded culverts (round or arch) must be embedded 1 foot deep or at least 20% of its height, whichever is more.

When deciding between bottomless arch and embedded culvert designs, the primary consideration is foundation substrate. If considerable bedrock is present, an open bottom arch is generally the appropriate choice; embedding a culvert would require extensive excavation. Where deep unconsolidated gravel and cobble are present, failure (undermining) of a bottomless arch foundation is a major concern.

Hydraulic controls may be required to (1) improve culvert entrance and exit conditions (e.g. using a beveled inlet configuration; providing resting pools at culvert entrance and exit), (2) concentrate low flows, (3) prevent erosion of streambed and banks, or (4) allow passage of bedload material. The need for, and design of, these project features should be developed in consultation with ODFW.

If water-crossing structures are placed in spawning areas, they must incorporate mitigation measures, as necessary, to achieve no-net-loss of spawning area.

Trash racks are discouraged at culvert inlets. But if necessary, these should be installed only above the high passage flow water level.

For culverts over 200 feet in length, illumination may be required. Contact the ODFW Fish Passage Coordinator, Portland, for a case-specific determination.

ODFW Culvert Evaluation Form

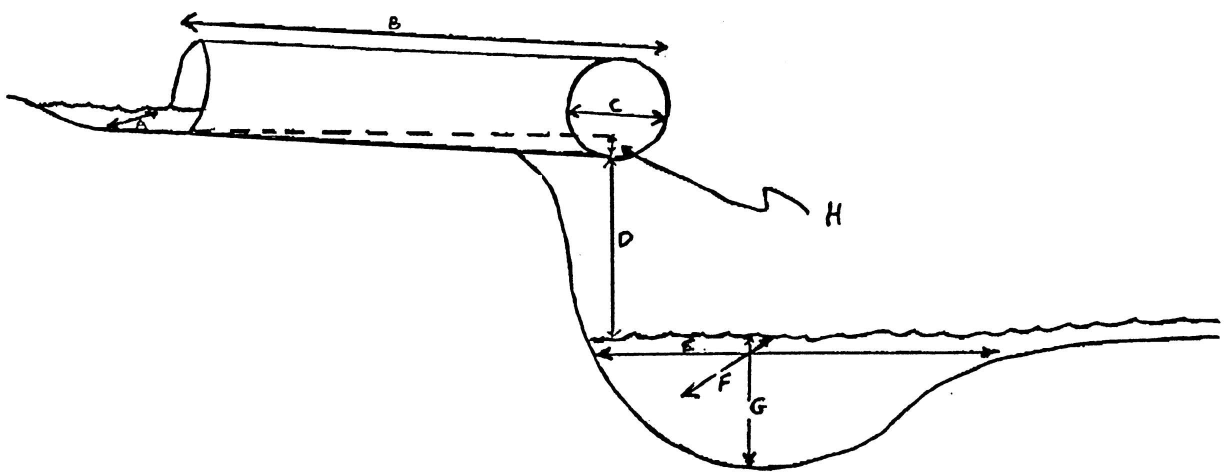
Evaluators:______________________________ Date:________________________

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

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?

6

Managing Rural Homes and Small Acreages to Protect Watersheds

Garry Stephenson
and Linda J. Brewer

The property you live on, no matter its size, is part of a larger mosaic of properties. Water drains over and through this land into streams, rivers, lakes, and eventually the ocean. Even if there are no streams on your property, water eventually makes its way to these bodies of water from your land. Thus, the quality of water before and after it leaves your property is critical for human consumption, fish habitat, and many other uses.

It might seem that small properties can't contaminate water resources or do much to improve water quality. But the combined impact of many rural homes and small acreages can represent a significant source of pollution or clean water depending on how well the land is managed. Your property is an important part of the watershed processes discussed in Chapter II-2, "Watershed Hydrology."

This chapter discusses several key sources of water-quality contamination on rural homesites and small farms and suggests ways to reduce water-quality problems.

The kind of pollution we're concerned with in this instance is *nonpoint source pollution.* This kind of pollution comes from many sources, some quite small. These sources might not be easy to identify, but added together they're a major contributor to water

In this chapter you'll learn:

- The role of soil in water quality
- How to manage home landscapes and gardens to protect water quality
- How to manage your domestic well and septic system to protect water quality
- How to manage livestock pastures to protect water quality
- How to manage manure and compost piles to protect water quality

contamination. *Point source pollution*, on the other hand, comes from easily identified sources such as factories or sewage plants.

The “Resources” section at the end of this chapter includes additional materials with more in-depth coverage of these topics.

MANAGING YOUR LANDSCAPE AND GARDEN TO PROTECT WATER QUALITY

See Section II, Chapter 2 and 4, and Section III, Chapter 3 for information related to this chapter.

Section II

2 Hydrology

4 Soils

Section III

3 Livestock

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides. Pounding rain and runoff carry away soil particles, organic matter, plant nutrients, and soil contaminants. This mix of water, soil, and chemicals can make water turbid or cloudy, stimulate excess algae growth, and contaminate aquatic life and drinking water.

Fortunately, you can minimize erosion and runoff with some fairly basic land management practices. The key is to minimize the amount of contaminated water that runs off your property by using fertilizers and pesticides correctly. Do not overapply any fertilizer or pesticide to your lawn, garden, or landscape.

Home landscape design and materials

The design of your landscape and the materials you use can have a major impact on how water behaves on your property. Water leaving a site as runoff is more likely to carry pollutants than water that has soaked through the soil and leaves as groundwater. When water soaks through the soil, the soil filters the water to a greater extent than when the water just runs off.

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides.

In general, more than 90 percent of the rain that falls on pavement runs off. Lawns have about 25 percent runoff, and dense forests have about 10 percent runoff. Therefore, when designing a landscape, it’s best to have fewer hard surfaces and more grass, trees, and natural landscaping.

It’s a good idea to select plants that are native or well adapted to your area. Often these plants require less supplemental water and fertilizer and fewer pesticides to remain healthy and attractive. By using fewer of these inputs, you decrease the cost of the landscape as well as the potential for water contamination.

The same is true for lawns. Consider using low-maintenance groundcovers instead of grass, particularly in areas where grass doesn’t grow well, such as dense shade.

THE ROLE OF SOIL IN WATER QUALITY

Soil as a filter

Eroding topsoil, fertilizer, petroleum products, and pesticides are some of the materials that degrade the quality of water that passes through or over soil. The type of soil you have and how you manage it help determine whether these contaminants reach bodies of water.

Activity in soil is a complex interplay of chemical and biological reactions. Most soil has a negative electrical charge, which allows it to attract and hold positively charged ions. Many plant nutrients and soil contaminants have a positive charge and therefore can be held by soil particles. In this case, soil acts as a chemical filter.

Soil also contains immense quantities of microorganisms that feed on organic matter and other material in soil. These organisms act as a biological filter when they degrade, alter, or inactivate contaminants.

There are many kinds of soil, and each has characteristic drainage patterns. Sandy soil has large pore spaces that permit water to drain quickly. Clay soil has very small pore spaces, so water moves through it very slowly. The pore sizes of silt loam, silty clay loam, and clay loam lie between those of sand and clay.

Each of these drainage characteristics has water-quality consequences. Soils with quick drainage reduce runoff but permit nutrients and contaminants to travel quickly into and through the soil toward groundwater. Soil with slower drainage reduces the rate of contaminants traveling into the soil profile but causes standing water and surface runoff. The soil type, slope, and rate and amount of rainfall or snow melt influence the exact amount of water flowing into and across soil (Figure 1).

Soil as a contaminant

Soil suspended in water causes clouding or turbidity. Soil contains organic matter and nutrients that can reduce the oxygen content of water. Fish and other aquatic animals suffer because of limited dissolved oxygen in the stream.

Clay soil particles, because of their small size, can be carried along in streams, keeping them cloudy. Heavier soil particles such as silt or sand settle out of flowing water more easily, especially where the flow slows. In these places, they build up, changing the course of the stream over time. Soil deposited on stream bottoms can cover or smother nurturing habitats for fish eggs as well as the insect eggs upon which fingerlings depend.

Continued

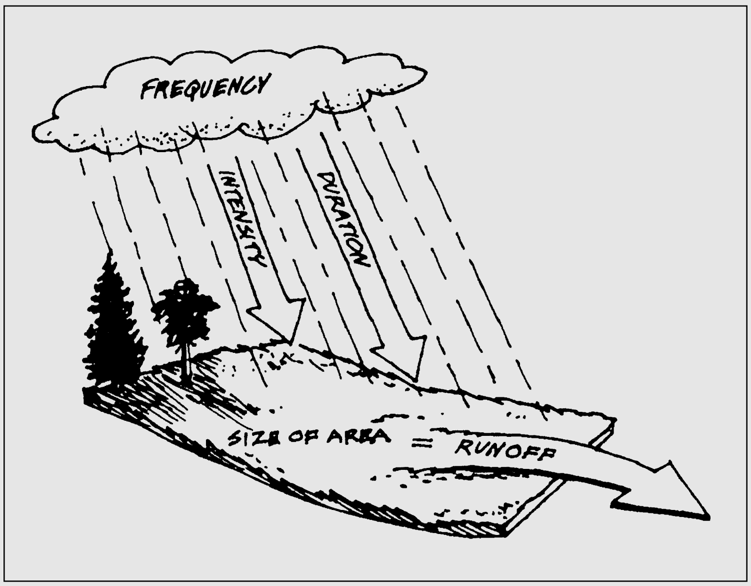


Figure 1.–Rainfall characteristics help to determine amounts of runoff. (Source: Water Quality Protection Guide, *Oregon Department of Agriculture, 1993)*

The role of soil in water quality

continued

How organic matter improves soil

Organic matter is an important ingredient in a healthy soil system. It can be supplied as crop residue, dead grass, or animal manure. When applied to the surface, it reduces erosion and the compaction caused by raindrop splash.

Organic matter, like soil, has a negative charge and attracts and holds positively charged plant nutrients and other materials. Thus, organic matter "ties up" nitrogen and pesticides, slowing their leaching into surface and groundwater.

Organic matter also acts like a sponge, slowing the flow of water through soils. This characteristic is especially beneficial to sandy soils. In clay soils, organic matter creates larger soil pore spaces, increasing the amount of air in the soil and enhancing drainage.

Chapter II-4, "Watershed Soils, Erosion, and Conservation," contains more information about how soils fit into the entire watershed picture.

Always mulch or plant some type of cover crop over bare soil. These techniques protect the soil from erosion and add organic matter.

Managing weeds

Weeds are plants that have a detrimental effect on agriculture, recreation, wildlife, or humans. Weeds cause production losses to agriculture, endanger native plants and animals by encroaching on forest and conservation areas, hamper the use of recreational areas, and can be poisonous or harmful to humans and animals.

Weeds also can be a source of conflict between neighbors when weed control is not practiced. Many states mandate that noxious weeds be controlled on lands managed privately or publicly. Regardless of enforcement, it is everyone's responsibility to control noxious weeds.

Several plants can be characterized as "plant barbarians." These plants invade and aggressively spread, dominating other, more favorable plants. They can harm humans, poison livestock, and make land unattractive and virtually unusable.

Riparian and wetland areas are susceptible to several very aggressive plants. If these plants are present, manage them so they do not spread, or plan to remove them. For instance, reed canarygrass (*Phalaris arundinacea*) is used as a pasture grass in many wet areas. Efforts should be made to keep it from escaping into riparian or wetland areas where it is not welcome. Proper grazing can keep this plant in check. In many areas, purple loosestrife (*Lythrum salicaria*) is a threat to wetlands. It always should be removed.

When possible, it's a good idea to allow native plants or plants highly compatible with native plants to dominate the uncultivated areas of your farm. You will find these plants are easy to manage, encourage appropriate wildlife, often assist in preventing weeds, and maintain important natural functions such as the water-filtering role of wetlands.

Reduce weed problems on your property with these guidelines for weed control:

- Know the difference between a weed and a benign plant.
- Control weeds when they are seedlings or are actively growing.
- Cut or kill weeds before they go to seed.
- Sow grasses or groundcovers on bare spots to compete with weeds.

- Don't disturb areas larger than you can reasonably manage when establishing garden sites, landscaping, pastures, and other improvements.
- Compost manure before spreading to reduce weed seeds.

Using fertilizers correctly

Homeowners usually add fertilizer to their landscapes and gardens to enhance plant growth. However, if you overapply compost, manure, or synthetic fertilizers, water can carry excess nutrients into streams or leach them into groundwater.

A soil test to determine the nutrients available to your plants will help you avoid adding unnecessary fertilizer. Information on how to test soil and the location of analytical labs is available from your county office of the OSU Extension Service.

When using fertilizer, use only the amount recommended. In some cases, plants can achieve adequate growth with less than the recommended amount of fertilizer.

Time fertilizer applications to match the plants' needs so the nutrients are not lost in runoff or leaching. Plants take up nutrients most vigorously during the active growing season. Don't add any kind of nitrogen during the short, cool days of late autumn and winter, when plant growth slows significantly. Most plants have reduced nutrient demands at this time, and nitrogen is easily leached into groundwater by precipitation.

It's best to fertilize trees and shrubs just before or as new growth begins in the spring. Fertilize grass and flowers when they're actively growing. Use slow-release fertilizers when possible. They release nutrients into the soil in small amounts over time and are less prone to leaching.

Excessive irrigation after a fertilizer application promotes runoff and leaching. Match the application of water to the needs of plants. Install irrigation timers if needed.

Manure can be a valuable fertilizer and soil conditioner and, when applied appropriately, will produce minimum ground- and surface water contamination. Land application is a logical and time-proven method of disposing of manure. To avoid water contamination, apply manure between periods of intense rainfall, when the ground is neither frozen nor saturated. Because the nitrogen in manure is so water soluble, try to apply it as the soil warms up and plants are growing vigorously.

It's also helpful to incorporate manure lightly into the soil. In permanent landscape plantings, apply up to 1 inch and work it into the surface with a hand rake or similar tool.

Cover and compost stockpiled manure to conserve its fertilizer value.

Using pesticides appropriately

Pests in gardens and landscapes fall into three major categories: weeds, insects, and diseases. There is an arsenal of organic, least-toxic, and highly toxic pesticides and methods available to control these problems. As with fertilizer, the tendency is to overuse pesticides. These excess chemicals threaten surface and groundwater quality.

When dealing with a problem in your yard, it's a good practice to begin to solve the problem by using the least-toxic method at your disposal. Then, if the problem continues, you can use more toxic methods until you achieve success. This strategy will decrease your use of more toxic pesticides, minimize your handling of pesticides, protect your family and pets, and limit environmental impacts.

Start by adjusting cultural practices to give your plants optimum growing conditions. A healthy plant is less susceptible to pest attack. Choose plants carefully based on the conditions of your yard. If you do encounter pest problems, consider using cultural, mechanical, and biological controls first.

Some "pest problems" are not problems at all. Good plant selections for home landscapes tolerate low levels of insect and disease damage. Putting up with some landscape imperfection reduces labor and chemical inputs.

Always use pesticides–organic or synthetic–for their intended purpose. Apply them at the recommended rate and follow label directions. Never dump pesticides into household drains, storm drains, or on the ground. Instead, either use the pesticide for its intended purpose or take advantage of a pesticide collection event. Your local garbage collection service or landfill can provide information on these collection events. Purchase only the amount of pesticide you'll need for a single growing season. In the case of pesticides, bigger is not necessarily better.

Limiting pesticide use

Here are just a few ways to limit pesticide use in your home landscape:

- Use disease-resistant plant varieties.
- Practice good sanitation.
- Use insect traps and barriers.
- Remove pests by hand.
- Create habitat for beneficial organisms.

MANAGING YOUR WELL AND SEPTIC SYSTEM

Domestic wells

Most rural homes get their drinking water or irrigation water from a well. By properly managing your wellwater system, you can protect groundwater and your drinking water supply. Proper management requires inspection and maintenance of all wells on your property and special attention to any practice that could potentially contaminate groundwater.

The location of your well relative to other farming activities is very important in protecting your drinking water. Common sense dictates that potential contaminants be located as far from a well as possible. For public health reasons, states and counties set minimum distances between wellheads and common pollution sources. These structures and activities include:

- Septic tanks
- Confined animal feeding or holding operations
- Animal waste holding ponds, lagoons, or other waste storage sites
- Pesticide or fertilizer storage
- Above-ground and buried fuel storage tanks
- Sewage disposal systems such as pit privies or septic system drainfields

Contact your county sanitarian to determine whether there are minimum setback limits regulating the placement of these or other structures in relation to your well.

Inspect your well to see whether it is properly constructed. See Figure 2. The well casing should extend 12 to 18 inches above the

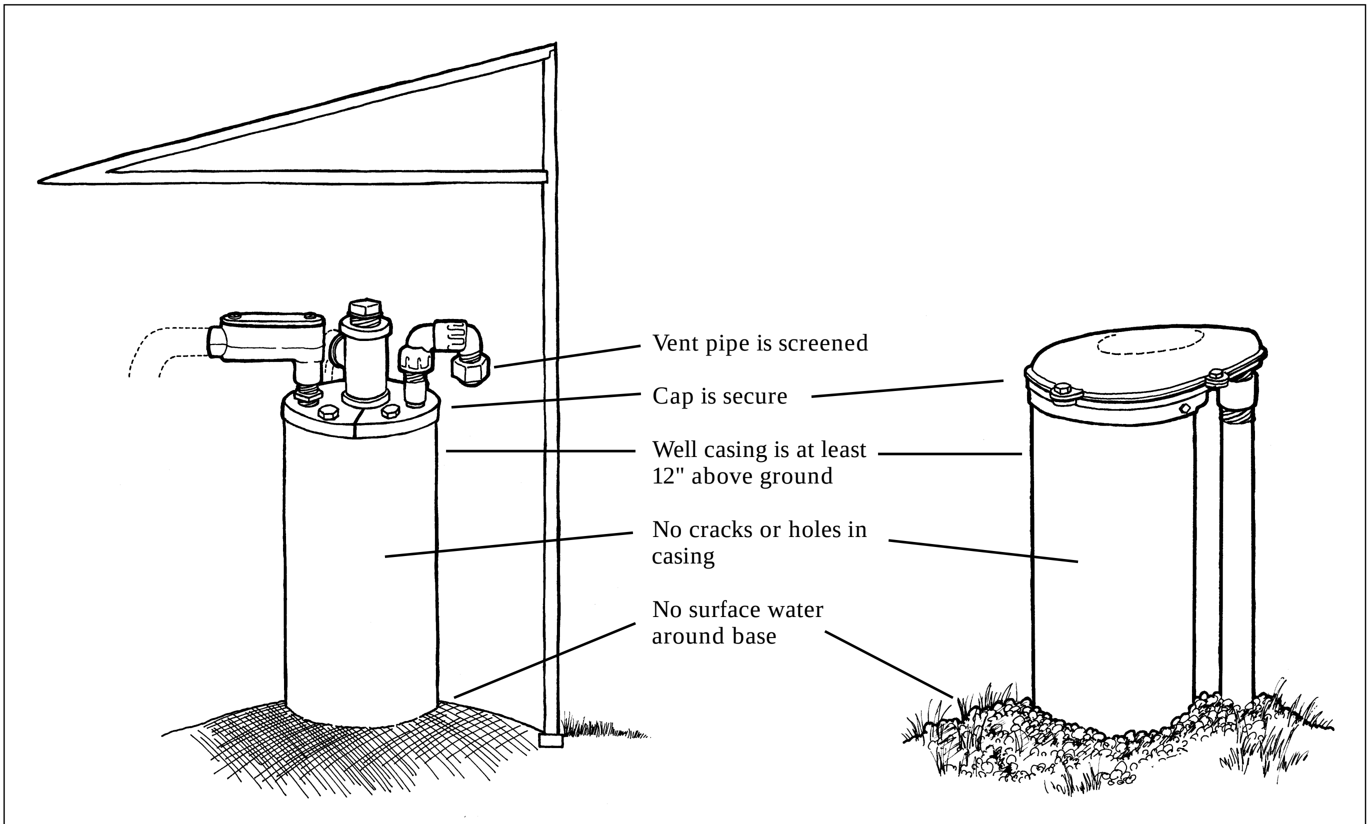


Figure 2.–A properly constructed well protects against contaminants entering your drinking water system.

ground surface, and there should be a concrete or soil pad surrounding and sloping away from the casing. This design protects the wellhead from contamination by surface water. If your wellhead does not extend above the ground surface, a shallow trench around the wellhead is recommended to protect the well from surface water.

Check the sanitary well cap to make sure the bolts are tight and that no gaps or cracks are visible in the cap or casing. Replace old and cracked sanitary seals, especially when surface water, as from flooding, can cover your wellhead. Make sure there is a screen covering the vent pipe to prevent insects and mice from entering your well.

It's a good idea to locate all of the wells on your property (Figure 3). Wells no longer in use present a high risk of groundwater contamination. These old wells provide a direct conduit for pollutants to reach groundwater. Abandoned wells may be visible only as an unnatural depression, a ring of bricks or rocks, or a pipe sticking out of the ground. Always abandon old wells properly and document their location. Pass this information on to the next property owner.

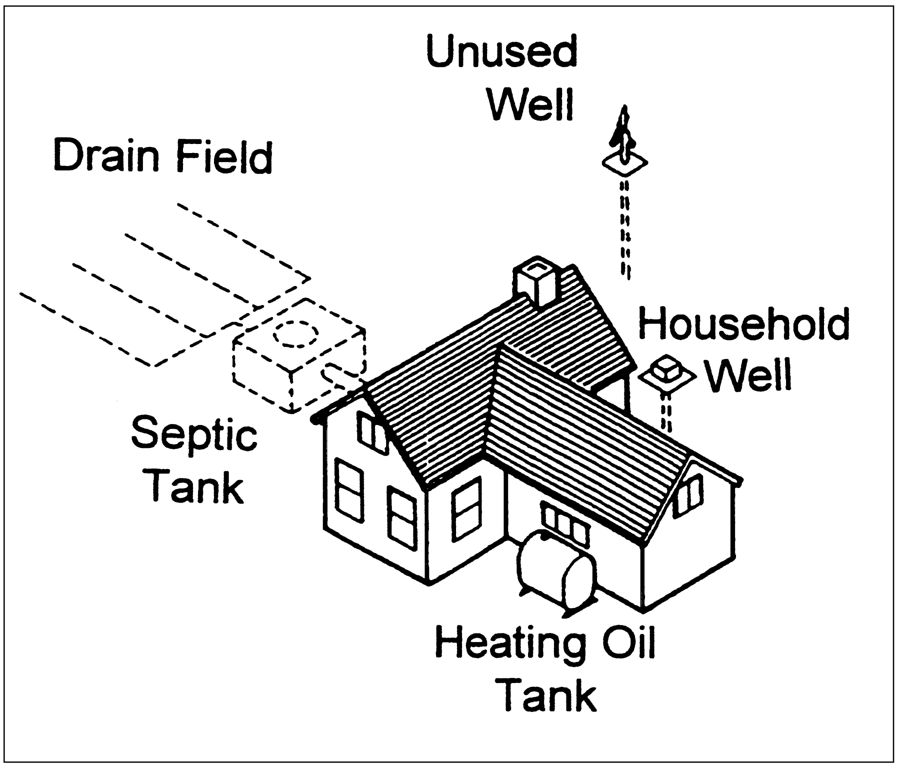


Figure 3.–Know the location of all active and abandoned wells on your property.

If your household well is located in a pasture, fence the wellhead to prevent urine and manure from reaching the well. If your soil is sandy (porous), remember that fecal bacteria can travel in groundwater as well as surface water.

Don't store pesticides and fertilizers in your well house. One spill could contaminate your drinking water. Find a suitable dry location for these materials away from your well.

Install an antibackflow or antibacksiphoning device on all outdoor faucets. These devices prevent contaminants from pesticide sprayers, livestock tanks, and so on from being siphoned into your household water system. As an alternative, never put the end of the hose in liquid–always maintain a gap between the end of the hose and any potential contaminant.

Test your water annually for bacteria and nitrate. These two tests serve as an indicator of the condition of your wellwater.

Septic systems

Properly operating septic systems safely process household wastewater and sewage. Failing septic systems are major groundwater and surface water hazards, as well as sources of odor and bacteria. Through routine inspection and maintenance, you can protect your household water supply as well as the surface water and groundwater in your watershed.

In a properly working septic system, liquids and solids from the household are separated in the septic tank (Figure 4). Liquids are passed from the tank into the drainfield, where they're leached into the soil. Solids are partially digested by micro-organisms, and the remaining solids settle and slowly fill the tank.

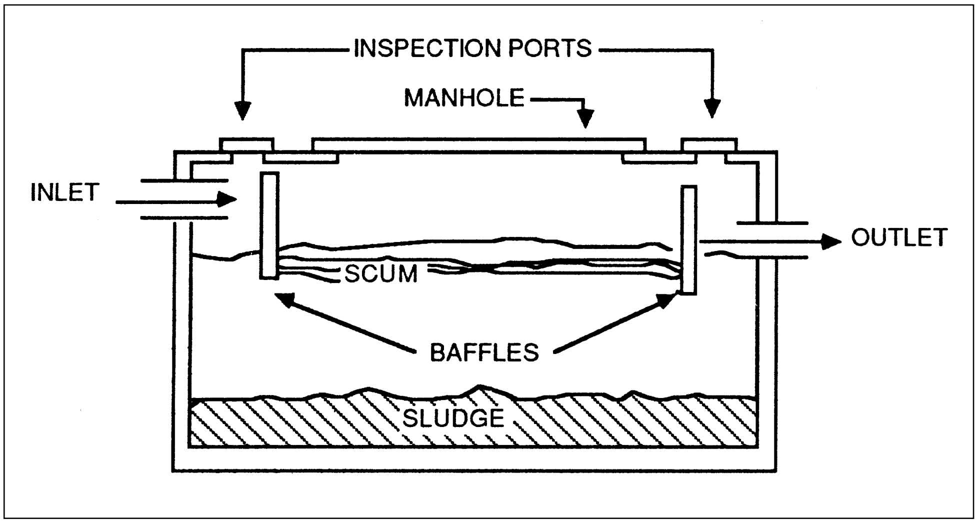


Figure 4.–Cross-section of a septic tank.

Most legally installed septic systems consist of a septic tank and a soil leach field. The proper size depends on the size of the dwelling, expected water use, and leach field soil type. States specify the size of septic tanks in newly constructed systems. The drainfield also must be the correct size for the household. You can obtain specific guidelines from your county sanitarian.

Have your septic tank inspected regularly by trained personnel. A properly sized tank should be pumped out every several years to remove accumulated solids. The pumping schedule varies with the size of the household and the size of the system. An overfilled tank can pass solids to the drainfield, thus clogging it and leading to leach field failure and costly repairs.

Don't flush material into your septic system that doesn't decompose readily or that might clog the system or interfere with the decomposing activity. These items include diapers, fats, grease, solvents, oils, paints, or pesticides. Using a garbage disposal also contributes to the accumulation of solids in the tank; more frequent pumping is required when garbage disposals are used. Normal use of household cleaning products and laundry bleach doesn't affect the system.

There is no need to purchase additives to increase the rate of decomposition in your system. Pumping the tank to remove solids is the most important maintenance you can schedule for your septic system.

Keep runoff from roofs and pavement away from your drainfield to avoid saturating the soil. Saturated soil won't accept any more wastewater. Don't allow water that doesn't need treatment to be added to the amount of wastewater in the septic system. Examples are water softener backwash water, basement floor drain sumps, and roof runoff water. Water-saving fixtures and other conservation practices also reduce the amount of wastewater entering your system.

Plant grass over the drainfield. The roots from trees and large shrubs can clog it. Avoid soil compaction over the drainfield. Compacted soil can damage the system or interfere with its function. Don't use the area for a parking spot or a road. Don't drive large equipment over it or allow large animals to stand on it, especially when the soil is wet. Don't cover the drainfield with plastic, cement, or other impermeable material. These materials reduce the soil's ability to "breathe," thus inhibiting proper function of the drainfield.

MANAGING SMALL PASTURES

Owning livestock often is an important benefit of living on a small farm. In areas with sufficient rainfall and soil fertility, pastures can supply large quantities of high-quality feed for animals. Maintaining the quantity and quality of feed in a pasture saves money and promotes healthy animals. The type of management that promotes high-quality pastures also protects water quality.

Here are some basic management recommendations. Each is discussed below:

- Base the number of animals you keep on the size and productivity of your land.
- Do not overgraze your pasture.
- Cross-fence pastures to provide several paddocks, then rotate grazing.
- Keep animals off saturated pastures.

Base the number of animals you keep on the size and productivity of your land.

One of the challenges of managing livestock on a small acreage is taking care of the needs of the animals in a small area without overusing it. Land has a limit to how much forage it can produce. If the number of livestock is in balance with the amount of forage produced, your land is considered to be within its carrying capacity. If the number of animals exceeds this amount, pastures are overgrazed, the quantity and quality of forage declines, weeds invade, and the soil becomes compacted from too much animal traffic.

In overgrazed and overused conditions, sediments and pollutants are no longer filtered by a vigorous stand of grass and can run directly into streams. The soil can't absorb excess water and isn't protected with a thick groundcover so it is more likely to erode. Too many animals produce excess manure and urine, perhaps supplying more nutrients than can be cycled naturally through the pasture.

The amount of pasture required for livestock varies by region and is dictated by climate, soil type, and other factors. Even within a given region, some land is more productive and can support more animals. Some land has limitations and can't support the recommended number of animals or isn't appropriate for every type of livestock. Some land is so wet that it simply isn't appropriate for livestock use except during the driest time of the year. Contact your local Extension Service office, USDA Natural Resources Conservation Service (NRCS) office, or Soil and Water Conservation District (SWCD) for specific information about your land's carrying capacity for livestock.

One of the challenges of managing livestock on a small acreage is taking care of the needs of the animals in a small area without overusing it.

Do not overgraze your pasture.

Pasture plants, like other plants, require leaf growth. When the leaves of pasture plants are continuously nipped close to the ground, the plants lose vigor and might die. On the other hand, when plants are grazed and then given time to recover, they remain healthy and vigorous. The rest period allows the plants to grow and store energy so they can withstand future grazing.

It is generally recommended to graze a pasture to about 3 inches in height and then allow it to rest until it regrows to about 6–8 inches. Correct grazing height varies somewhat depending on the type of grass.

This technique maintains vigorous pasture plants and decreases weeds and bare spots. A vigorous pasture does a great job of filtering sediments and using nutrients from manure that otherwise might run off into streams.

The plants typically grown in pastures require some additional fertilizer in order to maintain a productive stand. In addition to chemical fertilizers, manure and urine deposited by grazing stock contribute to pasture fertility. Periodic harrowing to distribute manure will promote general pasture quality. Legumes included in a pasture mix also can contribute to pasture fertility.

Cross-fence pastures and rotate grazing.

Dividing or cross-fencing your land into several small pastures allows one part of a pasture to rest while animals are grazing another. You then can rotate animals from one pasture to another. This method increases the productivity of pastures, decreases feed costs, and protects the soil with a heavy sod that filters runoff.

Pastures can be cross-fenced with permanent fencing or temporary electric fencing. Cross-fencing systems should have at least three pastures. Four are recommended; more are even better (Figure 5).

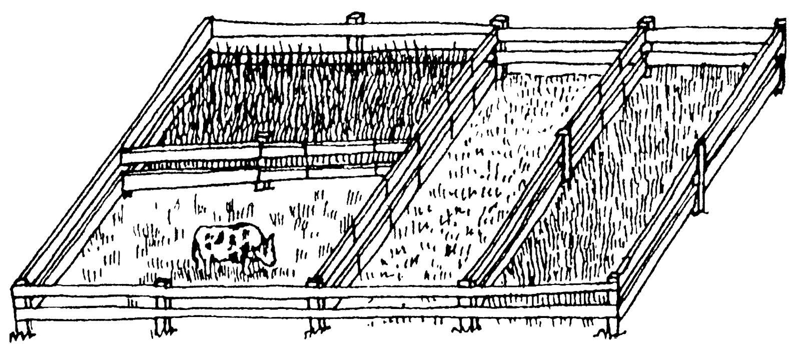


Figure 5.—Rotational grazing. (Source: Water Quality Protection Guide, *Oregon Department of Agriculture, 1993)*

The system for rotating pastures is simple. Put animals into the first pasture when the grass is about 6–8 inches tall. When the grass has been eaten to about 3 inches tall, move the animals to the next pasture.

The rest period needed varies depending on time of year and climate. Pastures grow fastest during spring and summer; during winter they grow very little if at all. The goal is to not return to a pasture until it has regrown to 6–8 inches tall.

Keep animals off saturated pastures.

During winter, pastures grow very slowly or stop growing altogether and sometimes are saturated with water. This is a good time to move your animals to a well-drained area or an all-weather paddock to avoid damaging the pasture.

When animals stay on wet pastures, they overgraze what little feed there is. They also compact and damage the soil and generally create a muddy mess. Pastures that have livestock on them all winter usually don’t support a good stand of grass the following year, cause stress for animals, and are a source of sediment in streams.

Sometimes landowners “sacrifice” an area for livestock to stay on during the winter. If you use this method, make sure the area is on high, well-drained ground and well away from streams.

On small farms, a good investment is to construct an all-weather paddock for animals to stay on until pastures are ready to graze in the spring (Figure 6). In addition to saving your pasture, these well-drained areas keep animals and their feet drier and provide a convenient area for winter feeding. If they’re large enough, they also can be used as an exercise area or arena.

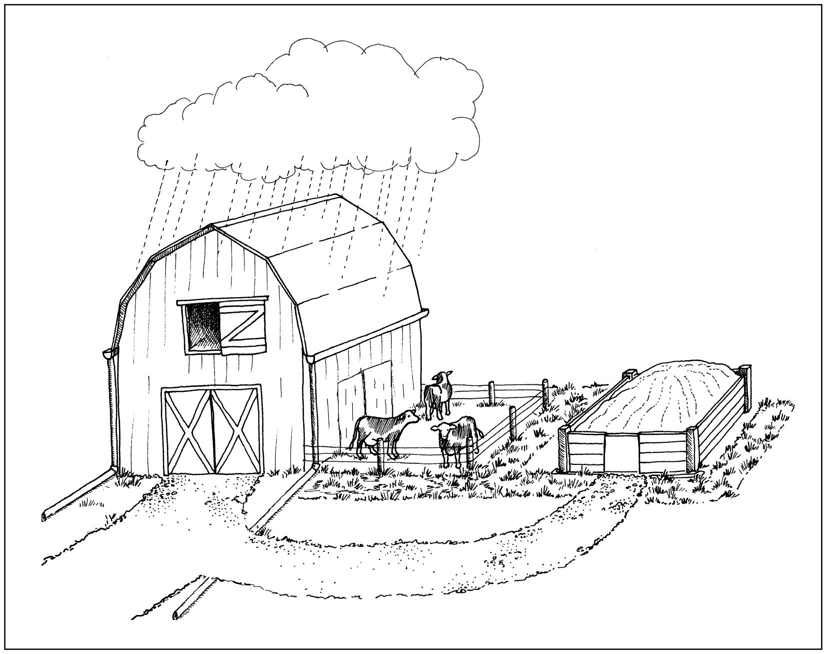


Figure 6.—Careful management of grazing, manure storage, and clean water runoff can protect surface water and groundwater from contamination during wet weather.

MANAGING COMPOST AND MANURE PILES TO PROTECT WATER QUALITY

Composting waste materials from the household, barn, and garden is a popular and effective way to generate fertilizer and organic matter to add to soil. Although composting is a good method of recycling nutrients, it can be a source of sediment, excess nutrients, and bacteria in streams when managed incorrectly.

Any accumulating mass of organic waste can threaten water quality. Common sources are large amounts of fresh manure and urine-soaked bedding generated from horse barns and other small livestock farms. These wastes contain both nutrients and potential disease-causing organisms.

The following suggestions, each discussed below, can help you minimize the possibility that waste will contaminate surface or groundwater:

- Site waste piles properly.
- Use buffer strips to trap flowing contaminants.
- Apply manure and compost when and where plants can use it.

Site waste piles properly.

It’s important to control the flow of water through compost and manure piles. Covering piles is an effective way to do this

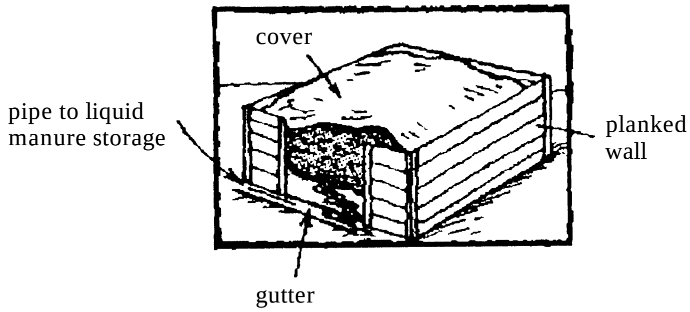


Figure 7.–Covered manure storage. (Source: Water Quality Protection Guide*, Oregon Department of Agriculture, 1993)*

(Figure 7). It also enhances the composting process and prevents the loss of nitrogen from water percolating through the pile.

If you keep horses or other livestock in a confined area during the winter, you'll need to store manure in piles so you can spread it on pastures later. When choosing a spot for long-term organic waste storage, consider the soil types on your property. Refer to the sidebar on soils (pages 3 and 4) for more information on how water and pollutants move through different soils.

Also consider the flow of surface water before siting a waste pile. Don't locate piles in low spots where drainage water flows. If necessary, divert surface water to prevent it from moving through the pile. Site the pile downslope from your well. A 200-foot separation ensures maximum wellwater protection. Be sure all waste is above the floodplain so it won't be carried downstream during floods.

Consider using a roofed, concrete pad for storage of large amounts of waste. Gutters divert clean rainwater downslope away from stored materials. Curbs further divert surface flows away from the pad, thus protecting water quality and manure nutrient content. Smaller amounts of waste can be stored on the ground, provided they are covered by weighted tarps during the rainy season.

Adequate, correctly sited manure storage space can reduce the pressure to dispose of manure by winter's end. The number and type of animal and the type of bedding affect the amount of space needed for manure storage. The following table can be used to estimate the area needed per animal for 6 months.

Animal	**Cu ft/animal/6 months**
Horse	175
Cattle	150
Sheep	10
Pig	27
Alpaca	16

On a practical level, assuming a pile 4 feet high, one horse requires about 45 square feet of storage space for a 6-month period. Keep in mind that these numbers are for manure only and do not include additional storage space for bedding.

Use buffer strips to trap flowing contaminants.

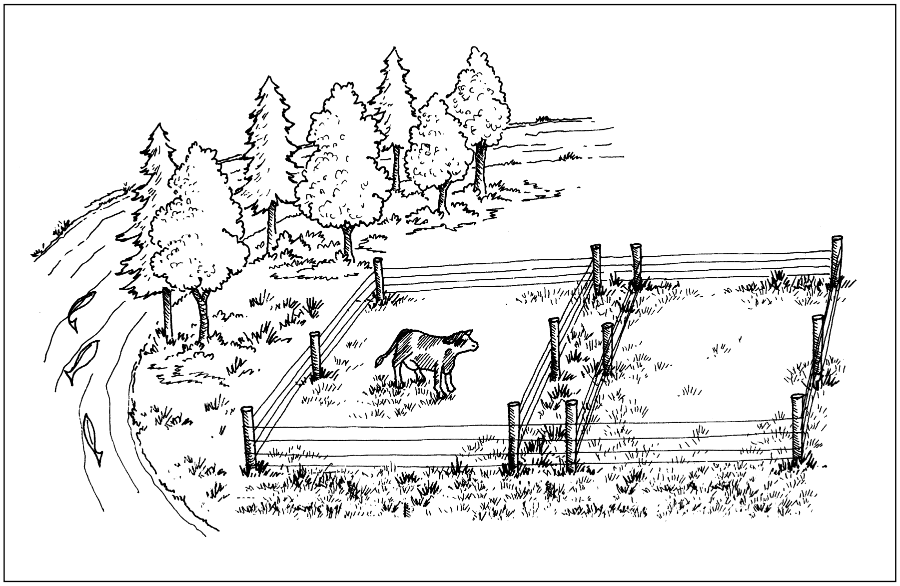


Figure 8.—Use vegetated filter strips to slow runoff, increase infiltration, and filter pollutants from runoff water.

Protect streams by maintaining a buffer strip between manure piles or sacrifice areas and streams. Buffer strips are areas planted with grasses and groundcovers (Figure 8). They enhance water quality by slowing runoff, promoting infiltration, and reducing the transport of pollutants. They serve as water filters and reduce amounts of sediment, nutrients, and microorganisms reaching the stream.

These vegetated strips take up dissolved nutrients before they reach the stream. Deeply rooted plants can recover nutrients that move deep into the soil.

Buffer strips must be protected from grazing and compaction by animal hooves, especially during wet weather. If you want to mow a buffer strip, do so only during the dry season. Set the mower high to promote lush, vigorous growth of grasses.

As a property's slope increases, the width of the buffer strip also must increase. A wider buffer provides increased filtration on sites where the volume and rate of water flow is high. For a 0–3 percent slope, provide 25–50 feet of buffer. For a 3–8 percent slope, 50–100 feet of buffer is necessary for effective filtration. These are minimum recommendations. Steeper slopes require even greater widths to protect streams from contamination.

Apply manure and compost when and where plants can use it.

Spread manure and compost only when actively growing plants can take up their nutrients. The safest times of year to apply manure to soils are:

- Just before planting, provided the soil isn't frozen or waterlogged
- When crops or pasture are actively growing

❖ Summary/Self review

The quality of water before and after it leaves your property is critical for human consumption, fish habitat, and other uses. The combined impact of many rural homes and small acreages can represent a significant source of pollution or clean water depending on how the land is managed.

Soil has an important role in maintaining water quality. It can act as a filter of pollutants or, if eroding, can become a pollutant itself. The organisms that live in soil and organic matter help digest and tie up pollutants. Plants growing on the soil, such as grass buffer strips, utilize excess nutrients. These functions prevent pollutants from reaching bodies of water.

Soil suspended in water causes clouding or turbidity. Soil contains organic matter and nutrients that can reduce the oxygen content of water. Fish and other aquatic animals suffer as a result of less dissolved oxygen in the stream.

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides. Landscapes should be designed to reduce water runoff. Use pesticides and fertilizers only when needed and according to directions.

Manage household wells and septic systems to prevent contamination of household water and groundwater. Protect household wells from sources of pollution, and have water tested routinely for nitrate and coliform bacteria. Septic systems should be pumped and inspected regularly by a trained person.

Base the number of livestock you keep on the size and productivity of the pasture. Provide adequate fertility for pasture plants to maintain a good stand. Manage livestock to prevent overgrazing. Minimize mud by avoiding use of pastures during the rainy season and by providing an all-weather paddock or sacrifice area.

Cover manure and compost piles to prevent leaching. Apply compost only when plants are actively growing. Maintain grass buffers to prevent sediment and excess nutrients from reaching bodies of water.

Exercises

You can do these exercises on your own.

Learning about your soil

Locate your property on the soil survey for your county. Soil surveys are available at county offices of the OSU Extension Service, local Natural Resources Conservation Service offices, and many public libraries. Study the drainage and erosion characteristics of the soil types on your property. Soil surveys also offer estimates for numbers of animals that can be supported by different soil types.

Managing compost piles

Look for water sources at risk from manure contamination. Plan for drainage and create a cover for manure piles.

Evaluating your well and septic system

Put together a file on your domestic well and septic system. When was the septic system last pumped? Locate your septic tank and drainage field and sketch a map of them. Do you have records of when the system was installed or repaired and its capacity? On the same map, sketch the location of your domestic well and any other wells on your property, abandoned or in use.

RESOURCES

Print materials

Gardening and Water Quality Protection: Using Nitrogen Fertilizers Wisely, EC 1493, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 1998).

Home Fruit, Vegetable, and Ornamental Garden Fertilizer Guide, EC 1503, by J. Hart and R. McNeilan (Oregon State University Extension Service, Corvallis, reprinted 2000).

*Home*A*Syst/Farm*A*Syst Assessment System*
Home*A*Syst is a set of 20 publications dealing with protecting the groundwater that supplies drinking water. It is a voluntary self-assessment system to help homeowners identify and reduce environmental hazards. Home*A*Syst and Farm*A*Syst (a similar program for farmers) are national programs supported by the USDA Cooperative State Research Education and Extension Service (CSREES), USDA Natural Resources Conservation Service (NRCS), and U.S. Environmental Protection Agency (EPA). The national office provides guidelines and educational support to states. Nearly every state currently operates or is developing a Home*A*Syst /Farm*A*Syst program.

Manure Management in Small Farm Livestock Operations: Protecting Surface and Groundwater, EM 8649, by D. Godwin and J.A. Moore (Oregon State University Extension Service, Corvallis, 1997).

Manure Storage and Compost Facilities for Operations with Limited Numbers of Livestock, USDA-NRCS and Washington County Soil and Water Conservation District, Hillsboro, OR, no date)

Septic Tank Maintenance, EC 1343, by J.A. Moore (Oregon State University Extension Service, Corvallis, reprinted 2000).

*Stream*A*Syst: A Tool to Help You Examine Stream Conditions on Your Property*, EM 8761, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 2001).

Twelve Simple Things You Can Do to Protect Your Well Water, EM 8651, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 1995).

Weeds of the West, Tom Whitson, ed. (University of Wyoming & Society of Weed Science, revised 2001).

Your Yard and Water Quality: Simple Things Gardeners Can Do to Prevent Water Contamination, EB 1744, by V. Bobbitt, R. Fox, H. Kenell, C. Moulton, G. Pinyuh, and M. Robson (Washington State University Cooperative Extension, Pullman, revised 1994).

Web sites

Fact Sheets: Functions and Values of Riparian Areas (Massachusetts Department of Fisheries and Wildlife). http://www.magnet.state.ma.us/dfwele/river/rivfstoc.htm

*Farm*a*Syst* (University of Wisconsin). http://www.uwex.edu/farmasyst

*Home*a*Syst* (University of Wisconsin). http://www.uwex.edu/homeasyst

Surf Your Watershed (U.S. Environmental Protection Agency). http://www.epa.gov/surf/

Water Quality Information Center (National Agriculture Library). http://www.nal.usda.gov/wqic/

Oregon Small Farms (Oregon State University). http://smallfarms.orst.edu/

Backyard Conservation fact sheets (Natural Resources Conservation Service). http://www.or.nrcs.usda.gov/

Wellwater program (Oregon State University). http://wellwater.orst.edu/

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself ahead in improving your ability to protect water quality on your property.

1.____

2.____

3.____

7

Wetland Functions, Management, Evaluation, and Enhancement

Jim Good
and Mike Cloughesy

Well-functioning wetlands are vital components of healthy watersheds. They absorb flood waters, remove excess sediment and nutrients, and help maintain base flow. Where these and other functions are degraded, wetland enhancement can contribute mightily to recovery of salmon and other valued aquatic life.

Wetlands are found in many locations where the soil is saturated and other conditions are right to support their development (Figure 1). Typical locations include:

- Along rivers and streams
- In depressions on floodplains and at higher elevations
- On hill slopes where water seeps out of the ground
- Along the shores of lakes and estuaries
- On flats such as vernal pools in southern Oregon or peat bogs near the coast

Wetlands perform many valuable functions that contribute to watershed health. For example, they help to purify runoff water, reduce flood damage by temporarily storing water, supplement base flows through release of this stored water, and provide life support through habitat for aquatic species, fish, wildlife, and pollinators.

In this chapter you'll learn:

- How wetlands are defined and identified
- The principal functions and services that wetlands perform
- Actions that can improve specific wetland functions
- How different kinds of wetlands are classified
- How to obtain and use National Wetlands Inventory maps, local wetland inventories, soil surveys, and other wetland information
- The basics of several methods for classifying and assessing wetland functions

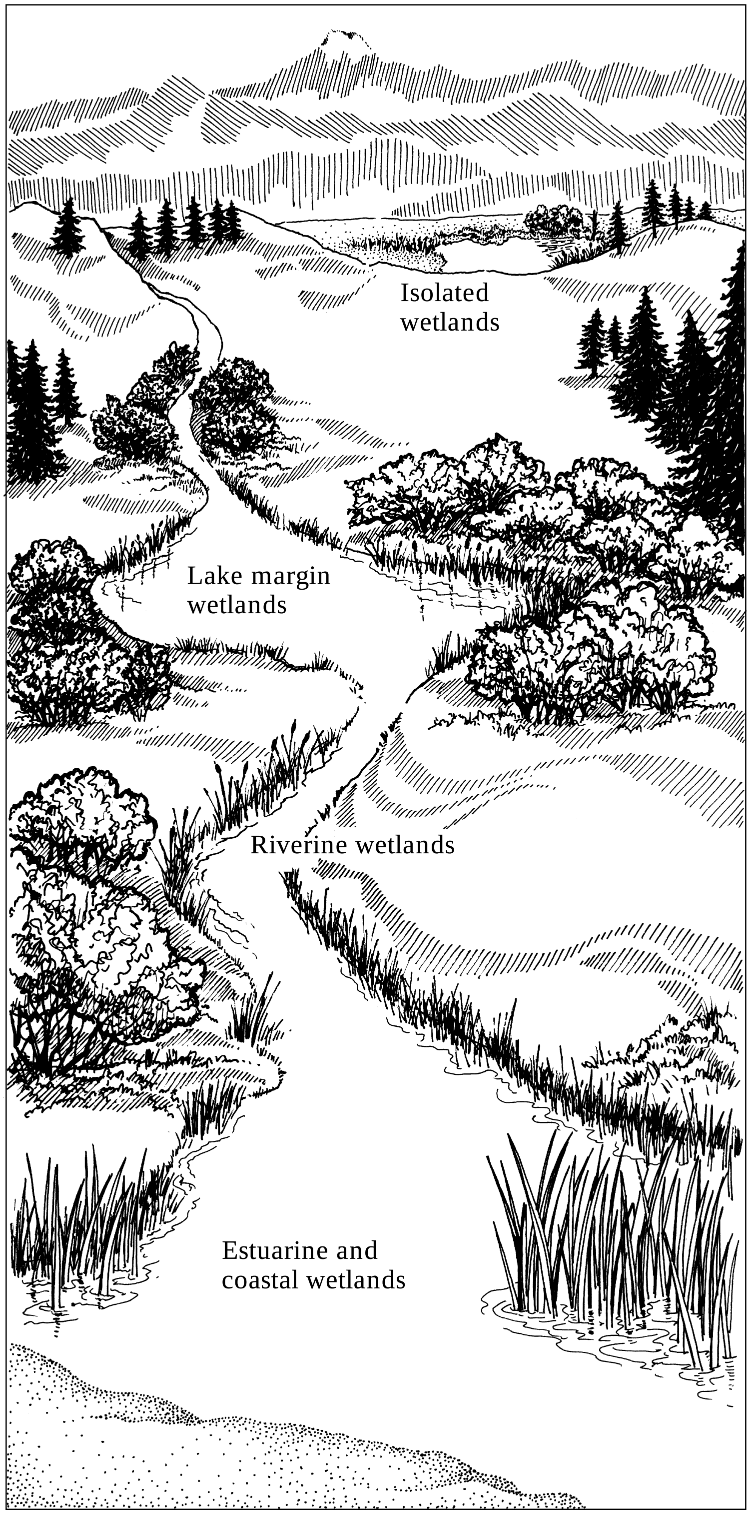


Figure 1.—Types of wetlands.

If you look around, you may see many wetlands in your area that have suffered from neglect or changes in the landscape—roads that interrupt drainage patterns, dirt fill over wetlands to provide building sites, and stream diversions that cut off the water supply to wetlands. These changes greatly diminish the watershed support functions of these wetlands. With increased care and attention, however, some degraded wetlands can be rehabilitated, thereby increasing their capacity to support fish, wildlife, and human needs.

Approximately 40 percent of Oregon's original wetlands have been altered or converted to other uses since European-Americans arrived. Many of the remaining wetlands have been degraded and no longer function as they should. Some of these former and degraded wetlands could be restored or enhanced to help restore salmon runs, improve water quality, and contribute to flood control. Identifying wetland restoration and enhancement potential thus is an important part of watershed action planning.

What is a wetland?

Marshes, bogs, swamps, fens, sloughs, and wet meadows are some of the more common names for particular kinds of wetlands. These terms conjure up an image of ecosystems that aren't quite aquatic and aren't quite terrestrial. In other words, they are "transitional."

Many wetlands fit this image of being part of a continuum between upland and open water ecosystems. Other wetlands, however, are isolated from open-water habitats and are maintained purely by groundwater and precipitation.

So is there an accepted scientific definition of wetland that covers all types? The answer is yes. To understand these definitions, you need to know three key terms–hydric soil, wetland hydrology, and hydrophyte.

Hydric soil is soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper layer. *Anaerobic* means there is no oxygen in the soil. This condition occurs when water fills all of the pore spaces in the soil, leaving no room for oxygen. Indicators of anaerobic conditions that can be observed in the field include low chromas according to the Munsell Color Chart (<2), distinct mottles, and Soft Iron Masses (SIMs).

Wetland hydrology recognizes that the conditions that support wetlands and form hydric soils range from permanently inundated to seasonally saturated. At minimum, saturation is required within 12 inches of the surface during approximately 2 weeks of the growing season to meet the hydrology criteria as a jurisdictional wetland as defined by the U.S. Army Corps of Engineers.

A *hydrophyte* is any plant growing in water or in soil that is at least periodically deficient in oxygen as a result of excess water. Hydrophytic also can mean plants typically found in wetland habitats. The U.S. Fish and Wildlife Service (USFWS) has developed a list of plants found in and near wetlands.

A well-accepted *comprehensive definition* of wetlands was developed in 1995 by the National Research Council:

A wetland is an ecosystem characterized by sustained or recurrent shallow inundation or saturation at or near the surface of the substrate and the presence of physical, chemical, and biological features reflective of such inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physiochemical, biotic, or human factors have removed them or prevented their development.

In other words, a wetland typically has hydric soils and hydrophytic plants, unless it has been disturbed by humans.

Another definition that is very important if you plan to do wetland restoration projects is the *regulatory definition*. This definition is used by the U.S. Army Corps of Engineers (the Corps) and the Oregon Division of State Lands (DSL) in their regulatory programs:

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions.

See Section II, Chapters 1, 2, and 5; and Section III, Chapters 1, 3 and 4 for information related to this chapter.

Section II
1 Planning
2 Hydrology
5 Assessment

Section III
1 Riparian Functions
3 Livestock
4 Stream Ecology

Three features of wetlands are common to these and most definitions:

- The presence of enough water to cause saturation of the upper 12 inches of soil for at least 2 weeks during the growing season
- Soils that are typical of saturated or ponded areas
- Plants that can tolerate such conditions

Detailed criteria for identifying upland-wetland boundaries for regulatory purposes are described in the Corps' 1987 *Wetland Delineation Manual*. These criteria also are used by most other state and federal agencies. Most of the time, however, a formal delineation of wetland boundaries isn't required for nonregulatory wetland restoration or enhancement projects.

AN OVERVIEW OF WETLAND FUNCTIONS

Wetlands often are ecological "hot spots," playing a role disproportionate to their size in supporting endangered species and maintaining biodiversity. Wetlands play other roles too; they usually help remove excess nutrients and other contaminants from water, store flood waters, release water during low flow periods, and provide food and shelter for salmon, trout, other animals, and pollinators.

All of these roles are known as *wetland functions*. You might think of them as the services that wetlands provide to watersheds. Although there are many ways to group and describe wetland functions, we will divide them into four categories:

- *Biogeochemical* (water-quality) functions
- *Hydrologic* (water movement) functions
- *Habitat and food web* functions
- *Cultural and social* functions

There are at least 16 functions within these 4 categories. They are discussed in this chapter. We'll describe why each function is important to watershed health, how wetlands contribute to the function, and ideas for wetland restoration or enhancement.

Note that these functions may not be unique to wetlands. Streams, lakes, riparian areas, and upland habitats also contribute to many of these functions. Although we separate watersheds into parts for analysis, the parts themselves and the functions they perform are interconnected. Thus, our analyses also must be interconnected.

Many wetland functions have an especially significant impact on water quality and fish habitat in streams. Thus, Chapter III-4, “Stream Ecology,” is closely related to the topics covered in this chapter. The hydrologic processes discussed in Chapter II-2, “Watershed Hydrology,” also are affected by wetland functions. Chapter III-1, “Riparian Area Functions and Management,” also discusses many related topics.

IMPROVING WETLAND FUNCTIONS

There are three basic kinds of wetland improvement projects–creation, enhancement, and restoration. *Wetland creation* involves the construction of a wetland at a site where no wetland has existed in the past 100–200 years (Figure 2). It may take a lot of landscape manipulation and/or maintenance to develop and maintain such a wetland.

Wetland enhancement involves the alteration, maintenance, or management of existing wetlands for long-term improvement of particular functions or services. In many cases, by choosing to enhance certain functions, you may diminish a wetland’s ability to perform other functions or services.

Wetland restoration is the return of a former or degraded wetland to a close approximation of a previous higher functioning state. *Former wetlands* are areas that once were wetlands, but now are nonwetland. *Degraded wetlands* are those that have been damaged but still perform some wetland functions (Figure 3).

In restoration, both the structure and the functions of the ecosystem are recreated, and ecological damage is repaired. The goal is to recreate a natural, functioning system that is integrated into the surrounding ecological landscape (Figure 4).

Wetland enhancement generally aims to improve a specific wetland function. Based on your assessment of wetlands in your watershed and the functions you want to improve, the following discussion suggests some actions you might take to identify potential wetland enhancement projects.

Figure 2.—Wetland creation projects, even in urban settings such as this one adjacent to a Portland-area shopping center, help reestablish some of the functions of stream and wetland corridors important to fish and wildlife. (Photo: Jim Good)

WETLAND FUNCTIONS AND POSSIBLE ENHANCEMENT OPPORTUNITIES

Water-quality functions

Function 1—Water temperature maintenance

Why important: High water temperatures can limit a stream's habitat value for fish and wildlife. High temperature can decrease fish survival, encourage growth of disease-causing organisms and undesirable algae, and reduce dissolved oxygen concentration.

Weather, volume of stream flow, streamside vegetation, flows to and from groundwater, and water released from industrial plants can influence stream temperature. Solar heating is the major cause of increased water temperature.

How wetlands contribute: Wetlands can help maintain desirable stream temperatures. In summer, wetlands discharge cool groundwater into streams. In winter, wetlands receiving substantial groundwater discharge may maintain ice-free conditions, which are required by wintering waterfowl. Riparian vegetation also can play an important role in shading streams from solar heating. See Chapter III-4, "Stream Ecology," and Chapter III-1, "Riparian Area Functions and Management," for more information.

To improve this function, watershed groups might:

- Target restoration efforts to watersheds with known water temperature problems.
- Identify native riparian corridors that shade streams and wetlands from solar heating.
- Identify existing and potential wetlands that receive groundwater discharge and release it to a stream either through surface or subsurface flows.
- Identify existing and potential wetlands that might recharge the aquifers that discharge groundwater to a stream.
- Identify headwater wetlands that maintain base flows during summer low flows.

Figure 3.—These farmed fields are an example of a degraded but still functioning wetland with good restoration potential. (Photo: Jim Good)

Function 2—Reducing bacterial concentration

Why important: Many *pathogenic* (disease-causing) intestinal bacteria pose a substantial health risk to humans. Fecal coliform bacteria *(Escherichia coli)* are used as a general indicator of the presence of this group of bacteria. When these indicator organisms are present, it represents a strong possibility of the presence of pathogenic bacteria that threaten public health. Reduction of these bacteria in aquatic systems makes it safe for humans to use water and eat shellfish from the water.

Figure 4.—Periodic monitoring of restoration projects is necessary to judge progress toward goals and to implement needed corrective measures. (Photo: Jim Good)

Intestinal bacteria come from human and animal waste. For example, bacteria may enter streams from septic tank failure, poor pasture and livestock management, city sewage, pet wastes, urban runoff, and sewage from stormwater overflows.

How wetlands contribute: Wetlands can retain and destroy intestinal bacteria. Wetland size, location, water source, and volume of inflow are key factors in determining how well a wetland performs this function. For example, wetlands constructed for wastewater treatment can assist with this function. A healthy riparian area also can play an important role by filtering runoff. See Chapter III-4, "Stream Ecology," and Chapter III-1, "Riparian Area Functions and Management," for more information.

To improve this function, watershed groups might:

- Target restoration efforts to watersheds with known or anticipated fecal coliform problems.
- Identify wetlands with the greatest potential to retain and process fecal coliform bacteria.
- Identify riparian areas that buffer streams from fecal coliform inputs.

Function 3—Sediment capture

Why important: Excess suspended sediments can cause many problems in streams. For example, they:

- Reduce stream channel capacity
- Transport bacteria and pollutants
- Fill gravel spaces, thus smothering eggs and juvenile fish
- Reduce algal growth

- Reduce fish feeding and growth
- Reduce dissolved oxygen concentrations
- Bury benthic (bottom-dwelling) organisms

Many human activities can increase suspended sediments, including timber harvest and related road development, construction-related earth moving, poor pasture management, and building of dikes. Loss of in-stream large woody debris, which often is caused by human activity, also reduces a stream's ability to store sediment.

How wetlands contribute: Wetlands can reduce the amount of suspended sediments in streams. Some wetlands capture and keep sediments from reaching a stream, while others capture sediments that already have entered a stream system. The flow of sediment-bearing runoff slows down when it enters a wetland, allowing suspended sediment to drop out of the water before entering a stream. See Chapter III-4, "Stream Ecology," and Chapter II-2, "Watershed Hydrology," for more information.

To improve this function, watershed groups might:

- Target restoration efforts to watersheds with known sediment retention problems.
- Identify wetlands that capture sediments before they enter streams.
- Identify wetlands that remove suspended sediments from stream systems.
- Create wetlands to remove suspended sediments from surface sheet or stream flows.

Wetland creation for sediment removal is a challenge in areas where land-use practices create large pulses of sediments.

Function 4—Nutrient removal and transformation

Why important: Nitrogen and phosphorus are essential nutrients for all aquatic systems. Each ecosystem has its own level of nutrient inputs and outputs. When inputs and outputs change, problems can occur. For example, excess phosphorus can cause lake eutrophication or algal blooms. Too much nitrogen in the form of nitrate also can cause problems, including fish habitat degradation, excess plant and algae growth, and reduced dissolved oxygen concentrations.

Human activities can substantially increase nutrient inputs to stream systems, thus changing the ecosystem. In-stream increases in nitrogen and phosphorus can come from agricultural and residential fertilizers, detergents, cleaning products, sewage, septic tank effluent, food residues, soil erosion, and decomposing vegetation.

How wetlands contribute: Wetlands can retain nutrients and change them into less harmful forms. For example, they can convert inorganic nutrients to their organic forms, which don't move as easily in water so are less likely to end up in streams. They also can change nitrate nitrogen into gaseous nitrogen through a process known as *denitrification*. Nitrogen gas then can escape harmlessly into the air. By keeping excess nutrients out of streams, wetlands help maintain fish habitat, dissolved oxygen levels, and nitrogen balance, while reducing algae blooms. See Chapter III-4, "Stream Ecology," for more information.

To improve this function, watershed groups might:

- Target restoration efforts to watersheds with known nutrient problems.
- Identify existing and potential wetlands capable of keeping nutrients from reaching streams.
- Identify existing and potential wetlands capable of removing nutrients from stream systems.
- Identify existing and potential native riparian buffers that could keep nutrients from entering wetlands or streams.

Function 5—Improving groundwater quality

Why important: In many areas, domestic water supplies are taken from groundwater *aquifers*. Aquifers are resupplied with groundwater as water percolates downward in *groundwater recharge areas*. The greatest potential for groundwater recharge occurs within *alluvial outwash deposits* (areas where flooding has deposited sediment).

Human activities within groundwater recharge areas can diminish groundwater quality and quantity. Drinking water contaminated with nitrate at levels above 10 mg/l can cause infant sickness or, in extreme cases, death. Threats to groundwater quality come from commercial and industrial development, concentrated dairy farming, and the use of agricultural chemicals within recharge areas.

How wetlands contribute: Wetlands in groundwater recharge areas can capture and retain nitrate-nitrogen from overland flows before it percolates downward into groundwater aquifers. Wetlands can store and release nitrate seasonally or retain it for a long time. How effective a wetland is in playing this role depends on how long the water and nitrate are retained, the level of dissolved oxygen, and how much of the nitrogen is converted to gas.

To improve this function, watershed groups might:

- Identify wetlands that recharge groundwater aquifers of importance to humans.

- Identify groundwater recharge wetlands whose ability to efficiently capture, retain, or remove nutrients has been reduced.

Hydrologic or water-flow functions

Function 6—High flow storage and reducing peak flows

Why important: Flooding can result in property damage, soil erosion, increased bedload movement, loss of fish redds (nests) and stream habitat, increased sediment, invasion by non-native plants, and stream channel erosion. See Chapter III-4, “Stream Ecology,” and Chapter II-2, “Watershed Hydrology,” for more information.

Runoff volume is related to human development. For example, hard surfaces such as pavement don’t let water enter the soil. Soils that have been compacted by heavy equipment don’t let water percolate very well. In these soils, plants also have a hard time taking up water and transferring it to the air through transpiration. Furthermore, water flowing just beneath the soil surface becomes surface runoff when road cuts send it into road ditches.

Thus, development, soil disturbance, timberland conversion, timber harvest, and slope alterations within the watershed all can increase the intensity of high flow or flood events.

How wetlands contribute: Wetlands can store waters that otherwise would intensify downstream high flows. In concert with other floodplain management activities, wetland restoration may reduce property damage, crop loss, and soil erosion by minimizing the effects of current and future development.

To improve this function, watershed groups might:

- Target wetland restoration efforts to watersheds with known flooding problems.
- Identify wetlands that capture surface flows before they reach the river system.
- Identify wetlands that capture and reduce peak surface flows within the floodplain.
- Identify wetlands that capture and reduce runoff from residential, agricultural, and disturbed lands.

Function 7—Base flow maintenance

Why important: Base flow is groundwater discharge and detained storm water that contributes to streamflow during periods of little or no direct precipitation. To function properly, a stream needs a minimum base flow. When flows drop below this rate, the stream is more susceptible to temperature increases and pollution from industrial, municipal, and agricultural wastes. Low flows also can obstruct fish passage to available habitat or can change habitat conditions.

Human activities have substantially altered both the timing and extent of surface and groundwater inputs to many streams by decreasing groundwater recharge and increasing overland flows. The result in many cases is reduced base flows.

Examples of factors that reduce base flows include:

- Draining of bottomland and depressions with seasonally high water tables
- Shallow excavations (e.g., road cuts) on well-drained soils, which intercept subsurface flows and convert them to overland flows
- Groundwater withdrawals for irrigation or domestic use
- Increased runoff resulting from forest conversion to agricultural or residential use
- The increase of hard surface areas

How wetlands contribute: Wetlands can help regulate the release of groundwater into streams and can recharge the aquifers that discharge groundwater to streams.

To improve this function, watershed groups might:

- Target wetland restoration efforts to watersheds with known or anticipated base flow problems.
- Identify wetlands that receive groundwater discharge and release it to a stream through either surface or subsurface flows.
- Identify wetlands that recharge the aquifers that discharge groundwater to a stream.
- Identify headwater wetlands that maintain base flows during summer low flows.

Function 8—Groundwater recharge

Why important: Groundwater is an important water source for domestic use.

The opportunity for surface water to recharge an underlying aquifer system depends largely on several physical conditions that don't change very much, including soil permeability, type of rock the surface soil was derived from, depth to water table, and topography. However, human activities often change these physical conditions so that less surface water recharges aquifers. Examples of factors that increase surface water runoff and reduce recharge potential include:

- Wetland drainage
- Forest clearing
- Soil compaction from agricultural activities, residential development, and other landscape-altering activities

- Road cuts that intercept groundwater and bring it to the surface
- Hard-surface barriers such as roads, parking lots, and roofs
- Incorrect riparian conversions that damage fragile streamside wetland areas

How wetlands contribute: Within groundwater recharge areas, wetlands capture and hold water that otherwise might become surface runoff, thus allowing it to move downward into groundwater aquifers.

To improve this function, watershed groups might:

- Identify potential wetland sites that could recharge groundwater.

Function 9—Shoreline stabilization

Why important: Erosion caused by waves, currents, tides, or ice can cause substantial shoreline property damage, loss of fish and wildlife habitat, and increased turbidity (cloudiness of water).

How wetlands contribute: Wetlands serve as a buffer between open water and upland areas. *Shoreline stabilization* is the binding of soil at the shoreline or water's edge by wetland plants, thus making the soil less susceptible to erosion. Wetland plants, therefore, protect beaches, stream edges, property, and ecosystems from erosion.

To improve this function, watershed groups might:

- Identify wetland restoration sites that stabilize shorelines of importance to public or private property or fish and wildlife habitat.

Habitat and food web support functions

Function 10—Anadromous and resident fish diversity and abundance

Why important: Development and land-use change have had a significant negative impact on fish habitat. While each river system is unique in the type and amount of habitat it has lost, fish habitat degradation has occurred throughout the Pacific Northwest.

Timber harvest, agricultural activities, residential development, and other activities have altered wetlands, riparian areas, and floodplains. As a result, there is less food, spawning gravel, and refuge for anadromous (migratory) and resident fish. Some of the biggest problems in Oregon include:

- Loss of channel structure
- Sedimentation in the upper watershed
- Loss of riparian trees, plants, and large organic debris

- High stream temperatures and low water quality
- Blocked access to wetland habitats
- Excessive sediment in the estuary
- Increased flooding frequency and intensity
- Loss of estuarine wetlands
- Tide gate and culvert passage problems
- Low summer flows
- Loss of winter cover
- Excessive bedload
- Degradation of near-shore habitat
- Scouring of spawning habitat
- Incorrect riparian conversion schemes that damage in-stream habitat

Damage to wetlands has contributed to these problems. The loss of wetland and riparian habitat, along with other factors, has increased flows and frequency, sediment inputs, water temperature, and barriers to fish passage. The same factors have reduced stream base flows and stream habitat diversity.

How wetlands contribute: Wetlands help maintain cool water temperatures, retain sediments, store high flows, augment stream base flows, and provide food and cover for fish.

Along with these broad watershed-level contributions to fish habitat, some wetlands may play other specific roles. For example, coho smolts survive winters of extremely high flows by using small tributary wetlands as winter habitat. In these cases, the best way to improve coho smolt production may be to restore side-channel and slough wetlands. See Chapter III-4, "Stream Ecology," for more information.

To improve this function, watershed groups might:

- Identify sites recognized by professional fish habitat biologists as having the greatest potential to provide the fish habitat that is needed most within your watershed.
- Identify additional wetland restoration sites that have some potential to provide the fish habitat that is needed most within your watershed.
- Restore degraded estuarine wetlands.
- Restore riparian habitat along stream reaches that support resident and/or anadromous fish (Figure 5).

Function 11—Migratory water bird diversity and abundance

Why important: Many migratory water birds have recreational and economic importance to humans. Extensive agricultural, industrial, and residential development within estuaries and river floodplains has destroyed or disturbed water bird wintering and migration habitat. As a result, birds are forced to seek alternative habitats. As birds are crowded into smaller areas, they must compete for limited food and space, and they're more exposed to predators, adverse weather, and disease.

In some cases, however, human activities create new habitats. Many waterfowl species, in particular, have adapted to new habitat opportunities. For example, farming practices in Oregon's Willamette Valley now provide abundant, readily available winter food that didn't exist before the area was cleared for agriculture. Some waterfowl that traditionally wintered in the central valley of California now winter in this area. On the other hand, many migratory shorebirds and wading birds haven't been able to adapt when confronted with a loss or change in their habitat.

How wetlands contribute: Wetlands provide important migration and wintering habitat for migratory water birds (Figure 6). Restoring degraded wetlands where there is a shortage of habitat can help stabilize and, in some cases, increase populations. The conversion of forested wetlands to emergent/open water wetlands also can create new wintering, migration, and production habitat for some migratory water bird species, although it may degrade habitat for others.

To improve this function, watershed groups might:

- Identify degraded wetlands that currently provide important habitat for water birds.
- Identify wetlands that are known to support migratory water birds.
- Identify wetlands that currently provide limited habitat for water birds but have the greatest potential to provide important habitat if restored.

Figure 5.—Dike and tide gate removal in a 1978 Salmon River estuary restoration project opens up tidal channels that provide important rearing habitat. (Photo: Diane Mitchell)

Function 12—Aquatic diversity and abundance

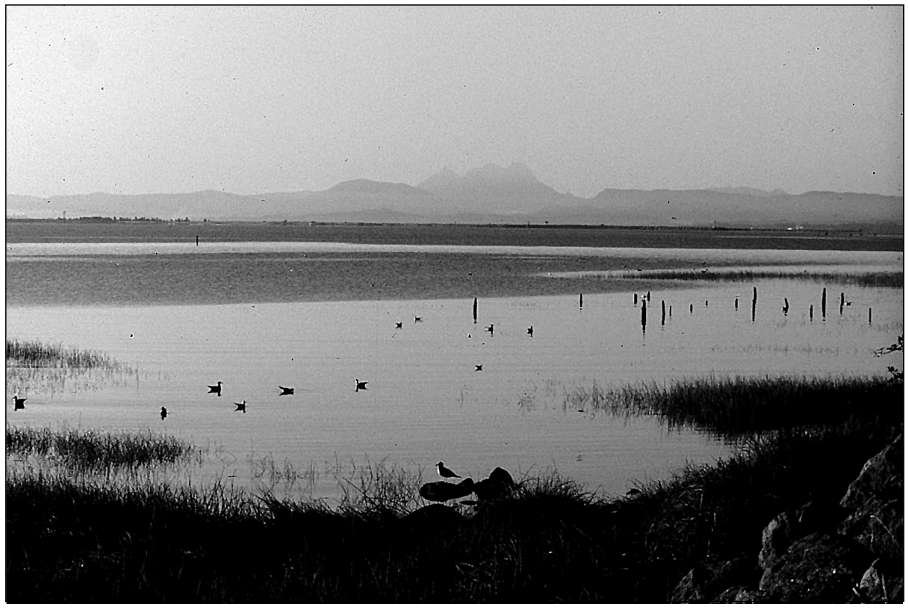


Figure 6.—Fringing marshes and shallow waters of the Columbia River estuary attract a wide variety of wildlife. (Photo: Jim Good)

Why important: Both direct and indirect impacts such as changing patterns of water movement, land-use change, and habitat fragmentation adversely affect native plant and animal communities. As wetlands are disturbed, the *number* of species may increase or decrease, but *complexity* usually decreases as non-native species tend to invade and dominate.

How wetlands contribute: Healthy wetlands support a wide variety of native plant and animal communities. Thus, by reestablishing near-natural conditions, wetland restoration can restore native species richness and abundance. This process takes time though. Once the natural water cycle is reestablished, it can take years to recreate the conditions most suited for native plants and animals. See Chapter III-4, "Stream Ecology," for more information.

To improve this function, watershed groups might:

- Identify wetlands with ditches, tile, canals, levees, or similar artificial features that change the retention time of water.
- Identify wetlands that have been altered by tilling, filling, excavation, addition of inlets, or blockage of outlets.
- Identify wetlands that support or once supported rare or unique plant communities.

Function 13—Rare, threatened, and endangered species diversity and abundance

Why important: Natural systems are made up of many related parts that are in a constantly changing state of balance (*equilibrium*). The loss of species diversity and abundance alters this equilibrium and the food chain it supports, thereby affecting many other species.

As species are lost, humans lose opportunities to find solutions to medical, agricultural, and industrial problems. Species loss is important in another way; it's a good indicator of how well or poorly we take care of our environment.

The exact causes of species declines are complex and not fully understood. We do know that species declines and extinction result from both human impacts and climate change. Some of the problems caused by humans are habitat destruction, poisoning from pesticides, competition from non-native species, and indiscriminate killing and overharvest.

How wetlands contribute: Wetlands provide habitat for many rare, threatened, or endangered plants and animals. The restoration of wetlands close to populations of these species can provide opportunities for them to relocate or expand their range.

To improve this function, watershed groups might:

- Identify wetland restoration sites having the greatest opportunity to provide habitat for rare, threatened, and endangered species.

Function 14—Food web support

Why important: Within a watershed or basin, there is a food web consisting of producers, consumers, and decomposers. Organic matter that reaches a stream system is eaten by fish and aquatic invertebrates, which in turn are eaten by predators.

How wetlands contribute: Wetlands are highly productive biological systems. *Food web support* is the production of organic material and its movement out of a wetland to areas downstream where it provides food for many fish and wildlife species. Thus, loss of wetland areas can adversely affect fish and wildlife that depend on these food sources. See Chapter III-4, “Stream Ecology,” for more information.

To improve this function, watershed groups might:

- Identify wetland restoration sites with the greatest potential to support food webs by supplying organic material to streams.

Cultural and social functions

Function 15—Recreation

Why important: As our population grows and prospers, interest in outdoor activities increases. At the same time, nature-centered recreational opportunities continue to be pushed farther from city centers as development spreads into previously “undeveloped” land. As a result, outdoor recreation opportunities become less accessible. Increasing development and population also cause more pollution in areas used for recreation.

How wetlands contribute: Fishing, hunting, shellfish gathering, swimming, kayaking, boating, sightseeing, birdwatching, and nature photography are just some of the recreational opportunities that wetlands provide. The restoration of wetlands and provision for public access provide new opportunities for recreation (Figure 7).

To improve this function, watershed groups might:

- Identify wetland restoration sites having the greatest potential to provide recreation opportunities.

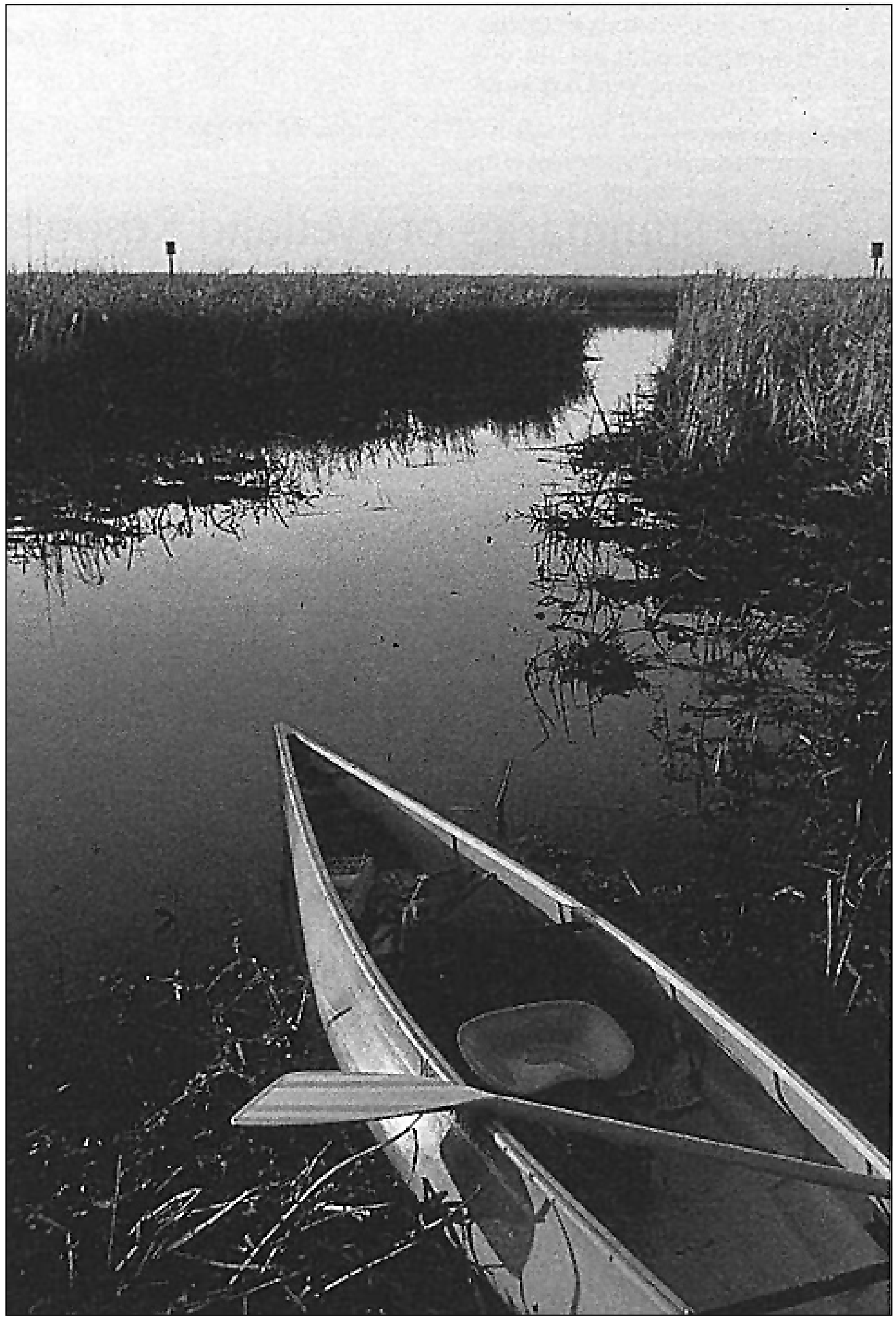


Figure 7.–In addition to their ecological functions, wetlands also are valued as recreational resources. (Source: USGS)

Function 16–Outdoor education

Why important: The use of outdoor classroom settings has increased substantially as educators recognize the benefits of allowing students to explore and test what they learn in the classroom. Opportunities to use an outdoor classroom setting depend on its distance from school, ease of access, and the diversity and condition of habitats found there. Activities that degrade natural areas mean less areas are available for educational use.

How wetlands contribute: Wetlands are excellent outdoor education classrooms because of the diversity of plants and animals that live there and because of their combination of aquatic, transitional, and terrestrial environments.

To improve this function, watershed groups might:

- Identify wetland restoration sites that can provide outdoor education opportunities.

Classifying Wetlands for Inventory and Management

The National Wetlands Inventory and the Cowardin classification system

The most widely available and comprehensive wetlands information in the United States is the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI).[1] The NWI does more than locate and classify wetlands. It also maps the entire aquatic ecosystem network.

NWI maps contain information on location in the watershed, water regime, vegetation class or subclass, morphology, and sheet versus channel flow. Thus, the NWI is a useful starting point for evaluating restoration opportunities for all aquatic ecosystems, not just for wetlands. It also is useful for planning at a watershed or subwatershed level.

The NWI wasn't developed for use in regulatory programs, although it has proved useful as a basic indicator of wetlands and their boundaries. It also is used to classify wetlands at larger scales.

The NWI is based on the *Cowardin classification system*, which was published as the *Classification for Wetland and Deepwater Habitats of the United States*. This system is the most widely used wetland classification system in the United States. It has four objectives:

- To describe ecological units whose natural attributes are fairly homogenous
- To arrange these units in a system that will help people make decisions about resource management
- To provide information for inventory and mapping
- To create standard concepts and terminology for use in classifying aquatic ecosystems

An electronic version of the *Classification for Wetland and Deepwater Habitats of the United States* is available on the World Wide Web at http://www.nwi.fws.gov/

The Cowardin system includes five major *systems:* Palustrine (marshes), Lacustrine (lakes), Estuarine (estuaries), Riverine (rivers), and Marine (ocean). These systems are divided into *subsystems,* which reflect water flow regimes. Finally, the subsystems are divided into many different *classes* (Figure 8). If site data are available, users also can include information on plants, water chemistry, soil types, wetland origin, and other site-specific factors. NWI maps use codes to convey all of this information (Figure 9).

The Cowardin system classifies wetlands by structural vegetative characteristics such as forest or meadow. It's easy to identify these characteristics through aerial photos.

[1]In Oregon, the NWI has been adopted as the State Wetland Inventory (SWI) and is distributed by the Division of State Lands (DSL). Local Wetland Inventories (LWIs), based on the Cowardin classification system and mapped according to rules published by DSL, also have been developed for many cities and parts of counties where more detailed information is needed to meet advance planning goals or deal with regulatory problems in advance.

System	Subsystem	Class
M---Marine	1 Subtidal	RB Rock Bottom UB Unconsolidated Bottom AB Aquatic Bed RF Reef OW Open Water/Unknown Bottom
	2 Intertidal	AB Aquatic Bed RF Reef RS Rocky Shore US Unconsolidated Shore
E---Estuarine	1 Subtidal	RB Rock bottom UB Unconsolidated Bottom AB Aquatic Bed RF Reef OW Open Water/Unknown Bottom
	2 Intertidal	AB Aquatic Bed RF Reef SB Streambed RS Rocky Shore US Unconsolidated Shore EM Emergent Wetland SS Scrub/Shrub Wetland FO Forested Wetland
R---Riverine	1 Tidal	RB Rock bottom UB Unconsolidated Bottom AB Aquatic Bed SB Streambed RS Rocky Shore US Unconsolidated Shore EM Emergent Wetland OW Open Water/Unknown Bottom
	2 Lower Perennial	RB Rock bottom UB Unconsolidated Bottom AB Aquatic Bed RS Rocky Shore US Unconsolidated Shore EM Emergent Wetland OW Open Water/Unknown Bottom
	3 Upper Perennial	RB Rock bottom UB Unconsolidated Bottom AB Aquatic Bed RS Rocky Shore US Unconsolidated Shore OW Open Water/Unknown Bottom
	4 Intermittent	SB Streambed

Figure 8.–Cowardin wetland classification system showing systems, subsystems, and classes.

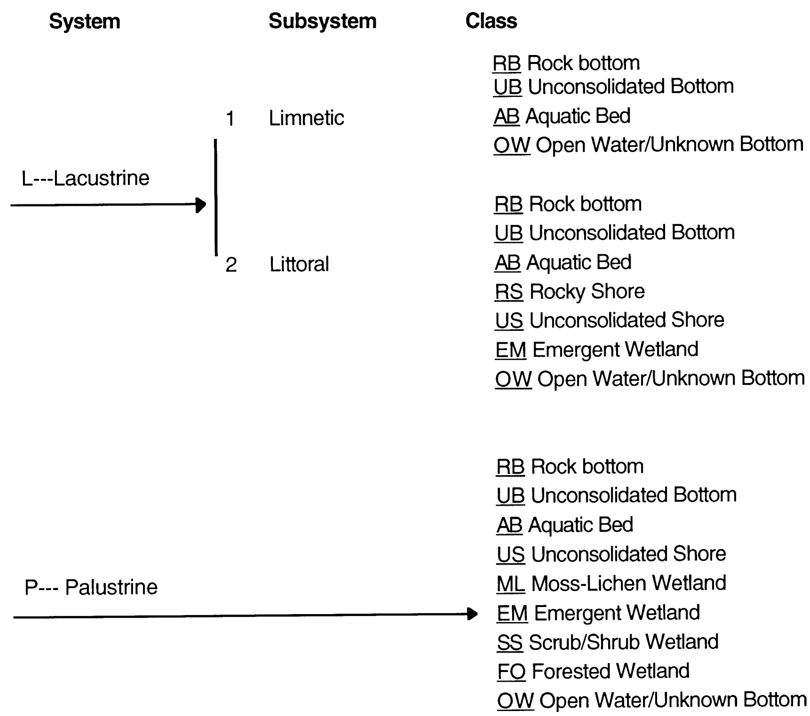


Figure 8.–Cowardin wetland classification system showing systems, subsystems, and classes (continued).

The classification of a mapped wetland is coded by a series of letters and numbers. The classification legend at the bottom of each map includes the alphanumeric code. The first letter of the code represents the system, the subsequent number represents the subsystem, and the next two letters indicate the class. If a wetland contains two different classes, they are separated by a horizontal line (see third example, below). Modifiers, when used, may be a letter or number.

CLASSIFICATION EXAMPLES

E2EM

System: Estuarine (E)
Subsystem: Intertidal (2)
Class: Emergent (EM)

Typical vegetation:

Lyngby's sedge (*Carex lyngbyei*)
seaside arrowgrass (*Triglochin maritimum*)
pickleweed (*Salicornia virginica*)
saltgrass (*Distichlis spicata*)

PSSC

System: Palustrine (P)
Subsystem: none
Class: Scrub-Shrub (SS)
Modifier: Water regime—Seasonally flooded (C)
Note: Palustrine system does not have subsystems.

Typical vegetation:

willow (*Salix spp.*)
salmonberry (*Rubus spectabilis*)
Douglas Spiraea (*Spiraea douglasii*)
red-osler dogwood (*Cornus stolonifera*)

P <u>EM</u> Hx
AB

System: Palustrine (P)
Subsystem: none
Class: Mixed—Emergent (EM)/Aquatic Bed (AB)
Modifiers: Water regime—Permanently flooded (H)
Special modifier—Excavated (x)

Typical emergent vegetation:

cattail (*Typha spp.*)
skunk cabbage (*Lysichitum americanum*)
reed canarygrass (*Phalaris arundinacea*)
slough sedge (*Carex obnupta*)

Typical Aquatic Bed vegetation:

common duckweed (*Lemna minor*)
white water lily (*Nymphaea odorata*)

Figure 9.–Cowardin classification codes for wetlands.

A major weakness of the Cowardin system and the NWI is that the descriptors of mapped units often don't relate consistently to ecosystem functions. Because of the system's reliance on plant types as identifying criteria, wetlands that function very differently often are grouped into the same Cowardin class simply because they have the same vegetation.

Nevertheless, because the NWI is the only universally available data, people try to identify wetland functions from NWI maps and descriptors. Often, scientists create hybrid systems that use both NWI data and other information.

Hydrogeomorphic classification

The *hydrogeomorphic* (HGM) wetland classification does address differences in wetland functions. This system is under development and will use three criteria–where a wetland is positioned in the landscape (*geomorphology*), its water source (precipitation, surface water, or groundwater), and its *hydrodynamics* (how water moves through it).

The HGM approach is being developed by the Army Corps of Engineers for use with the Section 404 regulatory program. It meets the need for a better rapid assessment tool to evaluate how wetlands are functioning and to develop requirements for actions to compensate for previous damage.

Nationally, all of the major resource agencies have agreed to develop and use HGM, but the process of "regionalizing" HGM will take some time. Oregon is just beginning to develop HGM in a way that will help people understand wetland functions at regional, watershed, and site-specific scales. Meanwhile, the national HGM prototype is being applied in Oregon because of its usefulness in describing and characterizing wetland functions.

There are seven wetland classes in the HGM system (Table 1). Identifying a wetland's class is the first step in the HGM approach to wetland functional assessment. Classes are based on three principal characteristics of wetlands, although water chemistry and soil properties also are important. These three characteristics are:

- *Geomorphic setting,* or the wetland's topographic position in the landscape
- *Water source* and *transport vector*. *Water sources* include precipitation, lateral flows from upstream or upslope, and groundwater. The *transport vector* is how water is transported. Precipitation is transported from the atmosphere; lateral flows are transported by surface or near-surface flows; and groundwater is transported by subsurface flow.

Table 1.–Hydrogeomorphic classes of wetlands showing associated dominant water sources, hydrodynamics, and examples of subclasses.

Hydrogeomorphic class	Dominant water source	Dominant hydrodynamics	Examples of subclasses
Riverine	Overbank flow from channel	Unidirectional, horizontal	Riparian forested
Depressional	Return flow from groundwater and interflow	Vertical	Vernal pools
Slope	Return flow from groundwater	Unidirectional, horizontal	Avalanche chutes
Mineral soil flats	Precipitation	Vertical	Large playas
Organic soil flats	Precipitation	Vertical	Peat bogs
Estuarine fringe	Overbank flow from estuary	Bidirectional, horizontal	Tidal salt marshes
Lacustrine fringe	Overbank flow from lake	Bidirectional, horizontal	Lakeside emergent marshes

- *Hydrodynamics*, or how water moves. There are three kinds of flow–vertical, unidirectional and horizontal, and bidirectional and horizontal. *Vertical* movements result from evapotranspiration and precipitation; *unidirectional* flows are downslope movement; and *bidirectional* flows are tides or wind-driven fluctuations in bays.

The strength of HGM is that variations in these hydrogeomorphic properties are directly related to the ecological functions of wetlands. Wetlands also will be evaluated in comparison to regional reference sites that are established by agencies during the process of developing the HGM for a particular state or region. However, the HGM classification system isn't intended to replace other wetland classification systems such as the NWI's Cowardin system. Both systems are useful in wetlands management.

ASSESSING WETLAND FUNCTIONS

Wetlands provide many benefits because of their functions. It therefore is important to evaluate each wetland from a functional point of view. What functions does it or could it perform, and how well is it performing them? This kind of evaluation is called a *wetland functional assessment*.

One of the frequent criticisms of wetland management and regulation is that all wetlands are treated equally, when in fact they often are very different in structure, function, and quality. Although these criticisms often are overstated, it's true that wetland managers haven't settled on a standard way to characterize and compare the functions of one wetland to another. There are many reasons for this lack of consistency:

- The ecological processes that support wetland functions often are quite complex.
- These processes aren't well understood, and there isn't enough information about them.
- Wetlands vary a lot, even within a particular type.
- Wetland functions have many parts, all of which must be considered as part of the whole.
- Assessments often have very different purposes.

Despite these very real limitations, it still is important to use the best available scientific information about wetlands to assess their functions. To accomplish this, several standardized rapid assessment methods have been developed.

Several of these methods are used in Oregon or elsewhere in the Pacific Northwest. Others are in the process of being customized for this region. No single approach is universally accepted. The most common approaches include:

- "Best professional judgment"
- The Wetland Evaluation Technique (WET)
- The Oregon Freshwater Assessment Methodology (OFWAM)
- The hydrogeomorphic approach (HGM)
- The Puget Sound Watershed Approach (PSWA)

Most of these methods require some training either in wetlands science and/or in the use of the particular method. They all rely on *indicators* of wetland function that can be observed in the field or gleaned from aerial photos, wetland or soil maps, and other resource materials.

Each of these methods is described briefly below, and sources of more information on each are listed in the Resources section of this chapter. In addition, National Wetlands Inventory (NWI) maps, local wetland inventories (LWIs), soil surveys, and other sources can help you characterize existing wetlands and identify restoration and enhancement opportunities in your watershed. See the Resources section of this chapter for more information.

Best professional judgment

Best professional judgment (BPJ) probably is the most commonly used and flexible method for evaluating wetland functions. In this approach, well-trained, experienced wetland professionals evaluate the principal functions and conditions of a wetland based on extensive field experience and information from NWI maps, soil maps and surveys, and aerial photos.

However, because BPJ is not a standardized approach, it isn't very precise, and no two individuals are likely to get the same results. Thus, it's often criticized in terms of scientific, legal, and public credibility. These shortcomings are the driving force behind the development of more precise, standardized approaches.

Wetland Evaluation Technique

The Wetland Evaluation Technique (WET) is a broad-brush, field-based approach to wetland evaluation. It's based on information about correlative predictors of 11 wetland functions and values. *Correlative predictors* are variables whose presence is highly correlated with certain watershed functions.

Data on correlative predictors can be gathered quickly in the field. Based on these correlative predictors, the WET process generates high, moderate, or low probability ratings that a particular wetland performs a given function.

A site-specific method, WET has been used mostly by regulatory agencies to assess wetlands proposed for alteration and to design and monitor restored or created wetlands. It also has been used to identify important wetlands needing protection and to set priorities for acquisition or research. WET isn't easily adaptable to landscape-level evaluation of wetland functions.

Oregon Freshwater Wetland Assessment Methodology

The Oregon Freshwater Wetland Assessment Methodology (OFWAM) assesses six wetland functions (wildlife habitat, fish habitat, water quality, hydrologic control, education, and recreation) and three wetland conditions (sensitivity to impacts, enhancement potential, and aesthetics). This method involves asking a series of questions about each of these functions or conditions. Based on the answers to these questions, assessments have three possible outcomes:

- The function is performed or is intact.
- Some of the function is performed, or it may be impacted or degraded.

- The function is not performed or has been lost.
- For each wetland assessed, results for each of the six wetland functions and three conditions are summarized in a tabular and narrative description.

OFWAM is used extensively as a planning tool because it allows functions and conditions of several wetlands to be assessed and compared. Its most common use has been as a follow-up to local wetland inventories. In this case, each wetland is assessed, and the results are used by a community to help decide which wetlands are significant and deserve special protection.

OFWAM's use for watershed-level restoration planning is limited for two reasons. First, only one of the assessed conditions addresses restoration potential. Second, OFWAM focuses solely on existing rather than on former wetlands. Nevertheless, it could be adapted for restoration purposes by asking the question, "If we restored or created a wetland here, how might each of these functions be performed?"

See the Resources section of this chapter for information on how to obtain the OFWAM.

The hydrogeomorphic approach

The hydrogeomorphic (HGM) wetlands classification system was described above as the first step in an HGM approach to assessing wetland functions. Recall that this classification is based primarily on three principal characteristics of wetlands (although water chemistry and soil properties are other important variables):

- *Geomorphic setting* (the wetland's topographic position in the landscape)
- *Water source* (e.g., precipitation or groundwater) and *transport vector* (for example, surface flows or subsurface flows)
- *Hydrodynamics* (how water moves)

Once the characteristics of the seven national HGM classes are described for a particular class or subclass of wetlands, they are used to develop a profile of the functions that subclass performs.

Oregon is developing a regional application of HGM for use at site-specific, watershed, and ecoregion scales. It will be several years before the Oregon HGM assessment method is complete. In the meantime, however, the national HGM system can be used to better understand and assess the functions of different types of wetlands. HGM also is the basis for the PSWA assessment method described below, so an understanding of HGM is important for watershed groups.

Puget Sound Watershed Approach (PSWA)

Washington State, in implementing the Puget Sound water-quality program, has developed a watershed-based wetland restoration approach known as the Puget Sound Watershed Approach (PSWA). It has been pilot-tested in the Stillaguamish basin and now is being extended to other watersheds. PSWA uses aspects of both HGM and OFWAM to evaluate the 16 functions of wetlands described earlier.

The PSWA guidebook *Restoring Wetlands at a River Basin Scale* includes a multistep process that explains how to analyze the functions a particular wetland might perform once restored. This process involves the following steps:

- Identifying a wetland's HGM class
- Establishing priorities for restoring functions based on the problems in the watershed (e.g., high water temperatures during low flows)
- Determining the potential of different wetland types to perform these functions
- Assessing the restoration potential of sites and ranking each function

One of the end products of this process is a "menu" of restoration sites and a description of how their functions could help solve locally identified watershed problems.

The PSWA method is relatively high tech, incorporating the best available science about wetland functions and using geographic information system (GIS) analysis to carry out some of the steps. At the same time, it is locally driven in terms of problems to be solved and the constraints on project implementation. And, as with watershed groups in Oregon, its restoration projects are based on the "willing landowner" principle.

You can download *Restoring Wetlands at a River Basin Scale: A Guide for Washington's Puget Sound: Operational Draft*, Publication No. 97-99, from the World Wide Web (http://www.ecy.wa.gov/). A hard copy is available from the Washington State Department of Ecology at the address given in the Resources section of this chapter.

WETLAND MANAGEMENT IN OREGON TODAY

The protection, restoration, and enhancement of wetlands in Oregon involves many players. Federal, state, and local government agencies each have certain legal responsibilities and authority, but private nonprofit land trusts and other nongovernmental organizations also play important roles. Responsibilities generally break out along functional lines and governmental levels as summarized in Table 2.

Mapping, assessment, and research

Responsibilities in this area are shared among levels of government and agencies and relate primarily to assigned management responsibilities. The U.S. Fish and Wildlife Service conducts the National Wetlands Inventory (NWI). All of Oregon has been mapped, but some maps, particularly in the Coast Range, are of poor quality. Only about 20 percent of the state's NWI maps are available in digital form.

The Division of State Lands (DSL) uses the NWI as its base State Wetlands Inventory (SWI) and also funds the development of Local Wetlands Inventories (LWIs) that provide more detail. As of 1997, 35 communities had developed LWIs.

Wetland functional assessment also is a priority at each governmental level and is used for a variety of purposes. The *Oregon Freshwater Wetland Assessment Methodology* (Roth et al., 1996), for example, is used in conjunction with LWIs and local land-use planning.

Wetland research in Oregon is conducted mainly by federal agencies–the Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), the Natural Resources Conservation Service (NRCS), and the U.S. Geological Survey (USGS) in particular. But state agencies, university academics, and private nonprofits such as The Nature Conservancy also conduct important research on wetland functions and characteristics, providing useful management information.

Nonregulatory wetland management

A variety of federal, state, and private programs focus on nonregulatory wetland management in Oregon. The principal activities of both public agencies and private organizations are land acquisition; management, restoration, or enhancement of wetlands; technical assistance to private landowners undertaking restoration or enhancement; and public education (Figure 10).

Table 2.–Principal wetland management functions, governmental agencies, private organizations, and authorities in Oregon.

Function	Federal government	State government	Local government	Private/ nonprofit
Mapping, assessment, and research	• *U.S. Geological Survey:* hydrology, nutrients, habitat • *U.S. Fish and Wildlife Service:* National Wetlands Inventory, habitat research, and functions assessment • *U.S. Army Corps of Engineers:* restoration and assessment research • *U.S. Environmental Protection Agency:* mitigation, risks, and cumulative impacts • *Natural Resources Conservation Service:* agricultural wetlands, functions assessment	• *Division of State Lands*: • State and Local Wetland Inventories, Oregon Freshwater Wetland Assessment Method, wetland research through EPA state grants program • *Governor's Watershed Enhancement Board:* funding for watershed assessments • *Universities and colleges:* scientific research on wetland characteristics, functions, and restoration	*Cities and counties:* Local Wetland Inventories, wetland functions assessment	• *The Nature Conservancy:* research on wetland characterization and mapping, historical ecology, functions assessment, and restoration monitoring
Nonregulatory: Land acquisition, management, restoration, enhancement, education, and technical assistance	• *U.S. Fish and Wildlife Service:* national wildlife refuges, Partners for Wildlife • *U.S. Forest Service:* natural areas management and restoration • *U.S. Bureau of Land Management:* natural areas • *Natural Resources Conservation Service:* Wetland Reserve Program, Conservation Reserve Program • *National Park Service:* national parks and monuments	• *Department of Fish and Wildlife:* wildlife management areas, funding and technical assistance, public education • *Division of State Lands:* public trust lands and waters of the state, South Slough National Estuarine Research Reserve, forest and range lands, public education • *Parks and Recreation Department:* state parks, public education • *Department of Forestry:* state forest lands • *Governor's Watershed Enhancement Board:* funding for restoration and enhancement projects, public education	• *Counties and cities:* parks, green spaces, and natural areas • *Watershed councils:* facilitation of private landowner cooperation, on-the-ground restoration	• *Oregon Wetland Joint Venture:* implementing North American Waterfowl Act-related plans for habitat restoration and enhancement, coordination and facilitation of public-private action • *The Nature Conservancy:* acquisition, restoration, and enhancement projects • *Ducks Unlimited:* acquisition, restoration, and enhancement projects • *Wetlands Conservancy:* acquisition, restoration, and enhancement projects • *Other local land trusts:* acquisition, restoration, and enhancement projects

Table 2.–Principal wetland management functions, governmental agencies, private organizations, and authorities in Oregon (continued).

Function	Federal government	State government	Local government	Private/ nonprofit
Regulation, mitigation, and permit review	• *U.S. Army Corps of Engineers*: Clean Water Act Section 404 • *U.S. Environmental Protection Agency:* Section 404 oversight • *Natural Resources Conservation Service*: "Swampbuster" agricultural wetlands • *U.S. Fish and Wildlife Service:* coordination under Fish and Wildlife Coordination Act (FWCA) • *National Marine Fisheries Service:* coordination under Fish and Wildlife Coordination Act	• *Division of State Lands:* Removal/Fill Law, Mitigation Banking Act • *Department of Fish and Wildlife:* permit review under Removal/Fill Law and federal FWCA • *Department of Environmental Quality:* CWA Section 401 wetland water quality certification • *Department of Land Conservation and Development:* state and federal consistency certification	• *Counties and cities:* local wetland and natural resource protection ordinances, federal and state permit review for consistency with local plan	No role except as occasional public commenter
Land use and watershed planning	• *U.S. Forest Service:* on national forest lands • *U.S. Bureau of Land Management:* on BLM-managed forest and range lands • *National Park Service:* on national parks and monuments	• *Department of Land Conservation and Development:* Goals 5, 16, and 17 • *Division of State Lands:* Goals 5, 17, and Wetland Conservation Plans, state-owned lands • *Department of Forestry:* watershed and land-use planning on state lands • *Governor's Watershed Enhancement Board:* funding for watershed action programs and plans	• *Counties and cities:* Goal 5, Goals 16 and 17 (coastal), and Wetland Conservation Plans • *Watershed councils:* restoration action plans, facilitation of private landowner cooperation	No significant role

The Oregon Department of Fish and Wildlife (ODFW), USFWS, the Bureau of Land Management (BLM), U.S. Forest Service (USFS), NRCS, and local Soil and Water Conservation Districts are the principal government agencies involved. Private nonprofit land trusts and similar groups involved in wetlands management include The Nature Conservancy, Ducks Unlimited, the Wetlands Conservancy, and others. Many of these private groups come under the umbrella of the Oregon Wetlands Joint Venture.

Regulation, mitigation, and permit review

At the federal level, Section 404 of the Clean Water Act (40 CFR 230) is the principal nationwide wetland regulatory program. Section 404 requires that anyone discharging dredge or fill material in the waters of the United States, including wetlands, obtain a permit from the U.S. Army Corps of Engineers (the Corps). The permit is subject to review by a number of agencies, principally the EPA (which also may veto the permit), USFWS, the National Marine Fisheries Service (NMFS), the Oregon Department of Fish and Wildlife (ODFW), and the Oregon Department of Environmental Quality (DEQ) (to certify that water-quality standards are met).

As part of the effort to implement the federal no-net-loss policy for wetlands, Section 404 applicants must follow a sequential mitigation process. First, wetland impacts must be avoided if at all possible, usually by maximizing use of nonwetland areas on or off the property. Next, onsite wetland impacts must be minimized. Finally, unavoidable wetland losses must be compensated by restoring, creating, or enhancing wetlands.

In practice, wetland compensatory mitigation (WCM) occurs on a project-by-project basis. In recent years, *mitigation banking* has become a popular alternative to the project-by-project approach. Mitigation banking involves restoration (or creation) of large

Figure 10.—Technical assistance teams with a range of expertise can be effective for watershed planning and for designing specific projects. (Source: ODFW)

wetland areas in advance of use as WCM. As needed, WCM credits are sold to permit applicants by the bank sponsor in lieu of requiring separate WCM projects.

The “swampbuster” provisions of the Food Security Act of 1985–often referred to as the “Farm Bill”–reversed a long-standing national policy of promoting drainage of wetlands for agricultural cropping. Instead, farmers who convert wetlands to agricultural uses may be penalized by removal of certain agricultural price supports and other subsidies. Wetlands that were converted to cropland prior to 1985 are exempted from the law.

The swampbuster provision of the farm bill is administered by the Natural Resources Conservation Service (NRCS) and was amended in 1990 and again in 1996. The most recent farm bill gives farmers more flexibility in meeting wetland conservation requirements, in particular expanded mitigation provisions that allow for restoration, creation, and enhancement of wetlands.

The Oregon Removal/Fill Law is the principal state regulatory tool for protecting Oregon’s wetlands. Although it predated the Section 404 program, the Removal/Fill Law is very similar. The law requires permits for fill or removal of 50 cubic yards or more from wetlands or waters of the state. In some areas, such as essential salmonid habitat, a permit is required for smaller amounts of fill or removal.

An important component of the law is a three-part sequential mitigation process similar to the federal requirement. Mitigation thus is the principal link between regulatory programs and wetland restoration programs. The program is administered by the Division of State Lands and applies statewide. Federal-state streamlining is achieved through a joint permit application and review process.

Wetlands regulatory policy and programs have been a lightning rod in recent years, as farming interests, developers, and private property rights advocates generally have sought to reverse the expanding jurisdiction of federal regulatory programs, speed up the permit process for development, and as much as possible, externalize the costs associated with cropping, dredging, filling, and other wetland conversions.

These efforts have been blunted to some degree by conservationists and resource managers who are promoting even stronger wetlands protection. Although protection of remaining wetlands remains a federal and state priority, the impasse over regulatory program changes has provided at least part of the rationale for putting more emphasis on nonregulatory programs such as restoration.

Land use and watershed planning

Oregon's statewide land-use planning program includes several provisions that provide for wetland protection and restoration. Statewide Planning Goals, especially Goal 5 (Open Spaces, . . . and Natural Resources), Goal 16 (Estuarine Resources), and Goal 17 (Coastal Shorelands) require the inventory and protection of significant wetlands.

However, there is little consideration of wetland restoration, except in Goals 16 and 17, where the emphasis is on locating sites for regulatory mitigation, not nonregulatory restoration. Recent revisions to Goal 5 have improved provisions for wetland and riparian protection, but again do not address restoration or enhancement as land-use management strategies.

The other principal planning authority dealing with wetland protection and restoration is the 1989 wetland conservation law (ORS 196.668 et seq.), also administered by DSL. This legislation enabled the development of local wetland inventories (mentioned above) and the preparation of local wetland conservation plans (WCPs). Although locating potential wetland restoration sites is a required part of the WCP process, only those necessary to mitigate future development affecting wetlands actually must be identified in inventories and plans.

Watershed planning in Oregon is carried out by federal, state, and private landowners and organizations. In recent years, the watershed approach has been institutionalized in Oregon, largely through the Oregon Watershed Enhancement Board (OWEB), which provides for establishment of local watershed councils and associations. More than 60 local watershed groups have been established in Oregon so far.

Many watershed councils have developed restoration action plans. However, few watershed plans and programs address wetland restoration as part of overall ecosystem restoration.

This brief overview of wetland management in Oregon illustrates the diversity and complexity of programs and activities addressing restoration in Oregon. In many ways, this diversity mirrors the larger society within which wetland and other aquatic ecosystem management occurs. What becomes very obvious as you examine these programs is the need and opportunity for improved public-private and interagency cooperation, better integration of wetland restoration into existing watershed and planning programs, and the enhancement and redirection of human and other resources if such goals are to be accomplished.

Summary/Self review

Wetlands are areas where water is at or near the surface at least part of the year, where soil development reflects this saturation, and where vegetation is dominated by plants adapted to a wet environment. Many wetlands are found at the transition between upland and aquatic environments, but others are isolated from open water.

Wetlands are ecological “hot spots” in watersheds, performing a variety of valuable functions that can be divided into four categories:

- Water quality-related functions
- Hydrologic functions
- Habitat and food web support functions
- Cultural and social functions

Functional interconnectedness with stream, lake, estuarine, and riparian ecosystems also is important. Thus, none of these environments can be considered in isolation from the others.

Wetlands types are classified using a number of systems. The most important are the Cowardin classification system (used for inventory and mapping) and the HGM classification system (being regionalized for Oregon to provide a better basis for functional assessment at a variety of scales).

Wetlands functions can be evaluated using a variety of methods. OFWAM is most commonly used today, and HGM is in the process of development. The PSWA method in Washington State is the only “watershed-level” method applicable to Oregon’s watersheds; it incorporates aspects of both OFWAM and HGM.

EXERCISES

Identifying and describing wetland characteristics using an NWI map

This exercise will familiarize you with the wetland and watershed information that can be gleaned from NWI maps and soil surveys. This information is useful in characterizing current watershed conditions, the predisturbance extent of wetlands, and the relationship of wetlands to aquatic and upland environments. You can do this exercise on your own, but it's helpful to work as a group so you can discuss your observations.

You'll need to order NWI maps (called "quad sheets") for your area. The Division of State Lands (DSL) can help you identify which maps you need. Each map covers about 56 square miles. Because most watersheds are larger than that, you may want to order all of the maps that overlap into your area of concern, or you may want to order just those in your immediate area. Many local Natural Resources Conservation Service (NRCS) field offices own a complete set of NWI maps for their county. You also should obtain your *county soil survey*, *hydric soils list*, and a large-scale aerial photo of the study area (color is best). See the "Resources" section for ordering information.

Using an NWI map and the soil survey and hydric soils list for the same area, answer these kinds of questions. (Locate specific areas or streams, and adapt the questions as needed.)

1. Following a creek or small river tributary to its headwaters source, what wetland types (classifications) do you encounter? List them in order, using the full name. Mark them on the map where the classification changes.
2. Moving to an area of more isolated wetlands, what are the general types of wetlands and how do they differ from the stream system you first examined?
3. Using your soil survey sheet for the two areas where you identified wetlands, draw cross-section lines through each area. Then, using the hydric soils list for the county, list the soil map units and identify which ones are hydric.
4. Using a highlighter, shade the approximate locations of the NWI wetlands you identified on your soil survey sheet. What are the differences in area between the NWI-mapped wetlands and the hydric soils? Which includes more area? Speculate why.

Conducting a wetland function assessment using OFWAM

Conducting a wetland functional assessment will familiarize you with the range of functions these ecosystems perform, how the functions vary among wetland types and within a given class of wetlands, and the "indicators" used to estimate whether or not a function is performed.

You will need a copy of the Oregon Freshwater Wetland Assessment Methodology, available from DSL (see Resources). OFWAM is designed as a step-by-step guide, and you can go through the process on your own or with your watershed group. However, it's best to arrange for some classroom and/or field training by DSL staff or other experienced users, such as wetland consultants. See "Resources."

1. Select at least three wetlands for the exercise. Two should be of a single Cowardin wetland type, for example, palustrine emergent seasonally flooded (PEMC). Collect site and regional information and do the off-site analysis.
2. Then go into the field (get property owner permission first!) and go through the OFWAM field questions, tally the results, characterize, and compare wetland functions for each site. Consider these questions:
    - Do the two wetlands that are of the same type (PEMC in the above example) perform the same functions? Are the assessment results the same? Speculate why or why not.
    - How does the assessment for the third, different type of wetland compare to the first two? Are the functions performed the same? Are the assessment results the same? Speculate why or why not.
    - Which of the wetlands is the most intact functionally? Which is the least intact? What are the causes for these differences?
    - If wetland functions at any (or all) of the sites are degraded to some extent, what would you suggest doing to restore each site to improve wetland functioning?

Resources

Training

Training on the following topics may be offered by the agencies listed, or these agencies can provide contacts or information for other scheduled training programs, some of which are fee-based.

The Cowardin classification system, the NWI, and local wetland inventories

Oregon Division of State Lands, Wetlands Program. Phone: 503-378-3805

U.S. Fish and Wildlife Service, Regional Wetland Coordinator. Phone: 503-231-6154

Agricultural wetlands, soil surveys, hydric soils

Natural Resources Conservation Service, regional office. Phone: 503-414-3200

Natural Resources Conservation Service, local offices

Oregon Division of State Lands, Wetlands Program. Phone: 503-378-3805

Wetland function assessment using OFWAM

Oregon Division of State Lands, Wetlands Program. Phone: 503-378-3805

Wetland identification and delineation

Oregon Division of State Lands, Wetlands Program. Phone: 503-378-3805

U.S. Army Corps of Engineers, Portland District, Wetlands Specialist. Phone: 503-808-4373

Information

National Wetlands Inventory maps

You can order NWI maps for your area or watershed from two sources. Specify the USGS quadrangle sheets you wish to order. (You can obtain a statewide map index and order form from DSL.)

State Distribution Center
Oregon Division of State Lands
Wetlands Program
775 Summer Street NE
Salem, OR 97310-1337
Phone: 503-378-3805, ext. 246

Earth Science Information Center
Western Mapping Center–ESIC
U.S. Geological Survey
Mail Stop MS 532
345 Middlefield Road
Menlo Park, CA 94025
Phone: 650-853-8300

Inventories of farmed wetlands, hydric soils, and soil surveys

The Natural Resources Conservation Service (NRCS) is compiling an inventory of farmed wetlands. It also maintains and distributes the Oregon list of hydric (wetland) soils.

Natural Resources Conservation Service
101 SW Main, Suite 1300
Portland, OR 97204
Phone: 503-414-3200

Local NRCS offices also can supply your county soil survey, which includes upland and hydric soils. Contact your local NRCS office or county Extension agent for more information.

Other materials

The U.S. Fish and Wildlife Service has a variety of information on the National Wetlands Inventory and other wetlands information. Contact the USFWS regional office (below) or explore the NWI Web site at: http://www.nwi.fws.gov/

Regional Wetland Coordinator
U.S. Fish and Wildlife Service
911 NE 11th
Portland Eastside Federal Complex
Portland, OR 97232-4181
Phone: 503-231-6192

The State Distribution Center (DSL) has a number of wetland fact sheets and other information that may be ordered from the address or phone listed on the previous page. Materials include:

About Local Wetlands Inventories, Just the Facts #2 (1993).

About the National Wetlands Inventory, Just the Facts #1 (1991).

How to Identify Wetlands, Just the Facts #4 (1992).

How Wetlands And Waterways Are Regulated, Just the Facts #3 (1992).

Oregon Freshwater Wetland Assessment Methodology, 2nd edition, by E. Roth, R. Olsen, P. Snow, and R. Sumner (Oregon Division of State Lands, Salem, 1996). 184 pages.

The Oregon Wetlands Conservation Guide: Voluntary Wetlands Stewardship Options for Oregon's Private Landowners (1995). 34 pages plus appendices.

Wetlands Functions and Assessment, Just the Facts #5 (1994).

Wetlands Inventory User's Guide, Pub. 90-1.

Wetlands Update (a periodic wetlands newsletter available by subscription; ask for available back issues as well).

The U.S. Army Corps of Engineers also has information on wetlands functions assessment, wetland restoration, and other topics. For a list of available publications, contact:

U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180
Phone: 601-634-2355

The Washington State Department of Ecology has many publications that may be applicable to wetlands in Oregon. Call 360-407-7470 to obtain a free order form, or write:

Washington State Department of Ecology
Publications Distribution Center
PO Box 47600
Olympia, WA 98504-7600

Restoring Wetlands at a River Basin Scale: A Guide for Washington's Puget Sound: Operational Draft, Publication No. 97-99 is available on the Web at http://www.ecy.wa.gov/. A hard copy is available from the address above.

Moving forward–the next steps

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in understanding wetland functions, management, evaluation, and enhancement.

1.____

2.____

3.____

8

Water-quality Monitoring

Beth Lambert

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, generally in terms of suitability for a particular use. *Water-quality monitoring* is the process of sampling and analyzing water conditions and characteristics (EPA, 1997). These characteristics, such as dissolved oxygen, pH, and temperature, are known as *parameters*. Under guidance from the U.S. Environmental Protection Agency, states develop water-quality standards that designate levels of each parameter that are acceptable for beneficial uses such as drinking water, irrigation, swimming, and aquatic life.

For many years, agencies and citizens across the United States have been monitoring water quality as a way to track pollution and determine the condition of aquatic ecosystems. We monitor water quality to:

- Identify particular pollutants of concern
- Identify whether the quality of the water is sufficient for a particular use
- Target sources of pollution
- Detect trends
- Determine the effectiveness of watershed restoration and enhancement projects

IN THIS CHAPTER YOU'LL LEARN:

- Why citizens are involved in water-quality monitoring
- Common water-quality monitoring parameters and why each is important
- Considerations for developing a monitoring plan
- The components of a successful monitoring program

Recently, citizens and agencies have begun to monitor additional aspects of aquatic systems to gain a more complete picture of watershed health. These aspects include stream life, such as macroinvertebrates, the physical structure of the stream, and habitat conditions. By monitoring water quality, stream life, and habitat, we can better understand the health of stream ecosystems.

Monitoring goals and objectives are discussed further in Chapter II-5, “Assessment and Monitoring Considerations.”

See Section II, Chapter 5 for information related to this chapter.

Section II

5 Assessment

CITIZEN-BASED MONITORING

Citizens play a large role in water-quality monitoring in our country. Citizen monitors work in partnership with a variety of groups, from grassroots nonprofits to watershed councils, soil and water conservation districts, and agencies. Citizens become involved in monitoring programs for many reasons. These reasons include:

- To promote stewardship
- To take ownership and responsibility for local water resources
- To identify problems in a water body
- To contribute to their community
- To learn about the environment

Citizen groups also partner with state agencies in the process of establishing Total Maximum Daily Loads (TMDLs) of pollutants, while others work with landowners to monitor the effects of best management practices.

Citizen monitors come together to share data, program management techniques, and experiences through such forums as the quarterly newsletter *The Volunteer Monitor* and the National Volunteer Monitoring Conference. Organizations such as Global Learning and Observations to Benefit the Environment (GLOBE) and Global Rivers Environmental Education Network (GREEN) promote the involvement of youth in water-quality monitoring.

This chapter is aimed at individuals or groups interested in learning more about citizen-based monitoring. It introduces parameters commonly monitored by volunteers and agencies. It also describes several monitoring strategies and presents 10 components of a successful monitoring project. This chapter complements chapter II-5, which discusses monitoring designs, goals, objectives, and results. Detailed information on parameters, monitoring strategies, and citizen-based monitoring can be found in the references at the end of this chapter.

WATER-QUALITY PARAMETERS

This section describes many common parameters monitored by citizens and agencies. These parameters are monitored for one or more of the following reasons:

- They are important for human health.
- They are important for aquatic health.
- They are part of state water-quality standards or federal water-quality criteria.

Information on recommended monitoring protocols is available from the *Water Quality Monitoring Guidebook,* published by the Oregon Plan for Salmon and Watersheds (1999). Information on Oregon's water-quality standards is available from the Oregon Department of Environmental Quality. Federal water-quality criteria, which serve as guidance for the states, are available from the U.S. Environmental Protection Agency.

Chemical parameters

pH is a measure of the level of activity of hydrogen ions in a solution, resulting in its acidic or basic quality (Figure 1). pH is measured on a range from 0 (acidic) to 14 (basic), with 7 being neutral. Each stream organism is adapted to a specific pH range.

The pH in most rivers unaffected by humans ranges from 6.5 to 8. In eastern Oregon, alkaline soils cause many rivers to have unusually high pH levels. Humans can impact pH through mining

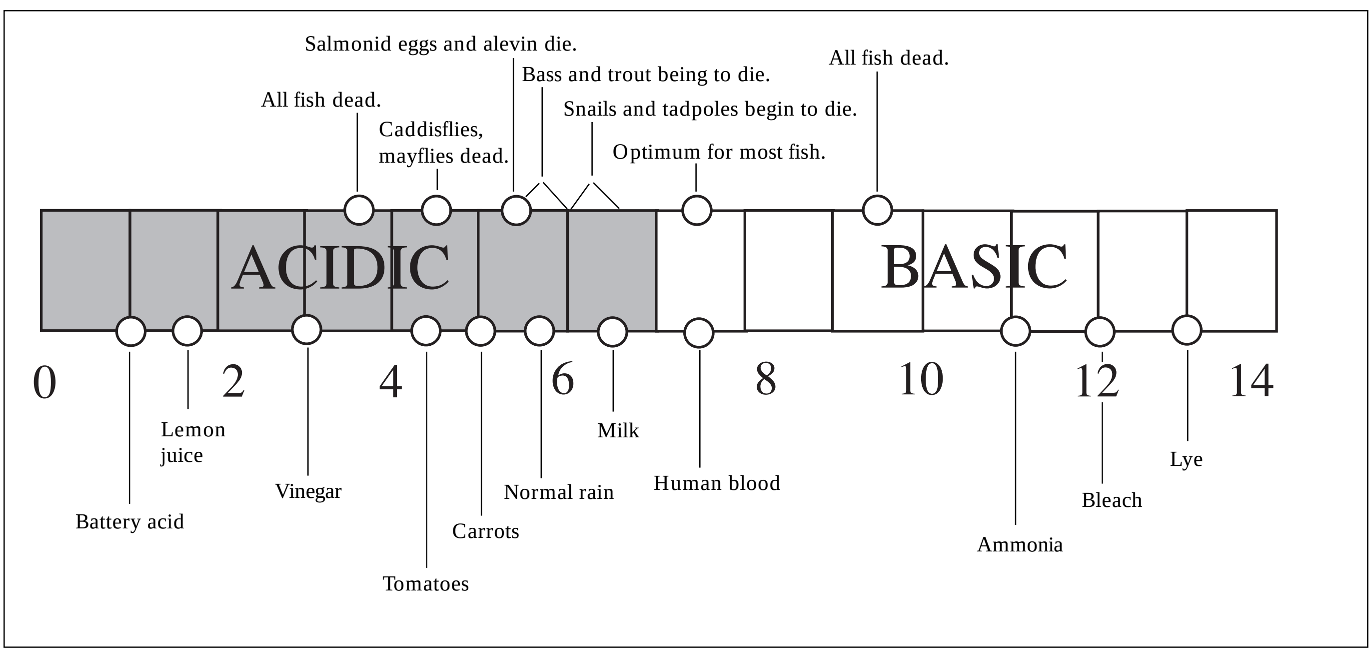


Figure 1.–pH scale. (Source: The Stream Scene, *by P. Bowers et al., Oregon Department of Fish and Wildlife, 1992)*

activities (some of which can make the water more acidic) and by increasing nutrients, which leads to increased algae growth and higher pH.

Total dissolved solids is a measure, in milligrams per liter (mg/L), of the amount of dissolved materials in the stream. Ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to a dissolved solids measurement. Measuring total dissolved solids is a way to estimate the suitability of water for irrigation and drinking. This is an important parameter for drinking water.

Groundwater has higher levels of dissolved solids than does surface water because of its greater contact with rock and more time to dissolve rock and mineral materials. When stream flow is low, most of the source water is from groundwater, and dissolved solids concentrations are high. When stream flows are high from rain or snowmelt, dissolved solids measurements typically are low.

Conductivity is the ability of a substance to conduct an electrical current, measured in microsiemens per centimeter (μS/cm). Ions such as sodium, potassium, and chloride give water its ability to conduct electricity. Thus, conductivity is an indicator of the amount of dissolved salts in a stream. Conductivity often is used to estimate the amounts of dissolved solids rather than measuring each dissolved constituent separately.

Nutrients are chemical elements that are essential to plant and animal life and growth. Nitrogen and phosphorus are two nutrients that are important to aquatic life. At high levels, however, they are considered contaminants. High levels of nutrients can cause increased growth of algae beyond what is normal. Decaying algae mats can cause foul odors and tastes. And as algae decay, they remove dissolved oxygen from the water.

Nutrients are measured in milligrams per liter (mg/L). Commonly measured forms of nutrients are nitrate, ammonia, orthophosphate, and total phosphorus.

Both nitrogen and phosphorus are affected by chemical and biological processes that change their form and transfer them to or from water, soil, decaying organisms, and the atmosphere. In nature, both nitrogen and phosphorus come from the soil and decaying plants and animals. Fertilizers and domestic animal waste are common human-added sources of nutrients.

The EPA has developed criteria for ammonia-nitrogen, nitrite-nitrogen, and nitrate-nitrogen. The ammonia criteria are designed to protect fish, while the nitrite and nitrate criteria are set for drinking water. The federal government does not have formal criteria for phosphorus, but it does have recommended levels. Because background levels of nutrients can vary from watershed to watershed, the EPA is working to develop nutrient criteria based on regional characteristics.

Dissolved oxygen is needed by fish and other stream organisms. In unaltered streams, dissolved oxygen levels usually are 100 percent of the carrying capacity of the water. As plant and animal material decays, it consumes dissolved oxygen. Turbulence, interaction with the air, and photosynthesis replenish oxygen in the water. Cold water can hold more dissolved oxygen than warmer water.

Dissolved oxygen measurements can be expressed as a concentration, milligrams per liter (mg/L) or as percent saturation (the amount of oxygen the water holds compared to what it could absorb at that temperature).

Manufactured chemicals such as solvents, PCBs, pesticides, and metals are expensive to monitor. The samples must be collected following strict protocols, and the water must be analyzed by a professional lab. State forest practices regulations and the Oregon Department of Environmental Quality have established procedures for sampling these chemicals.

Water temperature is a crucial aspect of aquatic habitat.

Physical parameters

Stream flow (discharge) is the volume of water moving through a stream at any given time. Stream flow often is expressed in cubic feet per second (cfs). The discharge of a stream can vary on a daily, weekly, monthly, and seasonal basis in response to precipitation, snowmelt, dry periods, and water withdrawals by people. Stream flow affects water chemistry; thus, water-quality measurements always should be interpreted in relation to stream flow.

Water temperature is a crucial aspect of aquatic habitat. Aquatic organisms are adapted to certain temperature ranges. As the upper and lower limits of the range are approached, the organism becomes more susceptible to disease. Also, fish that spend extra energy searching for cool areas might be at a disadvantage when competing for food. Stream temperature is regulated by solar energy, the surface area of the stream, the volume of water moving through the stream, and several other factors.

Suspended solids are particles of sand, silt, clay, and organic material moving with the water. Suspended solids usually are measured as a concentration, milligrams per liter (mg/L).

High levels of suspended solids can cause problems for aquatic organisms, both as the solids travel through the water and after they are deposited on the streambed. Suspended solids can reduce visibility, making it hard for fish to find prey. Solids also can clog the gills of fish and suffocate macroinvertebrates. Once the material is deposited, it can fill the spaces between gravel pieces in the streambed. This reduces the permeability of the bed material, meaning that water cannot filter through, bringing dissolved oxygen and nutrients to stream insects, fish eggs, and fry.

Turbidity measures the ability of light to pass through water, or its clarity. Turbidity is measured in Jackson Turbidity Units (JTUs) or Nephelometric Turbidity Units (NTUs). High levels of turbidity make it difficult for fish to find prey and indicate high levels of suspended solids. Turbidity often is measured by citizens as a way to estimate amounts of suspended solids. Turbidity is an optical property, however, and does not directly reflect the amount or types of solids; thus it must be used carefully.

Biological parameters

Bacteria such as *Escherichia coli (E. coli)* and fecal coliform are measured as indicators of more harmful bacteria. High numbers of these types might indicate the presence of other bacteria that cause illness.

Most analytical methods involve growing bacteria in a water sample and counting the colonies. The results are given as the number of colony-forming units per 100 milliliters (ml) of water.

Bacteria populations fluctuate in response to stream flow, disturbance of the streambed, time of year, and time of day. Bacteria can survive for long periods on land and in stream sediments.

MONITORING STRATEGIES

A monitoring strategy describes what, how, and where you will monitor in order to answer a particular water-quality question. In order to gain useful data from a water-quality monitoring project, it is essential to articulate the question you are trying to answer. From this question you develop the goals and objectives for the project. In turn, these goals and objectives will guide you in designing a monitoring strategy.

Chapter II-5, “Assessment and Monitoring Considerations,” addresses the importance of asking a monitoring question and outlines several types of monitoring. This section applies the monitoring concepts from Chapter II-5 to water-quality monitoring and examines baseline, trend, and effectiveness monitoring.

Asking monitoring questions

In order to get an answer from your monitoring project, you must have a question. The question will guide you in setting goals and objectives for monitoring. It also will guide you in deciding which

Table 1.–Examples of increasingly specific goals for watershed monitoring projects (DEQ Volunteer Monitoring Coordinator, 2001).

Purpose	Goals	Sample objectives
Support DEQ total maximum daily load (TMDL) development.	Collect data of appropriate quality for use in DEQ temperature computer models.	Measure continuous temperature and flow (end of summer) at the mouth of major tributaries to the mainstem river. Compile temperature data and quality assurance information in DEQ data forms. Submit data electronically in DEQ forms at end of season.
Fill data gaps identified in watershed assessment.	Measure water quality and habitat in low-gradient streams flowing through agricultural lands.	Measure pH, dissolved oxygen, and temperature frequently enough to detect diurnal fluctuations in summer. Collect macroinvertebrates in early fall and compare results from professional identification with those from DEQ reference sites.
Educate community about links between water quality and land use.	Collect sufficient data to demonstrate differences in water quality in streams bordered by healthy and degraded riparian zones.	Assemble existing water quality information from two contrasting areas and summarize in a poster for library display. Measure shade, channel width, and substrate once a year and water quality quarterly at two contrasting sites. Interpret data by comparing with existing standards and illustrating differences in seasonal fluctuations.
Monitor effectiveness of restoration projects.	Collect sufficient water quality data to detect trends or for at least 5 years.	Measure shade, flow, and channel characteristics at restoration sites once a year. Collect continuous temperature data upstream and downstream of restoration sites during summer. Use appropriate step trend analysis to compare temperature data collected before and after a restoration project.

parameters, where, and when to sample. Examples of monitoring questions include:

- Have suspended sediment levels changed over time at a site?
- How do nutrient levels vary among streams that flow through areas with different land uses?
- Has water temperature changed as a result of planting willows along a small stream?

Each question will produce a different monitoring strategy. See Table 1 for examples of increasingly specific goals and objectives.

One of the challenges of designing a water-quality monitoring strategy and interpreting the resulting data is that stream conditions can change hourly, daily, seasonally, annually, and over the long term, even without human impacts. Dissolved oxygen concentrations, for example, can change throughout the day as water temperature changes and algae respire. Stream flow can vary from day to day, month to month, and between years; these changes affect the levels of many parameters. To yield useful information, a monitoring strategy must address this variability.

Trend, baseline, and effectiveness monitoring

Trend, baseline, and effectiveness are three types of monitoring that address common monitoring questions. This section briefly introduces each type and applies it to monitoring stream temperature. These and other monitoring types are discussed further in many of the resources listed at the end of this chapter.

Trend monitoring: Has stream temperature increased over time at a particular site? Trend monitoring involves repeated measurements at a site over a period of time. These measurements are examined to see whether a pattern emerges such as an increase, decrease, or cycle.

In order to determine whether stream temperature has increased at a site, it is important to measure other factors that affect stream temperature. Stream flow, for example, is extremely important. The smaller the volume of water, the more easily it heats. Therefore, stream flow should be considered when developing a monitoring strategy. It is important to separate the effects of changes in stream flow from the effects of changes in land use.

It also is important to monitor at the same time in the summer each year. Monitoring should be done during the time that impacts are expected.

Baseline monitoring: What is the stream temperature at a site and how does that compare to Oregon's water-quality standard? Baseline monitoring establishes a reference point. This reference point then can be compared with future conditions or against a standard.

For stream temperature, monitor from late spring throughout the summer and into early fall at a particular point. If a particular part of the year is of concern due to fish use of the stream, monitoring should focus on that time. The resulting data can be compared with Oregon's water-quality standard for temperature.

Effectiveness monitoring: Did planting willows along the stream improve water temperature? Effectiveness monitoring is used to determine whether a management activity has produced the desired water-quality results or benefits. Three common approaches to effectiveness monitoring are to monitor before and after the project, upstream and downstream of the project, or paired reaches.

Monitoring before and after riparian planting provides data that can be difficult to interpret. In this approach, monitoring takes place at a single point at the downstream end of the area to be planted (Figure 2). Stream temperature is monitored before the trees are planted and again as the shade develops.

This approach is challenging because changes in precipitation and discharge can affect water temperature. The year before the willows are planted, for example, might be a low water year, while two summers later the flows might be extremely high. Take these fluctuations into account when interpreting data. It might be hard to say with certainty whether changes in stream temperature were caused by the increased shade or by natural factors.

Another common approach is to monitor upstream and downstream of a project (Figure 3, page 10). This strategy provides more information than the before–after approach because both sites experience the same changes in stream discharge, climate, and other factors. The natural variations in stream conditions are accounted for.

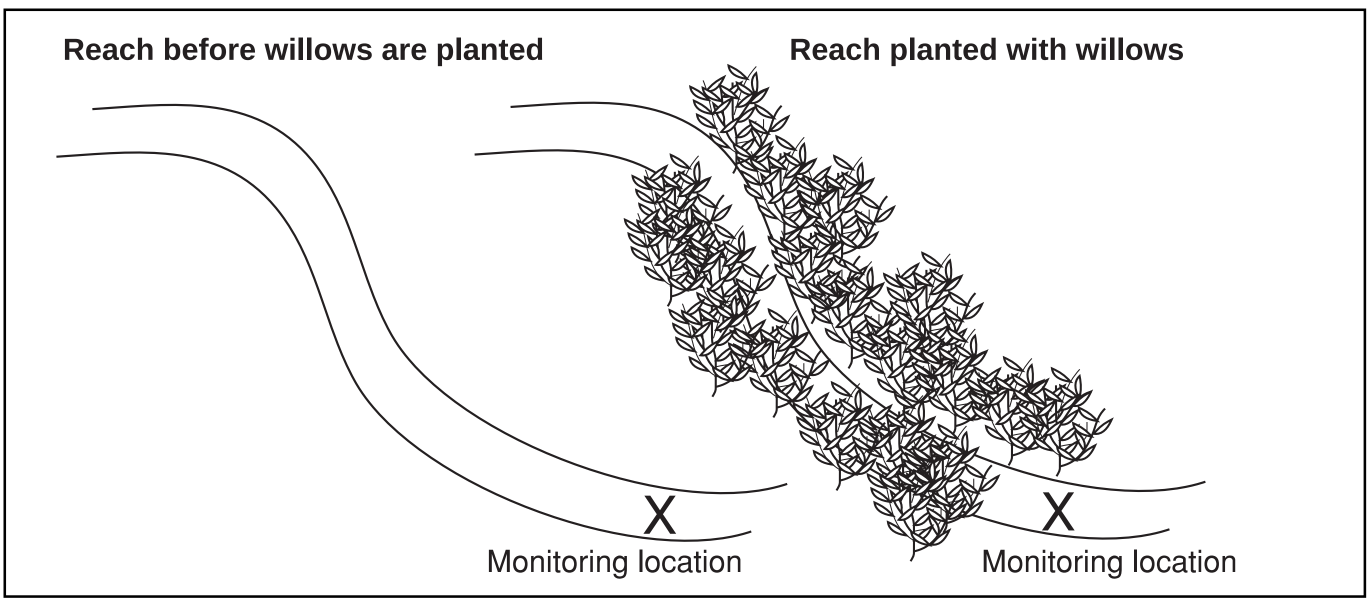


Figure 2.–Before-and-after monitoring. (Diagram is schematic and not to scale.)

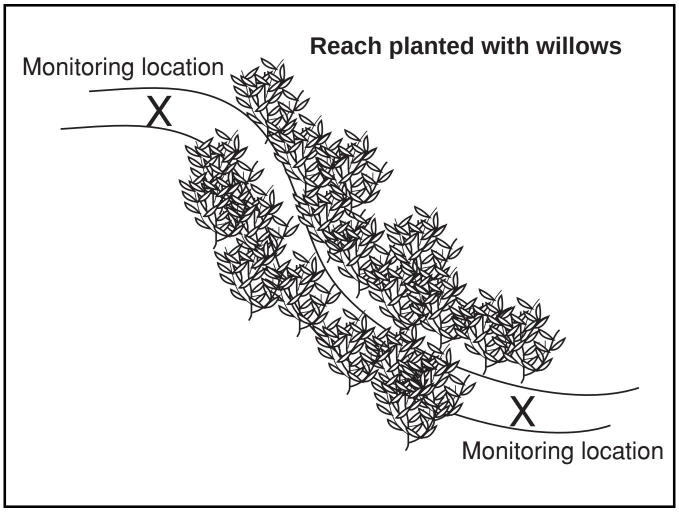


Figure 3.–Upstream and downstream monitoring of a reach planted with willows. (Diagram is schematic and not to scale.)

A drawback to this strategy, however, is that it's not known how the water temperature in the reach with trees compares to a reach without trees at the same time. There is no "control" reach for this experiment.

The most useful monitoring strategy is the paired reach strategy (Figure 4). In this strategy, water temperature is monitored at the upstream and downstream ends of two adjacent stream reaches. Then willows are planted along one of the reaches. Both reaches are monitored to see whether the planted reach responds differently over time than the unplanted reach. This strategy accounts for sources of variability before, during, and after the project. It also provides a control reach against which the planted reach can be compared.

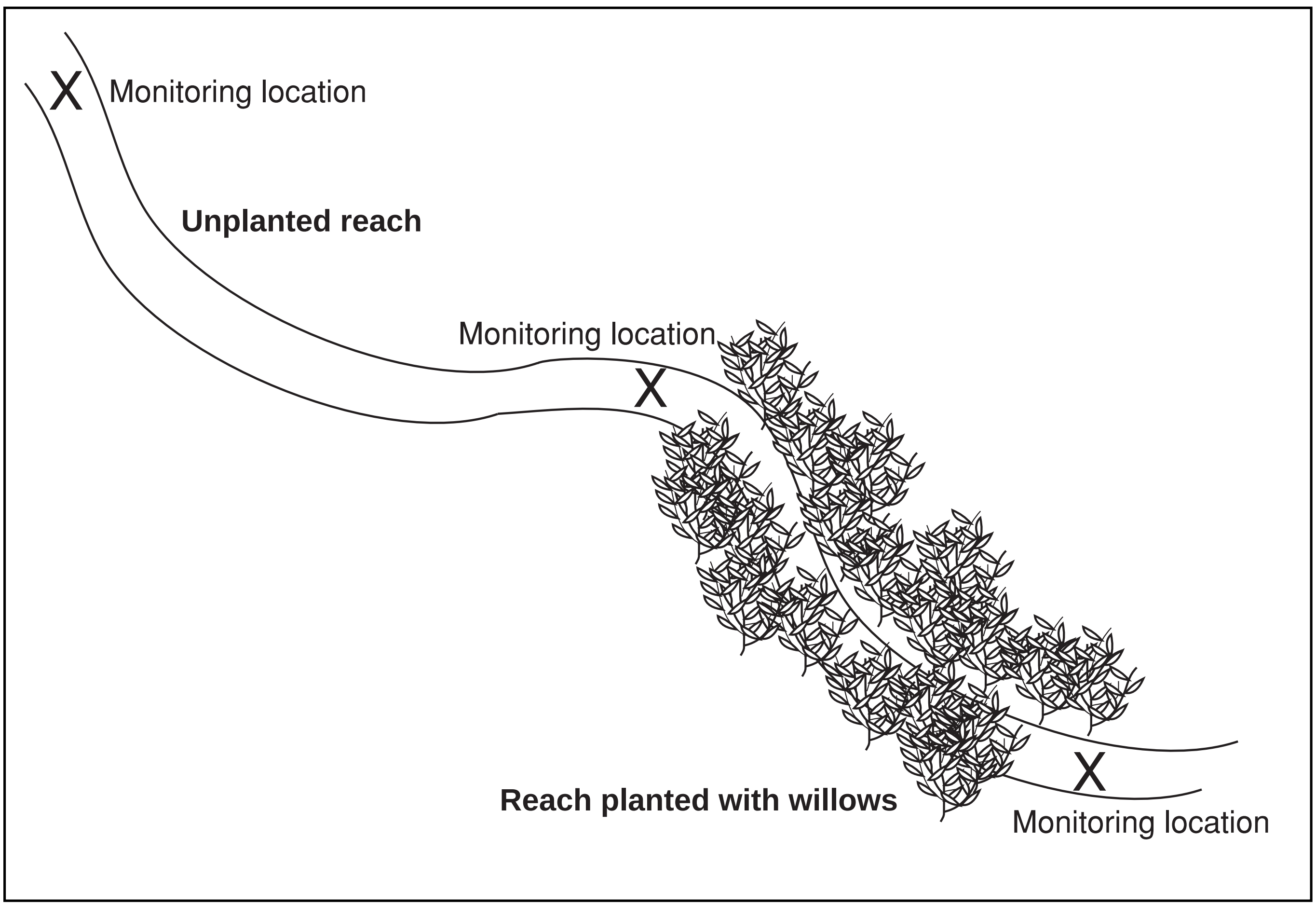


Figure 4.–Monitoring of paired reaches, one of which has been planted with willows. (Diagram is schematic and not to scale.)

TEN COMPONENTS OF A SUCCESSFUL WATER-QUALITY MONITORING PROGRAM

This section introduces considerations for anyone wishing to start a water-quality monitoring program. These considerations and others are discussed in more detail in publications such as *Volunteer Stream Monitoring: A Methods Manual* (EPA, 1997), *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (EPA, 1996), and the *Water Quality Monitoring Guidebook* (OPSW, 1999).

1. A diverse Technical Advisory Committee

A Technical Advisory Committee (TAC) is a group of people who can provide technical review of all stages of the monitoring project. A TAC might:

- Give advice on monitoring questions and the sampling strategy
- Find resources such as monitoring equipment and money
- Promote community buy-in of the project
- Review the results and conclusions for credibility
- Assist with data interpretation and presentation
- Vouch for the project's credibility to agencies

A broad selection of technical expertise and diverse perspectives will make the project both scientifically sound and acceptable to the community. The TAC might be composed of university scientists, natural resource agency staff, watershed stakeholders, landowners, and interested citizens.

Include state and federal monitoring experts as much as possible. You might want to invite participation from the United States Geological Survey, the Oregon Department of Fish and Wildlife, the Oregon Department of Environmental Quality, agencies that manage land in the watershed, major industries in the basin, and industries or cities that have permits to discharge into the river.

Different TACs have varying amounts of involvement in monitoring projects. Some meet annually to review the project and results. Other TACs never meet formally, but their individual members review draft plans and reports and are available for consultation as time allows.

2. Clear monitoring questions

A clear monitoring question is essential for producing useful monitoring results. The *Water Quality Monitoring Guidebook*, published by the Oregon Plan for Salmon and Watersheds, suggests that defining the problem, goals, and objectives at the beginning of a monitoring project will help structure the monitoring so that the data collected provide reliable answers to the questions (OPSW, 1999). Table 1 (page 7), produced by the Oregon Department of Environmental Quality Volunteer Monitoring Coordinator, provides a matrix that can help you set goals and objectives for your project. The TAC also can help with this process. Monitoring questions and objectives are discussed further in Chapter II-5.

A sampling design or strategy is the "what, where, when, and how" of water-quality monitoring.

3. A quality assurance project plan

A quality assurance project plan outlines monitoring procedures in detail so that the samples, data, and reports are of high enough quality to meet project objectives. It describes the field, lab, and data management protocols; procedures for training and overseeing volunteers; and data interpretation and presentation methods.

Ideally, the plan is developed in collaboration with the TAC and is approved by funding agencies or those that will use the data, such as DEQ. In Oregon, the DEQ's Volunteer Monitoring Coordinator provides input into these plans and approves them. EPA's *The Volunteer Monitor's Guide to Quality Assurance Project Plans* provides step-by-step instructions on how to develop a quality assurance project plan.

4. A well-designed sampling strategy

A sampling design or strategy is the "what, where, when, and how" of water-quality monitoring. Choose parameters, sampling schedules, sampling locations, and methods that will answer your monitoring questions. Sampling designs are discussed in Chapter II-5, "Assessment and Monitoring Considerations."

5. Appropriate testing methods

The method you choose to measure each parameter plays a large role in the overall quality of your data. In choosing methods, take the following factors into consideration.

Precision and accuracy describe the repeatability of the measurement and how close it is to the true value of the parameter. Most parameters can be measured at varying levels of precision and accuracy. A colorimetric pH kit, for example, might measure pH to a precision and accuracy of +/- 1 pH unit. A pH meter and probe, on the other hand, might measure pH with a precision and accuracy of 0.1 pH unit.

Cost generally increases as precision and accuracy increase. It is not always necessary to use highly accurate methods, so you might want to prioritize where to put your money.

The level of expertise necessary to produce reliable data depends on the method. Depending on the time available for training and supervision of volunteers, you might want to choose a simple method with few steps and chemical reagents versus a more complex method.

6. Quality assurance (QA) and quality control (QC)

Quality assurance and quality control, often referred to as QA/QC, ensure the quality of the data. According to the Oregon Plan for Salmon and Watersheds' *Water Quality Monitoring Guidebook*, quality assurance is the overall project management, including organization, planning, data collection, documentation, and quality control. Quality control, on the other hand, is a series of technical activities conducted routinely to minimize errors (OPSW, 1999). Errors can occur in the field, lab, or office, so QC should be included in all aspects of the project.

Examples of QC activities include repeating field measurements, splitting samples with a professional lab, reviewing data sheets for errors, and checking an electronic database against data sheets. The *Volunteer Monitor's Guide to Quality Assurance Project Plans* provides more detailed guidance on QA/QC activities (EPA, 1996).

7. Training

Monitoring staff or volunteers must receive training and commit to collect data according to the monitoring plan and selected methods. Staff or volunteers must coordinate sample collection, equipment calibration and maintenance, and chemical management (if any). Training should be conducted periodically, even if participants have been monitoring for a long time. Include a description of the training procedures and schedule in the monitoring plan.

8. Safety

Always follow safety precautions in the field and laboratory; no water sample is worth injury or death. Encourage individuals collecting field data to work with a partner at all times. Cancel monitoring during hazardous weather. If monitors will be wading streams, provide training on estimating hazardous stream flows. In both the lab and the field, wear gloves and goggles when using chemicals. Dispose of chemicals properly.

9. Data management

Collect and store data so that they are easily accessible in case your project experiences staff turnover or receives requests for data from outside organizations. Use a field data sheet when collecting water samples and testing them in the field. Data sheets will help you be consistent in your field procedures. They also provide space to record observations that might help you interpret the data.

Store data on a computer and back them up on disks. Whether you use a database program or spreadsheet program, the format should be easy for someone outside the project to understand. The Oregon Department of Environmental Quality might have a preferred data storage format for sharing data.

10. Data interpretation and presentation

Data interpretation and presentation are the final steps, and often the ultimate goal, of monitoring. When designing a monitoring plan, it is critical to include enough time and funding for data interpretation and presentation to the community, TAC, agencies, and other stakeholders. These steps allow the data to be used by water resource management agencies, landowners, and local decision makers.

When interpreting data, keep in mind the questions you asked when developing your monitoring plan. Use charts and graphs to attempt to answer the questions. Ask the TAC to review drafts of your reports and findings before you present them to the public.

When presenting your results and findings, keep your audience in mind. Different groups might want different products. An agency, for example, might be interested in tables, or might prefer to receive the data electronically. Citizens, on the other hand, might be more interested in seeing the information in newspaper articles, a poster at the local library, or an easy-to-read publication. For a lay audience, it is important to:

- Use charts, graphs, maps, and pictures
- Reduce tables of numbers to summary statistics
- Write clearly and eliminate technical terms

The Massachusetts Water Watch Partnership has produced a manual *Ready, Set, Present!* that focuses on presenting water-quality data to a range of audiences using many different methods. The manual covers oral presentations, written presentations, effective graphics, media relations, and exhibits (Massachusetts Water Watch Partnership, 2000).

Summary/Self review

Water quality describes the chemical, physical, and biological aspects of water, generally in terms of suitability for a particular use. Water-quality monitoring is the process of sampling and analyzing water conditions and characteristics (EPA, 1997). These characteristics, such as dissolved oxygen, pH, and temperature, are known as parameters.

Citizens and agencies monitor water quality to:

- Identify particular pollutants of concern
- Identify whether the quality of the water is sufficient for a particular use
- Target problem areas
- Detect trends
- Determine the effectiveness of restoration or enhancement projects

Commonly monitored parameters are:

- pH
- Total dissolved solids
- Conductivity
- Nitrogen
- Phosphorus
- Dissolved oxygen
- Stream flow
- Temperature
- Suspended solids
- Turbidity
- Bacteria

Asking a monitoring question and developing a monitoring strategy are two important parts of water-quality monitoring. Three common types of monitoring are trend monitoring, baseline monitoring, and effectiveness monitoring. To monitor the effectiveness of a best management practice, paired reaches provide the most useful information.

Ten important considerations to keep in mind when developing a monitoring program are:

1. A diverse Technical Advisory Committee
2. A quality-assurance project plan
3. Clear monitoring questions
4. A well-designed sampling strategy
5. Appropriate testing methods
6. Quality assurance and quality control
7. Training
8. Field and laboratory safety
9. Data management strategy
10. Data interpretation and presentation

Exercises

You can do these exercises on your own.

Water-quality monitoring field work

Volunteer to help an agency scientist collect water samples in the field. You might choose to participate in routine monitoring or a specific project. Observe the methods used. What is the precision and accuracy of each method? Why was it chosen? Observe the quality assurance and quality control protocols followed. How does each action contribute to a technically sound program?

Water-quality monitoring data interpretation

Contact a local watershed council involved in water-quality monitoring. Volunteer to help with the data interpretation part of the monitoring program. Obtain a copy of the monitoring plan. What monitoring questions does the group want to answer? Do the data answer those questions? Are some questions left unanswered? How would you answer them?

RESOURCES

Training

For more information, contact your local watershed council, OSU Extension Service office, Soil and Water Conservation District, or the Oregon Department of Environmental Quality Volunteer Monitoring Coordinator (DEQ Laboratory, 1712 SW 11th Ave., Portland, OR 97201, 503-229-5983).

Information

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, EPA 910/9-91-001, by L. MacDonald and R. Wissmar (U.S. Environmental Protection Agency, 1991).

Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams, by S. Bauer and T. Burton (Idaho Water Resources Research Institute, University of Idaho, Moscow, 1997).

Oregon Watershed Assessment Manual (Oregon Watershed Enhancement Board, Salem, 1998).

Ready, Set, Present! (Massachusetts Waterwatch Partnership, Amherst, 2000).

Volunteer Estuary Monitoring: A Methods Manual, EPA 842-B-93-004 (U.S. Environmental Protection Agency, 1993)

The Volunteer Monitor's Guide to Quality Assurance Project Plans, EPA 841-B-96-003 (U.S. Environmental Protection Agency, 1996)

Volunteer Stream Monitoring: A Methods Manual, EPA 841-B-97-003 (U.S. Environmental Protection Agency, 1997).

Water Quality Monitoring Guidebook (The Oregon Plan for Salmon and Watersheds, Salem, 1999).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in your ability to monitor water quality.

1.

2.

3.

Glossary

Action plan—a timeline of activities an organization pursues to achieve its goals, objectives, and benchmarks.

Active channel width—the distance across a stream channel at annual high flow. Usually recognized by slope breaks, high water marks, and changes in vegetation.

Advanced regeneration—young trees that become established naturally in a forest before cutting or planned regeneration begin.

Aggradation—the process of building up a stream channel as sediment is deposited.

Alevin—newly hatched fish still attached to its yolk sac.

Algal bloom—excessive growth of algae that depletes water of oxygen. Usually caused by excess nutrient inputs to a body of water.

Alluvial outwash deposit—an area where flooding has deposited sediment. These areas provide the greatest potential for groundwater recharge.

Anadromous—fish that spawn in fresh water, migrate to sea as juveniles, grow to maturity, and return to their freshwater stream to reproduce.

Anaerobic—without oxygen. This condition occurs in soil when water fills all of the pore spaces, leaving no room for oxygen.

Aquatic area—a stream, its side channels, and depressions in the flood plain away from the stream, or the area occupied by surface water.

Aquifer—a subterranean water-bearing layer of permeable rock, sand, or gravel.

Assessment—an evaluation of present conditions of a stream, wetland, riparian area, etc. compared to proposed future conditions.

Autecology—the biology of individual plant growth and development.

Azimuth—a measure of direction based on the 360 degrees of the compass, with north as 360 degrees. Azimuths are read clockwise from north, so east is 90 degrees, south is 180 degrees, and west is 270 degrees.

Baseline—in the rectangular survey system, an east-west line.

Baseline assessment—an assessment used to establish a reference point for measured conditions in order to compare this baseline measurement to measurements taken at different times or locations.

Baseline condition—A condition measured for comparison to measurements taken at different times or locations.

Bearing—a measure of direction based on four 90-degree quadrants. Beginning from a north-south line, bearings are read from north to either east or west or from south to either east or west. For example, a bearing of N 45 degrees W is the same as an azimuth of 315 degrees, and a bearing of S 30 degrees E is the same as an azimuth of 150 degrees.

Bedload sampling—measurements of the weight and size of sediment moving along a streambed during different-sized streamflows.

Bedload sediment—sediment that is too heavy to be constantly suspended and thus rolls and bounces along the bottom of a stream.

Before-and-after comparison—an assessment that compares conditions before and after a specific treatment, enhancement, or management practice is implemented.

Benchmark—a measure of achievement (syn. outcome).

Benthic organism—a bottom-dwelling stream organism found on stones, in mud, or on vegetation.

Bioengineering–the use of vegetation and rock to restore stability to a site (usually stream banks, eroding hillsides, and eroding road cuts).

Biogeochemical–water-quality factors such as sediment, turbidity, temperature, dissolved oxygen, pH, bacteria, and nutrients.

Biological diversity (biodiversity)–a measure of the variety of living things in an area.

Braided–a stream channel that forms secondary or smaller side channels.

Bulk density–the soil's dry weight per unit volume, a common measure of soil compaction.

Cadastral surveys–the most common type of property survey that creates, restores, marks, and defines boundaries of parcels of land to describe individual ownership.

Calibration–the practice of taking sample measurements and performing calculations to carefully define the relationship between similar measurements collected with different equipment.

Capture technique–a fish survey method that involves capturing, handling, marking, and releasing fish.

Carrying capacity–the number of animals a habitat can support.

Cascade–a fast, turbulent streamflow with many hydraulic jumps, strong chutes, and eddies. Usually has a 3.5–10 percent slope.

Catalyst–a person who makes things happen by his or her energy, integrity, and force of will.

Champion–a person who chooses issues that are personally meaningful and is willing to do battle for the collective interests of a group.

Channel erosion–the detachment and movement of material from a stream channel.

Clearcutting–removal of an entire forest stand in one cutting.

Codominant–trees with crowns forming the general level of the forest canopy. These trees receive full sunlight from above but little from the sides. The crowns are medium-sized.

Collector–a stream macroinvertebrate that gathers small particles of organic matter for food.

Commercial thinning–removal of trees that can be sold for at least as much as it costs to remove them in order to improve growth of residual trees.

Communication protocol–a code of behavior or conduct that helps an organization run smoothly.

Community ecology–how the living things that make up an ecosystem interact with and are dependent on each other.

Compliance monitoring–monitoring that assesses whether an activity meets legal or other administrative requirements.

Confined–a stream channel whose shape is constrained by resistant bedrock or large boulders.

Confluence–the point at which one stream joins another.

Control sample–a sample that contains a known amount of a material or other characteristic being evaluated (e.g., a water sample that is "spiked" with a carefully measured amount of nitrate) in order to verify procedures.

Control survey–a survey that serves as a reference framework for other surveys.

Core habitat–interior habitat large enough to be far from any edge habitat.

Correlative predictor–a variable whose presence is a strong indicator that a watershed, wetland, etc. is performing a specific function.

Corridor–a stretch of habitat that connects otherwise isolated patches of habitat.

Cowardin system–a stream classification system based on water regime such as lake, estuary, or river, and on structural vegetative characteristics such as forest or meadow.

Crab–misalignment that occurs when the camera or airplane is oriented incorrectly during aerial photography. This misalignment skews the orientation of the photo from true north-south or east-west.

Creel census–a survey of existing sport fishery catches used to measure fish populations.

Crown class–a designation of trees in a forest with crowns of similar development and occupying similar positions in the crown cover. Five crown classes commonly are recognized: dominant, codominant, intermediate, overtopped (suppressed), and wolf trees.

Crown closure–the stage in forest development when the tops of trees grow closer together and lower branches die due to lack of light.

Cut and fill construction–a method of road construction in which some of the excavated material is used to build up a portion of the road surface.

Datalogger–a matchbox-size recorder with temperature sensors for in-stream temperature measurement.

Debris avalanche–a type of shallow, rapid mass movement that is most common in steep, upland areas with thin soils over bedrock.

Debris flow (debris torrent)–a very fluid mass movement that occurs when a debris avalanche or slide reaches a stream channel.

Degradation–a process whereby habitat is worsened and functions are lessened. Also the process of downcutting of a stream channel from its floor.

Degraded wetland–a wetland that has been damaged but still performs some wetland functions.

Denitrification–the process by which nitrate nitrogen is changed into gaseous nitrogen, which then can escape harmlessly into the air.

Disturbance–a natural or human-caused event (such as fire, insect attack, large wind, timber harvest, or urban development) that changes the structure and function of an ecosystem.

Dominant tree–a tree whose crown extends above the general level of the canopy, so it receives full sunlight from above and some from the side.

Drift–misalignment that occurs when the camera or airplane is oriented incorrectly during aerial photography. This misalignment skews the orientation of the photo from true north-south or east-west.

Duff layer–forest litter and other organic debris in various stages of decomposition on top of the mineral soil.

Earthflow–a type of slow mass movement that occurs in areas of deep, fine-textured soils. May move only inches per year, and clues of movement may not be very obvious.

Ecological trap–the excessive vulnerability of some animals to predators in edge habitats because of the preference of some predators to hunt in these areas.

Ecosystem–a group of organisms that interact among themselves and with their nonliving environment.

Ecosystem management–coordination of local land-management activities in order to control ecological processes at landscape scales.

Ecotone–a boundary zone at the border of two different plant communities or different-aged forest stands. Examples are the edge between riparian habitats and upland sites, or the edge between a recent clearcut and an adjacent timber stand (syn. edge habitat).

Effectiveness monitoring–monitoring used to see whether an activity produces the desired results or benefits.

Electrofishing–a method for estimating fish populations. Fish are stunned by electrical current, netted before they recover, and released after species and length data are collected.

End-haul construction–a road-building method in which the excavated material is hauled to a stable location.

Enhancement–techniques that change present conditions and “speed up” ecosystem processes to reach desired future conditions.

Ephemeral channel–a stream that flows only during storms.

Epiphyte–plants such as ferns and mosses that live in trees high above the forest floor. The epiphytes benefit from greater sunlight, and the trees are not harmed.

Eutrophication–a condition of excess dissolved nutrients in a body of water and a corresponding deficiency of oxygen.

Evapotranspiration–loss of water to the atmosphere by the combined effects of interception, transpiration, and direct evaporation from ground surfaces and water bodies.

Even-age–a forest stand where the trees are close in age and have one canopy level.

Fecal coliform–bacteria that are used as an indicator of disease-causing bacteria. Large numbers of fecal coliform bacteria may indicate a contamination problem.

Felling to lead–the practice of felling trees toward skid trails.

Fencerow-scale corridor–a narrow row of appropriate habitat that connects close habitat patches.

Floodplain–the flat area adjacent to a river or stream that functions as a natural reservoir when flow exceeds channel capacity during a 1–2.5 year flow event.

Forest productivity–a site’s ability to maintain productive plant growth, primarily trees, regardless of whether they are used for timber, fish food, habitat, etc.

Former wetland–area that once was wetland, but now is nonwetland.

Full-bench construction–a road-building method in which the entire road width is cut into the slope.

Geodetic surveying–a technique used to determine relative positions of widely spaced points, taking into account the size and shape of the earth.

GIS (Geographic Information System)–use of vast amounts of geographic information stored on computers to make maps.

Glide–a stream habitat unit with generally uniform depth and flow with no surface turbulence.

Goal–a specific, straightforward statement of desired outcomes.

GPS (Global Positioning System)–a constellation of satellites orbiting the earth, transmitting very precise time and position data. These satellites send signals to a hand-held unit on the ground to determine the user’s exact position on the earth.

Gradient–stream channel slope.

Grazer–a macroinvertebrate that lives by scraping algae off rocks (syn. scraper).

Groundwater flow–water that flows through the soil and underground rock crevices (syn. subsurface flow).

Groundwater recharge area–an area where aquifers are resupplied with groundwater as water percolates downward.

Group selection method–timber harvest method that removes mature timber as small groups $^{1}/_{4}$ to 2 acres in size. Continuous establishment of reproduction is encouraged, and an uneven-aged stand is maintained in a series of many small even-aged stands.

Habitat fragmentation–the breaking up of habitat into smaller pieces, usually by human land-use activities such as urban development, agriculture, or forestry.

Headwaters–the point where a stream originates.

High thinning–removal of relatively few dominant and codominant trees (10–15 percent) to release a large number of remaining dominant and codominant trees.

Homing–the ability of adult anadromous salmonids to find their way back from the ocean to the streams where they were born to spawn.

Hydraulic conditions–the movement of water such as in a stream.

Hydric soil–soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper layer.

Hydrodynamics–how water moves through a watershed. Vertical movements result from evapotranspiration and precipitation; unidirectional flows are downslope movement; and bidirectional flows are tides or wind-driven fluctuations in bays.

Hydrogeomorphic (HGM) wetland classification–a system for classifying wetlands based on three criteria–where a wetland is positioned in the landscape (geomorphology), its water source (precipitation, surface water, or groundwater), and its hydrodynamics (how water moves through it).

Hydrograph–a graph of changing streamflow over time.

Hydrologic cycle–the general pattern of water movement consisting of precipitation, interception, overland flow, subsurface flow, transpiration, and evaporation.

Hydrophyte–any plant growing in water or in soil that is at least periodically deficient in oxygen as a result of excess water. Hydrophytic also can mean plants typically found in wetland habitats.

Impact monitoring–monitoring that is used to determine whether a resource use or management activity has negative or positive impacts.

Implementation monitoring–monitoring used to determine whether an activity such as a watershed enhancement project is being carried out as planned.

Indicator–a characteristic that can be observed in the field or gleaned from aerial photos, wetland or soil maps, and other resource materials and is used to indicate how well a wetland, riparian area, etc. is functioning.

Indicator bacteria–bacteria whose high numbers indicate the presence of harmful bacteria. The most common indicators are *Escherichia coli* (*E. coli*) and fecal coliform.

Infiltration–the rate at which a given volume of water can move into the soil surface.

Interception–the action of plant surfaces catching precipitation that otherwise would reach the ground.

Intermediate tree–a tree that is shorter than codominant trees. Usually has a small, often lopsided crown. The crown extends into the canopy and receives a little direct light from above, but none from the sides.

Intermittent channel–a stream that flows only part of the year.

Landscape ecology–the study of natural processes at large scales.

Landscape mosaic-scale corridor–a broad and long corridor that connects major landscape features and allows both interior and edge species to move among areas on a daily, seasonal, or more permanent basis. Examples include large strips of forest that connect forest habitats, riparian habitats along rivers, and mountain ridges.

Large wood material–wood greater than 6 inches diameter and longer than 10 feet.

Leave tree–a tree left in or just outside a harvest zone to reseed the area. Also may refer to trees left after a thinning.

Levee–a natural berm that keeps a stream within its floodplain or a portion of its floodplain when the stream flow exceeds channel capacity.

Limiting factor–a resource whose limited availability limits how many plants or animals of a given size and type can grow on a site and how well they grow.

Live crown ratio–the ratio of a tree's crown length relative to the tree's total height.

Log winching–the process of using a winch and cable to pull logs to a skidding machine or tractor that stays on a designated skid trail.

Low thinning–a method of forest thinning that focuses on removing trees from the lower crown classes and leaving the better codominant and dominant trees. Because the smaller trees are removed, the average diameter of the remaining trees is greater than the average diameter of the trees before thinning.

Macroinvertebrate ("macro")–an organism that lacks a backbone and is large enough to be seen with the naked eye; an important source of food for fish.

Mass movement–landslides and others types of downhill movement of large masses of soil and related material (e.g., rocks and woody debris). Mass movements can be rapid and dramatic, or very slow and subtle.

Meridian–a north-south line used in the rectangular survey system.

Mission–a practical statement of the responsibility that an organization is willing to shoulder to attain its vision.

Mitigation banking–restoration (or creation) of large wetland areas in advance of use as legally required compensation for wetland losses created by development activities. As needed, credits can be sold to permit applicants in lieu of requiring separate wetland creation, restoration, or enhancement projects.

Monitoring–evaluation of conditions over time.

Mortality–dead trees within a forested stand or unit. Highly suppressed trees usually die, and trees of any crown class may die from disease or insect attack.

National Wetlands Inventory (NWI)–a system for locating, mapping, and classifying wetlands throughout the United States. NWI maps contain information on location in the watershed, water regime, vegetation class or subclass, morphology, and sheet versus channel flow.

Noncapture technique–a method for surveying fish populations without capturing fish, e.g., visual spawning counts and snorkel surveys.

Nonpoint source pollution–pollution that comes from many diffuse sources that add up to a water quality problem, or any source of water pollution not considered "point source" in the Clean Water Act. Generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

Objective–a specific step with measurable outcomes that a group will take to achieve a specific goal.

Organizational structure–the pattern of relationships within a group. Includes hierarchy (who's in charge), roles and responsibilities, and many other factors.

Overgrazing–grazing so heavy that it impairs future forage production and causes range deterioration through damage to plants, soil, or both.

Overland flow–water from precipitation that moves over the ground surface (syn. surface runoff).

Overtopped tree–a tree whose crown is below the main canopy and receives reduced light from above or from the sides. Growth is very slow and the crown is small (syn. suppressed).

Paired watershed comparison–an assessment that compares conditions such as water quality or habitat features in two nearby similar watersheds.

Pathogen–disease-causing organism.

Penetrometer–an instrument that measures the resistance of 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.

Percolation–the downward movement of water through the soil, primarily because of gravity.

Permeability–how much water can be absorbed by the soil over time.

Phloem–the outer layer of tree tissue that conducts food from the leaves to the stem and roots.

Photogrammetric survey–a survey that uses data obtained by cameras (aerial photos) and other sensors.

Photosynthesis–the conversion by green plants of water, sunlight, and carbon dioxide from the atmosphere into food energy.

Plane survey–a survey method that assumes the earth is a flat horizontal surface (a plane).

Point source pollution–pollution from easily identified sources such as factories or sewage plants.

Pool–a stream habitat unit with a water surface slope of less than 0.5 percent.

Population ecology–the role of disturbance and change in forest development.

Population size–how many individuals of a species are present in an area.

Porosity–the various sizes and total volume of spaces in the soil. Highly porous soil allows water to infiltrate quickly.

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.).

Precommercial thinning–removal of some trees in a young stand to reduce competition for water and nutrients and to accelerate commercial growth of remaining trees. Trees thinned from these stands have no commercial value as logs.

Principal point–the center of an aerial photo. Images are displaced as they move away from the principal point.

Property survey–a survey that establishes property corners, lines, and areas of parcels.

Proposed condition–the desired condition of an area that maximizes its potential. Proposed future conditions must be within the area's potential or capacity for vegetation quantity and types.

Quarter corner–in the rectangular survey system, the midpoint on each of the lines forming the boundaries of a section. Sections can be divided into quarters and halves by connecting these points.

Rainfall simulator–an instrument that measures soil infiltration by adding a measured amount of water to the soil surface in drop form to resemble rain.

Random sampling–randomly identifying plots for sampling through use of a method such as a random number table.

Rapid–a stream habitat unit with swift, turbulent flow that includes chutes and some hydraulic jumps swirling around boulders. Usually has a 2–4 percent slope.

Reach–a segment of a stream between tributaries or between two points marked by a change in valley and channel form, vegetation, land use, or ownership. Reaches vary in length from approximately 1,500 feet to 5 miles.

Redd–a nest of gravel where fish lay their eggs.

Reference condition–a condition for a given area that would be expected to provide maximum potential benefits to fish, wildlife, water quality, and landowners.

Reference site–an area with climate, land forms, stream gradients, soils, and potential vegetation that is similar to an area being assessed and that is providing maximum potential benefits to fish, wildlife, water quality, and landowners.

Reforestation–the act of encouraging tree growth on lands that currently have no trees or have too few trees to fully occupy the site.

Refugia–an area of cool water surrounded by warm water.

Regional-scale corridor–a habitat corridor that connects nature reserves in regional networks.

Release–the practice of freeing understory or midsize conifers to grow by removing competing vegetation such as alder.

Replicate comparison–an assessment that compares various locations to see whether any effects due to management occur in a consistent pattern.

Retention capacity–the ability of a stream to retain food resources.

Return interval–the average number of years between events of a specific magnitude, for example a peak streamflow of a certain level.

Riffle–a stream habitat unit with fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble and usually an 0.5–2.0 percent slope.

Ring infiltrometer–an open metal ring that is partially inserted into the surface soil to measure soil infiltration. An observer then adds a measured amount of water and notes how long it takes the water to drain.

Riparian area–a zone adjacent to water where the soil is wet, for example, around springs, ponds, and streams.

Riprap–stones or other energy-absorbing material used to stabilize a road bank, stream bank, or stream channel.

River continuum concept–the typical pattern of primary food sources that occurs as a stream travels from its source to its mouth. Forests located at the source 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 mid-river tributaries.

Rotation–the period of years required to establish and grow a timber crop to a specified condition of maturity, when it may be harvested and a new tree crop started.

Rotation grazing–a system of moving animals among pastures.

Salmonid–the group name for salmon, trout, and char.

Sapwood–light-colored wood that appears on the outer portion of a cross section of a tree. Composed of dead cells, it serves to conduct water and minerals to the crown (syn. xylem).

Scalp–to physically remove the sod or surface layer of debris to expose mineral soil for tree planting.

Scarify–to disturb the forest floor and topsoil in preparation for natural regeneration or direct seeding or planting.

Scavenger–a stream macroinvertebrate that feeds on salmon carcasses and other decaying material.

Scraper–a stream macroinvertebrate that lives by scraping algae off rocks (syn. grazer).

Seasonal sampling–assessments of water quality during 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.

Section–in the rectangular survey system, an area of approximately 1 mile square (640 acres). There normally are 36 sections in a township.

Seed-tree regeneration–removal of all the mature timber in a stand in one cutting, except for a few seed trees left singly or in small groups to provide forest regeneration by seed dispersal.

Seining–a fish survey technique in which large nets are used to catch fish, which then are measured, identified, and released.

Self-thinning stage–a stage of forest development when the smallest (suppressed) trees die. The larger trees continue to grow at a similar or improved rate.

Shade tolerance–the capacity of a tree or plant species to develop and grow in the shade of and in competition with other trees or plants.

Shelterwood regeneration–removal of the mature timber in a stand in a series of cuttings over a relatively short period of time. The goal is to establish another even-aged forest under the shelter of 10–30 seed trees per acre. These shelter trees usually are removed within 5–10 years to release the regeneration.

Shredder–a macroinvertebrate that exists by shredding leaves into small pieces for food.

Silviculture–management of forests to guide the establishment, composition, and growth of forest trees to meet management objectives.

Single tree selection harvesting–removal of scattered individual mature trees at relatively short intervals. This process can be repeated indefinitely. New trees periodically establish, and an uneven-aged stand is maintained.

Sinuosity–measurement of the winding or snakelike pattern of a stream. Measured by stream length divided by valley length.

Skid road–a pathway over which logs are skidded (syn. skid trail).

Skidding–the process of dragging logs from the woods to a landing.

Slash–tree debris left after harvest.

Slash treatment–piling or burning slash to prepare a harvested site for tree planting.

Slide–a type of shallow, rapid mass earth movement that is most common in steep, upland areas with thin soils over bedrock.

Slump–a type of large, slow mass earth movement that is most common in areas of deep, fine-textured soils. May move only inches per year, and clues of movement may not be very obvious (e.g., leaning trees or soil cracks).

Smolt–a 1- to 3-year old anadromous salmonid that is ready to migrate to the sea.

Snag–a standing, dead tree or a standing section of the stem of a tree broken off at the height of 20 feet or more.

Species diversity–the number of species present in an area.

Sponsor–a person who provides direct support to a group by advocating, promoting, assisting, and furthering the goals of the group in many ways.

Step–an abrupt, discrete break in stream channel gradient, usually shorter than the channel width.

Stereoscope–a tool used with overlapping photos to see three-dimensional images on aerial photos.

Stomata–cells usually on the underside of a leaf that open each day to let in carbon dioxide for photosynthesis. When stomata are open, water evaporates from the leaf. When water is in short supply, the stomata close and photosynthesis stops.

Storm event monitoring–collection of samples during and immediately after a rainfall or snowmelt event.

Strategic alternative–a long-term, basin-wide action. Strategic alternatives usually cover a 5–10 year time horizon and identify projects that could accomplish management goals and objectives.

Stratified sampling–grouping of sample plots in areas with similar conditions (e.g., soil type, slope, cover, or habitat type).

Stream geometry–the "shape" of a stream, including factors such as width, depth, gradient, and sinuosity.

Stream order–a way of classifying streams. 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 order.

Stream productivity–how much food is generated at all levels of the food chain from initial energy inputs into a stream.

Structural diversity–the vertical and horizontal features of a landscape. For example, the different vegetation layers in a forest provide vertical structural diversity.

Subsurface flow–water that flows through the soil and underground rock crevices (syn. groundwater flow).

Subunit pool–an alcove, backwater, or isolated pool that usually isn't as long as the full channel width.

Succession–the stages of forest development, usually beginning with grasses and progressing to shrubs, seedling trees, mature trees, and finally old growth.

Suppressed–a tree whose crown is below the main canopy. Receives no direct light from above or from the sides. Growth is very slow and the crown is small (syn. overtopped).

Surface erosion–the movement of individual soil particles, usually by water flowing over exposed soil surfaces.

Surface runoff–water from precipitation that moves over the ground surface (syn. overland flow).

Survey plat–a graphic representation drawn to scale that depicts the actual survey as described in the official field notes. The plat illustrates lot sizes and locations; bearings and distances; and corners, courses, and distances of surveyed lines.

Suspended sediment–sediments that are carried in the water. Usually fine sediments such as clays, silts, and fine sands.

Systematic sampling–a method of sampling that is based on consistent, fixed distances between sample points.

Tactical alternative–a short-term, local action. Tactical planning is best conducted on a project-by-project basis.

Terrace–a landform that is an abandoned floodplain.

Test sample–a sample that is used to check handling and analytical procedures.

Thermal cover–any object (vegetation, rocks, etc.) that protects wildlife from extreme temperatures.

Topographic map–a map that shows relief features, hydrology, roads, and some other human-made structures.

Total suspended sediment–a measure of how much sediment a stream is carrying above the bed (not rolling along the bed).

Transect–a line established in the field along which measurements are taken.

Transpiration–the uptake of soil water by plants and its evaporation to the atmosphere through leaves and other plant surfaces.

Transport vector–how water is transported. Precipitation is transported from the atmosphere, lateral flows are transported by surface or near-surface flows, and groundwater is transported by subsurface flow.

Trend monitoring–an assessment method that repeats measurements over time and compares them to a baseline measurement to see whether a pattern emerges (e.g., increasing, decreasing, or a cycle).

Turbidimeter–an instrument that measures the amount of light absorbed by a water sample compared to clean water.

Turbidity–the degree to which light is blocked in water.

Understory-release stage–a stage in forest development when the larger trees start to fall down due to wind, old age, and illness. Natural gaps and openings develop, allowing light to reach the forest floor. Shade-tolerant understory plants and trees start to grow in these gaps.

Uneven-age–a forest stand in which there are considerable differences in the age of the trees and in which three or more age classes are represented.

Upstream vs. downstream comparison–an assessment method that compares measurements taken from stream locations immediately upstream and downstream of a stream reach where a particular management or enhancement practice is used.

Validation monitoring–a measurement that is designed to see whether a mathematical model or other prediction tool provides accurate results or should be improved or used differently.

Vented ford crossing–a combination of a small culvert (i.e., capacity for moderate storm flows) with heavily armored fill at or near the crossing to handle overflows during very heavy storms.

Vexar tube–a rigid, plastic-net tube made from Vexar (a trademark of the DuPont Corporation). Used to protect tree seedlings from animal damage.

Vision–an expression of the ideal future, what life would be like in the best of all possible worlds.

Water bar–a V-shaped trench cut into the surface of a road that collects water and channels it off the road surface to avoid erosion.

Water gap–a gap in a fence that allows livestock to have minimal access to a stream.

Water quality limited list (303(d) list)–a DEQ-developed list of streams in Oregon that do not meet applicable water-quality standards. The list specifies which measured factors cause the stream to be limited.

Water table–a layer of saturated soil.

Weir–an enclosure set in a stream to capture fish.

Wetland compensatory mitigation–the legally required creation, restoration, or enhancement of wetlands to compensate for wetland losses created by development activities.

Wetland creation–the construction of a wetland at a site where no wetland has existed in the past 100–200 years.

Wetland enhancement–the alteration, maintenance, or management of existing wetlands for long-term improvement of particular functions or services.

Wetland functional assessment–an evaluation of the functions a wetland performs or could perform and how well it is performing them.

Wetland restoration–the return of a former or degraded wetland to a close approximation of a previous higher functioning state.

Wildlife monitoring protocol–a detailed plan to assess the current condition of a specific population of a wildlife species.

Wolf tree–a tree that develops and grows in the open. Wolf trees have full crowns on all sides, with branches well below the canopy level. These trees are vigorous, but are poor timber trees because of large branches. They make excellent wildlife trees.

Xylem–light-colored wood that appears on the outer portion of a cross section of a tree. Composed of dead cells, it serves to conduct water and minerals to the crown (syn. sapwood).

Zone of influence–the many land-based factors that influence in-stream processes, including the plants that hang over the stream as well as trees growing farther away that might shade or fall into the stream.

Acronyms

4SOS	For the Sake of the Salmon
BLM	U.S. Bureau of Land Management
BPJ	Best Professional Judgement
CSRI	Coastal Salmon Restoration Initiative
DEQ	Oregon Department of Environmental Quality
DLCD	Oregon Department of Land Conservation and Development
DSL	Oregon Division of State Lands
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESIC	USGS regional Earth Science Information Center
GIS	Geographic Information System
GPS	Geographic Positioning System
HGM	Hydrogeomorphic
LWM	Large woody material
NMFS	National Marine Fisheries Service
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OCMP	Oregon Coastal Management Program
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OFRI	Oregon Forest Resources Institute
OFWAM	Oregon Freshwater Wetland Assessment Method
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PFC	Proper Functioning Condition
PRC	Pacific Rivers Council
PSWA	Puget Sound Watershed Approach
STEP	Salmon and Trout Enhancement Program
SWCD	Soil and Water Conservation District
USDI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey Department
WCM	Wetland Compensatory Mitigation
WET	Wetland Evaluation Technique